Noncystimorph Colonial Rugose Corals of the Onesquethaw and Lower Cazenovia Stages (Lower and Middle Devonian) in New York and Adjacent Areas

GEOLOGICAL SURVEY PROFESSIONAL PAPER 869

Noncystimorph Colonial Rugose Corals of the Onesquethaw and Lower Cazenovia Stages (Lower and Middle Devonian) in New York and Adjacent Areas

By WILLIAM A. OLIVER, Jr.

GEOLOGICAL SURVEY PROFESSIONAL PAPER 869

Paleobiology and biostratigraphy of 38 species of colonial rugose corals from New York, Ontario, Ohio, Kentucky, Indiana, Michigan, and Quebec

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1976

UNITED STATES DEPARTMENT OF THE INTERIOR

THOMAS S. KLEPPE, *Secretary*

GEOLOGICAL SURVEY

V. E. McKelvey, ***Director***

Library of Congress Cataloging in Publication Data

Oliver, William Albert, Jr., 1926–

Noncystimorph colonial rugose corals of the Onesquethaw and lower Cazenovia stages (Lower and Middle Devonian) in New York and adjacent areas.

(Geological Survey professional paper ; 869)

Bibliography: p.

Includes index.

Supt. of Docs. no.: I 19.16:869

1. Rugosa. 2. Paleontology—Devonian. 3. Paleontology—Northeastern states. 4. Paleontology—Canada. I. Title. II. Series: United States. Geological Survey. Professional paper ; 869.

QE778.044 563'.6 74–32012

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402
Stock Number 024-001-02815-8

CONTENTS

ILLUSTRATIONS

[Plates follow index]

TABLES

NONCYSTIMORPH COLONIAL RUGOSE CORALS OF THE ONESQUETHAW AND LOWER CAZENOVIA STAGES (LOWER AND MIDDLE DEVONIAN) IN NEW YORK AND ADJACENT AREAS

By William A. Oliver, Jr.

ABSTRACT

A succession of coral faunas is recognized within the Onesquethaw and lower Cazenovia Stages in Eastern North America. Corals are rare in the lower Onesquethaw (Siegenian and (or) Emsian age). A middle Onesquethaw (Emsian) coral assemblage is homogeneous and widespread and includes several colonial rugose corals. In New York this assemblage is found in the Schoharie and Bois Blanc Formations.

The Onondaga Limestone, except for its upper member, is upper Onesquethaw (Eifelian) in age. The Onondaga, and equivalent formations in other parts of Eastern North America, contain a large variety of corals including many colonial rugose corals. The areal distribution of upper Onesquethaw corals is partly controlled by facies, but successions of coral assemblages in New York, Ohio, and Kentucky are similar and provide the basis for biostratigraphic subdivision of the upper Onesquethaw. Colonial rugose corals are most numerous and diverse in bioherms found within the Edgecliff Member of the Onondaga in New York and southwestern Ontario. They are less diverse and numerous in biostrome facies of the same age, but this facies is more widely developed. A still smaller colonial rugose coral assemblage in the higher Moorehouse Member of the Onondaga Limestone is also widespread.

The Seneca Member of the Onondaga Limestone is in the lower part of the Cazenovia Stage (Eifelian). Only one colonial rugose coral is known from this member in New York, but additional forms are known from rocks of the same age in other areas.

All colonial rugose coral species known from the Onesquethaw and lower Cazenovia Stages in New York and Niagara Peninsula of Ontario, except the cystimorphs, are described on the basis of available specimens from all of Eastern North America. Additional species from Kentucky, Ohio, Michigan, Quebec, and Venezuela are described because of their importance in understanding the New York-Ontario genera and species. Genera are described and interpreted on the basis of all known species. Most of the genera and all of the species are endemic to the Eastern Americas Faunal Realm. Their histories in the Eastern Americas Realm and analogous Old World Realm genera are discussed in detail.

A morphologic and stratigraphic succession from early species of *Prismatophyllum* to *Grewgiphyllum* to *Eridophyllum* indicates the possible origin of the Craspedophyllinae in *Prismatophyllum* (Cylindrophyllinae). The earliest known cylindrophyllinid, however, is *Asterobillingsa*, which seems an unlikely ancestor for the whole group.

The nature and amount of variation, both within and between colonies, differs with the character considered, environment, and genetics. In general, number of septa is a low varying character within the studied colonies. Intercolony variation of the same character is a function of environment in some species. Variation tends to be greatest in situations of maximum coral diversity and least with low diversity. Variation in apparently the same ecologic situation differs in different taxa. In general, intracolony variation is less in the Craspedophyllidae than in the Zaphrentidae.

Thirty-nine species in 10 genera are described and assigned to 4 families, one of which is divided into 2 subfamilies. The families and new or only recently described subordinate taxa are: Stauriidae with *Synaptophyllum kladion* n. sp.; Craspedophyllidae, Cylindrophyllinae with *Cylindrophyllum laxtensum* n. sp. *C. deearium* n. sp., *Asterobillingsa* Oliver, type species *A. magdisa* Oliver, *A. magdisa magdisa* Oliver, and *A. magdisa steorra* Oliver; Craspedophyllinae with *Eridophyllum aulodokum* n. sp., *E. corniculum* n. sp., and *Grewgiphyllum* Oliver (type species *G. colligatum* (Billings)); Disphyllidae with no new taxa; and Zaphrentidae with *Cyathocylindrium* Oliver, type species *C. opulens* Oliver, *Heliophyllum megaproliferum* n. sp., *H. cassum* n. sp., and *H. procellatum* n. sp.

INTRODUCTION

This is primarily a study of the noncystimorph colonial rugose corals of the Onesquethaw and lower Cazenovia Stages (upper Siegenian-Eifelian) in Eastern North America. It is based on a detailed analysis of these corals from New York and the Niagara Peninsula of Ontario but also includes comparisons, discussions, and some descriptions of forms from rocks of the same age in Ohio, Kentucky, Indiana, Michigan, other parts of southwestern Ontario, Quebec, Virginia, and Illinois-Missouri (fig. 1). These areas are all within the Eastern North American (ENA) Faunal Province of Early and Middle Devonian time.

The Onesquethaw colonial rugose corals belong to several families: Stauriidae, Craspedophyllidae (Cylindrophyllinae and Craspedophyllinae), Zaphrentidae and one or more cystimorph groups. The Stauriidae, Craspedophyllidae and Zaphrentidae are the subject of this paper; the cystimorphs have not been studied. Although the first emphasis is on corals from New York and Ontario, their congeners from the Columbus Limestone in Ohio and the Jeffersonville Limestone in Kentucky-Indiana have been examined and compared; some of these are described and illustrated.

The first part of this paper is a review of the stratigraphy of Onesquethaw- and Cazenovia-age rocks in the study area with discussions of detailed correlations both within the Province and with other areas, principally Western North America and Europe. It includes a summary of the history of faunal provincialism and its extent in time and space and a description of the biostratigraphic sequence.

ACKNOWLEDGMENTS

The principal collection on which this study is based was accumulated over a number of years. Collecting began while I was a temporary geologist with the New York State Museum and Science Service, Geological Survey. I am indebted to the late Winifred Goldring, former State Paleontologist, and J. G. Broughton, former State Geologist, for financial support prior to 1957, and to them and D. F. Fisher, State Paleontologist L. V. Rickard, Assistant State Paleontologist, W. L. Kreidler, Senior Scientist, J. F. Davis, Senior Scientist and now State Geologist, and B. M. Bell, Curator of Paleontology, for moral and logistical help as well as intellectual stimulation over the many years of our formal and informal association. The State Museum freely loaned specimens and exercised great patience.

I received the full cooperation of the Geological Survey of Canada. D. J. McLaren and T. E. Bolton arranged for long-term loans of large collections, and McLaren, B. V. Sanford, and A. W. Norris consulted in the field.

Many additional institutions loaned specimens. These and the responsible authorities are: American Museum of Natural History, N. D. Newell and R. L. Batten; British Museum (Natural History), C. T. Scrutton and R. F. Wise; University of Buffalo, E. J. Buehler; University of California, Berkeley, J. H. Peck, Jr.; Harvard University, Bernhard Kummel; University of Iowa, H. L. Strimple; University of Michigan, E. C. Stumm, R. V. Kessling, and D. B. Macurda; Ohio State University, J. J. Burke and S. M. Bergstrom; Royal Ontario Museum, R. R. H. Lemon and John Monteith; and U.S. National Museum of Natural History, F. J. Collier.

I am obliged to the following individuals for permitting me to study American type and other specimens in their institutions: Rudolf Birenheide, Forschungsinstitut Senckenberg, Frankfurt-am-Main; Jürgen Kullman, Institut für Geologie und Paläontologie, Tübingen; C. T. Scrutton, British Museum (Natural History), London; and Pierre Semenoff-Tian-Chansky, Institute de Paléontologie, Paris. These visits were supported during 1969–70 by N.S.F. Grant No. GB 8357.

During the course of this study, specimens were given to the U.S. National Museum by J. W. Wells, Cornell University, and by E. J. Buehler, University of Buffalo. These are specifically acknowledged in the appropriate systematic descriptions.

Thin sections were expertly and often exquisitely prepared by William C. Pinckney, Jr., without whose help this study would not have been possible in its present form.

Photographs were made by D. H. Massie (thin sections) and R. H. McKinney (exteriors), except as noted. Film processing and printing was by H. E. Mochizuki and by Massie.

The manuscript was critically reviewed by J. T. Dutro, Jr., U.S. Geological Survey, and by J. E. Sorauf, State University of New York at Binghamton. Both reviewers helped substantially by noting errors, inconsistencies, and unclear statements.

ONESQUETHAW AND CAZENOVIA STAGES

The stage nomenclature for eastern North America was established by Cooper and others (1942) because of the recognized need for a provincial standard to permit the separation of problems of correlation within North America from problems of intercontinental correlation. The scheme has been particularly useful for Lower and Middle Devonian rocks in the eastern half of the continent because of the provincial nature of their enclosed fossils. It has been less useful in western North America and for Upper Devonian rocks.

The Onesquethaw Stage was defined to include the Esopus, Schoharie, and Onondaga Formations in

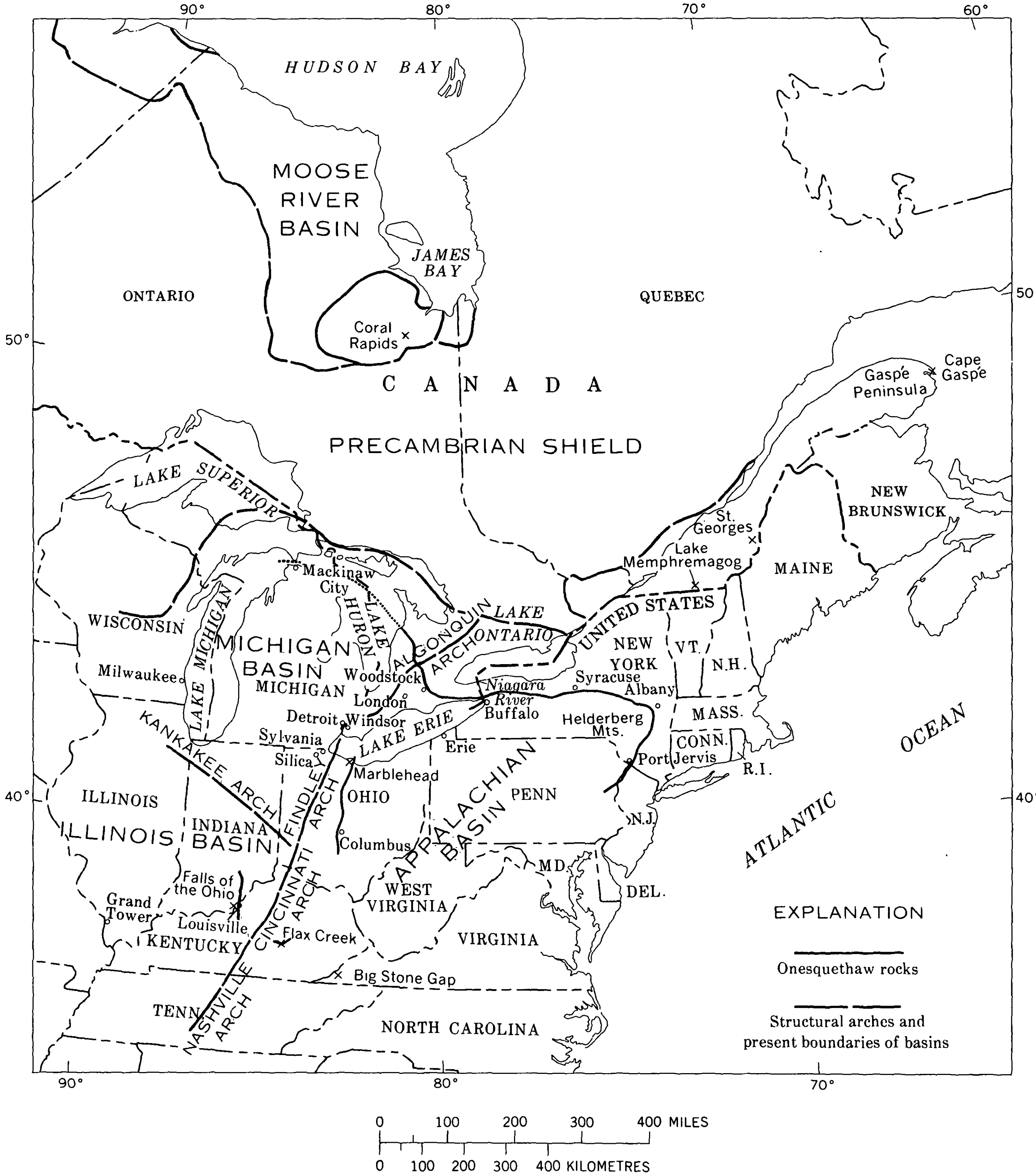


Figure 1.—Outline map of study area showing principal structural elements mentioned in the text. Geology from Geologic Map of North America, U.S. Geological Survey (1965).

Albany County, N.Y., and correlative units elsewhere. The succeeding formations of the Hamilton Group were placed in the Cazenovia and Tioughnioga Stages. General changes in the understanding of the stages can be realized by comparing the correlation charts of Cooper and others, 1942 with those of Rickard, 1964, and Oliver and others, 1968 (fig. 2). The modifications shown by Rickard represent acceptance of both the transgressive nature of the Onondaga-Marcellus boundary as discussed by Oliver (1954, p. 645–646; 1963a, p. 12; later Oliver references) and the consequent suggestion by Dennison (1961, p. 2, 10) that the upper limit of the Onesquethaw should be redefined as the top of the Tioga Bentonite Bed. These modifications had the result of placing the Seneca Member of the Onondaga Limestone in western New York in the lower Cazenovia Stage with time equivalent shale units to the east.

Rickard subdivided the Onesquethaw Stage into two stages, the Sawkill and the Southwood, to emphasize the lithic and faunal break between the Schoharie Grit and equivalent formations and the Onondaga Limestone. Earlier, Boucot (1959, p. 737–739) had suggested an Esopus Stage for the Esopus and equivalent formations (lower Onesquethaw) and had informally used "Schoharie" and "Onondaga" in a stage or substage sense. The threefold (Boucot) or twofold (Rickard) division of the Onesquethaw Stage is logical, but in this report the units are simply termed lower, middle, and upper Onesquethaw.

Changes in the correlation of the New York stages with the European standard are shown in figure 2. The position of the Lower-Middle and Middle-Upper Devonian boundaries have most recently been discussed by Oliver and others (1968, p. 1032–1035), and these correlations are used here. The bearing of the colonial rugose corals on problems of intercontinental correlation is discussed in a later section.

Figure 3 summarizes the stratigraphic nomenclature for the area under consideration. Only those rock units that are important in the present work are included. A more detailed correlation chart is in Oliver and others, 1968 and 1969.

EASTERN NORTH AMERICA

Eastern North America, as here designated, is that half of the present continent that was east of the Devonian Transcontinental arch (Eardley, 1951, p. 27–28). During Early and Middle Devonian time, the arch was important in separating an eastern from a western faunal province or realm. This will be more fully discussed below.

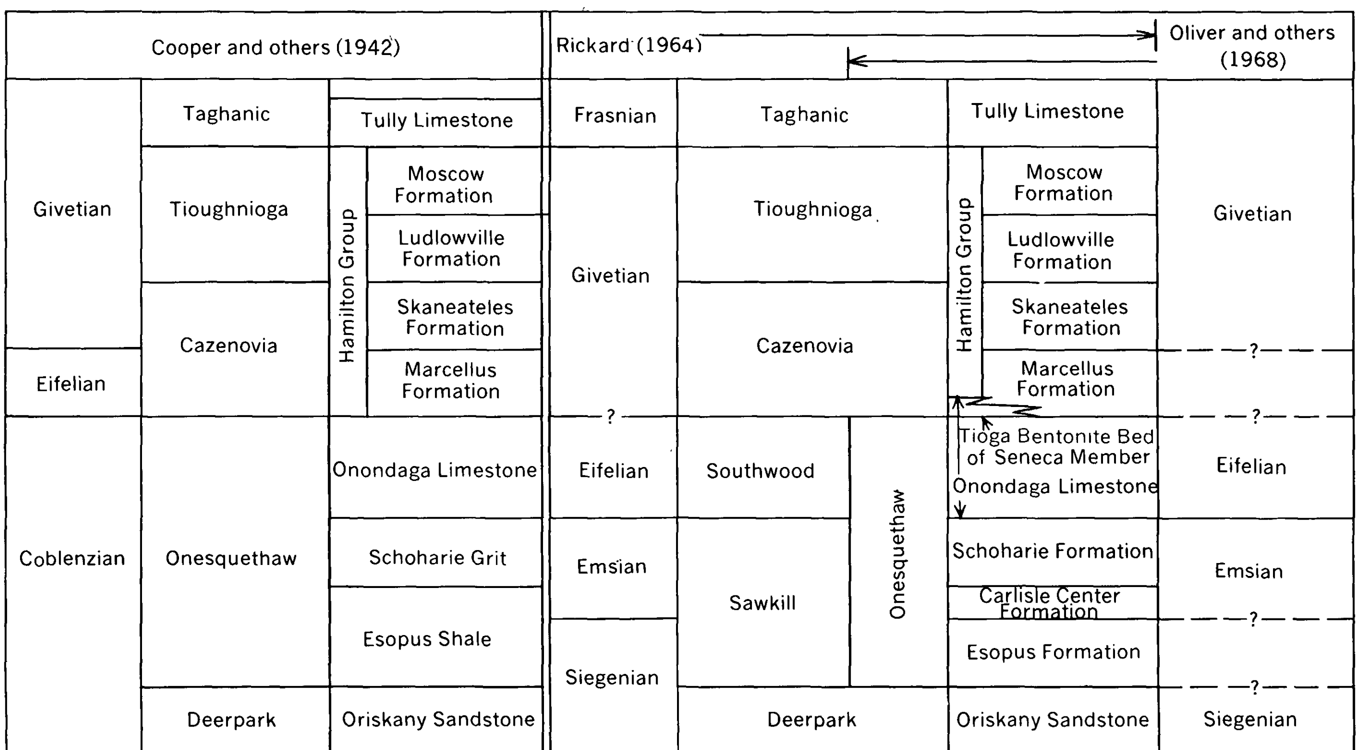


FIGURE 2.—Development of stage nomenclature in the New York standard sequence. The terminology of Oliver and others (1968) is followed in this paper.

That part of Eastern North America from which colonial rugose corals are herein described or discussed is shown in figure 1. Localities and areas mentioned in the text are identified on this map or on the more specialized maps that follow.

REGIONAL STRATIGRAPHY

APPALACHIAN BASIN

That part of Eastern North America east of the Nashville-Cincinnati-Findlay-Algonquin system of arches is termed the Appalachian Basin (fig. 1). The principal coral assemblages of this study are from the central part of the basin (New York and the Niagara Peninsula of Ontario), but a few corals from several other Appalachian areas, particularly central and northeastern Ohio but including east-central Kentucky, western Virginia, and southeastern Quebec, are also compared or described. The general stratigraphy of each area is discussed separately in the following sections to develop the regional picture of colonial rugose coral distribution and history.

Oliver and others (1968, 1969, 1971) reviewed the Devonian of the central and southern Appalachian Basin and adjacent areas. The correlation charts (1968, fig. 4; 1969) and Onesquethaw Stage isopach and lithofacies maps (1968, fig. 7; 1971, sheet 3) are summaries of much generalized data.

NEW YORK AND NIAGARA PENINSULA, ONTARIO

Colonial rugose corals are not known to occur in the lower and middle Onesquethaw Esopus and Carlisle Center Formations. They are important elements of the fauna in the Schoharie Grit in eastern New York, the Bois Blanc Formation in western New York and Ontario (both middle Onesquethaw), and in the Onondaga Limestone (upper Onesquethaw and lower Cazenovia) throughout the area. No colonial rugose corals are known from the lower part (Cazenovian Stage) of the overlying Hamilton Group.

Previous work and present understanding of the Schoharie Formation in eastern New York were summarized by Oliver (1967a, p. 1–2) and Berdan (1971, p. 161–162). Present facies interpretations and nomenclature were detailed by Goldring and Flower (1942) and Johnsen and Southard (1962). Colonial rugose corals are known only from the Rickard Hill Member of Johnsen and Southard, but this is equivalent to the original Schoharie Grit of Vanuxem (1842, p. 131) and will be referred to as the Schoharie Grit in this paper.

The Schoharie Grit consists of sandy limestone or calcareous sandstone containing a rich assemblage of brachiopods corals, cephalopods, other mollusks, and trilobites. The most comprehensive listing and discussion of the Schoharie fauna is that of Grabau (1906, p. 181–192, 325–327). Grabau did not mention or list corals although these are numerically important at many localities. Colonies of *Acinophyllum* (*A. stokesi*) and *Asterobillingsa* (*A. magdisa magdisa*) are relatively common in the Schoharie (table 1), but most specimens are poorly preserved and many are only casts. *Cylindrophyllum laxtensum* is very rare. Schoharie ostracodes were recently described by Berdan (1971).

Oliver (1966a, 1967a, p. 2–5) reviewed previous work on Bois Blanc-Onondaga stratigraphy in southwestern Ontario. Stauffer (1915) described and provided lists of fossils for numerous sections in the Niagara Peninsula. He referred to the whole sequence as Onondaga but clearly recognized that a lower fauna was distinct from that of the Onondaga proper. Cooper (in Cooper and others, 1942, p. 1774) and Flower (1943) were both referring to beds here classed as Bois Blanc when they discussed "lower Onondaga" faunas with Schoharie elements. After Ehlers (1945, p. 34, 89–109) named the Bois Blanc Formation for rocks in the Mackinac

TABLE 1.—*Geographic distribution of middle Onesquethaw (Bois Blanc-Schoharie) colonial rugose corals*

[Key: New York—eastern and western areas (see fig. 5): Ontario—Niagara Peninsula and central southwestern Ontario; Ohio—northeastern; Michigan—northern (Mackinac area); Ontario—north (Moose River Basin); Falls of the Ohio; Virginia—southwestern]

	New York		Ontario		Ohio	Michigan	Ontario	Falls of the Ohio	Virginia
	E	W	Niagara	C	NE	N	N		SW
Acinophyllum simcoense	------	×	×	×	×	------	------	------	------
A. stokesi	×	------	×	×	×	×	×	×	×
Cylindrophyllum laxtensum	×	------	×	×	------	------	------	------	------
Asterobillingsa rugosa	------	?	------	------	------	------	?	------	------
A. magdisa magdisa	×	×	×	×	------	------	------	------	------
Grewgiphyllum colligatum	------	------	×	×	------	?	------	------	------
Heliophyllum procellatum	------	?	------	------	------	?cf.	------	------	------
H. cassum	------	------	×	×	------	------	------	------	------
H. sp. (phaceloid)	------	------	×	------	------	------	------	------	×
H. coalitum	------	------	------	?	------	------	------	------	------

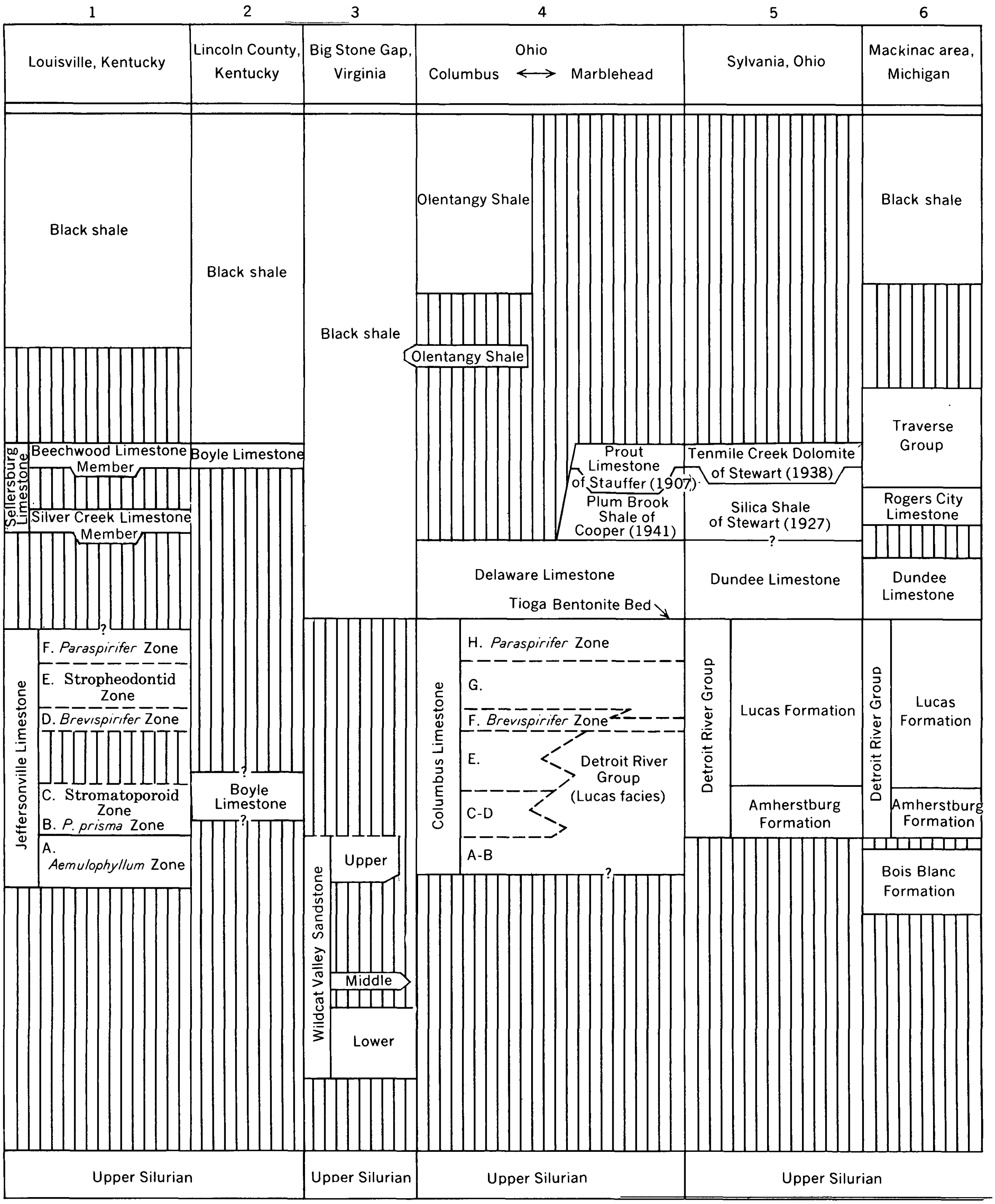
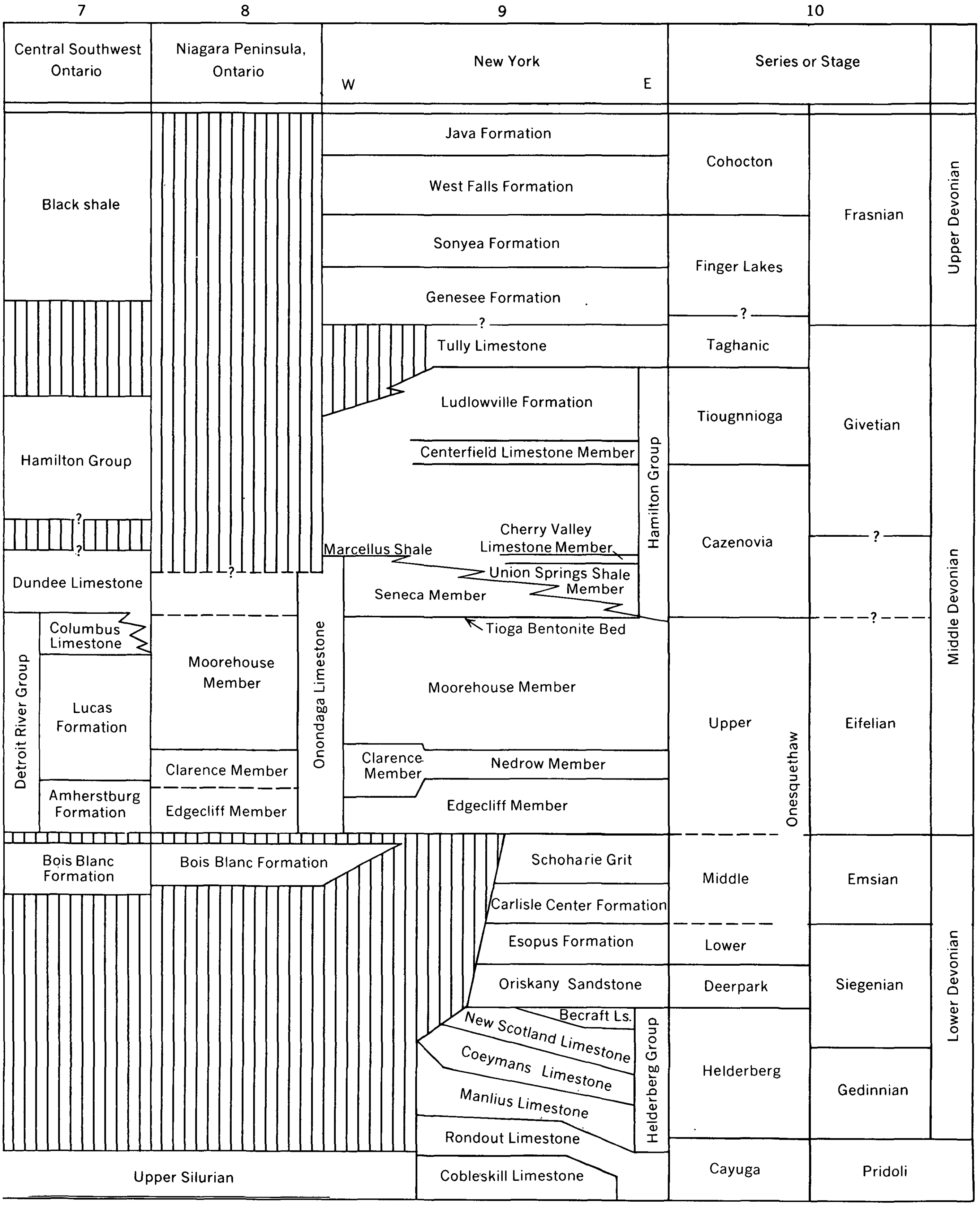


FIGURE 3.—Correlation chart of principal



stratigraphic sections discussed in text.

Straits region of Michigan, he and others (Caley, 1947; Ehlers and Stumm, 1951b; Ehlers and others, 1951; Stumm and others, 1956; Stauffer, 1957; and Sanford, 1958) correlated all or part of the New York-Ontario Onondaga and Bois Blanc with the Michigan Bois Blanc. Oliver (1960a) correlated the western New York zone of small *Amphigenia* (Bois Blanc of later reports) with the Bois Blanc and excluded it from the Onondaga. In addition he suggested that the Bois Blanc was separated from overlying formations by an unconformity. These correlations are now generally accepted (Boucot and Johnson, 1968b; Sanford, 1968).

The Bois Blanc is a medium-dark-gray, fine-grained limestone. Chert is uncommon in New York but becomes common west of the Niagara River where the formation is much thicker. Within New York, the formation is discontinuous, clearly absent in many places, and has a maximum thickness of 4 feet (1.2 m). Only one exposure is known east of the Genesee Valley.

In Ontario, the formation thickens to 15 feet (4.6 m) at Port Colborne and to at least 24 feet (7.3 m) at Hagarsville. It is a continuous unit from not far west of the Niagara River to Hagarsville and on into the Michigan Basin. In the vicinity of Hagarsville the lower few feet of the Bois Blanc is very sandy. This is the Springvale Sandstone (named by Stauffer, 1913, p. 85) which contains most of the same fossil forms as the succeeding limestone beds.

The Bois Blanc contains a rich and varied coral fauna. Among the colonial rugose corals, species of *Acinophyllum, Asterobillingsa, Cylindrophyllum,* and *Grewgiphyllum* are common (table 1), including all of the species known from the Schoharie Grit. Other corals were listed by Oliver (1968a, table 3, p. 740). Other elements of the fauna are abundant brachiopods (Boucot and Johnson, 1968b) and, less commonly, mollusks, tabulate corals, and trilobites.

Many identical coral and other species are common to both the Schoharie and Bois Blanc. The formations are considered to be time equivalents and of Emsian age as discussed below.

Both the Schoharie Grit and the Bois Blanc Formation are overlain by the Edgecliff Member of the Onondaga Limestone. Oliver (1967a) discussed the contact and concluded that both lithologic and faunal evidence indicated a disconformity between the Bois Blanc and Onondaga in western New York. The faunal break in Ontario and in eastern New York between the Schoharie and Onondaga is similar, and it is probable that there is a time gap in these areas also.

Colonial rugose corals are more abundant and varied in the Onondaga Limestone than in the underlying formations. This is partly due to the presence of more favorable conditions at the time of deposition of the Onondaga, but it also reflects the fact that the Onondaga includes a succession of faunas (Oliver, 1968a, p. 741–742) and probably represents a significantly greater amount of time.

The Onondaga is a complex of limestone facies that have been described in several papers (Oliver 1954, 1956c, 1962, 1963a, 1966c) which should be consulted for detailed descriptions of lithology, local successions, and lists of fossils in each unit. The general relationships of members and facies are shown in figure 4. The units are briefly described below, with emphasis on those that include colonial rugose corals. The Onondaga Limestone is exposed in a narrow belt that extends some 270 miles (432 km) from Buffalo to Albany, then south and southwest along the Hudson and Neversink Valleys to the New Jersey and Pennsylvania borders (fig. 5). Corals, especially colonial rugose corals, are uncommon in southeastern New York (south of Catskill), and the Onondaga of this area is not included in the following discussion.

The Edgecliff Member is the lowest unit and is present with relatively constant lithology over the whole outcrop area from Buffalo to Catskill. In general it is a massive light-gray coarsely crystalline limestone characterized by the number and variety of included rugose and tabulate corals and brachiopods. Four coral-bearing facies are recognized (figs. 4, 5). A biostrome (normal) facies occurs from Hagarsville to Catskill and contains solitary rugose and tabulate corals and brachiopods, but only one species of colonial rugose coral (*Acinophyllum segregatum*) is common, and only a few occur at all (table 2).

Locally, in the Niagara Peninsula and both eastern and western New York, but rarely in the central area, small bioherms are found (fig. 5). These are distinct mound-shaped masses, ranging from 10 to 70 or more feet (3 to 21 m) in thickness and from 30 to 1,200 feet (9 to 365 m) in diameter (Oliver, 1956a). The rock composing the bioherms is coarser grained and lighter in color than in the rest of the Edgecliff, although "reef cores" can be fine and dark (Oliver, 1966c, p. 38). The bioherms are much thicker than surrounding, contemporary beds and in some places project up into or through succeeding members. The fauna of the bioherm facies includes a variety of colonial rugose corals (table 2) in addition to solitary and tabulate corals and brachiopods. The bioherms are interpreted as representing small patch reefs in a shallow-shelf sea.

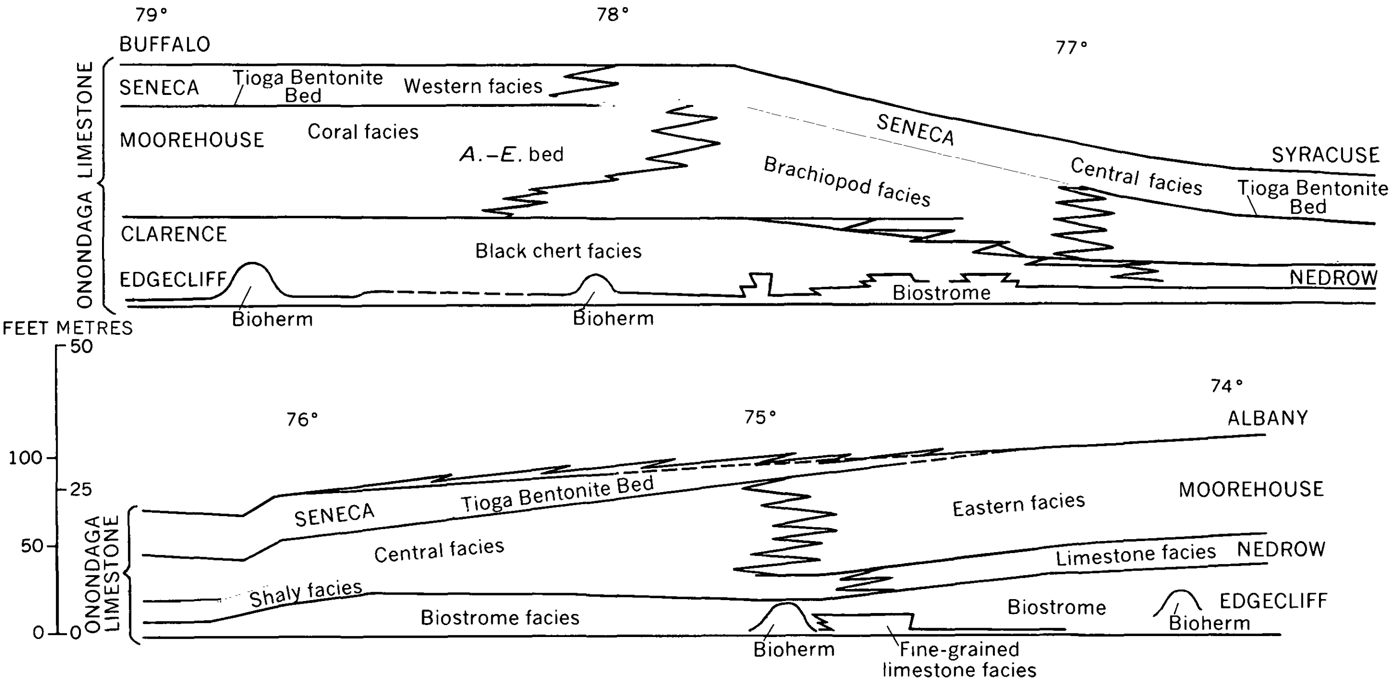


FIGURE 4.—West-to-east cross section of the Onondaga Limestone in New York showing generalized distribution and relationship of members, facies, and beds discussed in the text. The *A.-E.* bed is the *Acinophyllum-Eridophyllum* bed in the western Moorehouse Member.

TABLE 2.—*Geographic distributions of upper Onesquethaw, Edgecliff assemblage, colonial rugose corals*

[Key: New York—eastern, central, and western areas (see fig. 5); Ontario—Niagara Peninsula, Woodstock area, Formosa area; Ohio—central, northeastern; Falls of the Ohio—Zones B and C; Illinois-Missouri—Grand Tower area, R. Edgecliff bioherm facies]

Formation or unit	Edgecliff				Amherstburg		Columbus		Jeffersonville		Grand Tower
	New York			Ontario			Ohio		Falls of the Ohio		Ill.-Mo.
Location	E	C	W	Niagara	Woodstock	Formosa	C	NE	B	C	
Synaptophyllum arundinaceum	R	R	R	×	------	------	×	×	------	------	------
S. tabulatum	R	------	------	R or ×	------	?	------	------	------	------	------
S. kladion	------	------	------	?	------	------	------	------	------	------	------
Acinophyllum stramineum	R	------	R	R×	------	------	------	?	------	------	------
A. segregatum	R×	R×	R×	R×	------	------	×	×	------	------	------
A. mclareni	------	------	------	×	×	×	×	×	×	×	------
Cylindrophyllum elongatum	R	------	R	------	------	?	------	------	------	------	------
C. propinquum	R×	------	------	cf.	------	?	×	------	?	------	------
C. deearium	R	R	R	×	×	------	------	------	------	------	------
C. sp. A	------	------	R	------	------	------	------	------	------	------	------
Prismatophyllum prisma	------	------	------	------	------	------	×	------	×	------	×
P. ovoideum	------	------	R or ×	------	×	------	×	------	------	×	------
Asterobillingsa magdisa steorra	R	------	R	------	?	------	------	------	------	------	------
A. magdisa magdisa	------	------	R	R?	------	------	------	------	------	------	------
Eridophyllum subseriale	R×	R×	R or ×	------	------	?	------	------	------	------	------
Grewgiphyllum colligatum	------	------	R	×	------	------	------	------	------	------	------
Cyathocylindrium opulens	R	------	R	R×	------	------	------	------	×	------	------
C. gemmatum	R	------	R	R	------	------	------	------	------	------	------
Heliophyllum megaproliferum	R	------	R	R	------	------	------	------	------	------	------
H. n. sp. B	R	------	------	------	------	------	------	------	------	------	------
H. n. sp. C	R	------	------	------	------	------	------	------	------	------	------
H. coalitum	R	------	R	------	------	------	------	------	------	------	------
H. monticulum	R	------	R	R	------	------	------		------	------	------

A third Edgecliff facies is found only locally in eastern New York (fig. 4). This is a well-bedded unit in the lower part of the member and is composed of medium-gray fine-grained limestone. It contains a typical Onondaga assemblage of fossils, but colonial rugose corals are rare or lacking except in one local bed where *Acinophyllum segregatum* occurs. Presumably this "dark limestone" facies is

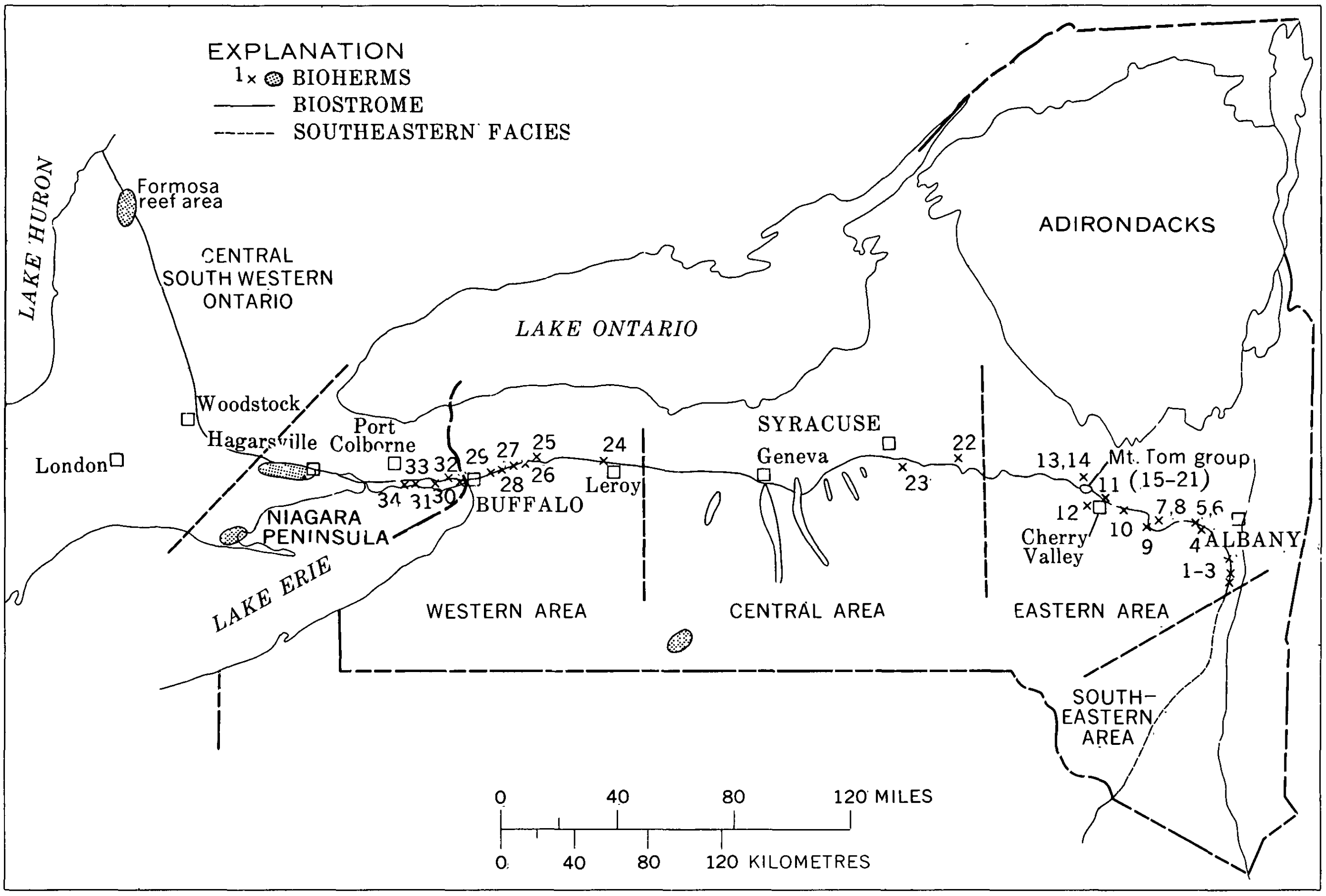


FIGURE 5.—Distribution of Edgecliff facies in New York and southwestern Ontario. The dashed lines separate the "areas" used in the text. From west to east these are central southwestern Ontario, the Niagara Peninsula, and the western, central, eastern, and southeastern areas of New York. Studied bioherms are numbered from east to west; brief descriptions are given in the "Locality Data" section for those bioherms from which colonial corals have been described. Others are described by Oliver (1956b, p. 17–22). Locality numbers are as follows: bioherm 1, locality 297; 2, 296; 3, 248; 4, 244; 6, 81; 7, 329; 8, 285; 9, 135; 11, 185; 13 and 14, 269; 15, 207; 16, 233; 18, 236; 20, 239; 21, 229; 22, 360; 23, 597; 24, 438; 25, Falkirk; 28, 348; 29, 108; 30, C3; 31, C5; 32, C7; 33, C9; and 34, C10. The Formosa bioherm area was described by Fagerstrom (1961). Other bioherm areas shown (patterned) are subsurface: Ontario, from Sanford (1968); New York from Kreidler (1972).

equivalent to the normal bioherm facies to both the east and west (fig. 3).

Another local facies of the Edgecliff (and Bois Blanc in this case) at Port Colborne, Ontario, consists of some 20 feet (6 m) of argillaceous, silty limestone beds with a distinct green color. This unit grades upward into typical Edgecliff lithology, and the upper part at least grades laterally into a nearby Edgecliff bioherm. Several colonies of colonial rugose corals were collected from various positions within the unit as follows:

Upper 16 ft (4.9m):
Acinophyllum segregatum
Grewgiphyllum colligatum

Lower 4 ft (1.2m):
Acinophyllum stokesi
A. simcoense
Asterobillingsa magdisa magdisa

These and other corals indicate that the lower 4 feet (1.2 m) are Bois Blanc in age, whereas the upper 16 feet (4.9 m) are Edgecliff. The unit should be studied in more detail to determine the reasons for its lithologic peculiarities and to see if in any sense it fills the time gap between the Bois Blanc and Onondaga.

A fifth Edgecliff facies, found in southeastern New York (fig. 5), is composed of a darker and finer grained limestone in which corals are uncommon and colonial rugose corals are unknown.

The Nedrow Member overlies the Edgecliff in central and eastern New York and passes westward into the Clarence Member which overlies and interfingers with the Edgecliff in western New York. The typical Nedrow is an argillaceous limestone at its base but grades upward into a more massive, fine-grained limestone so that its lower contact is sharp whereas the upper one is gradational. To the east, in the Helderberg area, the Nedrow is more massive throughout its thickness and the lower contact is less abrupt. Corals are common in the Nedrow, but are less varied than in the Edgecliff; colonial rugose corals are rare, but *Acinophyllum segregatum* is known to occur. The Nedrow seems to represent an influx of fine clastic material, and the base of the unit is interpreted as being virtually a time plane over its area of outcrop.

The Nedrow passes westward into the Clarence Member (Ozol, 1964; Oliver 1966b, c) in the vicinity of Geneva. The Clarence is a cherty limestone (45–75 percent chert) having few corals but including *Acinophyllum segregatum.* At some localities the Clarence and Edgecliff lithologies are interbedded and much of the thickness irregularity of the Edgecliff in western New York and the Niagara Peninsula is due to the interfingering of the two members.

The Moorehouse Member, which overlies both the Nedrow and Clarence Members, is the thickest member in all areas and generally contains the most diverse fauna. Brachiopods and mollusks are varied and numerous, but both rugose and tabulate corals are present or common in most facies. The Moorehouse is thinnest, finest grained, and darkest in central New York (central facies, fig. 4). It thickens toward both east and west and becomes lighter and coarser so that in both eastern and western New York it is nearly a repetition of the Edgecliff but without the development of biostromes or bioherms. Corals, including colonial rugose corals, are common and varied in the eastern and western facies but especially so in the west (coral facies, fig. 4), although neither the variety nor abundance is as great as in the Edgecliff. Species of *Synaptophyllum, Acinophyllum,* and *Eridophyllum* are present in the Moorehouse (table 3), but only *Acinophyllum segregatum* is generally common or widespread.

The *Acinophyllum-Eridophyllum* bed lies within the western coral facies of the Moorehouse (fig. 4). This is a bed of limestone and chert, some 20 inches (51 cm) thick, that extends for 20 or more miles (32 km) along the outcrop in the vicinity of Leroy. The bed is composed primarily of masses of *A. segregatum* and *E. seriale* (population B) and few other fossils.

In western and central New York and as far east as Cherry Valley, the Moorehouse Member is overlain by the Tioga Bentonite Bed of the Seneca. East of Cherry Valley the Tioga has not been recognized but may pass into the black shale that overlies the Onondaga (Oliver, 1956c, p. 1466–1467). The Tioga represents a widespread ash fall that is known throughout a large part of the Appalachian Basin (see Oliver and others 1968, p. 1019; 1969 for summary) and as far west as Illinois (Meents and Swann, 1965). The Tioga is an excellent marker horizon and is an important aid to correlation. It is accepted here as marking the top of the Onesquethaw Stage.

The Seneca Member and its Tioga Bentonite Bed overlie the Moorehouse in western and central New York and as far east as Cherry Valley. Farther east the Seneca is unrecognized (thin or missing), and the Moorehouse is overlain by the Union Springs Shale Member of the Marcellus Shale. Oliver (1956c, p. 1465–1467) has presented evidence that the Seneca and Union Springs laterally interfinger and are time equivalent. The Seneca is overlain by the Union Springs which thins to the west as the Seneca thickens so that the Cherry Valley Limestone Member of the Marcellus, overlying the Union Springs in central and eastern New York may be the approximate equivalent of the uppermost beds of the Onondaga in western New York.

In central New York, the Seneca Member is a succession of dark, fine-grained limestones with numerous brachiopods and corals representing only a few

TABLE 3.—*Geographic distribution of upper Onesquethaw, Moorehouse assemblage colonial rugose corals*

[Key: New York—southeastern, eastern, central and western areas (see fig. 5); Ohio—central and northeastern]

	New York				Ontario	Ohio		Falls of the Ohio
	SE	E	C	W	Niagara Peninsula	C	NE	
Synaptophyllum kladion	------	------	------	×	×	------	------	------
Acinophyllum segregatum	×	×	×	×	×	×	×	------
A. mclareni	------	------	------	------	×	------	------	------
Cylindrophyllum deearium	------	------	------	------	------	------	×	------
Prismatophyllum ovoideum	------	------	------	------	------	?	------	------
P. truncata	------	------	------	------	------	?	------	?
Eridophyllum seriale	------	×	------	×	------	×	cf.	------
E. aulodokum	------	?	------	×	------	------	------	------
E. corniculum	------	------	------	×	------	------	------	------
Cyathocylindrium opulens	------	------	------	------	------	------	?	------
C. n. sp. A	------	------	------	×	------	------	------	------

species. Only one specimen of a colonial rugose coral is known (*Prismatophyllum truncata*) (table 4). West of Leroy, the member is lighter in color and coarser grained and is similar to the underlying Moorehouse, but corals are uncommon and no colonial rugose corals have been found.

The Moorehouse and Seneca Members are not well exposed in the Niagara Peninsula. They are beneath Lake Erie to the east and outcrops are sparse in the western part of the area where the belt underlain by the Onondaga strikes away from Lake Erie toward Hagarsville.

There are few or no outcrops of either the Bois Blanc or Onondaga northwest of Hagarsville as far as the Woodstock area, where the sequence is sufficiently different to warrant separate discussion.

The various shale and dark limestone members of the Marcellus and Skaneateles Formations that succeed the Onondaga and, with the Seneca, compose the Cazenovia Stage in this area, contain relatively few corals and no known colonial rugose corals.

TABLE 4.—*Geographic distribution of lower Cazenovia (Seneca-Delaware) colonial rugose corals*

Stratigraphic unit	Seneca	Famine	Dundee	"Blue" limestone
Location	New York	Quebec	Michigan	Ohio
Disphyllum? rectiseptatum	------	------	×	------
D? stummi	------	×	------	------
Heliophyllum sp. cf. *H. proliferum* Hall	------	×	------	------
Prismatophyllum truncata	×	------	------	×

CENTRAL OHIO

The Onesquethaw-Cazenovia sequence in central Ohio (fig. 3, column 4) consists of the Columbus and Delaware Limestones and the Plum Brook Shale of Cooper (1941). In addition, Tillman (1970) has suggested that the lower part of the Olentangy Shale correlates with the Plum Brook. Colonial rugose corals are known only from the Columbus Limestone. Some of the Columbus species are known also from New York or Ontario and are discussed and (or) illustrated here for that reason. Both *Eridophyllum* and *Prismatophyllum* are more common and are represented by more species in Ohio than in New York.

The Columbus Limestone crops out in a belt that extends from Pickaway County, some 25 miles (40 km) south of Columbus, north through Columbus to Marblehead on Lake Erie. It is well exposed at many places and is very fossiliferous. The formation rests unconformably on rocks of Silurian age. The top of the Columbus is a widespread bone bed which may represent a lag concentrate and be mainly isochronous throughout the outcrop area (Wells, 1944). The Tioga Bentonite Bed has been identified at only one place in Ohio, near Sandusky (Oliver, 1967b; Oliver and others, 1968). It rests on the bone bed at the Columbus-Delaware contact indicating that the top of the Columbus Limestone correlates with the top of the Moorehouse Member of New York. The overlying Delaware Limestone includes the Seneca equivalent, but the top of the Delaware is probably younger than the top of the Seneca at Buffalo.

The basic biostratigraphic analysis of the Columbus Limestone is that of Stauffer (1909), reviewed and interpreted by Wells (1947). Stauffer proposed a series of Zones, A to H, based on a combination of lithic and biostratigraphic criteria. Zone A is a basal conglomerate, but Zones B through H are essentially assemblage zones.

Zone B is poor in megafossils and has been variously interpreted, but Ramsey (1969) listed conodonts from this unit and correlated it with the Bois Blanc and Schoharie of New York.

Zone C, the coral zone, is known only in the southern half of the outcrop. It contains several Edgecliff species (table 2) and is correlated with the Edgecliff of New York and its equivalents elsewhere.

The Columbus contains a succession of *Eridophyllum* forms with *E. seriale* being characteristic of Zone H. This species is limited to the upper Moorehouse in New York and, with the Tioga Bentonite Bed, is the basis for correlating these units.

At this time, the colonial rugose corals provide the basis for correlating only Columbus Zones C and H with the New York sequence, but these and other data indicate that Columbus Zones C through H are almost precisely the Edgecliff through Moorehouse of New York.

Only the upper zones of the Columbus can be traced to northern Ohio. Zone F, with *Brevispirifer gregarius*, is known as far north as Parkertown, less than 10 miles (16 km) from Marblehead. Zone H extends to Marblehead on Lake Erie, with its fauna including *Paraspirifer acuminatus* and *Eridophyllum seriale*. Lower zones are replaced to the north by a brown, dolomitic facies that should be referred to the Detroit River Group. Zone F, in northern Ohio, is actually in the Detroit River facies, but its position is marked by the persistent *B. gregarius*. If Ramsey (1969) is correct in correlating Columbus Zone B with the Bois Blanc, then it is probable that the lower part of the Columbus in the Sandusky-Marblehead area is also of this age.

Zone B at Columbus may represent the southernmost tongue of the Detroit River. My interpretations of the Columbus-Sandusky correlations are shown in figure 6.

NORTHEASTERN OHIO

The Bois Blanc Formation does not crop out in Ohio, although lower Columbus Zone B may represent the same time interval as discussed above. However, the Bois Blanc is known in the subsurface of northern Ohio, in the area east of the Columbus outcrop, and is apparently continuous from just east of the outcrop in Lorain County to Pennsylvania and New York. In Lorain and Lake Counties it is succeeded by a "coral biostrome" representing Columbus Limestone Zone C or the Edgecliff Member and then by limestones with more or less typical Columbus and Delaware lithologies. My knowledge of the subsurface paleontology is based on a study of the fossils extracted by University of Michigan students from three Lorain County cores and one Ashtabula County core and now preserved in the Museum of Paleontology, University of Michigan (unpub. M. S. theses: G. W. Rector, 1950; J. W. Parker, 1950; W. J. Truettner, Jr., 1954; and K. R. Newman and R. L. Woodhams, 1954). In addition, I was permitted to extract and study fossils from a Lake County core owned by the Diamond Alkali Co. All fossils listed in table 5 were studied and identified in my Washington laboratory during 1966 and 1967.

The Bois Blanc Formation was first recognized in the subsurface of northern Ohio by W. J. Truettner, Jr., and by K. R. Newman and R. L. Woodhams (both unpub. M. S. theses, Univ. of Michigan 1954). Published notices are by Dow (1962) and Janssens

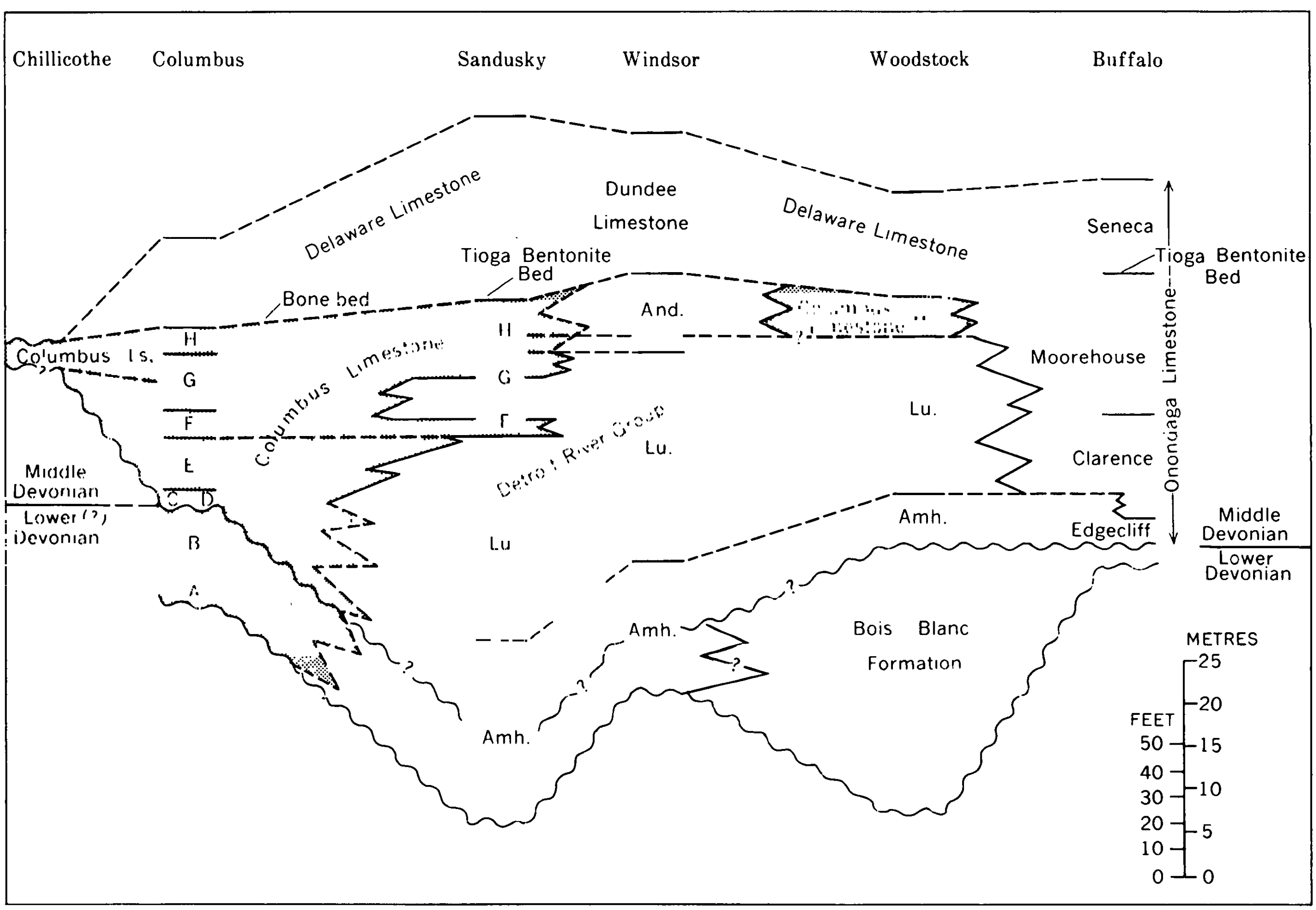


FIGURE 6.—Correlation of Onesquethaw sequence in central Ohio with those in southwestern Ontario and western New York (location of sections shown in fig. 8). Sections are drawn to approximate vertical scale but to no horizontal scale. Time relationships are discussed in the text and indicated here by the dashed lines drawn directly from section to section. Capital letters are the Columbus Limestone Zones of Stauffer. Detroit River formations: Amh., Amherstburg; Lu., Lucas; And., Anderdon Member of Lucas.

(1968, 1970b). Janssens (1970a, p. 21–27) summarized the information available in the Michigan theses and the other publications. The Bois Blanc of this area is certainly a southern extension of the Ontario unit; the subsurface Columbus and Delaware show the passage eastward from the outcropping formations to the Onondaga Limestone. My interpretations of the stratigraphy of the northern Ohio subsurface sequence are shown in figure 7, with general location of the key sections shown in figure 8. Corals and other identified fossils from the cores are listed in table 5, and the colonial rugose corals are included in tables 1, 2, and 3 as appropriate.

EAST-CENTRAL KENTUCKY

The Boyle Limestone crops out around the southwest, south, and southeast sides of the Cincinnati arch in Kentucky. Throughout its extent the Boyle is mostly Hamilton (early Tioughnioga) in age, but locally it includes older units of Onesquethaw age (Oliver and others, 1968, p. 1018; 1969, columns 34–36). One such unit, on Flax Creek, Broadhead quadrangle, Lincoln County, contains a coral fauna with mixed Columbus Limestone and Jeffersonville Limestone affinities, including *Acinophyllum mclareni*. The lithology of this 15-foot (4.6-m) unit is most similar to that of the Columbus Limestone,

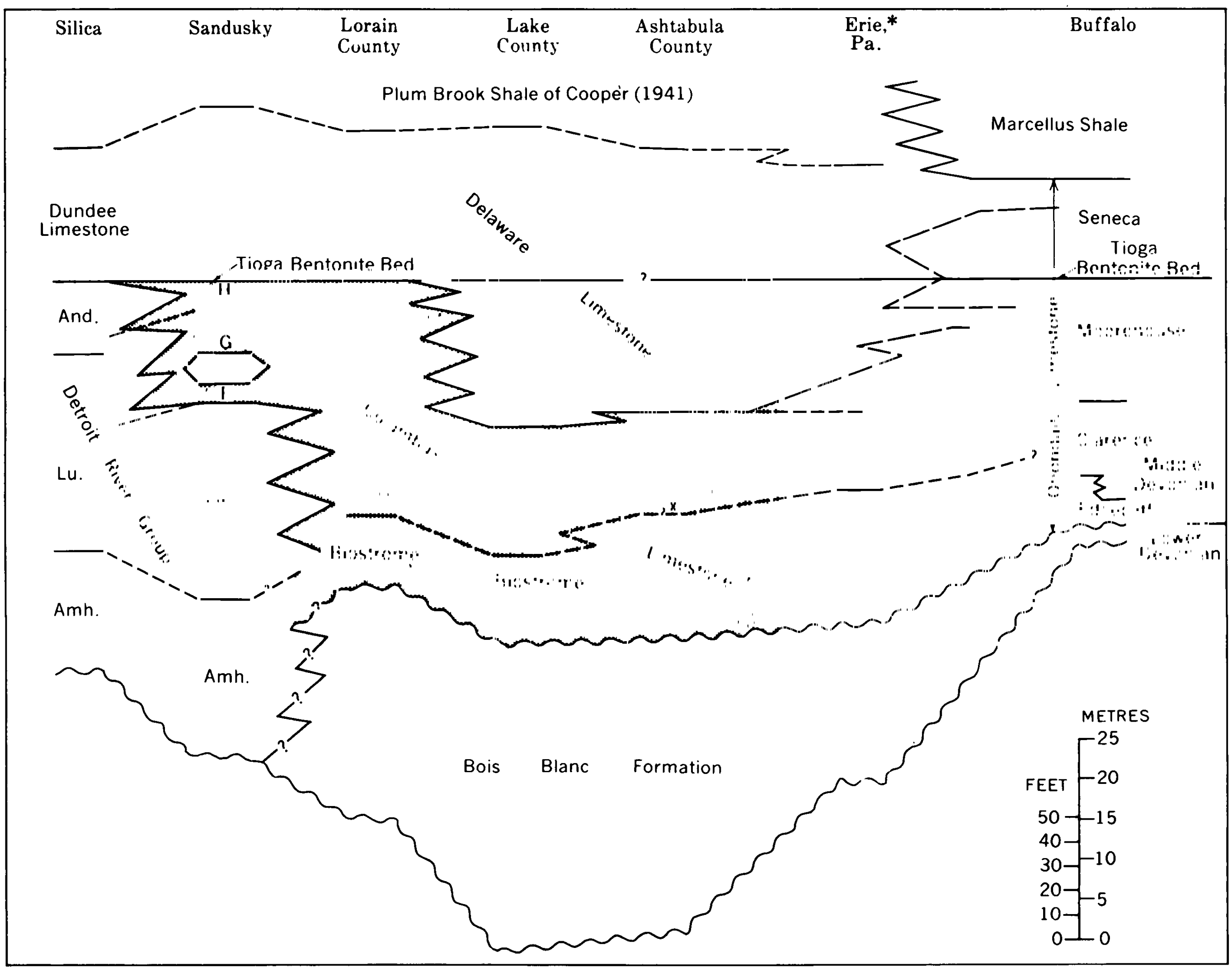


FIGURE 7.—Correlation of Onesquethaw sequences in northern Ohio sections (location of sections shown in fig. 8). Sections are drawn to an approximate vertical scale but to no horizontal scale. Time relationships are discussed in the text and indicated here by the dashed lines drawn directly from section to section. Capital letters are the Columbus Limestone zones of Stauffer. Detroit River formations: Amh., Amherstburg; Lu., Lucas; And., Anderdon Member of Lucas. Data points marked with the asterisk (*) are from L. V. Rickard (written commun., 1969).

TABLE 5.—*Summary of paleontologic data from northeastern Ohio cores*

[Ranges of key fossils in other areas indicated in parentheses: B, Bois Blanc; O, Onondaga; E, Edgecliff; M, Moorehouse or equivalents]

County	Lorain	Lake	Ashtabula
Upper Columbus:			
Acinophyllum segregatum (O)	----	×	×
Cylindrophyllum deearium (E)	----	×	----
Cyathocylindrium opulens (E)	----	----	×
Eridophyllum sp. (M)	----	×	----
Brevispirifer gregarius (M)	×	----	----
Lower Columbus ("biostrome"):			
Acinophyllum segregatum (O)	×	×	×
A. mclareni (O)	×	----	----
A. stramineum (E)	?	----	----
Synaptophyllum arundinaceum (E)	----	×	----
"*S*" *grabaui* Fagerstrom (E)	×	----	----
Heliophyllum sp. cf. *H. halli*	----	×	×
Siphonophrentis sp	×	----	----
Bois Blanc:			
Acinophyllum simcoense (B)	----	×	----
A. stokesi (B)	×	?	----
Aemulophyllum exiguum (B)	×	----	×
Homalophyllum sp. (B)	×	----	----
Scenophyllum sp. cf. *S. conigerum* (B)	----	×	----
Siphonophrentis sp	----	----	×
Amphigenia sp. (small sp.) (B)	----	----	×

and it seems likely that Columbus deposition was originally continuous around the Cincinnati arch. The age of the Limestone in this isolated patch is in the Edgecliff-to-Moorehouse range, with some suggestion that it may be Edgecliff.

APPALACHIANS SOUTH OF NEW YORK

Rocks of Onesquethaw age are widespread in the Appalachian Mountains south of New York. These are discussed and diagramed by Oliver and others (1968, p. 1018–1019 and fig. 7; 1969; 1971 pl. 3). A limestone facies is well developed in subsurface areas between the New York and Ohio outcrop, but in much of the rest of the area, including the outcrop belt, Onesquethaw rocks are clastic or very cherty and extensive coral faunas are not known. Solitary rugose corals are common in parts of the section and a few of them were described and illustrated by Kindle (1912, p. 66-67 pl. 2). In addition he listed rugose corals from several localities, commonly as "*Zaphrentis*" sp. Kindle's "Onondaga" is now recognized as including rocks of Esopus?, Schoharie, and Onondaga age.

Kindle's most extensive list of corals, and the only one including colonial rugose corals, is that from Big Stone Gap, southwestern Virginia (1912, p. 50–53). Here a "Grey coralline limestone and interbedded black chert" was considered a coral reef in which corals "practically excluded other forms of marine life" (p. 52). Dennison (1961, p. 35) briefly discussed the unit as the "Onondaga Limestone Formation."

Kindle's unit is part of the southwestern extremity of the Huntersville Chert in which limestone locally exceeds chert in volume. It is also the uppermost part of Miller, Harris, and Roen's (1964) Wildcat Valley Sandstone. Corals collected by Dennison and Miller were identified and listed by Oliver (1968a, table 3, p. 740) and are clearly of Schoharie age. *Acinophyllum stokesi* is the only identified colonial rugose coral but a second species of *Acinophyllum* is also present and fragments of a colonial zaphrentid are known.

QUEBEC

Rocks of Onesquethaw age are widely distributed in New England, Quebec, and the Maritime Provinces (Boucot 1968, p. 89–93; table 6–2, Esopus-Onondaga). Rugose corals are common, although mostly unstudied, but colonial rugose corals are apparently rare.

The only known lower Onesquethaw colonial rugose coral is *Asterobillingsa affinis* (Billings) redescribed by Oliver (1964) and discussed again in the systematic part of this paper. *A. affinis* is known from a single corallum from the upper part of the Grande Grève Limestone, on the Gaspé Peninsula.

Middle Onesquethaw (Schoharie age) corals are known from this area (for example, Oliver, 1960b, p. 16–20) and are probably widespread, but no colonial rugose corals are known.

Middle Devonian rocks and fossil assemblages of the Appalachians northeast of New York have been reviewed by Boucot and Drapeau (1968). Onesquethaw colonial rugose corals are known from two areas:

1. The Mountain House Wharf Limestone of Boucot and Drapeau crops out on the west side of Lake Memphremagog. Corals from this formation were identified by Oliver and listed and discussed in Boucot and Drapeau (p. 9–10, 26–28) but, unfortunately, the one colonial rugose coral reported was not included in the published list. This is an *Acinophyllum* represented in the collection by two or more crushed and distorted coralla. The specimens have the internal characters of *A. stramineum* and *A. segregatum,* both restricted to the Onondaga in New York. The lack of lateral supports suggests *A. stramineum* and an Edgecliff age, but the identification is not certain and a Nedrow to Moorehouse age cannot be ruled out.

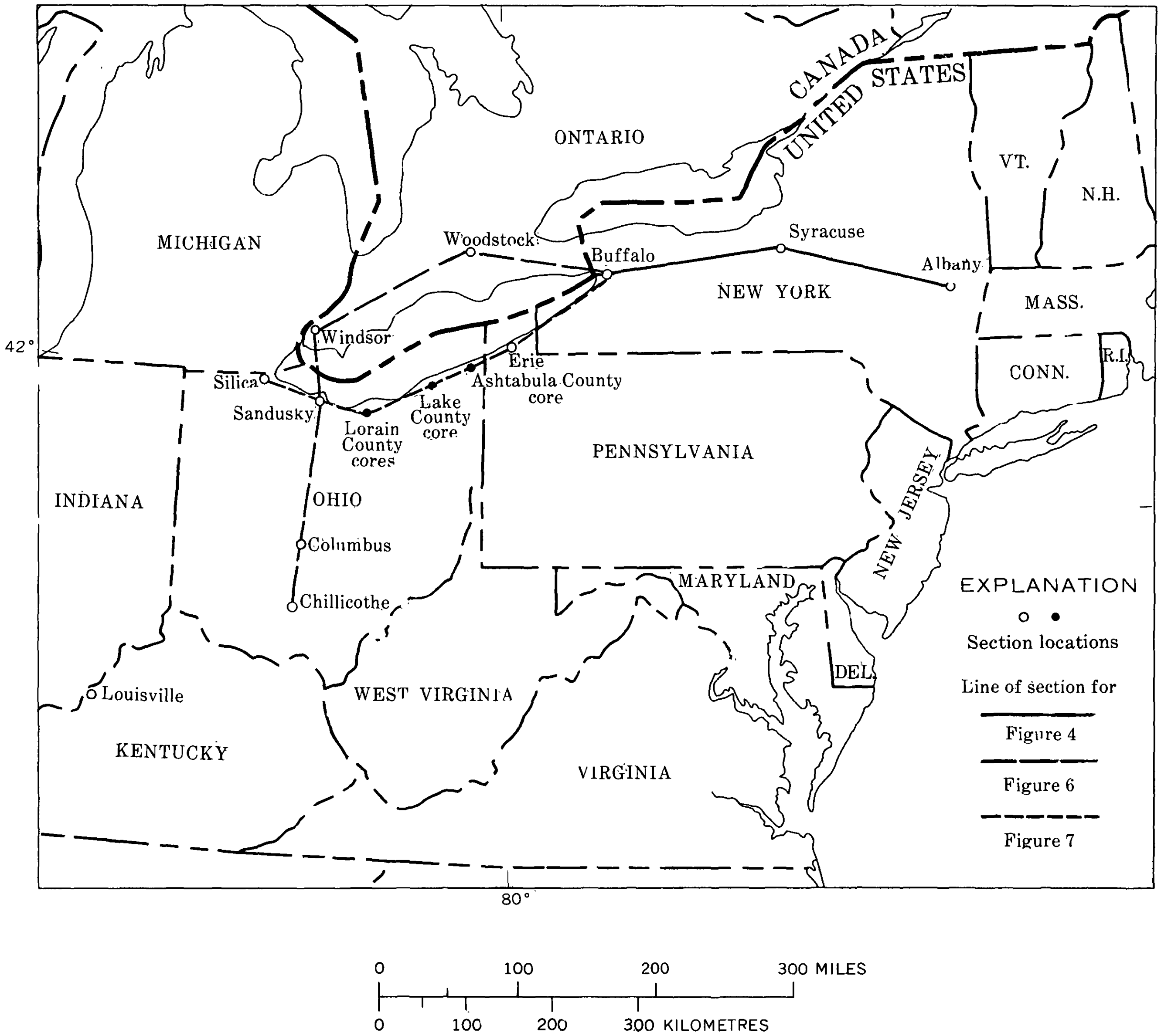


FIGURE 8.—Location of sections correlated in figures 6 and 7 and the continuous section shown in figure 4.

2. The Famine Limestone at St. Georges, Quebec, was discussed by Boucot and Drapeau (1968, p. 19, 22, 32–34, 37) and by Oliver (1971) who also described the coral fauna including colonial *"Cylindrophyllum" stummi* (here *Disphyllum*?) and *Heliophyllum* sp. cf. *H. proliferum* Hall (not Nicholson). The Famine Limestone is Onondaga in age (Uyeno, Boucot, and Oliver in Boucot and Drapeau, 1968, p. 37). Oliver (1971, p. 194–195) cited evidence for a post-Edgecliff, Onondaga age for the Famine Limestone based on the corals and on study of the brachiopods by A. J. Boucot and conodonts by Gilbert Klapper (University of Iowa) and T. T. Uyeno (Geological Survey of Canada). According to Klapper (written commun., 1968), the conodonts are comparable to specimens from the Dundee Limestone of northwestern Ohio. *Disphyllum*? *stummi* is most similar to forms of Cazenovia and Tioughnioga age in the Michigan Basin. The earliest of these *Disphyllum*? spp. occurs in the Dundee. Taken together, these data suggest a lower Cazenovia (Seneca, Dundee) position for the Famine Limestone.

MOOSE RIVER BASIN, ONTARIO

The stratigraphy of the Devonian rocks in the Hudson Bay Lowlands has been summarized by Sanford, Norris, and Bostock (1968), Norris and Sanford (1969), and McGregor, Sanford, and Norris (1970). Formations were correlated with the Bois Blanc, Onondaga, and Dundee of the central southwestern Ontario sequence. Rugose corals including colonial forms were described from a part of this sequence by Cranswick and Fritz (1958). Most of the Cranswick and Fritz corals came from "Coral Rapids, west bank of the Abitibi River." Both the Stopping River Formation (Bois Blanc age) and the Kwataboahegan Formation (Edgecliff age) crop out at this locality (Sanford and others, 1968, p. 30–31), the latter being described as a coral limestone. The Cranswick and Fritz collection seems to include some distinct Bois Blanc corals (Oliver, 1966c, p. 33; 1968a, p. 740, table 3, col. H) and it is assumed that the collection includes corals from both formations at Coral Rapids.

I have reexamined the Cranswick and Fritz collection, and the colonial rugose corals are discussed in the appropriate systematic discussion. Stratigraphic assignment is tentative pending study of new collections from known positions within the sequence.

MICHIGAN BASIN

The Michigan Basin is separated from the Appalachian Basin by the Algonquin and Findlay arches and from the Illinois Basin by the Kankakee arch (fig. 1). In the following discussions of corals, some colonial rugose corals are described or discussed from central southwestern Ontario, from the Mackinac Straits region of the northern southern peninsula of Michigan, and from northwestern Ohio. The first of these areas is on the arch that separates the Michigan and Appalachian Basins, but the formation nomenclature and lithofacies are closer to those of the Michigan Basin than to those of New York or the Niagara Peninsula. The other areas are well within the Michigan Basin (fig. 1). In this section, emphasis is placed on those stratigraphic units pertinent to the understanding of the colonial rugose corals, but in addition, some discussion is included of those other parts of the sequence important in the interpretation of time relationships.

WOODSTOCK AREA, ONTARIO

The general sequence of formations in this area is summarized in figure 3, column 7. The Bois Blanc Formation is present, as it is over much of the basin. The westerly thickening trend noted in the Niagara Peninsula continues so that the thickness is about 50 ft (15 m) in the Woodstock area and more than 400 ft (121 m) in central Michigan (Sanford, 1968, fig. 5a). Although the Bois Blanc includes cherty limestone and dolomite (Sanford, 1968, p. 979–980 and fig. 5a), the corals described and discussed herein are from cherty limestone facies (Sanford, 1968, fig. 5a). Throughout the Michigan Basin, the Bois Blanc is accepted as middle Onesquethaw, Emsian, pre-Onondaga in age (Oliver, 1967a; Sanford, 1968, p. 980; Boucot and Johnson, 1968b, p. 3).

The Bois Blanc is overlain by the Detroit River Group, dominantly a dolomite-evaporite complex representing a quite different sedimentary regime than most of the carbonates under discussion (Sanford, 1968). However, in central southwestern Ontario, limestone units are present that contain coral faunas comparable to those from New York and Ohio. Corals occur also in southeastern Michigan and adjacent Ontario (Windsor area), but they are not discussed in this paper.

The Detroit River Group in the Woodstock area consists of three distinct units. In ascending order these are the Amherstburg, Lucas, and "Columbus" limestones of Ehlers and Stumm (1951b). Sanford (1968) considered the "Columbus" to be only a local facies of the Lucas but it contains a distinct upper Columbus Limestone fauna, and I use the term in quotation marks to emphasize this relationship.

The Amherstburg is a light-medium-gray coarse-grained limestone like the Edgecliff, and it contains abundant *Heliophyllum* and *Favosites* and some (at least) typical Edgecliff colonial rugose corals. The "Formosa reef" limestone (fig. 5) northwest of Woodstock is considered to be of the same age and is included in the Amherstburg by Sanford (1968, p. 981) and other workers. A few colonial rugose corals are described or discussed from both the Woodstock and Formosa areas (table 2). The Amherstburg is correlated with Edgecliff (Oliver, 1960a; Fagerstrom, 1961; Sanford 1968).

The Lucas Formation consists of brown limestones in the Woodstock area, but it is dolomitic and contains anhydrite over much of the Michigan Basin (Sanford, 1968, fig. 6a). The fauna of the Lucas is rather specialized, and no Lucas corals are involved in this study.

The "Columbus" Limestone was first noted in the Woodstock area by Ehlers and Stumm (1951b) who listed several corals, including three species of colonial rugose corals: *Eridophyllum seriale*, *Hexagonaria* (here *Prismatophyllum*) *prisma*, and *Synaptophyllum* sp. (which would now be considered an *Acinophyllum*). On the basis of these and a long list of other fossil corals and brachiopods, Ehlers and Stumm assigned this unit to Zone H of the Columbus Limestone. Sanford (1968, p. 985) rejected this assignment on the basis of subsurface tracing of units and correlates the Lucas and "Columbus" with a postulated unconformity separating the Edgecliff and Moorehouse Members of the Onondaga in New York. My work supports Ehlers and Stumm on this point. *Eridophyllum seriale* is common in the Woodstock area "Columbus" and is elsewhere known only from the upper Moorehouse of New York and Columbus Limestone Zone H of Ohio. Preliminary analysis of the "Columbus" brachiopods (J. T. Dutro, Jr., oral commun., 1971) and other corals makes this correlation compelling. My interpretation of the relationships of the Woodstock section to the New York and Ohio sequences is shown in figure 6.

The Detroit River Group is overlain by the Dundee (or Delaware) Limestone. This is principally a medium-gray medium-fine-grained limestone in outcrop areas, similar to much of the Moorehouse Member of the Onondaga Limestone in New York and the Niagara Peninsula. In outcrop areas the Dundee is considered to be of Cazenovia age (Cooper and others, 1942, pp. 1754, 1756 and chart; Oliver and others, 1969 col. 41). As a lithologic unit, the Dundee becomes older to the south and east (figs. 6, 7). The Tioga Bentonite Bed occurs in the middle part of the Dundee (or Delaware) Limestone in the subsurface of Ontario south of Woodstock (Sanford, 1968, p. 987). To the east this "Dundee" passes into the Moorehouse and Seneca Members of the Onondaga (fig. 6; and Sanford, 1968, p. 985–987). Sanford (1968) considered the pre- plus post-Tioga Dundee and the Moorehouse-Seneca to be younger than the Woodstock area "Columbus" (his upper Lucas, p. 983–985) leaving a major unconformity in the middle of the Onondaga Limestone (Sanford, 1968, fig. 3 and text). My interpretation is based on the correlation of the Woodstock area "Columbus" with Columbus Zone H and with the upper Moorehouse as discussed above and shown in figures 6 and 7.

MACKINAC STRAITS, MICHIGAN

The Lower and Middle Devonian stratigraphy of the northern part of the Lower Peninsula of Michigan has been studied by Ehlers (1945) and summarized by Ehlers, Smith, and Sheldon (1959) and Briggs (1959). The general sequence is shown in column 6, figure 3.

The Bois Blanc Formation is 300–400 ft (91–121 m) thick and quite fossiliferous (Ehlers and others, 1959, p. 14–15). Corals including several colonial rugose corals that were listed or illustrated by Ehlers (1945, p. 80–109) are common in the upper middle part. Species of *Asterobillingsa, Acinophyllum, Cylindrophyllum, Prismatophyllum,* and zaphrentids are present, but only a few of the species are the same as, or similar to, New York-Ontario species (table 1).

The Bois Blanc Formation is succeeded by the Detroit River Group, the Dundee Limestone, and the Rogers City Limestone in that order (fig. 3, col. 6). Colonial rugose corals are not known from the Detroit River, but they do occur in the Dundee and Rogers City (Ehlers, 1945, p. 114–115). Some of these are mentioned or discussed in following sections.

NORTHWESTERN OHIO-SOUTHEASTERN MICHIGAN

The general sequence of formations in this area is shown in figure 3, column 5. The Bois Blanc Formation is missing (Sanford, 1968, fig. 5a and other references cited below), but the Detroit River Group and Dundee Limestone are comparable to other parts of the Michigan Basin. Both contain colonial and other rugose corals, and some of these are mentioned in the systematic discussions.

The Dundee Limestone is overlain by the Silica Shale (Stewart, 1927; Ehlers, Stumm, and Kesling, 1951; Mitchell, 1967; Janssens, 1970b). The lower part of this formation (beds 1–6 of Ehlers, Stumm, and Kesling 1951, p. 20) has been called the "Blue" limestone, which term is used here to distinguish these beds from the shaly parts of the formation. The "Blue" limestone contains *Prismatophyllum* (discussed below) and *Eridophyllum* and has previously been included in either the Dundee or Silica Formations by various workers. It is now generally accepted as part of the Silica and considered to be significantly younger than the upper Dundee.

ILLINOIS BASIN

The Illinois Basin lies west of the Appalachian Basin and south of the Michigan Basin (fig. 1). The Devonian stratigraphy of this area was recently summarized by Collinson and others (1968) and by Oliver and others (1968, southern part only). Corals from the Falls of the Ohio are important in any study of eastern North American Silurian or Devonian corals because of the many early studies that have priority over work in other areas. The only other part of the basin from which corals have been studied for this work is the Grand Tower area of Illinois and Missouri.

FALLS OF THE OHIO, INDIANA-KENTUCKY

The sequence of rock units in the vicinity of the Falls of the Ohio River at Louisville, Ky., is shown in figure 3, column 1. The Jeffersonville Limestone is of Onesquethaw age. The overlying Silver Creek Limestone Member of the Sellersburg Limestone is of Cazenovia age but contains few corals and no known colonial rugose corals.

The Jeffersonville Limestone at the Falls is only 30 ft (9.1 m) thick, but it is divided into six distinct units on a combination of lithology and contained fossils. These are assemblage zones, here designated Zones A–F and named after characteristic fossils, some of which are widespread and important in correlation. The present subdivision is based on: (1) previous work by many people (fig. 9); (2) cooperative field studies by J. T. Dutro, Jr., and myself; and (3) laboratory study of the corals.

Most previous zonation schemes are inadequate for detailed stratigraphic study, but the present scheme is very close to that of Campbell (1942, supplemented by unpub. notes), Oliver (1960a), and Perkins (1963). Perkins published the most detailed description of the Falls rocks, but unfortunately his measurements do not agree with those of other workers, and the base of his column was apparently not the base of the Jeffersonville Limestone.

Oliver (1960a) was the first to separate the Lower Coral Zone (Zone A) from the Upper Coral Zone and to recognize that it is of Bois Blanc-Schoharie age. Key corals from this *Aemulophyllum exiguum* Zone were listed by Oliver (1968a, p. 740, table 3, col. F).

Zone B (*Prismatophyllum prisma* Zone) and Zone C (Stromatoporoid Zone) are correlated with the Edgecliff and Amherstburg of New York and Ontario and Columbus Zone C. Zones D, E, and F (*Brevispirifer gregarius* Zone, Stropheodontid Zone, and *Paraspirifer acuminatus* Zone) are correlated with the upper Columbus (approximately Zones F–H) and the Moorehouse Member. The Falls sequence is probably less complete than the Columbus and Onondaga sequences and each of the Jeffersonville zones may be separated by unconformities.

The indicated correlations of the Jeffersonville zones (fig. 3) are based on all available data and, except for Zone A, are conventional. The separation of Zone A from the rest of the formation is based on an analysis of the coral fauna because few other kinds of fossils are found in these beds. The colonial rugose corals support the correlations of the higher zones, but species common to the Onondaga and Jeffersonville are not numerous (tables 2–4), and other corals and brachiopods are of greater importance.

Rexroad and Orr (1967, p. 65, 66) recognized two conodont faunules in the Jeffersonville. The lower faunule (Jeffersonville Zones C and D) is Onondaga in age. The upper faunule (upper Zone D through Zone F) was suggested to correlate with the Delaware and Dundee (Cazenovia age) because of the presence of *Icriodus angustus*. This correlation is unacceptable to me because the megafossils of the upper Jeffersonville are upper Columbus and upper Moorehouse in affinities, not Delaware-Dundee. It should be noted that Bultynck (1970, pl. 39) reports the *I. angustus* range in Belgium to be Emsian-early Eifelian.

GRAND TOWER AREA, ILLINOIS-MISSOURI

The Grand Tower Limestone crops out in both Illinois and Missouri in the area around Grand Tower, Ill. (fig. 1) The stratigraphy has been reviewed by Meents and Swann (1965) and by Collinson and others (1968, p. 952–954). Corals, including colonial rugose corals, are abundant and are generally similar to Onondaga and Jeffersonville forms. They have been listed by various workers but, with some few exceptions, have not been described or illustrated. One species of *Prismatophyllum* from the lower Grand Tower has been described (Fraunfelter, 1966) and is herein discussed and reassigned to a lower Jeffersonville species.

AGE OF THE ONESQUETHAW STAGE

Correlation of the New York standard sequence with the type section in western Europe has been discussed by Oliver and others (1968, p. 1032–1035) who summarized previous work on the subject.

The lower Onesquethaw is Siegenian and (or) early Emsian in age according to Boucot (in Boucot and others, 1970, p. 50). This statement was based on study of relatively few brachiopods that could be compared to European forms of known position in the standard stage sequence.

There is general agreement that the middle Onesquethaw (Schoharie-Bois Blanc) is Emsian, perhaps early Emsian in age (Boucot and Johnson, 1968; A. R. Ormiston, written commun.), and that most of the upper Onesquethaw (Onondaga) is Eifelian (Oliver, 1960a; House, 1962, p. 253, 1968, p. 1064; Klapper and Ziegler, 1967, p. 71).

Edgecliff fossils are strongly provincial (corals and brachiopods) or as yet unknown in Europe (conodonts, Klapper and Ziegler, 1967, p. 70–71) and conceivably could be either Emsian or Eifelian

Stage	This report (see discussion)			Lyon (1860)	Davis (1887)		Bassler (1908)	Campbell (1942)	Campbell Unpublished notes	Oliver (1960a)		Stumm (1965)	Perkins (1963)
Givetian	Sellersburg		Beechwood 3'6"	Encrinital	Upper Devonian	Encrinal	Sellersburg	Beechwood		Beechwood		Beechwood	
Givetian	Sellersburg		Silver Creek 15'6"	Hydraulic	Upper Devonian		Silver Creek	Silver Creek		Silver Creek		Silver Creek	
Eifelian	Jeffersonville 29.7'	F	*Paraspirifer* Zone 5'	*Spirific cultragulatus* bed	Middle Devonian		*Spirifer acuminatus* bed	*Spirifer acuminatus* Zone	covered	*Paraspirifer* Zone	Upper coral fauna—Eifelian	*P acuminatus* Zone	*P. acuminatus* Zone
Eifelian	Jeffersonville 29.7'	E	**Stropheodontid** Zone 6'	*Nucleocrinus* bed	Middle Devonian	"Red clay"	Bryozoan bed; *Nucleocrinus* bed; *Stropheodonta* bed	*Spirifer acuminatus* Zone	F	*Paraspirifer* Zone	Upper coral fauna—Eifelian	Weathered clay with bryozoans and ostracodes	Fenestrate bryozoan–brachiopod Zone
Eifelian	Jeffersonville 29.7'	D	*Brevispirifer* Zone 3'	*Spirifer gregarius* and *Turbo* beds	Middle Devonian		*Turbo* bed	*Spirifer gregarius* Zone	E: Eb, Ea	*Brevispirifer* Zone	Upper coral fauna—Eifelian	*B. gregarius* Zone	*B. gregarius* Zone
Eifelian	Jeffersonville 29.7'	C	**Stromatoporoid** Zone 6'	*Spirifer gregarius* and *Turbo* beds	Middle Devonian	Decomposed chert = zone C; "Blue clay"	white	*Spirifer gregarius* Zone	D; C: Cb, Ca	Coral–Stromataporoid Zone	Upper coral fauna—Eifelian	*B. gregarius* Zone; Blue clay 4–6"	*Amphipora* Zone
Eifelian	Jeffersonville 29.7'	B	*Prismatophyllum prisma* Zone Upper Coral Zone 4.7'	Coral beds	Lower Devonian		black (Coral beds)	Coral Zone	B 4'6"	Upper Coral Zone	Upper coral fauna—Eifelian	Coral Zone	Coralline Zone
Emsian	Jeffersonville 29.7'	A	*Aemulophyllum* Zone 4' Lower Coral zone	Coral beds	Lower Devonian	"Ferruginous clay" = zone A	brown (Coral beds)	Coral Zone	A 4': Ac, Ab, Aa	Lower Coral Zone	Lower coral fauna	Coral Zone	Coralline Zone
Lower Ludlovian	Louisville (2' exposed)			*Catenipora* beds	Niagara		Louisville	Louisville		Louisville		Louisville	

FIGURE 9.—History of nomenclature of the rock sequence at the Falls of the Ohio (Louisville, Ky., and Jeffersonville, Ind.). See text discussion.

in age. Edgecliff corals are of genera and species that are common in higher units but uncommon or lacking in the underlying Schoharie-Bois Blanc. To a lesser extent this is also true of the brachiopods. Therefore, it seems most logical to assign the Edgecliff to the Eifelian, at least until more definitive data is available.

The Eifelian-Givetian boundary has been suggested to be as low as the lower or basal Marcellus (House, 1962, p. 254). Others have placed the boundary above the Marcellus (G. A. Cooper, on the basis of brachiopods, and Gilbert Klapper, on the basic of conodonts; both oral commun., 1966). I have shown both alternatives in figure 2 and have nothing new to contribute on the question. The Seneca Member and Delaware Limestone fall into this questionable interval and may be either Eifelian or Givetian in age.

BIOSTRATIGRAPHY

The known geographic and biostratigraphic distribution of Onesquethaw stauriids, craspedophyllids, and zaphrentids that are described herein is summarized on tables 1 to 5. Table 6 and figure 10 show distribution by substages or zones recognized on the basis of these and other fossils. The separation between the middle and upper Onesquethaw assemblages is clear and has been noted before on the basis of rugose corals (Oliver, 1960a, 1968a), brachiopods (Boucot and Johnson, 1968b), and conodonts (Klapper and Ziegler, 1967, p. 70–71). The less clear separation between faunas of Edgecliff and Moorehouse age has been suggested previously (Oliver, 1954, 1968a, Klapper and Ziegler, 1967, p. 70–71) but has not been as thoroughly discussed.

Recognition of a lower Onesquethaw (Esopus) stage or substage was first recommended by Boucot (1959) after study of the brachiopod succession in the Hudson Valley, New York. Few corals, and only one colonial rugose coral, have been described or are known from rocks of this age in Eastern North America. (See Oliver, 1968a, p. 740, for summary). The earliest known craspedophyllid, *Asterobillingsa*

TABLE 6.—*Stratigraphic ranges of colonial rugose corals*

Stage	Onesquethaw					Cazenovia
Substage	Lower	Middle	Upper			Lower
Standard unit	Esopus	Schoharie	Edgecliff	Nedrow	Moorehouse	Seneca
Asterobillingsa affinis	×	------	------	------	------	------
Acinophyllum simcoense	------	×	------	------	------	------
A. stokesi	------	×	------	------	------	------
Cylindrophyllum laxtensum	------	×	------	------	------	------
Heliophyllum cassum	------	×	------	------	------	------
H. sp. (phaceloid other than spp. below)	------	×	------	------	------	------
Asterobillingsa rugosa	------	?	------	------	------	------
Heliophyllum procellatum	------	?	------	------	------	------
Asterobillingsa magdisa magdisa	------	×	×	------	------	------
Grewgiphyllum colligatum	------	×	×	------	------	------
Heliophyllum coalitum	------	?	×	------	------	------
Acinophyllum vermetum	------	------	×?	------	------	------
Synaptophyllum arundinaceum	------	------	×	------	------	------
S. tabulatum	------	------	×	------	------	------
Acinophyllum stramineum	------	------	×	------	------	------
Cylindrophyllum elongatum	------	------	×	------	------	------
C. propinquum	------	------	×	------	------	------
C. sp. A	------	------	×	------	------	------
Prismatophyllum prisma	------	------	×	------	------	------
Asterobillingsa magdisa steorra	------	------	×	------	------	------
Eridophyllum subseriale	------	------	×	------	------	------
Cyathocylindrium gemmatum	------	------	×	------	------	------
Heliophyllum megaproliferum	------	------	×	------	------	------
H. n. sp. B	------	------	×	------	------	------
H. n. sp. C	------	------	×	------	------	------
H. monticulum	------	------	×	------	------	------
Cyathocylindrium opulens	------	------	×	------	?	------
Prismatophyllum ovoideum	------	------	×	------	cf.	------
Synaptophyllum kladion	------	------	×	------	×	------
Acinophyllum segregatum	------	------	×	×	×	------
A. mclareni	------	------	×	------	×	------
Cylindrophyllum deearium	------	------	×	------	×	------
Eridophyllum seriale	------	------	------	------	×	------
E. aulodokum	------	------	------	------	×	------
E. corniculum	------	------	------	------	×	------
Cyathocylindrium n. sp. A	------	------	------	------	×	------
Prismatophyllum truncata	------	------	------	------	×	×
P. anna	------	------	------	------	?	×
Disphyllum? stummi	------	------	------	------	------	×?
D.? rectiseptatum	------	------	------	------	------	×

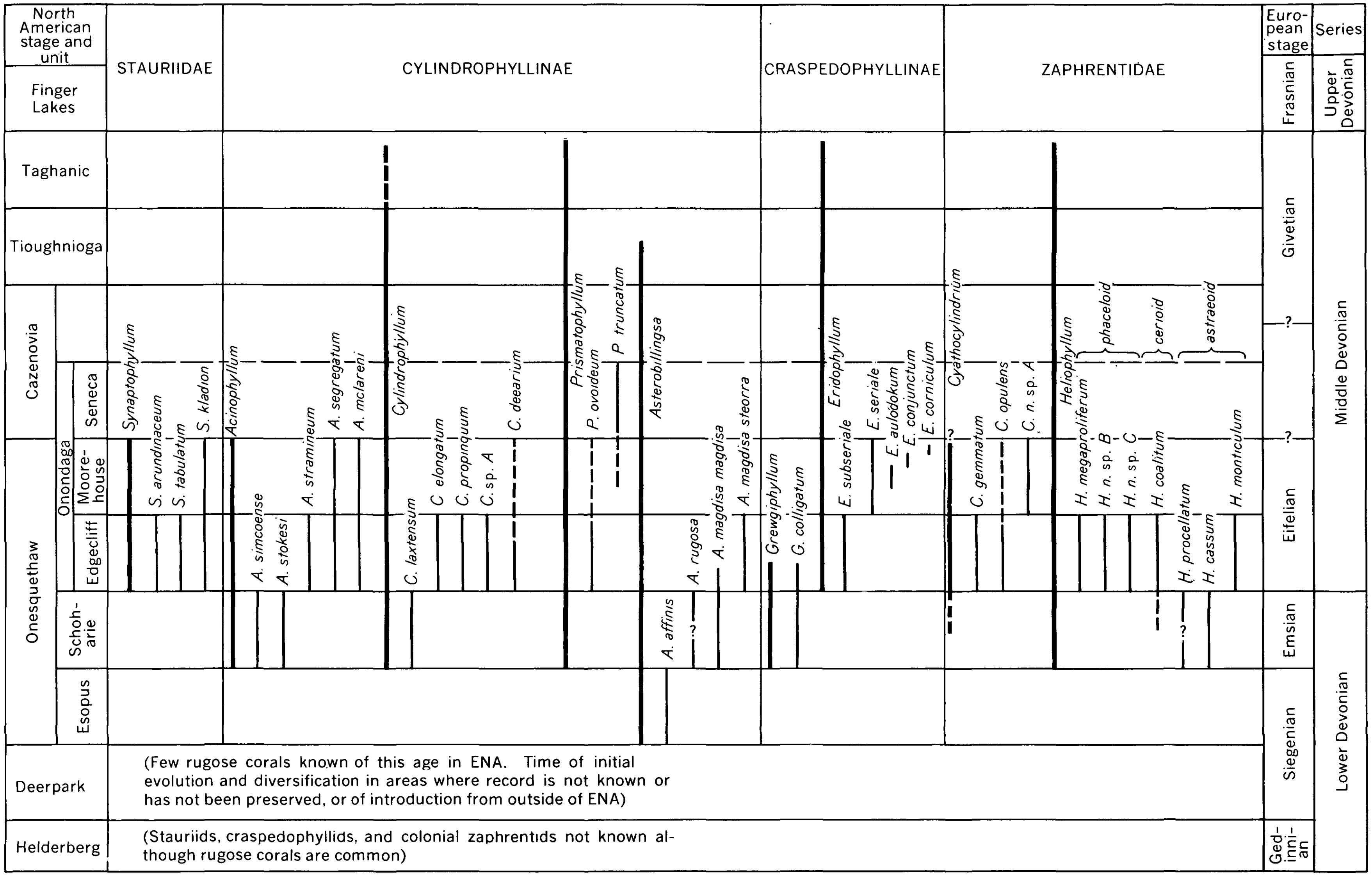


FIGURE 10.—Stratigraphic range of genera and species of colonial rugose corals described in this report. Solid lines indicate range of genera (heavy lines) and species (thin lines) in New York and southwestern Ontario; dashed lines indicate extensions of ranges based on occurrences in other areas of Eastern North America.

affinis, is of this age. It seems safe to assume that early Onesquethaw rugose corals were much more diverse than the present record indicates and that the middle-upper Onesquethaw record of craspedophyllids and zaphrentid colonial corals was preceeded by a period during which the various genera or morphologic types were established. Corals are common in several facies of Helderberg age (Oliver, 1960b, c, 1968a) but stauriids, craspedophyllids, and zaphrentids are lacking. Deerpark and lower Onesquethaw corals are rare. Either the precursors of the known craspedophyllids and zaphrentids evolved during this time in areas where no record has been preserved or recognized, or they entered Eastern North America during this time from another area.

A middle Onesquethaw substage or zone is clearly defined by the colonial rugose corals and by other studied groups. All known cylindrophyllinid genera are present (not all are known in New York or Ontario) although species diversity is not as great as in the succeeding substage. The Craspedophyllinae are represented by *Grewgiphyllum*, which may be an evolutionary link between the cylindrophyllinid *Prismatophyllum* and the craspedophyllinid *Eridophyllum*, as discussed in the systematic section. The first colonial zaphrentids also appear here and both phaceloid and astraeoid species of *Heliophyllum* are known.

The geographic source areas for the middle Onesquethaw corals described or discussed in this paper are shown in figure 11. The middle Onesquethaw coral assemblage was reviewed in somewhat greater detail by Oliver (1968a, p. 740–741 and table 3). It is dominated by endemic families and genera and is notable for its homogeneity, as many species are represented in a variety of lithologies over a large area. Associated brachiopods are more widespread than the corals (Boucot and Johnson, 1968a).

The upper Onesquethaw substage is characterized by two distinct coral assemblages that are here termed the Edgecliff assemblage and the Moorehouse assemblage. In New York the former is found in the Edgecliff Member and the lower Clarence Member. The Nedrow and upper Clarence Members have relatively few corals and are not characterized by either assemblage. The Moorehouse Member contains the Moorehouse assemblage, especially in coarser facies; the fine-grained medium-gray Moorehouse of central New York lacks most of the characteristic Moorehouse colonial species (table 3).

The Edgecliff assemblage represents the time of greatest diversity of rugose corals in Eastern North America. A favorable environment was widespread, and coral bioherms and biostraomes were developed over a large area (figs. 5, 12). The distinct Edgecliff assemblage is known from the Edgecliff Member in New York and Ontario, from the Amherstburg Limestone in Ontario, from the Columbus Limestone, Zone C, in Ohio, and from the Jeffersonville Limestone, Zones B and C, in Indiana-Kentucky. It occurs also in the central Mississippi Valley, in both Illinois and Missouri, although it is largely undescribed. It is generally absent from the central Michigan Basin where the Detroit River facies were generally inimical to this assemblage of corals.

All of the Onesquethaw colonial genera and 18 of the 33 New York-Ontario species are present in the Edgecliff assemblage; 13 to 15 species are restricted to the assemblage (table 6 and fig. 10). The assemblage is less homogeneous on the species level than the preceding Bois Blanc assemblage, and many colonial species remain to be described from Ohio, Indiana-Kentucky, the Mississippi Valley, and probably other areas.

The Moorehouse assemblage is almost as widely distributed as the Edgecliff one (fig. 13). It includes most, but not all, of the Edgecliff genera and a combination of species that are either holdovers from the Edgecliff, limited to the Moorehouse and equivalent units, or that range into later units. Only four Moorehouse colonial rugose coral species are limited to this assemblage, but additional forms remain to be studied from Ohio, Indiana-Kentucky, and other areas.

The Onesquethaw Stage is succeeded by the Cazenovia Stage with relatively few colonial rugose corals in the study area. Only one species is known from New York and this probably occurs in the Moorehouse assemblage in Ohio. Additional forms are known to occur in the Michigan Basin and other areas but are not covered in this study.

The generic and specific ranges given in figure 10 are based on the presently available information but will certainly require some modifications as corals from additional parts of Eastern North America are studied. The craspedophyllid ranges are most reliable, the zaphrentid ranges least so. All are described and discussed more extensively in the appropriate sections on distribution, which are included in the systematic descriptions.

PALEOBIOGEOGRAPHY

A definitive discussion of Onesquethaw paleobiogeography must necessarily be based on all available information, not just on three families of

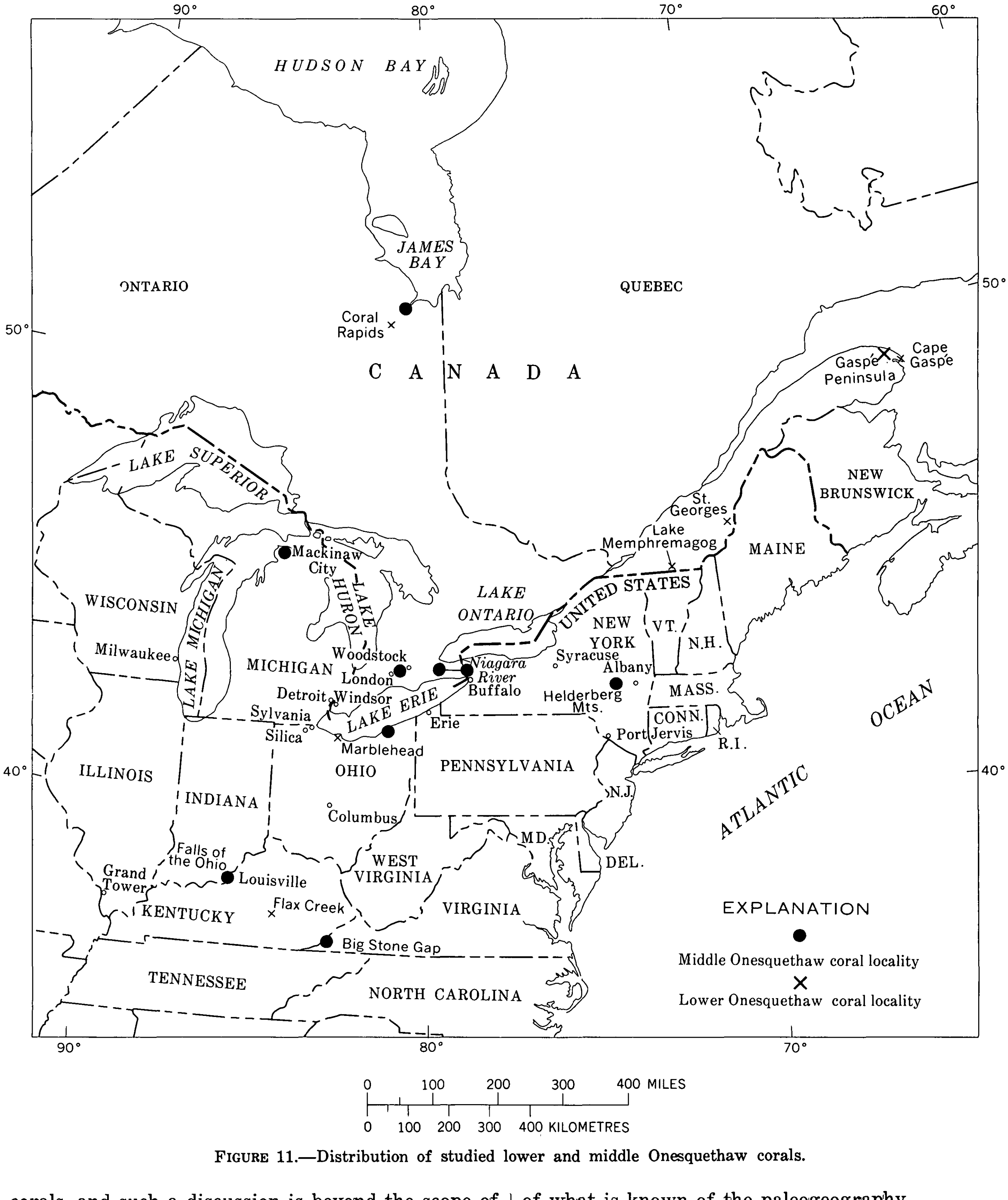


FIGURE 11.—Distribution of studied lower and middle Onesquethaw corals.

corals, and such a discussion is beyond the scope of this paper. However, a brief discussion is desirable as distribution in time and space of the genera being described can be better understood in the light of what is known of the paleogeography.

An Early and Middle Devonian Appalachian or Eastern North American province has long been recognized; in this paper I call it the Eastern North

FIGURE 12.—Distribution of studied upper Onesquethaw, Edgecliff assemblage corals.

American (ENA) Province of the Eastern Americas Realm (fig. 14). Boucot and Johnson (1967, 1968a) and Boucot, Johnson, and Talent (1968, 1969) have summarized Early Devonian brachiopod distributions and presented paleogeographic maps based on the known distribution of various groups of fossils and rock types for as many as five Early Devonian time intervals, including both early and

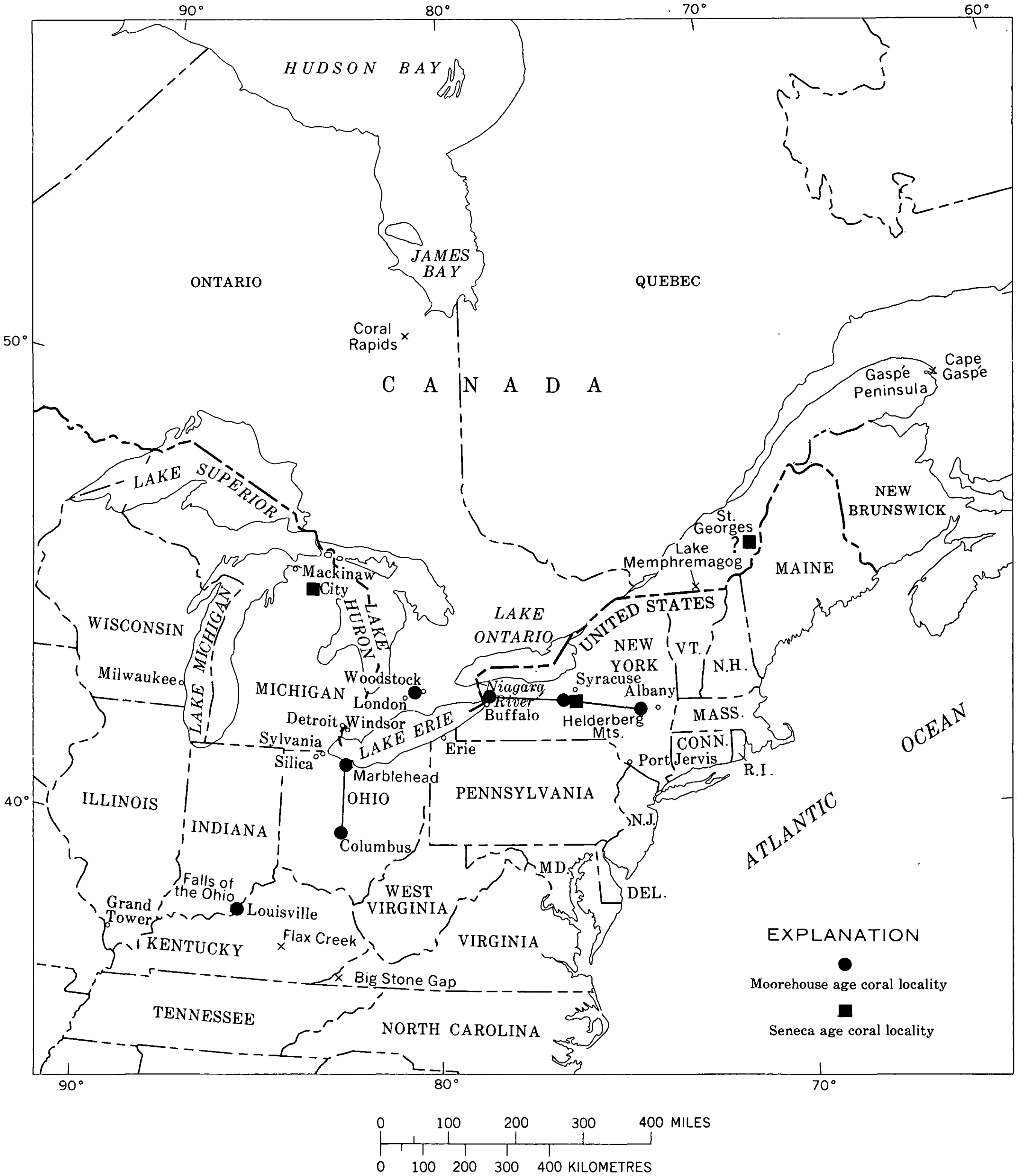


FIGURE 13.—Distribution of studied upper Onesquethaw, Moorehouse assemblage corals. General localities of Seneca-(Cazenovia) age corals are also shown.

and middle Onesquethaw. These provide an excellent framework in which to discuss Early Devonian coral distribution.

Spassky (1967) and Dubatolov and Spassky (1970) tabulated the distribution of Devonian coral genera for the world and presented generalized maps of Early, Middle, and Late Devonian biogeography on which they clearly distinguished the "Appalachian" (ENA) province during the first two epochs.

Hill (1957) presented the clearest statement on the nature and distinctness of ENA coral provincialism during Onesquethaw time. She called the Emsian-Givetian fauna the *Heliophyllum* fauna and noted its extension into Africa during the Middle Devonian. The contemporary faunas of the rest of the world (including western North America) were termed "Eurasaustralian" (Old World of Boucot and this paper), and Hill noted that regional differences within this Old World fauna during Emsian, Eifelian, or Givetian time were small in comparison with the differences between this fauna and the ENA fauna. Because of revisions in age and generic assignments, many of Hill's temporal distribution data are no longer useful (Hill, 1957, p. 47–48), but the recognized faunal differences are sharper now than when her paper was written.

Oliver (1968a, 1973, 1975) summarized the succession of rugose coral faunas in the Lower and Middle Devonian of Eastern North America. The Onesquethaw faunas were reviewed (1968a p. 740–742; 1975) and lists were given (1968a, tables 3 and 4; 1975, tables 2 and 3) of species of known stratigraphic position (their position having been determined partly on the basis of the families here described); many of the 1968 and 1973 data are updated by information tabulated in this paper.

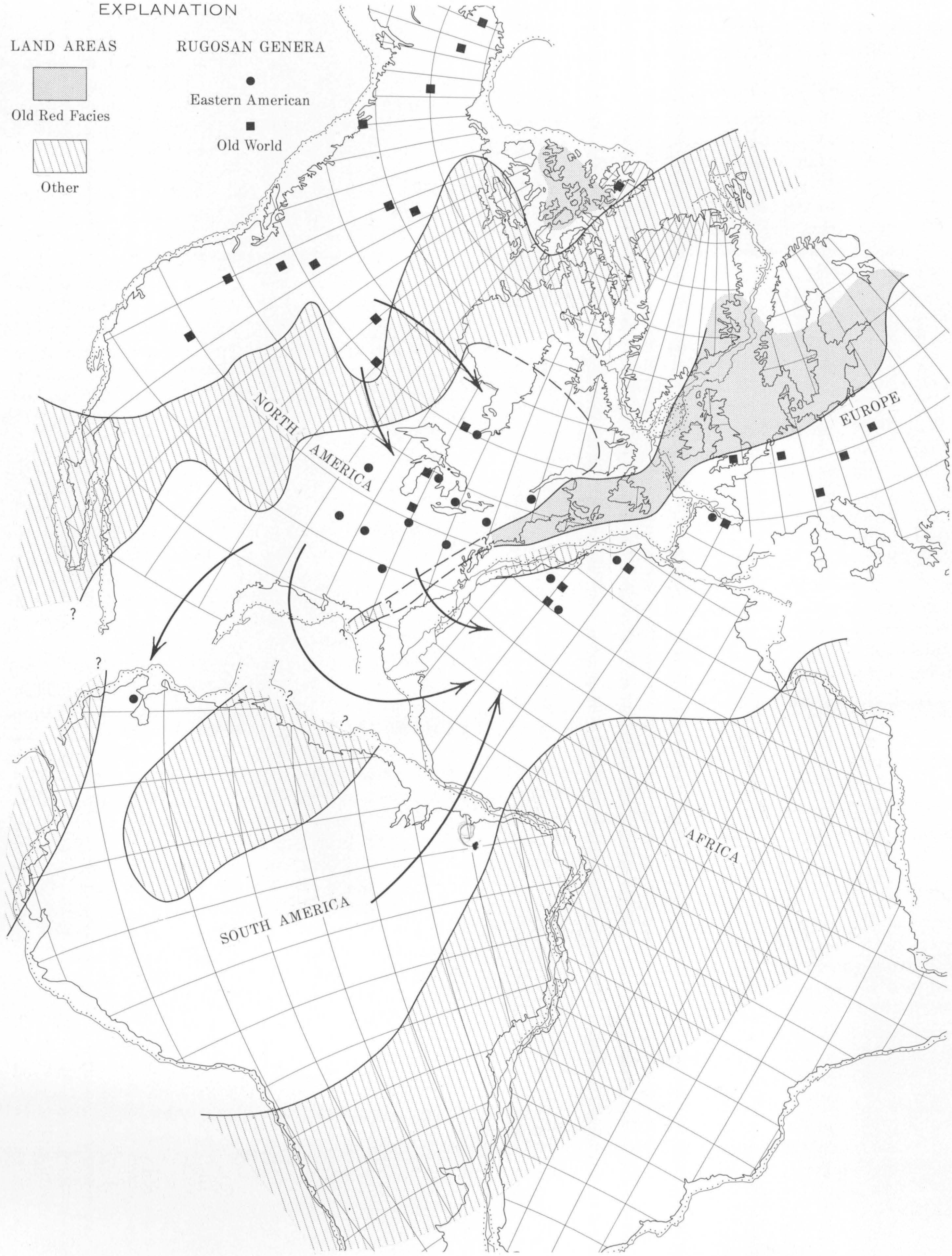
Early Onesquethaw paleogeography was mapped and discussed by Boucot and Johnson (1967, p. 49–50, fig. 4). The earliest craspedophyllid, and the only known one of this age, is from the Gaspé area (locations A–B on the Boucot and Johnson map).

Middle Onesquethaw paleogeography was also mapped and discussed by Boucot and Johnson (1967, p. 50–51, fig. 5, 1968a, p. 1264, fig. 3). The known distribution of the middle Onesquethaw coral assemblage (fig. 11; Oliver, 1975, fig. 2) is not as great as that of the brachiopods. Corals of this age are known from Maine (Oliver, 1960b, p. 16–20) and from the Llano region, Texas (unpub. data) but are few, simple, and not certainly related to species of the assemblage from the area of abundance. No colonial corals of this age are known from south of Missouri-Illinois- Kentucky or from Quebec and New England (fig. 11).

Upper Onesquethaw coral assemblages have approximately the same known distribution (figs. 12, 13) as the middle Onesquethaw assemblage. This is the "Appalachian * * * upper Emsian to Eifelian" of Boucot, Johnson, and Talent (1968, p. 1249, fig. 4; 1969, p. 24–26, fig. 4) who indicate that brachiopods of this age are uncommon south or west of Illinois-Missouri or north of New York. Upper Onesquethaw corals, including some genera typical of the Edgecliff and Moorehouse assemblages are present in southeastern Quebec. The craspedophyllid *Acinophyllum* sp. cf. *A. stramineum*, associated with typical ENA solitary *Heliophyllum*? and *Siphonophrentis* in the Mountain House Wharf Limestone, Lake Memphremagog, Quebec (fig. 12), is upper Onesquethaw, and probably Edgecliff, in age. Colonial *Heliophyllum* and solitary *Heliophyllum, Heterophrentis,* and *Siphonophrentis* in the Famine Limestone, St. Georges, Quebec, are ENA forms of post-Edgecliff Onondaga age (see above discussion) and are tentatively assigned to the Seneca assemblage (table 4 and fig. 13). Colonial *Disphyllum*? in the Famine, represents the only known occurrence of a disphyllid within the Appalachian Basin.

During Emsian-Middle Devonian time, ENA province corals were known from parts of northern South America, northwestern Africa, and Spain. The South American ENA corals were from the Caño Grande and Caño del Oeste Formations in the Rio Cachirí area, State of Zulia, northwestern Venezuela. Two species were initially described by Weisbord (1926), and these were redescribed with two additional forms by Wells (1943). *Acinophyllum vermetum* (Weisbord) (redescribed below) is very close to *A. stramineum* (Billings) of Edgecliff age. In addition, *Heliophyllum halli* Milne-Edwards and Haime, *Heterophrentis venezuelensis* (Weisbord), and *Zonophyllum* sp. were described. All but *Zonophyllum* are distinct ENA types and, with associated brachiopods (Liddle, 1943, p. 14–17), indicate an Onesquethaw age. The whole fauna has recently been listed and reviewed by Weisbord (1968, p. 217–222) who suggested again a late Early Devonian to Middle Devonian age range. Typical *Heliophyllum halli* suggests a Middle Devonian age, and the similarity of *A. vermetum* to Edgecliff *Acinophyllum* suggests an Edgecliff age. More definite age assignment must await study of more and better specimens.

The ENA affinities of northern South American Devonian faunal assemblages are discussed by Harrington (1968), Krömmelbein (1968), Weisbord (1968), and Boucot, Johnson and Talent (1968, 1969). These authors indicate that "Appalachian" (ENA) elements extend as far south as central-western Bolivia but that the fauna was "pure" ENA only at the northern end of its distribution area and


EXPLANATION
LAND AREAS
Old Red Facies
Other
RUGOSAN GENERA
Eastern American
Old World
NORTH AMERICA
EUROPE
SOUTH AMERICA
AFRICA
?

became progressively diluted with other elements to the south (Harrington, 1968, p. 664; Boucot and others, 1968, p. 1251, 1969, p. 27–28).

Eastern North American corals have been described from Morocco by Le Maitre (1947) and from Mauritania by Cottreau (1941). ENA forms are also present in Spanish Sahara collections now in the U.S. National Museum. All are Middle Devonian in age, but some or most are Givetian and are younger than the Onesquethaw corals described here.

The Moroccan corals (LeMaitre, 1947) are the most important because they were so well described and illustrated and because the Moroccan assemblage includes more ENA forms than any other known African assemblage. LeMaitre illustrated typical *Heliophyllum halli*, *Siphonophrentis gigantea*, and *Eridophyllum*. I have examined her specimens (in Lille) and agree with her ENA identifications except that her *Eridophyllum* is probably not *E. seriale*. However, it is a typical *Eridophyllum* and the only known example of this genus from outside of Eastern North America. The three Moroccan species are typical Hamilton forms (Tioughnioga Stage) and would be considered Givetian if collected in North America.

Cottreau (1941) described *"Zaphrentis"* sp. cf. *"Z." gigantea* and *Heliophyllum halli* from northern Mauritania. No sections were illustrated, but photographs of the *H. halli* exterior appear typical for that species and there is no reason to question either identification. Associated corals and brachiopods indicate a Middle Devonian age.

Heliophyllum halli also occurs in the Spanish Sahara along with *Siphonophrentis* sp. and *Heterophrentis* sp., all identified from collections sent to the U.S. National Museum by the Richfield Oil Co. and by Pan American Hispano Oil Co. The collections are probably of Eifelian age. Arden and Rehrig (1964, p. 1522) list *Heterophrentis prolifica* (Billings) and *Zaphrentis phrygia* (Rafinesque and Clifford) among other corals from Spanish Sahara as of Givetian age. These are ENA species of Eifelian age but identification has not been confirmed.

In all of the African collections, ENA forms are associated with more numerous and varied Old World genera and species. Brachiopod assemblages are similar mixtures with ENA elements forming a small part of dominantly Old World assemblages (Boucot, Johnson, and Talent, 1969, p. 35).

Altevogt (1968, and unpub. dissert., Münster) and Y. M. Cheng (unpub. dissert., Münster) have described typical ENA *Heliophyllum* and *Siphonophrentis* from the northern coast of Asturia, Spain. During a visit to Münster (1969) I was able to confirm the similarity of some of the Spanish forms to ENA species. I disagree, however, with some of the other identifications of specimens described and illustrated by Altevogt (1968). *Scenophyllum*, *Kionelasma*, and *Heliophylloides*, all typical ENA genera were misidentified, and his identification of *Bethanyphyllum* is uncertain. The fauna is dominated by *Acanthophyllum*, *Disphyllum*, and other Old World genera.

The Middle Devonian paleobiogeography of the ENA coral fauna is summarized in figure 14. The distribution of upper Onesquethaw to Taghanic coral assemblages is generalized and the boundaries of a reasonably "pure" Eastern Americas Realm are indicated. The western margin was the transcontinental arch of Eardley (1951) which apparently formed an unbroken barrier throughout Onesquethaw time. Old World genera entered Michigan and northern Indiana in middle or late Cazenovia time (Miami Bend Formation of Cooper and Phelan, 1966; Indiana) and at various times during the Tioughnioga (Traverse Group, Michigan), but only one is known to have reached the Appalachian Basin (*Disphyllum? stummi*, Famine Limestone, Quebec).

The nature of the northern or northeastern boundary is unknown. ENA corals are known from the southern Hudson Bay Lowland, but the Arctic Islands corals are Old World. Possible connections with Europe along the northwest side of the Old Red Continent seem unlikely.

The Old Red Continent formed the eastern side of the province and realm, but the size and extent of this land area to the south is a matter of speculation. It may well have extended farther than is

FIGURE 14.—World distribution of coral genera characteristic ◀ of the Eastern Americas Realm. Eastern American genera are those known only from Eastern North America, northern South America, northwest Africa, and Spain. Old World genera are those that were widespread in the Old World Realm and absent in the Eastern Americas Realm except in the Givetian of the Michigan Basin. (See text discussion.) The paleogeographic base is the best-fit map of Bullard, Everett, and Smith (1945; used by permission). Land areas from various sources. Possible migration routes (arrows) to Africa would be Emsian, Eifelian, or Givetian; routes to the Hudson Bay and Michigan Basin areas were Givetian. The Eastern Americas Realm included Eastern North America and northern South America. Western North America. Africa, and Europe were parts of the Old World Realm during Emsian and Middle Devonian time.

shown in figure 14 and could have been continuous at times.

Eastern North American faunas apparently migrated south to northern Venezuela and beyond, but in central South America they mixed with other forms that did not reach Eastern North America. ENA corals and other animals may have entered North Africa around the southern end of the Old Red Continent where they intermixed with Old World elements that did not reach Eastern North America. ENA elements moved as far east or north as Spain but seem to have formed progressively smaller percentages of the fauna as they moved north. More data on all assembleges concerned are needed before the migrations and distribution patterns can be described in any detail or understood.

PREVIOUS SYSTEMATIC WORK

Previous descriptions of Onesquethaw colonial rugose corals from New York and Ontario are those of Hall (1843), Billings (1859), Nicholson (1874, 1875), Simpson (1900), Lambe (1899, 1901), Ehlers and Stumm (1953), Stumm (1954, 1955), and McLaren (1959). The later papers redescribed specimens collected by earlier geologists, none of whom was working within a stratigraphic framework adequate by today's standards.

In the Niagara Peninsula, "Onondaga" or "Corniferous" corals may have been from either the Bois Blanc or Onondaga. In western New York the Bois Blanc is thin so that most "Onondaga" corals are Onondaga but some (for example, from Leroy) are almost certainly Bois Blanc and others may be. In central and eastern New York where the Bois Blanc is lacking, the Schoharie was recognized by the early geologists so there is less of a problem in making the distinction between a Lower and Middle Devonian source.

Some early collectors in New York distinguished the "Onondaga" (=Edgecliff) from "Corniferous" (=Nedrow and Moorehouse), and many distinguished the Seneca in central New York. Nevertheless, most museum specimens are simply labeled "Onondaga" which means various things depending on locality, collector, and date of collection.

Insofar as it is practical to do so, the following descriptions are based on new collections from known stratigraphic positions. However, study of many of the rare or uncommon forms is based on all available material, and it has been necessary to try to determine the source of many old collections that contain type material or representatives of uncommon species. Procedure used in determining the source of important specimens from old collections is discussed in the appropriate part of the systematic description. In general this involves one or more of the following: (1) knowledge of what is exposed at the source locality, (2) lithology of matrix or filling, (3) preservation characteristics, and (4) stratigraphic position of other specimens of the taxon in the same area.

Many of the New York-Ontario taxa are assigned to species originally described from: (1) the Falls of the Ohio, Indiana-Kentucky, (2) the Columbus Limestone, Ohio, and (3) the drift in the vicinity of Ann Arbor, Mich. Early collections from these and other areas pose the same problems of stratigraphic interpretation as do the New York and Ontario ones.

Falls of the Ohio corals have recently been revised by Stumm (1965) who briefly reviewed earlier work on Falls corals. Rominger (1876), Hall (1877, 1882, 1883b, 1884), Davis (1887), Greene (1898–1906), and numerous other works dating from 1820 to 1958 preceded Stumm and established approximately 900 nominal species based on type specimens from the Falls or its immediate vicinity. Stumm (1965) did much to reduce the nomenclatorial maze by synonymizing some two-thirds of the "species" and presenting brief descriptions of 291 species that he found acceptable. However, the stratigraphic confusion remained. The fossiliferous limestone at the Falls is less than 50 ft (15 m) thick but it includes rocks (and corals) of early Ludlow (Berry and Boucot, 1970, p. 180–181), Emsian, Eifelian, and Givetian age (figs. 3, 9). Stumm and some earlier workers separated the Silurian and Givetian corals with greater or lesser success, but none of the descriptive paleontology has been done within a really acceptable stratigraphic framework. In this report Falls specimens are assigned to stratigraphic units on the basis of all available information. Study of bed-by-bed collections made by Guy Campbell (later presented to the U.S. National Museum) and me, has indicated the probable source of many forms. Through the kindness of the late Prof. Stumm, I have a copy of the index pages to Davis' own copy of his 1887 Kentucky Fossil Corals (Davis, 1887). Davis annotated his copy with information on source position, but this is for his "species," not for individual specimens, and many indicated "ranges" are too great to be of help.

Columbus Limestone corals were described by Stewart (1938), who also reviewed the sparse previous work. Her descriptions were based on old collections as well as her own and some of the described species may not actually occur in Ohio or in the Columbus Limestone. Some, however, are well located in Stauffer's zone sequence (see stratigraphy discussion), and most are clearly from the Columbus. Because the parts of the Columbus that include corals are all upper Onesquethaw, the problem of stratigraphic assignment is reduced. However, the Columbus does include a sequence of five or six zones, most of which have a characteristic assemblage of corals. Columbus corals referred to in this work are assigned to stratigraphic position on the basis of Stewart's information or the position of the species as learned from study of my own collections.

Rominger (1876) described many corals, including several colonial rugose corals, from "the drift of Ann Arbor" (Michigan). These specimens could have been derived from the Mackinaw Straits region, Michigan (Bois Blanc Formation), or from southwestern Ontario or southeastern Michigan (Bois Blanc, Amherstburg, or Onondaga Formations). Until the coral assemblages of these areas are described, the source of many of Rominger's specimens will remain speculative. Rominger taxa referred to in this work are tentatively assigned to stratigraphic positions on the basis of the known position of similar specimens elsewhere.

Specific problems of stratigraphic source of type and other specimens referred to are fully discussed in the systematic section.

CORAL MORPHOLOGY

Insofar as is practical, morphological terms are used as defined in the Treatise (Moore, Hill, and Wells, 1956, p. F245–F251). Additional terms or usage modifications are explained in this section or where used. Terminology for increase is after Hill (1935, p. 491–492; 1956b, p. F244–F245) and Oliver (1968b, p. 19–21).

MICROSTRUCTURE

Microstructure is consistent with each of the three principal families of corals studied. The three species of *Synaptophyllum* have the same structure, described under the generic heading, but it is not known whether this is characteristic of the family.

The many craspedophyllid species have a common microstructure, here termed craspedophyllid to contrast with disphyllid structure. This structure is described under the family heading. Briefly, it consists of fine monacanths at a relatively high angle to the horizontal. Each carina, or part of septum between adjacent carinae, is composed of numerous closely spaced parallel trabeculae.

The colonial zaphrentids have craspedophyllid microstructure, but in species of *Heliophyllum* this is combined with coarser monacanthine trabeculae that develop locally. In such forms, craspedophyllid structure predominates, but some carinae, or parts of septa between carinae, are a single, coarse monacanth. This is described in more detail in the family description.

CARINAE

Carinae are flangelike elevations on the sides of septa. Where present they are a fundamental part of the septa and have the same microstructure. They may be either a thickened trabecula or be composed of several trabeculae, but in any case they are parallel to the trabeculae and so indicate growth direction even if the fine structure of the septum is not preserved.

The orientation of carinae varies with the coral and particularly with the shape of the calice and the distal edge of the septum. In the corals under study, carinae tend to be vertical or at a high angle in the outer and middle parts of dissepimentaria (pl. 84, fig. 3). In the outer disseptimentarium they angle away from the axis of corallites having a reflected calice platform (pl. 62, figs. 1–3) and form a broad fan pattern that should not be confused with or compared to the tight trabecular fans in the Phillipsastraeidae. Within the inner dissepimentarium they bend toward the axis and commonly are horizontal or at a low angle at the margin of the tabularium (pl. 42, figs. 3–5). Carinae are best developed in, and commonly limited to, the dissepimentarium but are present and even well developed within tabularia of some species (pl. 38, figs. 8–11) where they tend to deflect upward and be almost vertical (pl. 38, figs. 4, 9).

The appearance of carinae in transverse sections depends to a marked extent on their orientation. At the inner margin of the dissepimentarium, carinae may be almost parallel to the section and appear distorted as a result (pl. 93, fig. 3).

Carinae are on both sides of septa and either alternate in position or are opposite each other. Based on appearance in transverse section, these are termed zigzag and yard-arm carinae, but all gradations from one to the other exist.

Zigzag carinae may quite precisely alternate in position (pl. 43, fig. 11) or be only slightly offset (pl. 82, fig. 6). They may be sharp ridges on the septal faces (pl. 61, fig. 4) or may be little more than crenulations of the septum (pl. 43, fig. 11). They may be strongly or weakly developed and all of these variations can occur within a single corallite and on one septum although there tends to be a characteristic pattern for each species. Zigzag carinae are the most common type in all of the craspedophyllid genera and in the zaphrentid *Cyathocylindrium,* although in most species carinae that approach the true yard-arm type, occur.

Yard-arm carinae tend to extend farther from the septal surface than do zigzag carinae and ideally are truly opposite each other (pl. 93, fig. 4). Commonly however, either the septum or the carina is slightly offset (pl. 94, fig. 9). To aid in the description of the various species, the term "subyard-arm" is used for carinae that rise abruptly from the septal surface but that are slightly offset. Yard-arm carinae are characteristic of *Heliophyllum,* but they also occur in most of the other craspedophyllid and zaphrentid genera.

It is striking and important that the craspedophyllid and zaphrentid corals of the Eastern Americas Realm are characteristically carinate and, in spite of the noted variations, no coralla and few corallites are completely noncarinate. This is very much in contrast to the Old World disphyllids and phillipsastraeiids in which carinae tend to be poorly developed or absent. In many (most?) examples the Old World "carinae" are only the relief on the septal faces caused by the coarse monacanths that form the septa. Some Old World cyathophyllids (Birenheide, 1963) have craspedophyllid-type carinae, and their distinction from the zaphrentids is difficult. (See discussion in systematic section.)

INTRACOLONY AND INTERCOLONY VARIATION

Oliver (1968b) discussed general aspects of variation within and between coral colonies (1968b, p. 23–25), basing most of his arguments on studies of some of the same colonial rugose corals as described herein (1968b, p. 26–31). The 1968 data have been modified only slightly (tables 8–13, 16–39) and not so as to affect the general conclusions. The following nomenclatural changes have been made: (1) *Billingsastraea rugosa* of 1968 is *Asterobillingsa magdisa* of this paper, but the sample has been subdivided (subspecies *magdisa* and *steorra*) and a few specimens added so that the 1968 data are replaced by more refined data in tables 20 and 21. (2) *Eridophyllum seriale* n. subsp. of 1968 is *E. seriale* population B of this paper. (3) *E.* n. sp. of 1968, is *E. corniculum* of this paper.

Variation of each of the species is described in the systematic part of this paper. Where practical, measurements and septal counts are analyzed and tabulated (tables 8–13, 16–39). The data in this paper are more extensive and cover more species than the 1968 data.

Variation in *Acinophyllum segregatum* is described in detail because the analysis of this species has provided a standard by which other species can be evaluated. Some biologic and stratigraphic conclusions that I consider important were based initially on this form. In a following section, results of the analysis of other species are tabulated and discussed in comparison with *A. segregatum.*

VARIATION IN ACINOPHYLLUM SEGREGATUM

Acinophyllum segregatum is more common and occurs in more lithofacies than any other Onesquethaw colonial coral. Its general morphology makes it ideal for analysis; corallites are parallel and sufficiently small and closely spaced that a large number of well oriented individuals can be studied in one transverse section. Data are from one or more transverse sections in 58 colonies. The analyzed colonies, collected by the author from the Onondaga Limestone in New York, include most of those considered suitable for study. Colonies or parts of colonies that were broken or distorted before or during burial and those too poorly preserved were rejected, as were fragments of colonies too small to provide data on 20 or more individuals. This rejected material, however, added to the distribution data and provided additional qualitative information on variation.

The number of major septa (n) and diameter (d) have been analyzed; in each colony, 20 to 60 corallites were measured, and corresponding septal counts were made. In a given thin or polished section, all adequately preserved individuals were measured. This inevitably included a few immature specimens (conical stage) which could not be so identified. However, study of many colonies shows that only a few percent of the individuals in a given transverse section would be immature, and the only statistic that is significantly affected by their inclusion is the observed range of diameter. Results of the study are shown in tables 7 to 15 and on the scatter and bar diagrams (figs. 15–21).

TERMINOLOGY

The following characters are quantitatively treated in the present study: Diameter (d), measured to the nearest 0.1 mm by occular micrometer in a section through the colony which intersects the parallel corallites at right angles to their axes; septal number (n), number of major septa, counted in the same section as that in which corresponding diameter was measured. The septal ratio ($n:d$) is of aid in analyzing these characters.

The following standard statistical terms (the symbols for which also appear in tables 7–39) are used; methods are adapted from Imbrie (1956), to which reference can be made for further discussions:

Mean ($\bar{x}$) arithmetic average of character.

Observed range (OR_x), minimum and maximum values of given character in given sample.

Standard deviation (s_x), measure of variation from sample mean in units of character being analyzed.

Coefficient of variation (V_x), standard deviation expressed as a percentage of the mean; a dimensionless number useful in comparing variation in analogous characters of differing numerical range.

Correlation coefficient (r), measure of the closeness to a straight line of points plotted on a scatter diagram; the coefficient may vary from one to zero, one indicating a straight-line plot and zero indicating lack of any correlation.

P, the probability of the value r being not significant—a P of 0.01 indicates a probability of significance at the 99 percent level, a P of 0.10 indicates probability at the 90 percent level, and so forth; in the present work, P is derived from tables in Simpson, Roe, and Lewontin (1960, p. 426) and Fisher (1946, p. 174).

INDIVIDUAL VARIATION

Mean values for n and d based on 20 to 60 corallites and standard deviations and coefficients of variation for n and d were determined for all 58 colonies (table 7). Data on 32 (of the 58) colonies, selected within stratigraphic groupings, were further analyzed to determine the $n:d$ correlation coefficient (r). Of these 32 colonies, 12 (see asterisks, table 7) were selected to illustrate extremes in n, d, and $n:d$ correlation (scatter diagrams, fig. 15*A–D*).

Variation between colonies (intercolony) was analyzed for the same factors as variation within colonies (intracolony), but each colony was treated as an individual. Intercolony mean values are thus mean intracolony means, and intercolony coefficients of variation are V's of colony means, and so forth. Tables 8 to 13 and the scatter diagram (fig. 16) show the variation in the 58 colony means.

Intracolony variation in diameter is best indicated by the scatter diagrams (fig. 15*A–D*) and the coefficients of variation shown in table 7 (summarized in tables 8 to 13). Colony coefficients of diameter variation range for all 58 colonies from 5.8 to 15.9 and average 10.0. Intercolony size variation, based on 58 pairs of colony means, is illustrated in figure 16; variation between colonies (V_d=20.7, table 8) is approximately twice as great as that between individuals within colonies.

Septal number variation in *A. segregatum* is shown on the scatter diagram (fig. 16) and tables 7 to 13. Coefficients of intracolony variation are low (ranging from 1.9 to 8.7, mean value 4.4) and intercolony variation is approximately twice as great (V_n=11.0; table 8).

Normal distribution of the 58 coefficients of septal number variation (V_n) is shown in figure 17. Some of the data for the 32 colonies for which the $n:d$ correlation coefficient (r) was calculated are given in table 14, with the colonies in the order of increasing V_n. This shows the distribution of septal number in the 32 colonies, and the lack of correlation between V_n and P.

At the top of table 14 are two colonies in which at least 85 percent of the sampled corallites have the same number of major septa. Twenty-three colonies have at least 70 percent of their corallites in two septal number classes. At the other extreme, the bottom three colonies in table 14, have strikingly high coefficients of variation and show bimodal septal number variation.

From these data I have previously (1968b, p. 26–29) suggested that septal number in this species may have been genetically controlled within rather narrow limits. If the "normal" colony was genetically programed for a septal number range of three, sexually reproduced protopolyps would display normal genetic variation in this character, but asexually reproduced polyps in each colony would be restricted to the narrow range of their colonies' protopolyps genotype. This, at least, would explain the very restricted intracolony variation accompanying the broad intercolony variation in septal number and other characters.

Broader intracolony variation, especially if bimodal, suggests that the analyzed colony may have included two or more genotypes. This could have resulted from a genetic accident (somatic mutation) or more likely from a mechanical one such as intergrowth of two or more adjacent colonies. To test this possibility, colony USNM 162631 (tables 7 and 14 and fig. 15*B*) was analyzed. The original sample of 20 corallites showed bimodal distribution (table 14, upper line of data). Another sample of 85 corallites

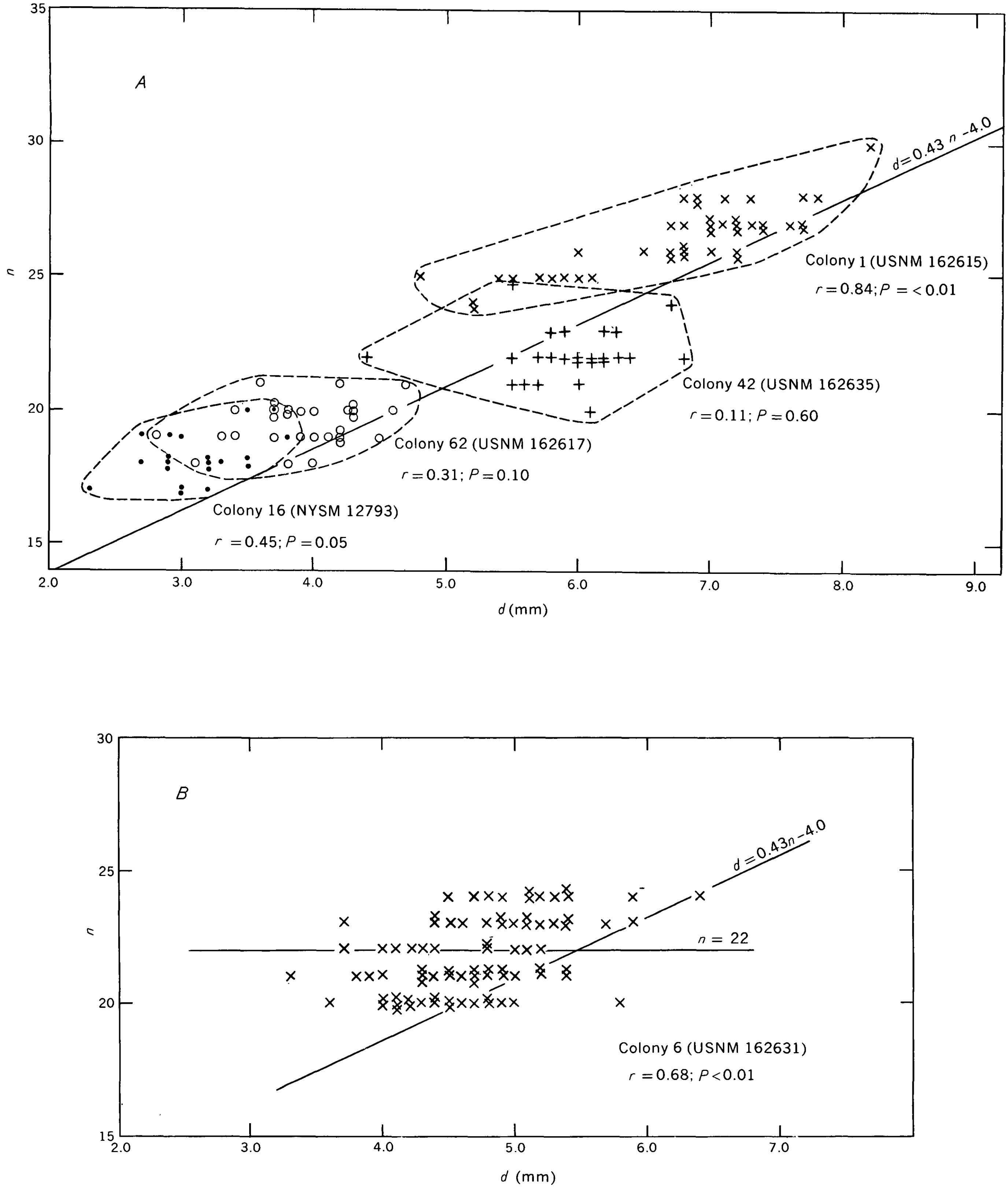
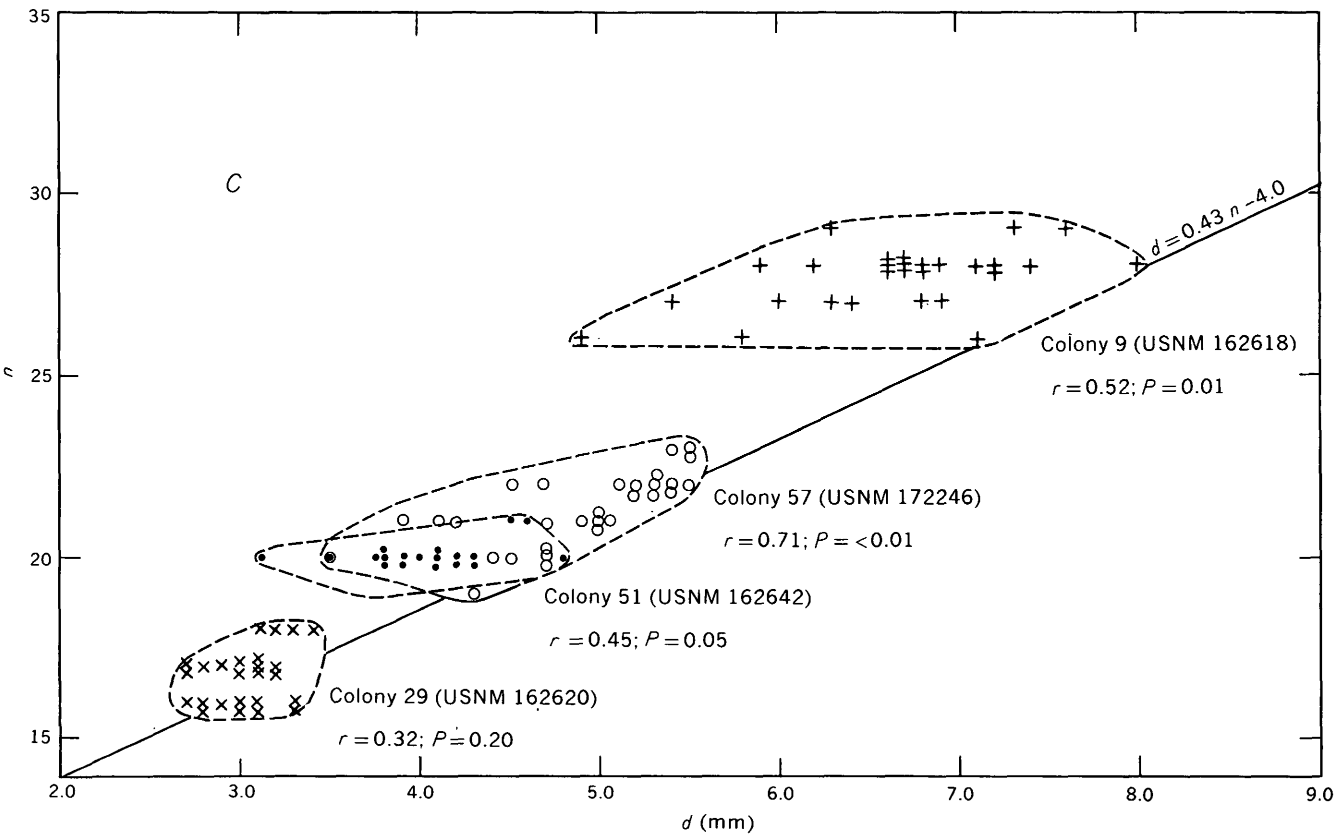
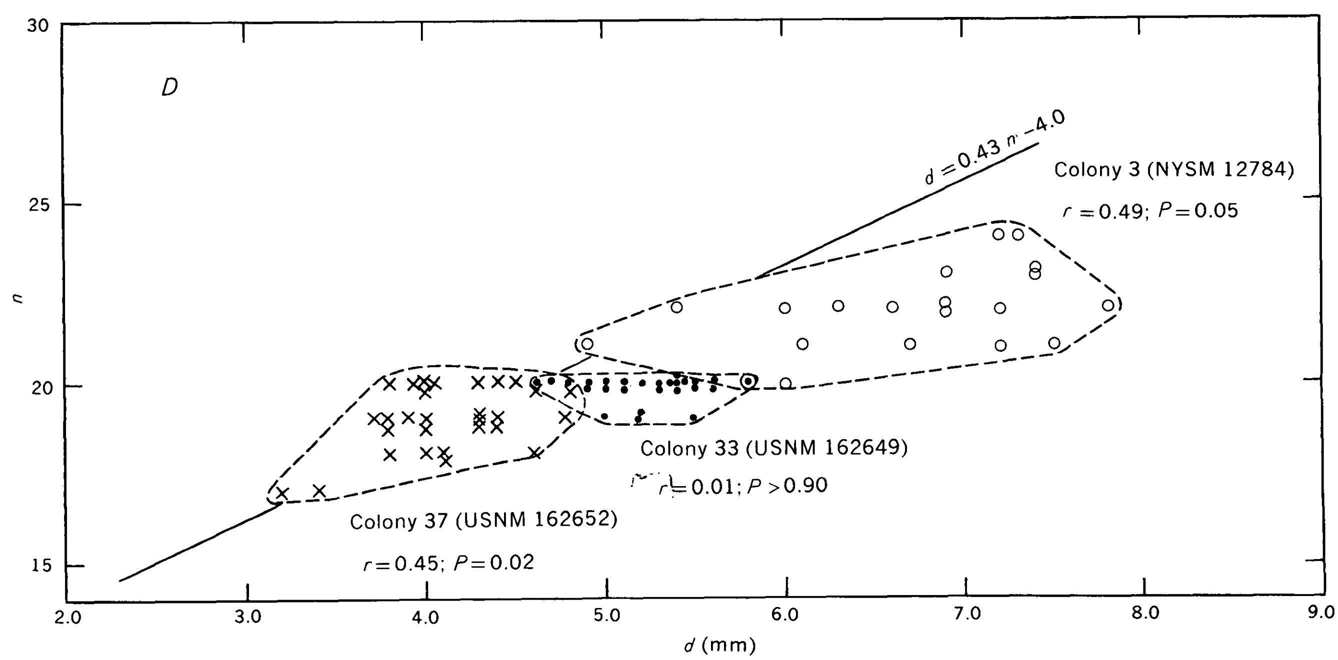


FIGURE 15.—Number of major septa (*n*) and diameter (*d*) in samples of selected colonies of *Acinophyllum segregatum*. Each polygon encloses data from one colony The line $d=0.43n-4.0$ represents the intercolony mean (see fig. 16) and is included here as a basis for comparison of the different colony samples. *A*, Four Edgecliff bioherm colonies. *B*, The colony shown in figure 18 and discussed in the text as having bimodal distribution of septal number; the line $n=22$ separates the two modes. *C*, Four Edgecliff colonies from the biostrome and fine-grained facies. *D*, Three Moorehouse colonies.


C
d = 0.43 n − 4.0
Colony 9 (USNM 162618)
r = 0.52; P = 0.01
Colony 57 (USNM 172246)
r = 0.71; P = <0.01
Colony 51 (USNM 162642)
r = 0.45; P = 0.05
Colony 29 (USNM 162620)
r = 0.32; P = 0.20
n
d (mm)


D
d = 0.43 n − 4.0
Colony 3 (NYSM 12784)
r = 0.49; P = 0.05
Colony 33 (USNM 162649)
r = 0.01; P > 0.90
Colony 37 (USNM 162652)
r = 0.45; P = 0.02
n
d (mm)

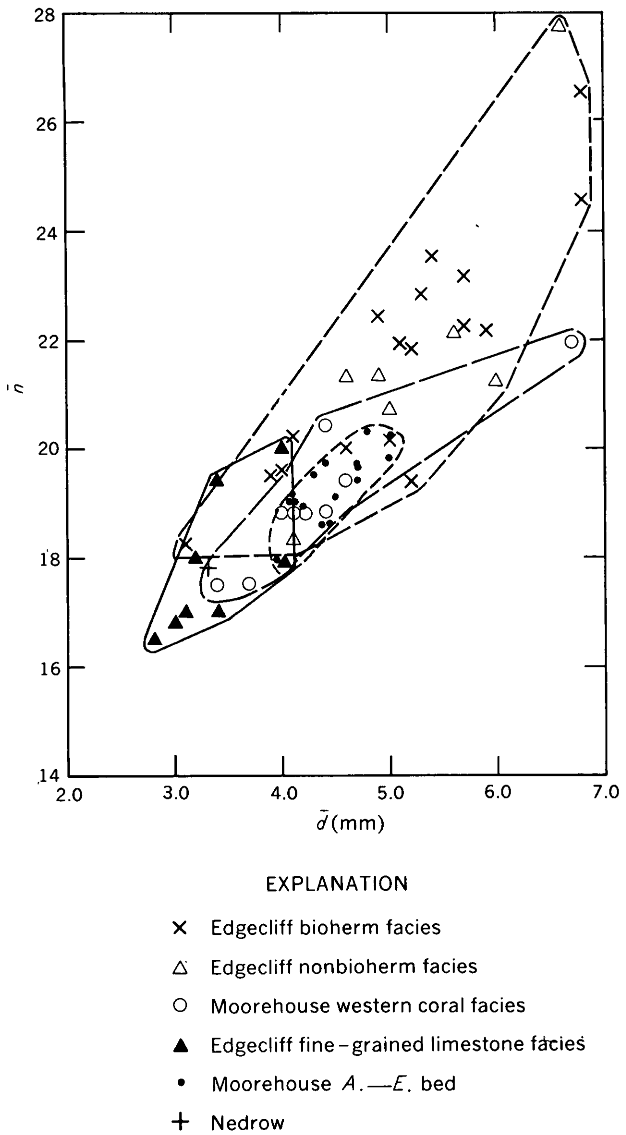


FIGURE 16.—Mean number of major septa ($\bar{n}$) and mean diameter ($\bar{d}$) in 58 colonies of *Acinophyllum segregatum* from the Onondaga Limestone in New York. Each polygon encloses samples from a different member and facies as discussed in the text. The line d=0.43—4.0 was calculated from the total sample of 58 to show how the unit subsamples vary.

(table 14, lower line of data) taken from a different thin section (fig. 18*A*) showed the same two modes (fig. 19). Figure 18*B* shows the distribution of septal numbers on the section. It seems significant that a line can be drawn across the section that almost completely separates the corallites of the two modes. The pattern strongly suggests that colony USNM 162631 was formed through intergrowth of two adjacent colonies with dominant septal number ranges of 20 to 22 and 22 to 24.

Intercolony variation in the correlation coefficient r is extreme (table 7). Scatter diagrams of selected colonies illustrate this (fig. 15*A–C*). The coefficient itself (r) ranges from 0.01 to 0.84, indicating almost no $n:d$ correlation in the former and a very high probability of correlation significance in the latter. P values are greater than 0.50 (low correlation probability) in 3 colonies of 32 tested, less than 0.01 (99 percent probability) in 11 colonies, and less than 0.05 (95 percent probability) in all but 9 of the 32 colonies (table 14).

The lowest correlation is found in colony USNM 162649 ($r=0.01$, $P>0.90$; fig. 15*D*) in which 22 of 26 sampled corallites have 20 major septa although there is considerable diameter variation ($OR_d=4.6$ to 5.8 mm). Other low-correlation colonies are typified by colonies USNM 162620 ($r=0.32$, $P=0.20$; fig. 15*C*) and USNM 162635 ($r=0.11$, $P=0.60$; fig. 15*A*). In both colonies, average n variation is coupled with low d variation.

Intercolony analysis (by colony means) shows a stronger correlation between diameter and septal number ($r=0.88$; $P<0.001$; table 8) than does any one colony. There is a strong correlation in these variables in *A. segregatum,* as in other corals (see Oliver, 1968b, p. 29 for discussion and references), but the two characters vary almost independently in some colonies.

The lack of $n:d$ correlation within some colonies suggests that the commonly held view that septal insertion is a response to diameter increase—that is, space filling—is untenable. The two processes are related, however, as is shown by the high correlation in all samples in which genetic variation is possible. The correlation means that variation in distance between septa was limited. With the broad septal number and diameter variation found in most species of rugose corals, a significant correlation resulted. In a clone in which septal number variation was very limited, diameter variation undoubtedly was restricted but was sufficient to effectively mask any control. In the extreme example (theoretical) in which all corallites in a corallum had the same number of septa, any diameter variation would appear to be random and uncorrelated. It appears reasonable to conclude that septal number was gentically controlled in many rugose corals, and that diameter was loosely controlled by septal number.

GEOGRAPHIC AND STRATIGRAPHIC VARIATION

Most of the colonies of *Acinophyllum segregatum* in the Onondaga Limestone are found at one of two

TABLE 7.—Acinophyllum segregatum *colony data arranged by stratigraphic unit*

Key to symbols used in tables 7–39; x, character; $\bar{x}$, mean value of character; N, sample size (N_1, intracolony; N_2, intercolony); n, number of major septa (septal number); OR_x, observed range; s_x, standard deviation; V_x, coefficient of variation; r, correlation coefficient; P, probability of r not being not significant; d, diameter; d^t, tabularium, diameter; d^{au} aulos diameter.

[See text for explanation and discussion. Dimensions are in millimetres]

Corallum		N	$\bar{n}$	OR_n	s_n	V_n	$\bar{d}$	OR_d	s_d	V_d	r	P
						Edgecliff bioherm facies						
*USNM	162615	43	26.5	24–30	1.2	4.7	6.8	4.8–8.2	0.8	11.6	0.84	<0.01
USNM	162629	24	23.5	22–26	1.0	4.3	5.4	4.4–6.2	.6	10.5		
USNM	162630	50	19.4	17–22	1.0	5.2	5.2	4.0–5.9	.3	5.8		
*USNM	162631	20	22.4	20–24	1.6	7.1	4.9	4.3–5.8	.4	8.0	.68	<.01
USNM	162632	32	21.8	20–23	.8	3.9	5.2	4.0–6.2	.6	10.7	.58	<.01
USNM	162616	20	20.1	18–21	.7	3.6	5.0	3.7–6.2	.5	10.7		
*NYSM	12793	20	18.2	17–20	.9	4.9	3.1	2.3–3.8	.4	11.8	.45	.05
NYSM	12794	20	20.2	18–21	.7	3.7	4.1	3.4–4.8	.4	10.0		
USNM	162633	25	20.0	18–22	1.1	5.4	4.6	3.1–5.3	.6	12.3		
USNM	162634	25	22.8	21–25	1.3	5.6	5.3	4.3–6.2	.5	9.3	.65	<.01
*USNM	162635	25	22.1	20–25	1.0	4.6	5.9	4.4–6.8	.5	8.0	.11	.60
NYSM	12795	30	24.5	22–26	1.0	4.0	6.8	5.2–7.9	.6	9.3		
NYSM	12796	23	21.9	20–23	.8	3.9	5.1	3.4–6.8	.8	15.9	.45	.05
USNM	162636	20	22.2	21–24	1.0	4.4	5.7	4.8–6.5	.4	7.9		
USNM	162637	30	23.1	21–25	1.0	4.2	5.7	4.2–7.3	.6	10.8		
USNM	162638	23	19.6	17–21	1.0	5.2	4.0	2.7–4.9	.6	14.1	.66	<.01
*USNM	162617	30	19.5	18–21	.8	4.2	3.9	2.8–4.7	.4	11.2	.31	.10
						Edgecliff biostrome facies						
NYSM	12780	20	22.1	19–24	1.1	5.1	5.6	4.5–6.3	0.4	7.6	0.56	0.01
USNM	162639	22	20.7	18–22	1.0	4.7	5.0	3.6–5.9	.5	10.1		
*USNM	162618	28	27.7	26–29	.8	3.0	6.6	4.9–8.0	.7	10.0	.52	.01
NYSM	12781	20	21.2	20–22	.7	3.3	6.0	4.4–6.7	.6	9.7		
NYSM	12782	21	21.3	20–23	1.1	5.0	4.6	3.8–5.3	.5	10.2	.55	.02
NYSM	12783	23	18.3	17–20	.8	4.4	4.1	3.4–4.9	.4	8.6		
*USNM	172246	30	21.3	19–23	1.0	4.8	4.9	3.5–5.5	.5	10.6	.71	<.01
						Edgecliff fine-grained limestone facies						
NYSM	12797	28	19.4	18–21	0.9	4.5	3.4	2.9–4.1	0.3	10.1	0.48	4.02
USNM	162640	30	17.9	17–19	.4	2.2	4.0	3.1–4.6	.4	9.0		
NYSM	12798	30	17.0	15–18	1.0	5.7	3.1	2.6–3.7	.3	9.5	.46	.02
USNM	162619	30	16.5	15–18	.7	4.1	2.8	2.3–3.4	.2	8.8	.30	.10
*USNM	162620	25	16.8	16–18	.7	4.3	3.0	2.7–3.4	.2	6.9	.32	.20
USNM	162641	30	18.0	16–19	.6	3.6	3.2	2.5–3.9	.3	10.1		
*USNM	162642	20	20.0	19–21	.4	2.0	4.0	3.1–4.8	.4	9.6	.45	.05
USNM	162643	23	17.0	16–19	.8	4.8	3.4	2.8–3.9	.3	8.7		
						Nedrow member						
USNM	162659	20	17.8	15–20	1.6	8.7	3.3	2.8–4.0	0.3	9.1	0.51	0.05
						Moorehouse western coral facies						
*NYSM	12784	20	21.9	20–24	1.1	5.1	6.7	4.9–7.8	0.8	11.5	0.49	0.05
NYSM	12803	20	20.4	18–22	1.0	4.9	4.4	3.0–5.5	.6	14.1	.60	.01
NYSM	12804	30	18.8	18–20	.9	4.8	4.1	3.5–4.8	.3	7.4		
USNM	162655	20	19.4	17–20	.9	4.5	4.6	3.2–5.3	.4	9.7		
USNM	162622	30	18.8	18–20	.7	4.0	4.4	3.7–5.3	.4	9.8	.29	.20
USNM	162656	30	18.8	18–20	.8	4.2	4.2	3.0–4.0	.5	12.1		
USNM	162657	23	18.8	17–20	1.0	5.5	4.0	2.9–4.9	.6	13.9	.70	<.01
USNM	162658	60	17.5	14–20	1.2	7.1	3.4	2.5–4.7	.4	11.8		
NYSM	12805	27	17.5	16–19	.8	4.6	3.7	2.8–4.4	.5	12.4	.30	.20
						Moorehouse Acinophyllum-Eridophyllum Bed						
NYSM	12799	40	19.6	18–20	0.6	3.0	4.7	3.8–5.2	0.3	6.4		
NYSM	12800	25	18.6	17–20	.9	4.6	4.4	3.2–5.4	.4	10.3	0.19	0.40
USNM	162644	40	19.0	17–21	.8	4.5	4.1	3.1–4.8	.4	10.4		
USNM	162645	20	17.9	17–19	.4	2.5	4.0	3.1–4.5	.5	11.8		
USNM	162646	30	19.1	17–20	.8	4.2	4.5	3.6–5.5	.4	9.8	.47	.02
USNM	162647	30	19.0	17–20	.9	4.6	4.1	3.4–4.6	.3	7.5		
NYSM	12801	30	19.7	18–22	.9	4.6	4.7	3.4–5.3	.5	10.1	.08	.70
NYSM	12802	30	18.9	18–20	.8	4.4	4.2	3.5–4.9	.4	9.9		
USNM	162621	30	20.2	18–22	.8	4.0	5.0	3.8–5.8	.4	8.6	.62	<.01
USNM	162648	30	19.5	18–20	.6	2.9	4.3	3.7–5.0	.3	7.9		
*USNM	162649	26	19.8	19–20	.4	1.9	5.2	4.6–5.8	.3	5.8	.01	>.90
USNM	162650	30	19.7	18–21	.7	3.6	4.4	3.4–5.5	.5	10.7	.45	.02
USNM	162651	30	20.3	19–23	.8	3.8	4.8	4.0–5.6	.4	7.2		
*USNM	162652	30	19.1	17–20	.9	4.8	4.1	3.2-4.8	.4	9.1	.45	.02
USNM	162653	28	19.4	18–21	.8	4.1	4.7	3.8–5.3	.4	9.4		
USNM	162654	20	18.6	16–21	1.2	6.4	4.4	3.0–5.2	.6	13.2	.45	.05

* Colonies graphed in figure 154–*D*.

TABLE 8.—Acinophyllum segregatum, *summary data*

	Intracolony			Inter-colony
	Minimum	Maximum	Mean	
N	20	60	---	58
n: $\bar{x}$	16.5	27.7	---	20.0
OR	15–18	26–29	---	16.5–27.7
s	.4	1.6	---	2.2
V	1.9	8.7	4.4	11.0
d: $\bar{x}$	2.8	6.8	---	4.6
OR	2.3–3.4	6.0–8.9	---	2.8– 6.8
s	.2	.8	---	1.0
V	5.8	15.9	10.0	20.0
*r	.01	.84	---	.88
*P	>.99	<.01	---	<.001

*r and P calculated for 32 of the 58 colonies.

TABLE 9.—Acinophyllum segregatum, *summary data, Edgecliff bioherm facies*

	Intracolony			Inter-colony
	Minimum	Maximum	Mean	
N	20	50	---	17
n: $\bar{x}$	18.2	26.5	---	21.6
OR	17–20	24–30	---	18.2–26.5
s	.8	1.6	---	2.1
V	3.6	1.7	4.6	9.9
d: $\bar{x}$	3.1	6.8	---	5.1
OR	2.3 – 3.8	4.8– 8.2	---	3.1– 6.8
s	.4	.8	---	1.0
V	5.8	15.9	10.5	19.1

TABLE 10.—Acinophyllum segregatum, *summary data, Edgecliff biostrome facies*

	Intracolony			Inter-colony
	Minimum	Maximum	Mean	
N	20	30	---	7
n: $\bar{x}$	18.3	27.7	---	21.8
OR	17–20	26–29	---	18.3–27.7
s	.7	1.1	---	2.9
V	3.0	5.1	4.3	13.1
d: $\bar{x}$	4.1	6.6	---	5.3
OR	3.4–4.9	4.9– 2.0	----	4.1– 6.6
s	.4	.7	---	.9
V	7.6	10.6	9.5	16.3

TABLE 11.—Acinophyllum segregatum *summary data, Edgecliff fine-grained limestone facies*

	Intracolony			Inter-colony
	Minimum	Maximum	Mean	
N	20	30	---	8
n: $\bar{x}$	16.5	20.0	---	17.8
OR	15–18	19–21	---	16.5–20.0
s	.4	1.0	---	1.3
V	2.0	5.7	3.9	7.2
d: $\bar{x}$	2.8	4.0	---	3.4
OR	2.3–3.4	3.1– 4.8	---	2.8– 4.0
s	.2	.4	---	.4
V	6.9	10.1	9.1	12.9

TABLE 12.—Acinophyllum segregatum, *summary data, Moorehouse Member (except* Acinophyllum-Eridophyllum *bed)*

	Intracolony			Inter-colony
	Minimum	Maximum	Mean	
N	20	60	---	9
n: $\bar{x}$	17.5	21.9	---	19.3
OR	14–20	20–24	---	17.5–21.9
s	.7	1.2	---	1.3
V	4.0	7.1	5.0	6.8
d: $\bar{x}$	3.4	6.7	---	4.5
OR	2.5–4.7	4.9– 7.8	---	3.4– 6.7
s	.3	.8	---	.9
V	7.4	14.1	11.4	20.6

TABLE 13.—Acinophyllum segregatum, *summary data, Moorehouse* Acinophylum-Eridophyllum *bed*

	Intracolony			Inter-colony
	Minimum	Maximum	Mean	
N	20	40	---	16
n: $\bar{x}$	17.9	20.3	---	19.3
OR	17–19	19–23	---	17.9–20.3
s	.4	1.2	---	.6
V	1.9	6.4	4.0	3.2
d: $\bar{x}$	4.0	5.2	---	4.5
OR	3.1–4.5	4.6– 5.8	---	4.0– 5.2
s	.3	.6	---	.4
V	5.8	13.2	9.3	7.8

stratigraphic levels: in the Edgecliff Member or in the upper part of the Moorehouse Member. These are plotted separately on the scatter diagram (fig. 16), and distinction is made between colonies from various facies or other subdivisions of the members.

No evolutionary pattern can be discerned. The oldest colonies are those from the Edgecliff fine-grained facies; reef and biostrome colonies are (on the average) slightly younger and the Moorehouse colonies are youngest. In none of the characters studied is there a progression from older to younger.

Differences between stratigraphically defined groups of colonies are shown on the scatter diagrams and summarized in tables 9 to 13. These differences relate to the character of the lithology and associated fossils (that is, environment) of the stratigraphic unit from which each group was collected. In general, the groups with greatest variation are found in the light-colored coarse-crystalline facies and are associated with a large variety of other corals. Groups with least variation are found in medium- to dark gray fine-grained limestone associated with few other corals.

Sufficient material for analysis has been collected from five stratigraphic subdivisions of the Onondaga. These and one other unit are discussed below to illustrate the ecological variation.

TABLE 14.—*Data from selected colonies of* Acinophyllum segregatum *arranged in order of increasing coefficient of septal number variation* (V_n)

Corallum	N	P	V_n	Number of major septa (n) per corallite: 15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Percentage of corallites in 1, 2, or 3 septal classes: 1	2	3
*USNM 162649	26	0.90	1.9	--	--	--	--	4	22	--	--	--	--	--	--	--	--	--	--	85	100	---
*USNM 162642	20	.05	2.0	--	--	--	--	1	17	2	--	--	--	--	--	--	--	--	--	85	95	100
*USNM 162618	28	.01	3.0	--	--	--	--	--	--	--	--	--	--	--	3	6	16	3	--	57	79	89
USNM 162650	30	.02	3.6	--	--	--	2	7	19	2	--	--	--	--	--	--	--	--	--	63	87	93
USNM 162632	32	.01	3.9	--	--	--	--	--	3	7	17	5	--	--	--	--	--	--	--	53	75	91
NYSM 12796	23	.05	3.9	--	--	--	--	--	1	6	10	6	--	--	--	--	--	--	--	43	70	96
USNM 162621	30	.01	4.0	--	--	--	1	2	18	8	1	--	--	--	--	--	--	--	--	60	87	93
USNM 162622	30	.20	4.0	--	--	--	11	13	6	--	--	--	--	--	--	--	--	--	--	43	80	100
USNM 162619	30	.10	4.1	1	16	11	2	--	--	--	--	--	--	--	--	--	--	--	--	53	90	97
USNM 162646	30	.02	4.2	--	--	1	5	14	10	--	--	--	--	--	--	--	--	--	--	47	80	97
*USNM 162617	30	.10	4.2	--	--	--	3	11	13	3	--	--	--	--	--	--	--	--	--	43	80	90
*USNM 162620	25	.20	4.3	--	10	11	4	--	--	--	--	--	--	--	--	--	--	--	--	44	84	100
NYSM 12797	28	.02	4.5	--	--	--	5	9	12	2	--	--	--	--	--	--	--	--	--	43	75	93
NYSM 12800	25	.40	4.6	--	--	1	12	7	5	--	--	--	--	--	--	--	--	--	--	48	76	96
NYSM 12801	30	.70	4.6	--	--	--	3	8	15	3	1	--	--	--	--	--	--	--	--	50	77	87
NYSM 12805	27	.20	4.6	--	3	10	12	2	--	--	--	--	--	--	--	--	--	--	--	44	81	93
*USNM 162635	25	.60	4.6	--	--	--	--	--	1	4	14	4	1	1	--	--	--	--	--	56	72	88
*USNM 162615	43	.01	4.7	--	--	--	--	--	--	--	--	--	2	8	10	15	7	--	1	35	58	77
*USNM 162652	30	.02	4.8	--	--	2	5	12	11	--	--	--	--	--	--	--	--	--	--	40	77	93
*USNM 172246	30	.01	4.8	--	--	--	--	1	6	9	11	3	--	--	--	--	--	--	--	37	67	87
NYSM 12803	20	.01	4.9	--	--	--	1	1	9	6	3	--	--	--	--	--	--	--	--	45	75	90
*NYSM 12793	20	.05	4.9	--	--	4	10	4	2	--	--	--	--	--	--	--	--	--	--	50	70	90
NYSM 12782	21	.02	5.0	--	--	--	--	--	6	5	7	3	--	--	--	--	--	--	--	33	57	86
*NYSM 12784	21	.05	5.1	--	--	--	--	--	2	5	8	3	2	--	--	--	--	--	--	40	65	80
NYSM 12780	20	.01	5.1	--	--	--	--	1	--	4	7	7	1	--	--	--	--	--	--	35	70	90
USNM 162638	23	.01	5.2	--	--	1	2	5	11	4	--	--	--	--	--	--	--	--	--	48	70	87
USNM 162657	23	.01	5.5	--	--	3	6	7	7	--	--	--	--	--	--	--	--	--	--	30	61	87
USNM 162634	25	.01	5.6	--	--	--	--	--	--	4	8	6	4	3	--	--	--	--	--	32	56	72
NYSM 12798	30	.02	5.7	3	4	12	11	--	--	--	--	--	--	--	--	--	--	--	--	40	77	90
USNM 162654	20	.05	6.4	--	1	--	11	2	5	1	--	--	--	--	--	--	--	--	--	55	65	90
*USNM 162631	20	.01	7.1	--	--	--	--	--	4	3	1	5	7	--	--	--	--	--	--	35	60	65
	85	---	--	--	--	--	--	--	20	24	11	18	12	--	--	--	--	--	--	28	52	65
USNM 162659	20	.05	8.7	2	3	2	7	3	3	--	--	--	--	--	--	--	--	--	--	35	50	65

* Colonies graphed in figure 15*A–D*.

Bioherm and biostrome facies.—Seventeen bioherm colonies were analyzed. Variation in diameter, septal number, and correlation coefficient is almost coextensive with that in the species as a whole (tables 7 and 9 and fig. 16). The bioherms are composed of coral skeletons (tabulates and solitary and colonial rugose) in a matrix of coarse crinoidal debris and are the most favorable environment for corals (Oliver, 1954, 1956b, c).

Seven colonies were analyzed from the normal Edgecliff (biostrome facies). The sample is small, and it is difficult to discern a significant difference between these and the bioherm facies (fig. 16). This nonbioherm facies is composed of bedded crinoidal debris with tabulate and solitary rugose corals being very common, in places forming a coral biostrome (Oliver, 1954, 1956c). *Acinophyllum segregatum* is not common and other colonial rugose corals are rare.

Collections from both the bioherm and biostrome facies of the Edgecliff Member are more extensive than indicated. In addition to the analyzed colonies, numerous fragments inadequate for statistical analysis have been studied. Most of these would easily fall within the scatter area of the samples in figure 16, but a few would fall at and below the lower end of this area. The additional material indicates even greater variation than is shown by tables 9 and 10. Colonies with small corallites are uncommon in the two facies but do exist. The more restricted scatter areas of other stratigraphic groupings all fall completely within the scatter area of the more or less coextensive bioherm and biostrome groupings.

Fine-grained facies.—A localized facies of the lower Edgecliff Member was designated the C1 facies by Oliver (1956c). This is composed of medium-gray rather fine-grained limestone. All fossils are less common here than in the rest of the member, but colonies of *Acinophyllum segregatum* form small local coral beds in several places. Intercolony variation is much less than in the other facies of the Edgecliff Member. Limits of variation are shown on the scatter diagram (table 7 and fig. 16). Coefficients of variation are 7.2 and 12.9 (table 11), as compared with 9.9 and 19.1 in the bioherm group and 11.0 and 20.7 in the whole Onondaga assemblage studied.

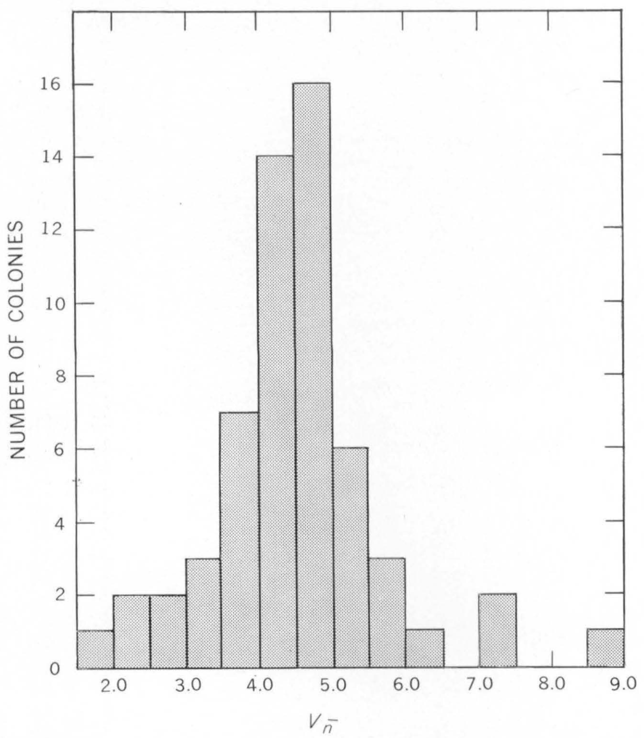


FIGURE 17.—Normal distribution of intercolony coefficients of septal number variation ($V_{\bar{n}}$) in *Acinophyllum segregatum*. Sample size (N) is 58.

Moorehouse coral facies.—The western coral facies of the Moorehouse Member (Oliver, 1954) as a whole represents a recurrence of conditions very much like the Edgecliff. The lithology is somewhat finer and darker, but corals are locally common, *Acinophyllum segregatum* and one other colonial rugose coral species compose the *Acinophyllum-Eridophyllum* bed (*Synaptophyllum-Cylindrophyllum* bed of Oliver, 1954). Elsewhere in the Moorehouse *A. segregatum* is widely scattered but not uncommon; other colonial rugose corals are less common or rare.

The scatter diagram (fig. 16) shows that Moorehouse *A. segregatum* colonies outside of the *Acinophyllum-Eridophyllum* bed are quite variable. Nine colonies analyzed show much of the range of bioherm and bioherm colonies. All but one of the colonies are from the western coral facies of the member. Intercolony coefficients of variation are 6.8 and 20.6 (table 12).

The *Acinophyllum* coral bed of the western Moorehouse Member represents the most restricted conditions of all. Although enclosed by the "coral facies," the 16 analyzed colonies show less intercolony variation than any other group in the formation (V=3.2 and 7.8, table 13). The matrix of this bed consists of fine medium-dark limestone and dark chert. Although only 12 to 18 inches (30 to 45 cm) in thickness, the bed extends for several miles.

Nedrow and Clarence Members.—Fragments of *Acinophyllum segregatum* have been collected from these members at four localities. Three specimens have been studied from the western Clarence and three from the east-central Nedrow. Data from only one of these is included in the statistical analysis (table 7), but all specimens collected fall within the area of the Edgecliff fine-grained limestone group of figure 16.

Two solitary rugose coral species characterize the Nedrow shaly limestone facies but, except for these, corals of all types are rare in both members.

Summary.—Data for the five principal samples of *A. segregatum* are brought together in table 15 and figure 20, where the samples are presented in the order of decreasing numbers of coral species identified from each facies (diversity index). Table 15 shows that for these five samples there is a general decrease in variation with decrease in diversity. It seems clear that the environmental factors that permitted high species diversity also permitted greater variation within the studied sample. At one extreme is the Edgecliff bioherm facies with high species diversity and high intercolony variation. At the other extreme is the Moorehouse *Acinophyllum-Eridophyllum* bed containing only two species of corals; although colonies are abundant, intercolony variation is minimal.

Figure 20 is based on the same data but shows more clearly that intracolony septal number variation is not very different in the five facies, but that intercolony variation is high in two facies, medium in two, and very low in one. This seems most likely to reflect environmental control.

VARIATION IN OTHER SPECIES

Study of variation in the other species of colonial rugose corals was similar to that of *Acinophyllum segregatum* but limited by smaller sample sizes, the restriction of most species to a single stratigraphic unit (formation, member, or facies), and by other practical difficulties such as the large individual size of most of the zaphrentids. Summary data for many of the species are given in tables 16 to 39. Part of this data is gathered on table 15 and figures 20 and 21.

Analysis of other phaceloid species is by the characters and methods outlined for *Acinophyllum segregatum* except that aulos diameter (d^{au}) was added for the *Eridophyllum* spp. In cerioid species, diameter was measured through the axis at right angles to

TABLE 15.—*Intracolony and intercolony coefficients of variation in 24 samples of colonial rugose corals*

Sample No.	Species	N_1	N_2	V_n Intracolony *OR*	V_n Intracolony Mean	V_n Intercolony	V_d or V_d^{az} Intracolony *OR*	V_d or V_d^{az} Intracolony Mean	V_d or V_d^{az} Intercolony	V_d or V_d^{au} Intracolony *OR*	V_d or V_d^{au} Intracolony *M*	V_d or V_d^{au} Intercolony	Diversity index
1a.	*Acinophyllum segregatum*, Edgecliff bioherm facies	20–50	17	3.6– 7.1	4.6	9.9	5.8–15.9	10.5	19.1	--------	---	---	34
1b.	*A. segregatum*, Edgecliff biostrome facies	20–30	7	3.0– 5.1	4.3	13.1	7.6–10.6	9.5	16.3	--------	---	---	26
1c.	*A. segregatum*, Moorehouse Member except *A.-E.* bed	20–60	9	4.0– 7.1	5.0	6.8	7.4–14.1	11.4	20.6	--------	---	---	21
1d.	*A. segregatum*, Edgecliff fine-grained limestone facies	20–30	8	2.0– 5.7	3.9	7.2	6.9–10.1	9.1	12.9	--------	---	---	9
1e.	*A. segregatum*, Moorehouse, *Acinophyllum-Eridophyllum bed.*	20–40	16	1.9– 6.4	4.0	3.2	5.8–13.2	9.3	7.8	--------	---	---	2
2.	*A. stramineum*, Edgecliff bioherm facies	15–22	8	3.3– 6.7	5.5	6.5	7.7–15.6	12.5	14.2	--------	---	---	--
3.	*A. simcoense*, Bois Blanc Formation	10–26	15	2.9– 6.5	4.2	7.4	6.9–15.2	11.1	16.9	--------	---	---	--
4a.	*A. stokesi*, Bois Blanc Formation	10–20	10	2.6– 7.6	4.6	5.6	7.3–13.6	10.1	10.1	--------	---	---	--
4b.	*A. stokesi*, Jeffersonville Limestone, Zone A	10–20	6	2.6– 4.6	4.0	5.1	6.2–14.1	9.6	10.9	--------	---	---	--
5.	*Cylindrophyllum elongatum*, Edgecliff bioherm facies	4–16	9	3.7– 7.2	5.1	7.7	3.6–20.0	12.1	12.1	--------	---	---	--
6a.	*C. propinquum*, Edgecliff bioherm facies (includes 1 biostrome facies colony).	4–15	6	1.6– 6.6	3.6	8.2	9.8–22.2	15.6	21.4	--------	---	---	--
6b.	*C. propinquum*, Columbus Limestone, Zone C	3– 9	5	0– 7.3	4.5	5.5	6.7–15.9	10.8	4.1	--------	---	---	--
7.	*C. deearium*, Edgecliff bioherm facies (includes two biostrome facies colonies).	3–14	9	1.5– 6.9	4.3	5.0	6.7–18.4	12.6	11.4	--------	---	---	--
8.	*Prismatophyllum prisma*, Jeffersonville Limestone, Zone B.	5–12	8	2.2– 8.4	5.7	5.6	10.8–25.3	18.7	9.6	--------	---	---	--
9.	*P. ovoideum*, Jeffersonville Limestone, Zone C	7–16	7	3.6– 7.1	5.4	7.5	3.3–24.5	16.9	11.7	--------	---	---	--
10.	*Asterobillingsa magdisa magdisa* (Edgecliff bioherm and Bois Blanc).	15–23	6	4.9– 7.8	5.8	11.1	8.7–13.7	6.6	16.1	5.6– 7.9	11.4	19.6	--
11.	*A. magdisa steorra*, Edgecliff, bioherm facies	10–36	15	4.4– 9.3	6.3	8.4	8.9–22.0	6.6	11.4	4.1–13.6	14.2	19.4	--
12.	*Eridophyllum seriale*, pop. B, Moorehouse *Acinophyllum-Eridophyllum* bed.	4–14	10	3.1– 6.4	4.8	4.2	6.6–15.7	11.4	7.5	15.8–30.6	21.1	15.0	--
13.	*E. corniculum*, Moorehouse Member, western coral facies.	5–10	11	2.4–14.8	6.7	9.9	5.3–28.9	13.9	21.7	13.4–30.7	21.1	20.5	--
14.	*E. subseriale*, Edgecliff bioherm facies	6–14	7	3.9–11.5	6.1	5.7	5.8–18.2	12.6	13.6	13.7–22.6	17.3	13.2	--
15.	*Grewgiphyllum colligatum*, Bois Blanc and Edgecliff bioherm facies.	5–20	10	3.8– 9.1	5.4	6.1	([1])	([1])	---	10.9–19.4	14.3	18.9	--
16.	*Cyathocylindrium opulens*, Edgecliff bioherm facies	4–20	13	0.0–14.4	7.5	11.9	3.6–24.5	13.7	19.6	--------	---	---	--
17.	*Heliophyllum monticulum*, Edgecliff bioherm facies	9–10	9	4.0– 7.0	5.7	15.1	10.0–18.9	13.9	15.5	3.7–11.1	7.3	21.4	--
18.	*Synaptophryllum arundinaceum*, Edgecliff bioherm facies.	12–20	9	2.5– 9.3	5.3	4.8	6.6–17.4	12.5	13.7	--------	---	---	--

[1] See table 35.

one wall; in corallites with two or more markedly different diameters, the shorter was recorded. Astraeoid species were analyzed for tabularium diameter (d^t); an average corallite diameter was obtained by measuring the distance between the axes of adjacent corallites (axial distance, d^{ax}), but these measurements cannot be related to an individual coral so that intracolony correlation of diameter and septal numbers cannot be tested in these forms.

Each sample represented in figures 20 and 21 and in table 15 can be considered to show one of three patterns, although it is probable that there is some distortion due to the small size of some samples. The patterns are:

1. Intercolony V_n being well above the observed range of intracolony V_n, including samples 1a, 1b, and 10.
2. Intercolony V_n being just above or at high end of observed range of intracolony V_n, including most of the samples.
3. Intercolony V_n being low in observed range of intracolony V_n, including samples 1e, 8, 12, 14, and 18.

Visual examination of figure 20 suggests that intracolony variation may not significantly differ among the studied samples. The 3 patterns are mostly a function of the position of intercolony variation relative to the common intracolony range of variation, thus patterns 1 and 2 are separated by a V_n of 9 to 10 with only one apparent exception, and patterns 2 and 3 are separated by a V_n of 5 with 2 exceptions.

In analyzing *Acinophyllum segregatum*, I suggested that these patterns as observed in samples 1a to 1e were environmentally controlled. Figure 21 groups the samples by stratigraphic unit and suggests that ecology is of importance in some of the groupings. The only two coral species in the Moorehouse *Acinophyllum-Eridophyllum* bed (with the lowest diversity index of any unit) have very low coefficients of intercolony variation. This fits the generalization that poor environments are characterized by large numbers of specimens of few species.

On the other hand, the Edgecliff bioherm and biostrome facies, with the highest diversity indices of the five Onondaga facies, have representatives of all three patterns. Most biohermal populations show medium to high intercolony variation, but some are low, and two species (14 and 18) are very low. I suggested in my 1968 paper that these two species may simply have been genetically less variable (1968b, p. 31).

Most of the other samples in figure 21 show medium intercolony variation and represent stratigraphic units in which an intermediate diversity of corals is found.

SUMMARY AND CONCLUSIONS

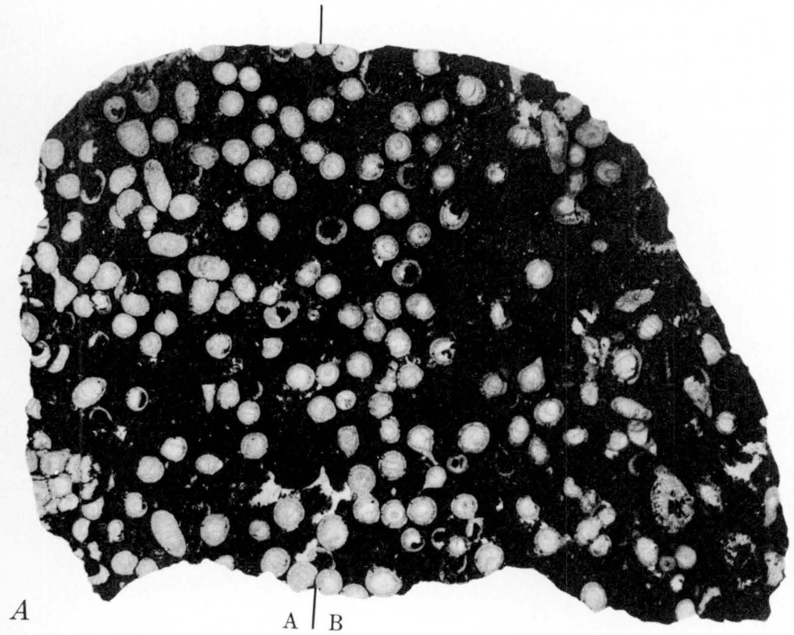
These data may be summarized and conclusions drawn as follows (Oliver, 1968b, p. 26–29):

1. *Acinophyllum segregatum* shows low intracolony variation, especially in septal number, and this narrow range of variation is found in samples from five different facies. This suggests that:
   a. Protopolyps were genetically programed for a narrow range of septal number variation, and this range was transmitted to each member of the colony by means of asexual reproduction.
   b. Broader (including bimodal) variation in some colonies may be due to genetic accidents or, more likely, mechanical accidents such as the intergrowth of two or more adjacent colonies.
2. Comparably low intracolony variation was found in the other species studied.
3. Intercolony variation in *A. segregatum* is related to gross environment; variation is greatest in facies with diverse coral faunas and least in facies with restricted faunas.
4. Intercolony variation in most of the other studied samples is roughly comparable to that of associated *A. segregatum* and may have been environmentally controlled.
5. Two samples (*Eridophyllum subseriale* and *Synaptophyllum arundinaceum*) show low intercolony variation although they are from the "best" facies (Edgecliff bioherm). These populations or species may have been genetically less variable.

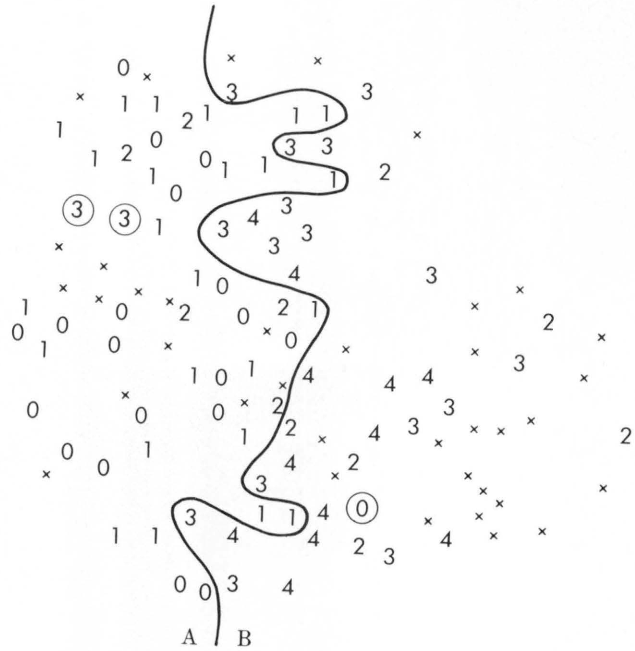
Intercolony variation is a product of the interaction of random genetic variation, ecologically induced variation, and astogenetic stage and is therefore analogous to variation in solitary animals. Such variation is commonly continuous, but discontinuous variation may result from genetically induced di- or polymorphism, from nonuniform environmental factors, or from inadequate sampling.

Intracolony variation may be very restricted because of genetic uniformity and the presence of relatively uniform environmental conditions. Genetic uniformity leaves room for phenetic differences however, and microenvironmental factors (situation within colony) may cause enough individual variaton to effectively mask the restrictive effects of genetic similarity.

Variation in any character may be severly limited within a colony because of the lack of genetic variation. Sampling of colonial species for statistical analysis must take this into account. The analysis should be based on a) equal numbers of randomly selected corallites from all colonies, or b) mean values calculated for each colony. Sample size should refer to number of colonies not number of corallites.



A



B

FIGURE 18.—Transverse thin section through colony 6 (USNM 162631) of *Acinophyllum segregatum* (× 0.7). *A*, Photograph. *B*, "Map" on which each numeral +20 is the number of major septa in the corresponding corallite (for example "O" marks corallites with 20 major septa, "3", those with 23). The line separates all corallites with 20 or 21 septa (area A) from those with 23 or 24 (area B) except for the three circled corallites. (See text discussion.) The small *x*'s mark corallites in which the septa could not be counted. The bimodal distribution of septal number in this colony is shown in figure 19.

The general assumption that number of septa in rugose corals is a function of diameter may be in error. Rather, it seems that numbers of septa may determine diameter within certain limits. (Oliver, 1968b, p. 31–32).

SYSTEMATIC PALEONTOLOGY

DEPOSITORIES

The following descriptions are based on specimens from many sources but principally on those from my collections made since 1950 while employed by the New York State Museum and the U.S. Geological Survey. All described material from these collections is now deposited in the U.S. National Museum of Natural History, the New York State Museum, or the collections of the Geological Survey of Canada. In addition, many specimens have been studied from earlier collections in these and many other institutions, and the New York-Ontario corals have been compared to ENA corals from still additional collections. All of these institutions are listed below with the abbreviations used for referring to them in depository lists and the descriptive texts.

Depositories of described New York-Ontario corals:

AMNH—American Museum of Natural History, New York.

GSC—Geological Survey of Canada, Ottawa.

NYSM—New York State Museum, Albany.

UBuff—Dept. Geology, University of Buffalo (SUNY), Buffalo.

UMMP—Univ. of Michigan, Museum of Paleontology, Ann Arbor.

USNM—U.S. National Museum of Natural History, Washington.

Depositories (in addition to those listed above) of other ENA corals serving as basis for descriptions or comparisons:

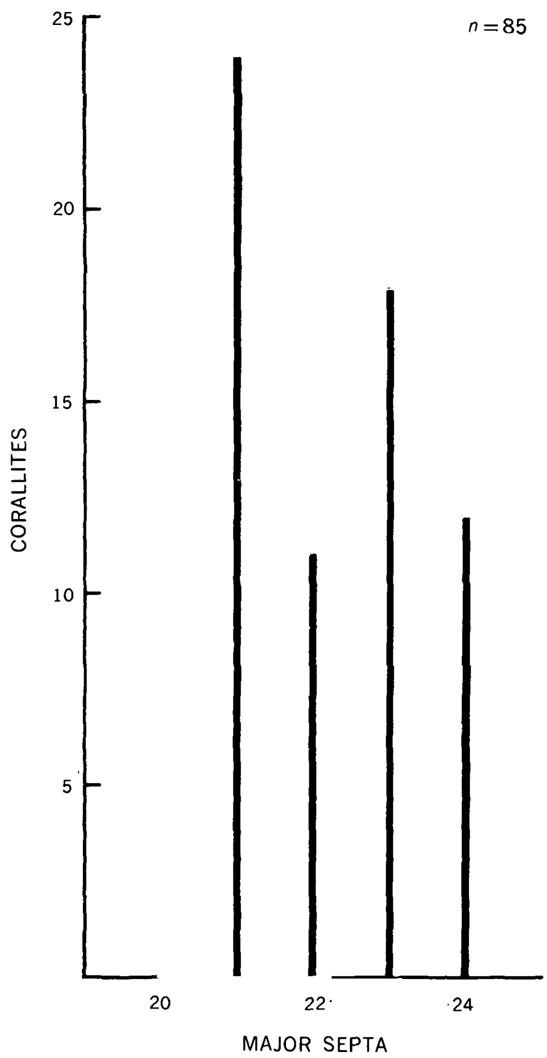


FIGURE 19.—Bimodal distribution of septal number (n) in a sample of 85 corallites of colony 6 (USNM 162631) of *Acinophyllum segregatum*. (See text discussion and fig. 18.)

BMNH—British Museum (Natural History), London.
FMNH—Field Museum of Natural History, Chicago.
MCZ—Harvard Univ., Museum of Comparative Zoology, Cambridge.
OSU—Orton Museum, Ohio State Univ., Columbus.
Paris—École des Mines, Paris.
PRI—Paleontological Research Institute, Ithaca.
ROM—Royal Ontario Museum, Toronto.
SIUM—Southern Illinois Univ. Museum, Carbondale.
SUI—Dept. Geology, State Univ. Iowa, Iowa City.
Tübingen—Quenstedt Collection, Paleontological Institute, Tübingen.
UCMP—University of California, Museum of Paleontology, Berkeley.

Several specimens collected by University of Buffalo students have been donated to the USNM by Prof. E. J. Buehler. The only known colonial rugose coral from the Seneca Member of the Onondaga Formation in New York was collected by Prof. J. W. Wells, Cornell University, and later given to the USNM.

CLASSIFICATION

The classification of the described corals is new (see Oliver, 1974), although ultimately based on suggestions of many previous workers. The classification is explained, discussed, and defended in the appropriate sections that follow, but it is outlined here, in combination with a species list, for convenience.

CLASSIFICATION AND SPECIES LIST—AN OUTLINE

Family Stauriidae Milne-Edwards and Haime
- *Synaptophyllum* Simpson
  - *S. arundinaceum* (Billings)
  - *S. tabulatum* (Simpson)
  - *S. kladion* n. sp.

Family Craspedophyllidae Dybowski
- Subfamily Cylindrophyllinae Oliver
  - *Acinophyllum* McLaren
    - *A. simcoense* (Billings)
    - *A. stramineum* (Billings)
    - *A. segregatum* (Simpson)
    - *A. mclareni* Fagerstrom
    - *A. stokesi* (Milne-Edwards and Haime)
    - *A. vermetum* (Weisbord)
  - *Cylindrophyllum* Simpson
    - *C. elongatum* Simpson
    - *C. propinquum* Stewart
    - *C. laxtensum* n. sp.
    - *C. deearium* n. sp.
    - *C.* sp. A
  - *Prismatophyllum* Simpson
    - *P. prisma* Lang and Smith
    - *P. ovoideum* (Davis)
    - *P. truncata* Stewart
    - *P. anna* (Whitfield)
  - *Asterobillingsa* Oliver
    - *A. rugosa* (Hall)
    - *A. magdisa magdisa* Oliver
    - *A. magdisa steorra* Oliver
    - *A. affinis* (Billings)
- Subfamily Craspedophyllinae Dybowski
  - *Eridophyllum* Milne-Edwards and Haime
    - *E. seriale* Milne-Edwards and Haime

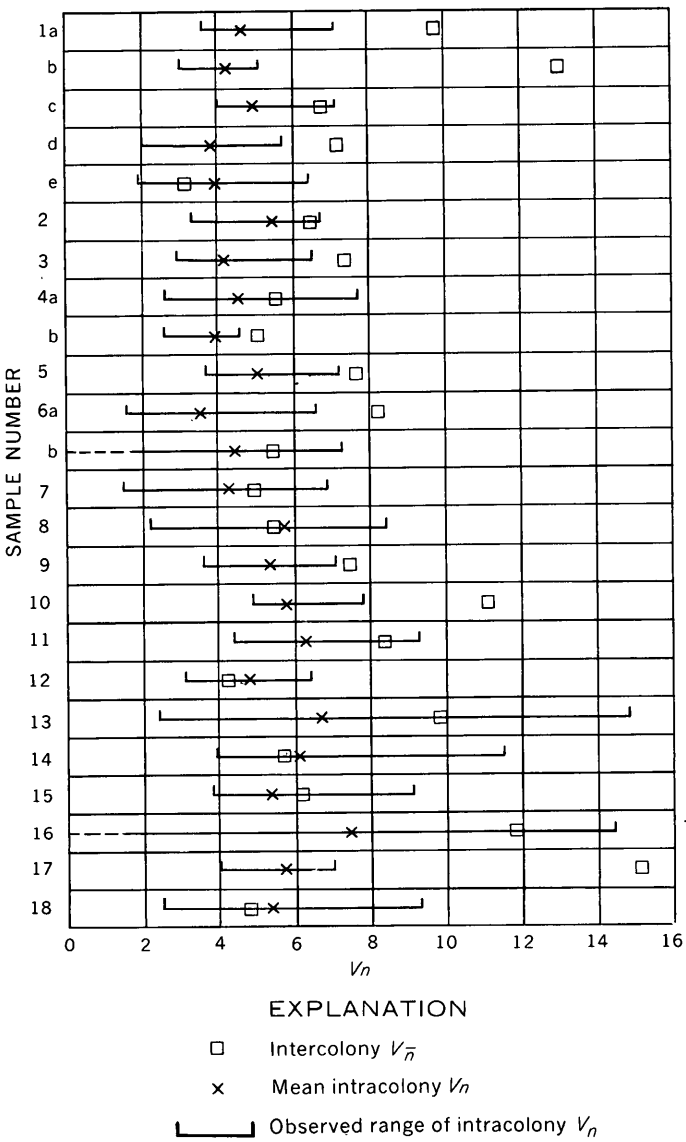


FIGURE 20.—Intercolony coefficient of septal number variation ($V_{\bar{n}}$) and observed range and mean of intracolony coefficients (V_n) in samples of colonial rugose corals. See table 15 for key to sample numbers.

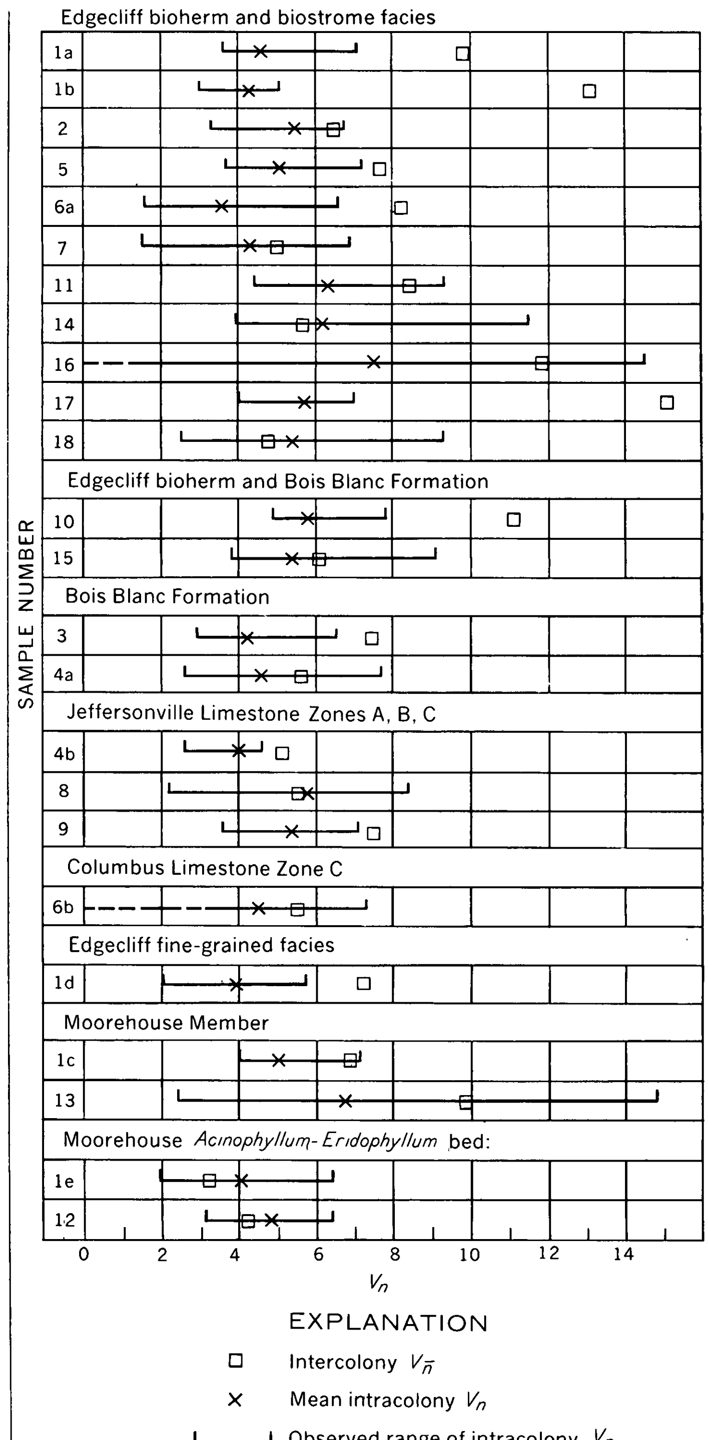


FIGURE 21.—Data of figure 20 rearranged by stratigraphic unit.

E. subseriale Stumm
E. aulodokum n. sp.
E. corniculum n. sp.
E. conjunctum (Davis)
Grewgiphyllum Oliver
G. colligatum (Billings)
?Family Disphyllidae Hill
Disphyllum Fromental
D? rectiseptatum (Rominger)
D? stummi (Oliver)
Family Zaphrentidae Milne-Edwards and Haime
Cyathocylindrium Oliver
C. gemmatum (Hall)
C. opulens Oliver
C. n. sp. A
Heliophyllum Hall
phaceloid species
H. megaproliferum n. sp.
H. n. sp. B.
H. n. sp. C.

cerioid species
H. coalitum (Rominger)
astreoid species
H. monticulum (Ehlers and Stumm)
H. cassum n. sp.
H. procellatum n. sp.

Family STAURIIDAE Milne-Edwards and Haime, 1850

Diagnosis.—"Fasciculate and cerioid coralla with slender corallites; a marginarium may develop as a narrow peripheral stereozone; a single series of elongate dissepiments, discontinuous vertically may occur between major and minor septa." (Hill, 1956b, p. F296).

Discussion.—The Stauriidae (Columnariidae of many authors) is a family of relatively simple, colonial rugose corals that is probably polyphyletic in origin. At least I doubt that the Onesquethaw genus here described is closely related to *Stauria* or that either is related to some of the other conventionally included genera.

Synaptophyllum Simpson (including *Placophyllum* Simpson) is the only "stauriid" known from the Onesquethaw Stage in Eastern North America, where its known range is Edgecliff to Moorehouse. *Depasophyllum* Grabau, Hamilton to Tully in the same area, is morphologically similar and a likely descendent of *Synaptophyllum*. *Synaptophyllum* may have been derived from the Ordovician and Silurian *Palaeophyllum* Billings. (See Oliver, 1963b, eastern North American Silurian form.)

Genus SYNAPTOPHYLLUM Simpson

part 1900 *Synaptophyllum* Simpson, p. 212–214 (type species only; others *Acinophyllum*).
1900 *Placophyllum* Simpson, p. 216.
not 1906 *Synaptophyllum* Simpson. Grabau and Shimer, p. 210 (=Acinophyllum).
not 1909 *Synaptophyllum* Simpson. Grabau and Shimer, p. 73 (=*Acinophyllum*).
1935a *Placophyllum* Simpson. Lang and Smith, p. 557–558.
not 1935a *Synaptophyllum* Simpson. Lang and Smith, p. 561–562 (=*Acinophyllum*).
not 1938 *Synaptophyllum* Simpson. Stewart, p. 42–43 (=*Acinophyllum*).
not 1939 *Synaptophyllum* Simpson. Stumm, p. 62 (=*Acinophyllum*).
1940 *Placophyllum* Simpson. Lang, Smith, and Thomas, p. 100.
part 1940 *Synaptophyllum* Simpson. Lang, Smith, and Thomas, p. 129.
not 1944 *Synaptophyllum* Simpson. Shimer and Shrock, p. 95 (=*Acinophyllum*).
not 1948 *Synaptophyllum* Simpson. Stumm, p. 43–44 (=*Phacellophyllum*?).
1949 *Placophyllum* Simpson. Stumm, p. 30.
not 1949 *Synaptophyllum* Simpson. Stumm, p. 37 (=*Phacellophyllum*?).
not 1949 *Synaptophyllum* Simpson. Schouppé, p. 124–127 (=*Phacellophyllum*?).
not 1953 *Synaptophyllum* Simpson. Rózkowska, p. 16 (=*Phacellophyllum*?).
not 1955 *Synaptophyllum* Simpson. Stumm, card 258 [part = *Acinophyllum*; part = *Phacellophyllum*?, part = *Disphyllum*?].
1956b *Placophyllum* Simpson. Hill, p. F298.
not 1956b *Synaptophyllum* Simpson. Hill, p. F280 (=*Acinophyllum*).
not 1958 *Synaptophyllum* Simpson. Cranswick and Fritz, p. 44 (=*Acinophyllum*).
not 1958 *Synaptophyllum* Simpson. Schouppé, p. 230–232 (=*Phacellophyllum*?).
1959 *Synaptophyllum* Simpson. McLaren, p. 16–18.

Type species.—By original designation, *Diphyphyllum arundinaceum*, Billings, 1859, p. 134–135. Edgecliff Member of Onondaga Limestone, Niagara Peninsula of Ontario and New York State.

Diagnosis.—Phaceloid or dendroid coralla with long, slender, cylindrical or tapering corallites connected by lateral projections of corallite walls. Septa noncarinate, thin, of two orders; the major may either be short or extend nearly to the axis, the minor are commonly short and rarely more than half as long as the major. The septa merge into a peripheral stereozone. There are no dissepiments. Tabulae complete, horizontal to arched axially. Increase peripheral. (Diagnosis modified from McLaren, 1959, p. 16.)

Microstructure.—The septa and wall appear to be primarily lamellar. Septa have dark, discontinuous center lines probably formed by monacanthine trabeculae. Discontinuous, overlapping lamellae follow the outline of the skeleton and are continuous from septa to wall. In some specimens, faint discontinuities can be observed in the wall, midway between septa, and crushed corallites show a tendency to break along these lines of apparent weakness.

The tabulae are extremely thin and no microstructure has been observed in them.

Discussion.—McLaren (1959) cleared up the confusion that has surrounded *Synaptophyllum* since its first description. Simpson (1900) named *Diphyphyllum arundinaceum* Billings as genotype but based his generic concept on *Eridophyllum simcoense* Billings. The two species are not congeneric. Lang and Smith (1935, p. 561–562) further confused the issue by illustrating a specimen of a third genus as *Synaptophyllum arundinaceum* Billings. McLaren redescribed the type material of *D. arundinaceum* and showed clearly that it is a stauriid (sensu Hill, 1956b, p. F296). He assigned *E. simcoense* to a new genus *Acinophyllum* which represents Simpson's and most American workers' concept of *Synaptophyllum* as a craspedophyllid. He reassigned Smith's material to *Phacellophyllum.* Prior to McLaren's excellent redescription of the type material of *Synaptophyllum,* all workers, using the erroneous concepts of either Simpson or Lang and Smith as their guides, had assumed the genus to have dissepiments.

Increase.—Increase is lateral in all observed examples, but separation of the offset by a skeletal tissue is effected in a relatively short growth distance, and protocorallite and offset are closely appressed through much of the offset's conical stage. This results in a very small "opening" between protocorallite and offset and in a double wall between the two that persists through most of the offset's conical stage. These features can be observed in both longitudinal (pl. 6, fig. 4) and transverse sections (pl. 7, fig. 10). Transverse sections show a complete wall (pl. 4, figs. 7, 8) at a much smaller offset diameter than is characteristic of other phaceloid species studied (cf. *Acinophyllum* spp. in pls. 14 and 22).

This description is based on several coralla of *S. arundinaceum* and *S. kladion* in which increase was observed. The single known fragment of *S. tabulatum* does not preserve any offsets.

Placophyllum Simpson has been considered unrecognizable by most workers. Until the present time, the only available specimens of the genus were two longitudinal thin sections (NYSM 300) which are the originals of Simpson's only illustration of the type species, *P. tabulatum.* To these have now been added a transverse thin section, of similar vintage and workmanship as the two type slides, which bears the same locality number as the others and which is accompanied by a label in Simpson's handwriting identifying it as "*Placophyllum tabulatum* Simpson." The transverse section may be from the type corallum and has been added to the type collection. In addition I have collected a single corallum which in every respect agrees with the types and which unquestionably belongs to *P. tabulatum.* It agrees with *S. arundinaceum* in all important respects except size and there is no longer any question that *Placophyllum* is a junior synonym of *Synaptophyllum* as suggested by McLaren (1959, p. 17).

Depasophyllum Grabau (1922, 1936, not Yu, 1934; type species *D. adnatum* Grabau, 1936, basal Tioughnioga, Michigan) is similar to *Synaptophyllum* in its general morphology, that is, short septa and strongly deflected tabulae, but differs as follows: (1) Minor septa are commonly lacking except in distal parts of large specimens (gerontic?); when present they tend to be contratingent. (2) Coralla are solitary and not known to produce offsets; "peripheral buds" of Ehlers and Stumm (1949, p. 31) are young of the species cemented to an adult. Only two species of *Depasophyllum* have been described, both from the upper Middle Devonian of eastern North America. It is possible that these are solitary descendents of the colonial *Synaptophyllum* but the differences are certainly great enough to warrant distinction as genera.

Three species of *Synaptophyllum* are known from the Onondaga Limestone. *S. arundinaceum* (Billings) and *S. tabulatum* (Simpson) are limited to the Edgecliff Member (possibly to the bioherm facies) and are distributed from eastern New York to the Niagara Peninsula of Ontario. *S. arundinaceum* is also known from the Columbus Limestone (Zone C), near Bellepoint, Ohio, and from the Perry core, Lake County, Ohio. *S. kladion* n. sp. is known only from the Moorehouse Member in western New York and southwestern Ontario. All three species are uncommon.

Synaptophyllum grabaui Fagerstrom (1961, p. 13, pl. 3, figs. 11–14), from the Formosa reef facies of the lower Detroit River Group in southwestern Ontario, is not a stauriid. It appears to be an aberrant form, possibly related to "*Tryplasma*" *rhopalium* Oliver, 1960b (=*Cyathophyllum marylandicum* Swartz, 1913).

Silurian species that were assigned to *Synaptophyllum* by Grabau (1910) and subsequent workers have been discussed by Oliver, 1963b (p. G5). These have vertically elongate dissepiments in a single row and differ from species of *Synaptophyllum* in this and other respects.

Synaptophyllum arundinaceum (Billings)

Plates 2–4; plate 7, figures 7–11

	1859	*Diphyphyllum arundinaceum* Billings, p. 134–135.
not?	1874	*D. arundinaceum* Billings. Nicholson, p. 32–33, pl. 6, fig. 1 (probably *Acinophyllum segregatum*).
not	1887	*E. arundinaceum.* Davis, pl. 112, fig. 2 (see *Acinophyllum davisi* Stumm).
not	1901	*D. arundinaceum* Billings. Lambe, p. 162–163, pl. 14, fig. 1, 1a, b (see *Acinophyllum segregatum* Simpson).
not	1923	*D. arundinaceum* Billings. Clark, p. 218 (see *Disphyllum? stummi* Oliver).
not	1935a	*Synaptophyllum arundinaceum* (Billings). Lang and Smith, (Phillipsastraeid, figs. 19, 20 p. 561, see McLaren, 1959, p. 29, for discussion).
not	1944	*S. arundinaceum* (Billings). Shimer and Shrock, p. 95, pl. 30, figs. 5–7 (see *Acinophyllum segregatum* Simpson).

not 1945 *Disphyllum* [*S.*] cf. *arundinaceum* (Billings). Smith, p. 22, pl. 12, figs. 1, 2 (Phillipsastraeid, see McLaren, 1959, p. 29).
not 1949 *Macgeea* (*Synaptophyllum*) *arundinaceum* (Billings). Schouppé, pl. 12, figs. 60, 61 (Phillipsastraeid).
not 1949 *Synaptophyllum arundinaceum* (Billings). Stumm, pl. 17, figs. 19, 20 (Phillipsastraeid, see McLaren, 1959, p. 29).
not 1955 *S. arundinaceum* (Billings). Stumm, cards 259, 260 (part=Phillipsastraeid; part unrecognizable).
not 1956b *S. arundinaceum* (Billings). Hill, fig. 191-6 (Phillipsastraeid, see McLaren, 1959, p. 29).
not 1958 *S. arundinaceum* (Billings). Schouppé, figs. 15, 16 (Phillipsastraeid, see McLaren, 1959, p. 29).
1959 *Synaptophyllum arundinaceum* (Billings). McLaren, p. 18–22, figs. 4–6; pl. 7, figs. 1–3; pl. 8, figs. 1–5.
not 1963 *Eridophyllum arundinaceum*. Kato, fig. 12–32 (probably = *Acinophyllum* sp.).

Occurrence of type material.—"Rama's farm, near Port Colborne, and in various localities in the townships of Walpole, Oneida, Cayuga, and Wainfleet, in the corniferous limestone" (Billings, 1859, p. 135). Lectotype selected by McLaren, 1959, is "from 3 miles west of Cayuga, Ontario"; syntypes are from Wainfleet township, Welland County, and Walpole township, Haldimand County, Ontario (McLaren, 1959, p. 19). All of these localities are most likely in the Edgecliff Member of the Onondaga Limestone.

Diagnosis.—Phaceloid *Synaptophyllum* with relatively small corallite diameters and tabulae that are axially flat and strongly deflected downward at the periphery.

External features.—Phaceloid colonies are composed of subparallel, straight or slightly flexuous, cylindrical corallites. The partly crushed lectotype corallum is 30.5 cm high and 28 by 5 cm wide; other parts of coralla on which this description is based range up to 19 cm high and 12 by 5 cm wide. Mature corallites range in diameter from 3.5 to 8.0 mm; within colonies size variation is more limited (table 16); the mean diameter in 10 colonies ranges from 4.5 to 6.9 mm (fig. 22).

Increase is lateral at infrequent intervals; expansion is rapid in the offsets. Corallites are supported within the colony by tapering lateral projections of the corallite wall, but these are rare in the coralla studied.

Corallites are irregularly rugose and marked by fine encircling growth striae. Longitudinal septal grooves and broad, rounded interseptal ridges are weakly to strongly developed, giving a scalloped cross-sectional outline to many corallites.

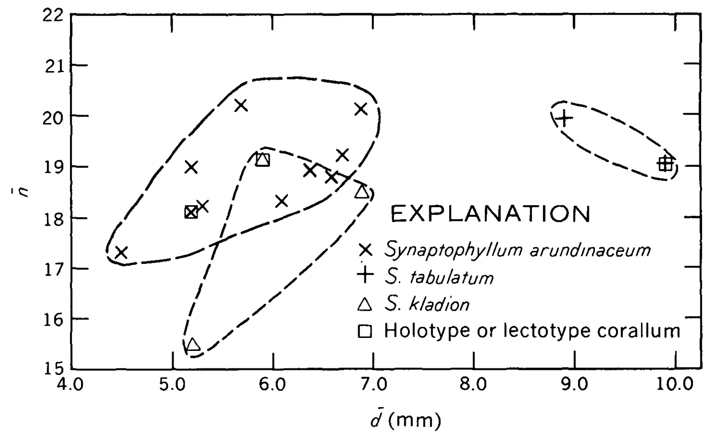


FIGURE 22.—Mean number of major septa ($\bar{n}$) versus mean diameter ($\bar{d}$) in *Synaptophyllum* spp. The polygons enclose samples of the different species.

TABLE 16.—Synaptophyllum arundinaceum *Billings, summary data*

		Intracolony			Intercolony
		Minimum	Maximum	Mean	
N		12	20	---	9
n:	$\bar{x}$	17.3	20.2	---	18.9
	OR	15–19	17–22	---	17.3–20.2
	s	.51	1.76	---	.91
	V	2.5	9.3	5.4	4.8
d:	$\bar{x}$	4.5	6.9	---	5.9
	OR	3.5– 5.9	6.2– 7.9	---	4.5– 6.9
	s	.44	.90	---	.81
	V	6.6	17.4	12.5	13.7

The coralla were structurally weak, and most specimens are broken. In some colonies the corallites have been pressed close together in one direction (pl. 3, fig. 2); in others the corallites were broken apart and scattered before fossilization. Better preserved parts of coralla indicate that the corallites were subparallel to each other and separated by a distance approximately equal to one corallite diameter.

Calices are deep and steep sided, with low septal ridges extending down the calice walls and part way over the flat bottom.

Internal features.—The septa are radially arranged. Major septa are amplexoid and commonly extend to or nearly to the axis on the surfaces of tabulae; between tabulae they range in length from one-third to three-fifths the radius and are commonly about one-half. The average number of major septa per corallite in 9 coralla ranges from 17.3 to 20.2 (fig. 22) with limited variation in any one colony (table 16). Septa are thin (average 0.15 mm peripherally) and taper toward the axis. Minor septa vary in length but average one-half the length of the major septa and are somewhat thinner. All septa are reasonably straight and lack carinae.

Peripherally, all septa dilate to form the outer wall which ranges from 0.2 to 0.5 mm in thickness. No dissepiments are present.

The tabulae are typically complete with broad, flat axial parts and sharply downbent peripheral parts. They are irregularly spaced, ranging from three to seven per 5 mm.

Microstructure.—As for genus.

Discussion.—*Synaptophyllum arundinaceum* was originally described by Billings (1859, p. 134–135), but internal features were first illustrated and examined by McLaren (1959). In the intervening 100 years, the name was used for cylindrophyllinid species now referred to *Acinophyllum* (McLaren, 1959).

S. arundinaceum differs from *S. tabulatum* (Simpson) in its smaller corallite size and in its longer septa and more highly arched tabulae. It differs from *S. kladion* n. sp. in the infrequency of its offsets and lateral connections, in its cylindrical corallites, and in the regular form of the tabulae and the lesser variation in length of major septa.

Distribution.—*S. arundinaceum* occurs in the Edgecliff Member of the Onondaga Limestone in New York and in the Niagara Peninsula of Ontario. The species is widespread in the Edgecliff bioherm facies, having been collected from nearly one-third of the known bioherms in both eastern and western New York and in the Niagara Peninsula. None of the known New York specimens are from the nonbioherm facies of the Edgecliff.

The lectotype and syntypes and four other specimens studied are from the Niagara peninsula of Ontario (McLaren, 1959). They are probably all from the Edgecliff Member, but at least two of the coralla are from nonbioherm facies.

Specimens are known from the Columbus Limestone (lower Columbus, coral zone, probably Edgecliff in age), both in the outcrop belt near Bellepoint, Ohio, and in the subsurface of Lake County, northeastern, Ohio.

Material studied.—The above description is based primarily on 10 coralla: (a) the lectotype (GSC 3602) of McLaren (1959, p. 19), (b) five coralla collected by the author (USNM 162576–78 and NYSM 12821, 22), (c) one additional corallum from the USNM (10719), and (d) three coralla from the Geological Survey of Canada (GSC 3422a, 31151–52). Counts and measurements are based on an analysis of seven lectotype corallites and 12 to 20 corallites in each of the other 9 coralla. Additional specimens providing supplemental morphologic and distribution data are: GSC 3431b–f, 3432 (paralectotypes, see McLaren, 1959, p. 19), nine specimens collected by the author (USNM 162579–86 and NYSM 3488), and GSC 22812.

The specimens from the Columbus Limestone are USNM 162587–88.

Detailed locality information for all specimens is in the locality section and tables 40 to 46.

Synaptophyllum tabulatum (Simpson)

Plate 5

1900 *Placophyllum tabulatum* Simpson, p. 216–217, fig. 41.
1935a *P. tabulatum* Simpson. Lang and Smith, fig. 16, p. 557.
1949 *P. tabulatum* Simpson. Stumm, pl. 14, fig. 8.
1956b *P. tabulatum* Simpson, Hill, fig. 203, p. 6. F299.
1959 *P. tabulatum Simpson.* McLaren, pl. 10, figs. 1, 2.
? 1961 *P.*? sp. Fagerstrom, p. 13, pl. 4, fig. 15.
? 1961 *Depasophyllum* sp. cf. *D. adnatum* Fagerstrom(p. 13, pl. 4, fig. 14.

Occurrence of type material.—According to the New York State Museum label and catalog, Simpson's type corallum was collected by C. D. Walcott in 1878 from the Onondaga Limestone at Walpole, Ontario. This is almost certainly the Edgecliff Member and may or may not be the bioherm facies.

Diagnosis.—*Synaptophyllum* with large corallite diameters; tabulae are axially flat and smoothly bent downward at the periphery.

External features.—Dendroid or possibly phaceloid coralla of unknown size and shape, the only corallum known other than the holotype, measures approximately 11 by 9 by 6 cm. Mature corallites are straight or somewhat flexuous and range in diameter from 7.4 to 10.7 mm in the specimens available for study; mean diameter of 14 corallites in one corallum is 9.3 mm, observed range is 7.4 to 10.7 mm; the diameter of the holotype corallite is approximately 9.8 mm.

Increase is presumed to be lateral at infrequent intervals, although no examples of increase have been observed in the specimens at hand. Lateral supports are apparently rare but have been observed in both the type specimens and in the supplementary corallum.

No well-preserved corallite exteriors have been directly observed, but weathered specimens and sections of corallites in the matrix indicate that encircling rugae and longitudinal septal grooves are present. Finer markings are not known. No calices have been preserved, but they may be deduced to be steep sided with virtually flat bottoms.

Internal features.—Septa are radially arranged. Major septa are amplexoid, and extend approximately two-fifths the distance to the axis on the tabulae surfaces, but are shorter above the tabulae. The number of major septa in the supplementary corallum ranges from 18 to 21 in 10 corallites and averages 19.9. Septa are thin (commonly 0.15 mm peripherally) and taper toward the axis. Minor septa are one-half as long as the major and somewhat thinner. All septa are straight and lack carinae.

Peripherally, all septa dilate to form an outer wall which ranges from 0.2 to 0.35 mm in thickness. There are no dissepiments.

Tabulae are typically complete with broad flat axial areas and gently downbent peripheries. Spacing is irregular, being two to four per 5 mm in the specimens studied.

Microstructure.—As for the genus.

Discussion.—The above description is based on three thin sections of individual corallites that compose the type lot (NYSM 300 and 1480) and on one additional corallum collected in the course of this study. The types are from southwest Ontario; the supplementary corallum is from eastern New York.

Placophyllum tabulatum was established by Simpson (1900, p. 216–217) by a generic description and illustration of a longitudinal section, a part of which is preserved as two thin sections (NYSM 300). Simpson seems to have based his description on one or more large coralla, but only the illustrated thin sections are included in the type collection.

The genus and species have been considered unrecognizable by most workers, and all descriptions have been based on Simpson. Subsequent illustrations have been copies of Simpson's illustration or new photographs of the type slides. To the type collection has now been added a transverse thin section of a corallite bearing the same locality number as the other sections and labeled *Placophyllum tabulatum* in Simpson's handwriting (NYSM 1480). This transverse section and the second corallum from eastern New York make possible a more adequate description of Simpson's species and its reassignment to the genus *Synaptophyllum.*

S. tabulatum differs from *S. arundinaceum* in its large corallite size, short thinner septa, and broader, more gently flexed tabulae. Corallite size was compared in the two species, using the method for small samples outlined by Simpson, Roe, and Lewontin (1960, p. 182–183). Two tests were made: (1) Comparing the mean corallite diameter of 10 coralla of *S. arundinaceum* with that of one corallum of *P. tabulatum* gave the values $t=3.56$, $P<0.01$. (2) Comparing the maximum diameters of the 10 coralla of *S. arundinaceum* with that of *S. tabulatum* gave the values $t=4.51$, $P<0.01$. According to both tests, the chances are less than one in a hundred that the single corallum was drawn from the same population as the 10 coralla. The tests suggest a significant difference in corallite size between *S. arundinaceum* and *S. tabulatum* and indicate that they may represent different species. This, plus the qualitative differences noted, makes it seem best to recognize both species until more adequate collections can be studied.

Placophyllum? sp. of Fagerstrom (1961, p. 13, pl. 4, fig. 15) has flat tabulae and very short septa (compare my pl. 5, fig. 4) and may be a fragment of *S. tabulatum. Depasophyllum* sp. cf. *D. adnatum* of Fagerstrom (1961, p. 13, pl. 4, fig. 14) has downturned tabulae and amplexoid septa and is very similar to typical *S. tabulatum.* Both forms are represented by cylindrical fragments and cannot be certainly identified. They were derived from the Formosa reef facies of the lower Detroit River Group and are probably Edgecliff in age.

Distribution.—*S. tabulatum* is known from only two localities. The type thin sections are labeled Walpole, Ontario. They are probably from the Edgecliff Member but might be from either the bioherm or biostrome facies. The supplementary corallum is from the bioherm facies of the Edgecliff Member in the Helderberg escarpment, southwest of Albany, N.Y. The two localities are more than 300 miles (480 km) apart and represent almost the western and eastern extremities of the exposed Edgecliff Member. Apparently the species was widespread but very rare.

The questionable specimens of Fagerstrom (see discussion) are from the Formosa reef limestone of probable Edgecliff age in central southwestern Ontario.

Material.—Holotype, NYSM 300 (two longitudinal thin sections); syntype NYSM 12875 (one transverse thin section); supplementary corallum, USNM 162607. *Placophyllum* sp. Fagerstrom, hypotype UMMP 36125A, B (two thin sections); *Depasophyllum* sp. cf. *D. adnatum* of Fagerstrom, hypotype UMMP 36121 (one fragment).

Synaptophyllum kladion n. sp.

Plate 6; plate 7, figures 1–6

Occurrence of type material.—Holotype, GSC 31153, Moorehouse Member, Onondaga Limestone, 5 miles (8 km) south-southeast of Cayuga, Ontario. Paratypes are from the Moorehouse Member near Leroy, Wilhelm, and Bellevue in western New York.

A single specimen is known from the upper part of the Edgecliff Member near Port Colborne, Ontario.

Diagnosis.—Dendroid *Synaptophyllum* with numerous offsets and lateral connections; tabulae are domed or irregular, septa are quite long in some corallites.

External features.—Colonies are dendroid, composed of radiating, flexuous, ceratoid corallites. The largest available corallum occupies a block of limestone 19 by 17 by 8 cm; the colony is broken, however, and the original was larger.

Individual corallites tend to expand gradually and assume a ceratoid or subcylindrical form. Mean diameters, based on 12 to 15 individuals in 3 colonies, are shown in figure 22, but their significance may be questioned. The measurements are from random thin sections and do not represent maximum diameters of individual corallites. In the following table the maximum measured diameter may be of somewhat greater value in comparing *S. kladion* with other species of the genus.

Colony	$d(mm)$	$OR_d(mm)$	n	OR_n	N
USNM 162589 ----	5.2	4.1–5.9	15.5	14–17	13
GSC 31153 --------	5.9	5.1–6.9	19.1	18–20	15
USNM 162590 ----	6.9	5.4–8.4	18.5	17–20	12

Increase is lateral and offsets are common; expansion is gradual in the corallites. Corallites are supported within the colony by tapering lateral projections of the corallite wall; these are common in parts of the coralla studied; as many as six lateral supports in 3 cm have been observed (pl. 6, figs. 9, 10).

Corallites are irregularly rugose and marked by fine encircling growth striae. Longitudinal septal grooves and broad, rounded interseptal ridges are weakly developed, giving a scalloped cross-sectional outline to corallites in transverse thin sections.

The coralla were apparently not very strong. Parts of each of eight coralla studied are preserved with corallites in their original relative positions but all are partly broken or crushed. Additional specimens in the collection consist of a few to several disoriented and broken corallites.

Calices are deep and steep sided; low septal ridges extend down the sides and part way across the floors. Calycinal rejuvenescence was noted in two colonies.

Internal features.—The septa are radially arranged. Major septa are amplexoid and range in length from one-third to two-thirds the radius; the length tends to be relatively less in larger sections and longer septa may represent immature parts of corallites. The average number of major septa in three coralla ranges from 15.5 to 19.1 with limited variation in any one colony (table above). Apparently the full quota of septa was obtained by most corallites well before they achieved maximum diameter. Septa are thin and taper toward the axis. Minor septa are one-half or less as long as the major. All septa are straight and lack carinae.

Peripherally all septa dilate to form the outer wall which ranges from 0.15 to 0.4 mm in thickness. No dissepiments are present.

The tabulae are commonly irregular in form. In longitudinal section they vary from flat to irregularly undulating to dome shaped having downbent peripheries as in the other species described. They are irregularly spaced, ranging from three to six per 5 mm in the specimens sectioned.

Microstructure.—As for genus.

Discussion.—The above description is based on eight coralla, seven collected by myself from known positions in the Moorehouse Member and one from the upper part of the Edgecliff Member.

S. kladion differs from both *S. arundinaceum* and *S. tabulatum* in its dendroid habit, ceratoid corallites, and irregular tabulae; in the last two species, growth form is phacelloid, corallites are cylindrical, and tabulae are regularly arched.

Distribution.—*S. kladion* is most common in the Moorehouse Member. The eight known specimens are distributed as follows: six specimens are from the western coral facies of the Moorehouse Member near Leroy, Wilhelm, and Bellevue, N.Y.; one specimen is from the middle Moorehouse at Dunnville, Ontario. The eighth specimen is from the Edgecliff Member (biostrome facies) at Port Colborne, Ontario. One more specimen, possibly referable to this species, was collected by A. Murray in 1860 from "near Woodstrock" (GSC 2599).

Material.—Holotype, GSC 31153; illustrated paratypes USNM 162589, 90, 92, 93; unillustrated paratypes USNM 162591 and 162594, NYSM 12823, and GSC 31154.

Family CRASPEDOPHYLLIDAE Dybowski, 1873

Diagnosis.—Solitary(?), phaceloid, cerioid, phaceloid-cerioid, astreoid, and thamnasterioid rugose corals with long or short, very attenuate major septa marked by zigzag carinae. The septa characteristically are composed of very find monocanthine trabeculae and appear in most sections to have a dark axial zone with light tissue on either side. The major septa are deflected to form an aulos in the Craspedophyllinae, but this structure is lacking in the Cylindrophyllinae. The dissepimentarium is formed by one to several rows of globose normal dissepiments. Tabulae are variable but commonly flat or slightly arched axially and downbent at the margin of the tabularium.

Included subfamilies.—Cylindrophyllinae new and Craspedophyllinae.

Discussion.—The Craspedophyllidae as here recognized includes *Eridophyllum* (=*Craspedophyllum*), and related forms in the nominate subfamily, and a group of genera previously generally classified as Disphyllidae, here assigned to the new Subfamily Cylindrophyllinae. The Cylindrophyllinae are essentially the Billingsastraeinae of Jell (1969, p. 63), but this name is not available as the genus *Billingsastraea* proves to be a Silurian coral unrelated to the forms on which our concept of *Billingsastraea* has been based. (See generic discussion.)

The cylindrophyllinids differ from the disphyllids (s.s.) (essentially the Disphyllinae of Jell) in having strongly attenuate septa formed of fine monocanths with well developed zigzag carinae. In contrast the disphyllids have thicker septa formed of coarse monacanths and generally lack such marked carinae. These characters are variable within genera and species, but it seems very significant that the cylindrophyllinid structure overwhelmingly predominates in eastern North American species and genera, whereas the disphyllid structure predominates in other areas of the world.

There are analagous genera in the two family units as outlined here:

Eastern Americas Realm	*Old World Realm*
Acinophyllum *Cylindrophyllum*	*Disphyllum*
Prismatophyllum	*Hexagonaria*

In general these generic "pairs" differ only in the characters mentioned above. The EAR *Asterobillingsa* (=*Billingsastraea* of authors) has no named Old World counterpart in the Disphyllidae.

Eridophyllum and its allies (Craspedophyllinae) differ from the Cylindrophyllinae only in the possession of an aulos and are also a distinctly ENA development. It seems likely that the Craspedophyllinae were derived from the Cylindrophyllinae in middle Onesquethaw time, as discussed below. The apparent close relationship of the two groups can best be noted by inclusion of them as subfamilies with the Craspedophyllidae.

The degree of relationship between the Craspedophyllidae and the Disphyllidae is more difficult to analyze. Probably too little is known of the early history of either family to offer a meaningful basis for an opinion as to whether they are more closely related to each other than to other families. On the basis of my analysis of the development and history of the Eastern Americas biogeographic realm, and of the morphologic similarities and dissimilarities, I suggest that the Craspedophyllidae evolved independently in the EAR at least from Siegenian time. I know of no pre-Siegenian North American rugose coral that is at all likely as an ancestor to the family. I doubt that either family is very closely related to the Phillipsastraeidae, although both have been so grouped by many workers in the past.

No true disphyllids are known from EAR rocks older than the Cazenovia Stage. Forms indistinguishable from *Hexagonaria* are known from the Miami Bend Formation of Cooper and Phelan (1966) (Cazenovian age in Indiana) and, with *Disphyllum*, from the Traverse Group (Tioughnioga age, Michigan). These probably represent invasions from the north or northwest, as they are accompanied by other Old World genera of rugose corals although apparently not by other disphyllids. The only possible Old World coral known to occur east of the Nashville-Cincinnati-Findlay-Algonquin axis is *Disphyllum? stummi.*

Distribution.—Craspedophyllids range in age from early Onesquethaw to Taghanic in the Eastern North American province. Early and Middle Devonian extensions of this provincal fauna into northern South America and northwest Africa are discussed above and under the appropriate generic heading.

Family name.—*Craspedophyllum* Dybowski (1873a, p. 83; type species by monotypy, *C. americanum* Dybowski, 1837b, p. 155–159, pl. 6, figs. 1–6) has commonly been considered a junior synonym of *Eridophyllum* although no one has redescribed the type species or compared it with other described species of *Eridophyllum*. The location of the type material is not known. Under the circumstances, any interpretation of *Craspedophyllum* must be based on (1) Dybowski's description and illustrations and (2) his statement that his specimens came from Columbus, Ohio.

Dybowski's description and illustrations are ambiguous although he clearly describes and illustrates the aulos. His figure 1 is suggestive of *Grewgiphyllum colligatum* in the presence of "growth swellings" that appear to extend in all directions from the corallite, but he does not show any contacts with other corallites or a cerioid stage. Dybowski's figures 2 and 5 are longitudinal and transverse sections of an *Eridophyllum*, possibly *E. seriale* Milne-Edwards and Haime. His figures 3, 4, and 6 are details and could represent most species of either genus. All of the figures are drawings and may be somewhat diagrammatic.

Dybowski makes much of the growth swellings but does not clearly describe the manner in which adjacent corallites make contact. He does describe the aulos clearly enough for identification of his specimens as *Eridophyllum*. Possibly he had specimens of two or more species so that his description is a composite.

Dybowski's only stratigraphic or geographic information is "Columbus, Ohio." This suggests the Columbus Limestone in which *Eridophyllum* (several species) is common and *Grewgiphyllum* is rare or does not occur. (See discussion under *G. colligatum.*)

The combined data indicate that *Craspedophyllum americanum* is a Columbus Limestone *Eridophyllum*, most likely *E. seriale.*

Microstructure.—The craspedophyllid wall is thin, thicker in the region of the lateral supports. Microscopically, it appears to be composed of an inner light-colored zone of minute fibers of calcite radially oriented in transverse section and an outer very thin dark zone of uncertain structure. In longitudinal section the fibers are seen to incline upward toward the axis at approximately the same angle as the top surface of each dissepiment so that in some places the dissepiments seem to be structurally continuous with the epitheca. More generally the dissepiments, although structurally similar are separated from the epitheca by a discontinuity. The tabulae are commonly very thin and their microstructure is obscure.

Septa are composed of parallel, fine, closely-spaced monacanthine trabeculae. Where the septal microstructure is well preserved it appears as follows. A dark central area, approximately 0.03 mm thick, indents the epitheca and extends the full length of the septum. This is apparently composed of closely spaced "centers of calcification." On either side of the dark central zone is a light-colored zone composed of minute fibers directed away from the central zone and inclined slightly toward the axis of the corallite, giving a pinnate appearance in transverse section. Septa are separated from the wall by a dark line but the light-colored zone is identical to the inner wall in texture. Septa are thickest at their peripheral ends; the light-colored tissue thins toward the inner part of the tabularium. Carinae form ridges on the sides of the septa and show the same structure as the septa in transverse section.

Subfamily CYLINDROPHYLLINAE Oliver, 1974

1969 Billingsastraeinae Jell, p. 63.
1974 Cylindrophyllinae Oliver, p. 167.

Type genus.—*Cylindrophyllum* Simpson.

Diagnosis.—Craspedophyllids that lack an aulos.

Included genera.—*Cylindrophyllum* Simpson, *Prismatophyllum* Simpson, *Acinophyllum* McLaren, *Asterobillingsa* Oliver (=*Billingsastraea* of most authors).

Discussion.—Possible relationships of the cylindrophyllinids to the disphyllids and a comparison of the two family-level taxa are included in the family discussion.

The cylindrophyllinid genus *Prismatophyllum* probably gave rise to the Craspedophyllinae. This idea is developed more fully in the discussion of that subfamily.

The earliest known cylindrophyllinid is *Asterobillingsa affinis* (Billings), from the Grande Grève Limestone, Gaspé, Quebec (Oliver, 1964), known from a single specimen. Except for this isolated occurrence, all four genera appeared at virtually the same time in the middle Onesquethaw. Similarities suggestive of intergeneric relationships are discussed under the appropriate species headings but none are particularly helpful in understanding evolution within the subfamily. A pre-middle Onesquethaw record is implied. Because *Asterobillingsa* seems unlikely to be the primitive member of the group, a history at least as ancient as Siegenian or Gedinnian seems probable.

Subfamily distribution.—Early Onesquethaw-Tioughnioga, Eastern North America; middle or upper Onesquethaw, Venezuela. No Taghanic or Frasnian forms are known. (See summaries of distribution under generic descriptions.)

Genus ACINOPHYLLUM McLaren

part 1900 *Synaptophyllum* Simpson, p. 212–214.
1906 *Synaptophyllum* Simpson. Grabau and Shimer, p. 210.
1909 *Synaptophyllum* Simpson. Grabau and Shimer, p. 73.
1935a *Synaptophyllum* Simpson. Lang and Smith, p. 561–562.
1938 *Synaptophyllum* Simpson. Stewart, p. 42–43.
1944 *Synaptophyllum* Simpson. Shimer and Shrock, p. 95.
part 1955 *Synaptophyllum* Simpson. Stumm, card 258.
1956b *Synaptophyllum* Simpson. Hill, p. F280 (not the illustrations).
1958 *Synaptophyllum* Simpson. Cranswick and Fritz, p. 44.
1959 *Acinophyllum* McLaren, p. 22–23.
1967 *Cylindrophyllum* (*Acinophyllum*) McLaren, Pickett, p. 22.
1974 *Acinophyllum* McLaren. Oliver, p. 167.

Type species.—By original designation, *Eridophyllum simcoense* Billings, 1859, p. 132, text fig. 27.

"Rama's Farm [in Port Colborne] and near the town of Simcoe." Southwestern Ontario; Bois Blanc Formation.

Diagnosis.—Compound cylindrophyllinid corals with dendroid or phaceloid coralla made up of slender corallites often connected by lateral projections of corallite walls. Increase is lateral and nonparricidal. Major and minor septa with weak to strong, commonly zigzag carinae in peripheral zone. Major septa short or long but do not extend to axis; radially arranged with no significant modification of protosepta in mature parts. Dissepimentarium consists of one row of globose, normal dissepiments; one or two additional rows of smaller dissepiments may be present. Tabularium wide; tabulae complete, commonly flat or concave axially, strongly downbent peripherally.

External features.—Phaceloid and dendroid colonies small to large, lenticular, as much as 100 cm or more in diameter and 30 cm in height, composed of radiating or subparallel corallites. Mature corallites are cylindrical, straight to slightly flexuous with diameters as much as 1 cm in some species.

Increase is lateral and nonparricidal at varying intervals; expansion is rapid in new corallites, and the initial conical stage is short.

Corallites are supported within the colonies of most species by tapering lateral projections of the wall; a single support may be formed by one or both of the adjacent individuals but the deposit of each is discrete and cemented to the wall or projection of the adjoined coral.

Growth lines are fine and(or) coarse and individuals in some species are quite rugose. Longitudinal septal grooves are shallow and separated by broad interseptal ridges giving a scalloped appearance in transverse section.

Calices are relatively deep (½ to 1½ times the diameter) with vertical sides and flat bottom.

Internal features.—Septa are radially arranged; major septa long or short, minor septa short. Zigzag carinae are present on peripheral parts of septa, commonly strongly developed as flanges. On the sides of the septa and in properly located longitudinal sections, these appear as low ridges directed inward and upward from the periphery and more steeply inclined at the periphery.

The dissepimentarium is formed of a single peripheral layer of normal, globose dissepiments, commonly augmented by additional discontinuous layers of smaller dissepiments. Transverse sections give the impression of an inner wall at the inner boundary of the principal layer of dissepiments. Longitudinal sections show a peripheral row, in some forms with one or even two inner rows of smaller dissepiments that are commonly discontinuous. The inner edge of each dissepiment rests on the next lower dissepiment; the outer edge rests on the corallite wall or an adjacent dissepiment; there are no horseshoe or sigmoidal dissepiments. Additional dissepiments fill the lateral supports.

Tabulae are thin, usually complete, commonly convex but shape varies widely in some species (fig. 23).

Increase.—Increase is lateral in all known species. Offsets project away from the protocorallite at a high angle and turn upward and expand to mature diameter in 1 cm or less. Protocorallite diameter is not affected by the offset. The lateral offsetting stages are similar in the various species except for minor details. Illustrations of offsetting stages are shown on plates 14, 15, 20, 22, and others.

Microstructure.—As for family.

Discussion.—*Acinophyllum* was described by McLaren (1959) to include species previously assigned to *Synaptophyllum* Simpson (1900).

McLaren cleared up many misconceptions regarding the genus *Synaptophyllum.* He redescribed some of the original material of *Diphyphyllum arundinaceum* Billings (type species of *Synaptophyllum* by original designation), and thereby established *Synaptophyllum* as a stauriid (sensu Hill, 1956b) rather than a disphyllid. Simpson's description of *Synaptophyllum* was based on "*Eridophyllum simcoense* (Billings)" (actually specimens of *Acinophyllum segregatum*) with normal dissepiments, which he listed as an example of his new genus. Many subsequent workers accepted Simpson's concept of the genus (based on *A. segregatum*), and no valid revision was made before McLaren's work.

The issue was further confused, however, by Lang and Smith (1935a, p. 561–562) who illustrated a specimen with horseshoe dissepiments as *Synaptophyllum arundinaceum.* Although Lang and Smith

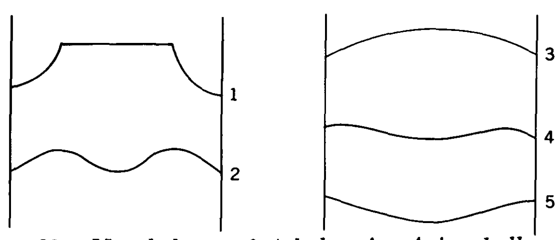


FIGURE 23.—Morphology of tabulae in *Acinophyllum* spp. Diagrammatic representation of five types described in text.

did not indicate the source of their specimen, McLaren (1959, p. 29) showed that it probably was from Upper Devonian coral collections from the Mackenzie River Valley (Canada), later described by Smith (1945). McLaren (1959, p. 29) redescribed the Smith species as *Phacellophyllum fenese.*

The *Synaptophyllum* concepts of most workers since 1935 have been colored by Lang and Smith's work. Stumm (1939, p. 62–63) followed Simpson's concept of normal dissepiments, but in later work (Stumm 1948b, p. 43–44; 1949, p. 37; and 1955, cards 258-275) followed Lang and Smith's concept of horseshoe dissepiments in his generic diagnoses but included species with normal dissepiments in the genus. Różkowska (1953, p. 16), and Schouppé (1949, p. 124–127, and 1958, p. 230–232) followed Lang and Smith. Hill (1956b) in the "Treatise on Invertebrate Paleontology," followed Simpson's concept but used Lang and Smith's illustrations.

McLaren's (1959) concept of *Synaptophyllum* (no dissepiments) based on part of Billing's type material is the only one that can be accepted. He reviewed most North American species of *"Synaptophyllum"* and assigned them as follows: (1) Those fitting Simpson's original (but erroneous) concept were assigned to a new genus, *Acinophyllum.* (2) Those fitting the Lang and Smith concept were studied in less detail, but were considered to be assignable to *Phacellophyllum.* (3) Only the type species was assigned to *Synaptophyllum.*

Planetophyllum Crickmay (1960) is similar to *Acinophyllum* in having a single basic row of dissepiments. The dissepiments, however, are elongate rather than globose. In addition, *Planetophyllum* has very short noncarinate septa and irregular commonly incomplete tabulae. The genus may be a disphyllid or unrelated to both the Disphyllidae and Craspedophyllidae.

Acinophyllum differs from *Cylindrophyllum* Simpson and from *Disphyllum* deFromental and other disphyllids in its very narrow dissepimentarium, basically one dissepiment thick. *Disphyllum* and *Cylindrophyllum* have wide irregular dissepimentaria composed of many rows of dissepiments and with an irregular inner margin. *Acinophyllum* differs from phaceloid phillipsastraeids such as *Peneckiella* Soshkina, *Thamnophyllum* Penecke, and *Phacellophyllum* Gürich in lacking horseshoe or sigmoidal dissepiments and in many other characters.

Acinophyllum *is not* Peneckiella.—McLaren (1959, p. 22–23) suggested that *Acinophyllum* might be a junior synonym of *Peneckiella* Soshkina. The type species of the latter, *Diphyphyllum minus* Roemer (1855), has been variously described as having normal or horseshoe dissepiments. Roemer's original illustrations (1855, pl. 6, fig. 12a–c) are rather crude sketches that suggest the presence of a single row of normal, peripheral dissepiments such as in *Acinophyllum.* However, Flügel (1956) redescribed Roemer's types and indicated the presence of a single row of horseshoe dissepiments. Lang and Smith (1935a, p. 576–577, pl. 35, fig. 3), Schouppé (1958, p. 186–204, 229–230, fig. 12–14), and Pickett (1967, fig. 14) studied topotype specimens and similarly concluded that the species possessed horseshoe dissepiments. Strusz (1965, p. 554–556) summarized recent descriptions and described and illustrated various modifications of dissepiments in *Peneckiella* and its allies. He considered horseshoe and peneckielloid dissepiments to be characteristic. Scrutton (1968, p. 271–273) redescribed the genus on the basis of the holotype of *P. minus* and noted that "no true horseshoe dissepiments can be positively identified in the holotype, although they do occur in a subsidiary role in the dissepimentaria of some topotype specimens" (p. 272). Scrutton considered *Acinophyllum* a junior synonym of *Peneckiella* because of the "peneckielloid" dissepiments of the former and other general similarities (p. 272–273).

I consider *Acinophyllum* to be distinct from *Peneckiella* in the nature of its dissepiments as well as in other characters mentioned in the family discussion. Examination of hundreds of longitudinal sections of several species of *Acinophyllum* has produced no suggestion of peneckielloid, sigmoidal, or horseshoe dissepiments. (See Strusz, 1965, fig. 15, for illustrations of these types.) *Acinophyllum* dissepiments are invariably globose normal dissepiments, both in the characteristic peripheral row and in inner, supplemental rows. My examination of *Peneckiella* material is more limited but I have seen the *P. minor* topotypes described by Schouppé (1958) and Pickett (1967) mentioned above and have excellent photographs of the holotype thin sections kindly provided by Dr. Scrutton. In addition I have examined the sections of *Peneckiella minor kunthi* and of *Sudetia lateseptata* of Różkowska (1960), both considered *Peneckiella* by Scrutton (1968, p. 273). In this material, horseshoe dissepiments are of common occurrence and nonhorseshoe dissepiments tend to be peneckielloid or sigmoidal. I consider it clear that *Peneckiella* is a phillipsastraeid, whereas *Acinophyllum* is not. Additional family-level characters that separate the two genera are the microstructure and the presence of abundant septal carinae in *Acinophyllum*. (See family discussion.) I have emphasized the dissepiments here because most *Peneckiella* discussions have recognized the paramount importance of this character in these forms.

Acinophyllum seems to be restricted to North America and northern South America although the detailed morphology of all Old World corals referred to *Peneckiella* is not clear. Soshkina described some *Peneckiella* as having normal dissepiments (for example, *P. jevlanensis* Bulvanker of Soshkina 1952, p. 103, 1954, p. 35; *P. nalivkini* Soshkina 1939, p. 25, 51, 1952, p. 103; and *P. minima* of Soshkina 1951, p. 106, 1952, p. 104), but her illustrations are not clear, and it seems likely that these are forms with peneckielloid rather than *Acinophyllum*-type dissepiments.

Onesquethaw species.—Five species of *Acinophyllum* are recognized in the Bois Blanc, Onondaga, and equivalents in New York, Ontario, and adjacent areas. One species of this age is known from Venezuela. These are listed here and described in following sections.

A. simcoense (Billings), type species, Bois Blanc Formation, Ontario, New York, and northern Ohio.

A. stramineum (Billings), Edgecliff Member (bioherm facies), Onondaga Limestone, Ontario, and New York; Mountain House Wharf Limestone(?), Lake Memphremagog, Quebec.

A. segregatum (Simpson), Edgecliff, Nedrow, and Moorehouse Members, Onondaga Limestone, New York and Ontario, and Columbus Limestone, Ohio. This is the common Onondaga species, and the one on which most descriptions of the genus and of *A. simcoense* have been based.

A. mclareni Fagerstrom, Detroit River Group and Moorehouse Member, Onondaga Limestone, Ontario; Columbus Limestone, Ohio; the lower part (Onondaga age) of the Boyle Limestone (locally) in Kentucky; and the upper coral zone (Onondaga age) in the Jeffersonville Limestone, Falls of the Ohio, Kentucky.

A. stokesi (Milne-Edwards and Haime), Schoharie Formation, New York; Bois Blanc Formation, Ontario, Michigan, and northern Ohio; lower coral zone (Schoharie age) of the Jeffersonville Limestone, Falls of the Ohio, Kentucky; upper part (Schoharie age) of the Wildcat Valley Sandstone, Virginia; and the upper Abitibi River Limestone, Hudson Bay Lowlands, Ontario.

A. vermetum Weisbord, upper? Onesquethaw age, northwestern Venezuela.

Other North American "species".—No other species of *Acinophyllum* are known, although superficially similar forms of Givetian and Frasnian age have been commonly assigned to the genus. (See McLaren, 1959, p. 27–28 for summary.) The following notes are based on an examination of the type suites of specimens and additional specimens as noted.

A. crassiseptatum (Ehlers and Stumm), from the Potter Farm Formation (Middle Devonian) in Michigan, has thick septa of coarse monacanthine trabeculae, and two or three rows of equal dissepiments, and is a true *Disphyllum*.

A.? rectiseptatua (Rominger), from the Dundee Limestone (Cazenovia Stage) in Michigan, has a narrow *Acinophyllum*-like dissepimentarium but the septa are relatively thick and are apparently composed of coarse monacanthine trabeculae; it may be a true *Disphyllum* and if so is one of the earliest known in eastern North America. It is described below because of its pertinence to the question of the relationship between the cylindrophyllinids and disphyllids and to the time of entry of the disphyllids into eastern North America.

A. fasciculum (Meek), Frasnian, Devils Gate Limestone in Nevada, has peneckielloid and near-horseshoe dissepiments. This and other characters suggest that the species is a phillipsastraeid. It is certainly not *Acinophyllum*.

A. occidens (Stumm), Frasnian, Martin Limestone in Arizona, is indeterminate. The holotype consists now of only the two thin sections illustrated by Stumm. The original was crudely silicified, and the morphology of the dissepimentarium is totally obscured.

A. camselli (Smith), Frasnian, Northwest Territories, Canada, has disphyllid septal structure and is a *Disphyllum*.

A. sp. D. McLaren, Frasnian, District of Mackenzie, Canada, is another *Disphyllum* with narrow dissepimentarium and closely appressed corallites.

Other Frasnian "*Synaptophyllum*" (that is, *Acinophyllum*) of Smith, 1945, were reassigned to *Phacellophyllum* by McLaren (1959, p. 28–30).

Grabau (1910), Williams (1919), and Northrup (1939) assigned the Silurian *Syringopora multicaule* Hall to *Synaptophyllum* (*Acinophyllum* of this paper) in the belief that Hall's species had a single, peripheral row of normal dissepiments. Reexamination of Hall's material indicates that no dissepiments of any kind are present and that *S. multicaule* is a species of *Palaeophyllum* (Oliver, 1963b, p. G5). *Columnaria*? *coralliferum* (Hall), from Upper Silurian rocks in New York and Quebec (Oliver, 1963c, p. 14), is superficially similar to *Acinophyllum* and does have a single row of peripheral dissepiments.

The dissepiments in *C.? coralliferum* are vertically elongate; in this and in other structures the species is quite unlike any cylindrophyllinid. It is likely that some of the material assigned to *S. multicaule* is congeneric or even conspecific with *C.? coralliferum.*

Distribution.—Known *Acinophyllum* species are restricted to rocks of Onesquethaw age in eastern North America and Venezuela. They are not known from western North America or other Old World areas. Other corals assigned to *Acinophyllum* (or "*Synaptophyllum*" in pre-1959 literature) are rejected as being misassigned or indeterminate.

Acinophyllum simcoense (Billings)

Plates 8–10; plate 11, figures 1, 2

1859 *Eridophyllum simcoense* Billings, p. 132, fig. 27.
1863 *E. simcoense* Billings. Billings, fig. 369 (p. 366).
1874 *E. simcoense* Billings. Nicholson, p. 34–35, pl. 6, fig. 5.
not 1875 *E. simcoense* Billings. Nicholson, p. 228. (Silurian specimen, probably an *Entelophyllum*)
not 1876 *Diphyphyllum simcoense* (Billings). Rominger (see *A. segregatum*).
not 1879 *E. simcoense* Billings. Quenstedt, p. 511, pl. 161, fig. 8 (see *A. segregatum*)
?not 1883b *E. simcoense* Billings. Hall (see *A. segregatum*).
not 1887 *E. simcoense* Billings. Davis, pl. 112, fig. 1 (=*Disphyllum synaptophylloides* Stumm, 1965, by objective synonymy).
not 1889 *D. simcoense* (Billings). Sherzer (see *A. mclareni*).
1899 *D. simcoense* (Billings). Lambe, p. 242–243.
not 1900 *Synaptophyllum simcoense* (Billings). Simpson (see *A. segregatum*).
1900 *S. baculoideum* Simpson. fig. 35–36 (p. 213).
1901 *D. simcoense* Billings. Lambe, p. 161–162, pl. 13, fig. 6, a–b.
not 1938 *S. simcoense* (Billings). Stewart (see *A. mclareni*).
not 1944 *S. simcoense* (Billings). Shimer and Shrock (see *A. segregatum*).
not 1949 *S. simcoense* (Billings). Stumm, pl. 17, fig. 18 (=*Disphyllum synaptophylloides* Stumm, 1965, by objective synonymy).
1955 *S. baculoideum* (Billings). Stumm, card 261.
part 1955 *S. simcoense* (Billings). Stumm, card 271–272 (figs. after Nicholson, 1874, only).
?not 1958 *S. simcoense* (Billings). Cranswick and Fritz (see *A. stokesi*).
1959 *Acinophyllum simcoense* (Billings). McLaren, p. 24–25, pl. 8, fig. 6, pl. 9, fig. 1–2, fig. 7.
1959 *A. baculoideum* (Simpson). McLaren, p. 27, pl. 10, fig. 3–4.
not 1967 *Cylindrophyllum* (*Acinophyllum*) *simcoense* (Billings). Pickett, p. 56–57, fig. 15 (note correction, Pickett, p. 56; see *A. segregatum*).

Occurrence of type material.—"Rama's Farm; and near the town of Simcoe." (Billings, 1859, p. 132), southwest Ontario. "Rama's Farm" was in what is now Port Colborne and was the source of a large number of "Onondaga" corals now known to be from the Bois Blanc Formation, although both the Bois Blanc and the Onondaga crop out in the immediate area. "The town of Simcoe" is certainly an Onondaga locality. Because Billings' illustration is clearly of the Bois Blanc species, the illustrated specimen is presumed to be from the Rama's Farm locality. Early Devonian (Emsian).

The present whereabouts of the illustrated specimen and Billings' other syntypes is unknown, although they may be in the collections of the Geological Survey of Canada. McLaren's (1959) redescription is based on part of Lambe's (1901) material from near Woodstock, Ontario, but I agree that this material is conspecific with the specimen illustrated by Billings. To stabilize the species and thereby the genus, I here select as lectotype the specimen illustrated by Billings, thus affixing the name to the Bois Blanc species. As the lectotype is unavailable and probably lost I select as neotype a specimen (USGS loc. 5052–SD) from the Bois Blanc Formation at Innerkip, Ontario; it is now deposited in the collections of the Geological Survey of Canada and numbered GSC 31144 (pl. 8, figs. 1–4).

Diagnosis.—Phaceloid *Acinophyllum* with abundant lateral supports and with short major septa extending less than half the distance to the axis.

External features.—Phaceloid colonies as much as 41 by 43 by 10 cm or more in height, length, and width. Mature corallites cylindrical, more or less straight; they range in diameter from 4 to 10 mm in the collection at hand; mean diameter in 15 colonies ranges from 4.7 to 8.0 mm (table 17 and fig. 24).

Increase is lateral at infrequent intervals. Corallites are supported within the colony by lateral projections that are numerous and on all sides of the corallites; the frequent projections (pl. 11, fig. 1) give a very rugose appearance to the specimens in longitudinal sections and triangular and quadrangular shapes in transverse sections. Broad, rounded, interseptal ridges with V-shaped septal grooves are characteristic.

Spacing of corallites within the colony ranges from less than one to nearly two diameters.

Calice deep and steep sided.

Internal features.—Septa radially arranged. Major septa less than one-half the radius in virtually all individuals. Average numbers of major septa per corallite in 15 colonies ranges from 21 to 28 table 17 and fig. 24). Minor septa alternate with the major and are nearly as long. Zigzag carinae are strongly developed on the outer parts of all septa.

The dissepimentarium is composed of one or two rows of globose, normal dissepiments; the inner row where present consists of smaller dissepiments than the outer row. The lateral supports are filled with large dissepiments and extensions of the septa. The tabularium is occupied by thin tabulae which are usually complete, variable in shape, and commonly convex.

Discussion.—The above description is based on a collection of 23 coralla from the Bois Blanc Formation at Innerkip, Hagarsville, and Port Colborne, Ontario, and three coralla from Leroy, N.Y., that are presumed to be from the Bois Blanc Formation. Counts and measurements are based on samples of 10 to 26 corallites in 15 colonies (table 17 and fig. 24).

A. simcoense is characterized by its short major septa and abundant lateral supports that give a box-like appearance to corallites in transverse sections. Other species of *Acinophyllum* here described have

TABLE 17.—Acinophyllum simcoense (*Billings*), *summary data*

		Intracolony			Intercolony
		Minimum	Maximum	Mean	
N		10	26	---	15
n:	$\bar{x}$	21.4	27.5	---	23.8
	OR	20–23	25–29	---	21.4–27.5
	s	.7	1.7	---	1.8
	V	2.9	6.5	4.2	7.4
d:	$\bar{x}$	4.7	8.0	---	5.9
	OR	3.7–5.2	6.6–9.9	---	4.7–8.0
	s	.36	1.05	---	.99
	V	6.9	15.2	11.1	16.9

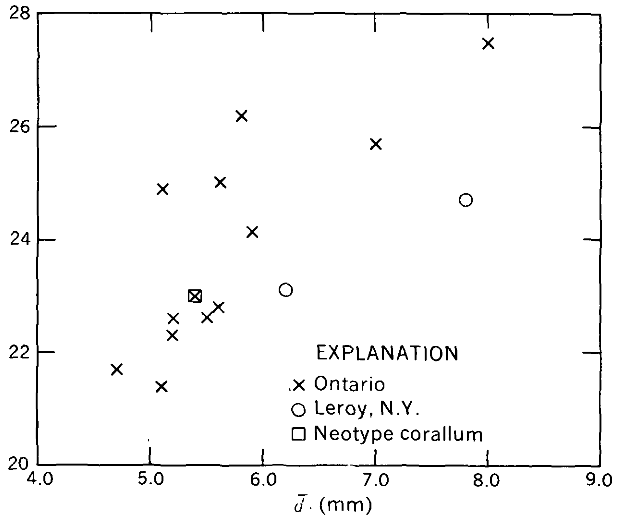


FIGURE 24.—Mean number of major septa ($\bar{n}$) versus mean diameter ($\bar{d}$) in colonies of *Acinophyllum simcoense.*

long major septa in all or many corallites and, except for *A. stokesi* have significantly fewer lateral supports.

The early descriptions of *"Eridophyllum"* or *"Diphyphyllum" simcoense* by Billings, Nicholson, and Lambe, were based on Ontario specimens, mostly from what is now known as the Bois Blanc Formation. Workers who based their descriptions of the species on material from outside Ontario were usually dealing with one of the species of Onondaga age so that the early concept of the species was virtually the present generic concept.

Synaptophyllum baculoideum Simpson (1900, p. 213; herein, pl. 8, figs. 5–7) was established by the publication of drawings of two transverse sections of individual corallites. Stumm (1955, card 264) and McLaren (1959, pl. 10, figs. 3, 4) published photographs of the syntypes including transverse sections of two additional corallites, and McLaren (1959, p. 27) provided the first description of the syntypes. None of Simpson's material other than the mentioned thin sections is known to exist, but several large parts of colonies found in the New York State Museum are probably from the same locality (2.5 to 3 miles [4 to 4.8 km] east-northeast of Leroy) and are conspecific with the types. *S. baculoideum* as interpreted from Simpson's material differs from *S. simcoense* only in its large corallite size (diameters 6.0 to 7.4 mm). Other specimens from the Leroy locality are also large (including colonies 50 and 52; pl. 9, figs. 3–5), corallite diameter in colony 52 ranging from 6.0 to 8.9 mm. These specimens agree in all respects with Simpson's material and can be considered topotypes. At the same time they cannot be separated from *A. simocense.* Size variation in that species is extensive (fig. 24) and, whereas specimens that could be referred to *S. baculoideum* are toward the large end of the size range, they cannot be separated from the mass of colonies studied. Figure 24 shows the size variation in specimens from Ontario and Leroy, N.Y.

The type specimen of *S. baculoideum* and the additional Leroy specimens were cataloged as being from the "Onondaga Limestone," but recent work showing that the Bois Blanc Formation extends into New York (see stratigraphy section) makes this assignment questionable. The Bois Blanc Formation crops out in several places just north and northeast of Leroy, and it now seems probable that the New York specimens of *A. simcoense* are from the Bois Blanc Formation as are the Ontario ones.

The synonymy presented for *A. simcoense* is as complete as is justified by the need to clear up the distribution record. Original hypotypes have been studied, where possible, but many of the assignments are based on the published illustrations or description where these are clear and specimens are lost. "*A. simcoense*" was something of a catchall term, and the list of accepted and rejected assignments is complete only for material described from rocks of Onesquethaw age in eastern North America.

Distribution.—Bois Blanc Formation (Lower Devonian, Emsian), Ontario, New York, and Ohio. The probable assignment of some New York specimens to the Bois Blanc was discussed in an earlier paragraph. Principal occurrences of described specimens are at Innerkip, Hagarsville, and Port Colborne, Ontario, and Leroy, N.Y.

Material studied.—Southwest Ontario: Neotype, GSC 31144; hypotype of Lambe (1901) and McLaren (1959), GSC 3436; illustrated specimens (six), USNM 162595–98, 27961; other measured specimens (eight), USNM 162599–606; others, USNM 162607 and eight more. Leroy, N.Y.: illustrated specimens (four), NYSM 334, 335 (holotype of *Synaptophyllum baculoideum* Simpson), 12811–13. Lake County, Ohio: two specimens from core.

Acinophyllum stramineum (Billings)

Plates 12–14

	1859	*Diphyphyllum stramineum* Billings, p. 135.
?	1874	*D. stramineum* Billings, Nicholson, p. 33, pl. 5, fig. 6 (unrecognizable).
?	1874	*D. gracile* McCoy, Nicholson, p. 33–34, pl. 5, fig. 5 (unrecognizable).
not	1882	*D stramineum* Billings, White (see (*A. segregatum*).
?	1883b	*D. stramineum* Billings, Hall, p. 261, pl. 9, fig. 2 (unrecognizable).
?	1926	*Diphyphyllum vermetum* Weisbord, p. 5–6, pl. 1, figs. 6, 7, pl. 2, fig. 1. (see description of this form below).
?	1943	*Synaptophyllum vermetum* (Weisbord), Wells, p. 96–97, pl. 10, figs. 3, 4 (see *A. vermetum*).
not	1945	*Disphyllum* [*Synaptophyllum*] *stramineum* (Billings), Smith, p. 23–24, pl. 13, figs. 1, 2, 4–12 (part=*Phacellophyllum tructense* McLaren, 1959; figs. 3a–c are reproductions of Simpson's figures of *S. simcoense* = *S. segregatum*).
not	1952	*Thamnophyllum stramineum* (Billings), Soshkina, p. 85.
part	1955	*S. stramineum* (Billings), Stumm, cards 273–275, fig. after Nicholson, 1874, only.
part	1959	*Acinophyllum stramineum* (Billings), McLaren, p. 25–26, pl. 9, figs. 3, 4, text fig. 8 [not pl. 10, fig. 5, which is *A. segregatum*].
not	1960b	*T. stramineum* (Billings), Spassky, p. 48–49, pl. 15, figs. 1–3.

Occurrence of type material.—"Common in the Corniferous limestone, lot 6, con. 1, Wainfleet." (Billings, 1859, p. 136.) This is 2.8 to 3 miles (4.5–4.8 km) west of Port Colborne (Welland Canal) and is probably identical to my locality C10. McLaren (1959) redescribed and designated as lectotype one of Billings syntypes. The lectotype (pl. 12, figs. 1–3) is from the bioherm facies of the Edgecliff Member. Middle Devonian (lower Eifelian).

Diagnosis.—*Acinophyllum* with only rare lateral supports.

External features.—The appearance of colonies of *A. stramineum* must be deduced as no coralla are known in which the individual corallites are in their original relative positions. Colonies were presumably phaceloid, but lateral supports are rare; apparently for this reason coralla are small and commonly preserved in a broken condition.

Individual corallites are cylindrical except for a brief, initial conical stage. Mean corallite diameter in eight colonies ranges from 2.9 to 4.7 mm (mean 3.6 mm) table 18 and fig. 25).

Increase is lateral at infrequent intervals; expansion is rapid in new individuals and the conical stage is short. Except for very rare lateral supports the basal attachments are the only points of individual support.

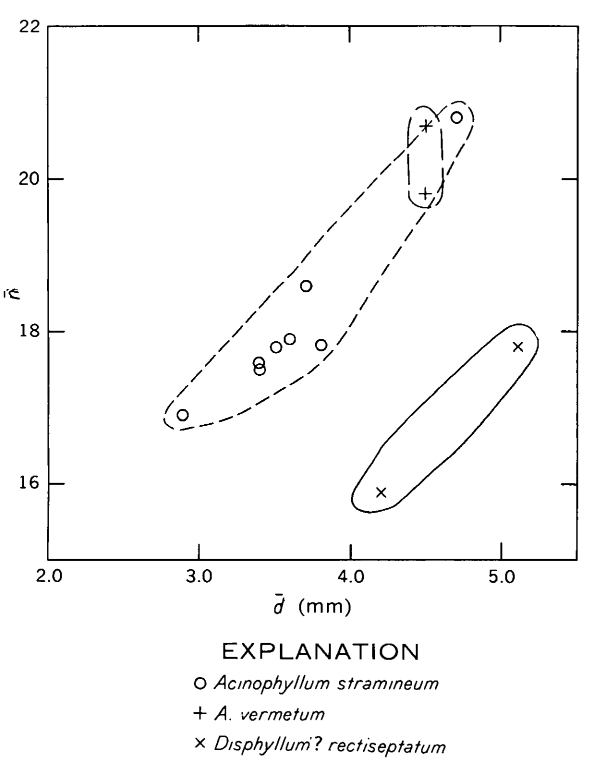


FIGURE 25.—Mean number of major septa ($\bar{n}$) versus mean diameter ($\bar{d}$) in colonies of *Acinophyllum stramineum*, *A. vermetum*, and *Disphyllum*? *rectiseptatum*.

TABLE 18.—Acinophyllum stramineum (*Billings*) *and* A. vermetum (*Weisbord*), *summary data*

	A. stramineum				*A. vermetum*	
	Intracolony			Intercolony	PRI 21598	PRI 27637
	Minimum	Maximum	Mean			
N	15	22	---	8	7	6
n: $\bar{x}$	16.9	20.8	---	18.1	20.7	19.8
OR	15–19	20–22	---	16.9–20.8	20–22	19–21
s	.7	1.2	---	1.2	.95	.75
V	3.3	6.7	5.5	6.5	4.6	3.8
d: $\bar{x}$	2.9	4.7	---	3.6	4.5	4.5
OR	2.9– 3.7	4.1– 5.4	---	2.9– 4.7	4.1– 5.2	4.1– 5.0
s	.3	.5	---	.5	.4	.3
V	7.7	15.6	12.5	14.2	8.6	6.4
r	.03	.69	---	.95	-------	-------
P	.90	$<.01$	---	$<.01$	-------	-------

Exteriors are marked by gentle (apparently) widely spaced rugae in addition to the usual septal grooves and fine growth lines.

Internal features.—Septa radially arranged. Major septa range in length from one-fourth to three-fourths the corallite radius. Average number of major septa per corallite in 8 colonies ranges from 17 to 21 (fig. 25) with comparatively little variation in any one colony (table 18). Minor septa alternate with the major and are about two-thirds as long. Septa are slightly amplexoid as in *A. segregatum.*

Zigzag carinae are well developed on peripheral parts of septa in most corallites (pl. 14, fig. 8.)

The dissepimentarium is composed of a single row of steeply inclined normal dissepiments. A few small dissepiments occur on the axial side of the single row, but these do not form a second row even locally.

The tabularium is occupied by thin, usually complete, tabulae which vary in shape from convex to concave. The same five types described for *A. segregatum* (fig. 23) are found in *A. stramineum* (pl. 12, fig. 4; pl. 13, figs. 7, 8). All types are found in many colonies; one to five types may occur in a single corallite. Tabulae spacing in 8 colonies ranges from 5 to 16 per 5 mm to 12 to 22 per 5 mm. Average spacing is approximately 10 per 5 mm.

The epitheca is thin, averaging 0.1 mm. Microstructure of all skeletal tissue is the same as described for the genus.

Variation.—Intercolony and intracolony variation based on 15 to 22 individuals in 8 colonies is shown by scatter diagram (fig. 25) and in table 18. Colonies vary in mean corallite diameter and mean number of major septa and in the correlation coefficients of these two. Diameter-septal number correlation based on colony means, however, is very strong ($r<0.01$).

In these and other characters, variation is much like that noted for *A. segregatum* and is discussed in the chapter on intercolony and intracolony variation.

Discussion.—The above description is based on a large collection from the Onondaga Limestone in New York and Ontario. Measurements are based on 15 to 22 individuals in each of 8 colonies.

McLaren (1959) designated a lectotype and described and illustrated it, giving a firm basis for the present description and discussion.

A. stramineum is very close to *A. segregatum* in most morphologic details and can be absolutely set off in none. Some workers have synonomized the two species (Rominger, 1876; Lambe, 1899, 1901; Smith, 1945), and others have noted their similarity. Stumm (1955, card 272) stated "The internal structure of *S. simcoense* [meaning *A. segregatum*] is identical with that of *S. stramineum.* The two species can be distinguished only by the connecting processes present on *S. simcoense.*"

Both species are extremely variable, and their separation has not been well defended because of limited numbers of specimens. Billings separated them on the presence or absence of lateral supports and this was followed by Stumm. Although the frequency of supports in *A. segregatum* varies widely, colonies of the *A. segregatum-stramineum* complex have either a lot of them or very few of them, and it is not difficult to separate colonies into groups on this basis. "Difficult identifications" invariably involve badly crushed specimens or small fragments. This morphologic difference accounts for significant differences in preservation. *A. segregatum* is commonly preserved with the individual corallites in their original relative positions. In contrast, *A. stramineum* corallites are almost invariably disoriented. The lateral processes of *A. segregatum* made the coralla rigid enough to be overturned without complete breakup, whereas *A. stramineum* coralla easily fell apart. The species are commonly associated in the Edgecliff bioherm facies where the contrast in preservation condition is marked and provides a useful means of identification in the field. *A. stramineum* is very rare or absent from other members of the Onondaga although *A. segregatum* is generally common.

In addition to the general lack of lateral supports and the disoriented preservation condition, the following observations can be made of *A. stramineum*-*A. segregatum* differences: *A. stramineum* tends to have longer minor septa, stronger carinae, more closely spaced tabulae, and just a single row of dissepiments.

A. stramineum differs from other described species of the genus as follows: *A. stokesi, simcoense* and *mclareni* have abundant or common lateral supports. In addition *A. simcoense* is characterized by short major septa and *A. mclareni* by long ones.

Thamnophyllum stramineum (Billings) of Soshkina (1952) and of Spassky (1960) were based on Smith's (1945) erroneous generic concept and are not conspecific or congeneric with Billings species.

Distribution.—Edgecliff Member, Onondaga Limestone (Middle Devonian, lower Eifelian), New York and Ontario. *A. stramineum* is common in the bioherm facies of the Edgecliff Member in eastern and western New York and in the Niagara Peninsula of Ontario. One corallum (USNM 163380) was collected from the biostrome Edgecliff at Hagarsville, Ontario (USGS loc. 5028–SD).

Several specimens of *Acinophyllum*, probably this species, are known from the Mountain House Wharf Limestone, Lake Memphramagog, Quebec.

Material studied.—Southwestern Ontario: Lectotype, GSC 3431; others, USNM 163381; biostrome specimen, USNM 163380; 1 additional specimen. New York: illustrated specimens (5), USNM 162608–09; NYSM 12806–08; other measured specimens (6), USNM 162610–14, NYSM 12809; others (19). Lake Memphramagog, Quebec: USNM 172178–179.

Acinophyllum segregatum (Simpson)

Plates 15–22; plate 11, figure 3

? 1874 *D. arundinaceum* (Billings). Nicholson.
part 1876 *Diphyphyllum simcoense* (Billings). Rominger, p. 123–124, pl. 46, figs. 2?, 3, 4.
1879 *Eridophyllum simcoense* Billings. Quenstedt, p. 511, pl. 161, fig. 8.
? 1882 *D. stramineum* Billings. White, p. 388, pl. 48, fig. 1.
? 1883b *E. simcoense* Billings. Hall, p. 262, pl. 9, fig. 1.
1900 *Synaptophyllum simcoense* (Billings). Simpson, fig. 33, 34 (p. 213).
1900 *S. segregatum* Simpson, fig. 37 (p. 213).
? 1901 *D. arundinaceum* Billings. Lambe, p. 162–163, pl. 14, figs. 1, 1a, 1b.
1944 *S. simcoense* (Billings). Shimer and Shrock, p. 95, pl. 30, figs. 5–7.
part 1945 *Disphyllum* [*Synaptophyllum*] *stramineum* (Billings). Smith, pl. 13, fig. 3a–c only (see McLaren, 1959, for description and discussion of Smith's other material).
1955 *S. segregatum* (Billings). Stumm, card 270.
part 1955 *S. simcoense* (Billings). Stumm, card 271–272 (figs. after Rominger, 1876 only).
1967 *Cylindrophyllum* (*Acinophyllum*) *simcoense* (Billings). Pickett, p. 56–57, fig. 15.

Occurrence of type material.—"Onondaga Limestone, Clarksville, Albany Co., N.Y." (Clarke and Ruedemann, 1903, p. 58.) Almost certainly the bioherm facies of the Edgecliff Member, Onondaga Limestone. Middle Devonian (Eifelian).

Diagnosis.—Phaceloid *Acinophyllum* with numerous lateral supports and with both long and short major septa.

External features.—Colonies small to large, lenticular, as much as 100 cm or more in diameter and as much as 30 cm or more in height; composed of radiating or subparallel corallites. Mature corallites range in diameter from 2.3 to 8.9 mm. In a single colony, size variation is limited (table 8); mean diameter in 58 colonies ranges from 2.8 to 6.8 mm (fig. 16).

Increase is lateral at infrequent intervals; occasional individuals show successive offsets only 1 cm apart, but in most individuals the offset interval is 5 cm or more. Expansion is rapid, and the conical stage is limited to the basal one-half cm. Lateral supports are present in all colonies and generally found on all corallites but may be closely or widely spaced (pl. 11, fig. 3; pl. 21, fig. 6) and limited to one or two vertical rows on each corallite. Corallites are markedly rugose at irregular intervals; the lateral supports are normally an extension of the rugae.

Spacing of corallites within a colony ranges from less than one to nearly two diameters.

Calices are known only in sections. They are deep (1 to 1½ diameters) with steep sides from which the septa project only slightly.

Internal features.—Septa radially arranged. Major septa range in length from one-fourth to three-fourths the corallite radius, commonly less than one-half, but longer septa characterize an estimated 10 to 50 percent of the corallites in all sections studied. Average number of major septa per corallite in 58 colonies ranges from 16 to 28 (fig. 16) with comparatively little variation in any one colony (table 8). Minor septa alternate with the major and are one-half (or less) as long. The septa are amplexoid, at least in some specimens; numerous eccentric longitudinal sections show that the major septa are longest on the surfaces of tabulae and slightly or markedly withdrawn in the space between tabulae. Septa are very thin (0.03–0.10 mm) and often slightly dilated in the peripheral region. Zigzag carinae are strongly or weakly developed on the outer parts of the septa.

The dissepimentarium is composed of one row of globose, steeply inclined dissepiments. A second, commonly discontinuous row of smaller dissepiments is locally developed in many individuals in many colonies (pl. 21, fig. 3). More rarely a third row is present. Occasional specimens lack dissepiments along part of their periphery, generally in the early conical stage of new individuals (pl. 20, fig. 3). In the cylindrical stage the number of rows of dissepiments is roughly related to size. Areas of no dissepiments are found only in colonies with the smallest diameters; the second and third rows are more common in colonies of large individuals. The lateral supports consist of a lateral extension of normal septal and dissepimental tissue within the out-bent epitheca.

The tabularium is occupied by usually complete, thin tabulae which vary in shape from quite convex to quite concave. Five basic types can be recognized (fig. 23) of which type 3, simple convex, is most common. All types are found in most colonies; one to five types may occur in a single longitudinal section of a single corallite. Spacing of tabulae varies widely within individuals as well as in the species as a whole. Spacing in colonies ranges from 2 to 10 per 5 mm to 10 to 19 per 5 mm. Average spacing is between 5 and 10 per 5 mm.

Microstructure.—To the family description can be added the following. The epitheca is thin, averaging 0.1 mm; thicker on the lateral supports. The septal trabecular zone (dark, axial area in transverse section) is approximately 0.03 mm thick. The septa average 0.1 mm thick at the periphery but thin toward the axis.

Variation.—Individual and colony variation is extreme in this species and is the subject of detailed description and discussion in the section titled "Intracolony and Intercolony Variation." Morphologic characters other than size and number of septa are difficult to treat quantitatively, but certain observations made in the systematic description can be summarized here. The species as a whole is quite variable in most characters. Intracolony variation is more limited than intercolony variation in many features, but even individual corallites are quite variable in some.

Intracolony variation is relatively low in exterior ornamentation (rugae and so forth), size and shape of dissepiments as well as number of septa and diameter, as previously discussed. All of these and colony size vary widely in the species as a whole.

Variation in length of major septa and shape and spacing of tabulae is most notable within a colony although these vary within individuals also.

Discussion.—The above description is based primarily on a large collection (made by the author) of colonies and parts of colonies from the Onondaga Limestone in New York. The nucleus of this collection is 58 specimens, which were analyzed to determine intercolony and intracolonial variation. Supplementary material collected in Ontario and New York and specimens from the New York State and U.S. National Museums and the Geological Survey of Canada provided additional data on morphology and geographic and stratigraphic distribution of the species.

This is the common *Acinophyllum* in the Onondaga Limestone, occurring in most facies of the Edgecliff, Nedrow, and Moorehouse Members throughout the extent of the formation.

A. segregatum differs from other Onesquethaw species of the genus in these characters: major septa are long or short in different individuals; lateral connections are common but tend to be thin and have a narrow base.

In contrast, *A. simcoense* has short septa and *A. mclareni* long septa; *A. stramineum* virtually lacks lateral connections; *A. stokesi* and *A. simcoense* have very broad based, thick lateral connections that are strikingly abundant.

Nomenclatorial problems.—*Synaptophyllum segregatum* Simpson was established by the publication of a drawing of a thin section of two connected corallites. The thin section from which the drawing was made is preserved (pl. 15, figs. 4, 6); it is the only remnant of the specimen(s) on which Simpson based the species.

Stumm (1955) published a photograph of the whole thin section including four additional corallites, and observed that the species was "probably conspecific with *S. simcoense* (Billings)." Because the accepted concept of *S. simcoense* at that time was based on the common Onondaga species (here assigned to *S. segregatum*), I am in agreement with this statement.

McLaren (1959) published another, larger photograph of the holotype section and with some question placed the species in synonymy with *S. stramineum* (p. 25–26).

To most previous workers the "Onondaga" has included both the Bois Blanc and Onondaga of this report. They have tended to recognize Billings' two species and to differentiate between them on the basis of presence or absence of lateral connections. In consequence, the species here described as *A. segregatum* has commonly been included in *A. simcoense*. In the literature on New York most references to *"S. simcoense"* can be safely translated as *A. segregatum*. This is not true for reports of Ontario occurrences as specimens of *Acinophyllum simcoense* are as common there as are specimens of *A. segregatum*.

The holotype thin section of *A. segregatum* shows the important characters of the common Onondaga species very well; the six corallites show both long and short major septa and a lateral connection. Although it would be preferable to base the most abundant known species of the genus on a large corallum from a known locality and stratigraphic position, I have no doubt of the identity of the holotype with the common species and little doubt of its provenance. The matrix of the holotype slide is characteristic of the Edgecliff bioherm facies. The Edgecliff outcrop belt runs through Clarksville (the type locality for the species); bioherms are known within a few miles of the village and may have occurred much closer at localities no longer exposed.

Distribution.—Middle Devonian (Eifelian), New York, Ontario, and Ohio. *A. segregatum* is the most common and widely distributed colonial rugose coral in the Onondaga Limestone of New York and Ontario. It is common or abundant in all of the Edgecliff bioherms and at all outcrops of the Moorehouse *Acinophyllum-Eridophyllum* bed. It is of frequent occurrence, not everywhere common, in other facies of the Edgecliff Member and in the western coral facies of the Moorehouse Member. The species is less common in the Nedrow Member and is not known from the Seneca Member.

In the Niagara Peninsula of Ontario, *A. segregatum* is common in the Edgecliff Member (both facies) and was collected from probable Moorehouse beds in the Simcoe area.

A. segregatum occurs in the Columbus Limestone in the Ohio, but its stratigraphic and geographic range there is yet to be worked out. It may be common in the lower Columbus coral bed (Zone C) in the outcrop belt from northern Pickaway County to Delaware and has been found in the same stratigraphic position in the subsurface of Morgan County (southeastern Ohio). It occurs throughout the lower 86 feet (27 m) of the Columbus-Onondaga in the subsurface of Lake County (northeastern Ohio).

Material studied.—New York: Holotype, NYSM 336; illustrated and measured specimens (13), USNM 162615–22, NYSM 12780–84 illustrated (14), USNM 162623–28, NYSM 12785–92; measured (45), USNM 162629–59, 172246, NYSM 12793–805. Ontario: Illustrated specimens (3), GSC 31162–64. The distribution of this species as indicated on tables 41–44 and 46, is based on 21 additional identified specimens from southwestern Ontario and more than 150 additional identified specimens from New York.

Acinophyllum mclareni Fagerstrom

Plates 23, 24

?1889 *Diphyphyllum simcoense* (Billings). Sherzer, p. 93–95, fig.
1938 *Synaptophyllum simcoense* (Billings). Stewart, p. 43, pl. 8, fig. 5–6.
1961 *Disphyllum* sp. A Fagerstrom, p. 13–14, pl. 3, fig. 1–3.
1961 *Acinophyllum mclareni* Fagerstrom, p. 14, pl. 3, fig. 18–20.

Occurrence of type material.—Formosa reef facies of the Detroit River Group, Bruce County, Ontario (Fagerstrom, 1961, p. 4, 14). Middle Devonian (Eifelian).

Diagnosis.—*Acinophyllum* with uniformly long major septa extending approximately two-thirds the distance to the axis.

External features.—Colonies large, as much as 25 cm or more high and one to several feet in diameter. Corallites are straight and parallel with relatively rare lateral supports. Mature (cylindrical) corallites range in diameter from 4.0 to 7.6 mm; mean diameter in 10 coralla ranges from 4.7 to 6.7 mm.

Increase is lateral and apparently infrequent; offsetting interval not known.

Corallite exteriors are marked by at least two orders of encircling rugae (growth lines) and by fine, longitudinal septal grooves.

Internal features. — Septa radially arranged. Major septa relatively uniform in length, extend from 0.6 to 0.9 the distance to the axis, rarely shorter. Average number of major septa in 10 coralla ranges from 20 to 28 (fig. 26). Minor septa alternate with the major and are commonly one-half or less as long. Zigzag carinae weakly to strongly developed.

The dissepimentarium is composed of one or two rows of globose dissepiments forming a continuous outer zone. Tabulae are commonly complete, broad-

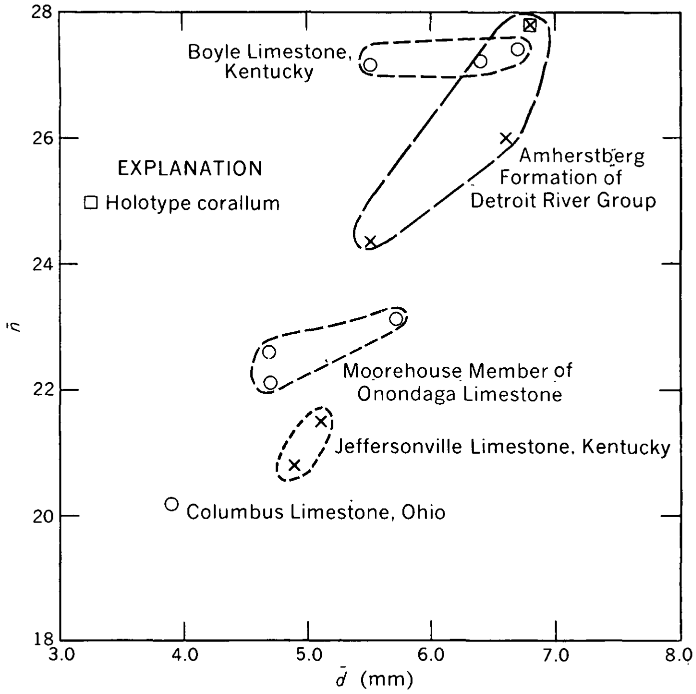


FIGURE 26.—Mean number of major septa ($\bar{n}$) versus mean diameter ($\bar{d}$) in colonies of *Acinophyllum mclareni* from different stratigraphic units.

ly arched with axial sag and steeply descending periphery; four to eight per 5 mm in the specimens studied.

Discussion.—The above description is based on specimens from five different formations and areas as indicated in figure 26. The species is rare in the Onondaga, occurring only in the Moorehouse Member in Ontario. The three known Moorehouse specimens are fragments (as much as 10 cm) of larger coralla and only one is well preserved. The species is distinguished by its long septa and is constant in most characters over its area of distribution. Although available samples from the Moorehouse Member and the Columbus and Jeffersonville-Limestones are very small, it is probably significant that mean diameters are smaller in these than in specimens from the Detroit River Group and Boyle Limestone (fig. 26). This may relate to environment as the former are from limestones, whereas the latter are from dolomites. The species was originally based on specimens from the Formosa reef facies of the lower Detroit River (Fagerstrom, 1961). This is a dolomite, and corallite diameters cited by Fagerstrom (p. 14) are correspondingly large.

A. mclareni differs from all other Onesquethaw species of the genus in its consistently long septa. *A. segregatum, stramineum,* and *stokesi* all have long septa in some corallites, but septa are commonly short.

Sherzer (1889) described a drift specimen from near Ann Arbor, Mich., as *Diphyphyllum simcoense* (Billings). Major septa "extend about two-thirds of the distance from the outer wall to the center, rarely reaching it." It seems likely that this is a specimen of *A. mclareni* from the Detroit River of either northern Michigan or Ontario.

Stewart's *Synaptophyllum simcoense* agrees with *A. mclareni* in its morphology and the characteristic long septa are well shown in the illustrations (Stewart, 1938, pl. 8, fig. 5; herein, pl. 24, fig. 4).

Fagerstrom's original description of the species was based on specimens from the Formosa reef facies of the Detroit River in Bruce County, Ontario, some 90 miles (144 km) north of the London-Woodstock area. The present description agrees with Fagerstrom's in most respects. It is broadened to include much greater size variation than could be found in the type area. In addition the consistently long septa are emphasized as a character distinguishing this from other species with which it might be confused.

Distribution.—Middle Devonian (Eifelian); Detroit River Group and Onondaga Limestone, Ontario; Columbus Limestone, Ohio; Boyle and Jeffersonville Limestones, Kentucky. The known Detroit River occurrences of *A. mclareni* are all in beds thought to be equivalent to the Amherstburg Formation in Michigan and the Edgecliff Member in New York-Ontario: (1) The Formosa reef facies is considered lower Detroit River or Amherstburg by Fagerstrom (1961, p. 45; written commun., 1966). (2) The Gorrie exposures (loc. C36) were convincingly shown to be lowest Detroit River or upper Bois Blanc by E. W. Best (unpub. PhD. thesis, Univ. Wisconsin, 1953, p. 87–88); the corals are clearly post-Bois Blanc (Oliver, 1960a, p. B173–B174) and the exposure is assigned to the lower Detroit River, Amherstburg Formation. (3) Ehlers and Stumm (1951b, p. 1886–1887) recognized the pressence of probable Amherstburg in the vicinity of Ingersoll, Ontario (USGS loc. 5051–SD); one specimen of *A. mclareni* was collected by the author from these beds.

The Onondaga specimens of *A. mclareni* are from the Moorehouse Member at Ontario localities near Dunnville (loc. C18) and south of Hagarsville (loc. C23). This, coupled with the Detroit River information, suggests a range from Edgecliff to Moorehouse equivalents in Ontario.

A. mclareni is known from the lower Columbus Limestone (Zone C) in the outcrop belt at Bellepoint, Ohio, and from the same position in the subsurface of Lorain County, Ohio. The species also occurs in the lower Boyle Limestone, in Lincoln County, Ky., and in the upper coral zone of the Jeffersonville Limestone at the Falls of the Ohio, Kentucky-Indiana.

Throughout the area of known distribution, *A. mclareni* is present and most common in units of Edgecliff age, but it ranges upward into units of Moorehouse age in southwestern Ontario.

Material studied.—Ontario: Detroit River—Holotype, UMMP 36120; illustrated specimens (two), USNM 162660–61; others, eight specimens from Gorrie. Moorehouse—illustrated (one), USNM 162662; other measured specimens (two), USNM 162665–66; others, one specimen. Ohio: Illustrated (two) OSU 17735 (hypotype of Stewart, 1938), UMMP 60484; others, three specimens from Zone C at Bellepoint. Kentucky: Boyle—Illustrated, USNM 162664; other measured (two), USNM 162668–69; others, four specimens. Jeffersonville—Illustrated, USNM 162663; other measured, USNM 162667.

Acinophyllum stokesi (Milne-Edwards and Haime)

Plates 25–28

	1851	*Lithostrotion stokesi* Milne-Edwards and Haime, p. 440, pl. 20, fig. 2.
	1860	*L. stokesi* Milne-Edwards and Haime. Milne-Edwards, p. 429.
	1887	*Eridophyllum arundinaceum* (Billings). Davis, pl. 112, fig. 2 (not Billings, 1859); objective synonym of *Acinophyllum davisi* Stumm.
not	1897	*Diphyphyllum stokesi* Milne-Edwards and Haime. Whiteaves, p. 152, pl. 17, figs. 5–5b.
not	1906	*Columnaria stokesi* Milne-Edwards and Haime. Whiteaves, p. 343.
not	1915	*C.* (*Palaeophyllum*) *stokesi* Milne-Edwards and Haime. Bassler, p. 261 (synonymy of Ordovician coral).
not	1926	*C.* (*P.*) *stokesi* Milne-Edwards and Haime. Hussey, p. 151, pl. 11, fig. 15.
not	1928	*C.* (*P.*) *stokesi* Milne-Edwards and Haime. Troedsson, p. 111, pl. 27, figs. 1a–d.
	1958	*Synaptophyllum simcoense* (Billings). Cranswick and Fritz, p. 45, pl. 3, figs. 1, 2.
not	1963	*Palaeophyllum stokesi* Milne-Edwards and Haime. Nelson, p. 31, pl. 6, fig. 6.
	1965	*Acinophyllum davisi* Stumm, p. 42, pl. 37, figs. 9–11.
	1968b	*A. davisi* Stumm. Oliver, p. 26, 27, 30 (character tabulations only).
	1973	*A. stokesi* (Milne-Edwards and Haime). Easton and Oliver, p. 915–918, pl. 1, figs. 1–6.

Occurrence of type material.—"Carbonifère, Amérique du nord: Lac Wennipeg." (Milne-Edwards and Haime, 1851, p. 441). This has commonly been taken to represent an Ordovician coral (see "nots" in synonymy) from the Lake Winnipeg area, Manitoba, Canada. The holotype was recently found by W. H. Easton and redescribed by Easton and Oliver (1973). It is clearly a Devonian *Acinophyllum* and was most likely moved from the Hudson Bay Lowlands (ENA Province) to the Lake Winnipeg area by glaciers. The species is known only from eastern North America except for this type occurrence.

Diagnosis.—Phaceloid *Acinophyllum* in which corallite diameter is small; dissepiments are small except in lateral connections which are large and numerous; major septa may be long or short.

External features.—Colonies lenticular, small to medium in size, composed of radiating to subparallel, cylindrical corallites. The largest specimens collected in the Bois Blanc are incomplete, one 10 cm high and 13 cm in diameter, one 23 cm in diameter. A corallum from the Falls of the Ohio measures 18 cm high and 28 cm in maximum diameter. The largest known fragment from the Schoharie Grit is approximately 4 cm high and 10 cm in diameter. Mature corallites are straight; diameters range from 3 to 5 mm in New York-Ontario specimens to as much as 6 mm in Falls of the Ohio specimens; mean diameters in 10 Bois Blanc colonies range from 3.3 to 4.4 mm, 6 Falls of the Ohio colonies range from 3.8 to 5.2 mm. Data on these and other colonies are shown in tables 19 and 20 and in figure 27. Spacing of corallites ranges from 0.5 to 1.5 times the corallite diameter.

Increase is lateral; offsetting intervals of 1.5 to 3.5 cm have been observed.

Corallites are gently to strongly rugose. Lateral connections are large and numerous and show no orientation.

Calice depth approximately 0.5 to 1.0 times corallite diameter.

Internal features. — Septa radially arranged. Major septa range in length from 0.3 to 0.9 the corallite radius; long and short septa appear in different corallites in the same colony. Number of major septa ranges from 16 to 21 in Bois Blanc specimens, 18 to 23 in Falls of the Ohio specimens; mean septal number in 10 Bois Blanc colonies ranges from 17.2 to 20.1, in six Falls of the Ohio colonies from 18.6 to 21.2. Minor septa alternate with the major and extend 0.3 to 0.4 the distance to the axis.

Carinae are abundant, commonly zigzag, rarely yardarm or nearly so; limited to the dissepimentarium.

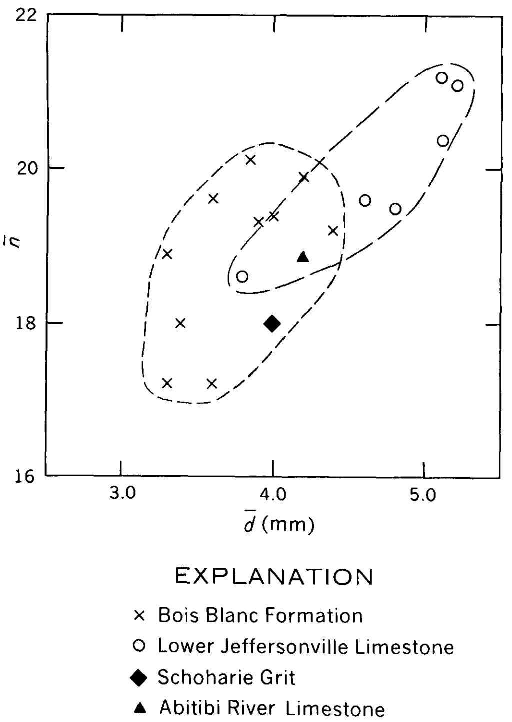


FIGURE 27.—Mean number of major septa ($\bar{n}$) versus mean diameter ($\bar{d}$) in colonies of *Acinophyllum stokesi.*

TABLE 19.—Acinophyllum stokesi (*Milne-Edwards and Haime*), *summary data, Bois Blanc Formation sample*

		Intracolony			
		Minimum	Maximum	Mean	Intercolony
N		10	20	---	10
n:	$\bar{x}$	17.2	20.1	---	18.9
	OR	16–18	19–21	---	17.2–20.1
	s	.47	1.33	---	1.05
	V	2.6	7.7	4.6	5.6
d:	$\bar{x}$	3.3	4.4	---	3.8
	OR	2.7–3.6	3.9– 5.0	---	3.3– 4.4
	s	.24	.57	---	.38
	V	7.3	13.6	10.1	10.1

TABLE 20.—Acinophyllum stokesi (*Milne-Edwards and Haime*), *summary data, lower Jeffersonville Limestone sample*

		Intracolony			
		Minimum	Maximum	Mean	Intercolony
N		10	20	---	6
n:	$\bar{x}$	18.6	21.2	---	20.1
	OR	18–20	19–23	---	18.6–21.2
	s	.50	.93	---	1.02
	V	2.6	4.6	4.0	5.1
d:	$\bar{x}$	3.8	5.2	---	4.8
	OR	3.0–4.7	4.5– 6.4	---	3.8– 5.2
	s	.32	.53	---	.52
	V	6.2	14.1	9.6	10.9

The dissepimentarium is composed of one row of globose dissepiments with a second incomplete row developed locally. The large connections are filled with larger, more elongate dissepiments in many irregular rows.

Tabulae are complete, commonly broadly arched with an axial depression and sharply descending at the periphery. Spacing ranges from 6 to 12 per 5 mm.

Discussion.—The above description is based primarily on 10 coralla from the Bois Blanc, 1 from the Schoharie and 6 from the Jeffersonville. For purposes of *n*:*d* analysis, 10 to 20 corallites in each colony have been studied, but the Bois Blanc and Jeffersonville samples have been kept separate. Bois Blanc specimens have somewhat smaller corallites with fewer septa than do Jeffersonville specimens (fig. 27 and tables 19, 20), but there is considerable overlap in the observed range of these characters and specimens are otherwise very similar. Only one Schoharie specimen was sufficiently well preserved for detailed study; it is not included in either of the above samples, but it is well within the Bois Blanc range in both characters (fig. 27).

The holotype is a fragment containing about 10 corallites. As discussed above and more fully by Easton and Oliver (1973), the holotype probably originated in the Hudson Bay Lowlands in northern Ontario or adjacent Manitoba (Moose River Basin). A corallum of this species from the Hudson Bay Lowlands (the "upper Abitibi River Limestone") was studied and is included in figure 27. This is the specimen described and illustrated by Cranswick and Fritz (1958, p. 45–46, pl. 3, figs. 1, 2) as *Synaptophyllum simcoense.* The known presence of the species in the area lends support to the argument that the Milne-Edwards and Haime specimen was derived there also. *Acinophyllum stokesi* is one of several species in the Abitibi River fauna indicating a Schoharie age. Fuller discussion of this point will be found in the stratigraphic section.

The species is also known from the Wildcat Valley Sandstone in southwest Virginia. All specimens are crudely silicified, and they add little to the description. They fall into the Bois Blanc diameter range but are too poorly preserved for septal counts.

Acinophyllum davisi was first described from the lower Jeffersonville Limestone (Schoharie equivalent) by Stumm (1965) who selected the specimen illustrated by Davis (1887) as holotype. No previous descriptions of this species from New York or southwestern Ontario are known; specimens have presumably been included in *A. simcoense* by most authors.

A. stokesi differs from other Onesquethaw species of the genus in these characters: corallites are small; major septa are long or short in different individuals; lateral connections are very common and tend to be thick and have a broad base. In contrast, the associated *A. simcoense* has large corallites and short septa; *A. stramineum* lacks lateral connections; *A. mclareni* has long septa; and *A. segregatum* has fewer and thinner lateral connections.

Within the lower Jeffersonville Formation, *"Disphyllum" synaptophylloides* Stumm (1965, p. 42) is very similar to *A. stokesi* in size and other external features. *"D." synaptophylloides* can be recognized by its peripheral offsetting and by distinctly different internal morphology. This species is not known to occur with *A. stokesi* in other areas.

Distribution.—Lower Devonian (Emsian), New York, Ontario, Virginia, Indiana-Kentucky, and northern Michigan. *A. stokesi* is common in the Schoharie, Bois Blanc, and lower Jeffersonville Formations, all of Schoharie age. It occurs also in the upper Abitibi River Limestone, Hudson Bay Lowlands, Ontario, and in the upper Wildcat Valley Sandstone, southwest Virginia, and provides evidence for the Schoharie age of these faunas (See stratigraphy discussion.)

Material studied.—Lower Jeffersonville Limestone, Falls of the Ohio: holotype of *A. davisi* Stumm, MCZ 7827; other measured specimens (5), USNM 163367–69 and 163378–79. Bois Blanc Formation, Ontario: here illustrated (5), USNM 162670–73, GSC 31143, other measured specimens (7), USNM 163370–76; others (10). Schoharie Grit, New York: here illustrated (3), NYSM 12810, USNM 162674–75. Upper Abitibi River Limestone, Ontario: holotype, Paris Museum No. 497a (probably this formation; see discussion); hypotype (of Cranswick and Fritz, 1958), ROM 27064. Wildcat Valley Sandstone, Virginia. Specimen listed by Kindle (1912, p. 52) as *"Diphyphyllum* cf. *gigas,"* USNM 172165.

Acinophyllum vermetum (Weisbord)

Plate 29

?1859 *Diphyphyllum stramineum* Billings, p. 135 (see synonymy above).

1926 *Diphyphyllum vermetum* Weisbord, p. 5–6, pl. 1, figs. 6, 7, pl. 2, fig. 1.

1943 *Synaptophyllum vermetum* (Weisbord). Wells, p. 96–97, pl. 10, figs. 3, 4.

Occurrence of type material.—Northwestern Venezuela, near Columbia border, near the headwaters of the Cachiri River. Devonian, probably Onondaga in age. (See discussion.)

Diagnosis.—Phaceloid *Acinophyllum* with rare lateral supports and major septa varying from long to short.

External features.—Phaceloid coralla of unknown size. Weisbord states, "This species virtually comprises the limestone in which it is found imbedded." This statement suggests that colonies may be large. Mature corallites are straight and cylindrical; diameter ranges from 4.1 to 5.2 mm in the available material (table 18 and fig. 25).

Increase is lateral. Lateral supports are present but uncommon. Broad, rounded interseptal ridges and septal grooves give a scalloped outline to well-preserved corallites in transverse sections.

Corallite spacing in corallum ranges from 0.5 to 1.5 diameters. Calice unknown but presumably steepsided.

Internal features. — Septa radially arranged. Major septa extend from 0.3 to 0.7 the distance to the axis; minor septa very short. Number of septa in 2 fragments of coralla ranges from 19 to 22 (table 18 and fig. 25). Zigzag carinae are weakly to strongly developed on most septa.

The dissepimentarium is composed of one or two rows of normal dissepiments. In most sections the dissepiments are globose, but there is considerable variation and some are quite elongate (pl. 29, fig. 6).

Tabulae are variable but commonly flat to gently convex.

Discussion.—The above description is based on three syntypes and six topotype fragments. The species is included here because it is the only known Early or Middle Devonian species of *Acinophyllum* from outside of Eastern North America. With associated corals and brachiopods, it indicates that Venezuela was part of the Eastern Americas Realm during this time.

A. vermetum is very similar to *A. stramineum*, from which the available specimens differ in no significant way. It differs from other described species in the same way that *A. stramineum* does. Because of its geographic remoteness, it seems best to recognize *A. vermetum* until the scope and direction of interspecific variation within the "species" is known.

Brachiopods associated with *A. vermetum* indicate a Schoharie or Onondaga age (J. G. Johnson, written commun., 1968). The similarity of *A. vermetum* to Onondaga rather than Schoharie species of *Acinophyllum* makes an Onondaga age more likely.

Distribution.—Caño Grande Formation, Rio Cachirí Series, on the Caño del Norte, branch of the Cachirí River, northwestern Venezuela (Liddle, 1943, p. 14–15; Weisbord, 1968, p. 217–222).

Material studied.—Lectotype (here selected), PRI 21598; paralectotypes, PRI 21595–96; topotypes, PRI 27637–38 (here illustrated and PRI 3332F (four unsectioned fragments).

Genus CYLINDROPHYLLUM Simpson

	1900	*Cylindrophyllum* Simpson, p. 217.
?	1910	*Cylindrohelium* Grabau, p. 102.
not	1915	*Cylindrophyllum* Yabe and Hayasaka, p. 90 (homonym; renamed *Fletcherina* by Lang, Smith, and Thomas, 1955).
not	1922	*Spinophyllum* Wedekind, p. 5–6.
	1935a	*Cylindrophyllum* Simpson. Lang and Smith, p. 544.
part	1938	*Cylindrophyllum* Simpson. Stewart, p. 43–44.
	1944	*Cylindrophyllum* Simpson. Shimer and Shrock, p. 95.
	1949	*Cylindrophyllum* Simpson. Stumm, p. 33.
part	1955	*Cylindrophyllum* Simpson. Stumm, card 136.
	1956b	*Cylindrophyllum* Simpson. Hill, p. F280.
?	1961	*Cylindrophyllum* Simpson. Fontaine, p. 98.
part	1967	*Cylindrophyllum* (*Cylindrophyllum*) Simpson. Pickett, p. 21–22.
	1974	*Cylindrophyllum* Simpson. Oliver, p. 167.

Type species.—*Cylindrophyllum elongatum* Simpson, 1900. Onondaga Limestone (probably Edgecliff Member, bioherm facies), eastern New York.

Diagnosis.—Phaceloid cylindrophyllinids with relatively wide dissepimentarium commonly consisting of from three to eight rows of normal globose dissepiments. Zigzag to subyard-arm carinae are present to abundant on major and minor septa.

Description.—Colonial, phaceloid or less commonly dendroid corals; lateral supports between corallites may be rare or abundant. Offsetting is lateral or, less commonly, peripheral. Calices deep with no platform.

Septa are radially or biradially arranged. Major septa do not reach the axis and may be very short. Major and minor septa are slightly to heavily carinate in the dissepimentarium; carinae are commonly zigzag, rarely yard-arm. Positions of cardinal and (or) counter septa may be marked by short major septa.

The dissepimentarium is composed of a few to several rows of normal, globose dissepiments. Tabulae are commonly complete; the tabularium occupies one-half or more of the corallite diameter.

Increase.—Lateral increase is common in all species studied and probably in all known species. Peripheral offsets are less common but are known in two species and may occur in others.

Microstructure.—As for the family. Specific details are described under the individual species.

Discussion.—*Cylindrophyllum* differs from phaceloid disphyllids in the presence of abundant septal carinae and in its relatively wide dissepimentarium. In contrast, *Disphyllum* commonly lacks carinae and has coarser trabeculae. (See family discussion). The evidence suggests that *Cylindrophyllum* is endemic to the Eastern Americas Realm.

Acinophyllum differs from *Cylindrophyllum* in having a single basic row of dissepiments; inner rows, if present, are composed of smaller dissepiments. The earliest species of both genera are in the Bois Blanc and its equivalents, and I interpret the genera to represent separate lines of cylindrophyllinid development as distinct from each other as either is from cerioid or astraeoid lines.

Cylindrohelium Grabau (1910) is generally considered to be a synonym of *Cylindrophyllum* (Stumm, 1949, p. 33; Hill, 1956b, p. F280; and others). The syntypes of *Cylindrohelium profundum* Grabau, the type species, are unrecognizable molds from Ohio and Alberta. I here select as lectotype the original of Grabau's plate 11, figure 5 (UMMP 13085) from the 'Lucas Dolomite, * * * near Sylvania, Ohio." The lectotype is thus a single calice mold from rocks of late Onesquethaw age in northwestern Ohio. Its selection will reduce the uncertainties regarding *Cylindrohelium,* but will not make it recognizable. *Cylindrohelium* can best be listed as unrecognizable and a nomen dubium.

Spinophyllum Wedekind (1922) is based on *Campophyllum spongiosum* Schlüter (1889). Schlüter described the species to include curved-conical, solitary horn corals whose only obvious similarity to *Cylindrophyllum* is in the possession of carinate septa. Wedekind apparently intended his genus to include colonial as well as solitary forms and possibly for this reason Stumm (1949), Hill (1956b), Pickett (1967), and others have placed *Spinophyllum* in synonymy with *Cylindrophyllum.* I have examined the Schlüter syntypes (Bonn 174a, b) and sectioned one of them (174a). They appear to be conspecific with the illustrated specimen of Wedekind (1922, fig. 2; SMF 3941, 3942). *S. spongiosum* differs from species of *Cylindrophyllum* in details of septal and tabulae morphology that may or may not be important, but it is solitary and lacks the characteristic craspedophyllid microstructure. I think that these are sufficient grounds for rejecting synonymy, and I consider it very unlikely that the two taxa are even closely related.

The following Onesquethaw age species from Eastern North America are assigned to *Cylindrophyllum* and described in the following sections:

1. *Cylindrophyllum laxtensum* n. sp.: Schoharie Grit, eastern New York, and Bois Blanc Formation, southwestern Ontario.
2. *C. elongatum* Simpson; type species; Edgecliff bioherm facies, New York.
3. *C. propinquum* Stewart; Edgecliff, bioherm and biostrome facies, eastern New York; Columbus Limestone, Zone C, Ohio.
4. *C. deearium* n. sp.; Edgecliff bioherm facies, New York; Edgecliff biostrome facies, southwestern Ontario; upper Columbus Limestone, Moorehouse equivalent, northeastern Ohio.
5. *C.* sp. *A;* Edgecliff bioherm facies, western New York.

The following additional Onesquethaw "species" are synonyms, of uncertain status, or reassigned:

1. *Cylindrohelium profundum* Grabau, 1910. Type species of *Cylindrohelium* (generally considered a junior synonym of *Cylindrophyllum*); Amherstburg Formation, Detroit River Group, Ohio (Stumm, 1955, card 151). Not recognizable.
2. *Cylindrohelium heliophylloides* Grabau, 1910. Lucas Formation, Detroit River Group, Michigan. Probably a *Cylindrophyllum* but not recognizable on the species level.
3. *Cylindrophyllum confluens* Stewart, 1935. Columbus Limestone (Zone C), Ohio. This is a zaphrentid possibly conspecific with *Cyathocylindrium opulens* n. sp. described below.
4. *Cylindrophyllum compactum* (Hall) of Stumm, 1965. Jeffersonville Limestone, Falls of the Ohio, Kentucky. Stumm synonymized several nominal species of Hall (1882, 1884), Davis (1887), and Greene (1904). I have reexamined the types and consider that most of the "species" are unrecognizable but agree that most are or may be conspecific. Most have long, bilaterally arranged septa with distinct fossulae and would be zaphrentids as here defined. *Heliophyllum gradatum* Greene is a *Cylindrophyllum* and possibly a senior synonymn of *C. propinquum* Stewart, described below. Stumm also included in his synonymy *C. propinquim* and *C. confluens* Stewart (1938) discussed above.
5. *Diphyphyllum gigas* Rominger, 1876, referred to *Cylindrophyllum* by Stumm, 1955, is a zaphrentid and is discussed under *Cyathocylindrium.*
6. *Cylindrophyllum* stummi Oliver, 1971, of late Onesquethaw or early Cazenovia age is redescribed below as *Disphyllum? stummi.*

Several species of "*Cylindrophyllum*" have been described from upper Cazenovia and Tioughnioga Middle Devonian rocks of eastern North America. These are not included in this study and are listed here without annotations except to question the assignment of some of the species. All are from the Traverse Group (Givetian) of Michigan.

1. *Cylindrophyllum delicatulum* Ehlers and Stumm, 1949.
2. *C.? grabaui* Ehlers and Stumm, 1949.
3. *C. hindshawi* Ehlers and White, 1932.
4. *C. magnum* Ehlers and Stumm, 1949.
5. *C.? panicum* (Winchell), 1866.
6. *C.? compactum* (Ehlers and Stumm), 1949.

Possible Middle Devonian *Cylindrophyllum* in western North America are of interest because of the relationship they might suggest between the eastern and western provinces. Only two species require consideration, both Givetian in age. The following notes are based on a restudy of the type specimens.

1. *Cylindrophyllum gruensis* McLaren (1964, p. 9–10, pl. 3, figs. 1a–2b), Horn Plateau Formation, Givetian, District of Mackenzie, Northwest Territories, Canada. This has relatively complex septa suggestive of some of the ptenophyllids and a dissepimentarium with from 4 to 10 or more rows of small dissepiments. In these respects, *C. gruensis* differs from *C.* spp. and may be a cyathophylloid rather than a craspedophyllid.
2. *Disphyllum occidens* Stumm (1938), assigned to *Cylindrophyllum* by Stumm (1955, card 148); upper part of Nevada Formation (Givetian), Nevada. This is not a *Cylindrophyllum.* It differs in having a dendroid growth form with trochoid, ceratoid and cylindrical corallites attaining widely differing diameters; and in having peripherally discontinuous septa. It is a cyathophylloid in the broad sense but its relationship to eastern zaphrentids is unknown.

Disphyllum was rare in Eastern North America during the Early and Middle Devonian. Some "*Disphyllum*" of authors are *Cylindrophyllum;* others are apparently unrelated to either *Disphyllum* or *Cylindrophyllum.* Onesquethaw species are briefly discussed here. I have reexamined the types of all of the species.

1. *Cyathophyllum cohaerens* Hall (1882), assigned to *Disphyllum* by Stumm (1965, p. 41), has weak zigzag carinae and probably belongs to the group discussed under *Cylindrophyllum compactum* above.
2. *Cyathophyllum septatum* Hall (1882), synonymized with *D. cohaerens* by Stumm (1965, p. 42) is a Silurian *Entelophyllum,* as is shown by thin sections of the holotype prepared in my laboratory.
3. *Disphyllum dyeri* Cranswick and Fritz (1958, p. 38, pl. 1, figs. 8, 9) is unrecognizable. The published illustrations do not show the nature of the dissepimentarium and the holotype (and only) specimen has been essentially destroyed since illustration, apparently by attempts to prepare a longitudinal thin section. From remaining fragments it is not clear whether any dissepiments are present, but the characteristic craspedophyllid or disphyllid dissepiments are certainly lacking.
4. *Disphyllum synaptophylloides* Stumm (1965, p. 42, pl. 37, figs. 5–8) differs from craspedophyllids and disphyllids in having strongly concave, complete and incomplete tabulae, and abundant twofold, threefold, and fourfold peripheral offset; it probably belongs to neither family. At present the species is known only from the holotype in the Davis collection (MCZ 7825). According to Davis' notes, kindly sent to me by Prof. Stumm, the specimen is from the lower 5 feet (1.5 m) of the Jeffersonville Limestone at the Falls of the Ohio (Schoharie equivalent). The species requires more detailed study before its relationships can be established.
5. *Disphyllum* sp. A of Fagerstrom (1961, p. 13–14, pl. 3, figs. 1–3) is *Acinophyllum mclareni.*
6. *Disphyllum* sp. B of Fagerstrom (1961, p. 14, pl. 3, fig.s. 9, 10) is a *Cylindrophyllum* possibly conspecific with *C. proprinquum* Stewart.

Only three species of Eastern North American post-Onesquethaw Middle Devonian age have been assigned to *Disphyllum*:

1. *Disphyllum compactum* Ehlers and Stumm, 1949, is a weakly carinate *Cylindrophyllum*? possibly synonymous with *C*? *panicum* Winchell. I have studied the type specimens of both "species" but analysis of much larger collections is needed to determine the extent of variation. Both forms are from the Traverse Group (Givetian) of Michigan and both occur in the Potter Farm Formation.
2. *Diplophyllum callawayensis* Branson, 1924(assigned to *Disphyllum* by Stumm, 1955, card 130), from the Callaway Limestone (Givetian) in Missouri, was inadequately described and illustrated and has not been seen by me. The description and transverse section (Branson, 1924, p. 50–51, fig. 3–3) indicate that minor septa are either lacking or very short and contratingent, and it is probable that the species is not related to the craspedophyllids or disphyllids at all.
3. *Disphyllum* sp. A Stumm, 1968 from the Tenmile Creek Dolomite of Stewart (1938) of Ohio was based on two fragments of single corallites. The form is indeterminate but appears to have carinae and bilaterally arranged septa and may be zaphrentid.

Two species of late Onesquethaw or early Cazenovia age are redescribed in a following section as *Disphyllum*?:

1. *Diphyphyllum rectiseptatum* Rominger, assigned to *"Synaptophyllum"* by Stumm, 1966, is the oldest probable disphyllid known from the Michigan Basin.
2. *Cylindrophyllum stummi* Oliver is the only probable disphyllid known from the Appalachian Basin.

In addition, *Disphyllum*? *crassiseptatum* (Ehlers and Stumm, 1949) occurs in the Potter Farm Formation (Taghanic Stage) in the Michigan Basin and some of the Traverse Group *Cylindrophyllum*? listed above may be *Disphyllum*? also. (See discussion of *Disphyllum*? below.)

Three Late Devonian species have been referred to *Cylindrophyllum.*

1. *Cylindrophyllum floydense* Belanski, 1928, limestone of Shellrock stage, Iowa. Examination of thin sections of the holotype indicates that this is not a *Cylindrophyllum.* It lacks carinae and has the thickened septa and coarse monacanths of typical *Disphyllum.*
2. *Disphyllum nevadensc* Stumm, 1939, Devils Gate Limestone, Nevada, reassigned to *Cylindrophyllum* by Stumm (1955, card 147). Carinae are weakly and very locally developed in the holotype. The species differs from Middle Devonian *Cylindrophyllum* in its somewhat di-

lated, spindle-shaped septa and in its very coarse, "European"-type trabeculae. I consider it unlikely that this form is a descendant of *Cylindrophyllum* s.s.; its gross characters may be due to convergence.

3. *Diphyphyllum tubiforme* Fenton and Fenton, 1924, Hackberry Stage, Iowa, referred to *Cylindrophyllum* by Stumm (1955, card 153). The published description and illustrations of this form are not adequate for meaningful evaluation, but Prof. J. E. Soranf states that it is a *Disphyllum* (written commun., 1971).

Only two species have been referred to *Cylindrophyllum* from areas outside of North America. The following notes are based on the published illustrations and descriptions.

1. *Cylindrophyllum asiaticum* Fontaine (1961, p. 98–99, pl. 19, figs. 11–13) is from an unknown stratigraphic position within the Devonian of Viet Nam. The species has the gross characters of *Cylindrophyllum,* but its assignment to the genus is difficult to assess without knowledge of its finer structure.
2. *Cylindrophyllum planivesiculosum* Chernychev (1941, p. 11, 53, pl. 1, figs. 4, 5) is from the base of the Lower Devonian, Taimyr Peninsula, USSR (Cherynchev, 1941, p. 61). This species has a single row of rather flattened dissepiments and may lack carinae, and it cannot be included in *Cylindrophyllum* as I understand the genus.

Generic range.—Species of *Cylindrophyllum* may be limited to rocks of late Early and Middle Devonian age in the Eastern Americas Realm. However, possible occurrences are noted in the late Middle Devonian of western North America and in the Devonian of Viet Nam. Possible Late Devonian occurrences have not been closely analyzed but seem very questionable to me.

Cylindrophyllum elongatum Simpson

Plates 31–33; plate 34, figures 1–7

1900 *Cylindrophyllum elongatum* Simpson, p. 217–218, fig. 42.
1944 *C. elongatum* Simpson. Shimer and Shrock, p. 95, pl. 30, fig. 8.
1949 *C. elongatum Simpson.* Stumm, p. 33, pl. 15, fig. 6.
1955 *C. elongatum* Simpson. Stumm, card 139.
1956b *C. elongatum* Simpson. Hill, p. F280, fig. 191, 8.
? 1961 *C.* sp. cf. *C. elongatum* Simpson. Fagerstrom, p. 14, pl. 3, figs. 7, 8.
part? 1961 *C* sp. cf. *C. propinquum* Stewart. Fagerstrom, p. 14, pl. 3, fig. 4 (not figs. 5, 6, see *C.* sp. A).

Occurrence of type material.—"Onondaga Limestone; Clarksville, Albany County, N.Y. J. W. Hall, coll. 1877" (NYSM catalog of types). Almost certainly the Edgecliff Member, probably in one of the bioherms that crop out within a few miles of the village.

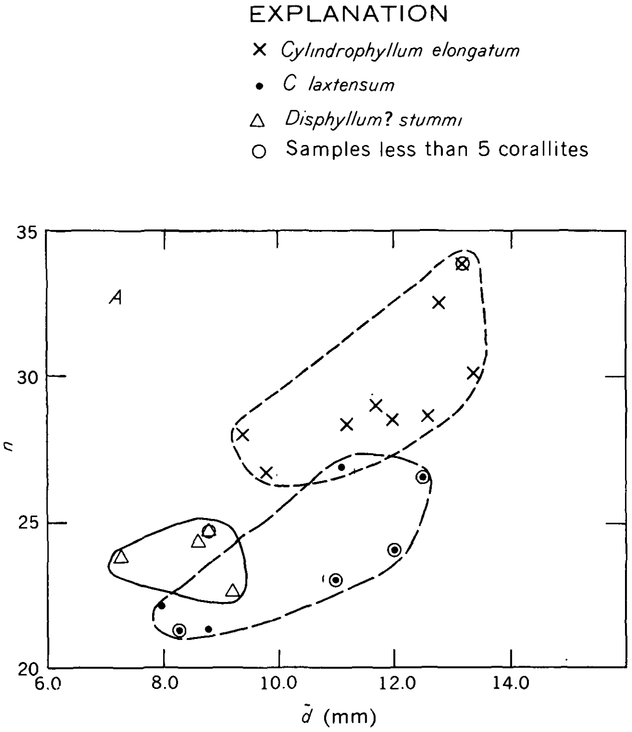
Diagnosis.—Phaceloid coralla with cylindrical corallites (diameter 8–15 mm) offsetting laterally or peripherally. Major septa biradially arranged, commonly with two long counter lateral minor septa; major septa short; dissepimentarium narrow containing two to five rows of globose dissepiments.

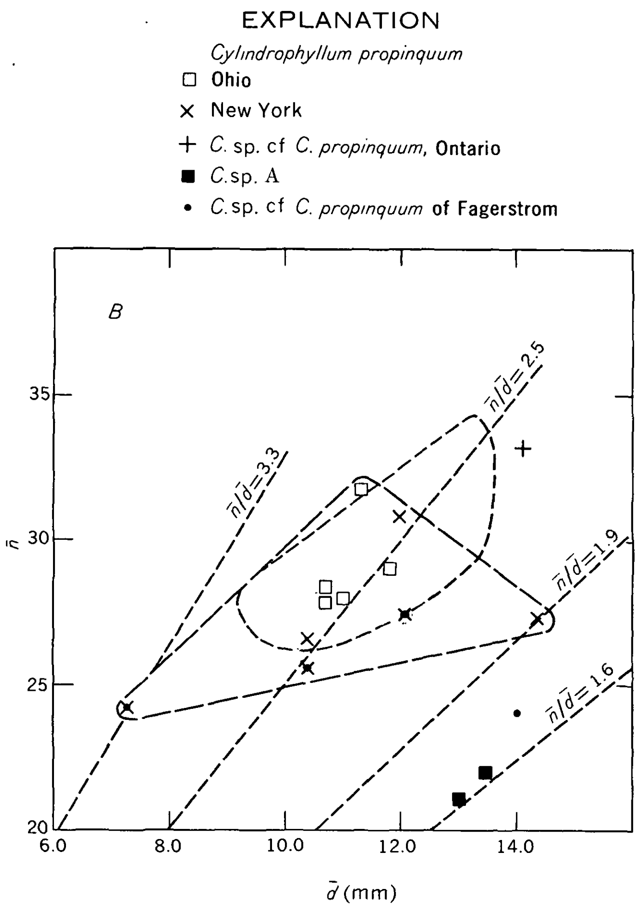
External features.—Phaceloid colonies are as much as 15 cm or more in height and 10 to 12 cm in diameter, composed of cylindrical corallites virtually parallel to each other. Corallite spacing ranges from 0.5 to 1.5 diameters; corallites rarely in contact except at points of origin. Observed diameters range from 7 to 16 mm (mean diameter in nine coralla, 9.4 to 13.4 mm) with considerable variation within each colony (table 21 and fig. 28). Increase is lateral or peripheral but both types of increase have not been observed in the same colony. Of 11 colonies studied, 5 offset laterally and 6 peripherally; no offsetting takes place within the holotype sections.

Internal features.—The major septa are biradially arranged and extend from 0.4 to 0.8 the distance to the axis, commonly 0.5 to 0.6. One or two of the major septa may be shorter than the others; presumably these are the cardinal and counter septa. In some corallites one major septum is flanked by long minor septa; this is probably the counter septum. Major septa number from 25 to 36 (mean numbers in 9 coralla, 26.7 to 33.8; table 21 and fig. 28). One exceptional corallite has 46 major septa. Except as noted, minor septa are from one-half to two-thirds as long as the major septa. All septa are lightly to moderately marked by zigzag carinae.

TABLE 21.—Cylindrophyllum elongatum *Simpson, summary data*

		Intracolony			Intercolony
		Minimum	Maximum	Mean	
N		4	16	8.7	9
n:	$\bar{x}$	26.7	33.8	29.2	29.5
	OR	25–28	33–36	---	26.7–33.8
	s	1.03	2.07	---	2.28
	V	3.7	7.2	5.1	7.7
d:	$\bar{x}$	9.4	13.4	11.9	11.9
	OR	8–11	12–15	---	9.4–13.4
	s	.48	2.10	---	1.44
	V	3.6	20.0	12.1	12.1





The dissepimentarium is narrow, occupying from one-third to one-half the radius, most commonly with three rows of dissepiments (observed range, one to six rows). Dissepiments are medium to large sized and globose.

Tabulae are complete or incomplete and variable in form. Most commonly they are complete, nearly flat with a broad, gentle axial depression and slightly downbent peripherally; others are incomplete, concave plates forming a strongly concave pattern. Intermediate types are common, but both extremes can be found in a single corallite or corallum. The tabularium occupies from one-half to two-thirds of the corallite diameter. Tabular spacing ranges from 2 to 10 per 5 mm; the widest spacing occurs only with the incomplete, strongly concave tabulae.

The production of lateral or peripheral offsets is as described above for the phaceloid corals as a group; offset intervals are not known.

Discussion.—Simpson's original description of *C. elongatum* is brief but adequate to clearly distinguish the species in the collections. His one illustration is a somewhat diagrammatic and apparently composite longitudinal section. The holotype consists of two longitudinal thin sections, one of which (NYSM 246a) is clearly the basis for the upper half of Simpson's illustration. The second thin section (246b) is not well centered in the corallite but is apparently the basis for the lower half of the figure. The two sections do not fit together in any obvious way but are assumed to be from the same corallite or corallum. Simpson omitted all structures but dissepi-

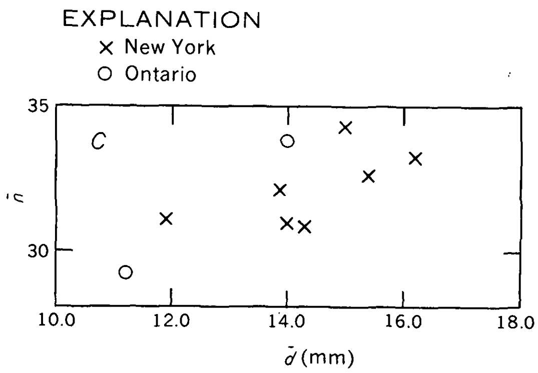


FIGURE 28.—Mean number of major septa ($\bar{n}$) versus mean diameter ($\bar{d}$) in *Cylindrophyllum* spp. and *Disphyllum? stummi.* Encircled symbols represent samples of less than five corallites. Polygons show observed ranges in species. *A, C. elongatum, C. laxtensum,* and *D.? stummi. B, C. propinquum, C.* sp. cf. *C. propinquum,* and *C.* sp. A. Straight lines mark indicated septal ratios. *C, C. deearium.*

ments, tabulae, and outer wall from his figure, although the sections show traces of septa with zigzag carinae as well. The presence of both septa and carinae are mentioned in the description, but their nature has been misunderstood by some workers. Both types of tabulae occur in both holotype thin sections and are well shown in the original figure.

The above description is based on 13 specimens including the holotype. Although some of the colonies have been compressed, little crushing was noted and most of the corallites are fairly well preserved.

Individual variation in this species is greater than in any of the other Onesquethaw species of *Cylindrophyllum*. Most notable are variation in septal length and tabulae shape as discussed in the description and in cylindrical diameters (table 21 and fig. 28).

Most characteristic are the narrow dissepimentarium and the relatively short septa.

Fagerstrom (1961, p. 14, pl. 3, figs. 4–10) described and illustrated four separate corallite fragments of probable *Cylindrophyllum* (as *Disphyllum* sp. B, *C.* sp. cf. *C. elongatum*, and *C.* sp. cf. *C. propinquum*) from the Formosa bioherm facies of the Detroit River Group in Ontario. The specimens are poorly preserved and inadequate for identification, but two of them are closer to *C. elongatum* than to any other described coral and are questionably assigned to this species as noted in my synonymy and list of materials studied.

Cylindrophyllum elongatum is morphologically closest to *C. propinquum* Stewart, originally described from the Columbus Limestone (Zone C) in Ohio. Study of five Ohio coralla suggests that *C. propinquum* differs in having longer septa that are less variable in length within coralla. Some New York Edgecliff colonies are so similar that I confidently assign them to *C. propinquum*, but I am not certain that much larger samples of both Edgecliff and Columbus forms won't show that there is continuous variation between *C. propinquum* and *C. elongatum*. As here defined, *C. elongatum* colonies all include individuals with very short septa (less than 0.5–0.6 radius); commonly such individuals predominate, but most colonies also include individuals with longer septa (as long as eight-tenths radius). In contrast, *C. propinquum* colonies commonly have medium to long septa (0.7–0.9 radius) with minimal intracolony variation; corallites with short septa are very rare.

Cylindrophyllum elongatum has decidedly longer septa than *C. laxtensum* and much shorter septa than *C. propinquum*. It differs from *C.* sp. A in its more closely spaced septa as indicated by the septal ratios (fig. 28).

Distribution.—Eleven specimens that I collected are all from the bioherm facies of the Edgecliff Member in New York. A twelfth specimen and the holotype are NYSM specimens from "Onondaga Limestone, Clarksville, N.Y." Edgecliff bioherms are known from the outcrop belt both north and south of Clarksville (fig. 5) and others may occur even closer to the village. It seems most likely that the NYSM specimens are from the Edgecliff Member and probably from the bioherm facies, as are the other specimens.

Fagerstrom's (1961) specimens indicate that *C. elongatum* may also occur in the Formosa bioherm facies, Amherstburg Formation, Detroit River Group, Ontario.

Material.—Holotype NYSM 246 (two longitudinal thin sections); measured and (or) illustrated specimens, USNM 163382–88, 172241–42; NYSM 12814–16; unillustrated studied specimens, USNM 163389–90.

Cylindrophyllum propinquum Stewart

Plates 35–38

1938 *Cylindrophyllum propinquum* Stewart, p. 45, pl. 8, figs 7, 8.
1955 *C. propinquum* Stewart. Stumm, card 152.
? 1961 *Disphyllum* sp. B, Fagerstrom, p. 14, pl. 3, figs. 9, 10.
part? 1961 *C.* sp. cf. *C. propinquum*, Fagerstrom, p. 14, pl. 3, figs. 5, 6 (see discussion under C. sp. A; not fig. 4 which may be *C. elongatum*).

Occurrence of type material.—Columbus Limestone, Zone C, Dublin, Ohio.

Diagnosis.—Phaceloid coralla with cylindrical corallites offsetting laterally. Major septa radially arranged but commonly with one or two short major septa defining the cardinal-counter plane. Major septa medium to long, extending seven-tenths to all the distance to the axis. Dissepimentarium narrow, commonly with three to six rows of globose dissepiments.

External features.—Known specimens are fragments of phaceloid colonies, as much as 25 or more centimetres high and 15 by 40 or more centimetres in diameter, composed of parallel, cylindrical corallites. Corallite spacing ranges from 0.1 to 1 diameters; corallites rarely in contact. Observed corallite diameters range from 6 to 17 mm; mean diameter in five Ohio colonies ranges from 10.7 to 11.8 mm; in six New York colonies 7.3 to 14.4 mm (table 22 and fig. 28). Only lateral offsets are known in the studied specimens.

Corallite exteriors are marked by broad V-shaped septal grooves and low, rounded interseptal ridges; two orders of rugae can be recognized.

TABLE 22.—Cylindrophyllum propinquum *Stewart, summary data*

	Ohio sample				New York sample				Ontario specimen USM 172185
	Intracolony			Inter-colony	Intracolony			Inter-colony	
	Minimum	Maximum	Mean		Minimum	Maximum	Mean		
N	3	9	---	5	4	15	9.8	6	5
n: $\bar{x}$	27.8	31.7	---	29.0	24.2	30.8	--	27.0	33.2
OR	27–29	29–33	---	----	22–26	30–31	--	----	31–35
s	0	2.31	---	1.6	.50	1.60	--	2.22	1.48
V	0	7.3	4.5	5.5	1.6	6.6	3.6	8.2	4.5
d: $\bar{x}$	10.7	11.8	---	11.1	7.3	14.4	--	11.1	14.1
OR	10.0–11.6	9.6–12.8	---	----	6–10	11–17	--	----	13.5–14.6
s	.76	1.75	---	.46	1.01	2.26	--	2.37	.43
V	6.7	15.9	10.8	4.1	9.8	22.2	15.6	21.4	3.0

Calices, known only from sections, are flat bottomed with nearly vertical lower walls and more gently inclined upper walls; there is no peripheral platform.

Internal features.—Most of the major septa are radially arranged and extend from seven-tenths to all the distance to the axis; corallites with shorter septa (six-tenths) are rare. Septa are irregularly bent within the tabularium. Most corallites have one or two major septa that are shorter than the others; presumably these mark the cardinal-counter plane. Adjacent major septa commonly bend around one or both of the short septa. Minor septa are 0.5–0.7 as long as the major septa.

All septa are carinate and carinae may be common in the tabularium as well as in the dissepimentarium. The pattern of carinae varies both within and between coralla. Zigzag to subyardarm carinae are prominent in the dissepimentarium; in some sections these are quite thick. At the tabularium boundary, thin but long yardarm or zigzag carinae may form a prominent zone in transverse sections (for example, pl. 38, figs. 10, 11). Within the tabularium, major septa tend to be very irregular; zigzag carinae are short but distinct in many corallites but some coralla seem to lack these entirely. Longitudinal sections show the carinae to be steeply inclined at or near the periphery, gently inclined to nearly horizontal through most of the dissepimentarium, and turning to a near vertical position in the tabularium (pl. 38, figs. 4, 9). Variations in carinae development can best be understood through reference to the plates. The dissepimentarium occupies approximately half of the radius and consists of from three to six rows of globose, medium- to small-sized dissepiments.

Tabulae are complete or incomplete, commonly with a broad axial depression and downbent peripherally; longer septa tend to distub the pattern and short, inclined incomplete tabulae are common at the margin of the tabularium.

Microstructure.—See family description.

Discussion.—This description is based on five fragments of colonies from Ohio and six from New York. Four of the Ohio specimens are new but are clearly conspecific with the Stewart type material. The New York specimens are very similar but colonies with both larger and smaller mean diameters than the Ohio forms are known and the New York specimens tend to have fewer septa at a given diameter (table 22 and fig. 28). An Ontario specimen is still larger, having even more septa, and is described separately as *C.* sp. cf. *C. propinquum. C.* sp. A is also similar to *C. propinquum* and may be conspecific; it has a much lower septal ratio and is separately noted for that reason.

Comparison of these *Cylindrophyllum* with long septa can be summarized as follows:

	$\bar{n}$	$\bar{d}$	$\bar{n}/\bar{d}$
C. propinquum:			
Ohio	28–32	11–12	2.5–2.8
New York	24–21	7–14	1.9–3.3
C. sp. cf. *C. propinquum*:			
Ontario	33	14	2.4
C. cf. *C. propinquum*:			
of Fagerstrom	24	14	1.7
C. sp. A	21–22	13	1.6

These data are also plotted in figure 28*B*.

Stewart (1938, p. 45) based her original description on "cotypes" from a single locality and to which she assigned only one number. It is not clear from her description or the type collection whether her "cotypes' represent different individuals from one colony or from two or more colonies, but they are here treated as being from one colony and termed holotype.

Cylindrophyllum propinquum differs from other described species of *Cylindrophyllum* in its long septa and in the arrangement of its septa within the tabularium. It is closest to *C. elongatum* as discussed under that species.

The holotype of *Heliophyllum gradatum* Greene (1904; see discussion under genus) from the Coral Zone(?) of the Jeffersonville Limestone at the Falls of the Ohio is a *Cylindrophyllum* possibly conspecific with *C. propinquum.*

Two of the four fragments of probable *Cylindrophyllum* described and illustrated by Fagerstrom (1961, p. 14, pl. 3, figs. 4–10) and discussed under *C. elongatum* have long septa and may represent *C. propinquum* as noted in my synonymy and list of materials studied. (But see also discussion of *C.* sp. A.)

Distribution.—The holotype and other Ohio specimens are from the Columbus Limestone, Zone C, within 30 miles (48 km) of Columbus, Ohio. The New York specimens are from the bioherm and biostrome facies of the Edgecliff Member, in eastern New York.

Material.—Holotype, OSU 17779, consisting of six thin sections assumed to be from one corallum. Other Ohio specimens, USNM 172186–189. New York specimens: Edgecliff bioherm, USNM 172180–183, NYSM 12818; Edgecliff biostrome, USNM 172184.

Fagerstrom specimens from the Formosa bioherm facies and possibly this species, UMMP 36114, 36119.

Cylindrophyllum sp. cf. C. propinquum Stewart

Plate 45, figures 8–10

One specimen from a bed of probable Edgecliff age (see distribution discussion) in Ontario is similar to *C. propinquum* in septal length and arrangement, in having short zigzag carinae within the tabularium, and in the general arrangement and configuration of dissepiments and tabulae. The specimen differs in having moderately dilated septa in some parts of some corallites. This feature is sufficiently unusual in Onesquethaw craspedophyllids to warrant separate notice.

The specimen is an incomplete fragment of a colony that was at least 15 cm high and 15 by 20 cm in diameter. Corallite diameters range from 13 to 15 mm and number of major septa from 31 to 35 (table 22 and fig. 28*B*). The corallites are large for *C. propinquum* but within the known range of variation in most characters. The dissepimentarium is relatively narrow and short zigzag carinae are present within the tabularium of several corallites. These can be seen in both longitudinal and transverse sections. The septal dilation is such that some septa are wedge shaped, tapering from the periphery to the axis. Other septa are locally dilated in the inner part of the dissepimentarium; in some corallites the thickening is great enough to mask the carinae.

Distribution.—The only known specimen is from beds exposed on the north shore of Lake Erie, just west of the mouth of the Grand River, south of Dunnville, Ontario. These beds are Edgecliff on the basis of their fossil content, lithology, and geographic position not far south of Bois Blanc outcrops.

Material.—Illustrated specimen, USNM 172185.

Cylindrophyllum laxtensum n. sp.

Plates 39, 40

Diagnosis.—Phaceloid coralla composed of cylindrical corallites connected by numerous lateral supports. Corallite diameters range from 6 to 13 mm. Major septa short, dissepimentarium narrow, tabulae complete.

External features.—Phaceloid colonies are as much as at least 17 cm in height and diameter; corallites radiate and may be nearly horizontal in the lower part of the corallum but are generally erect and nearly parallel in the upper parts; high and broad lateral supports are common. Corallite spacing is approximately half the diameter. Corallites are more or less straight; diameters range from 6 to 13 mm, mean diameters in three coralla range from 8.0 to 11.1 mm (table 23 and fig. 28*A*). Increase is lateral at infrequent intervals. Corallite exteriors are marked by prominent broad V-shaped septal grooves separated by rounded interseptal ridges; these are prominent enough in well-preserved individuals to give a decidedly scalloped appearance in transverse section. Gentle rugae and the lateral supports are additional features of the exterior.

Calices are flat bottomed with steep walls and narrow peripheral platforms that gently slope toward the axis.

Internal features.—Septa are radially arranged, commonly with no modification of the protosepta although short septa in some individuals may mark the cardinal-counter plane. Major septa are short, extending from 0.4 to 0.9 the distance to the axis, but five-tenths or less in most corallites. Number of major septa in cylindrical parts of corallites ranges from 21 to 29 in the studied sample; the mean number in 3 coralla ranges from 21.3 to 26.9 (table 23 and fig. 28*A*). Minor septa are 0.5 to 0.9 the length of the majors, commonly 0.7 to 0.8. Zigzag carinae are strongly developed in some corallites, almost absent in others. Variations in septal features can best be judged by examination of the illustrations.

Dissepimentaria are narrow, widths commonly four-tenths of the radius; they are composed of two

TABLE 23.—*Cylindrophyllum laxtensum n. sp., intracolony data*

		GSC 3585a	GSC 31146	USNM 182813
N		15	12	10
n:	$\bar{x}$	26.9	22.1	21.3
	OR	25–29	21–24	21–22
	s	1.06	1.08	.48
	V	3.9	4.9	2.3
d:	$\bar{x}$	11.1	8.0	8.8
	OR	9–13	6–10	8–10
	s	1.25	1.54	.79
	V	11.2	19.2	9.0

to five rows (most commonly three) of dissepiments. Dissepiments are medium to large, usually globose, often elongate parallel to the carinae, rarely depressed. Lateral supports are filled with dissepiments.

The tabularium occupies from 0.5 to 0.6 the diameter and is composed of usually complete, nearly horizontal tabulae; tabulae are broadly concave axially and gently downbent periaxially.

Increase.—Lateral offsets are apparently widely spaced. Initial offset growth is nearly at right angles to the parent: full diameter is attained in 0.5 to 1 cm. In other respects the development of offsets is as described for the family as a whole.

Microstructure.—See family description.

Discussion.—The above description is based on 9 specimens; 2 are coralla measuring 19×12×9 and 7×18×15 cm in height and long and short diameters, respectively, and including 40 to 100 or more corallites. The remaining specimens are smaller fragments including from 3 to 30 or more corallites. All specimens are at least partly silicified, but parts of the larger ones are calcitic and show the microstructure very well.

Some aspects of individual variation within and between coralla is shown on table 23 and the graph (fig. 28*A*); variation in septal number in some colonies is quite restricted and outside the observed range of other colonies. Other aspects of variation were qualitatively studied, but most variation is as great within colonies or even corallites as it is within the available sample of the species.

Cylindrophyllum laxtensum differs from both *C. elongatum* and *C. propinquum* in its short major septa, numerous lateral supports, and nearly complete radial symmetry. *C. elongatum* and *C. propinquum* lack lateral supports and show frequent or occasional modifications of the cardinal and counter septa.

Distribution.—Bois Blanc Formation, Niagara Peninsula and London area, Ontario; Schoharie Formation, Albany County, N.Y.

Material.—Bois Blanc Formation, Ontario: holotype, GSC 31146; illustrated paratypes, USNM 163391, 182813, and GSC 3585a, 31147; unillustrated paratypes; USNM 163392 and GSC 31148–49. Schoharie Formation, New York; illustrated paratype, USNM 163393; unillustrated paratype, USNM 163394.

Cylindrophyllum deearium n. sp.

Plates 41–43

Occurrence of holotype.—Onondaga Limestone, Edgecliff Member, bioherm facies; central New York, 6.5 miles (10.5 km) southwest of Oneida.

Diagnosis.—Phaceloid coralla with lateral or peripheral increase; corallite diameters commonly 12 to 16 mm. Septa extend 0.6 to 0.9 the distance to axis; dissepimentarium wide, commonly composed of five to nine rows of globose dissepiments; tabulae complete.

External features.—Phaceloid coralla, as much as 30 cm or more in height and 15 by 25 cm or more in diameter, composed of subparallel, cylindrical corallites, 10 to 20 mm in diameter. Colony means (table 24 and fig. 28*C*) range from 11 to 16 mm, but are based on small samples. Contacts between neighboring corallites are common, usually at expansion of the coarse rugae, but in places the rugae are so expanded in one direction as to form lateral supports; maximum observed distance between individuals is approximately one-half corallite diameter. Increase is both lateral and peripheral, but both types of offsets are not known to occur in the same colony.

Corallites are gently to strongly rugose; longitudinal markings include broad V-shaped interseptal grooves and low rounded septal ridges. Finer longitudinal and transverse striae are seen only in particularly well preserved areas of outer wall.

Calices are relatively steep walled and flat bottomed; calice depth equals approximately one-half the corallite diameter; there is no peripheral platform.

Internal features.—Septa are biradially arranged; the cardinal-counter plane is commonly defined by short cardinal and counter septa, but the two defining septa are similar and specimen orientation is only possible in the early, conical part of a corallite where major septa are being inserted.

Major septa extend 0.6 to 0.9 the distance to the axis; they rarely meet at the cardinal-counter plane. The number of major septa ranges from 28 to 35 in cylindrical parts of corallites; the mean septal number for 8 colonies ranges from 29 to 34 (diameters 11 to 16 mm), but samples are small and the figures are only approximate (table 24 and fig. 28*C*).

TABLE 24.—Cylindrophyllum deearium, *n. sp., summary data*

		Intracolony			Intercolony
		Minimum	Maximum	Mean	
N		3	14	7.8	9
n:	$\bar{x}$	29.2	34.3	---	32.0
	OR	28–31	33–35	---	----
	s	.50	2.12	---	1.64
	V	1.5	6.9	4.3	5.0
d:	$\bar{x}$	11.2	16.2	---	14.0
	OR	9–14	13–20	---	----
	s	1.00	2.99	---	1.59
	V	6.7	18.4	12.6	11.4

Minor septa are one-half to two-thirds as long as the major. All septa are carinate in the dissepimentarium; carinae are weakly to strongly developed, commonly zigzag.

The dissepimentarium is composed of from 5 to 12, commonly 7 to 9 rows of very globose dissepiments, occupying approximately one-half the radius of the corallite. Individual dissepiments are small to medium sized, commonly elongate parallel to the carinae.

The tabularium occupies approximately one-half the diameter. Tabulae are commonly complete, flat or slightly concave axially and sharply bent downward peripherally; inclined periaxial tabulae connect the complete tabulae with the dissepimentarium.

Microstructure.—See family description.

Discussion.—The above description is based on fragments of 13 coralla; preservation is only fair and most of the specimens are partly compressed and crushed.

In comparison with other species of the genus, *Cylindrophyllum deearium* is of large diameter and has more numerous rows of dissepiments. It is intermediate in length of septa and in this respect is closest to *C. elongatum* although intracolony variation of septal length is much greater in that species.

Distribution.—*Cylindrophyllum deearium* is known from the bioherm facies of the Edgecliff Member in New York. Specimens were collected at four localities in central and eastern New York. Two specimens from the collection of the USNM and NYSM are labeled Leroy, N.Y.; these are probably from an Edgecliff bioherm also.

Additional specimens were collected from the Edgecliff nonbioherm facies at Port Colborne and Cheapside, Ontario. The species is also known from the lower Detroit River (Amherstburg) at Gorrie, Ontario.

A single specimen is known from beds, equivalent to the Moorehouse Member, in the upper part of the Columbus Limestone in the subsurface of northeastern Ohio (Lake County core).

Material.—Holotype, USNM 172190; illustrated or measured paratypes: New York, USNM 172191–93, 172243, 25870, NYSM 12819–20, 12871; Ontario, USNM 172194–95, GSC 31145, UMMP 50576. Specimen from Lake County, Ohio core: USNM 172196.

Cylindrophyllum sp. A

Plate 34, figures 8–13

part? 1961 *Cylindrophyllum* sp. cf. *C. propinquum*, Fagerstrom, p. 14, pl. 3, figs. 5, 6 (not fig. 4 which may be *C.* elongatum).

Description.—Two small corallum fragments, each including approximately six corallites, were found at the same locality; the specimens are very similar and may be fragments of one corallum.

The corallum of this form is of unknown size but includes cylindrical corallites, 13 to 14 mm in diameter and approximately parallel to each other. Increase is lateral.

The septa are radially arranged; short, diametrically opposite major septa in two of four corallites thin sectioned are presumed to be the cardinal and counter septa. Major septa extend nine-tenths or more the distance to the axis and number 21 to 23. Minor septa are 0.5 to 0.6 the length of the major septa. Weak zigzag carinae are limited to the disseptimentarium.

The dissepimentarium is composed of three to four rows of globose dissepiments and occupies approximately one-half the radius. Tabulae are incomplete and tend to be horizontal axially and irregularly inclined peripherally; spacing is two to five or more per 5 mm.

Discussion.—As shown by the graph (fig. 28*B*), *C.* sp. A is set off from other Onondaga species of *Cylindrophyllum* by having relatively few septa for its diameter. It further differs from both *C. elongatum* and *C. propinquum* in its incomplete tabulae and larger dissepiments. It is closest to *C. propinquum* in septal length and arrangement, but the low septal ratio is apparently distinct.

The only previously described *Cylindrophyllum* that is close to *C.* sp. A is one of the two specimens of *C.* sp. cf. *C. propinquum* of Fagerstrom, 1961. This specimen is closer to *C.* sp. A in septal ratio ($n=14$; $n/d=1.71$) than it is to *C.* sp. cf. *C. propinquum* but is closer to *C. propinquum* in general morphology. Possibly *C.* sp. A should be included in *C. propinquum* in spite of the noted differences.

Distribution.—Bioherm or flank facies of the Edgecliff Member in the Williamsville bioherm near Buffalo, N.Y. (loc. 108).

Material.—Illustrated specimens USNM 163395 and NYSM 12817.

Genus PRISMATOPHYLLUM Simpson

part 1900 *Prismatophyllum* Simpson, p. 218.
part 1935a *Prismatophyllum* Simpson. Lang and Smith, p. 558 (type species only).
1938 *Prismatophyllum* Simpson. Stewart, p. 48–49.
part 1939 *Prismatophyllum* Simpson. Hill, p. 229–231.
part 1939 *Prismatophyllum Simpson.* Sloss, p. 68–69.
1940 *Prismatophyllum* Simpson. Stainbrook, p. 270–273.
1940 *Prismatophyllum* Simpson. Lang, Smith, and Thomas, p. 104.

1944 *Hexagonaria* Gurich. Shimer and Shrock, p. 95.
part 1945 *Prismatophyllum* Simpson. Smith, p. 44–45.
1947 *Prismatophyllum* Simpson. LeMaitre, p. 46–47.
part 1948 *Prismatophyllum* Simpson. Wang, p. 7–8.
1948a *Hexagonaria* Gurich. Stumm, p. 7–13
part 1949 *Hexagonaria* Gurich. Stumm, p. 33.
part 1950 *Prismatophyllum* Simpson. Wang, p. 218.
1969 *Prismatophyllum* Simpson. Jell, p. 63.
1974 *Prismatophyllum* Simpson. Oliver, p. 167.

Type species.—By original designation, *Cyathophyllum rugosum* (Hall) of Milne-Edwards and Haime, 1851, p. 387, pl. 12, figs. 1, 1a, b (not *Astraea rugosa* Hall), renamed *P. prisma* by Lang and Smith, 1935a, p. 558. Jeffersonville Limestone, Coral Zone, Charleston Landing, Ind. (See species discussion.)

Diagnosis.—Cerioid coralla with polygonal corallites separated by walls. Calices commonly with an axial pit and peripheral platform. Septa radially arranged; major commonly extend to within the tabularium, though in some species they are only slightly longer than the minor septa which are more or less limited to the dissepimentarium. The septa are thin with weakly to strongly developed, zigzag to sub-yard-arm carinae. The dissepimentarium is composed of several rows of horizontal or inclined, globose dissepiments. The tabularium is formed by complete or incomplete tabulae which in some species are divided into axial flat and periaxial arched series.

Remarks.—The above diagnosis is based on a study of the type species and the other eastern North American species described or mentioned below. *Prismatophyllum* differs from *Hexagonaria,* with which it has commonly been synonymized, in its attenuate septa composed of fine monacanthine trabeculae; in addition it commonly has a relatively broad dissepimentarium. *Hexagonaria* is typically disphyllid in its characters and its gross similarity to *Prismatophyllum* is interpreted as due to parallel or convergent evolution. (See also Jell, 1969, p. 68–69.)

The generic synonymy given here is incomplete as it has not been practical to reexamine all American "*Hexagonaria*" or to exhaustively study the world literature. Most generic descriptions have been based partly on *Prismatophyllum* and partly on *Hexagonaria* and some are so broad as to include virtually any cerioid coral.

The type species of *Prismatophyllum* is *P. prisma* Lang and Smith. (See Lang, Smith, and Thomas, 1940, p. 104, for details of its selection.) Smith (1945, p. 45, not Lang and Smith, 1935a, as stated by Smith) selected the original of Milne-Edwards and Haime, 1851, plate 12, figures 1a, b, as lectotype and illustrated thin sections for the first time. These authors cited "Falls of the Ohio, Charleston Landing * * *" as type locality, apparently not realizing that this was two localities. However, the lectotype in the de Verneuil collection, École des Mines, Paris, is clearly labeled Charleston Landing. This is the Jeffersonville Limestone, and almost certainly the Middle Devonian part of the Coral Zone. Charleston Landing, Ind., is approximately 8 miles (12.8 km) northeast of the Falls of the Ohio, on the north side of the Ohio River. The following redescription of *P. prisma* is based on the lectotype plus specimens from the Falls.

Two species of *Prismatophyllum* occur in the Middle Devonian part of the Coral Zone of the Jeffersonville Limestone. The two can be differentiated on the basis of the configuration of the major septa within the tabularium in transverse sections and on the other features described below. From the Coral Zone (Zone B proper), all *Prismatophyllum* collected by me have an irregular axial complex or whorl; from the Coral-stromatoporoid Zone (Zone C), all specimens have relatively straight septa. The Milne-Edwards and Haime (1851, pl. 12, fig. 1b) illustration (drawing) of the lectotype of *P. prisma* shows straight septa, but thin sections of the lectotype show clearly that *P. prisma* is the species with the axial complex or whorl. Stainbrook (1940) recognized that two species were present but was misled by the Milne-Edwards and Haime illustration. He described the species with straight septa as *Prismatophyllum prisma* and the one with the whorl as *P. cinctum* so that now *P. cinctum* is a junior subjective synonym of *P. prisma.* The second species, erroneously called *P. prisma* by Stainbrook and subsequent workers, is here synonymized with *P. ovoideum* (Davis). The latter occurs in New York, southwestern Ontario, and Ohio, as well as in the Falls area.

Prismatophyllum is very rare in New York and the Niagara Peninsula of Ontario, and for this reason the genus is treated here in less detail than some of the other genera. Two specimens of *P. ovoideum* are apparently from the Edgecliff Member, and one specimen of *P. truncata* Stewart is from the Seneca Member. These species are based on specimens from Kentucky and Ohio respectively, where coralla are more common. *P. prisma* Lang and Smith and *P. anna* (Whitfield), are described for comparison with the New York-Ontario forms, but are not known from New York or Ontario. "*Hexagonaria*" *coalita* (Rominger) from the Edgecliff Member in western

New York is a *Heliophyllum.*

No *Prismatophyllum* is known from the post-Onondaga Devonian of New York or Ontario. *Hexagonaria prisma* Lang and Smith, listed by Oliver (1951, p. 712) from the Ludlowville Formation (Givetian) in NewYork has an aulos and is close to *Eridophyllum arachnoideum* Stumm. West of New York, *Prismatophyllum* and (or) *Hexagonaria* are common in Middle Devonian (Onondaga and Hamilton age) deposits in Michigan, Ohio, Indiana, and Kentucky.

The paucity of *Prismatophyllum* in New York, even in bioherm and biostrome facies, is difficult to explain, especially as the rest of the New York corals have much in common with the more western faunas. This is discussed more fully in the section on paleoecology.

Hexagonaria is not known to occur in the Onesquethaw Stage of eastern North America. *Hexagonaria* occurs, along with *Australophyllum* and a variety of chonophylloid corals, in the Miami Bend Formation of Cooper and Phelan (1966), Cazenovia Stage, Indiana. These Old World forms are associated with Old World brachiopods and mollusks (Cooper and Phelan, 1966) and apparently represent an incursion from western North America. In Michigan, the correlative Rogers City Limestone contains many of the same species (Cooper and Phelan, 1966) including the same *Hexagonaria.* In Michigan, the Cazenovia-Tioughnioga age Traverse Group includes a succession of faunas, some of which are dominated by Old World forms including *Hexagonaria.* Eastern forms are also present and the details of this faunal mixing are still unclear. The Traverse species of *"Hexagonaria"* were reviewed by Stumm (1970). Some of these are certainly *Prismatophyllum,* but a detailed restudy has not yet been undertaken. The late Middle Devonian species from Iowa (Cedar Valley Limestone) described by Stainbrook (1940) are mostly *Prismatophyllum* but may include some *Hexagonaria.* These too need reexamination.

I have not reviewed the several species of *Hexagonaria* that have been described from Lower and Middle Devonian rocks in western North America or those from the North American Frasnian. I do not know that any are *Prismatophyllum,* but close reexamination is needed to identify many of them, and this is beyond the limits of the present study.

Generic range.—*Prismatophyllum* is presently known only from rocks of middle Onesquethaw (Schoharie; Emsian) to Taghanic (Hamilton and Tully; Givetian) age in the Eastern North American Province. Possible occurrences in western North America and in the Upper Devonian need to be restudied.

Prismatophyllum prisma Lang and Smith

Plates 46–48

part 1851 *Cyathophyllum rugosum* (Hall). Milne-Edwards and Haime, p. 387, pl. 12, fig. 1a–b (fig. 1) (not *Astrea rugosa* Hall, 1843, which is an *Asterobillingsa*).

not 1879 *C. rugosum* Edwards and Haime. Quenstedt, p. 529, pl. 162, fig. 31a–b (=*P. ovoideum*).

not 1887 *C. rugosum* (Hall). Davis, pl. 90, fig. 1, pl. 93, fig. 3 (see *P. ovoideum*).

1900 *Prismatophyllum rugosum* (Edwards and Haime). Simpson, 1900, p. 218 [not figs. 44, 45] (cited as type species of *Prismatophyllum* new genus).

1935a *P. primsa* Lang and Smith, p. 558–559, (not figs. 17 and 18 which are diagramatic) (as new name for *Prismatophyllum rugosum* Milne-Edwards and Haime of Simpson 1900).

not 1938 *P. prisma* Lang and Smith. Stewart, p. 50–51, pl. 9, figs. 13–15 (see *P. ovoideum*).

not 1940 *P. prisma* Lang and Smith. Stainbrook, p. 273–275, pl. 37, figs. 1, 2, 4 (see *P. ovoideum*).

1940 *P. cinctum* Stainbrook, p. 275–276, pl. 37, figs. 3, 5, 6, pl. 36, fig. 4.

not 1944 *Hexagonaria prisma* (Lang and Smith). Shimer and Shrock, p. 95, pl. 30, figs. 11, 12 (see *P. ovoideum*).

1945 *P. prisma* Lang and Smith. Smith, p. 45–46, pl. 14, figs. 1–3 (originals of figs. 2 and 3, not seen).

not 1948a *H. prisma* (Lang and Smith). Stumm, p. 17–18, pl. 1, figs. 1, 2, pl. 8, figs. 1–7 (see *P. ovoideum*).

1948a *H. cincta* (Stainbrook). Stumm, p. 23–24, pl. 10, figs. 1, 2.

1949 *H. prisma* (Lang and Smith). Stumm, pl. 15, figs. 14, 15.

1955 *H. cincta* (Stainbrook). Stumm, cards 170, 171.

1955 *H. prisma* (Lang and Smith). Stumm, cards 209, 210.

not 1955 *H. prisma.* Carman, p. 70, fig. 3 (cf. *Eridophyllum*).

not 1958 *H. prisma* (Lang and Smith. Cranswick and Fritz, p. 39–40, pl. 2, fig. 1 (a crushed specimen of *Asterobillingsa* sp.).

1965 *H. cincta* (Stainbrook). Stumm, p. 43, pl. 38, figs. 10–12.

not 1965 *H. prisma* (Lang and Smith). Stumm, p. 44, pl. 38, figs. 7–9 (see *P. ovoideum*).

1966 *H. mesocincta* Fraunfelter, p. 347–351, figs. 3, 4.

Occurrence of type material.—The lectotype is clearly labeled as from Charleston Landing, Ind.

This is the Jeffersonville Limestone. At the Falls of the Ohio, 8 miles (12.8 km) down river from Charleston Landing, the species occurs only in the Middle Devonian Coral Zone (Zone B). (See distribution discussion below.)

Diagnosis.—*Prismatophyllum* with medium-sized corallites in which the major septa extend to, or nearly to the axis where (in transverse section) they appear to form an irregular network or whorl that in some individuals is almost an aulos.

External features.—Cerioid colonies are as much as several feet in diameter and 2 to 3 feet (0.61 to 0.91 m) in thickness. Smaller colonies are lens shaped, circular in plan view, with diameter three or four times the maximum thickness. Corallites are polygonal with straight sides except in offsets. Corallite diameters range from 8 to 18 mm, mean diameters in eight coralla range from 11.5 to 15.8 mm (table 25 and fig. 29*A*).

Calices are known only in longitudinal sections; shallow, depth approximately equal to tabularium diameter; walls may be uniformly sloping or with narrow peripheral platform or slightly reflexed. A low boss formed by the twisted ends of the major septa may have appeared in some calices.

Internal features.—Septa radially arranged, straight to somewhat irregular in dissepimentarium. The major septa extend to or nearly to the axis where they turn to form an irregular network or a loose whorl. Minor septa are 0.5 to 0.8 the length of the majors. Major septa number 19 to 27 in presumably mature corallites; mean number in eight coralla ranges from 21 to 24 (table 25 and fig. 29*A*). In a few corallites a short major septum is flanked by long minor septa; these may mark the counter position.

Major and minor septa are commonly heavily carinate in the dissepimentarium with long zigzag or subyard-arm carinae. Locally, dilation tissue may almost bury the carinae. Major septa are lightly dilated in the tabularium. A few septa are incomplete at their peripheral ends, forming small lonsdalioid areas.

Corallite walls commonly thin (0.1 to 0.15 mm, locally as much as 0.4 mm), composed of a dark central zone and light-colored outer zones. Adjacent corallites are everywhere in contact.

The dissepimentaria occupy one-half or more of the corallite radius and consist of from four to eight rows of small to medium-large globose dissepiments. The septal carinae are prominent features of the dissepimentaria in most longitudinal sections.

The tabularia occupy from one-third to one-half the diameter. In most longitudinal sections the tabulae appear to be separated into a periaxial series of commonly complete, concave tabulae and an axial series of incomplete convex or concave tabulae. The periaxial tabulae are bounded by the dissepimentarium and the axial complex; the axial tabulae are within the axial complex where they are interrupted by the irregular septa.

Increase.—Increase is lateral or peripheral, but nonparicidal. Seen in transverse section, offsets commonly appear as a distinct bulge in the hysterocorallite wall and development is the same as in phaceloid craspedophyllids except that growth is within a confined space. One example of two contemporaneous offsets is known that appears to represent peripheral rather than lateral increase. Peripheral increase may be represented in one illustrated colony (pl. 47, fig. 4; note base of central corallite).

Microstructure.—As for the family. Corallite walls are thin but show the three-layer structure very clearly. The light layers are distinctly fibrous with the fibers at right angles to the wall. Septal dilation within the dissepimentarium is extreme in some parts of some colonies. Locally, dilation tissue may completely envelope the very long carinae

TABLE 25.—*Prismatophyllum prisma Lang and Smith, summary data*

		Intracolony			Intercolony	Lectotype BMNH R31730
		Minimum	Maximum	Mean		
N		5	12	---	8	[1] 4(3)
n:	$\bar{x}$	20.7	24.0	---	22.5	22.5
	OR	19–22	20–27	---	20.7–24.0	21 –23
	s	.53	1.87	---	1.27	1.00
	V	2.2	8.4	5.7	5.6	4.4
d:	$\bar{x}$	11.5	15.8	---	13.0	12.7
	OR	8.0–16.0	9.5–18.5	---	11.5–15.8	10.0–15.0
	s	1.41	3.42	---	1.25	2.52
	V	10.8	25.3	18.7	9.6	19.9

[1] Diameter measured for only three corallites.

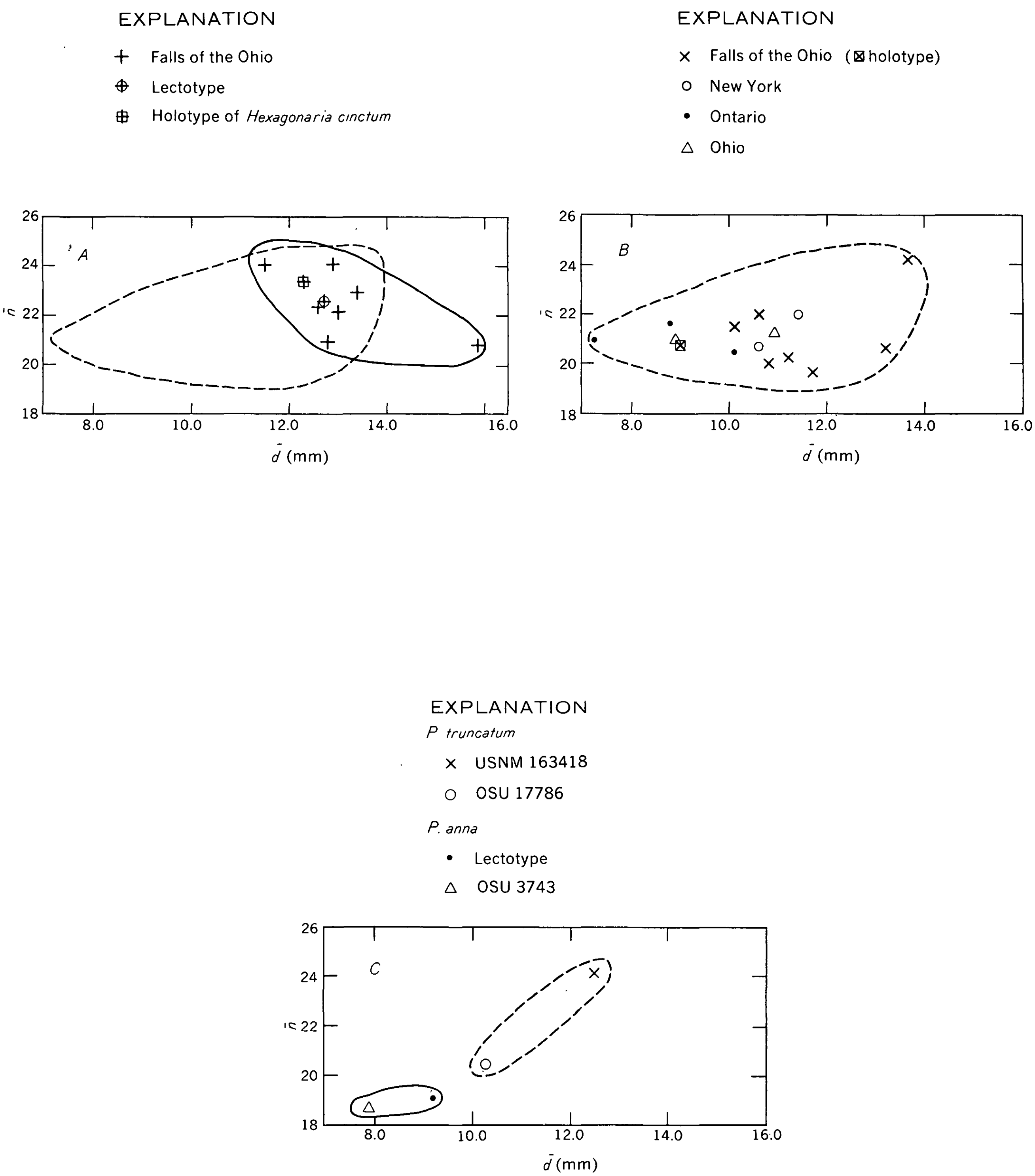


FIGURE 29.—Mean number of major septa ($\bar{n}$) versus mean diameter ($\bar{d}$) in *Prismatophyllum* spp. *A*, *P.* prisma; dashed polygon shows observed range of variation in *P. ovoideum* (see *B*). *B*, *P. ovoideum*. *C*, *P. truncata* and *P. anna*.

although the dark axial planes of the carinae can be seen if preservation is good.

Discussion.—The above description is based on 10 specimens of *Prismatophyllum prisma* from the Falls of the Ohio, in addition to 2 thin sections taken from the holotype.

Cyathophyllum rugosum Milne-Edwards and Haime was originally designated the type species of *Prismatophyllum* Simpson (1900, p. 218) who recognized that the species described by Milne-Edwards and Haime was not the same as *Astraea rugosa* Hall with which Milne-Edwards and Haime had identified their material. The Milne-Edwards and Haime species was renamed *Prismatophyllum prisma* by Lang and Smith, 1935a, and the lectotype (the original of Milne-Edwards and Haime, 1851, pl. 12, figs. 1a, b) was described and illustrated from thin sections for the first time by Smith, 1945. The specimens illustrated by Simpson are not this species.

The figures (drawings) of Milne-Edwards and Haime show straight septa within the tabularium although the lectotype sections illustrated by Smith and additional lecotype sections in the British Museum (NH) illustrated here, clearly show the axial complex or whorl described above. The original figures misled Stainbrook (1940) into describing another Falls species with straight septa as *P. prisma* and to describing the species with the axial complex as *P. cinctum.* Comparison of thin sections from the lectotypes of *P. prisma* (pl. 46, figs. 1, 2) and *P. cincta* (pl. 47, figs. 1–5) leaves no question that they are conspecific. The species with straight septa is here described as *Prismatophyllum ovoideum* (Davis).

Hexagonaria mesocincta Fraunfelter from the Grand Tower Limestone in Illinois and Missouri falls well within the range of morphologic variation of *P. prisma* and is approximately of the same age. I consider it to be a junior synonym of *P. prisma.*

Prismatophyllum prisma is particularly characterized by its axial complex or whorl and differs from most other species in this respect. The older *P. subcincta* (Stumm, 1948a) has an even better and more distinct whorl and may have been ancestral to *P. prisma. P. subcincta* was originally described from the Bois Blanc Formation in Michigan but may occur also in the lower Coral Zone (Schoharie age) at the Falls because I consider that the specimens illustrated by Davis (1887, pl. 91–92) as *Cyathophyllum colligatum* is more likely *P. subcincta* than "*H. cincta*" (=*prisma*) as stated by Stumm (1965, p. 43).

If the relationship *P. subcincta* → *P. prisma* is correct, a continuation of the trend toward a simpler axial structure could have led to *P. ovoideum,* which appears in the succeeding zone of the Jeffersonville Limestone.

All other Onesquethaw species of *Prismatophyllum* known to me have short major septa, or lack the axial complexities of *P. prisma.*

Distribution.—Milne-Edwards and Haime (1851, p. 387) included two Jeffersonville localities, the Falls of the Ohio and Charleston Landing, Ind., plus localities in Ohio, Iowa, and Michigan in their locality list for the species. Lang and Smith (1935a, p. 558), Lang, Smith, and Thomas (1940, p. 104) and Smith (1945, p. 99) all cite "Falls of the Ohio, Charleston Landing, Indiana" as the type locality without noting that the Falls and Charleston Landing were distinct and separate localities. The lectotype is clearly labeled Charleston Landing.

Five specimens of *P. prisma* collected by me in 1957 and 1961 all came from the Middle Devonian part of the Coral Zone (Zone B) at the Falls of the Ohio. Four specimens collected by Guy Campbell, and now in the U.S. National Museum, are from the same zone. The type of *P. cincta* is from the "coral zone." *Prismatophyllum* that I collected from Jeffersonville Zones A, C, D and E all belong to other species. Therefore, it seems likely that in the Jeffersonville Limestone, *P. prisma* is restricted to the early Onondaga age, Zone B.

As noted above, I consider that *P. mesocincta* Fraunfelter is *P. prisma.* The only other specimen that I have assigned to *P. prisma* is one collected from Columbus Limestone, Zone C, in a quarry 27 miles (43 km) west-southwest of Columbus. These occurrences extend the known geographic range of the species west into the Mississippi Valley and east into Ohio.

Hexagonaria prisma of Carman, 1955, from the "Columbus Limestone" in the Chillicothe test core, taken 45 miles (72 km) south of Columbus, has an imperfect but distinct aulos and is not this species.

Material studied.—Jeffersonville Limestone, Coral Zone (Zone B), Charleston Landing, Ind.: Lectotype, de Verneuil collection, École des Mines, Paris; the sections illustrated by Smith (1945) were not seen, but two thin sections from the lectotype were studied and are illustrated here (BMNH R31730 and BMNH R31731). Falls of the Ohio: Holotype of *Prismatophyllum cinctum,* SUI 21198; measured and (or) illustrated herein, USNM 163399–405; and two additional specimens. Columbus Limestone, Ohio: Coral Zone(Zone C), locality USGS 8289–SD, USNM 163406. Grand Tower Limestone, Missouri:

Holotype of *Hexagonaria mesocincta* Fraunfelter, SIUM 701.

Prismatophyllum ovoideum (Davis)

Plates 49–52

1881 *Cyathophyllum rugosum* Milne-Edwards and Haime. Quenstedt, p. 529, pl. 162, fig. 31a, b.
1887 *C. rugosum.* Davis, pl. 90, fig. 1, pl. 93, fig. 3.
1887 *C. ovoideum* Davis, pl. 93, fig. 1.
1938 *Prismatophyllum prisma* Lang and Smith. Stewart, p. 50–51, pl. 9, figs. 13–15.
1940 *P. prisma* Lang and Smith. Stainbrook, p. 273–275, pl. 37, figs. 1, 2, 4.
1944 *Hexagonaria prisma* (Lang and Smith). Shimer and Shrock, p. 95, pl. 30, figs. 11– 12.
1948a *H. ovoidea* (Davis). Stumm, p. 15–16, pl. 1, fig. 4, pl. 6, figs. 3–5.
1948a *H. prisma* (Lang and Smith). Stumm, p. 17–18, pl. 1, figs. 1, 2, pl. 8, figs. 1–7.
? 1948a *H. bathycalyx* Stumm, p. 22, pl. 2, fig. 1, pl. 9, figs. 3–4.
1965 *H. ovoidea* (Davis). Stumm, p. 44, pl. 38, figs. 4–6.
1965 *H. prisma* (Lang and Smith) Stumm, p. 44, pl. 38, figs. 7–9.

Occurrence of type material.—"Decomposed chert of the Middle Devonian near Louisville" (Davis 1887, explanation, pl. 93). Probably Zone C (Coral-Stromatoporoid Zone), at or near the Falls of the Ohio.

Diagnosis.—*Prismatophyllum* with medium-sized corallites in which the attenuate major septa extend nearly to the axis and are straight within the tabularium; zigzag carinae are short and weak.

External features.—Cerioid coralla are lens or dome shaped; available specimens are as much as 15 cm in diameter and 8 cm in height. Coralites are polygonal with straight sides in top view except on offsets. Calcitic coralla tend to break between individuals; separate corallites are prismatic with irregular rugae and larger undulations along the length of each side; septal grooves and interseptal ridges are also present. Corallite diameters in seven coralla from the Falls of the Ohio range from 7.0 to 16.5 mm; mean diameters range from 10.1 to 13.7 mm (table 26). Data from the holotype are not included in table 26 as this specimen is poorly preserved and has not been sectioned. Measurements and counts made on the surface of the holotype indicate that it falls at the smaller end of the observed range of variation ($d=8$ to 18 mm) as shown in figure 29. Studied specimens from New York, Ohio, and Ontario fall into the size range of Falls of the Ohio specimens or are smaller (table 26 and fig. 29).

Increase is lateral with offsets expanding rapidly to mature size. The calice in silicified Falls of the Ohio specimens has an axial pit, nearly flat platform, and steeply rising outer wall; total depth is one-half to two-thirds the diameter. Calice, holotheca, and other features of the corallum exterior are not known from the New York or Ontario specimens.

Internal features.—Septa are radially arranged and uniform in size, extending from the outer wall to the margin of the tabularium where the minor septa dilate slightly and terminate. The major septa are somewhat dilated in the tabularium; they extend to the axial region where most of them stop short of the axis itself. In a few corallites the major septa reach the axis and touch. Minor septa tend to be more irregular in length in smaller corallites, possibly an immature character.

The number of major septa in the Falls of the Ohio sample and in specimens from New York, Ontario, and Ohio, are shown on table 26 and figure 29. Studied specimens from New York, Ontario, and Ohio fall within the range of intercolony variation of the Falls of the Ohio sample ($n=19.6$–24.2).

Most septa are carinate in the dissepimentarium but the carinae are short and weak and even absent in some parts of the coralla. All carinae are zigzag. Where strongest, spacing of the carinae ranges from four to eight per 2.5 mm, counted on one side of a septum.

In transverse sections, the corallite walls are straight except around offsets where the walls tend to be rounded. Corallites are everywhere in contact but tend to break apart along wall midplanes in calcite specimens. Walls range in thickness from 0.1 to 0.4 mm but are commonly less thon 0.15 mm.

The tabularia range from 3 to 5 mm in diameter, averaging approximately 4 mm. Tabulae are incomplete and closely spaced. No inner and outer zones of tabellae are defined, but the inner ones tend to be horizontal whereas the outer ones are inclined toward the axis so that the overall pattern is concave.

The dissepiments are small and globose, arranged in four or more rows depending on size and local width of dissepimentarium. The rows are steeply inclined near the axis, gently inclined to almost horizontal away from the axis, but commonly steeper again at the periphery.

Microstructure.—Preservation of fine detail is poor in the available specimens, but the structure appears to be similar to that of the family. In transverse sections the midlines of septa, carinae, and walls are dark; tabulae, dissepiments, and surface layers of the septa, carinae, and walls are light and more transparent. No structural detail is well preserved in either type of tissue, but there is a suggestion that the light wall and septal tissue is composed

TABLE 26.—Prismatophyllum ovoideum (*Davis*), *summary data*

	Falls of the Ohio [1]				New York		Ontario			Ohio	
	Intracolony			Inter-colony	NYSM 12829	NYSM 12830	USNM 163414	UMMP 24178	UMMP 24176	USNM 163415	USNM 163417
	Minimum	Maximum	Mean								
N	7	16	---	7	20	15	11	9	10	7	[2] 10(5)
n: $\bar{x}$	19.6	24.2	21.2	21.2	22.0	20.7	20.5	21.6	21.00	21.0	21.3
OR	17–22	21–26	---	19.6–24.2	21–23	19–22	19–23	21–23	19–22	20–22	20–25
s	.73	1.72	---	1.59	.60	.81	1.21	.73	1.15	.82	1.57
V	3.6	7.1	5.4	7.5	2.7	3.9	5.9	3.4	5.5	3.9	7.4
d: $\bar{x}$	10.1	13.7	---	11.6	11.4	10.6	10.1	8.8	7.2	8.9	10.9
OR	7.0–12.0	8.5–16.5	---	10.1–13.7	9.0–15.0	7.0–13.5	6.0–13.0	6.7–10.5	6.0– 8.8	8.0–10.0	8.0–13.5
s	.44	2.77	---	1.36	2.01	1.62	2.02	1.34	.93	.80	2.22
V	3.3	24.5	16.9	11.7	17.6	15.3	20.0	15.3	13.0	9.0	20.4

[1] Holotype not included.
[2] *d* measured in only five corallites because of crushing.

of fibers oriented at right angles to the structural surfaces.

Discussion.—The above description is based on specimens from a wide geographic area. The largest sample (seven coralla plus the holotype) is from Jeffersonville Limestone, Zone C, and individual specimens from New York, Ontario, and Ohio add little to the observed range of variation of this sample. The holotype has the smallest corallites of any Falls of the Ohio specimen but is matched in this respect by Ontario and Ohio specimens (fig. 29).

Two fragments of this species in the collections of the New York State Museum are labeled "Onondaga Limestone, western New York." There is no rock matrix attached to either specimen but the color and preservation suggest that they were collected from the biohermal facies of the Edgecliff Member. No other specimens of the species are known from New York. Four coralla were studied from the lower Detroit River ("Amherstburg" of Ehlers and Stumm 1951) at Beachville, Ontario. Size and septal number data for the New York and three of the Ontario specimens are given in table 26 and figure 29.

Stumm (1948a, 1965) separated his *P. "prisma"* from *P. ovoideum* on the basis of the greater corallite size and septal number of the former and on various other morphological features that I consider to be a product of individual variation. *Prismatophyllum bathycalyx Stumm* may be synonymous also. The holotype has very large corallites but is poorly preserved so that other features are difficult to analyze. Septa extend to or nearly to the axis and are arranged as in *P. ovoideum.*

Distribution.—Jeffersonville Limestone, Coral-Stromatoporoid Zone (Zone C), Falls of the Ohio; Columbus Limestone,, Zone C and ?H, Ohio; Onondaga Limestone, Edgecliff(?) bioherm facies, western New York; Detroit River Group, Amherstburg Formation, Beachville, Ontario.

All specimens of *P. ovoideum* that were collected by the author are from units equivalent to the Edgecliff. Specimens illustrated by Stewart (1938, pl. 9, figs. 13–15) and Stumm (1948a, pl. 8, figs. 3, 5) from Columbus Limestone, Zone H (*Paraspirifer* Zone) in northern Ohio are apparently of this species. The precise stratigraphic position of the holotype and some other Falls specimens included in my synonymy is not known, but all specimens in my collection or in the Campbell collection (USNM) are from Zone C. The New York specimens are labeled only "western New York" but are thought to be from the Edgecliff Member on the basis of their color and preservation characters.

Material.—Falls of the Ohio, Jeffersonville Formation: Holotype, MCZ 7910; measured or illustrated herein, USNM 163407–413 (163407–412 and three other studied specimens are from Zone C, collected by Guy Campbell or by the author). Western New York, Onondaga Limestone, Edgecliff(?) bioherm facies: NYSM 12829–30 (both illustrated). Beachville, Ontario, Amherstburg Formation, Detroit River Group: USNM 163414 and UMMP 21478 (illustrated), and UMMP 24176–24177. Columbus Limestone, Zone C, Ohio: USNM 163415–417, and three other specimens.

Prismatophyllum truncata Stewart

Plates 53, 54

1938 *Prismatophyllum truncata* Stewart, p. 51–52, pl. 10, figs. 1, 2.
1948a *Hexagonaria curta* Stumm, p. 26–27, pl. 4, figs. 2, 3, pl. 12, figs. 1–6.
1948a *H. truncata* (Stewart). Stumm, p. 28–29, pl. 12, figs. 7–8.
1955 *H. curta* Stumm. Stumm, cards 178–179.
1955 *H. truncata* (Stewart). Stumm, card 223.
1965 *H. curta* Stumm. Stumm, p. 43–44, pl. 38, figs. 1–3.
not? 1970 *H. truncata* (Stewart). Brice, p. 280–281, pl. 16, figs. 3a–c.

Occurrence of type material.—Stewart (1938, p. 101) reported the holotype to be from the "Blue Limestone, Whitehouse Quarry," Lucas County, Ohio. I consider this unlikely and suspect that it probably came from the Dundee Limestone or the highest part of the Columbus Limestone (Zone H) in northern Ohio. (See discussion.)

Diagnosis.—*Prismatophyllum* with medium-sized corallites. Major septa extend just into the tabularium and minor septa are three-fourths as long to nearly equal in length; subyard-arm carinae predominate. Tabulae are complete or incomplete, more or less flat in the axial region. Dissepiments tend to be steeply inclined and elongate on the innner side of the dissepimentarium.

External features.—The only known Onondaga specimen is a fragment of a cerioid corallum that was broken before preservation; dimensions of the fragment are: length, 8 cm; width, 7 cm; height, 11 cm. No part of the exterior surface of the colony is preserved.

Longitudinal sections suggest that the calices include an axial flat area approximately one-third the diameter of the coral with walls sloping steeply upward to the margin. Calice depth is somewhat greater than the diameter of the flat axial area and there is no peripheral platform.

Diameters of 15 corallites in the specimen range from 10 to 17 mm and average 12.5 mm (table 27, and fig. 29).

Increase is lateral and frequent in the part of the colony preserved, as several offsets can be recognized by their small size and low septal number. Offsets increase rapidly to mature size.

Internal features.—Septa are radially arranged. The major septa extend only a short distance into the tabularium; the minor septa are about three-fourths as long and are restricted to the dissepimentarium. The minor septa are thinner than the major septa; all septa dilate slightly at their axial ends. In 15 corallites the number of major septa varies from 22 to 26, averaging 24.1 (table 27 and fig. 29*C*). All septa are carinate; subyard-arm carinae predominate but zigzag ones are locally common. The carinae are closely spaced, five or six per 2.5 mm being common.

The corallite walls are straight or gently curved; in detail they may or may not zigzag depending on whether the septa in adjacent corallites alternate or correspond in position. Corallite walls range in thickness from 0.2 to 0.3 mm; the thinner walls are more common.

Tabularia are comparatively large, occupying approximately one-third of the diameter. Tabulae are complete or incomplete, axially flat or gently convex, bent upwards at the margin of the tabularium.

In the peripheral one-half of the dissepimentaria, the dissepiments are small, globose, and gently inclined. Toward the tabularium they become large, elongate, and steeply inclined. The dissepimentarium is composed of from five to seven rows of dissepiments.

Microstructure.—Quality of preservation varies widely in the Onondaga specimen, part of which is silicified. Locally the calcite preservation is good enough to show that the microstructure is the same as described for the family.

TABLE 27.—Prismatophyllum truncata *Stewart and* P. anna *(Whitfield) intracolony data*

		P. truncata		*P. anna*	
		New York	Ohio	Ohio	
		USNM 163418	[1] OSU 17786	[1] UCMP 34218	OSU 3743
N		15	7	15	17
n:	$\bar{x}$	24.1	20.4	19.0	18.6
	OR	22–26	18–23	18–20	18–20
	s	1.1	1.7	.8	.7
	V	4.6	8.4	4.4	3.8
d:	$\bar{x}$	12.5	10.3	9.2	7.9
	OR	10–17	7.0–14.5	5.0–12.0	3.5–10.0
	s	1.8	2.9	2.1	2.0
	V	14.1	28.0	22.8	25.1
r		.94	.76	.42	.20
P		<.01	.05	.90	>.50

[1] Holotype.

Septa and carinae have an irregular dark midplane enveloped in light, featureless tissue which is similar to that composing the tabulae and dissepiments. The septa indent the outer wall and the light, surface tissue of the septa may be continuous with the wall tissue. The light wall tissue, however, is thicker and appears to be formed of fibers oriented at right angles to the surface of the wall. Each wall segment was built by two adjacent corallites. The deposits of each are distinct and separated by a dark mid-surface, which is more uniform in thickness than the presumed trabecular layer in the septa.

Discussion.—The above description is based on the only known New York specimen of the species. The specimen is morphologically close to the Ohio holotype with which it has been directly compared. The Ohio specimen has smaller corallite diameters and fewer septa (table 27, fig. 29*C*) and somewhat longer minor septa, but both specimens show considerable intercolony variation in these characters. Offsets in the Ohio specimen show occasional discontinuous septa, which have not been observed in the New York one.

Stewart stated that the species occurs in "hemispherical masses up to a foot or more in diameter" (1938, p. 51) and indicated that it occurs in the Columbus Limestone as well as in the "Blue" limestone (1938, p. 52). However, the only specimen in the Ohio State University type collection that can be related to Stewart's work is the holotype, consisting of two small fragments of a corallum and two thin sections cut from the fragments. The thin sections were illustrated by Stewart (1938) and by Stumm (1948a, 1955). Stumm (1948a, p. 10) lists the species from the "Blue" limestone and questionably from the Dundee Limestone.

P. truncata differs from other ENA species of *Prismatophyllum* in its short major septa and predominance of yardarm carinae. In comparison with other species that have short major septa, it is characterized by the coarse, elongate dissepiments in the inner part of the dissepimentaria. *P. truncata* is closest morphologically to *P. anna* (Whitfield) which is briefly redescribed below although it does not occur in New York or Ontario.

P. truncata differs from *P. anna* (Whitfield) in its larger corallites and greater number of septa and in its coarser and more variable dissepiments. Stewart (1938) and Stumm (1948a) separated the species on the same characters. In large collections from the "Blue Limestone" beds of the Silica Formation of Stewart (1927) near Sylvania, Ohio, I have found only *P. anna*. *P. truncata* is the common *Prismato-*

phyllum in Columbus Limestone Zone H, in north-central Ohio, and in the upper Jeffersonville Limestone at the Falls of the Ohio (where Stumm described it as *Hexagonaria curta*). Stewart cited *P. truncata* from "Columbus limestone (?): Franklin County, locs.? Blue Limestone: Lucas County" [Whitehouse quarry] (1938, p. 52) but noted the holotype to be from the latter locality (1938, p. 101).

Hexagonaria truncata (Stewart) of Brice, 1970, from the Middle Devonian of Afghanistan, is probably not this species. It differs in the nature of its carinae, in having thickened septa, and in its "tendency to become phaceloid" (Brice, 1970, p. 280). The microstructure is not described or illustrated but the thickness of the septa and the bulbous appearance of the carinae suggests coarse disphyllid trabeculae. The Afghanistan species is probably a *Hexagonaria* and unrelated to *P. truncata* Stewart.

Distribution.—*P. truncata* is the only colonial rugose coral known from the Seneca Member of the Onondaga Limestone. The single specimen was collected from above the *Chonetes lineatus* Zone (Zone J, Oliver, 1954, p. 629–631) by Professor J. W. Wells of Cornell University.

The species is common in Columbus Limestone, Zone H, in north-central Ohio and may occur in the overlying Delaware or Dundee Limestone. It also occurs in the Jeffersonville Limestone, Zones D and E at the Falls of the Ohio.

Material.—Holotype, OSU 17786; New York specimen, USNM 163418. Additional specimens from Columbus Limestone, Zone H and Jeffersonville Limestone Zones D and E in the USNM.

Prismatophyllum anna (Whitfield)

Plates 55, 56

1882 *Stylastrea anna* Whit,eld, p. 199–200.
1891 *S. anna* Whitfield. Whitfield, p. 520–521, pl. 6, figs. 1–5.
1893 *S. anna* Whitfield. Whitfield, p. 420, pl. 2, figs. 1–5.
1938 *Prismatophyllum annum* (Whitfield), Stewart, p. 49, pl. 9, figs. 11, 12.
1948a *Hexagonaria anna* (Whitfield). Stumm, p. 25; pl. 5, fig. 3; pl. 11, figs. 1–3; pl. 13, figs. 1, 2; pl. 14, figs. 3–6.
1955 *H. anna* (Whitfield). Stumm, cards 156, 157.
1967 *H. anna* (Whitfield) Stumm, p. 105–107, pl. 1, figs. 1–21.
1969 *H. anna* (Whitfield). Stumm, p. 240, pl. 10, figs. 5, 6.
1970 *H. anna* (Whitfield). Stumm, p. 82, pl. 1, figs. 1, 6, 10, pl. 2, figs, 1, 2, 6, 7, 9, 10.

Occurrence of type material.—The syntypes are from the "Upper Helderberg, Paulding Co., Ohio" (Whitfield, 1899, p. 146). According to Stewart (1938, p. 50) the specimens are probably from the "Blue" limestone layer (basal unit of Silica Formation of Stewart, 1927) rather than from the Columbus Limestone, as would be indicated by the term "Upper Helderberg."

Remarks.—This species has not not been found in New York but is included for comparison with *P. truncata* Stewart. Thin sections of some of the syntypes are here illustrated for the first time.

Diagnosis.—*Prismatophyllum* in which major and minor septa are of approximately equal length and limited to the dissepimentarium and in which the dissepiments are uniformly small and globose.

External features.—None of the specimens studied are complete or show the external characters. The largest fragment, the lectotype, measures 12 by 7 by 6 cm, parallel and at right angles to the corallite axes.

Longitudinal sections indicate that the calices have a flat or gently arched floor formed by the uppermost tabula. The floor is approximately one-third the diameter of the corallite. The sides of the calice are steep, becoming gently inclined toward the periphery. Septal ridges mark the calice walls but apparently not the floor. Calice depth is approximately the same as the diameter of the floor.

Increase is lateral, as in most other species of the genus. Corallite diameters in two coralla, range from 3.5 to 10.0 and from 5.0 to 12.0 mm, with mean diameters of 7.9 and 9.2 mm, respectively (table 27, fig. 29*C*). Inclusion of a few immature corallites affect the observed range but has no significant effect on the means.

Internal features.—The septa are radially arranged. Major septa extend to or just into the tabularium; minor septa extend nearly to the tabularium and in some corallites and parts of corallites are only slightly shorter than the major septa. There is no significant difference between major and minor septa in thickness, or in number, size, and spacing of carinae. Zigzag carinae predominate but subyardarm carinae are common; carinae are strongly to weakly developed in different parts of the same corallite. Number of major septa ranges from 18 to 20 in each corallum (table 27, fig. 29*C*).

The corallite walls are straight or gently curved; in detail they commonly zigzag as septa in adjacent corallites alternate in position. Corallite walls range in thickness from 0.1 to 0.3 mm.

Tabularia occupy more than one-third of the diameter of the corallites. Most tabulae are incomplete and gently arched. Tabularium diameters range from 3.5 to 5.0 mm.

Dissepiments are commonly small and globose, but locally are quite elongate. They are steeply inclined next to the tabularium, becoming gently inclined or horizontal at the periphery. The dissepimentaria are composed of from five to nine rows of dissepiments.

Microstructure.—Preservation of detail is poor in the specimens studied, but the septal and wall structure seem to be the same as described for the other species of the family. The wall shows the dark, uniform mid-plane with fibers at right angles to it forming light-colored tissue on either side. The septal structure is obscure with only local suggestion of a dark center line.

Discussion.—The above description, included here for comparison with *H. truncata* and to illustrate thin sections if the lectotype of *H. anna,* is based on 5 Ohio specimens from the original Whitfield collection and 16 additional specimens from the same stratigraphic unit.

Whitfield first illustrated the species in 1891 (pl. 6, figs. 1–5) and repeated the same illustrations in 1893 (pl. 2, fig. 1–5). In neither publication did he indicate whether the five figures were from one or more than one colony, nor did he indicate the number of specimens on which his species was based. In 1899, he listed the illustrated specimen(s) as being located at the University of California and referred to it (them) as "type," this suggesting that a single colony was involved (Whitfield, 1899, p. 146). Stewart based her description on two specimens labeled paratypes from the Whitfield collection in the Orton Museum, Ohio State University. Both of these were sectioned, and two sections from one specimen were illustrated. Stumm (1948a) redescribed the "paratypes" and selected one as "lectotype" (p. 26) in the belief that "Whitfield's holotype, the original of his plate 2, figures 1–5, is lost." Both Stewart and Stumm overlooked Whitfield's statement of 1899, in which he indicated the location of his specimens. Stumm (1969, p. 240, pl. 10, figs. 5, 6) briefly noted and illustrated the Whitfield type from thin sections prepared in my laboratory, but he cited them only as a paratype.

The type lot in the Museum of Paleontology, University of California, includes three fragments of coralla that are clearly the originals for Whitfield's figures 2, 4, and 5 and probably his figure 3. Whitfield's figure 1 represents a nearly complete corallum which may have been broken up to provide the sections and views shown in the other figures. (If this is so, some pieces are missing, as the remaining ones cannot be fitted together.) As more than one colony may be involved, I here select specimen UCMP 34218, a part of which was the original of Whitfield's figure 4, as lectotype. Before thin sectioning, this specimen measured 12×8×7 cm parallel and at right angles to the corallite axes. The illustrated thin sections are from this specimen. The "lectotype" selection of Stumm (1948a, p. 26) is invalidated by the existence of the specimen(s) designated as "type" by Whitfield.

Distribution.—According to Stewart (1938, p. 50) the Whitfield specimens are probably from the "Blue" limestone of the Silica Formation of Stewart (1927). Other studied specimens are from this same stratigraphic unit in northwestern Ohio. The species has been reported from the upper Dundee Limestone of the same area and from the lower part of the Traverse Group in Michigan.

Material.—Lectotype, UCMP 34218; illustrated paratypes, UCMP 34216 and 34217. Illustrated by Stewart (1938, pl. 9, figs. 11, 12) and Stumm (1948a, pl. 11, figs. 1, 2), OSU 3743–2; unillustrated specimen, OSU 3743–1. The two OSU specimens are from the Whitfield collection.

I have also examined thin sections of 16 coralla from the "Blue Limestone" near Sylvania, Ohio (USGS collns. 7333, 7776, 7778, 7779–SD).

Genus ASTEROBILLINGSA Oliver, 1974

not	1917	*Phillipsastraea* (*Billingsastraea*) Grabau, p. 957.
part	1937	*Billingsastraea* Grabau. Stumm, p. 437–438.
not	1937	*Radiastraea* Stumm, p. 439.
part	1944	*Billingsastraea* Grabau. Shimer and Shrock, p. 97.
part	1949	*Billingsastraea* Grabau. Stumm, p. 35.
not	1951	*Billingsastraea* Grabau. Prantl, p. 7–8.
part	1951a	*Billingsastraea* Grabau. Ehlers and Stumm, p. 85.
part	1953	*Billingsastraea* Grabau. Ehlers and Stumm, p. 1.
part	1955	*Billingsastraea* Grabau. Stumm, card 230.
	1956b	*Billingsastraea* Grabau. Hill, p. F280.
part	1958	*Billingsastraea* Grabau. Cranswick and Fritz, p. 41–42.
not	1958	*Billingsastraea* Grabau. Schouppé, p. 235–237.
not	1962	*Billingsastraea* Grabau. Soshkina and Dobrolubova, p. 336.
part	1964	*Billingsastraea* Grabau. Oliver, p. 2–3.
not	1965	*Billingsastraea* Grabau. Strusz, p. 547.
	1967	*Billingsastraea* Grabau. Sorauf, p. 24–25.
not	1967	*Billingsastraea* Grabau. Pickett, p. 19–20.
part	1967	*Billingsastraea* Grabau. Scrutton, p. 275–276.
	1974	*Asterobillingsa* Oliver, p. 167–168.

Type species.—Asterobillingsa magdisa Oliver. Schoharie Grit, Clarksville, N.Y.

Diagnosis.—Astreoid to thamnasterioid cylindrophyllinid corals with calices having a central pit and a broad horizontal or reflexed peripheral platform, commonly with a raised zone around the pit. Septa are radially arranged and lightly to heavily carinate with zigzag to subyard-arm carinae. Major and minor septa extend from the periphery; minor septa terminate at the outer margin of the tabularium; major septa extend to or almost to the axis. At their peripheral ends the septa abut against those of adjacent corallites, are continuous into the next corallite, or more rarely are partly discontinuous. The tabularium is narrow and composed of closely spaced, more or less horizontal, complete and incomplete tabulae. The dissepimentarium is composed of gently to strongly globose dissepiments that are horizontally arranged, except next to the tabularia where they are inclined toward the corallite axes.

Discussion.—*Asterobillingsa* was proposed to replace *Billingsastraea* Grabau which is unuseable in its conventional concept and is probably a junior synonym of *Arachnophyllum* Dana. *Billingsastraea* was established by Grabau (1917, p. 957) who merely used the word in a fossil list as "*Phillipsastraea* (*Billingsastraea*) *verneuili* E. & H." No description or other indication of his taxonomic concept was given. Clearly, the specific reference was to *Phillipsastraea verneuili* Milne-Edwards and Haime (1851, p. 447–448, pl. 10, fig. 5), stated to be from Wisconsin. The type specimen of this species has been assumed to be a drift specimen, originating in either the Onondaga or the Bois Blanc of Ontario or Michigan (Stumm, 1949, p. 35). None of the subsequent descriptions or diagnoses of the genus or species have been based on the holotype; all have been based on specimens of one or another of three species or subspecies of astreoid rugose corals from the Onondaga and the Bois Blanc in Ontario and New York.

I chose to use a new generic name for these three species and their congeners for the following reasons:

1. Inquiries and searches by interested specialists have failed to locate the holotype which is presumably in the de Verneuil Collection, École des Mines, Paris. Through the kindness and with the cooperation of Dr. P. Semenoff-Tian-Chansky, I also made an unsuccessful search for the specimen (1969). Because the specimen cannot be found and its source is not known, the generic group can be stabilized only through a new genus with a known type species.
2. Although the Milne-Edwards and Haime specimen has not been found, Dr. Semenoff located another specimen in the collection that is remarkably like the original in surface appearance (the only view of the original that was illustrated). This specimen is labeled as being from an area, now in northeastern Iowa, that was a part of the Wisconsin Territory from 1836 to 1838. This second specimen is clearly an *Arachnophyllum* and probably from the Hopkinton Dolomite (Niagaran) that outcrops in northeastern Iowa and southwestern Wissin. Therefore it is possible (even probable?) that the holotype of *Billingsastraea verneuili* would prove to be an *Arachnophyllum* if found.
3. The only known local source for a Devonian coral in Wisconsin, would be the small area of Devonian rocks at Milwaukee, Wis. However, no "*Billingsastraea*" are known from this area, and there is no indication that this area was known, or that collections from this area were available, before about 1860 (Cleland, 1911, p. 21).
4. The suggestion that the holotype of *Billingsastraea* is a drift specimen ultimately derived from Michigan or Ontario does not pass critical examination. Possible sources would be the Mackinac Straits area of the northern Lower Peninsula of Michigan, and southwestern Ontario. "*Billingsastraea*" occurs in both areas, but transportation to Wisconsin would require southwesterly and westerly glacial movement across the Lake Michigan basin. Reference to the Glacial Map of North America (Flint, 1945) and other generalized sources, suggests that ice movement was generally southerly, parallel to the Lake Michigan trough, and that a source east of the Lake is unlikely for any drift specimen found in Wisconsin. A source in the Silurian of southwestern Wisconsin is far more likely.

Any one of these reasons is an adequate argument for abandoning *Billingsastraea* and starting fresh. A new start is long overdue and is logically made by basing a new genus on a species that will maintain, insofar as is practical, the common concept of "*Billingsastraea.*" I tried to do this by basing *Asterobillingsa* on the species most often referred to as "*verneuili*" and selected a name for the genus that is reminiscent of both the first name applied to this genus by Vanuxem and the name under which it was known for so many years.

Other names that have previously been suggested to be synonyms of "*Billingsastraea*" are *Asterocycles* Vanuxem, 1842, *Radiastraea* Stumm, 1937, and *Keriophylloides* Soshkina, 1951.

Asterocycles Vanuxem and its type species (*A. confluens* Vanuxem, 1842, p. 136) were described but not illustrated. They were probably based on a specimen of *A. magdisa steorra* (described below) but the holotype is lost or unrecognizable and there is no way to be certain of its identity. Vanuxem's genus and species are indeterminate and not suitable as a replacement for *Billingsastraea.*

Radiastraea Stumm (type species *R. arachne* Stumm, 1937, p. 439–440, pl. 53, fig. 13, pl. 55, figs. 8a, b) is from the Emsian part of the Nevada Formation in Nevada. The holotype has been well described and illustrated and is available for study. Stumm originally described the form as having major septa "usually deflecting at their axial ends to form a small tubular ring," and without carinae (1937, p. 439) but later corrected his description and considered *R. arachne* to be a "weakly carinate species of *Billingsastraea*" (1949, p. 35). Most subsequent workers have agreed (for example, Oliver, 1964), but Pedder (1964, p. 446–447) and Jell (1969, p. 63) have separated the two genera, and I now agree that they are distinct although I do not necessarily accept all of Pedder's or Jell's points. *Asterobillingsa* includes a group of species that, in addition to the family characters and an astreoid-thamnasterioid form, have incomplete tabulae that form a flat or gently concave or convex pattern. Further, specimens of *A.* spp. normally have raised (reflexed) calice rims and heavily carinate septa. In contrast, *Radiastraea arachne* (pl. 66) has incomplete tabulae, some of which are strongly arched in the periaxial region. (In this respect, *Radiastraea arachne* is very similar to *Martinophyllum ornatum* Jell and Pedder, 1969, p. 736–737.) Further, *R. arachne* lacks raised calice rims and is only weakly carinate. Family assignment of *Radiastraea* is uncertain. It is not a disphyllid and may be a "paradisphyllinid" as suggested by Jell (1969, p. 63).

Keriophylloides Soshkina (type species *Keriophyllum astreiforme* Soshkina, 1936, p. 62–64, figs. 71–74; 1951, p. 102–103, pl. 19, figs. 1a–c; Eifelian, Urals) was placed in synonymy with *"Billingsastraea"* by Soshkina and Dobrolubova (1962, p. 336). However, most astreoid corals that have been assigned to *Keriophylloides* show marked septal thickening and seem to be phillipsastraeids as suggested by Jell (1969, p. 63). The morphology of the type species is unclear. The "carinae" of Soshkina are not clear in her illustrations but are unlike craspedophyllid carinae and the septa appear to break into separate strands or to become discontinuous in peripheral regions. These characters suggest that *Keriophylloides astreiforme* is quite unrelated to the Craspedophyllidae.

Prantl (1951) described two Emsian forms from Bohemia as *Billingsastraea bohemica* and *B. branikensis.* These have recently been restudied and placed in a single species of *Iowaphyllum* by Oliver and Galle (1971).

Schouppé (1958, p. 235–237) referred to *Billingsastraea* some Late Devonian corals previously included in *Phillipsastraea* but which lacked horseshoe dissepiments. These forms have a zone of septal thickening at the inner margin of the dissepimentarium and display trabecular fans. This indicates a relationship to the phillipsastraeids rather than the craspedophyllids. (See discussion by Sorauf, 1967, p. 24–25.)

Strusz (1965) and Pickett (1967) followed Schouppé's concept of the genus, basing their description primarily on Australian and European astreoid corals with dilated, fusiform septa; I consider these to be probable phillipsastraeids.

Scrutton (1967, p. 275–278) discussed *Billingsastraea* and classified it with *Marisastrum* Rózkowska, *Haplothecia* Frech, and other genera in the Marisastridae. He noted that *Billingsastraea* differed from the other genera in its unthickened septa and tentatively assigned one Devon species to *Billingsastraea* while noticing in this species "slight dilation of the septa, which are also non-carinate." I have examined Scrutton's thin sections and am of the opinion that these differences are significant and that the species is a phillipsastraeiid, possibly a *Frechastraea.*

"Billingsastraea" as used for corals of Early and Middle Devonian age in eastern North America has included astreoid forms that I interpret as belonging to two groups, cylindrophyllinids and zaphrentids. *Asterobillingsa* is established for the cyllindrophyllinids and is considered to include the following species:

Early Onesquethaw Stage

A. affinis (Billings). Grande Grève Formation, Quebec. (See Oliver, 1964.)

Middle Onesquethaw Stage

A. magdisa magdisa Oliver. Schoharie and Bois Blanc Formation, New York and Ontario; Edgecliff bioherm facies, New York.

A. rugosa (Hall). Bois Blanc Formation (?), Leroy, N.Y.

Late Onesquethaw Stage

A. magdisa steorra Oliver. Edgecliff Member, Onondaga limestone, New York and Ontario.

Tioughnioga Stage

A. canadensis (Ehlers and Stumm). Widder Formation, Ontario.

The following species that have been assigned to *Billingsastraea* in North America are considered not to be *Asterobillingsa* and tentatively reassigned as indicated:

Billingsastraea arachne (Stumm). = *Radiastraea.* (See pl. 66, figs. 1–4.)

B. billingsi (Calvin), = *Heliophyllum.*

B. confluens (Hall), = *Heliophyllum.*

B. ingens (Davis), = *Heliophyllum.* (See Stumm 1965 for synonymy.)

B. longicarinata Ehlers and Stumm, = *Heliophyllum.*

B. monticula Ehlers and Stumm, redescribed below as *Heliophyllum monticulum.*

B. nevadensis Stumm, = ?cyathophyllid.

B. pauciseptata Ehlers and Stumm, = *Heliophyllum.*

B. rockportensis Ehlers and Stumm, = *Heliophyllum.*

B. romingeri Ehlers and Stumm, = *Heliophyllum.*

B. scheii (Loewe), possibly = *Radiastraea.*

B. southworthi Ehlers and Stumm = *Heliophyllum.*

B. stirps Crickmay, probably = *Radiastraea.*

B. tapetiformis Crickmay, probably = *Radiastraea.*

B. trichomisca Crickmay, = phillipsastraeid?

B. verneuili Milne-Edwards, and Haime, = *Arachnophyllum* or unrecognizable. (See *Asterobillingsa* discussion.)

B. verrilli (Meek), = *Radiastraea.* (See Pedder, 1964.)

B. yandelli (Rominger), = *Heliophyllum.*

Distribution.—*Asterobillingsia* is known in rocks of early Onesquethaw to Tioughnioga age (late Siegenian to Givetian) in eastern North America.

Asterobillingsa magdisa Oliver, 1974

Plates 57–64

?	1842	*Asterocycles confluens* Vanuxem, p. 136 (not recognizable).
?not	1851	*Phillipsastraea verneuili* Milne-Edwards and Haime, p. 447, pl. 10, fig. 5 (not recognizable but probably an *Arachnophyllum*; see discussion).
	1859	*P. verneuili* Milne-Edwards and Haime. Billings, p. 127–128, fig. 24.
	1863	*P. verneuili* Milne-Edwards and Haime. Billings, fig. 363, p. 365.
?	1875	*P. verneuili* Milne-Edwards and Haime. Nicholson, p. 78 (probably this species because of locality).
not	1876	*P. verneuili* Milne-Edwards and Haime. Rominger, p. 128, pl. 38, fig. 2 (=*A. canadensis*).
not	1876	*P. verneuili* Milne-Edwards and Haime. deKoninck, p. 53. (Australian specimen, see discussion).
not	1898	*P. verneuili* Milne-Edwards and Haime. Whiteaves, p. 365 (probably *A. canadensis* as stated by Ehlers and Stumm, 1953, p. 3).
	1899	*P. verneuili* Milne-Edwards and Haime. Lambe, p. 250–251. ("Corniferous fm. of Ontario" specimens only).
	1901	*P. verneuili* Milne-Edwards and Haime. Lambe, p. 166–167, pl. 14, fig. 4 (but excluding specimens mentioned in text other than "Corniferous fm. of Ontario").
part	1906	*P. verneuili* Milne-Edwards and Haime. Grabau and Shimer, p. 206, fig. 107.
part	1909	*P. verneuili* Milne-Edwards and Haime. Grabau and Shimer, p. 69, fig. 107.
not	1922	*P. verneuili* Milne-Edwards and Haime. Benson, p. 150, (Australian specimen, see discussion).
part	1944	*Billingsastraea verneuili* Milne-Edwards and Haime. Shimer and Shrock, p. 97, pl. 31, fig. 7.
not	1949	*B. verneuili* Milne-Edwards and Haime. Stumm, p. 35, pl. 16, fig. 6.
part	1953	*B. verneuili* Milne-Edwards and Haime. Ehlers and Stumm, p. 2–3, pl. 1, figs. 2, 3 (reillustrated herein), (not fig. 1,=*A.* sp.).
part	1955	*B. verneuili* Milne-Edwards and Haime. Stumm, card 243.1 (not fig. 1, which is *A.* sp., and not card 243, which is not recognizable but probably an *Arachnophyllum*).
not	1956b	*B. verneuili* Milne-Edwards and Haime. Hill, p. F280, fig. 191–7.
not	1958	*B. verneuili* Milne-Edwards and Haime. Cranswick and Fritz, p. 42, pl. 2, figs. 2, 4, 7 (=*A.* sp. undet.).
	1974	*Asterobillingsa magdisa* Oliver, p. 168–170, figs. 2a–e, 3a–d.

Occurrence of holotype.—Schoharie Grit, near Clarksville, Albany County, N.Y. (USGS loc. 5891–SD).

Diagnosis.—*Asterobillingsa* with small to medium-sized corallites; major septa extend to or nearly to the axis where a few commonly meet; zigzag carinae are strongly to weakly developed on all septa within the dissepimentarium.

External features.—Astreoid colonies, small to medium sized, disk or lens shaped, as much as 30 cm or more in diameter and 12 cm or more in thickness. Corallites are irregularly prismatic, radiating to subparallel in outer parts of coralla. Corallite diameters vary, but in a single colony size variation is limited (tables 28, 29); mean diameter (d^{ax}) in 18 colonies ranges from 7.9 to 16.9 mm (fig. 30*B*).

Increase is lateral or peripheral. Offsets apparently grow rapidly as few immature individuals are seen in transverse sections of coralla.

The holotheca has been observed in only one corallum. This is an extremely rugose and irregular basal covering having concentric growth lines and fine radiating septal grooves (pl. 59, fig. 2).

Calices are crater shaped with the rim of the "crater" corresponding to the outer margin of the tabularium. Inside of the rim the calice is bowl shaped, shallow, with a gentle boss in some corallites. Outside of the rim, the calice is reflexed downward, becoming horizontal toward the edge.

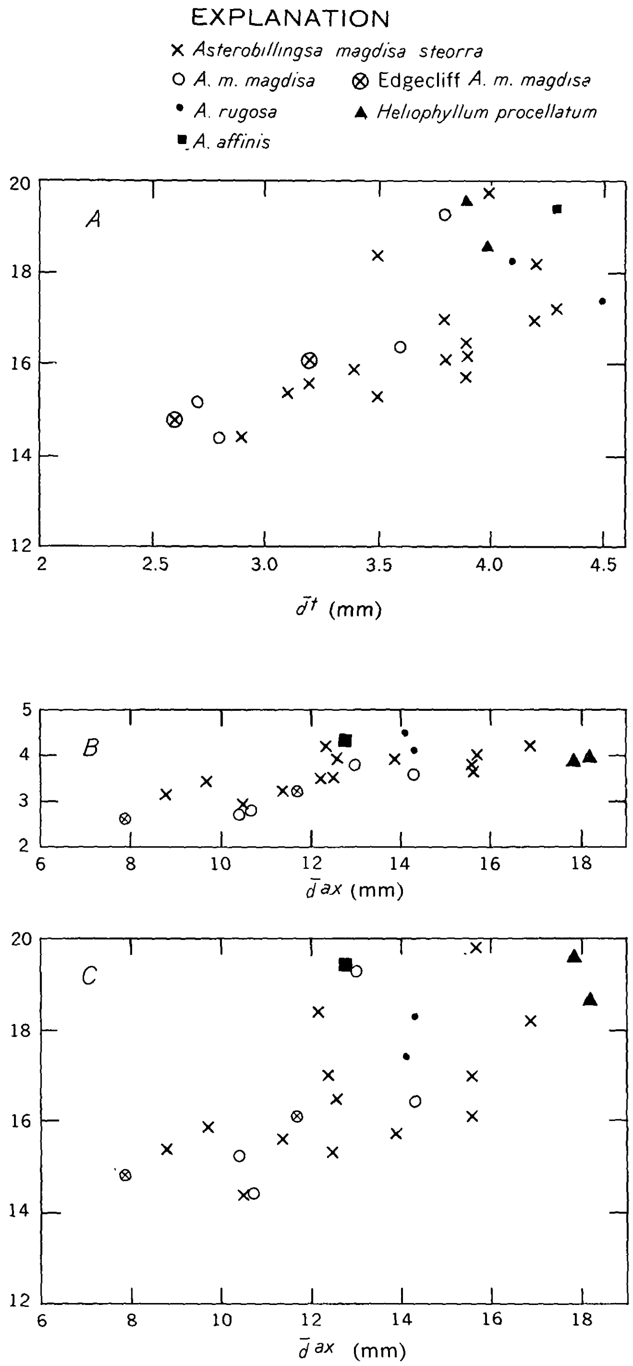


FIGURE 30.—*Asterobillingsa* spp. and *Heliophyllum procellatum* data. *A*, Mean number of major septa ($\bar{n}$) versus mean tabularium diameter ($\bar{d^t}$). *B*, Mean tabularium diameter ($\bar{d^t}$) versus mean diameter (axial distance; $\bar{d^{ax}}$). *C*, Mean number of major septa ($\bar{n}$) versus mean diameter (axial distance; ($\bar{d^{ax}}$).

Internal features.—Septa radially arranged. Major septa extend from margin of corallite nearly to the axis where two or more septa may join to form a simple axial structure. Minor septa are limited to the dissepimentarium. Peripherally the septa abut against those of the adjacent corallite or in a few places appear to be continuous with those of the next corallite; peripherally discontinuous septa are rare. All septa are attenuate and uniform in thickness in the dissepimentarium; in some colonies the major septa thicken slightly as they enter the tabularium. The average number of major septa per corallite ranges from 14 to 20 in the studied coralla (tables 28, 29 and figure 30).

TABLE 28.—Asterobillingsa magdisa magdisa *Oliver, summary data*

	Intracolony			Intercolony
	Minimum	Maximum	Mean	
N[1]	15	23	19.7	6
n: $\bar{x}$	14.4	19.3	---	16.0
OR	12–16	17–23	---	14.4–19.3
s	.8	1.5	---	1.77
V	4.9	7.8	5.8	11.1
d^t: $\bar{x}$	2.6	3.8	---	3.1
OR	2.4– 2.8	3.4 – 4.2	---	2.6– 3.8
s	.1	.2	---	.50
V	5.6	7.9	6.6	16.1
r	.18	.75	---	.89
P	.50	<.001	---	<.01
d^{ax}: $\bar{x}$	8.0	14.3	---	11.3
OR	6.4–11.0	12.2 –17.8	---	7.9–14.3
s	.9	1.6	---	2.2
V	8.7	13.7	11.4	19.6

[1] Intracolony d^{ax} based on samples of 20 corallites from each colony.

TABLE 29.—Asterobillingsa magdisa steorra *Oliver, summary data*

	Intracolony			Intercolony
	Minimum	Maximum	Mean	
N[1]	10	36	18.3	15
n: $\bar{x}$	14.4	19.8	---	16.6
OR	13–16	18–22	---	13.4–19.8
s	.7	1.4	---	1.4
V	4.4	9.3	6.3	8.4
d^t: $\bar{x}$	2.9	4.3	---	3.7
OR	2.6– 3.2	3.9 – 5.0	---	2.9– 4.3
s	.1	.4	---	.4
V	4.1	13.6	6.6	11.4
r	.05	.86	---	.62
P	.90	<.001	---	<.01
d^{ax}: $\bar{x}$	8.8	16.9	---	12.9
OR	6.4–11.2	14.0– 21.8	---	8.8–16.9
s	1.1	2.7	---	2.51
V	8.9	22.0	14.2	19.4

[1] d^{ax} data from samples of 20 corallites from each of 13 colonies.

Zigzag and scattered yard-arm carinae are long and closely spaced in most corallites of most coralla. On the sides of the septa, and in properly oriented longitudinal sections, the carinae appear as low, flangelike ridges, directed inward and upward, which are steepest toward the periphery.

The dissepimentaria occupy a large part of each corallum. In longitudinal sections the dissepiments are arranged horizontally in rows that are more or less horizontal except near the tabularia where they arch sharply upward, then downward to form a crest at the tabularium-dissepimentarium boundary.

The boundaries between adjacent corallites are not recognizable in longitudinal sections. In most parts of the coralla the dissepiments are confined to interseptal spaces, but locally the septa may be vertically discontinuous and the dissepiments large.

The tabularia are narrow; the average diameter in 21 coralla ranges from 2.6 to 4.3 mm. Tabulae are incomplete, forming a shallow W-shaped pattern that is gently arched axially and depressed peripherally. Tabulae are closely spaced, averaging several per mm.

Chronological subspecies.—Specimens of *Asterobillingsa* occurring in the Schoharie-Bois Blanc and in the Edgecliff Member are similar in most respects but generally differ in the morphology of their dissepimentaria. There are local lonsdaleoid areas in most transverse sections of the older form. These commonly occur where three or four corallites meet (pl. 60, fig. 1, and others). In longitudinal sections the dissepiments are generally larger in the older form and may be quite large where the septa are peripherally incomplete. The younger form has smaller dissepiments that are much more uniform in size and tend to be depressed.

In other morphologic features, the two forms show considerable variation but have approximately the same range of variation. Figure 30 illustrates this for corallite and tabularium diameters and septal number. In both forms the major septa may or may not meet at the axis but are similarly arranged in either form. In addition, the tabularium morphology is quite variable, but the same variations are found in both forms.

My description and analysis of *A. magdisa* and its two subspecies is based on 35 specimens. These were derived as follows:

	Dissepiments "Large"	"Small"
Schoharie	3	
Bois Blanc	3	
Bois Blanc(?)	2	
Edgecliff(?)	1	12
Edgecliff	1	10
Onondaga		3

Provenance was determined by (1) reliable field identification of stratigraphic unit by collector, (2) reliable citation of locality where only one stratigraphic unit is exposed, and (3) associated lithology for eastern New York specimens where the Schoharie and the Onondaga are easily distinguished. The Bois Blanc and the Onondaga of western New York and Ontario are less easily separated so that the stratigraphic assignments of 15 specimens are queried although I am reasonably sure that they are correct.

All known Schoharie-Bois Blanc specimens have "large" dissepiments. Two additional "large" types are probably from the Bois Blanc but one is Edgecliff and another probably Edgecliff. All of the "small" dissepiment types are Edgecliff, Onondaga, or probably Onondaga. In the following descriptions and discussions all specimens are assigned to subspecies on the basis of their morphology, although it would be equally reasonable to assign them by stratigraphic position on the assumption of overlapping ranges of variation in two successive "populations." The two apparent survivors of the early form in the Edgecliff are specially designated in figure 30, and in all plate illustrations.

Comparisons.—*A. magdisa* differs from other species of the genus in its well developed zigzag carinae, its arrangement of major septa at the axis, and its small to medium corallite size. *A. magdisa* is certainly the same as *Billingsastraea verneuili* of many authors. Specimens from the "Onondaga Limestone" in southwestern Ontario, described as *B. verneuili* by Billings (1859), Nicholson (1875), and Lambe (1899, 1901), belong to *A. magdisa* although internal features were not described and none can be assigned to a subspecies. Later descriptions of "*B. verneuili*" cited in the synonymy are discussed with the appropriate subspecies.

A. rugosa (Hall) differs from *A. magdisa* in its profusion of yard-arm carinae and axial complex. *A. canadensis* also has a higher percentage of yard-arm carinae.

Asterobillingsa magdisa magdisa Oliver, 1974

Plates 57–60

part 1953 *Billingsastraea verneuili* (Milne-Edwards and Haime) Ehlers and Stumm, p. 2–3, pl. 1, figs. 2, 3 (not fig. 1).

part 1955 *B. verneuili* (Milne-Edwards and Haime). Stumm, card 243.1 incl. figs. 2, 3 (not fig. 1 and not card 243).

1974 *Asterobillingsa magdisa magdisa* Oliver, p. 170, figs. 2a–e.

Occurrence of type material.—Schoharie Grit, Clarksville, N.Y.; USGS locality 5891–SD; collected 1961 by the author.

Diagnosis.—*A. magdisa* in which the largest dissepiments are commonly 2.0 by 0.5 mm (measured in longitudinal section) or larger; medium and small dissepiments are globose.

Discussion.—A description of this subspecies and a comparison with *A. magdisa steorra* are in the description-discussion of *A. magdisa*. The subspecies description is based on eight specimens from or probably from the Schoharie and the Bois Blanc and two from the Onondaga. These all have large dissepiments and, with one exception, are uncrushed. The exception is from the "green beds" at Port Colborne, which apparently underwent more consolidation during burial than most other stratigraphic units under discussion. (See "Stratigraphy.")

The specimen illustrated by Ehlers and Stumm (1953) and by Stumm (1955) as *Billingsastraea verneuili* from Port Colborne, Ontario, belongs to this subspecies; it is reillustrated here (pl. 58, figs. 4–6) because of its very large dissepiments. The specimen is probably from the Bois Blanc Formation.

Distribution.—Schoharie Grit, eastern New York, Bois Blanc Formation, southwestern Ontario, and Edgecliff Member, Williamsville, N.Y. The species is not common anywhere, but many additional specimens, probably of this subspecies, are preserved as molds of the colony surface in the Schoharie Grit. These have the size and septal arrangement of other Schoharie specimens but cannot be certainly identified. Museum labels indicate some of these to be from the lower Hudson Valley and are presumably from the Kanouse Sandstone (Schoharie equivalent, Boucot, 1959) in the Highland Mills area.

Material.—Schoharie Grit, eastern New York; Holotype, USNM 163419; paratypes, NYSM 12828 and AMNH 641.

Paratypes, Bois Blanc Formation, Ontario: USNM 163420–21, 163423, and GSC 31156. Paratypes USNM 128016, "Port Colborne, Ontario," and paratype NYSM 12827, "Leroy, New York" are probably Bois Blanc also (on the basis of lithology and preservation of specimens).

Paratype, Edgecliff Member, bioherm facies, Williamsville, N.Y.: USNM 163422. Paratype USNM 113264, "Port Colborne, Ontario" is probably Edgecliff (based on lithology and preservation).

Asterobillingsa magdisa steorra Oliver, 1974

Plates 61–64

1974 *Asterobillingsa magdisa steorra* Oliver, p. 170, figs. 3a–d.

Occurrence of type material.—"Corniferous Limestone, Clarksville, Albany Co., New York." Onondaga Limestone, probably Edgecliff Member, bioherm facies.

Diagnosis.—*A. magdisa* in which the largest dissepiments are relatively small (maximum size in longitudinal section 2.0 by 0.5 cm), commonly no larger than 1.0 by 0.4 mm; dissepiments tend to be depressed.

Discussion.—A description of the morphology of this subspecies and a comparison with *A. magdisa magdisa* is included in the description-discussion of *A. magdisa*. The subspecies description is based on 25 coralla or parts of coralla from or probably from the Edgecliff Member. These commonly have small dissepiments in thin layers that give a laminated appearance to broken specimens; often coralla will split along these layers. A large percentage of specimens are partly crushed; this is noted for some other bioherm species also and may indicate either a more rigorous environment or greater post-burial compaction than occurred in other stratigraphic units. *A. magdisa steorra* with larger dissepiments are less commonly crushed and *A. magdisa magdisa* is only rarely so. Possibly the forms with larger dissepiments were better engineered and more resistant to compression.

Distribution.—Edgecliff Member, bioherm facies, eastern and western New York and Niagara Peninsula of Ontario. One specimen known from Woodstock, Ontario, is probably from the "Amherstburg" Limestone. Two specimens from the "Onondaga" in eastern New York are probably from the Edgecliff and possibly bioherm facies also. Eighteen of the 25 specimens studied are from the old Fogelsanger quarry, Williamsville, N.Y. (loc. 108), but only two specimens were collected by me at this locality. Others represent museum accumulations from an often collected locality. Apparently the species is not common.

Material.—Holotype, NYSM 12824, "Corniferous Limestone, Clarksville, Albany Co., New York," probably the Edgecliff Member bioherm facies. Illustrated paratypes, USNM 172166–68; NYSM 12826; and GSC 31155. Additional measured paratypes, USNM 26000a, 113263, 172169–76; NYSM 12825; other paratypes USNM 143121 and 172177 (five coralla).

Asterobillingsa rugosa (Hall)

Plate 65

1843 *Astraea rugosa* Hall, p. 159, pl. 32, fig. 2.

not 1844 *A. rugosa* Hall. Owen, p. 33 [407], pl. 7, fig. 6 (possibly an Upper Devonian phillipsastraeid).

not 1847 *A. rugosa* Hall. Yandell and Shumard, p. 8.

not 1850 *Favastraea rugosa* (Hall). d'Orbigny, p. 107.

not 1851 *Cyathophyllum rugosum* (Hall). Milne-Edwards and Haime, p. 387, pl. 12, figs. 1, 1a–b (see *Prismatophyllum prisma*).

not 1876 *C. rugosum* (Hall). Rominger, p. 106, pl. 37, figs. 1, 2 (*Prismatophyllum* spp.)

not 1887 *C. rugosum* (Hall). Davis, pl. 90; pl. 93, fig. 3 (=*Prismatophyllum* spp.).

1953 *Billingsastraea rugosa* (Hall). Ehlers and Stumm, p. 5, pl. 2, fig. 6.

1955 *B. rugosa* (Hall). Stumm, cards 241, 241.1.
part 1958 *B. verneuili* (Milne-Edwards and Haime). Cranswick and Fritz, p. 42–43 (not the illustrated specimen).

Occurrence of holotype.—Leroy, N.Y. Probably the Bois Blanc Formation. (Statement based on lithology of specimen.)

Diagnosis.—*Asterobillingsa* with medium-sized corallites; major septa extend to the axis where they irregularly meet; long subyardarm and zigzag carinae are abundant within the dissepimentarium.

External features.—The holotype and only known New York specimen, is a partly crushed fragment of an astreoid or thamnasterioid colony 11 by 13 cm in length and width and 3.5 cm in height. The surface of the specimen is weathered so as to distort the original appearance of the colony. Sections indicate that calice pits were relatively deep (depth equaling tabularium diameter) having a high surrounding ridge and a sharply reflexed platform flattening toward the periphery. Coralite diameters (d^{ax}) range from 10 to 17 mm, average 14.3 mm (table 30, fig. 30).

Internal features.—Septa are radial or subbilateral. Major septa extend from the periphery, where they are commonly confluent with those of adjacent corallites (thamnasterioid), to the axis where they meet other septa in pairs or groups, forming irregular or distinctly bilateral patterns. Minor septa are limited to the dissepimentarium. All septa are strongly carinate within the dissepimentarium, having both zigzag and subyard-arm carinae, neither predominating. Some major septa thicken slightly in the tabularium but most septa are very attenuate throughout their length.

The number of major septa in the holotype corallum ranges from 17 to 21 in 20 corallites, average 18.3 (table 30).

TABLE 30.—Asterobillingsa rugosa *and* A. affinis *intracolony data*

		A. rugosa NYSM 299	*A. rugosa* ROM 27128	*A. affinis* GSC 3270
N[1]		20	7	16
n:	$\bar{x}$	18.3	17.4	19.4
	OR	17–21	15–19	18–21
	s	1.1	1.4	1.1
	V	6.2	8.0	5.6
d^t:	$\bar{x}$	4.1	4.5	4.3
	OR	3.5– 4.5	4.0– 4.4	3.7– 4.8
	s	.3	.28	.3
	V	6.5	6.2	6.9
r		.56	---------	.32
P		<.02	---------	.30
d^{ax}:	$\bar{x}$	14.3	14.1	12.8
	OR	10.0–17.0	10.8–18.0	9.6–15.6
	s	2.1	2.4	1.5
	V	14.5	17.3	12.0

[1] Sample size for d^{ax} is 20, 14, and 20 respectively in the three specimens.

Tabularia are narrow, occupying only slightly more than one-fourth the corallite diameter (d^t= 3.5–4.5 mm, average 4.1 mm). Tabulae are generally incomplete, nearly flat, and very closely spaced. Dissepimentaria are correspondingly broad, composed of relatively small, globose dissepiments in numerous rows.

Abitibi River Limestone specimen.—The only known specimen of *A. rugosa* other than Hall's holotype is a fragment from the Hudson Bay Lowlands that Cranswick and Fritz (1958) identified as *Billingsastraea verneuili.* This specimen is remarkably similar to the holotype in morphology and is less crushed, so that features of the longitudinal section and the contacts between corallites in transverse section are more easily observed. Numbers of septa and tabularium and corallite diameters are similar to the holotype (table 30).

Discussion.—The holotype is crushed so that the peripheral parts of corallites are broken or distorted. The Abitibi River specimen is better preserved and shows some features more clearly than the holotype.

The holotype is from Leroy, N.Y., where both Bois Blanc and Onondaga beds are exposed. One corner of the specimen is silicified; the appearance of this silicified area in thin section and the general color and preservation of the specimen as a whole is suggestive of the Bois Blanc Formation. The Abitibi River Limestone fauna described by Cranswick and Fritz (1958) certainly includes Bois Blanc forms but may include Onondaga forms as well. The combined evidence available suggests that both specimens are more likely of Bois Blanc than Onondaga age.

Figure 30 compares *A. rugosa* with *A. magdisa* and *Heliophyllum procellatum* in size characters and number of septa. *A. rugosa* is characterized by the axial arrangement of major septa and by the presence of both yard-arm and zigzag carinae in approximately equal numbers. *A. magdisa* has a simpler axial arrangement of septa, commonly with only a few septa in contact; in addition, this species has predominantly zigzag carinae. Yard-arm carinae predominate in *H. procellata* and the axial complex is very involved.

Milne-Edwards and Haime (1851) mistakenly described as *Cyathophyllum rugosum* (Hall) a species of *Prismatophyllum* from the Jeffersonville Limestone at the Falls of the Ohio. This was recognized by Simpson (1900, p. 218–220) who used the Milne-Edwards and Haime (not Hall) species as the basis for the genus *Prismatophyllum;* Lang and Smith (1935a, p. 558–559) renamed the species *P. prisma.* Citations of *Astraea* or *Cyathophyllum rugosum*(*a*) prior to 1900 are based on specimens of either *Asterobillingsa* or *Prismatophyllum* having corallites in the 8 to 15 mm diameter range. In many instances, descriptions and (or) illustrations are poor and specimens lost or unknown.

Material.—Holotype, NYSM 299. Specimen from Abitibi River Limestone, ROM 27128.

Distribution.—Known only from Leroy, N.Y., and Matagami River, Ontario. Both occurrences are probably of Bois Blanc (Emsian) age.

Asterobillingsa affinis (Billings)

1870 *Phillipsastraea affinis* Billings, p. 11
1964 *Billingsastraea affinis* (Billings). Oliver, p. 3– 4, pl. 1, figs. 1–5, pl. 2, figs. 1–4 (see for synonymy, description, and illustrations).

Occurrence of holotype.—"Indian Cove, Gaspé, in the Gaspé limestone No. 8" (Billings, 1874, p. 11). Gaspé Limestone Group, Grande Grève Formation, Indian Cove Member of Cumming (1959, p. 4, 24). Lower Devonian, "Esopus Stage," *Etymothyris* Zone of Boucot (1959, p. 737–739).

Diagnosis.—*Asterobillingsa* with medium-sized corallites; calicular pits are deep and steep sided with a low, arched floor; the platform curves gently from the pit becoming horizontal only near the periphery (not reflexed). Major septa extend nearly to axis; zigzag carinae short and abundant. Dissepiments medium sized and globose; tabulae incomplete, arched, or sagging but forming a convex pattern.

Discussion.—The holotype and only known specimen of *A. affinis* was described by Oliver (1964). This paper should be seen for a full synonymy and description with illustrations. The species is included here to complete the coverage of described Onesquethaw *Asterobillingsa* and because of its position as the earliest known craspedophyllid.

A. affinis differs from other *Asterobillingsa* in its "normal" calice shape (lacking the reflexed, outwardly sloping platform) and in having very short zigzag carinae that are, however, distinct and abundant. (See also table 30 and fig. 30).

Occurrence.—There is general agreement that the Indian Cove Member, Grande Grève Formation, is either Deerpark or early Onesquethaw in age, but recent opinion (see Oliver, 1964, p. 1; Boucot, 1968, p. 90) places it in the early Onesquethaw. In either case, *A. affinis* is of Siegenian age, whereas other known *Asterobillingsa* are Emsian or younger in age.

Material.—Holotype and only known specimen, GSC 3270.

Subfamily CRASPEDOPHYLLINAE Dybowski, 1873

Type genus.—*Eridophyllum* Milne-Edwards and Haime, 1859 (=*Craspedophyllum* Dybowski, 1873).

Diagnosis.—Solitary(?) or compound craspedophyllids with general cylindrophyllinid characters except that major septa are deflected in the tabularium to form an aulos, separating the tabularium into axial and periaxial zones. Septa are thin and strongly carinate, and may or may not enter the axial zone.

Included genera.—*Grewgiphyllum* Oliver and *Eridophyllum* Milne-Edwards and Haime.

Discussion.—The craspedophyllinids are morphologically close to the cylindrophyllinids and were probably derived from early members of that group within eastern North America. At this time, I recognize only two genera. *Eridophyllum* (=*Craspedophyllum*), with a nearly perfect aulos, is limited to the Middle Devonian of eastern North America and Morocco. Early species are all phaceloid, but later ones are solitary(?) and cerioid as well. *Grewgiphyllum* ranges from the Emsian into the lower Middle Devonian and is restricted to Eastern North America. It is characterized by an imperfect aulos and an alternately cerioid and phaceloid growth form. In these characters it is intermediate between *Eridophyllum* and the cylindrophyllinid *Prismatophyllum* (middle-upper Onesquethaw) and it seems likely that the morphologic series *Prismatophyllum* → *Grewgiphyllum* → *Eridophyllum* represents an evolutionary series as well.

Subfamily distribution.—Middle Onesquethaw through Taghanic (Emsian-Givetian) in eastern North America. One species of *Eridophyllum* is known from the Givetian of Morocco.

Genus ERIDOPHYLLUM Milne-Edwards and Haime

1850 *Eridophyllum* Milne-Edwards and Haime, p. lxxi.
1851 *Eridophyllum* M.-E. and H. M.-E. and H., p. 423–424.
1857 *Eridophyllum* M.-E. and H. Pictet, p. 459.
part 1859 *Eridophyllum* M.-E. and H. Billings, p. 130–131.
1860 *Eridophyllum* M.-E. and H. Milne-Edwards, p. 414–415.
1873b *Eridophyllum* M.-E. and H. Dybowski, p. 337.
1873b *Craspedophyllum* Dybowski, p. 339.
1873a *Craspedophyllum* Dybowski, Dybowski, p. 160.
part 1874 *Eridophyllum* M.-E. and H. Nicholson, p. 34.
1877 *Crepidophyllum* Nicholson and Thompson, p. 149–150.
1878 *Crepidophyllum* Nicholson and Thompson, Nicholson, p. 51–54.
part 1883 *Eridophyllum* M.-E. and H. Roemer, p. 356.
not 1889 *Craspedophyllum* Dybowski. Miller, p. 180.

1889 *Crepidophyllum* Nicholson and Thompson. Miller, p. 180.
1890 *Craspedophyllum* Dybowski. Sherzer, p. 59–60.
1891 *Craspedophyllum* Dybowski. Sherzer, p. 290.
1898 *Craspedophyllum* Dybowski. Grabau, p. 129.
part 1901 *Crepidophyllum* Nicholson and Thompson. Lambe, p. 154.
part 1906 *Eridophyllum* M.-E. and H. Grabau and Shimer, p. 208.
1906 *Craspedophyllum* Dybowski. Grabau and Shimer, p. 212.
1907 *Craspedophyllum*, Anderson, p. 59–66.
1907 *Eridophyllum*, Anderson, p. 65–66.
part 1909 *Eridophyllum* M.-E. and H. Grabau and Shimer, p. 71.
1909 *Craspedophyllum* Dybowski. Grabau and Shimer, p. 75.
not 1916 *Eridophyllum*, Hüffner, p. 318–319.
1927 *Eridophyllum* M.-E. and H. Smith and Lang, p. 307–308.
1933 *Eridophyllum* M.-E. and H. Smith, p. 518–519.
1935a *Eridophyllum* M.-E. and H. Lang and Smith, p. 547–548.
1938 *Eridophyllum* M.-E. and H. Stewart, p. 40.
1938 *Schistotoecholasma* Stewart, p. 45.
not 1940 *Craspedophyllum* Dybowski. Lang, Smith, and Thomas, p. 41.
1940 *Crepidophyllum* Nicholson and Thompson. Lang, Smith, and Thomas, p. 42.
1940 *Eridophyllum* M.-E. and H. Lang, Smith, and Thomas, p. 58.
1940 *Schistotoechelasma* Stewart. Lang, Smith, and Thomas, p. 117.
not 1941 *Eridophyllum*, Hill, p. 270–271.
not 1942b *Eridophyllum*, Hill, p. 186.
1944 *Eridophyllum* M.-E. and H. Shimer and Shrock, p. 89.
1947 *Eridophyllum* M.-E. and H. LeMaitre, p. 36.
1949 *Eridophyllum* M.-E. and H. Stumm, p. 37–38.
part 1950 *Eridophyllum* M.-E. and H. Wang, p. 223.
1952 *Eridophyllum* M.-E. and H. Lecompte, p. 475.
1954 *Eridophyllum* M.-E. and H. Stumm, p. 3.
1955 *Eridophyllum* M.-E. and H. Stumm, card 306.
1956b *Eridophyllum* M.-E. and H. Hill, p. F282.
not 1957 *Eridophyllum*, Ivania (not seen, but see discussion).
not 1960 *Eridophyllum*, Zheltonogova and Ivania, p. 379–380.
not 1962 *Eridophyllum*, Soshkina and Dobrolubova, p. 336.

Type species.—By original designation, *E. seriale* Milne-Edwards and Haime, 1850, p. lxxi; erroneously renamed *E. verneuilanum* by Milne-Edwards and Haime, 1851, page 424, plate 8, figures 6, 6a. Devonian, Columbus, Ohio. Generally assumed to be from the Middle Devonian Columbus Limestone. (See following discussion.)

Diagnosis.—Solitary or compound corals with general cylindrophyllinid characters except that the major septa are deflected to form a complete or nearly complete aulos separating the tabularium into periaxial and axial zones. Septa are carinate and ordinarily do not enter the axial zone.

Description.—Solitary, phaceloid, and cerioid species have been described. "Solitary" forms often form small colonies having from one to a few offsets. Most species are phaceloid and composed of cylindrical corallites that are or are not connected by lateral projections of the corallite wall. Increase is lateral and nonparricidal.

Growth lines are fine and (or) coarse and some species are quite rugose. Longitudinal septal grooves are inconspicuous.

Calices are deep with steep walls, but the aulos forms an axial boss in some species.

Major and minor septa are lightly to heavily carinate in the dissepimentarium, carinae are commonly zigzag but subyard-arm carinae are prominent in some species. Major septa do not extend to axis but are deflected to form an inner wall, the aulos; minor septa do not extend as far as the aulos. All septa are radially arranged except that the aulos may create a secondary bilateral symmetry.

The aulos is commonly open in immature individuals, but may be open or closed in ephebic individuals. The opening, when present, is most commonly (possibly always) at the position of the cardinal septum. Rarely, two openings are present, presumably cardinal and counter.

The dissepimentarium is composed of a few to several rows of normal, globose dissepiments. The tabularium is divided into two zones by the aulos. Tabulae within the aulos are commonly complete and horizontal but may be incomplete and inclined. Tabulae outside of the aulos are complete or incomplete and horizontal or inclined.

Increase.—Increase is lateral in all known phaceloid species; increase analagous to peripheral increase is known in one cerioid species. (See Stumm, 1954, pl. 2, fig. 2). Lateral offsetting in phaceloid species is similar to that in phaceloid cylindrophyllinids. Commonly the offset aulos is open in the direction of the parent, although this opening does not necessarily correspond to the position of the ephebic opening in the offset individual. The opening of the parental aulos (if present) may be unrelated to the position of the offset; a secondary opening may form temporarily at the offset position.

Immature corallites tend to have relatively large auloi, in some specimens actually larger than the adult aulos. Immature auloi are invariably(?) open and commonly the positions of septal insertion can be identified. In all examples studied, the aulos opening is in the cardinal position.

In the earliest stages of offset development (pl. 72, figs. 3, 4) no aulos is present and atavo- and neotissue are formed as in the cylindrophyllinids.

Microstructure.—Craspedophyllid type. See general description.

Discussion.—*Eridophyllum* was described by Milne-Edwards and Haime (1850) who named *E. seriale* as type species. The same authors later described *E. verneuilanum* as type but this is clearly the same species as *E. seriale* and is a junior objective synonym in addition to being an erroneous type designation. The holotype of *E. seriale* is from the "Devonian, Columbus, Ohio." This can only be the Columbus Limestone, but the Columbus contains at least four species of the genus at different stratigraphic levels. The growth habit illustrated by Milne-Edwards and Haime (1851, pl. 8, fig. 6) is characteristic of forms limited to the upper Columbus (*Paraspirifer* Zone) and it is assumed for present purposes that these forms compose *E. seriale.* The holotype specimen is thought to be in the de Verneuil collection, École des Mines, Paris, but was not found during a recent visit and search (1969).

As thus understood, *E. seriale* s.s. is rare in New York, except in the widespread *Acinophyllum-Eridophyllum* biostrome in the Mooreshouse Member.

Axinura Castelnau (1843, p. 49) has been considered by some workers as a possible senior synonym of *Eridophyllum* (for example, Lang, Smith, and Thomas, 1940, p. 25; Hill, 1956, p. F321). *Axinura* is probably unrecognizable but, in any case, should not be allowed to replace the well known and reasonably well based *Eridophyllum.*

Craspedophyllum Dybowski (1873a, b) based on "*C. americanum,* Columbus, Ohio," is a junior synonym of *Eridophyllum.* Dybowski's description of the aulos is clear and leaves no doubt as to the generic affinities of his material. Specific identification of *C. americanum* is uncertain but the species is probably based on a specimen of *E. seriale.* Craspedophyllidae Dybowski was established for corals in which the "side faces of septa were supplied with lateral outgrowths" (carinae) or "thorny outgrowths" (translated in Sherzer, 1890, p. 60). The genus was based on the presence of an inner wall (aulos).

Milne-Edwards and Haime (1850) mentioned the "inner mural investment" but emphasized the lateral connections in their first description of the genus. In 1851 they gave more attention to the inner wall and clearly illustrated it but still emphasized the profusion of lateral supports. Many subsequent workers used the name *Eridophyllum* for a variety of forms with lateral supports; others rejected the name because lateral supports were not an adequate basis for a genus.

Under this misunderstanding of *Eridophyllum,* it is not surprising that *Crepidophyllum* Nicholson and Thompson (1877) was erected to include forms with an inner wall. (But as Sherzer (1890) pointed out, these authors misunderstood Dybowski.) The type species of *Crepidophyllum* was selected by Miller (1889) and happens to be a species in which lateral supports are rare. This character was later used by some workers to separate *Crepidophyllum* from *Eridophyllum* even after it was recognized that the two nominal species were both characterized by the aulos. It is now generally accepted that the presence or absence of lateral supports is not of generic importance and that the two genera are synonyms.

Schistotoecholasma Stewart (1938) was separated from *Eridophyllum* because of the presence of an open aulos rather than a closed one, but this is a character that varies within many colonies as has been recognized by many workers. *S. obliquum* and *S. typicale* (both Stewart, 1938) are certainly conspecific and are probably the same as *E. seriale* the type species of *Eridophyllum.*

The following Onesquethaw taxa are described in the following sections:

1. *E. subseriale* Stumm; Edgecliff Member, New York.
2. *E. seriale* Milne-Edwards and Haime; Moorehouse Member, New York.
3. *E. seriale* population B; *Acinophyllum-Eridophyllum* bed, Moorehouse Member, western New York.
4. *E. aulodokum* n. sp.; middle(?) Moorehouse Member, New York.
5. *E. conjunctum* (Davis); Moorehouse Member just above *A.-E.* bed, western New York.
6. *E. corniculum* n. sp.; Moorehouse Member above *Acinophyllum-Eridophyllum* bed, western New York.

Additional *Eridophyllum* are known from the Onesquethaw-age Columbus and Jeffersonville Limestones and from various formations of Cazenovia through Taghanic age. The youngest *Eridophyllum* known to me is from the Tully Limestone in central New York.

Typical *Eridophyllum* was described from the Middle Devonian of Morocco by Le Maitre (1947), although I disagree with her assignment to *E. seriale.*

Other reports of *Eridophyllum* outside of Eastern North America are unacceptable to me.

From Turkey, Hüffner (1916, p. 318–319) briefly described "*Eridophyllum* spec. (nov. spec.?)" but did not illustrate it. I know of no further reference to this occurrence and it must be discounted.

"*Eridophyllum bartrumi*" Allen (1935, p. 4–6; Hill, 1941, p. 271–272; 1942a, p. 158) from the Middle Devonian of New Zealand and New South Wales has since been referred to *Tipheophyllum* Hill (Hill, 1956a, p. 9). The species lacks an aulos and does not appear to have craspedophyllid septal structure.

"*E. immersum*" Hill (1942b, p. 186–187) from the Devonian of New South Wales has dilated septa. An aulos is present in some individuals but appears to be formed by dilation of the axial ends of septa rather than by deflection of attenuate septa as in *Eridophyllum* s.s.

"*E. asiaticum*" Ivania (1957, p. 70–71, pl. 5, fig. 4, not seen; Zheltonogova and Ivania, 1960, p. 380; Soshkina and Dobrolubova, 1962, p. 336) from Eifelian deposits in Salair, USSR, has an irregular aulos or pseudoaulos which is tabular rather than septal in origin; the well defined innner and outer zones of tabulae are lacking.

"*E. crebrum*" Cherepnina, 1967 (p. 172, pl. 4, figs. 3, 4), from the Eifelian of the Gorny Altai, lacks any aulos. A sharp boundary between the dissepimentarium and tabularium gives the appearance of an inner wall in some transverse sections.

Distribution.—*Eridophyllum* is known only from Middle Devonian deposits in eastern North America and Morocco. Reported forms from Asia and Oceania differ significantly from the genus as clearly defined by numerous North American species. In Eastern North America, the range is from upper Onesquethaw through Taghanic.

Eridophyllum seriale Milne-Edwards and Haime

Plates 67–69

1850 *Eridophyllum seriale* Milne-Edwards and Haime, p. lxxi.
1851 *E. verneuilanum* M.-E. and H., p. 424, pl. 8, figs. 6–6a.
? 1873a *Craspedophyllum americanum* Dybowski, p. 155–159, pl. 1, figs. 1–6.
1933 *E. seriale* M.-E. and H. Smith, p. 519–520, pl. 1, fig. 12; ? figs. 13, 14.
1938 *E. seriale* M.-E. and H. Stewart, p. 41–42, pl. 8, figs. 1–4.
1938 *Schistotoecholasma obliquus* Stewart, p. 46, pl. 9, figs. 4–6.
1938 *S. typicalis* Stewart, p. 46–47, pl. 9, figs. 7–10.
not 1947 *E. seriale* M.-E. and H. LeMaitre, p. 36, pl. 6, figs. 1–5.
1954 *E. seriale* M.-E. and H. Stumm, p. 3–4, pl. 1, figs. 1–5.
1956b *E. seriale* M.-E. and H. Hill, figs. 192–1a, b.
not 1961 *E. seriale*, Fagerstrom, p. 15 (see *E. subseriale*).
part 1965 *E. seriale* M.-E. and H. Stumm, p. 46, pl. 41, figs. 2, 3, ?fig. 1.

Occurrence of type material.—According to Milne-Edwards and Haime, "Devonian, Columbus, Ohio." This is certainly the Columbus Limestone, Middle Devonian. As indicated in the following discussion, the type specimen was probably derived from the upper part of the formation, Zone H, the *Paraspirifer* Zone.

Diagnosis.—Phaceloid *Eridophyllum* with medium-sized corallites (as much as 15 mm in diameter) that are irregularly cylindrical with very numerous lateral supports. The aulos is small to medium sized, occupying as much as one-third of the corallite diameter; either open or closed.

Discussion.—*Eridophyllum seriale* was originally described from the "Devonian, Columbus, Ohio." This is assumed to be the Columbus Limestone at Columbus since *Eridophyllum* is common in the Columbus and not known from other formations in the area. Both descriptions of Milne-Edwards and Haime (1850, 1851) are very brief, and the descriptions of most characters are so generalized as to be meaningless except on the generic level. The growth form, however, is both described and illustrated—parallel corallites with numerous lateral connections, commonly lined up on the same side of each corallite. Further, the aulos is illustrated as being small and complete.

Preliminary analysis of my own and USNM collections of *Eridophyllum* from the Columbus Limestone indicates the presence of as many as six morphologic types. Two types, both from the upper part of the formation (Zone H, the *Paraspirifer* Zone), have the growth form of the type specimen and are noted below as *E. seriale* and *E. seriale* population A. The former is widespread geographically and is morphologically variable. The latter shows little variation and is known only from one bed at one locality. A third type is described as *E. seriale* population B; this also shows little variation and is restricted to the *Acinophyllum-Eridophyllum* biostrome in the Moorehouse Member, western New York.

The synonymy given above is incomplete but includes the important contributions to the present concept of *E. seriale.*

"*E. seriale*" was described from the lower part of the Detroit River Group by Fagerstrom (1961, p. 15) on the basis of a fragment of one corallite. The fragment has a very large aulos (6 mm diameter) but is decorticated so that corallite diameter is unknown (15 mm plus). The specimen is probably not identifiable but is closer to *E. subseriale* than to *E. seriale*.

LeMaitre (1947) described a specimen of *Eridophyllum* from the Givetian (Hollard, 1962) of Morocco as *E. seriale*. The specimen is the only *Eridophyllum* that has been described from outside of eastern North America. It differs from *E. seriale* in its very small diameter ($d=5.2$ mm; $n=21.5$; $N=6$) and in its narrow dissepimentarium with only two or three rows of dissepiments; it probably represents a new species.

The coralla that I interpret as belonging to typical *E. seriale* are found more or less randomly distributed through Zone H of the Columbus Limestone from Columbus to Marblehead. These have the growth form described and illustrated by Milne-Edwards and Haime but are extremely variable in internal morphology. The aulos diameter ranges from approximately 0.15 to 0.35 of the corallite diameter and may be open or closed. Aulos diameter is less variable within colonies than within the whole species, but all colonies studied have both open and closed auloi, although the ratio of open to closed varies widely. Stewart's (1938) *E. seriale, Schistotoecholasma obliquus,* and *S. typicalis* all seem to represent fragments of specimens of this species with different characters predominating.

A 6-inch (15.4-cm) coral bed at Venice, Ohio, is composed of *Eridophyllum* colonies that are very consistent in morphology. These colonies fall within the range of variation of *E. seriale* and are interpreted as representing a local population (population A). Ohio specimens of *E. seriale,* including population A, are not described here.

A similar situation exists in New York except that only two specimens of typical *E. seriale* are known, both probably from the Moorehouse Member. However, the *Acinophyllum-Eridophyllum* bed, in the upper Moorehouse, contains only *A. segregatum* and another relatively unvarying group of *Eridophyllum,* here interpreted and described as a second local population of *E. seriale* (population B). The New York material is described in the following paragraphs.

I interpret *E. seriale* as representing a generalized stock persisting through much of Moorehouse time under somewhat varying conditions. Individuals are rare in New York where conditions may have been sufficiently different to severely limit their distribution and development. *E. seriale* populations A and B represent conservative, localized developments under uniform conditions, probably with considerable inbreeding; as a result very little morphologic variation is present. The beds that they formed may have covered rather large areas, but they existed for only short periods of time.

Eridophyllum seriale population A

Diagnosis.—*E. seriale* with small aulos occupying 0.15 to 0.25 the corallite diameter; open or closed, more commonly closed but both types occurring in all studied coralla. Tabulae within the aulos widely spaced, 6 to 14 per 5 mm.

Discussion.—This form differs from typical *E. seriale* in the smaller aulos and more widely spaced tabulae. It differs from *E. seriale* population B in having both open and closed auloi.

At present, this form is known only from a 6-inch (15-cm) bed 2 feet (0.6 m) below the top of the Columbus Limestone, at Venice, Ohio. The sample studied shows relatively little variation and is tentatively treated as representing a local population temporarily isolated in space. The bed is one corallum in thickness and certainly represents a very brief period of time.

New York material

Specimen 1

Plate 67, figures 1–4

External features.—The single specimen consists of 10 or more corallites not in their original relative positions but otherwise well preserved. The corallum was phaceloid, composed of relatively straight corallites. Corallite diameters range from 10 to 19 mm, average 14.2 mm (table 31). No lateral supports have been observed, but corallites are in frequent contact. This contact suggests that they were closely spaced. Increase, calice, and external markings not known.

Internal features.—Major septa radially arranged but deflected to form an aulos; minor septa extend from 0.5 to 0.9 the distance to the aulos. Number of major septa in cylindrical parts of corallites ranges from 28 to 31, average 29.6, in 7 corallites (table 31 and fig. 31).

Septa are thin. Long zigzag carinae are common in all corallites studied; subyard-arm carinae are present in most individuals.

The aulos diameter to total diameter ratio ranges from 0.25 to 0.45, average 0.36 (table 31 and fig. 31). The aulos is circular in transverse section and is open and closed in different corallites. Where open, the cardinal septum and adjacent minor septa are free at their axial ends or are deflected to join the aulos wall. Where closed, the cardinal septum seems to split and be deflected in both directions.

The dissepimentarium occupies approximately 0.4

to 0.5 the corallite radius and is composed of from four to eight rows of globose dissepiments.

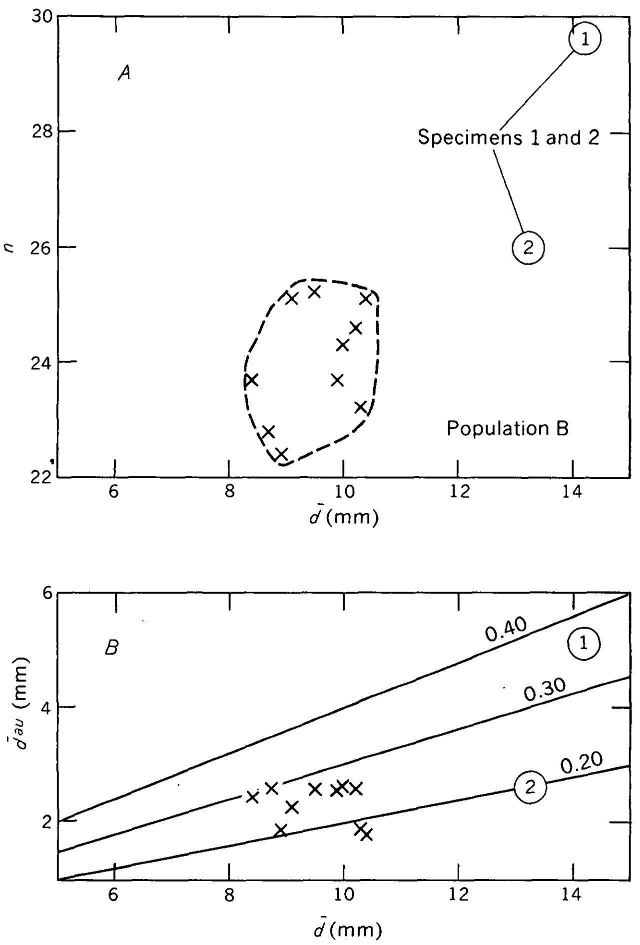


FIGURE 31.—*Eridophyllum seriale* data. *A*, Mean number of major septa ($\bar{n}$) versus mean diameter ($\bar{d}$). *B*, Mean aulos diameter ($\bar{d}^{au}$) versus mean diameter ($\bar{d}$). Straight lines are selected $\bar{d}^{au}/\bar{d}$ ratios.

The tabularium is divided into two parts by the aulos wall. The inner tabulae are complete or incomplete, flat or convex, from 4 to 13 per 5 mm. Incomplete tabulae may be short, arched plates. The outer tabulae are commonly complete, flat or concave, horizontal or inclined, from 4 to 12 per 5 mm.

Microstructure.—As for genus and family.

Discussion.—This specimen differs from other Onondaga *Eridophyllum* in the size and detailed morphology of the aulos, in the presence of long carinae, and in the large corallite size. It is comparable to several specimens of *Eridophyllum seriale* from the Columbus Limestone in Ohio, including the specimen described and illustrated by Stewart (1938) as *E. seriale.*

Material and distribution.—Illustrated specimen, USNM 163424, Moorehouse Member of Onondaga Limestone, locality 497, western New York.

Specimen 2

Plate 67, figure 5–7

External features.—A fragment is 13 cm high and 9 by 6 cm in diameter; it contains 10 or more cylindrical corallites. Spacing between corallites is less than one diameter, commonly they are in contact for part of their length. Mature corallites 11 to 15 mm in diameter; average diameter 13.2 mm (table 31 and fig. 31).

Increase is lateral and frequent in the small fragment available. Lateral supports are present.

Corallites are coarsely rugose; fine growth lines and septal grooves are also present.

Calice, known from thin sections, is moderately deep (two-thirds corallite diameter) with steep sides and a very narrow peripheral platform. A floor, corresponding to the outer tabularium, is flat; a cylin-

TABLE 31.—Eridophyllum seriale *Milne-Edwards and Haime, summary data*

		Population B				Specimen 1	Specimen 2
		Intracolony			Intercolony	Intracolony	Intracolony
		Minimum	Maximum	Mean			
N		4	14	9.0	10	7	6
n:	$\bar{x}$	22.4	25.2	---	24.0	29.6	26.0
	OR	20–24	24–26	---	22.4–25.5	28–31	25–27
	s	.76	1.58	---	1.01	1.27	.63
	V	3.1	6.4	4.8	4.2	4.3	2.4
d:	$\bar{x}$	8.4	10.4	---	9.5	14.2	13.2
d^{au}:	$\bar{x}$	7.2 – 9.7	8.4–12.3	---	8.4–10.4	10.0–18.8	11.1 –14.8
	OR	.63	1.56	---	.72	2.70	1.61
	s	6.6	15.7	11.4	7.5	19.1	12.2
	V	1.8	2.7	---	2.3	5.1	2.6
	OR	1.4 – 2.6	1.8– 3.1	---	1.8– 2.7	4.6– 5.8	1.8 – 2.9
	s	.40	.72	---	.35	.39	.40
	V	15.8	30.6	21.1	15.0	7.7	15.6
r/d:	$\bar{x}$	2.3	2.8	---	2.5	2.1	2.0
	OR	---------	---------	---	2.3– 2.8	---------	---------
d^{au}/d:	$\bar{x}$	.17	.30	---	.24	.36	.20
	OR	---------	---------	---	.17– .30	---------	---------

drical axial pit, corresponds to the inner tabularium and also has a flat bottom.

Internal features.—Septa radially arranged; major septa extend eight-tenths the distance to the axis, where they are sharply deflected to form a small, open aulos. Minor septa extend from 0.4 to 0.6 the distance to the aulos; two minor septa adjacent to cardinal (?) septum may be longer than the other minor septa. Number of major septa in six corallites ranges from 25 to 27, average 26 (table 31 and fig. 31). Septa thin to slightly dilated; zigzag and subyard-arm carinae very common.

The aulos is small, averaging only two-tenths the total diameter in six corallites (table 31). The aulos is open, presumably in the direction of the cardinal septum; the opening is occupied by only one, two, or three septa depending on whether or not the cardinal and adjacent minor septa are deflected to help form the aulos wall.

The dissepimentarium occupies approximately six-tenths of the radius and consists of seven to nine rows of globose dissepiments.

The tabularium is divided into two parts. Within the aulos, tabulae are complete, flat, or concave and are spaced four to five per 5 mm; at the aulos opening the tabulae bend downwards and rest on the next lower tabula. Outside the aulos, tabulae are concave or inclined, complete or incomplete; spacing five to eight per 5 mm.

Microstructure.—As for the genus and family, but specimen is not well preserved, and the two types of tissue are indistinct.

Discussion.—The single specimen was found in the USNM collections labeled "Albany Co., New York." The stratigraphic position is not recorded but the adhering rock is suggestive of the middle Moorehouse of this area.

The specimen is characterized by its very small open aulos and by its well-developed carinae. In these and other known characters the New York specimen is similar to the specimens described and illustrated as *Schistotoecholasma obliquus* and *S. typicalis* by Stewart (1938).

Material and distribution.—Illustrated specimen, USNM 10721, from the Onondaga Limestone, Albany County, N.Y.; horizon and exact locality unknown, but most likely the middle part of the Moorehouse Member.

Eridophyllum seriale population B

Plates 68, 69

Occurrence of typical material.—*Acinophyllum-Eridophyllum* bed, western coral facies, Moorehouse Member, Onondaga Limestone, Leroy and Stafford, N.Y.

Diagnosis.—*E. seriale* with a relatively small, closed aulos and dissepimentaria with alternate zones of small and large dissepiments. Interpreted as a population developed in a restricted area over a short period of time.

External features.—Phaceloid coralla as much as 20 or more centimetres in height and probably several times that in diameter, composed of subparallel corallites. Mature corallites irregularly cylindrical, 8 to 13 mm in diameter (colony means ranges from 8.4–10.4 mm, average 9.5 mm; table 31 and fig. 31).

Increase is lateral at infrequent intervals. Expansion is rapid and the conical stage is limited to the proximal 1.0 to 1.5 cm. Lateral supports are numerous; they tend to be closely spaced and oriented in one direction in many coralla. Corallites are irregularly rugose and the lateral supports are extensions of the coarser rugae.

Spacing of corallites within a colony varies, commonly from one-half to one diameter.

Calices not known but apparently rather broad, depth approximately one-half diameter.

Internal features.—Septa radially arranged. Major septa extend into the tabularium where they are deflected to form the aulos, which is closed in transverse section. Average number of major septa in mature corallites of 10 coralla ranges from 22.4 to 25.2 (intercolony average 24.0; table 31 and fig. 31); mature corallites have as few as 20 and as many as 28 major septa. Minor septa extend 0.5 to 0.7 the distance to the aulos.

Primary septa are not recognizable in sections through the cylindrical parts of most corallites. A short major septum, commonly "leaning" on an adjacent septum, may mark the cardinal position in some individuals. The deflection of the major septa at the aulos tends to be away from the cardinal-counter plane and marks the general position of these septa in some corallites but doesn't differentiate between them; in such corallites, the cardinal and (or) counter septa seem to split and deflect in both directions.

The aulos is circular in transverse section and almost invariably closed except in the presence of "worm" tubes. (See discussion.) The open aulos in some specimens is a pathologic condition.

The aulos is extremely irregular in any individual corallite so that shape and diameter commonly vary in successive serial transverse sections a few millimetres apart. The figures for aulos diameter given in table 31 and figure 31 are of limited value but serve to show the approximate average value and range of variation. "Colony averages" of 0.17 to 0.30 of corallite diameter indicate a relatively small aulos in comparison with other described species.

Zigzag carinae are present in all corallites but may be strongly or weakly developed. They are commonly limited to the dissepimentarium.

Septa are thin but slightly thicker peripherally.

The dissepimentarium is composed of four or more rows of globose, steeply inclined dissepiments. Both large and small dissepiments may occur in a corallite, commonly in alternating growth zones.

The tabularium is divided into two zones by the aulos. Tabulae within the aulos are flat and commonly horizontal, two to six per 5 mm. Tabulae outside the aulos are flat or concave, 6 to 11 per 5 mm.

Tabulae and dissepiments are thin.

Increase.—Lateral offsets are formed as described for the genus. The offset aulos tends to open in the direction of the parent but the parental aulos is closed throughout the offsetting stage.

Microstructure.—As for family and genus.

Variation.—Intracolony and intercolony variation in selected characters is shown in table 31 and figure 31. Samples are small because of the difficulty of finding undisturbed coralla, but semiquantitative examination of many additional specimens shows that the indicated observed ranges encompass most of the specimens collected.

Discussion.—*Eridophyllum seriale* population B and *Acinophyllum segregatum* compose the *Acinophyllum-Eridophyllum* biostrome within the western coral facies of the Moorehouse Member. The biostrome is 1 to 2 ft (0.3 to 0.61 m) thick and extends for 20 or more miles (32 or more km); the two coral species are approximately equally abundant. Comparable specimens of *E. seriale* are known from two other localities in the western Moorehouse; both are in the upper part of the member and may represent the horizon of the *Acinophyllum-Eridophyllum* bed and parts of the same population. Comparable forms are not known from central or eastern New York or from Ontario.

Within the *Acinophyllum-Eridophyllum* bed, many coralla are in growth positions but are so closely set that a continuous bed is formed. The bed is partly chertified and known only in vertical quarry walls and in one deeply weathered near-surface exposure. For these reasons, coralla boundaries cannot be recognized and samples consist of blocks of varying size removed from the bed at intervals of no less than 10 ft (3 m). Studied "colonies" may be from one corallum or from two or more intergrown coralla.

"Worm" tubes are commonly found within corallites of this species (pl. 69, figs. 6–9). The "worm" apparently lived within the tentacular ring of the coral and grew upwards with the coral. The "worm" tubes are long, straight, and hollow and are attached on their outer sides to dissepiments, tabulae, and septa within the dissepimentarium or the outer tabularium of the coral.

Corallite structures are irregular adjacent to the tubes and the aulos is commonly open toward the tube (pl. 69, fig. 9). The opening, however, is a pathologic condition resulting from the presence of the "worm." "Worm" tube microstructure consists of a thin, dark inner layer and a thicker and lighter-colored outer layer. By analogy with the structure of dissepiments and tabulae, it is clear that the tube was deposited by the coral to protect itself from the "worm" parasite. Somewhat similar tubes have been described in horn corals (Clarke, 1908, 1921) and in favositid corals (Sokolov, 1948).

Distribution.—Abundant in the *Acinophyllum-Eridophyllum* bed (rare elsewhere) in the western coral facies, Moorehouse Member, Onondaga Limestone, western New York; Middle Devonian, Eifelian.

Material studied.—Illustrated or measured specimens, USNM 163426–163435 and NYSM 12831. Additional studied specimens, USNM 5308C, D, 5308aB, 5311A, B, and 5334D; NYSM 3488–3491.

Eridophyllum subseriale Stumm

Plates 70–72

1954 *Eridophyllum subseriale* Stumm, p. 5, pl. 1, figs. 6, 7.

? 1961 *E. seriale,* Fagerstrom, p. 15, pl. 3, figs. 15, 16.

Occurrence of type material.—"Lower Onondaga Limestone; Caledonia, New York" (Stumm, 1954, p. 10). This is certainly the Edgecliff Member. Middle Devonian (Eifelian).

Diagnosis.—Phaceloid *Eridophyllum* with large, open aulos, and relatively few lateral supports.

External features.—Colonies as much as 25 or more centimetres in diameter, 15 cm or more in height; composed of radiating or subparallel corallites. Corallites closely spaced, one-half to one diameter apart, rarely in contact, with few lateral supports. Mature corallites range in diameter from 8 to 16 mm; average diameter in six reasonably well preserved coralla ranges from 9.3 to 13.5 mm, average 10.9 mm (table 32 and fig. 32).

Increase is lateral at infrequent intervals. Expansion is rapid and the conical stage is limited to the basal 1 to 1.5 cm.

Corallites are relatively smooth with subdued rugae: septal grooves very lightly marked.

Calices not known; the morphology of the dissepiments and carinae suggest that they were broad and shallow.

Internal features.—Septa radially arranged; major septa extend more than half the distance to the axis, where they are sharply deflected to form the aulos; minor septa variable, extend 0.2 to 0.7 the distance to the aulos. Number of major septa in cylindrical parts of corallites ranges from 22 to 30, average number in six coralla ranges from 23.8 to 27.7, average, 25.8 (table 32 and fig. 32).

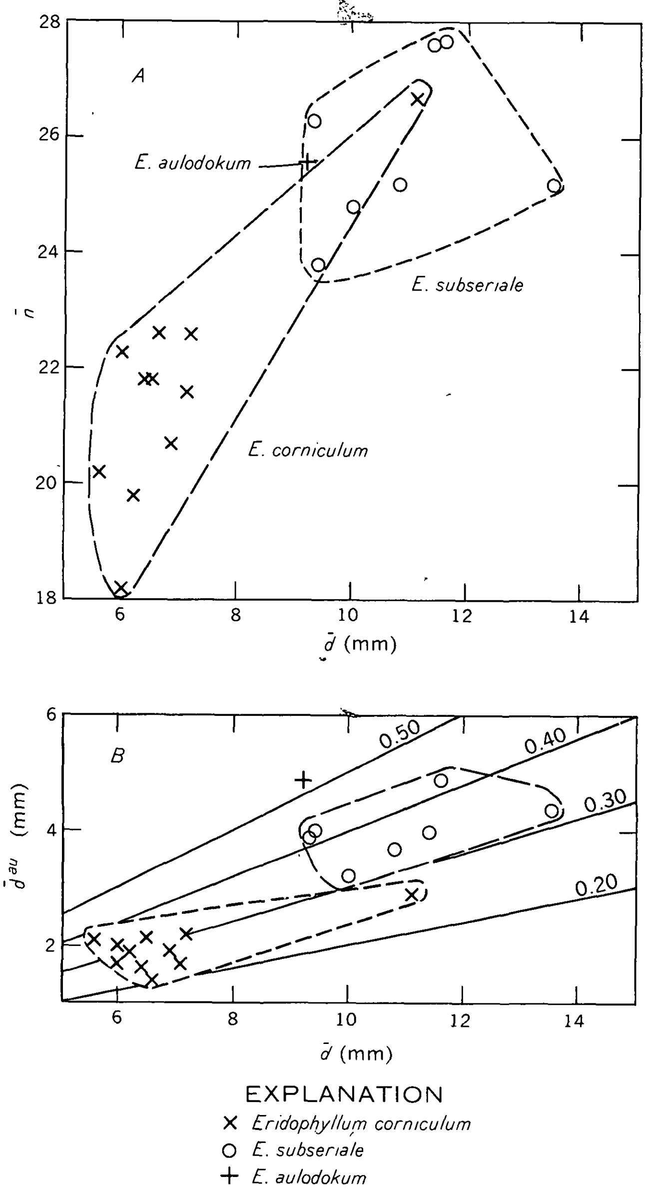


FIGURE 32.—*Eridophyllum* spp. data. *A*, Mean number of major septa ($\bar{n}$) versus mean diameter ($\bar{d}$). *B*, Mean aulos diameter ($\bar{d}^{au}$) versus mean diameter ($\bar{d}$). Straight lines are selected $\bar{d}^{au}/d$ ratios.

Septa are thin. Zigzag carinae weakly to strongly developed; present in all corallites but variably developed within corallites and coralla.

The aulos is large, averaging from 0.32 to 0.49 of total diameter in seven colonies analyzed (table 32 and fig. 32*B*). Within colonies, the aulos is rarely less than three-tenths, but may exceed five-tenths of total diameter; there is some variation along the length of individual corallites. The aulos is commonly bulb shaped in transverse section, open at the position of the cardinal septum; commonly this opening is occupied by the cardinal septum and by the two adjacent minor septa which may be longer than the other minor septa (pl. 71, fig. 3); in some transverse sections, the cardinal septum curves to one side and may join the aulos leaving a single minor septum to occupy the opening in the aulos. The counter septum is flanked by long minor septa in some corallites (pl. 71, fig. 3). The dissepimentarium occupies 0.25 to 0.40 of the corallite radius and is composed of from two to six, commonly three or four rows of globose, rarely elongate, dissepiments. The lateral supports consist of a lateral extension of normal septal and dissepimental tissue within the outbent epitheca.

The tabularium is divided into two parts. Within the aulos, tabulae are complete or incomplete, flat or slightly arched; they terminate abruptly against the aulos wall; at the opening in the aulos they bend down and rest on the next lower tabula (pl. 71, fig. 4); spacing within the aulos ranges from 2 to 11 per 5 mm. Between the aulos and the dissepimentarium, tabulae are complete or incomplete, either flat or concave, and horizontal or steeply inclined; at the aulos opening the outer tabulae terminate against the downbent inner tabulae; spacing of outer tabulae ranges from 3 to 11 per 5 mm. There is considerable variation in shape, orientation, and spacing of both inner and outer tabulae within any individual.

Microstructure.—As for the genus and family.

Increase.—Offsetting is lateral as in all species of the genus; commonly only one offset is formed, but one example of "twin" offsets is known. In transverse section the aulos in the hystero-corallite breaks at the position of the offset, commonly not the position of the cardinal break. The septa in the offset are short; the offset aulos may form after separation from the hystero-corallite, or may be partly formed before separation.

One corallite is known that was apparently formed by two polyps that failed to separate. For a length of 2 cm, the corallite is elongate in cross section (15 by 19 mm), with an elongate aulos (4.6 by 9.5 mm), two openings in the aulos (? two cardinal septa), and

TABLE 32.—Eridophyllum subseriale *Stumm and* E. aulodokum *n. sp., summary data*

		E. subseriale				*E. aulodokum*
		Intracolony				
		Minimum	Maximum	Mean	Intercolony	Intracolony
N		6	14	8.7	7	10
n:	$\bar{x}$	23.8	27.7	---	25.8	25.6
	OR	22–25	26–30	---	23.8–27.7	23–29
	s	.98	2.86	---	1.46	1.7
	V	3.9	11.5	6.1	5.7	6.7
d:	$\bar{x}$	9.3	13.5	---	10.9	9.2
	OR	8.2–10.5	12.5–16.0	---	9.3–13.5	7.9–12.0
	s	1.0	2.1	---	1.5	1.3
	V	5.8	18.2	12.6	13.6	14.1
d^{au}:	$\bar{x}$	3.2	4.9	---	4.0	4.9
	OR	2.5– 3.7	4.1– 6.0	---	3.2–4.9	3.7–6.3
	s	.4	.9	---	.5	.8
	V	13.7	22.6	17.3	13.2	16.3
n/d:	$\bar{x}$	1.9	2.8	---	2.4	2.8
	OR	---------	---------	---	1.9–2.8	---------
d^{au}/d:	$\bar{x}$	.32	.43	---	.37	.53
	OR	---------	---------	---	.32–.43	---------

nearly twice the normal complement of major septa (42; average of 11 round corallites, 25) (pl. 71, figs. 6–8). This might represent an example of incomplete fission (axial increase) or of parent and lateral offset that failed to completely separate.

Discussion.—The above description is based on more than 30 specimens but most of these are fragments containing only a few corallites. Figures in table 32 are based on 6 to 14 corallites in seven coralla including the holotype.

Eridophyllum subseriale is the only species of the genus known to occur in the Edgecliff Member. It is most common in eastern New York where specimens have been collected from nearly half of the known bioherm localities. It is known from the biostrome facies of the Edgecliff at two localities. The holotype specimen is from western New York (Caledonia), presumably from the Edgecliff Member. A number of overturned and crushed coralla were found in the top bed of the Edgecliff at a locality near Syracuse. None of these specimens are suitable for quantitative study but they indicate that the species was at least locally common in the nonbioherm facies of the Edgecliff. It is not known with certainty that the species occurs elsewhere.

Fagerstrom described as *E. seriale* a single fragment of a cylindrical corallite of *Eridophyllum* from the Formosa bioherm facies of the Detroit River Group in southwestern Ontario. Restudy of the specimen indicates that it is morphologically closer to *E. subseriale* in its very large aulos (6 mm in diameter), relatively large dissepiments, and widely spaced tabulae. Identification of the fragment is not possible, but it is tentatively placed here pending the discovery of more adequate material.

E. subseriale is characterized by its large aulos, opening at the position of the cardinal septum, and differs from most other species of the genus in this character. *Eridophyllum aulodokum,* in the Moorehouse Member, has an even larger aulos and fewer and weaker carinae. Some specimens of *E. seriale* from the Columbus Limestone and specimen 1 from the Moorehouse Member have auloi that average only slightly smaller than those of *E. subseriale,* but these may be open or closed in the same corallum. Examination of numerous coralla has convinced me that the Edgecliff and Columbus-Moorehouse forms are distinct.

Distribution.—Known only from the Edgecliff Member of the Onondaga in New York. Most specimens are from the bioherm facies in the east-central and eastern areas; a single specimen is known from the biostrome facies near Schoharie (eastern area) and 20 or more coralla are known from the top bed of the Edgecliff near Syracuse (central area). The holotype was collected from the "Lower Onondaga Limestone, Caledonia, N.Y." (Stumm, 1954, p. 10); this is almost certainly the Edgecliff Member, and is the only specimen known from the western area.

Material studied.—Holotype, UMMP 5272; illustrated or measured specimens USNM 163454–457, NYSM 12832–34; 11 additional sectioned specimens, USNM 163458a-d, 163459–462, NYSM 3492–94; nine more specimens provided additional distribution data.

Questionable specimen from the Detroit River Group, UMMP 36122 (hypotype of Fagerstrom, 1961).

Eridophyllum aulodokum n. sp.

Plate 73

Diagnosis.—Phaceloid with few or no lateral supports; very large aulos averages more than half the total diameter; carinae very weak; tabulae closely spaced.

External features.—A single specimen is in a block of limestone approximately 40 by 20 by 14 cm; the corallites are not in their original relative positions, but the corallum evidently was somewhat larger than the block. The corallum was apparently phaceloid, with straight to somewhat curved cylindrical corallites. Diameters of cylindrical parts of corallites range from 8 to 12 mm (table 32). Increase is lateral; conical stage is short. Lateral supports are rare.

Corallite exteriors are relatively smooth; septal grooves are very fine. Very fine growth lines appear on well-preserved exteriors; coarser rugae are virtually absent. Calice not known.

Internal features.—Major septa radially arranged but deflected to form a large aulos; minor septa extend 0.3 to 0.6 the distance to the aulos wall. Number of major septa in cyclindrical parts of corallites ranges from 23 to 29, average number in 10 corallites is 25.6 (table 32 and fig. 32).

Septa are thin. Zigzag carinae very weakly developed to absent.

The aulos is large, ranging from 0.46 to 0.71 of total diameter in 10 corallites, averaging 0.53 (fig. 32*B*). The aulos is bulb shaped in transverse section, open at the position of the cardinal septum; the opening is occupied by 0, 1, 2, or 3 septa, as any or all of the cardinal and the two adjacent minor septa may be deflected to help form the "neck" of the aulos. The minor septa that are adjacent to the cardinal and counter septa are commonly longer than other minor septa.

The dissepimentarium occupies approximately one-fourth of the corallite radius and is composed of from two to four rows of globose dissepiments.

The tabularium occupies approximately three-fourths the corallite diameter and is divided into two zones. Tabulae within the aulos are complete, flat or slightly concave; spacing ranges from 5 to 12 per 5 mm. Between the aulos and the dissepimentarium, tabulae are complete, and commonly concave and inclined away from the aulos; spacing averages six per 5 mm with little variation in the small sample studied.

Microstructure.—As for genus and family.

Increase.—As for genus. The position of the offset appears unrelated to the aulos opening or the cardinal position of the parent.

Discussion.—*Eridophyllum aulodokum* is known from a single block of limestone that was knocked loose during normal quarry operations but was set aside by a quarry employee and given to me while I was collecting in the quarry (loc. 112, western area). The stratigraphic position of the specimen is not known; the quarry wall exposes all but the lower few feet of the Moorehouse Member of the Onondaga Limestone and locally the basal few feet of the overlying Seneca Member. Therefore, the specimen is probably from the Moorehouse but possibly from the Seneca. A small fragment of an *Eridophyllum* from the Moorehouse Member in eastern New York is tentatively assigned to the same species.

E. aulodokum is unique in the possession of an aulos occupying more than half the corallite diameter. It differs from *E. subseriale* in its larger aulos (fig. 32), complete tabulae, and weak or absent carinae. *E. aulodokum* may have been derived from *E. subseriale* but, in the absence of more material, this is pure speculation.

E. seriale from the Moorehouse Member is larger with a relatively smaller aulos and with well developed, long carinae.

Material and distribution.—Holotype, USNM 163436, locality 112, western area, Moorehouse(?) or Seneca(?) Member. A second specimen including fragments of four corallites is tentatively assigned to this species; USNM 163437, locality 246, eastern area, upper Moorehouse Member.

Eridophyllum corniculum n. sp.

Plates 74, 75

Occurrence of type material.—Moorehouse Member of Onondaga Limestone, Harris Hill and Pembroke Station, New York.

Diagnosis.—*Eridophyllum* with an auloporoid growth habit; corallites commonly short and cone shaped. Aulos variable, tending to be medium sized and open at position of cardinal septum.

External features.—Colonies small, varying from a few individuals to several hundred; the largest known corallum is 37 by 20 cm in diameter and 6 cm in height. Most known coralla are formed of short, curved cone-shaped, reptant corallites, attached at points of lateral budding (pl. 74, fig. 5). Lateral supports are present and help to form a fairly rigid network by attaching the corallite to another corallite or to the substrate. Some coralla are only one corallite thick; each corallite rests on the substrate and curves upward so that the upper surface of the colony shows upward directed, uniformly spaced calices. Each corallite gives rise to from one to three or more offsets, commonly on the underside of the parent, just above the substrate position.

Individual corallites commonly range in length from 1 to 3 cm, but one corallum is known in which individuals lengthened to 6 or more centimetres. Diameters of mature corallites range from 5 to 13 mm (colony averages 5.6 to 11.1 mm; table 33 and fig. 32).

TABLE 33.—Eridophyllum corniculum *n. sp., summary data*

		Intracolony			
		Minimum	Maximum	Mean	Intercolony
N		5	10	6.7	11
n:	$\bar{x}$	18.2	26.7	---	21.7
	OR	17–19	24–30	---	18.2–26.7
	s	.55	1.94	---	2.15
	V	2.4	14.8	6.7	9.9
d:	$\bar{x}$	5.6	11.1	---	6.9
	OR	5.3–6.0	8.5–13.2	---	5.6–11.1
	s	.30	1.91	---	1.49
	V	5.3	28.9	13.9	21.7
d^{au}:	$\bar{x}$	1.4	2.9	---	2.0
	OR	1.1–2.0	1.9–3.6	---	1.4–2.9
	s	.23	.64	---	.40
	V	13.4	30.7	21.1	20.5
r/d:	$\bar{x}$	2.4	3.9	---	3.3
	OR	---------	---------	---	2.4–3.9
$\overline{d^{au}}/d$:	$\bar{x}$	.21	.37	---	.29
	OR	---------	---------	---	.21–.37

Corallites are strongly rugose, especially at positions of lateral supports. Shallow septal grooves and low, broad interseptal ridges are present.

Spacing of corallites ranges from zero to approximately one diameter.

Calices are broad and shallow with an axial pit, corresponding to the tabularium, a rather steep inner wall, and a gently sloping to nearly flat peripheral platform.

Internal features.—Septa radially arranged. Major septa extend 0.6 to 0.8 the distance to the axis, where they are sharply deflected to form an aulos. Number of major septa ranges from 17 to 30 in corallites of 5 to 13 mm diameter; average number of major septa in 11 colonies ranges from 18.2 to 26.7 (table 33 and fig. 32). The cardinal septum is commonly straight with a break in the aulos at this point. Minor septa are short, extending from 0.1 to 0.5 the distance to the aulos. Septa are thin; zigzag carinae are strongly or weakly deveioped within the dissepimentarium; subyard-arm carinae are present in some sections.

The dissepimentarium is composed of two to six, commonly two to three, rows of globose dissepiments. The lateral supports are an outpocketing of the outer wall filled with dissepiments. The tabularium consists of outer and inner zones of more or less horizontal, complete tabulae, separated by the aulos. Aulos diameter ranges from 0.2 to 0.4 of the total diameter; tabularium diameter is as much as six-tenths of total diameter. Tabulae within the aulos are flat, either horizontal or slightly inclined; three to nine per 5 mm. Tabulae outside of the aulos are horizontal and flat, or sagging or inclined toward the axis; commonly seven to nine per 5 mm.

Microstructure.—All known specimens of *E. corniculum* are at least partly silicified and microstructure is not well preserved. Insofar as it can be determined, septal and wall structure are as described for the genus.

Increase.—Offsetting is lateral; commonly a single set of from one to three offsets is present a short distance below the distal margin of the calice on the convex side of the corallite. The offset is commonly located at the position of the opening in the parental aulos; the offset aulos forms early and opens toward the parent.

Discussion.—The above description is based on a collection of 25 complete and incomplete coralla from Harris Hill, N.Y. (loc. 112) and seven fragmentary coralla from Pembroke Station, N.Y. (loc. 393); one of the latter is a silicified fragment, naturally etched from the rock and showing the auloporoid habit to good advantage (pl. 74, fig. 5). Fourteen coralla, including two from Pembroke Station were thin sectioned, and all measurements and counts are based on from 5 to 10 corallites in 10 of the coralla. The Harris Hill coralla were found at a single horizon over an area 10 by 40 feet (3 by 12 m) and may represent a single living population. The Pembroke Station fragments, with the exception of the naturally etched one, are possibly fragments of a single corallum. In any case the type lot consists of specimens drawn from two small areas and variation within the species is likely to be significantly greater than that indicated by this description.

E. corniculum has typical craspedophyllid internal structures and the characteristic *Eridophyllum* type of aulos. It differs from all other known *Eridophyllum* in its auloporoid (reptant) growth habit although the lateral offsetting is characteristic of the genus. *Disphyllum catenatum* Smith 1945 (p. 21–22, pl. 11, figs. 9–12) has a nearly identical growth habit and may be profitably compared in this respect. Smith noted that this mode of colony formation is unusual in rugose corals but "that the type specimens of *D. catenatum* may be merely the beginnings of a phaceloid colony and that possibly this mode of colony building is less uncommon than it appears to be." *Eridophyllum seriale* and *E. aulodokum* have not been found associated with *E. corniculum* although all three species occur in the Moorehouse Member in western New York. *E. seriale* and *E. aulodokum* differ in the size and nature of the aulos as well as in growth form so it is unlikely that they represent different growth forms of the same species.

In its general form, *E. corniculum* is distinct from all other known Onesquethawan species.

Distribution.—Moorehouse Member, Onondaga Limestone (Middle Devonian), western New York. The Harris Hill "population" was taken from a level approximately 10 ft (3 m) below the Tioga Bentonite Bed and 20 ft (6.1 m) above the level of the *Acinophyllum-Eridophyllum* bed. The Pembroke Station specimens were taken from an isolated 16-ft (4.85-m) exposure of the middle or upper Moorehouse and are probably older than the Harris Hill population.

Material studied.—Holotype, USNM 163438; illustrated or measured paratypes, USNM 163439–450, and NYSM 12835; unillustrated paratypes, USNM 163451–452 (12 specimens), 163453 (2 specimens), and NYSM 12836–41 (6 specimens).

Eridophyllum conjunctum (Davis)

Plates 107, 108

1887 *Diphyphyllum conjunctum* Davis, pl. 116, figs. 1–3.
1887 *D. coalescens* Davis, pl. 117, fig. 1.
1900 *D. adjunctum* Greene, p. 27, pl. 12, fig. 1.
1955 *Eridophyllum conjunctum* (Davis). Stumm, cards 307, 322.
1955 *E. coalescens* (Davis). Stumm, card 317.
? 1955 *Hexagonaria prisma*. Carman, p. 70, fig. 3.
1965 *E. conjunctum* (Davis). Stumm, p. 45–46, pl. 42, figs. 5–7.

Occurrence of type material.—"Jeffersonville Limestone, above coral zone" (Stumm, 1965, p. 46), Falls of the Ohio.

Diagnosis.—Cerioid *Eridophyllum* with corallites 12 to 18 mm in diameter. Aulos diameter, 2 to 4 mm, complete or open at cardinal position. Major septa number 23 to 25 in two Falls specimens. Carinae consistently present but variously developed.

Description.—A single specimen of a cerioid craspedophyllid with well-developed *Eridophyllum*-type aulos was found in the upper part of the Moorehouse Member in western New York. The specimen is lens shaped, 27 cm in diameter and 8 cm high. Corallite and aulos diameter and number of major septa are given in table 34, where they can be compared with corresponding data from the Falls of the Ohio specimens. There are no obvious differences between the Moorehouse specimens and those from the Falls that cannot readily be accounted for by even less intercolony variation than is common in other craspedophyllids.

Discussion.—I agree with Stumm (1965) in synonymizing the three Falls species of Davis and Greene: thus making *E. conjunctum* the only described cerioid *Eridophyllum* from rocks of Onesquethaw age. Another species, *E. arachnoideum* Stumm (1954, p. 6), is also cerioid but has a much smaller aulos and differs in other ways also. This species is known from beds of Centerfield and younger age in the Hamilton Group of New York.

Carman (1955, p. 70, fig. 3) described and illustrated as *Hexagonaria prisma* a cerioid craspedophyllid with a weak aulos from an unknown position within the Columbus Limestone in a core taken at Chillicothe, Ohio, south of Columbus. The specimen was crushed before burial and is known only from a small fragment, but it may be conspecific with *E. conjunctum* (table 34).

TABLE 34.—Eridophyllum conjunctum (*Davis*) *intracolony data*

		New York	Falls of Ohio		Ohio
		USNM 172245	MCZ 7859	MCZ 7877	OSU 21336
N		10	2	4	5
n:	$\bar{x}$	26.1	24.0	24.0	23.0
	OR	23–30	23–25	23–25	22–25
d:	$\bar{x}$	15.5	16.0	13.0	12.2
	OR	13–18	13–18	8–18	10–14
d^{au}:	$\bar{x}$	2.8	2.8	3.6	--------
	OR	2.6–3.5	2.2–3.4	3.2–4.0	1.6–2.0

Distribution.—Moorehouse Member, Onondaga Limestone, 18 inches (46 cm) above (*Acinophyllum-Eridophyllum* bed, at locality near Stafford, western New York (collected by A. Ferrari, Bologna).

Jeffersonville Limestone, Falls of the Ohio. "Above coral zone" (Stumm, 1965, p. 46); probably Zone D, E, or F.

Material studied.—Lectotype of *D. conjunctum* Davis, MCZ 7859; holotype of *D. coalescens* Davis, MCZ 7877; holotype of *D. adjunctum* Greene, AMNH 23501. Additional specimens in the Davis collection were studied but not sectioned.

Moorehouse specimen, USNM 172245.

Specimen illustrated by Carman from the Columbus Limestone, OSU 21336.

Genus GREWGIPHYLLUM Oliver, 1974

1974 *Grewigphyllum* Oliver, p. 170.

Type species.—*Heliophyllum colligatum* Billings, 1859, p. 126–127. First illustrated by Nicholson, 1874, p. 28, pl. 5, figs. 3, 3a. "Rama's Farm, near Port Colborne [Ontario]" (Billings, 1859, p. 127). Presumably the Bois Blanc Formation, Emsian. (See discussion.)

Diagnosis.—Craspedophyllinids with an imperfect and irregular aulos formed by deflected major septa, some of which continue into the aulos and are irregularly bent and twisted. Colonial, with corallum composed of straight corallites that are at alternate levels expanded to form a cerioid stage and contracted to form a phaceloid stage. Increase is lateral.

Description.—Only one species is known; see description of *G. colligatum.*

Discussion.—*Grewgiphyllum colligatum* (Billings) has generally been assigned to *Eridophyllum* because of the presence of a distinct aulos. However, it differs from that genus in its imperfect aulos (possibly primitive) and in its distinctive growth form, not otherwise known in the Craspedophyllidae. It could be considered an early (primitive) *Eridophyllum,* but its distinct morphology and stratigraphic position can be emphasized by giving it a new generic name. It is the earliest known craspedophyllinid and may be the necessary evolutionary intermediate between the cylindrophyllinid *Prismatophyllum* and *Eridophyllum* as discussed elsewhere in this paper.

Smith and Lang (1927, p. 308) and Lang, Smith, and Thomas (1940, p. 41) synonymized *Craspedophyllum americanum* Dybowski (1873, type species of *Craspedophyllum* Dybowski, 1873) with *G. colligatum.* If correct this would make *Craspedophyllum* a senior synonym of *Grewgiphyllum.* I do not accept this for the following reasons: (1) Dybowski's aulos description is of an *Eridophyllum;* his figure 1 could be either an *Eridophyllum* or a *Grewgiphyllum,* but his figures 2 and 5 are of a good *Eridophyllum,* (2) Stewart (1938, p. 40) reported two specimens of "*E. colligatum*" from Columbus, Ohio (type locality of Dybowski's species), as drift specimens; one of these is an *Arachnophyllum;* the other is correctly identified as *G. colligatum* but is similar in preservation to Ontario Bois Blanc specimens and may not be from the Columbus at all. I know of no other reports of *G. colligatum* in the Columbus Limestone and on this basis it seems far more likely that *C. americanum* was based on one of the common Columbus *Eridophyllum* rather than on a (at least rare) *Grewgiphyllum.*

Distribution.—Only one species is known. This is limited to rocks of middle and early late Onesquethaw age (Bois Blanc-lower Edgecliff) in eastern North America.

Grewgiphyllum colligatum (Billings)

Plates 76–79

1859 *Heliophyllum colligatum* Billings, p. 126–127.
1874 *H. colligatum* Billings. Nicholson, p. 28, pl. 5, figs. 3, 3a.
1876 *Diphyllum colligatum* (Billings). Rominger, p. 127, pl. 38, fig. 3.
not 1887 *Cyathophyllum colligatum* Davis, pls. 91, 92 and pl. explanations.
1901 *Crepidophyllum colligatum* (Billings). Lambe, p. 155–156, pl. 13, figs. 2a, b.
1906 *Eridophyllum colligatum* (Billings). Grabau and Shimer, p. 209.
1909 *E. colligatum* (Billings). Grabau and Shimer, p. 72–73.
1933 *E. colligatum* (Billings). Smith, p. 520.
part 1938 *E. colligatum* (Billings). Stewart, p. 40, pl. 7, fig. 7, (not fig. 8 which is an *Arachnophyllum* sp.).
part 1944 *E. colligatum* (Billings). Shimer and Shrock, p. 91, pl. 27, figs. 6–9 (not fig. 10 which is an *Arachnophyllum* sp.).
not 1949 *E. colligatum* (Billings). Stumm, pl. 98, figs. 7–11 (fig. 7 is *Arachnophyllum* sp., figs. 8–11 are *Eridophyllum* spp.).
1955 *E. colligatum* (Billings). Stumm, cards 320, 321.
1974 *Grewgiphyllum colligatum* (Billings). Oliver, figs. 4a–b.

Occurrence of type material.—The neotype is from the Bois Blanc Formation at Hagarsville, Ontario.

Neotype.—Billings cited "Rama's Farm, near Port Colborne" (Billings, 1859, p. 127) as the type locality. Billings specimen is apparently lost and as it was not illustrated would not be recognizable unless it was clearly labeled in Billing's hand. Nicholson, 1874, was first illustrator but his specimens apparently were destroyed by fire. The specimen on which Lambe, 1901, apparently based his description and illustrations (diagrammatic) is available (GSC 3590) but is poorly preserved and is not from the type area. Both the Bois Blanc and the lower Onondaga crop out at and near Port Colborne and both formations are represented in collections from "Rama's Farm." During this study, specimens of *G. colligatum* were found in the Edgecliff Member at Port Colborne and in the Bois Blanc Formation farther west at Hagarsville. I here select as neotype, specimen GSC 31158 (pl. 76, figs. 1–5), collected by J. DeCew, from the Bois Blanc Formation near Hagarsville, Ontario. (Oliver, 1974, p. 172, erroneously cited this as lectotype.)

External features.—Semimassive coralla are composed of straight, parallel, or radiating corallites that are alternately free (round in transverse section) and in lateral contact with neighboring corallites (polygonal in section). The expansions are at the same level throughout so that the corallum alternately appears to be cerioid and phaceloid. Coralla may be as large as 35 cm in diameter and more than 15 cm high. Four specimens from the Edgecliff bioherm facies show considerable breakage along surfaces passing through the dissepimentaria; unprepared specimens give the impression of a halysitoid growth habit. Specimens from the Bois Blanc Formation don't show this effect. This fact suggests a difference in living or preservation environment effecting a structurally weak corallum.

Mature corallites range from 9 to 19 mm in diameter although much of this variation results from the alternate expansion and contraction. (See table 35 and fig. 33.)

Increase is lateral and apparently infrequent in mature coralla. Lateral expansions are characteristic; these tend to be concave on the underside, nearly flat on the upper. Each corallite is expanded uniformly in all directions. Expansion interval ranges from 7 to 14 per 5 cm in the examples studied but is commonly 7 or 8 per 5 cm.

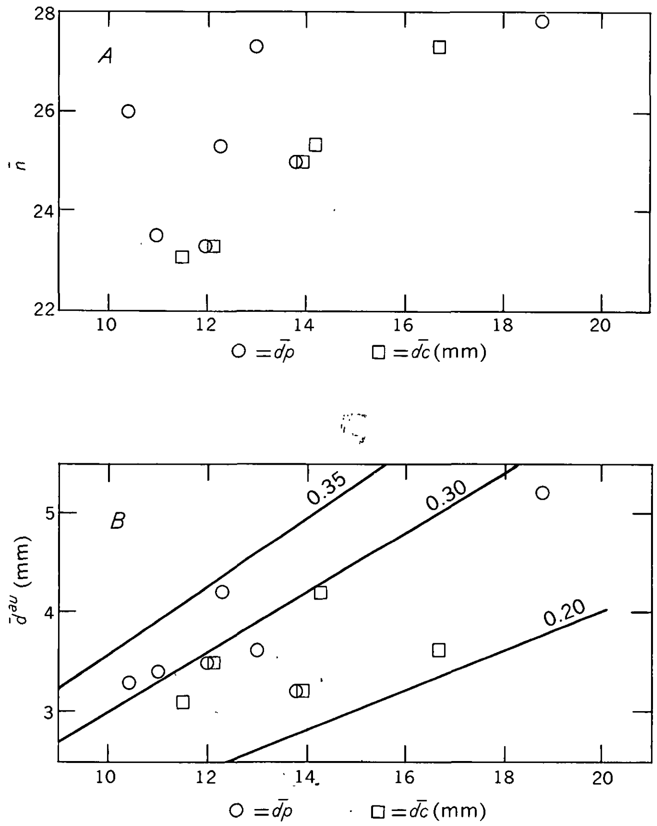


FIGURE 33.—*Grewgiphyllum colligatum* data. Mean diameters are plotted for both cerioid stage ($\bar{dc}$) and phaceloid stage ($\bar{dp}$) but not for all coralla. *A*, Mean number of major septa ($\bar{n}$) versus mean diameter ($\bar{dp}$ and $\bar{dc}$). *B*, Mean aulos diameters ($\bar{d}^{au}$) versus mean diameter ($\bar{dp}$ and $\bar{dc}$). Straight lines are selected $\bar{d}^{au}/\bar{d}$ ratios.

Corallites are gently rugose between expansions; septal grooves are fine and inconspicuous.

Calice inferred to be shallow with an axial boss corresponding to the aulos; a peripheral platform is present and especially broad during stages of expansion.

TABLE 35.—Grewgiphyllum colligatum (*Billings*), *summary data*

[*dp*, phaceloid diameter; *dc*, cerioid diameter]

		Intracolony Minimum	Intracolony Maximum	Intracolony Mean	Intercolony
n:	*N*	5	20	---	10
	$\bar{x}$	23.1	27.8	---	25.1
	OR	21–26	26–29	---	23.1–27.8
	s	.95	2.35	---	1.53
	V	3.8	9.1	5.4	6.1
dp:	*N*	3	6	---	7
	$\bar{x}$	10.4	18.8	---	13.0
	OR	8.7–12.6	16.2–22.0	---	10.4–18.8
	s	1.41	2.11	---	2.78
	V	11.0	18.3	14.3	21.3
dc:	*N*	3	12	---	5
	$\bar{x}$	11.5	16.7	---	13.7
	OR	9.3–14.5	16.0–17.7	---	11.5–16.7
	s	.89	2.08	---	2.07
	V	5.3	17.1	10.7	15.2
d^{au}:	*N*	5	18	---	8
	$\bar{x}$	3.1	5.2	---	3.7
	OR	2.6– 3.8	4.0– 6.3	---	3.1– 5.2
	s	.38	.83	---	.70
	V	10.9	19.4	14.3	18.9

Internal features.—Septa radially arranged. Major septa extend to within 1.5 to 2.6 mm of axis, where they are irregularly deflected to form an irregular aulos; several major septa extend into aulos after deflection to form an erratic pattern. Average number of major septa in 11 coralla ranges from 23 to 28, average 25 (table 35 and fig. 33); individual corallites have from 21 to 29 major septa. Minor septa are long, extending 0.6 to 1.0 the distance to the aulos, commonly 0.7 to 0.8. All septa are very thin.

Zigzag carinae are abundant in the dissepimentarium and commonly are found in both the inner and outer tabularium as well.

The aulos is irregular and variable although commonly closed. Mean diameter in 11 coralla range from 2.9 to 5.2 mm, approximately one-fourth the mean cerioid diameter (fig. 33*B*).

The dissepimentarium is composed of three to eight rows of dissepiments; these are commonly large although zones of small dissepiments may alternate with zones of large ones. The periodic expansions of the outer wall are filled with dissepiments and the diameter of the tabularium is unaffected.

The tabularium is in two parts. Outside of the aulos, tabulae are commonly complete, concave and inclined away from the aulos wall; spacing ranges from 4 to 17 per 5 mm. Within the aulos, tabulae are irregular because of the erratic septa, but they tend to be complete and horizontal where uninterrupted; spacing ranges from 6 to 15 per 5 mm.

Microstructure.—As for genus and family.

Discussion.—The above description is based on specimens from the Bois Blanc Formation in Ontario and from the lower few feet of the Edgecliff Member of the Onondaga Limestone in Ontario and western New York. This is one of two colonial rugosans known to occur in both formations.

The species is distinguished by its imperfect aulos and erratic septa and by its growth form. In the field, the species is most easily confused with species of *Prismatophyllum* of comparable size, but these are truely cerioid and lack the aulos.

Distribution.—Common in the Bois Blanc Formation and in the lower few feet of the Edgecliff Member of the Onondaga in the Niagara Peninsula of Ontario. Four specimens are from the lower Edgecliff bioherm facies near Buffalo, N.Y. Three specimens from Michigan ("Drift, Ann Arbor") are probably from the Bois Blanc Formation in the Mackinac area.

Two specimens reported from the Columbus Limestone by Stewart (1938, p. 40) are suspect. One (her fig. 8) is an *Arachnophyllum;* the other is a drift specimen, possibly from the Bois Blanc Formation in Ontario.

Material.—Neotype: GSC 31158. Illustrated or measured specimens: USNM 163463–466, 172161–162, 113554, 113556; NYSM 12842; GSC 31157. Other studied specimens: USNM 172163, 172164a–c; 113552; plus three specimens from "Drift, Ann Arbor, Michigan" in USNM.

Family DISPHYLLIDAE Hill, 1939

Diagnosis.—Solitary (?) and colonial rugose corals with thin or thickened major septa composed of coarse monacanthine trabeculae. The dissepimentarium is formed by one to several rows of normal globose to vertically elongate dissepiments. Tabulae are variable but commonly incomplete with central, flat, horizontal tabulae and periaxial tabulae inclined toward the axis.

Discussion.—The above is not intended as a complete diagnosis, and no description is offered of the family or its assigned genera. My interpretation of the family is conventional except for excluding the genera here grouped as the Cylindrophyllinae and those commonly known as phillipsastraeids (Phillipastraeinae of Jell, 1969); it is essentially the Disphyllinae of Jell (1969) but excluding *Acinophyllum,* which is clearly a craspedophyllid as discussed above.

A comparison of the Cylindrophyllinae and Disphyllidae and annotated lists of species previously assigned to the disphyllid genera *Disphyllum* and *Hexagonaria* are included in the discussions of the Craspedophyllidae and the genera *Cylindrophyllum* and *Prismatophyllum.* Except as noted below, all such previous assignments are considered erroneous.

Disphyllids occur in the Michigan Basin in rocks of middle Cazenovia to Tioughnioga age (Givetian). These have been interpreted as being part of an invasion of Old World forms from the northwest (Oliver, 1973, 1975). Both *Hexagonaria* and *Disphyllum* are represented and associated with species of typical cylindrophyllinids. Further discussion of these forms is beyond the scope of this paper.

Two older species of possible *Disphyllum* are of immediate interest because they are of the same age (or only slightly younger) as some of the upper Onondaga Limestone species. One of these is from the Dundee Limestone (lower Cazenovia, probably Eifelian, and approximately equivalent in age to the Seneca Member of the Onondaga Limestone) in the Michigan Basin. The other is from the Famine Limestone (upper Onesquethaw or Cazenovia; Eifelian) in Quebec. Both are redescribed below for comparison with species of *Acinophyllum* and *Cylindrophyllum* and because of their importance in paleobiogeographic considerations. If properly assigned, they indicate that the incursion of Old World genera occurred earlier than previously thought likely. The Quebec species would be the only known disphyllid in the Eastern Americas Realm except in the Michigan Basin.

Distribution in Eastern North America.—The age of the Quebec *Disphyllum*? is in doubt (see discussion of Famine Limestone under "Stratigraphy") but the evidence suggests that it is post-Edgecliff Onesquethaw or Cazenovia. The Michigan *Disphyllum*? is of Cazenovia age (Dundee). Other *Disphyllum* and *Disphyllum*? are from the Traverse Group (Givetian; upper Cazenovia and Tioughnioga) in Michigan.

Hexagonaria s.s. first appears in the Miami Bend Formation of Cooper and Phelan (1966) (middle Cazenovia; Givetian) in northern Indiana. The Traverse Group contains both *Hexagonaria* and *Prismatophyllum.*

?Genus DISPHYLLUM Fromental

The two species described below plus *Disphyllum*? *crassiseptatum* (Ehlers and Stumm) 1949 and possibly some additional *Cylindrophyllum*? spp. from the Michigan Basin Traverse Group make a group of *Cylindrophyllum*- or *Disphyllum*-like corals with thickened septa composed of coarse monacanthine trabeculae. These are quite strikingly different from the Onesquethaw *Cylindrophyllum* but may have evolved from *Cylindrophyllum* through thickening of the trabeculae. As noted above, they more likely are true disphyllids representing stocks that entered the Eastern Americas Realm from the northwest by way of the Michigan Basin.

Disphyllum? rectiseptatum (Rominger)

Plate 30

1876 *Diphyphyllum rectiseptatum* Rominger, p. 124.
1955 *Synaptophyllum rectiseptatum* (Rominger). Stumm, card 269, three figures (of two syntypes).
1959 *Acinophyllum*? *rectiseptatum* (Rominger). McLaren, p. 28 (synonymy only).

Occurrence of type material.—"Dundee Limestone, Quarry of the Michigan Limestone and Chemical Co., Rogers City, Michigan" (Stumm, 1955, card 269), Middle Devonian, upper Eifelian or lower Givetian.

Diagnosis.—*Disphyllum*? with very short septa, narrow dissepimentarium, numerous and vertically elongate lateral connections, and both complete and incomplete tabulae.

External features.—Phaceloid coralla of unknown size. The largest fragment available to me is 6 cm high and 3 by 6 cm in diameter and includes 50 or more corallites. Corallite diameter ranges from approximately 3.5 to 6.0 mm; measurements from two colonies are recorded in table 36.

Increase is lateral. Lateral supports are common and tend to be vertically elongate; in some sections the colonies appear cateniform because of the numbers of connections (pl. 30, figs. 1, 4). Corallites are closely spaced, commonly less than one diameter apart.

Internal features.—Septa are radially arranged and very short; commonly the major septa barely enter the tabularium; minor septa are nearly as long. Major septa number 15 to 19 in cylindrical parts of corallites in two measured coralla (table 36; fig. 25).

Zigzag carinae are present but less sharply defined than in species of *Acinophyllum* or *Cylindrophyllum* because of the general thickening of the septa. Carinae are well defined on attenuate septa but subdued or apparently lacking on dilated septa.

One, rarely two, rows of normal globose dissepiments are regularly present and give the appearance of an inner wall in most transverse sections. Dissepiments are lacking in early parts of some coralla (pl. 30, fig. 3).

Tabulae are complete or incomplete and vary from horizontal to strongly convex or less commonly concave.

All structures are relatively thicker than in the described species of the Craspedophyllidae.

Septal microstructure is uncertain because of mediocre preservation. There is a suggestion of disphyllid structure (coarse monacanths) in some longitudinal sections (pl. 30, fig. 2) and in the thickness of the septa (pl. 30, fig. 6).

Discussion.—*D.*? *rectiseptatum* was originally described but not illustrated by Rominger (1876). The first illustrations were published by Stumm (1955), who identified three syntype specimens in the Rominger collections. I here select the original of Stumm's thin section illustrations (UMMP 14378) as lectotype. The above description is based on the three Rominger specimens only and is included here to complement the description and illustration of other colonial rugose corals.

D.? *rectiseptatum* is analagous to species of *Acinophyllum* in its narrow dissepimentarium consisting

TABLE 36.—Disphyllum? stummi (*Oliver*) *and* D? rectiseptatum (*Rominger*), *summary data*

		D.? stummi						*D.? rectiseptatum*	
		USNM 163237	USNM 163397	GSC 24639	USNM 163288	Mean	Inter-colony	UMMP 14378	UMMP 14380
N		6	6	3	8	---------	4	20	13
n:	$\bar{x}$	24.3	23.8	24.7	22.6	---------	23.8	15.9	17.8
	OR	24–25	22–27	24–25	22–24	---------	22.6–24.7	15–17	16–19
	s	.5	1.7	.6	.7	---------	.9	.4	.8
	V	2.1	7.2	2.4	3.3	3.8	3.8	2.8	4.5
d:	$\bar{x}$	8.6	7.3	8.8	9.2	---------	8.5	4.2	5.1
	OR	7.2–10.5	6.6–8.5	7.4–9.7	8.5–9.8	---------	7.3–9.2	2.9–5.2	4.4–6.0
	s	1.14	.81	1.25	.42	---------	.82	.55	.44
	V	13.3	11.0	14.2	4.5	10.8	9.7	13.1	8.6

of one basic row of dissepiments. It differs in its very short, thickened septa and in the probable presence of disphyllid microstructure.

Distribution.—Dundee Limestone, early Cazenovia age. The syntypes are from the quarry of the Michigan Limestone and Chemical Co., Rogers City, Mich. (Crawford's quarry of Rominger), but Rominger reported the species from other Dundee localities as well.

Material.—Lectotype, here selected, UMMP 14378; illustrated paralectotypes, UMMP 14379, 14380.

Disphyllum? stummi (Oliver)

Plate 44; plate 45, figs. 1–7.

1971 *Cylindrophyllum stummi* Oliver, p. 195–196, pl. 1 figs. 1–6, pl. 2, figs. 4, 5.

Occurrence of type material.—Famine Limestone, St. George, Quebec. Middle Devonian.

Diagnosis.—Phaceloid coralla with cylindrical corallites commonly in lateral contact with each other so as to form short "chains." Septa short, wedge shaped, radially arranged; minor septa nearly equal to major septa in length; septal carinae present or very common. Dissepimentarium narrow with one to four rows of normal, globose dissepiments. Tabulae complete or incomplete, variable in form.

External features.—Phaceloid (partly cateniform) colonies are as much as 17 cm or more in height and 30 cm or more in diameter, composed of cylindrical corallites 6 to 11 mm in diameter; mean diameter in four coralla ranges from 7.3 to 9.2 mm (table 36 and fig. 28). Corallites are virtually parallel in astogenetically advanced parts of corallum, radiating in early stages. Corallite spacing was apparently less than one diameter and many corallites grew in lateral contact with one or two neighboring corallites to form short "chains" (pl. 44, fig. 3). Average or maximum distance between corallites is unknown, as all specimens are from a structurally disturbed area and some crushing and distortion is evident in parts of most coralla. Offsetting is lateral.

Internal features.—The major septa are radially arranged and very short, commonly extending from 0.2 to 0.5 the distance to the axis; minor septa are nearly as long. Major septa number 19 to 27 (average 22.6 to 24.7 in four coralla) in cylindrical parts of studied corallites (table 36, and fig. 28). Septa are wedge shaped, somewhat thickened peripherally. Microstructure poorly preserved except locally where septa seem to be composed of coarse and medium-sized trabeculae (pl. 44, fig. 1). Zigzag carinae are inconspicuous in most transverse sections but are more prominent in parts of most longitudinal sections. Locally, septa expand at their axial ends; in such places the coarse trabecular structure of the septa is particularly clear (pl. 44, figs. 3, 5).

The dissepimentarium is narrow, commonly occupying less than three-tenths the corallite radius. Dissepiments are normal and commonly globose; arranged in one to four rows. Inner dissepiments where present are as large or larger than peripheral ones. Size and shape variation is considerable as can be seen from the illustrations.

The tabularium is wide and composed of complete tabulae supplemented by incomplete peripheral tabulae. Tabula shape varies from nearly flat to irregularly but gently convex or concave.

Discussion.—*Disphyllum*? *stummi* is characterized by its very short, relatively thick septa. It is analagous to species of *Cylindrophyllum* described here but these have longer, very attenuate septa and more prominent septal carinae. In transverse section, *C. stummi* is similar to *Disphyllum*? *crassiseptatum* (Ehlers and Stumm) (1949, p. 28–29, pl. 6, figs. 1–6), but *D.*? *crassiseptatum* differs in having very coarse septal trabeculae and a peripheral row of dissepiments that are larger than any inner dissepiments. *D.*? *rectiseptatum* (Rominger) is much smaller in diameter and has fewer rows of dissepiments.

Distribution.—*D.*? *stummi* is known only from the Famine Limestone, St. George, Quebec, and is of Onesquethaw or early Cazenovia age. (See discussion in chapter on stratigraphy.)

Material.—Holotype, USNM 163236; paratypes illustrated by Oliver (1971), GSC 24639 and USNM 163237; additional paratypes illustrated here, GSC 24797–98 and USNM 163237, 163398; unillustrated paratypes, GSC 24640 and two others, USNM 163396–97, and additional topotype fragments in both collections.

Family ZAPHRENTIDAE Milne-Edwards and Haime, 1850

Tentatively, I am accepting the commonly assumed relationship between *Zaphrentis* and *Heliophyllum* but separating both from *Cyathophyllum* and the Cyathophyllidae. I consider the Zaphrentidae to consist of predominantly solitary forms but recognize that *Heliophyllum,* at least, includes small colonies within its type species (*H. halli* Milne-Edwards and Haime, 1850). I am also including Eastern North American colonial cyathophylloid species in *Heliophyllum* and in the genus *Cyatho-*

cylindrium Oliver but with some reservations, as noted in the following paragraphs.

There are striking similarities between *Cyathophyllum* and some forms that I assign to the Cylindrophyllinae or to the Zaphrentidae. Indeed, my present interpretation of relationships has required shifting of several species from one family to another and some of both families have, at one time or another, been assigned to *Cyathophyllum* or the Cyathophyllidae.

Hill (1956b, p. F278), Birenheide (1963, p. 368, 404), and Jell and Hill (1969, p. 3) included *Zaphrentis, Heliophyllum,* and *Cyathophyllum* in the same family (Zaphrentidae or Cyathophyllidae). The type (*C. dianthus* Goldfuss) and other species of *Cyathophyllum* from the Eifel region, Germany, have been redescribed by Birenheide (1963). My interpretation of *Cyathophyllum* used in the following comparisons and analysis are based on (1) Birenheide's published work, (2) an examination of Birenheide's material in the Seckenberg Museum, Frankfurt-am-Main, and (3) preparation and study in my laboratory of specimens of colonial *Cyathophyllum* from the Eifel area. The Middle Devonian Eifel species form a distinct group and Birenheide's study of them gives a good basis for understanding the genus, if not necessarily the Family Cyathophyllidae.

Cyathophyllum can be diagnosed as follows: Solitary or colonial corals with numerous biradially arranged septa, long or variously withdrawn from the axis, smooth to strongly marked with zigzag carinae; cardinal and counter septa commonly shorter than other major septa. Tabulae arched, flat, or sagging axially, complete or incomplete and tending to be more complete in species with withdrawn septa. Dissepimentarium wide, composed of small to medium-sized, globose dissepiments.

Birenheide (1963) separated the Eifel species of *Cyathophyllum* into two subgenera. *C.* (*Cyathophyllum*) has major septa not extending to the axis and more or less complete tabulae; *C.* (*Peripaedium*) has major septa extending to the axis and incomplete tabulae. Comparable morphologic types are represented in the Onesquethaw Stage in *Cyathocylindrium.*

The type species of both *Zaphrentis* (*Z. phrygia* Rafinesque and Clifford, 1820) and *Heliophyllum* (*H. halli* Milne-Edwards and Haime, 1850) are basically solitary although *H. halli* certainly includes small colonies. Stumm (1949, p. 17) suggested that *Heliophyllum* (with wide dissepimentarium) evolved from *Zaphrentis* (no dissepiments) and assigned intermediate forms to his genus *Heliophylloides* (narrow dissepimentarium). Schindewolf (1938, p. 445) and Smith (1942, p. 341) had already suggested the derivation of *Heliophyllum* from *Zaphrentis* but they were interpreting *Zaphrentis* as having a narrow dissepimentarium (=*Heliophylloides* of Stumm). Lecompte (1952, p. 475) and Hill (1956b, p. F278) both accepted this derivation while interpreting *Zaphrentis* as having at least some dissepiments. Oliver (1960b, p. 17–18) and Stumm (1965, p. 34–35) have since redescribed *Zaphrentis phrygia* on the basis of topotype collections. Oliver described *Zaphrentis* as having a very narrow dissepimentarium, possibly limited to the ephebic stage, whereas Stumm again described the genus as lacking dissepiments. Stumm selected a neotype but the specimen was not sectioned.

Both *Zaphrentis* and *Heliophyllum* are characterized by a bilateral (subpinnate) septal arrangement and by the presence of strong yard-arm septal carinae. Whether or not *Zaphrentis* has a dissepimentarium, there seem to be gradations from very broad to very narrow dissepimentaria within the *Zaphrentis-Heliophyllum* group. In addition, *Zaphrentis* and solitary (and some colonial) *Heliophyllum* have strongly dilated dilated septa in early ontogenetic stages that may completely fill the lumen; septa become attenuate in later stages with the attenuation appearing at the periphery and migrating toward the axis. Commonly the dilation emphasizes the bilaterality of the corals, as in any given section dilation may be stronger in two of the quadrants than in the others. The ontogenies of *Zaphrentis* and most species of *Heliophyllum* are unknown.

Within Eastern North America, *Heliophyllum* ranges from the middle Onesquethaw (Bois Blanc and equivalent; Emsian) to the Taghanic Stage (late Givetian). The range of *Zaphrentis* is not known but the genus may be restricted to the upper Onesquethaw (early Eifelian). This throws doubt on the evolutionary sequence *Zaphrentis*→*Heliophyllum* as postulated, but doesn't affect the morphological similarity. In spite of confusion and lack of information on many aspects of the genera, a close relationship between *Zaphrentis* and *Heliophyllum* still seems likely and at present it seems best to assign them to the same family (Zaphrentidae).

Cyathophyllum appeared earlier than *Heliophyllum* (Jell and Hill, 1969, p. 3–4) so, if one accepts the *Zaphrentis*→*Heliophyllum* evolution, a relationship between *Cyathophyllum* and *Heliophyllum* is unlikely since all similarities are with the mature stage of *Heliophyllum.*

Cyathophyllum and *Heliophyllum* are similar in adult morphology and in microstructure. *Heliophyllum* is more bilateral in septal arrangement and is characterized by long yard-arm carinae and by extreme septal dilation in early stages. *Cyathophyllum* is less bilateral, has short zigzag carinae and less globose dissepiments and apparently lacks the septal dilation. These differences, coupled with the available distribution data, suggest that the genera are not closely enough related to justify placing them in the same family. If the postulated relationship of *Heliophyllum* to *Zaphrentis* is accepted, the *Cyathophyllum-Heliophyllum* relationship is even less tenable. I would speculate that *Cyathophyllum* evolved from a Silurian coral with a wide dissepimentarium (such as *Entelophyllum*), whereas *Heliophyllum* evolved in eastern North America from either a zaphrentoid ancestor or a lykophyllid, possibly *Phaulactis,* with which *Heliophyllum* has much in common.

If *Cyathophyllum* and *Heliophyllum* are unrelated, then what are the affinities of the numerous large, heavily carinate, bilateral colonial corals in the Onesquethaw Stage of eastern North America? With some hesitation I divide them into two genera mainly on the basis of their carinae. Some have extremely long, *Heliophyllum*-like carinae and may (or may not) show septal dilation. These are assigned to *Heliophyllum* although the lack of dilation in some forms makes this questionable. The second group, composed of forms with short zigzag carinae are included in *Cyathocylindrium.* These show no septal dilation.

Specimens in both groups consistently differ from *Cyathophyllum* in having a small but well-developed fossula in the calice, in having more bilateral septal arrangement, and in having more globose and generally larger dissepiments. Specimens and species show considerable variation in these characters and on an individual basis the differences are often slight. However, the Onesquethaw complex of cyathophylloid individuals and species are clearly separable from Eifel *Cyathophyllum* on these characters, and I take this to indicate a long period of separate development and probably an independent origin, as suggested above.

The separation of *Cyathocylindrium* from the Craspedophyllidae is also a problem. Phaceloid colonies of both are similar in many morphologic details. Craspedophyllids tend to be smaller, to have a more radial septal arrangement, and to have a characteristic mature diameter. *Cyathocylindrium* tend to be larger with greater size irregularities within colonies and to be more bilateral in septal arrangement. Septal microstructure and the shape and arrangement of tabulae and dissepiments are very similar. I consider the similarities due to convergence because the group can best be interpreted as having independent origins and because most craspedophyllids are very different from most *Cyathocylindrium.* It is possible that *Cyathocylindrium* represents a craspedophyllid "end point" of convergence with *Heliophyllum,* but at present an evotionary relationship with *Heliophyllum* seems more likely.

In considering possible relationships of the Onesquethaw colonial corals, I have studied typical *Heliophyllum,* both solitary and colonial, in some detail. However, I have not considered other solitary genera that have been assigned to the same family as *Heliophyllum* by other workers, and I am not ready to define or further discuss the family at this time.

Ontogeny and increase.—Increase in the *Heliophyllum* and *Cyathocylindrium* species described below follows a common pattern for each growth form with only minor deviations in individual species. The following descriptions are made to avoid repetition. The terminology used is that of Hill (1935, p. 490–495). In the studied zaphrentids, phaceloid and dendroid forms display either peripheral or lateral increase; cerioid and astreoid forms increase peripherally. In peripheral increase several offsets (new corallites) are formed on the peripheral platform of the protocorallite (parent). In all species here described, the offsets crowd together in such a way that the parent could not have survived the reproductive stage (parricidal increase). In lateral increase a single (rarely two) offset projects laterally from the margin of the calice (nonparricidal increase).

Peripheral increase.—In no example is the founder or initial corallite of the colony known. Presumably this individual was produced sexually, and its ontogeny may have differed significantly from that of subsequent, asexually produced individuals.

In the species studied, from three to eight offsets were formed on the horizontal or slightly inclined calicular platform of the protocorallite. Earliest indication of the reproductive phase is the formation of a partial or complete wall connecting the inner edges of the protosepta at the inner margin of the calicular platform (pl. 85, fig. 9; pl. 89, fig. 1). This wall was built by the offset polyp as is clearly indicated by the "dark line" on the side toward the parental axis (pl. 89, fig. 4). A few new short thin septa may have formed on this wall (pl. 89, fig. 1) or these may be the axial ends of parental septa. Subsequently the wall became curved to form the axial sides of the offsets (pl. 85, fig. 9).

At their earliest recognizable stage, offsets had significant diameters (6–10 mm) and numerous septa. New septa appeared on the new wall, and the parental septa were modified along the old (parental) wall. Commonly, there is no indication of the neanic or early brephic ontogenetic stages characteristic of solitary corals. Soon after their formation, offsets were in lateral contact with each other, in some coralla being sufficiently crowded to fill the parental calice and appear triangular in cross section (pl. 89, fig. 2). At diameters of 9 or 10 mm, offsets commonly had complete, encircling walls and were spread out sufficiently to be free on all sides. At this stage they were miniature adults except that septa were still being introduced (the insertion positions can be recognized in many individuals (pl. 85, fig. 9). Major and minor septa were inserted throughout the conical stage of each corallite; the insertion frequency decreased as cylindrical growth was assumed.

Peripheral increase in these species is similar to that described and illustrated by Smith and Tremberth (1927) for *Entelophyllum articulatum.*

Lateral increase.—This description should be compared with that of the craspedophyllids which commonly reproduced in a similar way although individuals are much smaller. In no colony studied was the founder corallite recognized. Its morphology may be somewhat different from that of the subsequent asexually reproduced offsets.

In lateral increase, one (rarely two) offset was formed at one time. In serial sections taken at right angles to the axis of the protocorallite, the earliest indication of budding is a bulge in the corallite wall; the protosepta extend into the bulge, and there is no indication of neotissue. In succeeding sections, offset septa were first differentiated on the side away from the protocorallite. As an incomplete wall gradually developed between offset and parent, new septa were differentiated on the side toward the parent. The wall remained incomplete until the offset was virtually free of the parent. Many septa are present at the earliest recognizable stage of the offset and characters are virtually adult except in size and number.

Microstructure.—The fine structure of septa and walls in many of the zaphrentid species described below is similar to that of the craspedophyllids. This is particularly so where septa and walls are thin. Microscopically, the wall appears to be composed of an inner, light-colored zone of minute fibers of calcite radially oriented in transverse section and an outer, very thin, dark zone of uncertain structure. In longitudinal section the fibers are seen to incline upward toward the axis, at approximately the same angle as the top surface of each dissepiment, so that in some places the dissepiments seem to be structurally continuous with the epitheca. More generally, the dissepiments, although structurally similar, are separated from the epitheca by a discontinuity. The tabulae are commonly very thin and their microstructure is obscure.

Septa are composed of parallel, fine, closely spaced monacanthine trabeculae. Where the septal microstructure is well preserved it appears as follows. A dark central area, approximately 0.03 mm thick, indents the epitheca and extends the full length of the septum. This is apparently composed of closely spaced "centers of calcification." On either side of the dark central zone is a light-colored zone composed of minute fibers directed away from the central zone and inclined slightly toward the axis of the corallite, giving a pinnate appearance in transverse section. Septa are separated from the wall by a dark line, but the light-colored zone is identical to the inner wall in texture. Septa are thickest at their peripheral ends; the light-colored tissue thins toward the inner part of the tabularium. Carinae form ridges on the sides of the septa and show the same structure as the septa in transverse section. Carinae and parts of septa between carinae are composed of several parallel monacanths.

The size of the monacanths varies in some of the zaphrentids, so that a single carina or part of a septum between carinae may be formed by as few as two or three monacanths. In some *Heliophyllum* with dilated septa, carinae may be thickened, triangular or diamond shaped in cross section and formed by a single coarse monacanth. This is especially characteristic of *Heliophyllum halli,* less so of the colonial species. But in all of these, very fine monacanths are the most common structural element. If medium or coarse monacanths are present in an individual there is a complete gradation from very fine to medium or very fine to coarse.

Distribution.—Colonial *Heliophyllum* range from middle Onesquethaw (Emsian) to Taghanic (late Givetian) in eastern North America. *Cyathocylindrium* may be restricted to the middle and late Onesquethaw (Emsian-Eifelian). Possible occurrences elsewhere have not been studied but are apparently uncommon. Solitary *Heliophyllum* are known from North Africa, Spain, and Venezuela and many Old World areas as well.

Genus CYATHOCYLINDRIUM Oliver, 1974

1974 *Cyathocylindrium* Oliver, p. 172.

Type species.—*Cyathocylindrium opulens* Oliver, 1974, Onondaga Limestone, Edgecliff bioherm facies, New York.

Diagnosis.—Dendroid or phaceloid rugose corals. Septa numerous, biradially or bilaterally arranged, long or variously withdrawn from the axis; attenuate and weakly to strongly carinate (zigzag); cardinal and counter septa commonly shorter than other major septa. Wide dissepimentarium is composed of many rows of very globose dissepiments. Tabulae arched, complete or incomplete, tending to be more complete in forms with shorter major septa.

Description.—Colonial, phaceloid, or dendroid colonies composed of cylindrical or ceratoid individuals; corallites tend to be rugose and may or may not be in lateral contact at points of maximum expansion. Increase is lateral or peripheral. Calices are moderately deep with broad peripheral platforms.

Septa are biradially or bilaterally arranged although this is not obvious in species with short septa. Cardinal and counter septa are short; other major septa tend to become longer away from the cardinal-counter plane; the counter septum may or may not be flanked by long minor septa.

Major septa may reach the axis and meet along the cardinal-counter plane or may be withdrawn from the axis. All septa are attenuate and carinate. Carinae are zigzag to subyard-arm but the former predominate; they may be weakly to strongly developed but commonly are relatively short.

Dissepimentaria are wide, composed of many rows of very globose dissepiments. Tabulae are complete, arched but axially depressed or concave in species witht major septa that do not reach the axis; incomplete in species with very long major septa.

Microstructure.—As for the family and the Craspedophyllidae.

Discussion.—This genus is established for species, formerly referred to *Cylindrophyllum* or *Heliophyllum*, but that differ from species of the former in their larger size and decidedly more pronounced bilateral septal arrangement. In both of these characters, *Cyathocylindrium* is close to *Heliophyllum*. However, the latter differs in having predominant long, yard-arm carinae and dilated early-stage septa. *Cyathocylindrium* is most similar to *Cyathophyllum* from which it differs primarily in its more globose dissepiments and more variable carinae. Possible relationships and reasons for placing it in the Zaphrentidae are discussed under the family heading.

Three Onesquethaw species are here referred to *Cyathocylindrium*.

1. *C. opulens* Oliver; Edgecliff Member, bioherm facies, Niagara Peninsula, Ontario, and eastern and western New York; nonbioherm facies, Niagara Peninsula; Jeffersonville Limestone, Zone B(?), Falls of the Ohio; upper(?) Columbus Limestone, northeastern Ohio.
2. *C. gemmatum* (Hall); Edgecliff member, bioherm facies, Niagara Peninsula, Ontario, eastern and western New York.
3. *C.* n. sp. A; Moorehouse Member, western New York.

Cyathocylindrium opulens Oliver, 1974

Plates 80–86

?	1874	*Heliophyllum proliferum* Nicholson, p. 59. (not *Cyathophyllum proliferum* Roemer, 1855, p. 29, or *C. proliferum Dybowski*, 1874, p. 445–447.
?	1874	*H. proliferum* Nicholson, p. 27–28.
not	1877	*H. proliferum* Hall, pl. 26, figs. 1, 2, 5 (junior homonym of Nicholson's name).
?	1882	*H. latericrescens* Hall, 49–50.
?	1883a	*H. latericrescens* Hall. Hall, p. 314, pl. 27, fig. 1.
not	1938	*H. proliferum* Nicholson. Stewart, p. 38–39, pl. 7, fig. 6.
part?	1965	*H. latericrescens* Hall. Stumm, p. 37, ?pl. 29, fig. 8 (not? fig. 7 or pl. 30, fig. 13.
	1974	*Cyathocylindrium opulens* Oliver, p. 172-174, figs. 5a–e.

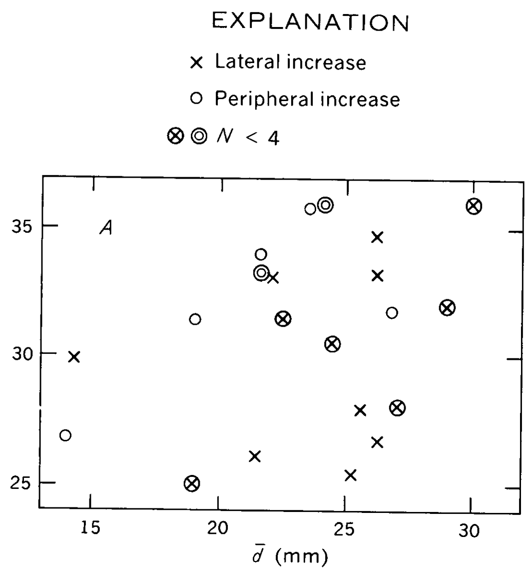
Occurrence of holotype.—Onondaga Limestone, Edgecliff Member, bioherm facies, Thompson's Lake bioherm (loc. 81), 15 miles (24 km) west of Albany, N.Y.

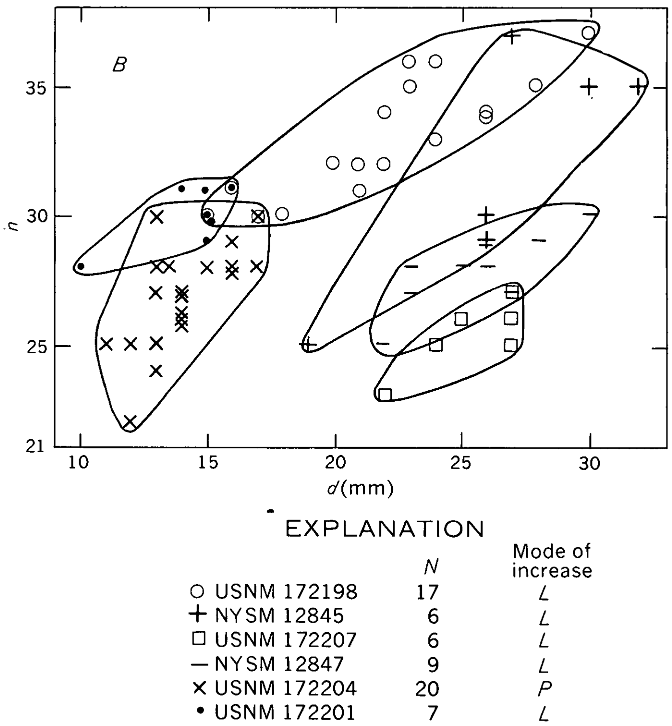
Diagnosis.—Phaceloid and dendroid *Cyathocylindrium* in which the septal arrangement is strongly bilateral; major septa extend to the cardinal-counter plane which is defined by short cardinal and counter septa. Tabulae are incomplete. Corallites are only rarely in contact.

External features.—Coralla are phaceloid or dendroid and composed of subparallel or radiating corallites which are rarely in contact except at their lower ends; there are no lateral supports. Colony heights and diameters in excess of 60 cm are not uncommon. Two silicified parts of colonies (pls. 80 and 81) measure 13 by 15 by 18 and 18 by 13 by 12 cm in height and diameters; these include 35 and 20 or more corallites respectively. In both of these specimens, corallites are in living position relative to each other, but both are incomplete and may be parts of much larger colonies. Other specimens studied are fragments of coralla consisting of a few to several dozen corallites. Colonies are commonly preserved with corallites in parallel arrangement but pressed together and broken at their points of origin.

Corallites are trochoid or ceratoid becoming cylindrical and attaining diameters of from 10 to 32 mm (table 37 and fig. 34). Corallites are coarsely and more or less regularly rugose at intervals of a few to 10 mm, averaging 6 to 8 mm. Finer encircling growth lines and longitudinal septal grooves are also present.

Increase is lateral and peripheral. Of 33 colonies in which increase was observed, 24 offset laterally, 8 offset peripherally and 1 was dominantly lateral with a single peripheral offset. Mode of increase was not determined in several additional specimens.





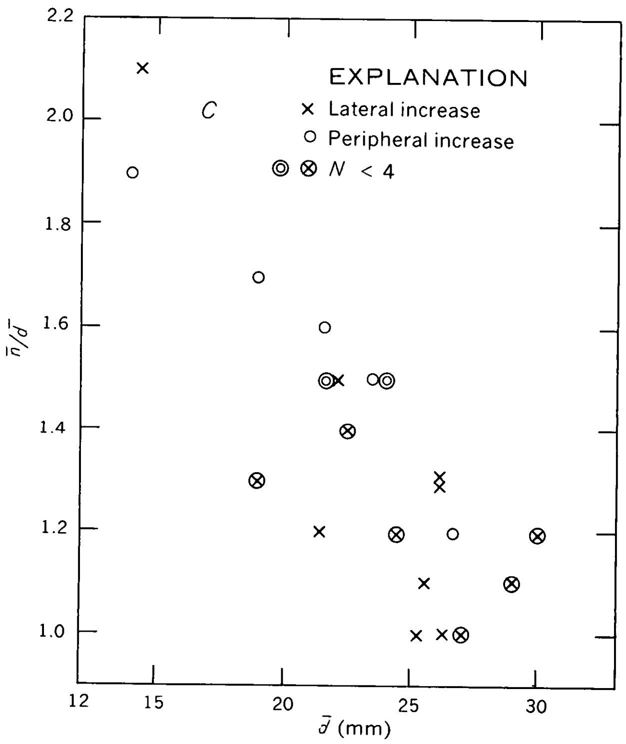


FIGURE 34.—*Cyathocylindrium opulens* data. *A*, Mean number of major septa ($\bar{n}$) versus mean diameter ($\bar{d}$). Data is from 21 coralla but sample size (*N*) is very small in several (see text discussion). *B*, Number of major septa ($\bar{n}$) versus diameter ($\bar{d}$) in six selected colonies. Sample size (*N*) and mode of increase (*P*, peripheral; *L*, lateral) are given. *C*, Mean septal ratio ($\bar{n}/\bar{d}$) versus mean diameter ($\bar{d}$) showing decrease in ratio with increasing diameter.

Commonly only one lateral offset is formed at a time in this species although examples of two contemporaneous offsets are known. Peripheral offsets commonly number three to six. Initial offset diam-

TABLE 37.—*Cyathocylindrium opulens*, *n. sp.*, *summary data*

		Intracolony			Inter-colony
		Mini-mum	Maxi-mum	Mean	
N		4	20	7.5	13
n:	$\bar{x}$	25.3	35.8	---	30.5
	OR	23–27	32–41	---	----------
	s	.00	4.58	---	3.63
	V	.0	14.4	7.5	11.9
d:	$\bar{x}$	14.0	26.7	---	22.5
	OR	11–17	19–32	---	----------
	s	.96	5.77	---	4.40
	V	3.6	24.5	13.7	19.6

eters range from 8 to 15 mm; offsets expand to mature diameters in 20 to 60 mm. Offsetting intervals of 5 to 8 cm were observed although they are commonly much greater than this.

Calices are moderately deep (average one-half corallite diameter), having gently sloping walls and broad peripheral platforms that commonly slope inward but may be horizontal or reflexed in some individuals. A cardinal fossula is formed by a short cardinal septum. The calice floor is flat.

Internal features.—Septa are bilaterally arranged. The cardinal and counter septa are commonly shorter than the adjacent major septa and one of these may be shorter than the other. In some sections the counter septum is flanked by long minor septa although other sections of the same corallite may not show this feature. Commonly the cardinal and counter septa are of approximately equal length and not individualized by the arrangement of other septa; a cardinal-counter plane is clearly defined, however. Adjacent major septa turn toward the symmetry axis at their axial ends and are longer toward the 90° positions, so that the major septa tend to meet along the cardinal-counter plane but not at a point. Alar septa can be recognized only in some early (conical) stages where new septa are being introduced.

The length of the minor septa varies with position but is commonly one-half to two-thirds the length of the adjacent major septa. Major and minor septa are slightly thickened in the inner dissepimentarium and the outer tabularium.

Observed numbers of major septa are shown in table 37 and on the graphs (fig. 34). The value of colony means is limited by small sample size and by the difficulty of eliminating the effects of ontogeny. Sections through cylindrical parts of corallites range in diameter from 10 to 32 mm; colony means range from 14 to 27 mm. Numbers of major septa range from 23 to 41; colony means range from 25 to 36.

Carinae abound; they are predominantly zigzag but are locally yard-arm or nearly so. Length and spacing of carinae varies and can best be judged by reference to the illustrations. Carinae are limited to the dissepimentarium and are peripherally steep, flattening at their axial ends.

The dissepimentarium consists of from 7 to 12 or more rows of globose dissepiments ranging in height from 0.5 to 2.5 or more millimeters. Some dissepiments are elongate parallel to the carinae; near the inner margin of the dissepimentarium they tend to be less globose and may be elongate in the other direction.

The tabularium is clearly separated from the dissepimentarium. Tabulae are incomplete, short, arched plates, forming an arched or double-arched pattern.

Microstructure.—See under family description.

Individual variation.—Both intercolony and intracolony variation are extensive in *C. opulens* as in the other species described. Variability of many structures is discussed in the above description. Figure 34 provides additional data but must be interpreted carefully. Figure 34*A* shows observed intercolony size and septal number variation, but the samples on which it is based are small. Twenty-one colonies are represented by from 1 to 20 corallites. Because of the large corallite size it was impractical to collect or section adequate numbers of individuals in all colonies. Nevertheless, it seems better to present only one value per colony on this graph rather than to show a much larger number of corallites, but with most from only a few coralla. Table 37 summarizes data from 13 colonies (N=4–20).

Figure 34*B* shows the data for 6 to 20 corallites in each of six colonies. Colonies were selected to show maximum size and septal number differences between colonies. Comparison of figures 34*A* and *B* will show how other coralla tend to occupy the middle area.

Septal ratio variation is similar to that noted in other species in which there is adequate data. Figure 34*C* illustrates the decrease of septal ratio with increasing diameter. The negative correlation is significant at the 0.001 level ($P<0.001$).

An example of discontinuous variation in *C. opulens* is found in the presence of two distinct modes of colony development. Of 33 specimens in which offsetting was determined, 25 offset laterally and 8 offset peripherally .In one of the lateral coralla, a single peripheral offset was formed at the same time as a lateral offset (pl. 84, fig. 6); the parent corallite was itself offset laterally. The single peripheral offset attained a length of only a few millimeters and a diameter of 10 mm. This is the only observed example of the occurrence of both types of increase within a single colony in the Onesquethaw fauna. In none of the coralla seemingly characterized by peripheral offsetting were fewer than three offsets noted for any one reproductive phase.

In respect to mode of offsetting, *C. opulens* is dimorphic, although on a colony rather than individual level. Such polymorphism is commonly genetically controlled and the 25:8 ratio suggests that mode of offsetting may have been a case of simple Mendelian inheritance with lateral offsetting dominant over peripheral offsetting and the forms appearing in a 3:1 ratio.

Discussion.—The preceding description is based on 39 coralla or parts of coralla; other fragments provided additional distribution data but have not been otherwise used; all are from the Edgecliff Member in New York and southwestern Ontario.

In the field, *C. opulens* can be confused with only one other Onondaga species, *C. gemmatum*. It differs from *C. gemmatum* in its long septa, strong bilateral septal arrangement, incomplete tabulae, and infrequent contacts between corallites. From all other Onesquethaw species it differs markedly in corallite size or corallum form.

Cyathocylindrium opulens is probably the same as *Heliophyllum proliferum* Nicholson, 1874 (not *H. proliferum* Hall, 1877), but this form was never illustrated, and no type specimens are known. Nicholson's species is "extraordinarly abundant in one bed of the Corniferous Limestone of Ridgeway" (Nicholson, 1874, p. 28). This locality is some 10 miles (16 km) east of Port Colborne, Ontario, and might be within either the Bois Blanc or lower Onondaga. "Extraordinarily abundant," however, can only apply to the Edgecliff bioherm facies and probably to *C. opulens*.

Heliophyllum proliferum Hall (1877, not Nicholson), from the Hamilton Group in New York, differs from *C. opulens* in initial offset growth nearly at right angles to the parent corallite and in abundant and prominent yard-arm carinae.

Heliophyllum latericrescens Hall, 1882, from the Jeffersonville Limestone at the Falls of the Ohio, is a *Cyathocylindrium* similar to *C. opulens*. Stumm, 1965 (p. 37) placed several Falls of the Ohio "species" of Greene (1898–1906) in synonymy with Hall's species but all of these are represented by fragmental, poorly preserved, and unrecognizable holotypes. Hall's holotype is not well preserved but has between 45 and 50 major septa and is probably not conspecific with *C. opulens*. *C. opulens* does occur at the Falls as discussed under distribution below, but no previously described Falls "species" can be so identified at present.

Heliophyllum proliferum Nicholson of Stewart (1938) is a Hamilton form, possibly closer to *H. proliferum* Hall (not Nicholson) than to any Onesquethaw species.

Cylindrophyllum confluens Stewart (1938), from Columbus Limestone, Zone C, in Ohio is poorly known. Stewart's "cotypes" include two or more species, one of which is similar to *Cyathocylindrium opulens* in having long septa and incomplete tabulae. But this form has a relatively small diameter (approximately 16 mm) with more septa ($n=37, 38$) than are known in the larger *C. opulens*.

"*Hexagonaria*" *martinsoni* Cranswick and Fritz differs from *C. opulens* in its somewhat larger corallite size and in its semicerioid habit at some growth stages.

Distribution.—*Cyathocylindrium opulens* is the most common colonial zaphrentid known from the Onondaga. It is common in the bioherm facies of the Edgecliff Member, and specimens were collected from every known bioherm area from Port Colborne, Ontario, to Albany in eastern New York.

Two NYSM specimens from "Leroy, New York" (pls. 80 and 81) are probably from an Edgecliff bioherm also.

The species also occurs in the nonbioherm Edgecliff in the Niagara Peninsula (two specimens known).

Two specimens were collected from the Jeffersonville Limestone at the Falls of the Ohio. Both were from the base of Zone B or the top of Zone A.

One specimen from the upper part of the Columbus Limestone in the subsurface of northeastern Ohio is tentatively assigned to this species.

Material.—Edgecliff Member, New York and Ontario: Holotype, USNM 172197; illustrated or measured paratypes, USNM, 172198–208, NYSM 12843–48, GSC 31159; additional sectioned paratypes, USNM 172211, 182846–53; NYSM 12849–50; GSC 31160. Identified specimens: Jeffersonville Limestone, Zone A or B, USNM 172209–210. Upper Columbus Limestone, Ashtabula County, Ohio, UMMP 60485.

Cyathocylindrium gemmatum (Hall)

Plates 87–90

1882 *Heliophyllum gemmatum* Hall, p. 49.
1883a *H. gemmatum* Hall. Hall, p. 310, pl. 26, fig. 12.
1884 *H. gemmatum* Hall. Hall, p. 453.
? 1887 *Cyathophyllum oedipus* Davis, pl. 84, fig. 1 (probably not pl. 83, figs. 6–9, which are unrecognizable).

part 1965 *Cylindrophyllum compactum* (Hall), Stumm p. 42 (not *Heliophyllum compactum* Hall, or most of Stumm's synonymy or any of the illustrations; see discussion).

Holotype.—The original of Hall's only illustration, FMNH 35872WM. Jeffersonville Limestone (position unknown), Falls of the Ohio.

Diagnosis.—*Cyathocylindrium* in which the septal arrangement is bilateral to biradial but the septa extend only 0.8 to 0.9 the distance to the axial plane, leaving an elliptical open space around the axis. The septa are thin; tabulae are complete and incomplete. Corallites are in lateral contact at several points, usually at expanded rugae.

External features.—No complete colonies are known; most available fragments are small, as much as 30 cm high and 21 cm in diameter and include 25 to 100 or more corallites. The largest known specimen (pl. 87, figs. 1, 2) was found in a limestone block 16 cm high and 95 by 75 cm in diameter; the specimen is incomplete but apparently not crushed or compressed; corallites as much as 50 cm in length are included. Colony form is phaceloid in the larger specimens. Individual corallites are trochoid, become ceratoid or cylindrical, and reach diameters of 30 mm or more (fig. 35).

Corallites are strongly and more or less regularly rugose. There are no lateral supports, but individuals are closely spaced and the coarse rugae of adjacent corallites are in frequent contact. The restoration shown on plate 1 displays these characters very well.

Increase is peripheral and parricidal, three to five offsets commonly being formed at the same time. Initial offset diameters of less than 10 mm have been observed; offsets expand to their mature diameters in 40 to 60 mm. Offsetting intervals have not been observed.

External markings consist of fine longitudinal septal grooves in addition to encircling rugae.

Calices are moderately deep (average one-half the diameter) with gently inclined sides and a peripheral platform that is nearly flat or gently inclined toward the axis. A cardinal fossula is formed by a short cardinal septum.

Internal features.—Septa are bilateral or biradial, but the major septa extend only from 0.8 to 0.9 the distance to the axis, leaving a central, elongate open area. The cardinal-counter plane is commonly well defined but primary septa are not individually recognizable except in some of the immature sections.

Numbers of major septa relative to corallite diameters are shown in figure 35 for a sample of the available specimens. No statistics other than means have been calculated because of the small sample size and the impracticality of eliminating data from early ontogenetic stages. Diameters measured on cylindrical parts of corallites range from 12 to 28 mm; the corresponding range in numbers of major septa is 22 to 44. Minor septa are from two-thirds to three-fourths the length of adjacent major septa.

Carinae are abundant in most corallites; they are mostly zigzag but are locally subyard–arm in appearance. Length and spacing of carinae can best be judged by reference to the illustrations. Carinae are limited to the dissepimentarium; they are steeply inclined peripherally, more gently so within the dissepimentarium, steeper at their axial ends.

The dissepimentarium consists of from 5 to 10 or more rows of normal, globose dissepiments. Height of the spaces between dissepiments ranges from 0.6 to 2.0 mm but is commonly ±1.0 mm. Some dissepimental spaces are elongate parallel to the carinae.

Tabulae are complete or nearly so and commonly horizontal in the axial part of the tabularium, but in-

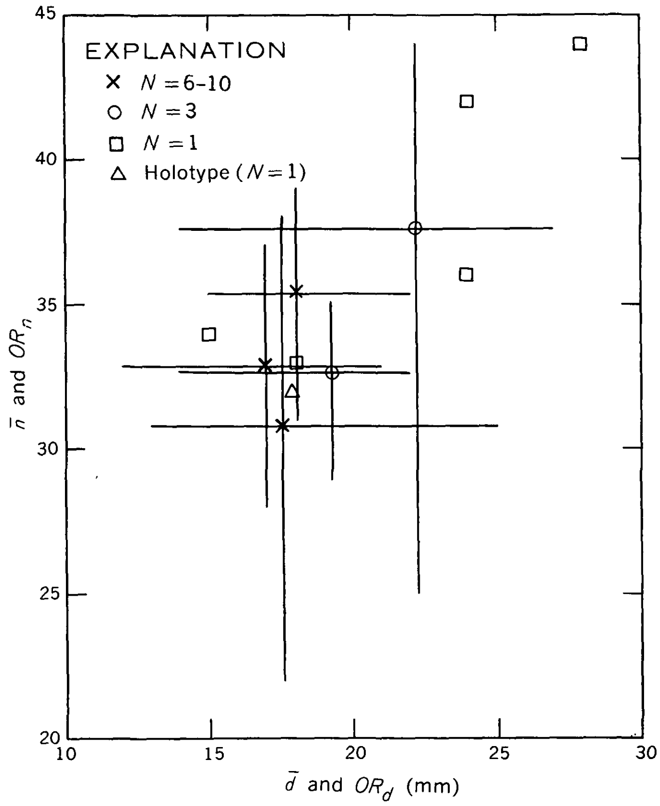


FIGURE 35.—*Cyathocylindrium gemmatum* data showing mean and observed range of number of major septa ($\bar{n}$ and OR_n) versus mean and observed range of diameter ($\bar{d}$ and OR_d). Mean shown by symbols; observed ranges shown by vertical and horizontal lines through symbol. Sample size (N) shown by symbols.

complete and arched peripherally, forming an overall concave pattern.

Microstructure.—See family description.

Discussion.—This description is based on 16 coralla or parts of coralla from the Edgecliff in New York and Ontario.

In the field, *C. gemmatum* can be confused with *C. opulens*, which differs in having a more obviously bilateral septal arrangement, incomplete tabulae, and less frequent contacts between corallites. From all other Onondaga species, *C. gemmatum* differs markedly in corallite size and corallum form.

I consider this Onondaga form to be conspecific with the single specimen described by Hall (1882, 1883, 1884) as *Heliophyllum gemmatum.* Unfortunately, the species has not been found in any more recent Falls of the Ohio collections and the exact stratigraphic position of the holotype is not known.

Stumm (1965, p. 42) redescribed *Heliophyllum compactum* Hall as *Cylindrophyllum compactum* and included *H. gemmatum* in the synonymy of that species along with five other Falls species of Hall, Davis, and Greene. *H. compactum* Hall and *H. pocillatum* Hall are based on silicified fragments of single corallites that may or may not have been parts of colonies; I consider both species to be unrecognizable. *H. fecundum* Hall is based on a silicified cylindrical fragment having four peripheral offsets; this may be a *Cyathocylindrium* but is present unrecognizable on the species level. *Cyathophyllum oedipus* Davis may be a junior synonym of *C. gemmatum* but more detailed study is required to determine this. *Cyathophyllum coralliferum* Davis and *Heliophyllum gradatum* Greene are probably *Cylindrophyllum* and are discussed under that genus. Of the species in Stumm's synonymy, *Heliophyllum gemmatum* Hall is the senior recognizable form.

Distribution.—Edgecliff Member, New York and the Niagara Peninsula of Ontario. Thirteen of the 16 specimens on which this description is based were collected from the Edgecliff bioherm facies at Williamsville, N.Y. (Fogelsanger quarry). Single coralla were collected from two bioherms in eastern New York and from the Edgecliff "green beds" at Port Colborne, Ontario. The holotype fragment is from the Jeffersonville Limestone at the Falls of the Ohio, stratigraphic position not known. *Cyathophyllum oedipus* Davis, which may be conspecific, is probably from the Middle Devonian coral zone (Zone B).

Material.—Holotype: FMNH 35872WM. Illustrated or measured specimens: USNM 172212–217 and NYSM 12860–63. Other specimens: USNM 172218 and 172219 a–e.

Cyathocylindrium n. sp. A

Plate 91

Diagnosis.—Phaceloid *Cyathocylindrium* with strongly rugose, ceratoid-cylindrical corallites that are commonly in lateral contact with other corallites at positions of maximum expansion; maximum corallite diameters as much as 50 mm. Septa long, bilaterally arranged; tabulae are complete and incomplete.

External features.—Dimensions in centimeters and approximate number of corallites in the two specimens on which this description is based are tabulated below. As explained under remarks, they may be parts of the same colony.

	Height	*Length*	*Width*	*Corallites*
USNM 172220 ------	35	50	10	50+
NYSM 12864 -------	25	15	10	15+

Specimen.—

Colony form is phaceloid, with large cylindrical corallites parallel or slightly diverging; ceratoid-cylindrical corallites range from 30 to 50 mm or more in diameter. There are no lateral supports, but individuals are markedly rugose and in lateral contact at points of maximum expansion.

Increase is peripheral (parricidal); five and seven offsets were formed in the studied examples. New individuals expand and diverge rapidly, after which growth is approximately cylindrical and parallel. An offsetting interval of 12 cm was observed in one specimen.

Corallites are strongly and regularly rugose at intervals of from 5 to 15 mm; finer encircling rugae and longitudinal septal grooves are also present.

Calices as inferred from internal structure have moderately steep inner walls rising to an almost horizontal peripheral platform. Calices are relatively shallow and flat bottomed; cardinal fossula not prominent.

Internal features.—Major septa are bilaterally arranged. The cardinal and counter septa are shortest; in some specimens one of these, presumably the counter, is flanked by extra-long minor septa; adjacent major septa become longer toward the sides and extend to the cardinal-counter plane. Minor septa are approximately two-thirds as long as the adjacent major septa except as noted. Alar septa can be recognized only in early stages where new septa are being introduced. All septa are somewhat thickened in the inner part of the dissepimentarium.

Number of major septa in five corallites ranges from 30 to 38; diameters range from 25 to 35 mm. The measured specimens have larger individual diameters and fewer major septa at a given diameter ($n/d=1.1$) than the other species of *Cyathocylindrium* or *Heliophyllum* with which this species is most comparable. Cylindrical stage diameters range from 25 to 40 mm or more.

Carinae are long or short, strongly or weakly developed, commonly zigzag but subyard-arm occasionally, all within the same thin section. Carinae are limited to the dissepimentarium and are steeply inclined peripherally, gently inclined or nearly horizontal as they approach their inner limit.

The dissepimentarium consists of many rows of normal dissepiments. These are mostly globose but the three or four inner rows are elongate and steeply inclined. The globose dissepiments are commonly medium size but may be as much as 2.5 mm in height.

Tabulae are closely spaced, complete or incomplete, individually convex or concave but forming a horizontal or concave pattern.

Microstructure.—See family description.

Discussion.—The preceding description is based on two specimens that were collected in different years from the same locality in the Moorehouse Member, western New York, and may be parts of the same colony. The specimens are of particular interest because they are the only large colonial corals known from the Moorehouse in New York or Ontario.

C. n. sp. A differs from other *Cyathocylindrium* in the combination of characters noted. It has longer septa and larger size than *C. gemmatum* and has complete tabulae, unlike *C. opulens. C.* n. sp. A could have been derived from *C. gemmatum* by a lengthening of the major septa, an increase in diameter, and a decrease in distance between corallites.

Distribution.—Known only from one locality in the Moorehouse Member of the Onondaga Limestone, western New York.

Material.—Illustrated specimens: USNM 172220 and NYSM 12864.

Genus HELIOPHYLLUM Hall

1846 *Cyathophyllum* (*Heliophyllum*) Hall, in Dana, p. 183.
1848 *C.* (*Heliophyllum*) Hall, in Dana, p. 356.
1850 *Heliophyllum* Hall, Milne-Edwards and Haime, p. lxix.
1940 *Heliophyllum* Hall, Lang, Smith, and Thomas, p. 66.
1956b *Heliophyllum* Hall, Hill, p. F278.

Type species.—*Strombodes helianthoides?* Hall, 1843, (not Goldfuss, 1826) p. 209, fig. 87–3, and no. 48, fig. 3, p. 44 of tables; renamed *Heliophyllum halli by* Milne-Edwards and Haime, 1850, p. lxix. Ludlowville and Moscow Formations, Tioughnioga Stage, central and western New York.

Diagnosis.—Solitary and colonial rugose corals, widely varying in shape and type of colony, characteristically having a moderately deep calice with broad axial pit, a steeply inclined lower calice wall, a broad horizontal or gently inclined peripheral platform, and a shallow fossula.

Major septa tend to be long and are bilaterally arranged about the cardinal-counter plane; mature septa may be attenuate, but septa are moderately to heavily dilated at least in early ontogenetic stages. Carinae are abundant and prominent, commonly long yard-arm but short zigzag carinae may also occur; they are commonly, but not necessarily, limited to the dissepimentarium.

Dissepiments are globose and in numerous rows. Tabulae are incomplete, commonly convex but forming a generally concave pattern.

Discussion.—The genus badly needs revision as its limits are poorly understood at present, even though some "populations" of *H. halli* have been admirably described (Wells, 1937). Of Onesquethaw colonial corals, I am including phaceloid, ceriod, and astreoid species characterized by long yard-arm carinae and, in some examples, by septal dilation.

Distribution.—*Heliophyllum halli* is common in upper Onesquethaw to Taghanic formations, and a *Heliophyllum* that may be *H. halli* is present but not common in the middle Onesquethaw Bois Blanc Formation. However, small colonies of *H. halli* are known only from the upper part of this range (Tioughnioga and Taghanic) and none are described in this paper.

Colonial *Heliophyllum* described here are widespread in both middle and upper Onesquethaw formations, but most species are represented by few specimens. The following species are described from New York and Ontario:

Phaceloid:

1. *H. megaproliferum* n. sp., Edgecliff bioherm facies, New York and Niagara Peninsula, Ontario.
2. *H.* n. sp. B, Edgecliff bioherm facies, eastern New York.
3. *H.* n. sp. C, Edgecliff bioherm facies, eastern New York.

Cerioid:

4. *H. coalitum* (Rominger), Edgecliff bioherm facies, New York; ?Ontario; Bois Formation(?), Ontario and Michigan.

Astreoid:

5. *H. monticulum* (Ehlers and Stumm), Edgecliff bioherm facies, New York and Niagara Peninsula, Ontario.
6. *H. cassum* n. sp., Bois Blanc Formation, Niagara Peninsula and Woodstock area, Ontario.
7. *H. procellatum*, n. sp., Bois Blanc Formation(?), Falkirk, N.Y.

The phaceloid species are types that have previously been referred to *Cylindrophyllum* or *Heliophyllum*, depending on source and specialist. The single cerioid species and similar forms were referred to *Hexagonaria* by Stumm (1948, 1955, 1965) because of the growth form with well-developed intercorallite walls. The astreoid species have been assigned to *Billingsastraea* by recent workers solely on the basis of growth form. Differences between these species and analagous craspedophyllid forms are discussed in the description of families and genera and in some of the species comparisons.

Phaceloid Species

Heliophyllum megaproliferum n. sp.

Plates 92, 93

Occurrence of type material.—Edgecliff Member, bioherm facies, Niagara Peninsula, Ontario, and eastern and western New York.

Diagnosis.—Phaceloid coralla composed of large (25–45-mm diameter) ceratoid to cylindrical corallites that increase laterally. Septa are long and thin or dilated and have abundant long yardarm carinae.

External features.—The holotype is a fragment 18 cm high and 11 by 32 cm in diameter and includes 17 corallites; the size of the complete colony is not known. Three other specimens are smaller than the holotype. The description is based on these four partial coralla.

Individual corallites are ceratoid becoming cylindrical; measured cylindrical stage diameters range from 26 to 42 mm (fig. 36). Increase is lateral; after initial growth away from parent, corallites tend to become parallel; no lateral supports are present and corallites are only incidentally in lateral contact with each other.

Epitheca is marked by shallow septal grooves and broad, rounded interseptal ridges; corallites are regularly rugose.

No calices have been observed, but the arrangement of structures in longitudinal sections suggests the following: diameter at base from one-third to two-fifths that of the corallite, depth 10 to 15 mm; lower sides nearly vertical but curving away to form a flat or gently inclined peripheral platform; low septal ridges may be present on floor and walls and a shallow cardinal fossula is probable.

Internal features.—Major septa reach or nearly reach the axis and are biradially arranged. The cardinal-counter plane is defined by short cardinal and counter septa; adjacent major septa are arranged symmetrically about the plane; in some corallites, the presumed counter septum is flanked by extra-long minor septa. Number of major septa ranges from 26 to 41 (fig. 36). Minor septa are two-thirds as long as the major. All septa are thin but may thicken slightly in the inner part of the dissepimentarium. Carinae are well developed, commonly long, and of the yard-arm type; they are limited to the dissepimentarium and vary in inclination from nearly vertical at the periphery to nearly horizontal at their inner ends.

The dissepimentarium is wide, occupying from three-fifths to two-thirds of the radius, and consisting of 12 or more rows of relatively small dissepiments. Dissepiments are globose and horizontal near the periphery, vertical and elongate near the tabularium, with intermediate shapes and orientations in between.

Tabulae are incomplete; flat or gently curved plates form a flat or slightly convex pattern. Tabularia are sharply separated from dissepimentaria and occupy from one-third to two-fifths the total diameter.

Microstructure.—The specimens assigned to this species are silicified and microstructure is obscured. Dark and light layers can be recognized in some corallites, and the structure is apparently as described for the genus.

Discussion.—The above description is based on four partial coralla, all collected from the Edgecliff bioherm facies. The two Ontario specimens are from the same locality and might have been part of the same colony although this seems unlikely. The other specimens are from Williamsville and Coxsackie, N.Y. Each of the specimens shows considerable intracolony variation, but they are very similar to each other. The three western specimens are partly silicified but not in such a way that they can be etched from the enclosing rock.

Within the Onondaga fauna, *H. megaproliferum* is most similar to *Cyathocylindrium opulens* and *H.* sp. *B. C. opulens* differs in its smaller corallite size, and in its irregular septa having predominantly zigzag carinae. *H.* sp. *B* differs in having peripheral offsets, large coarse dissepiments and markedly dilated septa.

Distribution.—Known only from the bioherm facies of the Edgecliff Member in areas adjacent to

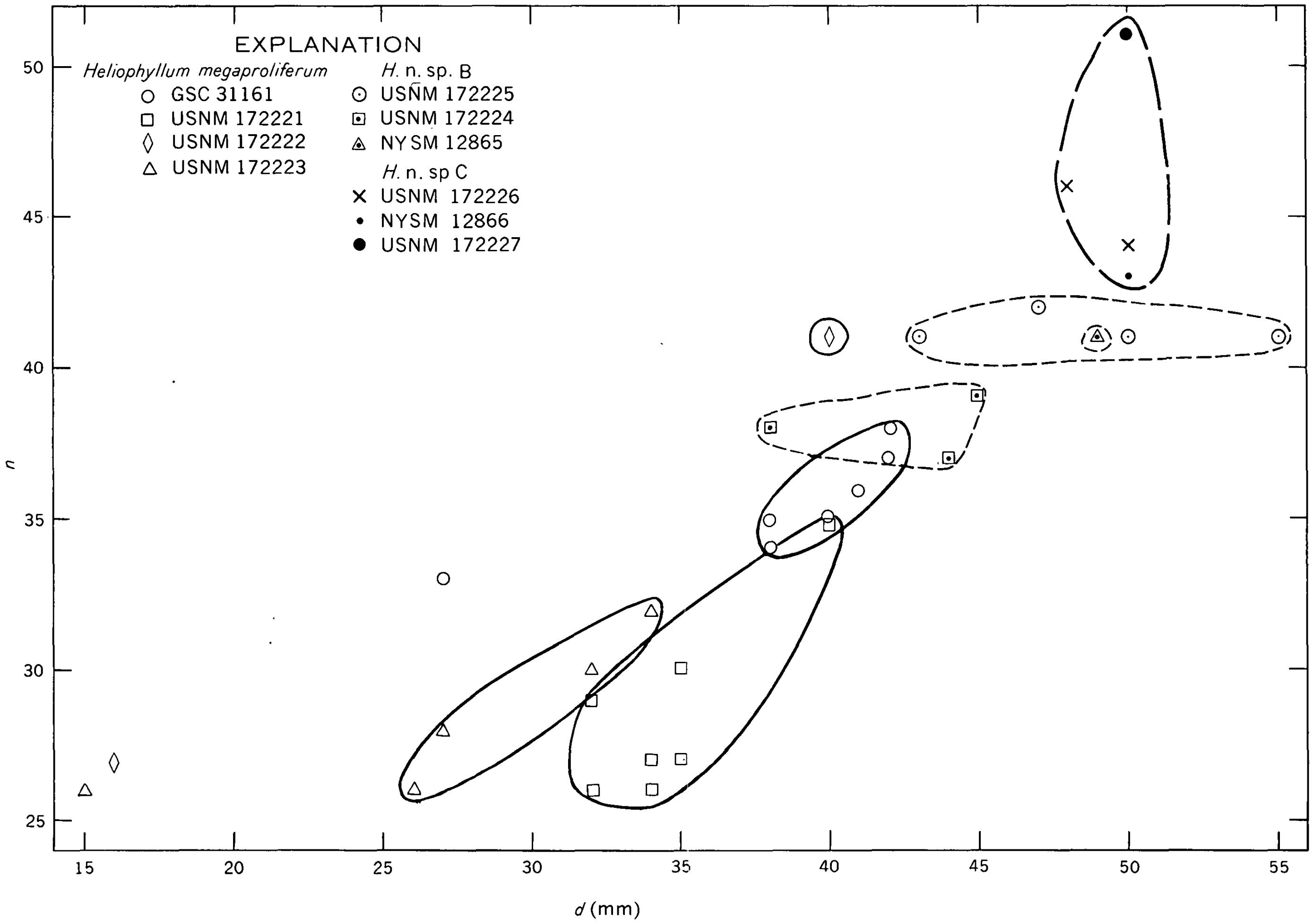


FIGURE 36.—*Heliophyllum* n. sp. B. *H. megaproliferum,* and *H.* n. sp. C data showing number of major septa (*n*) versus diameter (*d*) in small samples of several colonies. Polygons enclose data for *H.* n. sp. C and for each corallum in the other species. The three unenclosed symbols in the lower left are offsets in the *H. megaproliferum* coralla indicated. Other data are from cylindrical (mature) stage.

the Niagara River in both Ontario and New York and in eastern New York.

Material.—Holotype, GSC 31161; paratypes, USNM 172221–223 (specimen 172221 was collected at the type locality and may be a part of the holotype).

Heliophyllum n. sp. B

Plate 94

Diagnosis.—Phaceloid coralla increasing peripherally, composed of large (as much as 55-mm diameter) cylindrical corallites. Septa are attenuate in the dissepimentarium and have short, zigzag carinae but are dilated in the tabularium.

External features.—Three fragments of phaceloid coralla include two to five large corallites and appear to represent a distinct new species. Because of the inadequacy of the material, the species is described informally. Individual corallites are cylindrical, having diameters ranging as much as 55 mm (fig. 36); maximum observed length for a single corallite is 13 cm. Increase is peripheral with five offsets in one observed example. Offsets expand within a few centimeters to their full diameters. There are no connections between corallites, except at points of origin. External markings are not known.

Calices are inferred from orientation of dissepiments and carinae to be moderately deep (approximately one-half corallite diameter) and have steep inner walls and a broad peripheral platform.

Internal features.—The septa are bilaterally arranged. Cardinal and counter septa are relatively short and the counter septum is flanked by extra-long minor septa. Other major septa are mainly radial in arrangement; commonly they meander slightly in the tabularium and extend to or nearly to the axis, where some of them meet. Observed numbers of major septa range from 37 to 42 (fig. 36). Minor septa, except the counter laterals, are two-fifths to two-thirds the length of the majors.

Septa are attenuate in the dissepimentarium but thicken in the tabularium by a factor of four or more. Abundant zigzag carinae are short; long yard-arm carinae are also present; considerable variation occurs within a single cross section of a corallite. Carinae are steep peripherally, gently inclined at their inner ends.

The dissepimentarium is formed by 8 to 15 rows of medium to large dissepiments and occupies approximately two-thirds of the corallite radius. Outer rows are composed of large dissepiments that are nearly circular (2 mm high) in longitudinal section; inner dissepiments are smaller and vertically elongate.

The tabularium occupies one-third of the diameter of the corallite. Tabulae are incomplete; tabulae pattern in longitudinal sections is obscured by the axial ends of the major septa.

Microstructure.—Septa are composed of a dark, granular-appearing mid-layer and light brown surface layers of fibers arranged perpendicular to the plane of the septum. Structure is particularly well preserved in dilated axial parts of the septa.

Discussion.—The above description is based on three fragments of coralla, each including two to five large corallites. The specimens are worn and partly crushed but otherwise well preserved. The specimens vary in detail but are united by their large corallite size, septal dilation, and large dissepiments. In these characters, *H.* sp. B differs from all other phaceloid corals known from the Onondaga within the study area.

H. n. sp. B is most similar to *H.* n. sp. C. The two species differ however in the form of their carinae, dissepiments, and calice:

	H. n. sp. B	*H. n. sp. C*
Carinae	short, zigzag	long, yard-arm.
Dissepiments	large, round	medium large.
Calice	broad platform	no platform.

It differs from the other *Heliophyllum* spp. in having predominantly zigzag carinae; long yard-arm, *Heliophyllum*-type carinae are present but less common.

Distribution.—Known only from the bioherm facies of the Edgecliff Member at one locality near Schoharie, in eastern New York.

Material.—Illustrated specimens, USNM 172224, 172225 and NYSM 12865.

Heliophyllum n. sp. C

Plate 95

Diagnosis.—Phaceloid coralla, increasing peripherally, composed of large (as much as 50-mm diameter) cylindrical corallites. Septa are dilated in the tabularium; long yardarm carinae are common in the dissepimentarium.

Description.—Three coralla fragments are composed of two to eight ceratoid-cylindrical individuals and appear to represent a distinct new species. Corallite diameters average 50 mm; corallites have 43 to 54 major septa (fig. 36). Increase is peripheral with eight offsets in one observed example. There are no connections between corallites except at points of origin. Calices are inferred to be moderately deep (approximately three-fourths corallite diameter) and have walls sloping from the corallite margin to the floor of the calice; peripheral platform absent or very narrow.

Septa are bilaterally arranged. Cardinal and counter septa are relatively short and the counter septum is flanked by long minor septa. Other major septa extend to or nearly to the axis. Septa are attenuate in the dissepimentarium but thicken in the tabularium by a factor of three or four. Yard-arm carinae are long and abundant; zigzag carinae are present but are estimated to represent less than 10 percent of the carinae in any one transverse section. Carinae slope gently from the inner to outer margins of the dissepimentarium. This slope suggests a broad V-shaped calice profile.

The dissepimentarium is composed of 8 to 15 or more rows of medium to large dissepiments and occupies approximately one-half of the corallite radius. Outer dissepiments are globose; inner ones are vertically elongate.

Tabulae are incomplete, and the pattern is obscure.

Microstructure.—As for genus.

Discussion.—This description is based on three fragments of coralla from a single locality. The species is distinguished from all other colonial corals in the Onesquethaw by its combination of characters, but it is most similar to *Heliophyllum* n. sp. B, from which it differs in having long yard-arm instead of short zigzag carinae, in smaller and less regularly globose dissepiments, and in lacking a calicular platform.

Distribution.—Known only from the Edgecliff bioherm facies at one locality in eastern New York.

Material.—USNM 172226–227, NYSM 12866.

Cerioid Species
Heliophyllum coalitum (Rominger)

Plates 96–98

1876 *Cyathophyllum coalitum* Rominger, p. 108–109, pl. 38, fig. 4.
not 1881 *C. coalitum* Rominger. Quenstedt, pl. 161, fig. 3 (probably *Heliophyllum yandelli*).
part? 1883b *Heliophyllum coalitum* (Rominger). Hall, p. 259–260, pl. 7, fig. 3 (not figure 2).
1887 *C. coalitum* Rominger. Holmes, p. 16, pl. 10, figs. 4a–e.
? 1901 *Cyathophyllum coalitum* Rominger. Lambe, p. 152.
1948a *Hexagonaria coalita* (Rominger). Stumm, p. 20–21, pl. 1, fig. 3; pl. 9, figs. 5, 6.
? 1948a *H. bathycalyx ponderosa* Stumm, p. 23. pl. 3, fig. 1.
1955 *H. coalita* (Rominger). Stumm, cards 172–173.
? 1955 *H. bathycalyx ponderosa* Stumm. Stumm, card 208.
? 1965 *H. ponderosa* Stumm. Stumm, p. 44, pl. 39, fig. 1.

Occurrence of type material.—Ann Arbor, Mich.; "Found frequently in silicified condition in the drift, connected with fossils of the corniferous limestone." (Rominger, 1876, p. 109). Presumably derived from (1) Amherstburg, Onondaga, or Bois Blanc of southwestern Ontario, or (2) Bois Blanc of Mackinac Straits region, Michigan. (See discussion.)

Diagnosis.—Cerioid or subcerioid *Heliophyllum* composed of large corallites separated by very thin walls; calices with axial boss and broad peripheral platform. Septa attenuate; major extend to axis where they bend and twist slightly without forming an axial structure.

External features.—The coralla are large, as much as at least 30 by 45 cm in diameter and 15 cm high. Mature corallite diameters range from 23 to 41 mm; in one large corallum 10 corallites range from 25 to 32 mm (average 29.9 mm; fig. 37).

Calicular pits are broad and shallow with a low boss, formed by the axial ends of the septa, covering most of the base; the peripheral platform is horizontal and wide.

Increase is peripheral, four or more offsets being produced at one time.

Internal features.—The septa are bilaterally arranged although this is obscured in many corallites by slight twisting of septa at the axis. Major septa extend to or nearly to the axis and tend to bend or twist at their axial ends without forming an axial structure (except in one aberrant colony in which an aulos is formed; see pl. 98 and discussion). Cardinal and counter septa are shorter than other major septa and (in many corallites) adjacent major septa tend to bend toward the cardinal-counter plane so that they meet along a line or form a small elliptical area with their ends. Minor septa extended to the edge of the tabularium without entering it. All septa are uniformly thin in the dissepimentarium; the major septa are slightly dilated within the tabularium. The number of major septa per corallite ranges from 31 to 49 in the few specimens analyzed (fig. 37); in one large corallum the number of major septa in 10 corallites ranges from 34 to 40 and averages 38.1.

All septa are carinate in the dissepimentarium. Long yard-arm carinae predominate but zigzag carinae are not uncommon. Carinae are closely spaced, ranging from 6 to 11 per 5 mm, averaging approximately 9 per 5 mm, in transverse sections. Short zigzag carinae are present in the tabularium.

The corallite walls are straight or curved, forming an irregular polygonal pattern in transverse sections. Individual corallites are not everywhere in contact so that open spaces between individuals exist locally. At these places, the wall between two corallites splits into its two parts and is curved as in a phaceloid coral. Walls between adjacent corallite range in thickness from 0.15 to 0.50 mm.

The tabularia are wide, occupying approximately two-fifths the diameter of each corallite. Tabulae are incomplete, forming a pattern that is axially arched and peripherally concave. Spacing of tabulae varies.

The dissepimentaria are formed by small to medium-sized globose dissepiments arranged in rows that are steeply inclined near the tabularium, almost horizontal in peripheral parts of corallites.

Discussion.—The above description is based on five fragments of coralla from the Onondaga Limestone in New York which have been compared with the Michigan type specimens. The largest of these measures approximately 30 by 45 by 15 cm and includes several dozen corallites. Other fragments are smaller including, 4 to 20 corallites. None of the fragments preserves the original form of the colony or any part of the holotheca and all are broken or crushed internally, apparently because of very thin septa and walls.

The New York specimens are similar to the holotype and paratypes from Michigan. Most characteristic seems to be the large corallite size, the occasional curved walls, and the attenuate structures. In these characters, *H. coalitum* differs from other described species of *Heliophyllum* or *Cyathocylindrium*. In the field, *H. coalitum* is most easily confused with *H. monticulum* because of similar corallite size and delicate structure. The latter species differs mainly in the absence of a wall between corallites and in the arrangement of dissepiments.

Variation in *Heliophyllum coalitum* is consider-

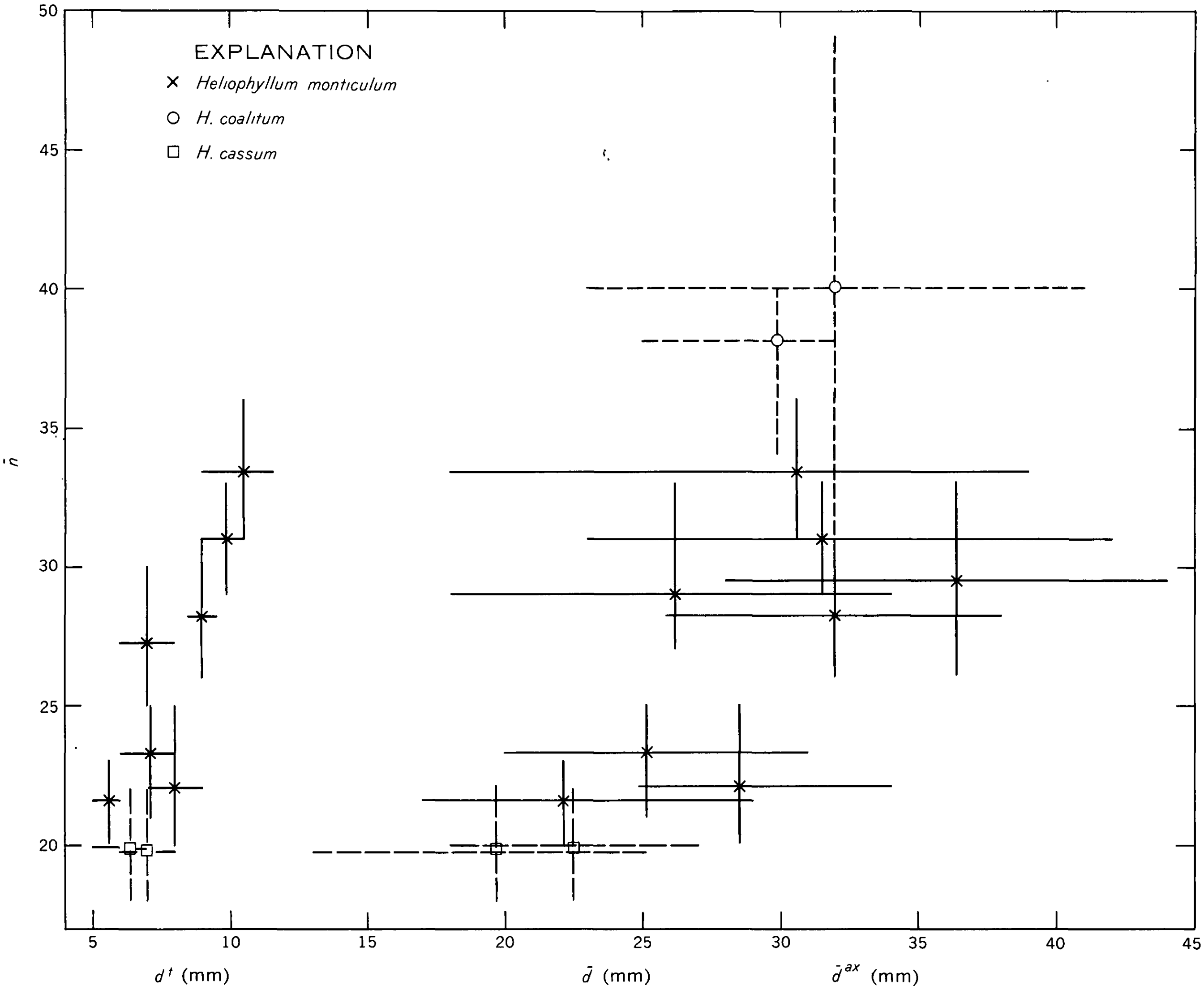


FIGURE 37.—Massive *Heliophyllum* spp. data. Mean and observed range of number of major septa ($\bar{n}$ and OR_n). versus mean and observed range of diameter ($\bar{d}$ and OR_d). In the two astreoid species, diameter is measured as axial distance ($\bar{d}^{ax}$) and $\bar{n}$ is also plotted against mean tabularium diameter ($\bar{d}^t$).

able, particularly in the size and shape of corallites (straight or curved walls) and in the axial arrangement of major septa. The small sample and the crushing of most specimens makes analysis difficult. One specimen consisting of parts of three or four corallites is particularly interesting in having a well-developed aulos, formed as in *Eridophyllum* by the deflection of the major septa (pl. 98). The auloi are large, 4 to 6 mm in diameter and apparently continuous, as one aulos has a length of 2 cm or more with complete, approximately horizontal tabulae inside the aulos.

Distribution.—Rominger's types were drift specimens collected near Ann Arbor, Mich. According to Stumm (1948a, p. 21), they were probably derived from the Onondaga Limestone in southwestern Ontario, but it seems equally possible that they could have come from the Bois Blanc Formation of the same area or from the Mackinac Straits region.

The New York specimens described in this paper were collected from the bioherm facies of the Edgecliff Member. Three of the specimens are from near Leroy, in western New York; two specimens are from near Coxsackie, in the Hudson Valley. The species was apparently widespread, although rare, and in New York may have been restricted to the bioherm facies of the Edgecliff Member.

One specimen in the collections of the Geological Survey of Canada, is from "N. Oxford township, Oxford County, Ontario." This is the Woodstock area and the specimen is most likely from the Bois Blanc Formation but possibly from the Amherstburg. The specimen is silicified; this and the general appearance of the specimen also suggests a Bois Blanc source.

Hall (1883b) illustrated a cerioid coral from the Jeffersonville Limestone as this species. This may be the form later described by Stumm (1948a) as *Hexagonaria ponderosa* and both may be conspecific with *Heliophyllum coalitum*. The holotype of *H. ponderosa* is probably indeterminate, and I have not seen Hall's specimen; none of the corals illustrated by Davis or Greene in their Falls monographs is at all similar, so the presence of this form at the Falls must remain conjectural.

Material.—Michigan: holotype, UMMP 8579; Stumm hypotype, UMMP 24195. New York: specimens herein illustrated, USNM 172228–231 and NYSM 12867 (part of USMN 172229). Additional specimen, NYSM 3495. Ontario: here illustrated, GSC 3586.

Astreoid Species

Heliophyllum monticulum (Ehlers and Stumm)

Plates 99–102

- ? 1899 *Phillipsastraea billingsi* Calvin, Lambe, p. 249 (not Calvin, 1893).
- ? 1901 *P. billingsi* Calvin, Lambe, p. 169.
- 1953 *Billingsastraea monticula* Ehlers and Stumm, p. 4, pl. 2, figs. 1–3.
- 1955 *B. monticula* Ehlers and Stumm, Stumm, card 236.4.
- ? 1958 *B. billingsi* (Calvin), Cranswick and Fritz, p. 43, pl. 2, fig. 3.

Occurrence of type material. —Bioherm facies of Edgecliff Member, Onondaga Limestone, Williamsville, N.Y.

Diagnosis.—Astreoid *Heliophyllum* with large corallites, prominent yard-arm carinae, and long major septa which are irregular in the axial region.

External features.—The astreoid coralla are very large, as much as 60 cm or more in diameter and 15 cm or more in height. Corallites are irregularly prismatic with indefinite boundaries. Diameters range from 17 to 44 mm but variation is more limited within individual colonies (table 38 and fig. 37); mean diameter in eight colonies ranges from 22 to 36 mm.

Increase is peripheral but offsets expand rapidly and few can be recognized in any one colony.

Calices are crater shaped with the rounded rim of the crater projecting 4 to 5 mm above the marginal level. Inside the rim the calicular pits are bowl shaped, approximately 1 to 2 mm deep and 6 to 12 mm in diameter. No boss is present, but the pattern of the major septa is apparent. Outside of the rim, the calicular platform is reflexed downward, becoming horizontal toward the edge of the corallite.

TABLE 38.—Heliophyllum monticulum *(Ehlers and Stumm), summary data*

		Intracolony			Intercolony
		Minimum	Maximum	Mean	
N[1]		9	10	----	9
n:	$\bar{x}$	21.6	33.4	----	27.3
	OR	20–23	31–36	----	-----
	s	1.07	2.07	----	4.11
	V	4.0	7.0	5.7	15.1
d^{ax}:	$\bar{x}$	22.1	36.4	----	29.1
	OR	17–29	28–44	----	-----
	s	2.75	5.96	----	4.51
	V	10.0	18.9	13.9	15.5
d^t:	$\bar{x}$	5.6	10.5	----	8.2
	OR	5.0–5.9	9.0–11.5	----	-----
	s	.27	1.08	----	1.74
	V	3.7	11.1	7.3	21.4

[1] Axial distance (d^{ax}) based on 15 or 20 measurements in each of 8 coralla; tabularium diameter (d^t) was measured in 4 to 10 corallites in each of 7 coralla.

Internal features.—The septa are bilaterally arranged; the cardinal and (or) counter septa are commonly shorter than the other major septa which are longer away from the cardinal-counter plane. Major septa extend to or nearly to the axis but rarely meet; axial ends tend to form a linear or ellipsoidal pattern along the cardinal-counter plane. Minor septa on either side of the counter septum may be slightly longer than other minor septa but commonly are undifferentiated. In some specimens major septa are irregularly deflected to form a weak whorl (as described by Ehlers and Stumm, 1953, p. 4); in the holotype this is accentuated by crushing.

The minor septa are limited to the dissepimentarium, are thinner, and have shorter carinae than the major septa. Peripherally the septa commonly continue into the next corallite but may abut against other septa. Septa are attenuate, but may dilate slightly in the inner dissepimentarium or tabularium. Number of major septa ranges from 20 to 36; the average number per corallite in 9 coralla ranges from 21.6 to 33.4 (average 27.3) (table 38 and fig. 37).

Yard-arm and fewer zigzag carinae are strongly developed along all septa in the dissepimentarium. The average number of carinae in the 5 mm closest to the tabularium ranges from 7.5 to 12.4, averaging 9 to 10. On the sides of the septa, in longitudinal sections, the carinae appear as abruptly projecting ridges directed upward and inward which become less steep toward the axis. Very short zigzag carinae are commonly present within the tabularium.

The dissepimentaria occupy a large part of each corallum. Dissepiments are small and inflated, steeply inclined adjacent to the tabularia, and gently inclined to horizontal near corallite boundaries.

Tabularia range in diameter from 5.0 to 12.0 mm but show less variation within coralla; in seven well-preserved colonies, mean tabularium diameter ranges from 5.6 to 10.5 mm and averages 8.2 mm (table 38 and fig. 37). The tabularia are composed of closely spaced, short, arched, incomplete tabulae that form a horizontal pattern of successive calice floors.

Septa, dissepiments, and tabulae commonly are very thin and apparently were delicate. Most coralla collapsed slightly during burial and now exhibit broken septa. A few specimens were obviously distorted, but in most specimens, horizontal dimensional changes appear to have been slight.

Microstructure.—Same as for the family. Some carinae are dilated and formed of a single, coarse monacanth, but craspedophyllid microstructure predominates.

Discussion.—The above description is based on 35 colonies or fragments of colonies from the Onondaga Limestone in New York. Only nine of these were large enough and sufficiently well preserved for the measurements and counts indicated in the text (table 38 and fig. 37).

This and the following species have been referred to *Billingsastraea* (=*Asterobillingsa*) by Stumm and other recent workers in eastern North America. The species differ from that genus in their large corallites with marked bilateral symmetry, their long yardarm carinae, and their septal dilation. Large, astreoid *Heliophyllum* differ from *Taimyrophyllum* Chernychev (or *Eddastraea* Hill) in the morphology of both carinae and dissepiments; the latter have zigzag carinae or no carinae and depressed dissepiments. (See Pedder, 1964, for description and discussion of *Taimyrophyllum.*)

Large astreoid corals, with corallite diameter in the range of 2–4 cm are not uncommon in the ENA Onesquethaw Stage. Early workers referred to these as *Phillipsastraea gigas* (a Silurian *Arachnophyllum*) or *P. billingsi* (Late Givetian, Iowa), but none was illustrated until 1953 when Ehlers and Stumm described the Edgecliff species as *Billingsastraea monticulum.*

A species distinct from *H. monticulum* is present in the Bois Blanc Formation, Ontario. Material described by Billings (1859) and Nicholson (1875) is probably from the Bois Blanc and presumably not *H. monticulum.* Specimens of Lambe (1899, 1901) may be either the Bois Blanc or Edgecliff species, but Lambe describes septa "reaching the centre and becoming somewhat twisted," a character of *H. monticulum* rather than the Bois Blanc form.

The longitudinal section from northern Ontario, illustrated by Cranswick and Fritz (1958, p. 43, pl. 2, fig. 3) as *Billingsastraea billingsi* (Calvin), shows morphologic characters closer to those of *H. monticulum* than to *H. billingsi.* Cranswick and Fritz partly based their identification on specimens of "*B. billingsi*" from the "Onondaga" limestone in Ontario (Cranswick and Fritz, 1958, p. 44) although *B. billingsi* was described from the Cedar Valley Limestone in Iowa (Ehlers and Stumm, 1953, p. 10). Pending redescription of the Cranswick and Fritz material, their specimens are tentatively placed in *H. monticulum.*

Heliophyllum yandelli and a second form from the Jeffersonville Limestone at the Falls of the Ohio consistently differ from *H. monticulum* in having long, prominent minor septa on either side of the counter(?) septum. *H.? billingsi* differs in that the major septa tend to meet at the axis and the carinae are dominantly zigzag (possibly this should be referred to *Cyathocylindrium*). The septa also meet at the axis in *H. ingens,* but this form has distinct *Heliophyllum*-type carinae.

Distribution.—*Heliophyllum monticulum* is known only from the Edgecliff Member of the Onondaga Limestone and is probably restricted to the bioherm facies. Of the 33 studied colonies or fragments, 29, including the holotype, are from a single Edgecliff bioherm near Williamsville, N.Y. (loc. 108). Half of these were collected during the present study, the rest were borrowed from collections in the Geology Department, University of Buffalo, and in the USNM.

The largest and best preserved colony (pl. 101, figs. 1–3) was collected from the Edgecliff bioherm north of Thompson's Lake, New York (loc. 81).

Three specimens borrowed from the New York State Museum are labeled Thompsons Lake (NYSM 3497), Falkirk (NYSM 12868), and Falkirk (NYSM 12869). These are almost certainly from the Edgecliff Member and probably from the bioherm facies. A single specimen is known from the Edgecliff bioherm facies near Port Colborne, Ontario.

Material.—Holotype: UMMP 28519 (fragment is USNM 128015). Illustrated or measured specimens: USNM 172232–236, 136711, 136692; NYSM 12868–70. Other thin-sectioned specimens: USNM 9003a; NYSM 3498–3500; and UBuff (five specimens). Other studied specimens: USNM 172237a–d, 172238, 113262, 182908, and UBuff (six specimens).

Heliophyllum cassum n. sp.

Plate 103

? 1859 *Phillipsastrea gigas* Owen, Billings, p. 128.
? 1875 *P. gigas* Owen, Nicholson, p. 77–78.

Occurrence of type material.—Bois Blanc Formation (Emsian), Hagersville and Innerkip, Ontario.

Diagnosis.—Astreoid *Heliophyllum* with moderately large corallites and relatively short major septa. Septa are locally discontinuous with development of lonsdaleoid dissepimentarium; tabulae are complete or incomplete.

External features.—Two known specimens measure 11 by 10 by 3 and 15 by 10 by 12 cm in length, width and height; both are fragments of larger coralla. No part of the original surface of either colony is preserved, but parts of the holotheca are preserved on both. Corallite diameters (d^a) range from 13 to 27 mm and average 22.5 and 19.7 mm in the two specimens (fig. 37).

Increase is peripheral and offsets are very numerous in the holotype which was a young, expanding corallum. In both specimens, increase was primarily on the outside half of the outside corallites of the colony.

Calices interpreted from longitudinal sections are shallow and have moderately steep walls, a rim, and a slightly reflexed platform; the calice floor is approximately horizontal.

Internal features.—The septa are bilaterally arranged although this is obscured in many corallites by irregularities. The major septa extend approximately halfway through the tabularium and are variously arranged within the tabularium. Bilateralism may be marked by relatively shorter cardinal and counter septa, by adjacent septa that bend toward the cardinal-counter plane, and by longer than normal minor septa on either side of the cardinal septum. In some corallites the septa irregularly bend within the tabularium and no plane of bilateral symmetry can be discerned.

Number of major septa ranges from 18 to 22 and averages 19.9 and 19.8 in the available colonies (fig. 37). Minor septa are limited to the dissepimentarium.

All septa are heavily carinate, commonly with long yard-arm carinae, but subyard-arm and zigzag carinae are also present. The septa are commonly continuous from one corallite into an adjacent one, but spaces where three or four corallites join may be without septa and occupied by large dissepiments. Such spaces are characteristic of all transverse and longitudinal sections.

The dissepimentarium is broad, composed of small to medium-sized globose dissepiments; in spaces lacking septa the dissepiments are large; spaces between dissepiments are as much as 1.5 mm high and 6 mm or more in diameter.

The tabularium diameter ranges from 5 to 8 mm and averages 6.4 and 7.0 in the two coralla. Tabulae are complete or incomplete, flat or gently concave axially, and strongly downbent peripherally.

Microstructure.—Not well preserved but apparently as for family. No significant dilation was noted in either specimen.

Discussion.—The above description is based on only two specimens, but they seem distinct enough to warrant description as a new species. They differ from all known astreoid *Heliophyllum* in their short major septa that are lonsdaleoid in peripheral "corners."

Large astreoid corals described by Billings (1859) and Nicholson (1875) have not been examined but were from the Bois Blanc Formation and may have been this species.

Distribution.—Known only from the Bois Blanc Formation at Hagarsville (loc. C19) and Innerkip (loc. C28), Ontario.

Material.—Holotype, GSC 31165 (and USNM 172244); paratype, UMMP 31601.

Heliophyllum procellatum n. sp.

Plates 104, 105

Occurrence of type material.—The holotype and paratype are from Falkirk, N.Y., and probably the Bois Blanc Formation. (Statement based on occurrence of similar forms in Bois Blanc of Michigan; see discussion.)

Diagnosis.—*Heliophyllum* with medium-sized corallites in which long yard-arm carinae predominate. The major septa form an anastomosing network in the tabularium.

External features.—Astreoid or thamnasterioid corals; two New York specimens studied are 19 by 13 by 2 cm and 13 by 13 by 3 cm. Corallites are irregularly bounded, radiating to subparallel. Corallite diameters (d^{ax}) range from 13 to 23 mm and average 17.9 and 18.2 mm in the two coralla studied (table 39 and fig. 30).

Calices are crater shaped with the inner slope of the crater corresponding to the outer margin of the tabularium. Inside the rim the calicular pit is shallow, 1 to 2 mm deep, and has a broad gentle boss. The calicular platform is deflected sharply downward so that the rim of the crater projects 2 to 4 mm above the margins of the corallites.

Internal features.—The septa are radially arranged. The major septa extend to the axial region where they are irregularly deflected in all directions to form an anastomosing structure one-half to two-thirds the diameter of the tabularium. The number of major septa ranges from 18 to 21 (average 19.6), and 17 to 20 (average 18.6) in the two coralla (table 39 and fig. 30).

TABLE 39.—Heliophyllum procellatum, *intracolony data*

		New York		
		NYSM 12872	NYSM 12873	Michigan
N		20	20	(1)
n:	$\bar{x}$	19.6	18.6	23.7
	OR	18–21	17–20	21.3–27.0
	s	1.1	.9	2.23
	V	5.4	4.7	9.4
d^t:	$\bar{x}$	3.9	4.0	6.8
	OR	3.5–4.6	3.5–5.0	5.7–7.5
	s	.3	.4	.72
	V	8.1	9.2	10.5
	r	.27	.44	---------
	P	.30	<.05	---------
d^{ax}:	$\bar{x}$	17.9+	18.2+	---------

[1] Intercolony variation based on three to six corallites in five crushed coralla.

Minor septa are limited to the dissepimentarium and are slightly thinner than the major ones. All septa are attenuate and relatively uniform in thickness throughout their lengths. Peripherally some septa are continuous into the next corallite, but others abut against other septa.

Yard-arm and zigzag carinae are strongly developed; the former appear to predominate, but many of the yard-arm carinae are zigzag with only slight offset. The carinae are closely spaced, averaging eight per 2.5 mm at the inner margin of the dissepimentarium. Within the tabularium major septa have short zigzag carinae irregularly distributed.

The dissepimentaria are composed of small, globose dissepiments, steeply inclined toward the coralite axes near the tabularium, irregularly inclined to horizontal elsewhere. The dissepiments are confined to interseptal spaces. The boundaries between adjacent corallites cannot be recognized in longitudinal sections.

The tabularia range in diameter from 3.5 to 4.6 mm (average 3.9) and from 3.5 to 5.0 mm (average 4.0) in the two coralla (table 39 and fig. 30). Tabulae are incomplete and dissepimentlike and are almost lost in the anastomosing axial ends of the major septa.

Discussion.—The above description is based on two incomplete specimens from the Bois Blanc Formation(?) at Falkirk, N.Y. Eight thin sections labeled Falkirk, from the NYSM are of this species and may have been cut from the same two specimens.

H. procellatum is distinguished by the anastomosing arrangement of major septa in the tabularia, by the predominance of yard-arm carinae in the dissepimentarium, and by the presence of zigzag carinae in the tabularium. In these characters it is so different from other Onesquethaw species of the genus that it seems worth naming in spite of the small sample and limited information on provenance. The two known specimens of *H. procellatum* were found in the NYSM labeled "Falkirk, New York." The labels indicate that they had been selected by G. B. Simpson as types of a new species which was to have been described in a monograph on the corals of New York. This was never completed, and no written notes or description are known. Both the Bois Blanc Formation and the Edgecliff Member crop out at Falkirk (near Akron); there is no matrix adhering to either specimen and no direct way of determining the source bed.

As discussed below, similar corals, possibly conspecific, occur in the Bois Blanc Formation of Michigan. This limited evidence suggests that a Schoharie age is more likely than an Onondaga one (see discussion in section on "Stratigraphy") and that *H. procellatum* in New York may be from the Bois Blanc rather than the Onondaga.

Material.—Holotype, NYSM 12872; illustrated paratype, NYSM 12873; eight additional thin sections labeled Falkirk, NYSM 12874 (probably from one or both of the above specimens).

Heliophyllum sp. cf. H. procellatum n. sp.

Plate 106

1876 *Phillipsastraea gigas*, Rominger (not Owen, 1844) p. 129–130, pl. 37, fig. 3.

1945 *Billingsastraea* sp., Ehlers, pl. 13, figs. 1, 2.

Ten specimens from the Bois Blanc Formation of Michigan are similar enough to *H. procellatum* to warrant notice and comparison. The specimens are all partly crushed so that corallite diameters and features of the corallite peripheries cannot be accurately determined.

The Michigan specimens are strikingly similar to *H. procellatum* in the morphology of their carinae and in the axial arrangement of major septa. Carinae are long, closely spaced (six to nine per 2.5 mm) and predominantly yard-arm or only slightly offset. Major septa extend to the axis where, in most corallites, they irregularly bend and twist as in *H. procellatum*; short, zigzag carinae are present in the tabularium.

The Michigan specimens have a much larger tabularium diameter and correspondingly more septa than *H. procellatum*. Limited data from five better preserved coralla are given in table 39. Tabularium diameter in other specimens is similar. Total diameter (d^{ax}) in the Michigan specimens has not been measured because of the crushing, but it appears to be not significantly greater than in *H. procellatum*.

At present, too few specimens are known from New York or Michigan to determine the limits of individual variation. The Michigan specimens are so similar to the New York ones in the morphology of septa and carinae that some relationship seems probable. Size and septal number differences may or may not be significant.

Distribution.—Bois Blanc Formation, Mackinac Straits region, Emmet County, Mich.

Material.—Illustrated specimen, UMMP 18804; other studied specimens, USNM 172239, 172240, and UMMP 23602 (figured by Ehlers, 1945, pl. 13, fig. 1, as *Billingsastraea* sp.), 23603 (figured by Ehlers, 1945, pl. 13, fig. 2 as *B.* sp.), 8574 (figured by Rominger, 1876, pl. 37, fig. 3, as *Phillipsastraea gigas*), 22953, 22954, 50630a, 50749.

LOCALITY DATA

New localities in New York and southwestern Ontario are described in sufficient detail so that anyone with the proper map should be able to find the locality and identify the stratigraphic units present. Each locality represents one to many collections. Data on the position of collections at the localities is not given because no pattern or significance to position within members or facies has been recognized. The collection data is preserved in the records of the U.S. Geological Survey (Silurian-Devonian catalog and field notebooks). Assignment of all specimens and species to members, facies, and beds discussed in the stratigraphy section is indicated in the systematic descriptions and in tables 40–46.

Old localities in New York and southwest Ontario are identified in as much detail as is possible, but many localities can only be assigned to a general area.

Localities of comparative material from other areas are similarly described if new. Data on locality of type and previously described specimens can be obtained in the original publication.

TABLE 40.—*Distribution of colonial rugose corals in the Bois Blanc and Schoharie Formations, New York and southwestern Ontario.*

[Localities are listed in geographic order from west to east. Numbered localities are "new" (see locality list); letters refer to "odd" localities as follows: A, Woodstock and Oxford; B, Hagarsville and Walpole; C, Port Colborne; D, Falkirk; E. Leroy; F, Schoharie and Schoharie County; G, in Berne 15-min quadrangle; H, in Albany 15-min quadrangle. G and H consist only of external molds but are identified with reasonable certainty. Number of coralla known from each locality is indicated].

Localities	Bois Blanc Formation											Schoharie Grit					
	Central southwest Ontario		Niagara Peninsula, Ontario							Western New York		Eastern New York					
	A	C28	C19	C20	C22	B	C17	C10	C	D	E	F	79	G	505	73	H
Acinophyllum simcoense	7	1	4	1	6	1	1	2	--	--	3	--	--	--	--	--	--
A. stokesi	2	--	1	1	13	--	--	4	1	--	--	1	2	(4)	1	--	(5)
Cylindrophyllum laxtensum	2	4	2	--	--	1	--	--	--	--	--	--	--	--	2	--	--
Asterobillingsa rugosa	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--
A. magdisa magdisa	1	--	--	1	--	--	--	1	1	--	1	2	--	--	--	1	--
Grewgiphyllum colligatum	--	2	2	--	--	4	--	--	--	--	--	--	--	--	--	--	--
Heliophyllum procellatum	--	--	--	--	--	--	--	--	--	2	--	--	--	--	--	--	--
H. cassum	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--

TABLE 41.—*Distribution of colonial rugose corals in the bioherm facies of the Edgecliff Member of the Onondaga Limestone*

[Localities are listed in geographic order from west to east. Numbered localities are "new" (see locality list); letters refer to "old" localities as follows: A, Port Colborne; B, Falkirk; C, Leroy; D, Thompsons Lake. Albany County; E, Clarksville. Number of coralla known from each locality is indicated].

Localities	Niagara Peninsula, Ontario						Western New York				Central New York			Eastern New York																
	C10	A	C9	C7	C5	C3	108	348	B	438	C	597	360	207	233	236	239	229	269	185	135	285	329	D	81	244	E	248	296	297
Synaptophyllum arundinaceum.	2	--	--	--	--	--	3	1	--	2	--	1	--	2	--	1	--	--	--	2	--	--	--	--	2	--	--	--	--	--
S. tabulatum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--
Acinophyllum stramineum.	1	--	1	--	--	--	23	--	1	3	--	--	--	1	--	--	--	1	--	--	1	--	--	--	--	--	--	--	--	--
A. segregatum	2	--	1	3	1	--	34	--	--	10	--	1	3	6	13	1	1	2	7	1	2	--	4	--	5	3	--	1	3	1
Cylindrophyllum elogatum.	--	--	--	--	--	--	3	--	--	--	--	--	--	2	1	--	--	--	--	--	1	--	2	--	--	--	2	--	2	--
C. propinquum	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	1	--	1	--	--	--	--	--	--	--	2	--
C. deearium	1	--	--	--	--	--	--	--	--	--	2	--	1	--	--	--	--	--	--	--	--	--	--	--	3	1	--	--	1	--
C. sp. A	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Asterobillingsa magdisa steorra.	--	--	--	--	--	--	18	--	1	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	1	--	1	--	--	--
A. magdisa magdisa	--	1	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Eridophyllum subseriale	--	--	--	--	--	--	--	--	--	--	--	--	2	--	1	--	3	--	--	--	2	1	4	--	--	--	--	1	2	7
Grewgiphyllum colligatum.	--	--	--	--	--	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cyathocylindrium opulens	2	--	--	2	1	--	8	--	--	3	2	--	--	2	10	1	--	--	2	--	3	--	4	--	2	1	--	2	3	1
C. gemmatum	1	--	--	--	--	--	13	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--
Heliophyllum megaproliferum.	--	--	--	--	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--
H. n. sp. B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	--	--	--	--	--	--	--
H. n. sp. C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3
H. coalitum	--	--	--	--	--	--	--	--	--	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--
H. monticulum	1	--	--	--	--	--	30	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	1	--	--	--	--	--

TABLE 42.—*Distribution of colonial rugose corals in the nonbioherm facies of the Edgecliff Member of the Onondaga Limestone*

[Localities are listed in geographic order from west to east. Numbered localities are "new" (see locality list); letters refer to "old" localities as follows: A, Formosa area (see discussion of stratigraphy in central-southwestern Ontario); B, Woodstock; C, Walpole; D, Cheapside; E, Cayuga. Number of coralla known from each locality is indicated. The asterisk marks collections from the Edgecliff dark-limestone facies]

	Central southwest Ontario				Niagara Peninsula, Ontario									Western New York			
Localities	A	C36	C27	B	C22	C	C23	D	E	C45	C11	C10	C5	339	109	114	119
Synaptophyllum arundinaceum.	--	--	--	--	--	--	1	--	2	1	--	--	--	--	--	--	--
S. tabulatum	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--
S. kladion	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--
Acinophyllum stramineum	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--
A. segregatum	--	--	--	--	6	--	--	--	--	3	1	2	1	1	1	2	1
A. mclareni	1	9	1	--	--	--	3	--	--	--	--	--	--	--	--	--	--
Cylindrophyllum propinquum	--	--	--	--	--	--	--	--	--	cf.	--	--	--	--	--	--	--
C. deearium	--	1	--	--	--	--	--	1	--	--	--	1	--	--	--	--	--
Prismatophyllum ovoideum	--	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Asterobillingsa magdisa steorra.	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--
Eridophyllum subseriale	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Grewgiphyllum colligatum	--	--	--	--	--	--	--	--	--	--	--	5	--	--	--	--	--
Cyathocylindrium opulens	--	--	--	--	1	--	1	--	--	--	--	--	--	--	--	--	--

	Central New York							Eastern New York															
Localities	104	101	56	3	7	598	54	215	206	198*	188	188*	191*	337*	336*	164	154	135	90	286	82	77	292
Synaptophyllum arundinaceum.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
S. tabulatum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
S. kladion	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acinophyllum stramineum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
A. segregatum	1	1	1	1	2	2	2	1	1	11	3	4	1	1	1	1	1	2	3	1	1	2	1
A. mclareni	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cylindrophyllum propinquum	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--
C. deearium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Prismatophyllum ovoideum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Asterobillingsa magdisa steorra.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Eridophyllum subseriale	--	--	--	--	12	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--
Grewgiphyllum colligatum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cyathocylindrium opulens	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

TABLE 43.—*Distribution of colonial rugose corals in the Clarence and Nedrow Members of the Onondaga Limestone*

[Only four specimens of one species (one from each of four localities) were studied. The localities are listed in geographic order from west to east]

	Clarence Member Western New York			Nedrow Member Eastern New York
Localities	114	421	119	132
Acinophyllum segregatum	1	1	1	1

TABLE 44.—*Distribution of colonial rugose corals in the Moorehouse Member of the Onondaga Limestone*

[Localities are listed in geographic order from west to east. Numbered localities are "new" (see locality list); letters refer to "old" localities as follows: A, Woodstock; B, Port Dover; C, Naticoke; D, Albany County. The number of coralla known from each locality is indicated. The atserisk marks collections from tne *Acinophyllum-Eridophyllum* bed]

	Southwest Ontario				Western New York										Central New York		Eastern New York			South-east New York	
	Central	Niagara Peninsula																			
Localities	A	B	C	C18	110	111	112	497	373	393	118*	120	120*	493*	102	336	86	D	246	301	324
Synaptophyllum kladion	1	--	--	1	1	--	--	--	2	--	--	3	--	--	--	--	--	--	--	--	--
Acinophyllum segregatum	--	1	1	--	--	3	9	3	3	4	14	9	10	4	1	1	1	--	--	2	1
A. mclareni	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Eridophyllum seriale	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	1	--	--	--
E. seriale population B	--	--	--	--	--	1	--	1	--	--	17	--	7	2	--	--	--	--	--	--	--
E. aulodokum	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	1	--	--
E. conjunctum	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--
E. corniculum	--	--	--	--	--	--	28	--	--	6	--	--	--	--	--	--	--	--	--	--	--
Cyathocylindrium n. sp. A	--	--	--	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--

TABLE 45.—*Location of the single colonial rugose coral known from the Seneca Member of the Onondaga Limestone*

	Central New York, locality 46	
Prismatophyllum truncata	1	--

TABLE 46.—*List of museum numbers of all type, illustrated, and otherwise mentioned specimens, giving the species, collection number, and locality*

[Museum numbers are in numerical order within the following sequence of institutions 1. U.S. National Museum of Natural History. 2. New York State Museum. 3. Geological Survey of Canada. 4. American Museum of Natural History. 5. British Museum (Natural History). 6. Harvard University Museum of Comparative Zoology. 7. University of Iowa, Department of Geology. 8. University of Michigan, Museum of Paleontology. 9. Orton Museum, Ohio State University. 10. Royal Ontario Museum. Species are keyed as follows: 1. *Synaptophyllum arundinaceum*, 2. *S. tabulatum*, 3. *S. kladion*. 4. *Acinophyllum simcoense*, 5. *A. stramineum*, 6. *A. segregatum*, 7. *A. mclareni*, 8. *A. stokesi*, 9. *Cylindrophyllum elongatum*, 10. *C. propinquum*. 11 *C. laxtensum*, 12. *C. decarium*. 13. *Prismatophyllum ovoideum*. 14. *P. truncata*. 16. *Asterobillingsa magdisa steorra*, 17. *A. magdisa magdisa*, 18. *A. rugosa*. 19. *Eridophyllum seriale*, 20. *E. seriale* population B, 21. *E. corniculum*. 22. *E. subseriale*. 23. *Grewgiphyllum colligatum*. 24. *Cyathocylindrium opulens*, 25. *C. gemmatum*, 26. *C.* n. sp. A., 27. *Heliophyllum megaproliferum*, 28. *H.* n. sp. B, 29. *H.* n. sp. C, 30. *H. coalitum*, 31. *H. monticulum*, 32. *H. cassum*. 33. *Cylindrophyllum* sp. A. 34. *Disphyllum*? *stummi*. 35. *Prismatophyllum prisma*. 36 *Eridophyllum aulodokum*. 37 *Heliophyllum procellatum*. 38. *Eridophyllum conjunctum*]

Museum number	Species number	Collection number	Locality
U.S. National Museum of Natural History Washington, D.C.			
10719	1		Williamsville.
10721	19		Albany County.
25870	12		Leroy.
26000a	16		Schoharie County.
27961	4		Hagarsville, Ontario.
113262	31		Williamsville.
113263	16		Do.
113264	17		Port Colborne, Ontario.
113552	23		Manitoulin Island (Ontario) drift.
113554	23		Hagarsville, Ontario.
113556	23		Do.

TABLE 46.—*List of museum numbers of all type, illustrated, and otherwise mentioned specimens, giving the species, collection number, and locality*—Continued

Museum number	Species number	Collection number	Locality
U.S. National Museum of Natural History Washington, D.C.—Continued			
128015	31		108 (part of UMMP 28519).
128016	17		Port Colborne, Ontario.
136692	31		Williamsville.
136711	31		Do.
143121	16		Do.
162576	1	236n	236
162577	1	5318–SD	438
162578	1	5312–SD	438
162579	1	81–(1)–5a	81
162580	1	1815r	185
162581	1	5358b–SD	207
162582	1	236	236
162583	1	348–3	348
162584	1	USNM 9003	108
162585	1	7525–SD	C10
162586	1	7525–SD	C10
162587	1	7807–SD	Ohio.
162588	1	Core spec.	Do.
162589	3	5338–SD	373
162590	3	5310–SD	120
162591	3	5309b–SD	120
162592	3	5310–SD	120
162593	3	373	373
162594	3	7524–SD	C11
162595	4	5052–SD	C28
162596	4	5052–SD	C28
162597	4	5052–SD	C28

TABLE 46.—*List of museum numbers of all type, illustrated, and otherwise mentioned specimens, giving the species, collection number, and locality*—Continued

Museum number	Species number	Collection number	Locality
U.S. National Museum of Natural History Washington, D.C.—Continued			
162598	4	5052–SD	C28
162599	4	5052–SD	C28
162600	4	5024–SD	C19
162601	4	5014–SD	C10
162602	4	5052–SD	C28
162603	4	7509–SD	C22
162604	4	7505–SD	C22
162605	4	7518–SD	C19
162606	4	7515–SD	C22
162607	2	244	244
162608	5	108–17b	108
162609	5	135	135
162610	5	108–17b–e	108
162611	5	108–15b	108
162612	5	108–15b	108
162613	5	5351a–SD	229
162614	5	108–17b–e	108
162615	6	5353–SD	269
162616	6	5362d–SD	329
162617	6	5353–SD	269
162618	6	5357b–SD	188
162619	6	5354c–SD	198
162620	6	5354c–SD	198
162621	6	5308a–SD	118
162622	6	5309a–SD	120
162623	6	5350b–SD	233
162624	6	233–3	233
162625	6	269–r2N	269
162626	6	329–1	329
162627	6	135	135
162628	6	108–17l	108
162629	6	5352–SD	269
162630	6	5350c–SD	233
162631	6	5319–SD	438
162632	6	5351a–SD	229
162633	6	5312–SD	438
162634	6	5364–SD	81
162635	6	5314–SD	438
162636	6	5313–SD	438
162637	6	5330–SD	108
162638	6	296–1b	296
162639	6	5357a–SD	188
162640	6	5354c–SD	198
162641	6	5355–SD	188
162642	6	5354a–SD	198
162643	6	5355–SD	188
162644	6	4673–SD	493
162645	6	4673–SD	493
162646	6	5308a–SD	118
162647	6	5311a–SD	120
162648	6	5308b–SD	118
162649	6	5308b–SD	118
162650	6	5311b–SD	120
162651	6	5308b–SD	118
162652	6	5311a–SD	120
162653	6	5308a–SD	118
162654	6	5311a–SD	120
162655	6	5310–SD	120
162656	6	5338–SD	373
162657	6	5329–SD	112
162658	6	5361–SD	336
162659	6	421–N	421
162660	7	5051–SD	C27
162661	7	5063–SD	C36
162662	7	5021–SD	C18
162663	7	4728–SD	Falls
162664	7	7101–SD	Ky
162665	7	5030–SD	C23
162666	7	5030–SD	C23
162667	7	4724–SD	Falls

TABLE 46.—*List of museum numbers of all type, illustrated, and otherwise mentioned specimens, giving the species, collection number, and locality*—Continued

Museum number	Species number	Collection number	Locality
U.S. National Museum of Natural History Washington, D.C.—Continued			
162668	7	7101–SD	Ky
162669	7	7101–SD	Ky
162670	8	7534–SD	C10
162671	8	7516–SD	C22
162672	8	7516–SD	C22
162673	8	7511–SD	C22
162674	8	5887a–SD	505
162675	8	5895–SD	79
163367	8	4721–SD	Falls
163368	8	4725–SD	Do.
163369	8	4721–SD	Do.
163370	8	7515–SD	C22
163371	8	7503–SD	C20
163372	8	7506–SD	C22
163373	8	7517–SD	C22
163374	8	5028–SD	C22
163375	8	5028–SD	C22
163376	8	7508–SD	C22
163377	8	5895–SD	79
163378	8	4721–SD	Falls
163379	8	4721–SD	Do.
163380	5	5028–SD	C22
163381	5	5013–SD	C9
163382	9	108–11	108
163383	9	108–8f–a	108
163384	9	5350e–SD	233
163385	9	5362c–SD	329
163386	9	5362c–SD	329
163387	9	108–8f	108
163388	9	296–1c	296
163389	9	207	207
163390	9	135	135
163391	11	5052–SD	C28
163392	11	7518–SD	C19
163393	11	5887a–SD	505
163394	11	5887a–SD	505
163395	33	108–19d	108
163396	34	5828–SD	Quebec
163397	34	5828–SD	Do.
163398	34	5828–SD	Do.
163399	35	4724–SD	Falls
163400	35	5933–SD	Do.
163401	35	5934–SD	Do.
163402	35	USNM Campbell 368B	Do.
163403	35	USNM Campbell 368B	Do.
163404	35	USNM Campbell 368B	Do.
163405	35	USNM Campbell 368B	Do.
163406	35	8289–SD	Ohio
163407	13	4728–SD	Falls
163408	13	4728–SD	Do.
163409	13	4728–SD	Do.
163410	13	4728–SD	Do.
163411	13	USNM Campbell 368C	Falls
163412	13	USNM Campbell 368C	Do.
163413	13	USNM 1558	Do.
163414	13	5051–SD	C27
163415	13	7808–SD	Ohio
163416	13	8289–SD	Do.
163417	13	7809–SD	Do.
163418	14	Cornell U. 202	46
163419	17	5891–SD	73
163420	17	5027–SD	C20
163421	17	7530–SD	C10
163422	17	108–S	108
163423	17	USNM (no number)	Hagarsville
163424	19	5334–SD	497
163425	19	7786–SD	Ohio
163426	20	5308a–SD	118
163427	20	5308b–SD	118
163428	20	5308a–SD	118

TABLE 46.—*List of museum numbers of all type, illustrated, and otherwise mentioned specimens, giving the species, collection number, and locality*—Continued

TABLE 46.—*List of museum numbers of all type, illustrated, and otherwise mentioned specimens, giving the species, collection number, and locality*—Continued

Museum number	Species number	Collection number	Locality	
		U.S. National Museum of Natural History Washington, D.C.—Continued		
163429	20	5311a-SD	120	
163430	20	5308a-SD	118	
163431	20	5308a-SD	118	
163432	20	5308a-SD	118	
163433	20	5308a-SD	118	
163434	20	5308a-SD	118	
163435	20	4673-SD	493	
163436	36	112	112	
163437	36	246	246	
163438	21	5328-SD	112	
163439	21	5328-SD	112	
163440	21	5328-SD	112	
163441	21	5328-SD	112	
163442	21	5328-SD	112	
163443	21	5328-SD	112	
163444	21	5327b-SD	112	
163445	21	5328-SD	112	
163446	21	5325-SD	393	
163447	21	5325-SD	393	
163448	21	5328a-SD	112	
163449	21	393	393	
163450	21	5328a-SD	112	
163451	21	5328-SD	112	6 specimens
163452	21	5328a-SD	112	5 specimens
163453	21	5325-SD	393	2 specimens
163454	22	5362a-SD	329	
163455	22	5349-SD	360	
163456	22	5362b-SD	329	
163457	22	5349-SD	360	
163458	22	7541-SD	7	4 specimens
163459	22	5363-SD	90	
163460	22	5362a-SD	329	
163461	22	239	239	2 specimens
163462	22	297-3	297	
163463	23	7518-SD	C19	
163464	23	7518-SD	C19	
163465	23	7529-SD	C10	
163466	23	7527-SD	C10	
172161	23	5331-SD	108	
172162	23	USNM 9003	108	
172163	23	USNM 9003	108	
172164	23	7529-SD	C10	3 specimens
172165	8	59b of Kindle	Virginia	
172166	16	Buffalo Univ.	108	
172167	16	108-16, 151	108	
172168	16	108	108	
172169	16	Buffalo Univ.	Akron	
172170	16	Buffalo Univ.	108	
172171	16	Buffalo Univ.	108	
172172	16	Buffalo Univ.	108	
172173	16	Buffalo Univ.	108	
172174	16	Buffalo Univ.	108	
172175	16	81(1)-3	81	
172176	16	Buffalo Univ.	108	
172177	16	USNM 9003	108	5 specimens
172178	5	USNM Boucot 1	Quebec	
172179	5	USNM Boucot 1	Do.	
172180	10	296	296	
172181	10	5367-SD	296	
172182	10	5352-SD	269	
172183	10	5358a-SD	207	
172184	10	5357b-SD	188	
172185	10	7520-SD	C45	
172186	10	7809-SD	Ohio	
172187	10	7808-SD	Do.	
172188	10	8289-SD	Do.	
172189	10	8289-SD	Do.	
172190	12	5349-SD	360	
172191	12	81	81	
172192	12	81-(1)-2	81	
172193	12	244	244	
172194	12	5063-SD	C36	
172195	12	7529-SD	C10	
172196	12	Perry 202	Ohio	
172197	24	81	81	
172198	24	5350e-SD	233	
172199	24	5029-SD	C22	
172200	24	5010-SD	C7	
172201	24	5350d-SD	233	
172202	24	5362b-SD	329	
172203	24	5350a-SD	233	
172204	24	329	329	
172205	24	5030-SD	C23	
172206	24	5350e-SD	233	
172207	24	5330-SD	108	
172208	24	5038-SD	C25	
172209	24	4721-SD	Falls	
172210	24	4721-SD	Do.	
172211	24	5317a-SD	438	
172212	25	USNM 9003	108	
172213	25	5330-SD	108	
172214	25	108-51	108	
172215	25	108-51	108	
172216	25	81	81	
172217	25	5014-SD	C10	
172218	25	233-3	233	
172219	25	Various	108	5 specimens
172220	26	5338-SD	373	
172221	27	5004-SD	C3	
172222	27	5330-SD	108	
172223	27	5621-SD	248	
172224	28	5362a-SD	329	
172225	28	329-2	329	
172226	29	5625-SD	297	
172227	29	297-1	297	
172228	30	7149-SD	296	
172229	30	5316b-SD	438	
172230	30	5314-SD	438	
172231	30	296-53	296	
172232	31	5331-SD	108	
172233	31	5364-SD	81	
172234	31	5331-SD	108	
172235	31	7528-SD	C10	
172236	31	5331-SD	108	
172237	31	5330-SD	108	4 specimens
172238	31	5331-SD	108	
172239	37	7662-SD	Michigan	
172240	37	7662-SD	Do.	
172241	9	207-5	207	
172242	9	108-8f-a	108	
172243	12	207	207	
172244	32	7518-SD	C19	
172245	38	8773-SD	118	
172246	6	154-lb-2	154	
182813	11	----------------	Woodstock	
182846	24	5350b-SD	233	
182847	24	5367-SD	296	
182848	24	5358d-SD	207	
182849	24	248	248	
182850	24	5350b-SD	233	
182851	24	5330-SD	108	
182852	24	5358a-SD	207	
182853	24	7525-SD	C10	
182908	31	USNM (no number)	Hagarsville, Ontario.	
		New York State Museum Albany, N.Y.		
246	9	----------------	Clarksville.	
299	18	----------------	Leroy.	

TABLE 46.—*List of museum numbers of all type, illustrated, and otherwise mentioned specimens, giving the species, collection number, and locality*—Continued

Museum number	Species number	Collection number	Locality
New York State Museum Albany, N.Y.—Continued			
300	2		Walpole, Ontario.
334–335	4		Leroy.
336	6		Clarksville.
337	6		Leroy.
338	6		Do.
12780	6	164–lb	164
12781	6	188–lb–2	188
12782	6	286–1	286
12783	6	90–1	90
12784	6	112–71	112
12785	6	NYSM E828B	Leroy
12786	6	108–17k	108
12787	6	269–r2N	269
12788	6	120–5	120
12789	6	236	236
12790	6	336–1a1	336
12791	6	337–1–A	337
12792	6	206–1b	206
12793	6	233–5	233
12794	6	207	207
12795	6	5330–SD	108
12796	6	5330–SD	108
12797	6	336–1a1	336
12798	6	5354b–SD	198
12799	6	118–cs	118
12800	6	118–cs	118
12801	6	5308b–SD	118
12802	6	5311a–SD	120
12803	6	373	373
12804	6	118	118
12805	6	102e–3	102
12806	5	108–8f–a	108
12807	5	108–8e–c	108
12808	5	108–16b	108
12809	5	NYSM 1453	Falkirk.
12810	8	NYSM 1415	Clarksville.
12811	4	NYSM 1452	Leroy.
12812	4	NYSM E828a	Do.
12813	4	NYSM 1452	Do.
12814	9	NYSM 1466	Clarksville.
12815	9	296–2	296
12816	9	207–SW	207
12817	33	108–19d	108
12818	10	135	135
12819	12	296–2	296
12820	12	81	81
12821	1	108–17k	108
12822	1	81NW	81
12823	3	110–1	110
12824	16	NYSM 1466	Clarksville.
12825	16	NYSM 608	Schoharie County.
12826	16	269–r1	269
12827	17	NYSM 1452	Leroy.
12828	17	NYSM G4033	Schoharie.
12829	13	NYSM F691	Western New York.
12830	13	NYSM F691	Western New York.
12831	20	120–5	120
12832	22	297	297
12833	22	285	285
12834	22	329–1	329
12835	21	5328–SD	112
12836	21	5328–SD	112
12837	21	5328–SD	112
12838	21	5328–SD	112
12839	21	5328a–SD	112
12840	21	5328a–SD	112
12841	21	5325–SD	112
12842	23	108–9	108
12843	24	5350e–SD	233
12844	24	NYSM (no number)	Leroy.
12845	24	NYSM (no number)	Do.
12846	24	5362b–SD	329
12847	24	108–SW	108
12848	24	135	135
12849	24	135	135
12850	24	236	236
12851	24	248	248
12852	24	108–51	108
12853	24	296–2	296
12854	24	244	244
12855	24	135	135
12856	24	296–2	296
12857	24	108–171	108
12858	24	269r2N	269
12859	24	329a	329
12860	25	108–51	108
12861	25	108–SW	108
12862	25	108–SW	108
12863	25	108–51	108
12864	26	373	373
12865	28	329–1	329
12866	29	5625–SD	297
12867	30	5316b–SD	438 (part of USNM 172229).
12868	31	NYSM 1453	Falkirk.
12869	31	NYSM 1462	Do.
12870	31	108–12e	108
12871	12	NYSM 1452	Leroy.
12872	37	NYSM 1462	Falkirk.
12873	37	NYSM 1462	Do.
12874	37	NYSM 1462	Do.
12875	2	NYSM 1480	Walpole, Ontario.
Geological Survey of Canada Ottawa, Ontario			
3422a	1		Cayuga, Ontario.
3431, a	5		Wainfleet Township, Ontario.
3431b–f	1		Do.
3432a–d	1		Walpole Township and Wainfleet Township, Ontario.
3436	4		Woodstock, Ontario.
3585a	11		Walpole Township, Ontario.
3586	30		North Oxford Township, Ontario.
3602	1		Cayuga, Ontario.
31143	8	GSC 2596	Oxford, Ontario.
31144	4	5052–SD	C28
31145	12	5014–SD	C10
31146	11	5026–SD	C19
31147	11	GSC 23676	C28
31148	11	GSC 2599	Woodstock, Ontario.
31149	11	GSC 2599	Do.
31151	1	GSC 22795	Port Maitland, Ontario.
31152	1	GSC 2645	?Woodstock, Ontario.
31153	3	5021–SD	C18
31154	3	GSC 2599	Woodstock, Ontario.
31155	16	GSC 3877	Do.
31156	17	GSC 23676	C28
31157	23	GSC 2599	Woodstock, Ontario.
31158	23	GSC 2617	Walpole Township, Ontario.
31159	24	5010–SD	C7
31160	24	7525–SD	C10
31161	27	5004–SD	C3
31162	6	GSC 23521	Port Dover, Ontario.
31163	6	GSC 22978	Naticoke, Ontario.

TABLE 46.—*List of museum numbers of all type, illustrated, and otherwise mentioned specimens, giving the species, collection number, and locality*—Continued

Museum number	Species number	Collection number	Locality
		Geological Survey of Canada Ottawa, Ontario—Continued	
31164	6	GSC 23657	Chepstow, Ontario.
31165	32	7518–SD	C19 (part of USNM 172244).
		American Museum of Natural History New York, N.Y.	
641	17		Schoharie, N.Y.
23501	38		Falls.
		British Museum (Natural History) London, England	
31730–31	35		Falls.
		Harvard University Museum of Comparative Zoology Cambridge, Mass.	
7827	8		Falls.
7859	38		Do.
7877	38		Do.
		Department of Geology, University of Iowa Iowa City, Iowa	
21198	35		Falls.
		University of Michigan, Museum of Paleontology Ann Arbor, Mich.	
8579	30		Drift, Ann Arbor, Mich.
18804	37		Mackinac County, Mich.
24178	13		C27
24195	30		Drift, Ann Arbor, Mich.
28519	31		108
31601	32		C28
36120	7		Formosa area, Ontario.
50576	12		Cheapside, Ontario.
60484	7		Loraine County, Ohio.
60485	24		Ashtabula County, Ohio.
		Orton Museum, Ohio State University Columbus, Ohio	
17735	7		Bellepoint, Ohio.
17779	10		Dublin, Ohio.
21336	38		Chillacothe, Ohio.
		Royal Ontario Museum Toronto, Canada	
27064	8		Northern Ontario.
27128	18		Do.

NEW YORK LOCALITIES

Base maps for fieldwork in New York were the 7½-minute (1:24,000) topographic quadrangle maps published by the U.S. Geological Survey. New localities are those studied and collected by the author; old localities are those known from museum labels or catalogs. Where an old locality can definitely be identified with a new locality, the new locality number is used in parentheses.

Western, central, eastern and southeastern areas are shown in figure 5.

NEW LOCALITIES

3. Syracuse West quad., central area. Split Rock quarry near Highway Dept. Shops on southwest side of Syracuse.

Onondaga Limestone:

	Feet
Nedrow Member (top not exposed)	10
Edgecliff Member (type locality)	8
Unconformity.	
Helderberg Group.	

7. South Onondaga quad., central area. Abandoned quarry on Onondaga Indian reservation, 1 mile (1.6 km) south of Nedrow.

Onondaga Limestone:

	Feet
Seneca Member (top not exposed)	15
Tioga Bentonite Bed	½
Moorehouse Member	19
Nedrow Member	13
Edgecliff Member (base not exposed)	10½

46. Romulus quad., central area. Warren Bros. quarry, 1 mile (1.6 km) west of Canoga.

Onondaga Limestone:

	Feet
Marcellus Shale (black shale).	
Seneca Member	21
Tioga Bentonite Bed	½
Moorehouse Member (only top few inches exposed).	

54. Munnsville quad., central area. Munnsville Limestone Corp. quarry, 1 mile (1.6 km) southeast of Munnsville.

Onondaga Limestone:

	Feet
Edgecliff Member (top not exposed)	22
Unconformity.	
Helderberg Group.	

56. Phelps quad., central area. General Crushed Stone Co. quarry at Oaks Corners, northwest of Geneva.

Onondaga Limestone:

	Feet
Moorehouse Member	36
Clarence Member	16
Edgecliff Member	8–10
Unconformity with 1 ft + relief.	
Silurian rocks.	

73. Clarksville quad., eastern area., Route 32 roadcut 2 miles (3.2 km) southeast of Clarksville and ravine parallel to and west of road.

Onondaga Limestone and Schoharie Formation. Section in roadcut (Oliver, 1963a, p. 29):

	Feet
Moorehouse Member (top not exposed)	49
Nedrow Member (base not exposed)	12
Edgecliff Member and the Schoharie are exposed in ravine to west.	

77. Clarksville quad., eastern area. Outcrop along Indian Ledge Road, 1.3 miles (2.1 km) south of the north edge of the map. Edgecliff Member rests on 2 ft + of the Schoharie Formation. (base not exposed). Higher Onondaga members are discontinuously exposed to south.

79. Altamont quad., eastern area. Mine lot Creek in Thacher State Park, 0.6 of a mile (1 km) south of Route 157.

Schoharie Formation crops out below the poorly exposed Edgecliff Member.

81. Altamont quad., eastern area. Hill and roadcut on south side of east-west road north of Thompsons Lake, 0.2 of a mile (0.3 km) east of Route 157 (Thompsons Lake reef of Oliver, 1956b, p. 18; bioherm 6 in fig. 5). Roadcut shows Edgecliff bioherm facies resting on 4½ ft of bedded, biostromal Edgecliff that is underlain by 2 ft of Schoharie Formation.

82. Altamont quad., eastern area. Outcrop on north-south private road, half a mile (0.8 km) east of Knox. Ten-foot exposure of lower Edgecliff Member.

86. Gallupville quad., eastern area. Bed of Fox Creek in Berne. Fifty-foot exposure of upper Onondaga; collection only from middle Moorehouse Member.

90. Schoharie quad., eastern area. Glen on southwest side of Schoharie Hill, south of light-duty road at 1,080-ft contour. Lower Edgecliff rests on poorly exposed Schoharie Formation.

101. Victor quad., central area. Great Brook south of Victor (0.2 of a mile (0.3 km) south of east-west Dryer Rd.) Small outcrop of lower Edgecliff Member.

102. Honeoye Falls quad., central area. In Honeoye Falls village, just above dam.

Onondaga Limestone:

	Feet
Clarence Member (top not exposed)	16
Edgecliff Member	2
Unconformity.	
Silurian.	

Additional outcrops in Honeoye Creek southeast of village on both sides of Route 65 and extending to North Bloomfield expose 40 ft or more of Moorehouse Member.

104. Honeoye Falls quad., central area. Railroad cut south of Honeoye Creek, 0.9 of a mile (1.45 km) northwest of Honeoye Falls.

Onondaga Limestone:

	Feet
Clarence Member (top not exposed)	9
Edgecliff Member	3
Unconformity.	
Silurian.	

108. Buffalo NE quad., western area. Complex of quarries north of Route 5 between Williamsville and Snyder; outcrops now largely destroyed or inaccessible due to construction of Youngmann Expressway interchange. Bioherm 29 in figure 5. This is the old Fogelsonger quarry (name variously spelled, sometimes with initial "V") of the literature. The Edgecliff bioherm facies was well exposed here; one or more bioherms rested on the Akron Dolomite with bedded Edgecliff and Clarence dipping away in all directions. Numerous collections from different sites and subfacies were examined, but no faunal differentiation was found except between bioherm and off-bioherm facies. The 140 identifiable coralla of 12 species of colonial rugose corals, noted on table 41, represent the largest collections and diversity of any locality in the study area.

109. Clarence quad., western area. Creek-side exposure in Clarence. Probably "Clarence Hollow" of early reports. Edgecliff Member (3½ ft) between poorly exposed Clarence Member and Bois Blanc(?) Formation.

110. Lancaster quad., western area. Federal Crushed Stone Co. quarry at Bellevue.

Onondaga Limestone:

	Feet
Seneca Member (top not exposed)	6
Tioga Bentonite Bed	½
Moorehouse Member (western coral facies)	52
Clarence Member (top only).	

111. Lancaster quad., western area. Ellicott Creek at Browmansville. Five-foot exposure of upper Moorehouse Member.

112. Lancaster quad., western area. Active quarry of Buffalo Crushed Stone Co., north of Thruway near Harris Hill. Forty-five-foot exposure of Moorehouse Member (western coral facies).

114. Clarence quad., western area. Quarry north of Route 5, 3 miles (4.8 km) east of Clarence.

Onondaga Limestone:

	Feet
Clarence Member (top not exposed)	20
Edgecliff Member	4
Unconformity.	
Silurian.	

118. Stafford quad., western area. Active quarry of Genesee Stone Products Corp., 1 mile (1.6 km) west of Stafford. Forty-two-foot west face of quarry is entirely within Moorehouse Member. *Acinophyllum-Eridophyllum* bed is 25 ft below the top of the face. Tioga Bentonite Bed exposed at top of east quarry face so measured section extends virtually to top of Moorehouse.

119. Leroy quad., western area. Quarry of General Crushed Stone Co., 1.4 miles (2.2 km) northwest of Limerock.

Onondaga Limestone:

	Feet
Clarence Member (top not exposed)	21
Edgecliff Member	5
Unconformity(?).	
Bois Blanc Formation	2
Unconformity.	
Silurian.	

120. Leroy quad., western area. Large quarry north of railroad, 1.5 miles (2.4 km) east of Leroy.

Moorehouse Member of Onondaga Limestone:

	Feet
Limestone	2
Bed with *Acinophyllum* and favositids	1
Limestone with chert	4½
Acinophyllum-Eridophyllum bed	1½
Limestone with chert	22½

132. Cobleskill quad., eastern area. Quarry on northeast boundary of Cobleskill.

Onondaga Limestone (see Oliver, 1956c, p. 1454, for section and discussion):

	Feet
Nedrow Member (top not exposed)	13
Edgecliff Member	30
Unconformity?	
Schoharie Formation	2½
Carlisle Center Formation.	

135. Cobleskill quad., eastern area. Outcrop 0.15 of a mile (0.24 km) southwest of farmhouse on Route 7 (at intersection) 0.7 of a mile (1.12 km) west of East

Cobleskill. Small Edgecliff bioherm (East Cobleskill reef of Oliver,, 1956b, p. 19; bioherm 9 in fig. 5). Bioherm facies rests on, and passes west into normal bedded Edgecliff.

154. Sharon Springs quad., eastern area. Roadcuts on Route 20, 1 mile (1.6 km) east-southeast of Sharon Center. Onondaga Limestone: exposures above the highway are in the Moorehouse Member; small exposures between the new and old roads are Nedrow(?) or lower Moorehouse; 14 ft of Edgecliff is exposed below the old road.

164. Sprout Brook quad., eastern area. Field west of School No. 2 road and south of Creek, 1.45 miles (2.4 km) west of Leesville. Extensive field outcrop of Edgecliff Member.

185. Sprout Brook quad., eastern area. Small hill, just east of north-south road between railroad and creek on north edge of Cherry Valley. Edgecliff bioherm forms hill; small quarry 100 ft east of reef is in normal Edgecliff; Nedrow crops out in railroad cut just south of quarry. This is the Cherry Valley reef of Oliver, 1956b, p. 19; bioherm 11 in figure 5.

188. Sprout Brook quad., eastern area. Field exposures by W. Judd Falls road, 1.2 miles (2.1 km) north of Route 20 at west edge of map. Edgecliff Member of Onondaga Limestone:

	Feet
Edgecliff, normal (coarse, coralline) facies	10
Edgecliff, dark-limestone facies	6½
Unconformity?	
Schoharie Formation(?) (few inches).	
Carlisle Center Formation.	

191. Sprout Brook quad., eastern area. Outcrops by west Judds Falls road, 1.5 miles (2.4 km) north of Route 20 at west edge of map. Fifteen ft Edgecliff; lower 3 ft are dark-limestone facies. Top and bottom of member not exposed.

198. East Springfield quad., eastern area. Ravine at east edge of map, 2.7 miles (4.5 km) north of old Route 20 in Cherry Valley.

Incomplete exposure of Edgecliff Member:

	Feet
Edgecliff normal (coarse, coralline) facies)	9
Edgecliff dark-limestone facies	6

206. East Springfield quad., eastern area. Northwest-facing hillslope, 1.2 miles (2.1 km) east-northeast of Summit Lake and 0.7 of a mile (1.12 km) south of north edge of map at 1,600–1,620-ft contour. Edgecliff Member exposed in extensive ledges; section incomplete with scattered exposures of Carlisle Center Formation below and higher members of Onondaga above.

207. East Springfield quad., eastern area. Mount Tom in northwest one-ninth of map. Edgecliff bioherm (700×500×70 ft) forms upper part of hill, rests on 6–10 ft of bedded Edgecliff. This is the thickest of the known, exposed bioherms. It is the Mount Tom reef of Oliver, 1956b, p. 20–21; bioherm 15 in figure 5.

215. Jordanville quad., eastern area. Field outcrops along Herkimer-Otsego county boundary at corner of Otsego County. Extensive ledges of Elgecliff Member in its normal facies.

229. Jordanville quad., eastern area. Hillocks 0.2 of a mile (0.32 km) north of Chyle Road just west of north-south road that crosses Merry Hill. Edgecliff Member: six to eight biohermal mounds may represent the dissected remnants of a large bioherm or several small ones; they rest on bedded Edgecliff that crops out along the south side of the exposure. This is the Mount Tom No. 7 reef of Oliver, 1956b, p. 22; bioherm 21 in figure 5.

233. East Springfield and Richfield Springs quads., eastern area. Broad, low hill 0.5 of a mile (0.8 km) west-southwest of Mount Tom. Edgecliff bioherm rests on bedded Edgecliff; described as Mount Tom No. 2 reef by Oliver, 1956b, p. 21; bioherm 16 in figure 5. Bioherm dimensions of 1,200×900×40 ft makes this the largest of the known, exposed bioherms.

236. Richfield Springs quad., eastern area. Hillside at southeast corner of woods, 0.4 of a mile (0.64 km) north of Marshall cemetery and 1.4 miles (2.2 km) north-northeast of Warren. Edgecliff bioherm; described as Mount Tom No. 3 reef by Oliver, 1956b, p. 21; bioherm 18 in figure 5.

239. Richfield Springs quad., eastern area. Low hills just west of road, 1.5 miles (2.4 km) due north of Warren. Edgecliff bioherm; described as Mount Tom No. 4 reef by Oliver, 1956b, p. 22; bioherm 20 in figure 5.

244. Clarksville quad., eastern area. Hill and cliff face around house located directly above Route 157, 1.6 miles (2.56 km) north of Route 85 intersection and 1.3 miles (2.1 km) northwest of New Salem. Edgecliff bioherm very well exposed; grades northward into normal Edgecliff. This is the New Salem reef of Oliver, 1956b, p. 18; bioherm 4 in figure 5.

246. Ravena quad., eastern area. Small quarries on either side of dead-end road and 0.3 of a mile (0.48 km) southwest of Aquetuck School (south of Route 143 near west side of map). Twenty-five ft of upper Moorehouse Member.

248. Ravena quad., eastern area. Hill, 400 ft west of north-south road at point 0.25 of a mile (0.4 km) south of BM 390 (in northwest corner of map). Edgecliff bioherm; described as Northern Coxsackie reef by Oliver, 1956b, p. 18; bioherm 3 in figure 5.

269. Jordanville quad., eastern area. Hills at Deck triangulation station, 1.1 miles (1.75 km) southwest of Deck. Complex of small Edgecliff bioherms or disssected remnants of one or two larger ones. Described as Deck Reef Group by Oliver, 1956b, p. 20; bioherms 13, 14 in figure 5.

285. Schoharie quad., eastern area. Northern extremity of Schoharie Hill, 2.4 miles (3.8 km) northwest of Schoharie. Edgecliff bioherm; described as Schoharie Hill reef by Oliver, 1956b, p. 19; bioherm 8 in figure 5.

286. Gallupville quad., eastern area. Hillslope 0.8 of a mile (1.3 km) south of Gallupville; between quarry (Esopus Formation) and west Berne road. Normal Edgecliff Member in ledges.

292. Clarksville quad., eastern area. Roadcuts 0.5 of a mile (0.8 km) south of Callanans Corners. Lower Edgecliff (8 ft) rests on Schoharie Formation (3 ft).

296. Ravena quad., eastern area. Hills on both sides of north-south road, 1.6 miles (2.56 km) west-southwest of Hannacroix and 0.3 of a mile (0.48 km) northwest of Lish Homestead Cemetery. Edgecliff bioherm facies; described as Albrights reef by Oliver, 1956b, p. 17–18; bioherm 2 in figure 5.

297. Ravena quad., eastern area. Hill on east side of Limekiln Road, just north of Hass Hill Road junction; 0.7 of a mile (1.1 km) west of Roberts Hill. Edgecliff bioherm facies; described as Roberts Hill reef by Oliver, 1956b, p. 17; bioherm 1 in figure 5.

301. Leeds quad., southeastern area. Gorge of Catskill Creek at millpond in Leeds.

Onondaga Limestone:

	Feet
Moorehouse Member (top not exposed)	37
Nedrow Member	43
Edgecliff Member (southeastern facies)	36
Schoharie Formation.	

Beds are nearly vertical, older to west in the area of the measured section. Described by Oliver, 1962, p. A16–A17.

324. Port Jervis South quad., southeastern area. Tristates Point between Laural Grove Cemetery and Delaware River. Moorehouse Member (estimated 25 ft exposed). Locality briefly described by Oliver, 1962, p. A-20.

329. Schoharie quad., eastern area. Terrace Mountain, 2.2 miles (3.52 km) north-northwest of Schoharie. Edgecliff bioherm forms the northwestern high point of hill. Described as Terrace Mountain reef by Oliver, 1956b, p. 19; bioherm 7 in figure 5.

336. Sprout Brook quad., eastern area. Roadcuts on "new" Route 20 extending from just east of Judds Falls to top of hill.

Onondaga Limestone (diagramed and discussed by Oliver, 1963a, p. 26–27):

Union Springs Shale Member of Marcellus:

	Feet
Seneca Member	6½
Tioga Bentonite Bed	½
Moorehouse Member (upper third not exposed)	78
Nedrow Member	12
Edgecliff Member, normal facies	17
Edgecliff Member, dark-limestone facies	6
Unconformity.	
Carlisle Center Formation.	

337. Sprout Brook quad., eastern area. Roadcuts on "new" Route 20 just west of Judds Falls. Onondaga Limestone in section similar to that of loc. 336; top part incomplete.

339. Buffalo NE quad., western area. Inactive quarry, 0.4 of a mile (0.64 km) east of Bennett High School, Buffalo (Bennett quarry in early reports).

Onondaga Limestone:

	Feet
Clarence Member (top not exposed)	20 (estimated)
Edgecliff Member	1–9
Unconformity (with 2–3 ft relief).	
Akron Dolomite (Silurian).	

Bois Blanc is apparently absent.

348. Lancaster quad., western area. Old quarry east of Youngs Road in Buffalo Country Club (Young's quarry of early reports); just northeast of Williamsville. Edgecliff bioherm facies; bioherm was largely quarried away but flanking and margin beds are well exposed. Bioherm 28 in figure 5.

360. Oneida quad., central area. Limestone Creek bed, 1.45 miles (2.4 km) north of south edge of map; 0.1 of a mile (0.16 km) east of light-duty road. Boulders of bioherm facies Edgecliff; not found in place but these indicate a nearby bioherm, one of the two known in the central area. Bioherm 22 in figure 5.

373. Lancaster quad., western area. Lehigh Properties Corp. test opening for possible quarry development; 0.25 of a mile (0.4 km) west of Gunnville Road at point 0.5 of a mile (0.8 km) north of Wilhelm (intersection of Gunnville Road and Route 33). Small exposure of Moorehouse Member (western coral facies) of Onondaga Limestone.

393. Akron quad., western area. Abandoned quarry on Lake Road, 0.35 of a mile (0.49 km) south of Pembroke Station. Moorehouse Member (14 ft; western coral facies).

421. Oakfield quad., western area. Small quarry on U.S. Gypsum Co. property, 0.8 of a mile (1.4 km) west of Pearl Road and 0.6 of a mile (1.1 km) north of Town Line Road; 1.2 miles (1.9 km) southwest of Oakfield.

Onondaga Limestone:

	Feet
Clarence Member (lower part only)	10
Edgecliff Member	5½
Unconformity.	
Silurian.	

438. Byron quad., western area. Old Empile Limestone Co. quarry, 0.4 of a mile (0.64 km) north of Walcott Road-Keeney Road junction in southeast part of map. Edgecliff bioherm facies with flanking beds and partly equivalent Clarence Member well exposed in immediate area. Bioherm 24 in figure 5.

493. Leroy quad., western area. Small quarry just south of railroad and 0.3 of a mile (0.48 km) northwest of St. Anthony Church, Limerock. Moorehouse Member (8 ft; western coral facies) of Onondaga Limestone. *Acinophyllum-Eridophyllum* bed at ground surface so exposure is principally of section just below this unit.

497. Lancaster quad., western area. Quarry of Lancaster Stone Products Corp. Just east of Barton Road and north of Thruway; 1.2 miles (1.9 km) southeast of Harris Hill. Moorehouse Member (18 ft; western coral facies).

505. Clarksville quad., eastern area. Mouth of Gorge of Onesquethaw Creek at Clarksville.

Edgecliff Member (lower part only).

	Feet
Schoharie Formation	2
Carlisle Center Formation.	

597. Jamesville quad., central area. Wooded hill on west side of Taylor Road at point where road diverges from Lafayette-Pompey town line. Edgecliff bioherm; only exposed one in central area. Bioherm 23 in figure 5.

598. Jamesville quad., central area. Quarry of Solvay Process Co., north and east of Jamesville.

Onondaga Limestone:

	Feet
Seneca Member (top not seen)	18
Tioga Bentonite Bed	¾
Moorehouse Member	32
Nedrow Member	12
Edgecliff Member	20
Unconformity.	
Oriskany(?) Sandstone.	

See Oliver, 1963a, p. 18–21 for discussion of comparable section just southeast of Jamesville.

OLD LOCALITIES

Akron. Akron and Walcottsville quads., western area. Several natural outcrops and old quarries in and near the city expose the Bois Blanc Formation and the Edgecliff and Clarence Members of the Onondaga. There is evidence from old collections and the field that an Edgecliff bioherm existed near Akron; possibly this was located in one of the two large quarries on the east side of Akron and was quarried away.

Albany County. Eastern area. The Schoharie Formation and all members of the Onondaga crop out in southwest Albany County.

Clarksville. Clarksville quad., eastern area. Onondaga Limestone and Schoharie Formation crop out in or near the village. Collections of apparent bioherm corals labeled Clarksville may have come from the New Salem bioherm (loc. 244; bioherm 4 in fig. 5) or an unknown bioherm.

Falkirk. Akron quad., western area. Located in what is now eastern Akron. The falls of Murder Creek and a quarry just north of the falls expose the lower Onondaga (Edgecliff and Clarence Members). "Reefy" beds in the falls section suggest that an Edgecliff bioherm may be or may have been in the vicinity.

Leroy. Leroy quad., western area. The Bois Blanc Formation and all members of the Onondaga crop out in or near Leroy. Locs. 119, 120, and 438 could have been referred to as "Leroy." Collections of apparent Bois Blanc and bioherm-facies Edgecliff corals from "NE of Leroy" must have come from loc. 120 or nearby.

Schoharie. Schoharie quad., eastern area. The Schoharie Formation and all members of the Onondaga crop out in or near Schoharie.

Schoharie County. Eastern area. Numerous outcrops of Schoharie Formation and all members of the Onondaga Limestone occur in the county.

Thompsons Lake. Altamont quad., eastern area. Probably Edgecliff bioherm: see loc. 81.

Western New York. Locality citation almost meaningless. Two specimens of *Prismatophyllum ovoideum* are the only known representatives of the species from the State.

Williamsville. Buffalo NE and Lancaster quads., western area. Collections labeled "Williamsville" most likely came from loc. 108 but other exposures in the village and nearby (e.g., loc. 348) could be sources also.

SOUTHWESTERN ONTARIO

Base maps for fieldwork in Ontario were the 1:50,000-scale topographic maps available from the Canadian Department of Mines and Technical Surveys. All references here are to the editions available in 1958. The Niagara Peninsula here refers to the area between the Niagara River and the vicinity of Hagarsville, Ontario; as noted in the stratigraphy discussion, Onondaga and Bois Blanc facies in the Niagara Peninsula are similar to those in western New York and this is considered as part of the principal study area. Collections from central southwestern Ontario (the London-Woodstock area and north) were mostly used for comparative purposes only, but some are so similar to those in the Niagara Peninsula and New York that they were included in the principal study.

NIAGARA PENINSULA

NEW LOCALITIES

C3. Fort Erie map sheet. Windmill Point Station; two quarries just north of Route 3C (near west edge of map) (lot 12, Bertie T.). Edgecliff bioherm complex with bioherm and flank facies and Clarence Member exposed in various parts of quarries. Bioherm 30 in figure 5. These are the Buel quarries in Stauffer, 1915, p. 22–24.

C5. Welland East map sheet. Quarry on west side of road, 3.2 miles (5.1 km) northeast of Ridgeway (lot 4, con. VIII, Bertie T.). Edgecliff bioherm in north face of quarry; Clarence Member overlies normal Edgecliff Member on east and west faces. Bioherm 31 in figure 5. This is the Baxter quarry in Stauffer, 1915, p. 20–22.

C7. Welland East map sheet. Quarry at Shisler Point on Lake Erie. Edgecliff bioherm. This is the Empire Limestone Co. quarry of Stauffer, 1915, p. 25–26; bioherm 32 in figure 5.

C9. Welland West map sheet. Quarry of Canada Portland Cement Co., Ltd., on west side of Port Colborne (lot 33, con. I, Humberstone T.). Edgecliff bioherm facies. Bioherm 33 in figure 5. This is probably the quarry discussed by Stauffer, 1915, p. 31–35.

C10. Welland West map sheet. Quarry on west side of road that extends north from Camelot Beach (Reebs Bay) on Lake Erie (lot 6, con. I, Wainfleet T.). Studied exposures are between Canadian National Railroad and quarry spur line track and are just south of spur. An Edgecliff bioherm is well exposed south of the spur and in the highest part of the east wall just north of the spur (bioherm 34 in fig. 5). North of the spur and extending to the Canadian National Railroad is the anomalous exposure discussed in the stratigraphy section. A sequence of argillaceous beds some 20 ft thick (beds a–c) dips gently south and grade upward into typical Edgecliff bioherm facies lithology. Included fossils clearly indicate that the lowest part of the anomalous facies sequence is Bois Blanc in age (approx 4 ft); the upper part (16 ft; beds b and c) contains typical Edgecliff corals.

Composite generalized section follows:

- e. Beds of bioherm facies.
- d. 6 ft of gray limestone with *Gnewgiphyllum colligatum* and *Heliophyllum monticulum.*
- c. 7–11 ft of green *Cystiphylloides* biostrome (thickness varies).
- b. 6 ft of green argillaceous beds with *Acinophyllum segregatum* and *G. colligatum.*
- a. 4 ft of green argillaceous beds with *A. simcoense, A. stokesi, Asterobillingsa magdisa magdisa,* and *Aemulophyllum exiguum.*

Beds c and d may pass laterally (south) into the bioherm facies, but the gap in the quarry wall just north of the bioherm makes this uncertain. Compare section C11.

C11. Welland West map sheet. R. E. Law quarry, on north side of Route 3, 1.1 miles (1.75 km) west of County line (lot 5, con. II, Wainfleet T.).

Composite section:

- e. 9 ft of gray limestone, upper half very cherty.
- d. 7 ft of green argillaceous beds.
- c. 8 ft, 6 in. of Bois Blanc facies.

b. 4 in. of green argillaceous beds.
a. 2 ft of Bois Blanc facies with scattered blobs and grains of sand in basal 4 in (Springvale Sandstone)
Unconformity.
Silurian

Unit e is clearly Onondaga and probably Edgecliff; units a, b, and c are typical Bois Blanc in lithology and fossils with beds of the green "anomalous" facies noted at loc. C10; unit d is of uncertain age as it has not been studied in detail. This section is less than a mile from loc. C10 with which it should be compared.

C17. Dunnville West map sheet. Quarry 300 yd (273 m) north of Route 3, 3.3 miles (5.3 km) west-southwest of Grand River at Cayuga (lot 45, con. I, North Cayuga T.). Some 5 ft of Bois Blanc rests unconformably on Silurian rocks This is discussed in Stauffer, 1915, p. 56–58.

C18. Dunville West map sheet. Quarry 0.6 of a mile (1.1 km) south of Mount Olivet, 150 yd (136 m) north of Old Indian Line (road) intersection with road running west-southwest (con. IV, South Cayuga T.) Moorehouse Member (15–20 ft).

C19. Simcoe East map sheet. Large quarry of Haldimand Quarries and Construction, Ltd., north of Michigan Central Railroad on east side of Hagarsville (con. I, Oneida T.). Bois Blanc Formation (15 ft) with Springvale Sandstone in lower part. This is the R. Hamilton quarry of Stauffer, 1915, p. 68–70.

C20. Simcoe East map sheet. Large quarry of Canada Crushed Stone Co. on west side of Hagarsville just north of Michigan Central Railroad (lot 13, con XIII, Walpole T.). Bois Blanc Formation (25 ft); Springvale Sandstone Member of Edgeville was seen in floor of quarry in 1958; by comparison with section at nearby loc. C22, the section extends almost to the top of the formation. This is the J. C. Ingles' quarry of Stauffer, 1915, p. 71–73.

C22. Simcoe East map sheet. Large quarry of Hagarsville Quarries, Ltd., west of Hagarsville and just south of Michigan Central Railroad (lot 12, con. XIII, Walpole T.).

Bois Blanc and Onondaga section:

	Feet
Edgeclic Member (top not exposed)	14
Bois Blanc cherty limestone facies	16
Bois Blanc (Springvale Sandstone) base not exposed)	4

There is no evidence here of an unconformity between the Edgecliff and Bois Blanc.

C23. Simcoe East map sheet. Falls of Sandusk Creek, east of road 0.2 of a mile (0.32 km) south of Sandusk (lot 13, con IV, Walpole T.). Fifteen-foot section of Edgecliff Member. This is the Haggerty Falls of Stauffer, 1915, p. 51–53.

C45. Dunnville East map sheet. Lake Erie shore at end of road running south from Dunville (lot 19, con. V, Dunn T.). Fifteen-foot exposure interpreted as Edgecliff Member; neither top nor base of unit is exposed.

OLD LOCALITIES

Cayuga. Dunnville West map sheet. "3 mi [4.8 km] W of Cayuga" would be near my loc C17 (GSC 3602). CSC 3422a is simply labeled "Cayuga, Ont." Both are thought to be from the Edgecliff Member.

Cheapside. Dunnville West map sheet. UMMP 50576 is from "bed 1 of Stauffer" (1915, p. 49); this is in Dry Creek, 0.75 mile (1.2 km) north of Cheapside. Stauffer's unit is probably Edgecliff.

Hagarsville. Simcoe East map sheet. Several large quarries (loc. C19, C20, C22) and natural outcrops expose the lower part of the Onondaga and the Bois Blanc Formation. USNM 27961, 113554, 113556, 163423, 182908 are labeled "Hagarsville, Ont." only.

Naticoke. Simcoe East map sheet. GSC loc. 22978 is "Naticoke quarry, Ont." This is a small quarry in the Naticoke Creek valley just south of the road. Moorehouse Member of Onondaga.

Port Colborne. Welland East and Welland West map sheets. Lake Erie terminus of Welland Canal on boundary of two map areas. This is the general locality of many of the early collections that are generally referred to "Port Colborne" only or to "Rama's (Ramey's) Farm" (see below as separate locality). Bois Blanc Formation and Edgecliff Member of Onondaga Limestone USNM 113264 and 128016 are from "Port Colborne."

Port Dover. Simcoe East map sheet. GSC loc. 23521 is "Lake Erie shore, 3.5 miles [5.6 km] east of Port Dover." Moorehouse Member of Onondaga Limestone.

Port Maitland. Dunnville East map sheet. GSC loc. 22795 is "1¾ mi [2.8 km] W of Port Maitland, Lake Erie shore." This is close to my loc. C45 and is in approximately the same stratigraphic position; Edgecliff Member of Onondaga Limestone.

Ramey's Farm, Port Colborne. (See Port Colborne as separate entry.) Stauffer (1915, p. 27–28) notes the H .S. Ramey farm, lot 27, con. II, Humberstone Twp. as having been on the Welland canal: "There is no section exposed at that place, but over the fields and along the canal much weathered out material may be found." Stauffer's list of fossils and earlier reports make it clear that both Bois Blanc and Edgecliff were the source. The site of "Ramey's Farm" is now entirely urbanized but many excellent localities are near Port Colborne (for example locs. C10, C11).

Wainfleet. Welland West map sheet. Township just west of Port Colborne; Bois Blanc Formation and Edgecliff and Clarence Members of Onondaga Limestone are exposed (for example locs. C10, C11). GSC loc. 3431 is "lot 6, con. I, Wainfleet." This is the position of loc. C10 and the GSC specimens may have come from the same quarry. GSC 3432 is from "Walpole Twp. [see following] and Wainfleet Twp."

Walpole. Simcoe East and Dunnville West map sheets. Township including the south half of Hagarsville and a large area south of Hagarsville. The Bois Blanc and all members of the Onondaga are exposed (for example locs. C20, C22, C23, Cheapside). NYSM 300 and 1480 and GSC 3432 are "Wapole" with no further data. GSC 3585 is "lot 3, con. XIV, Walpole Twp."; this is west of Springvale and either Bois Blanc or Edgecliff. GSC 2617 is "lot 5, con XIV and lot 3, con. XV, Walpole Twp.", also west of Springvale and either Bois Blanc or Edgecliff.

CENTRAL SOUTHWESTERN ONTARIO

NEW LOCALITIES

C27. Woodstock West map sheet. Quarry of Gypsum, Lime and Alabastine, Canada, Ltd., 1.5 miles (2.4 km) southwest of Beachville (lot 18, con. III, North Oxford T.).

Detroit River Group:

	Feet
Lucas Formation (top not exposed)	62
Amherstburg Formation (base not exposed)	16

C28. Woodstock East map sheet. Inactive quarry on South side of Innerkip. Lower part of Bois Blanc Formation (12 ft) rests on Silurian rocks.

C36. Wingham East map sheet. Small quarry 1.6 miles (2.56 km) east of Gorrie, on east side of Maitland River (lot 11, con. VIII, Howick T.). Amherstburg Formation.

OLD LOCALITIES

Chepstow. Walkerton West map sheet. This is the area of the "Foremosa reef" facies of the Amherstburg Formation GSC loc. 23657 is "dump on East bank of Teeswater River, due N of church at Chepstow."

Formosa area. Area of "Formosa reef" facies of Amhertsburg Formation. UMMP 36120 is from this unit and areà (Fagerstrom, 1961).

Manitoulin Island is in Lake Huron, just east of the Northern Peninsula of Michigan.

Oxford. The name of three townships and a county. They include Ingersoll, Beachville, Woodstock, and Innerkip. (See locs. C27 and C28.) GSC 3586 is from "North Oxford Twp."; GSC 2596 is "Oxford, Ontario." Bois Blanc and Amherstburg Formations crop out in the area.

Woodstock. Woodstock West and East map sheets. GSC loc. 2599, 3436, 3437, and 3877 are all "Woodstock" or "near Woodstock." GSC 2645 is "unknown but with fossils from Woodstock and Kilsworth, Ontario." Bois Blanc and Amherstburg Formations crop out in the area.

OTHER AREAS

Specimens from these localities are cited or illustrated as type or previously illustrated specimens of species occurring also in New York or southwestern Ontario or as new comparative material. Site data is generalized and, where feasible, reference is made to locality information in original descriptions.

FALLS OF THE OHIO

Ohio River at Louisville, Ky., and Jeffersonville, Ind. The north side of the river is the State boundary so that outcrops in the bed of the river and on the south side are in Kentucky, whereas the bluffs on the north side are in Indiana. The stratigraphic sequence is discussed in the stratigraphy section, and species and specimens are assigned to formation and zone in the appropriate systematic description.

EAST-CENTRAL KENTUCKY

USGS loc. 7101–SD; Broadhead quad.; just north of Route 150, west of south tributary of Flax Creek on hillslope at approximate elevation of 950 ft, Boyle Limestone; see stratigraphy section for further discussion of age.

MICHIGAN

USGS loc. 7662–SD is "2 mi [3.2 km] W of Mackinaw City, NW¼, NW¼, sec. 14, T 39N, R 9W; field of Pierce and Son Dairy Farm; Bois Blanc Formation." Collection presented to the U.S. Geological Survey by the late Prof. E.C. Stumm, University of Michigan.

"Drift, Ann Arbor" includes material from several stratigraphic units; specimens cited here may be from the Bois Blanc Formation in Michigan or from the Bois Blanc or Amherstburg Formations in Ontario.

"Mackinac County" is on the north side of the Mackinac Straits and is most likely Bois Blanc Formation.

OHIO

USGS LOCALITIES

7786–SD. Kelly Island quad. Marblehead quarry. Columbus Limestone, *Paraspirifer* Zone (Zone H).

7807–SD. Shawnee Hills quad. Union Stone Co. quarry, 2.4 miles (3.84) southwest of Bellepoint. Columbus Limestone Coral Zone (Zone C).

7808–SD. Same as 7807.

7809–SD. Same as 7807.

8289–SD. Clarksburg quad. Hal-Mar Stone quarry, 1 mile (1.6 km) east-southeast of Crownover Mill; 0.2 of a mile (0.32 km) north of road. Columbus Limestone, Coral Zone (Zone C).

USNM 162588. Core from well in lot 18, tract 4, Perry T., Lake County. Specimen from 1430.5 ft. Columbus Limestone, Coral Zone (Zone C).

OSU LOCALITIES

17735. Bellepont, quarry opposite mouth of Mill Creek. Columbus Limestone, Zone C (Stewart, 1938, p. 11, 99).

17779. Dublin, quarry at south edge of town. Columbus Limestone, Zone C (Stewart, 1938, p. 10, 99).

21336. Well, 3 miles (4.8 km) southwest of Chillicothe (see Carman, 1955 for details of core).

UMMP LOCALITIES

60484. International Salt Co. well 1 Nagel, Avon T., sec. 28, Loraine County (see Janssens, 1970a, p. 25). Specimen from from 1,097 ft. Columbus Limestone, Coral Zone (Zone C).

60485. International Salt Co., Ohio well 1; 2 miles (3.2 km) southwest of Ashtabula, Ashtabula County. Specimen from 1,613 ft. Columbus Limestone, upper part.

MOOSE RIVER BASIN, ONTARIO

Specimens illustrated or noted from this area in the Hudson Bay Lowlands, were described by Cranswick and Fritz (1958) and are deposited in the Royal Ontario Museum, Toronto.

QUEBEC

Studied specimens are from three areas: St. Georges, Famine Limestone; see Oliver, 1971. Lake Memphramagog, Mountain House Wharf Limestone; see stratigraphy discussion and Boucot and Drapeau, 1968. Gaspé, Grande Grève Limestone; see Oliver, 1964.

VIRGINIA

Los. 59b of Kindle (field notes 9/15/10) is "Big Stone Gap, Va., near old Woolen Mills." See Kindle, 1912, p. 51–52.

REFERENCES CITED

Allan, R. S., 1935, The fauna of the Reefton Beds (Devonian), New Zealand: New Zealand Geol. Survey Paleont. Bull. 14, 72 p.

Altevogt, Gustav, 1968, Devonian tetracorals from Spain and their relation to North American species, *in* Oswald, D. H., ed., Internat. Symposium on the Devonian System, Calgary, Alberta, 1967 [Proc.]: Calgary, Petroleum Geologists, v. 2, p. 755–769 [1967].

Anderson, G. E., 1907, Studies in the development of certain Paleozoic corals: Jour. Geology, v. 15, p. 59–69.

Arden, D. D., and Rehrig, W. A., 1964, Middle Devonian stratigraphy of northeastern Spanish Sahara: Am. Assoc. Petroleum Geologists Bull., v. 48, no. 9, p. 1513–1525.

Bassler, R. S., 1915, Bibliographic index of American Ordovician and Silurian fossils: U.S. Natl. Mus. Bull. 92, v. 1, 718 p.

Belanski, C. H., 1928, Descriptions of some typical fossils of the Shellrock stage (of the Devonian of Iowa): Am. Midland Naturalist, v. 11, no. 5, p. 171–212, 6 pls.

Benson, W. N., 1922, Materials for the study of the Devonian paleontology of Australia: New South Wales Geol. Survey Recs., v. 10, p. 83–204.

Berdan, J. M., 1971, Some ostracodes from the Schoharie Formation (Lower Devonian) of New York, *in* Dutro, J. T., Jr., ed., Paleozoic perspectives, a paleontological tribute to G. Arthur Cooper: Smithsonian Contr. Paleobiol., no. 3, p. 161–174.

Berry, W. B. N. and Boucot, A. J., eds., 1970, Correlation of the North American Silurian rocks: Geol. Soc. America Spec. Paper 102, 289 p.

Billings, Elkanah, 1859, On the fossil corals of the Devonian rocks of Canada West: Canadian Jour. Industry, Sci., and Art, new ser., v. 4, p. 97–140, illus.

——— 1863, *in* Logan, W. E., Report on the geology of Canada: Canada Geol. Survey, Rept. Prog. to 1863: 983 p, 498 figs.

——— 1874, On some of the fossils of the Gaspé series of rocks: Canada Geol. Survey, Palaeozoic fossils, v. 2, pt. 1, p. 1–64.

Birenheide, Rudolf, 1963, Cyathophyllum- und Dohmophyllum-Arten (Rugosa) aus dem Mittledevon der Efel: Senckenbergiana Lethaea, v. 44, no. 5–6, p. 363–458, pls. 46–62.

Boucot, A. J., 1958, Beginning of the Acadian orogeny in the Northern Appalachians [abs.]: Geol. Soc. America Bull., v. 69, no. 12, pt. 2, p. 1537.

——— 1959, Brachiopods of the Lower Devonian rocks at Highland Mills, New York: Jour. Paleontology, v. 33, p. 727–769.

——— 1968, Silurian and Devonian of the northern Appalachians, *in* Zen, E-an and others, eds., Studies of Appalachian geology, northern and maritime: New York, Interscience Pub., p. 83–94.

Boucot, A. J., and Drapeau, G., 1968, Siluro-Devonian rocks of Lake Memphremagog and their correlatives in the Eastern Townships: Quebec Dept. Nat. Resources Spec. Paper 1, 44 p.

Boucot, A. J., and Johnson, J. G., 1967, Paleogeography and correlation of Appalachian Province Lower Devonian sedimentary rocks, *in* Symposium—Silurian-Devonian rocks of Oklahoma and environs: Tulsa Geol. Soc. Digest, v. 35, 35–87.

——— 1968a, Appalachian Province Early Devonian paleogeography and brachiopod zonation, *in* Oswald, D. H., ed., Internat. Symposium on the Devonian System, Calgary, Alberta, 1967 [Proc.]: Calgary, Alberta Soc. Petroleum Geologists, v. 2, p. 1255–1267 [1967].

——— 1968b, Brachiopods of the Bois Blanc Formation in New York U.S. Geol. Survey Prof. Paper 584–B, 27 p.

Boucot, A. J, Johnson, J. G., and Talent, J. A., 1968, Lower and Middle Devonian faunal provinces based on Brachiopoda, *in* Oswald, D. H., ed., Internat. Symposium on the Devonian System, Calgary, Alberta, 1967 [Proc.]: Calgary, Petroleum Geologists, v. 2, p. 1239–1254 [1967].

——— 1969, Early Devonian brachiopod zoogeography: Geol, Soc. America Spec. Paper 119, 113 p.

Branson, E. B., 1924, The Devonian of Missouri: Missouri Bur. Geology and Mines, 2d ser., v. 17, p. 1–129.

Brice, Denise, 1970, Étude paléontologique et stratigraphique du Dévonien de l'Afganistan: Notes et mémoires sur le moyen-Orient, v. 11, 364 p.

Briggs, L. I., Jr., 1959, Physical stratigraphy of the lower Middle Devonian rocks in the Michigan Basin, *in* Michigan Basin Geol. Soc. Guidebook, Ann. Geol. Excursion, June 1959: p. 39–58.

Bullard, E. C., Everett, J. E., and Smith, A. G., 1965, The fit of the continents around the Atlantic—Symposium on continental drift: Royal Soc. London Philos. Trans., ser. A, v. 258, p. 41–51.

Bultynck, P., 1970, Révision stratigraphique et paléontologique brachiopodes et conodontes de la coupe type du Couvinien: Louvain, Univ., Inst. Géol. Mém., v. 26, 152 p., 39 pls.

Caley, J. F., 1947, Stratigraphic position of the Detroit River Limestone in Ontario [abs.]: Geol. Soc. America Bull., v. 58, p. 1170.

Campbell, Guy, 1942, Middle Devonian stratigraphy of Indiana: Geol. Soc. America Bull., v. 53, p. 1055–1072.

Carman, J. E., 1955, Revision of the Chillicothe test-core section: Ohio Jour. Sci., v. 55, no. 2, p. 65–72.

Castelnau, F. de, 1843, Essai sur le système Silurian de l'Amérique septentrionale: Paris, P. Betrand, 56 p.

Cherepnina, S. K., 1967, [New species of Middle Devonian rugose corals from the Gorny Altai]: Tomsk ordena trudovogo krasnogo znameni gosurdarstvennyi universitet, Uchenye zap. no. 63, p. 168–174.

Chernyshev, B. B., 1941, Silurian and Lower Devonian corals from the Tareia River Basin (Southeastern Taimyr Peninsula), *in* Paleontology of the Soviet Arctic, pt. 5: Arctic Inst. Tr., v. 158, p. 9–64.

Clark, T. H., 1923, The Devonian limestone at St. George, Quebec: Jour. Geology, v. 31, no. 3, p. 217–225.

Clarke, J. M., 1908, Early Devonic history of New York and eastern North America: New York State Mus. Mem. 9, pt. 1, 366 p.

——— 1921, Organic dependence and disease—their origin and significance: New York State Mus. Bull., nos. 221, 222, 113 p., 105 figs.

Clarke, J. M. and Rudemann, Rudolf, 1903, Guelph fauna in the State of New York: New York State Mus. Mem. 5, 195 p., 21 pls.

Cleland, H. F., 1911, The fossils and stratigraphy of the middle Devonic of Wisconsin: Wisconsin Geol. Survey Bull. 21 (science series 6), 222 p.

Collinson, Charles, and others, 1968, Devonian of the north-central region, United States—Illinois Basin, *in* Oswald, D. H., ed., Internat. Symposium on the Devonian System, Calgary, Alberta [1967] Calgary, Alberta Soc. Petroleum Geologists, v. 1, p. 940–962 [1967].

Cooper, G. A., 1941, New Devonian stratigraphic units: Washington Acad. Sci. Jour., v. 31, no. 5, p. 179–181.

Cooper, G. A., and others, 1942, Correlation of the Devonian sedimentary formations of North America: Geol. Soc. America Bull., v. 53, p. 1729–1794.

Cooper, G. A., and Phelan, Thomas, 1966, *Stringocephalus* in the Devonian of Indiana: Smithsonian Misc. Colln., v. 151, no. 1, 20 p.

Cottreau, Jean, 1941, Coralliaires, brachiopodes et crinoïdes mésodévoniens du Sahara mauritanien et occidental: Soc. Géol. France Bull. 5, v. 10, no. 7–9, p. 187–200.

Cranswick, J. S. and Fritz, M. A., 1958, Coral fauna of the Upper Abitibi River Limestone: Geol. Assoc. Canada Proc., v. 10, p. 31–81, 6 pls.

Crickmay, C. H., 1960, The older Devonian faunas of the Northwest Territories: Calgary, Evelyn de Mille Books, 21 p., 11 pl.

Cumming, L. M., 1959, Silurian and Lower Devonian formations of the eastern part of the Gaspé Peninsula, Quebec: Canada Geol. Survey Mem. 304, 45 p.

Dana, J. D., 1846, Genera of fossil corals of the family Cyathophyllidae: Am. Jour. Sci. v. 1, p. 178–186.

——— 1848 United States Exploring Expedition during the years 1838–1842, under the command of Charles Wilkes: v. 7, Zoophytes [1846].

Davis, W. J., 1887, Kentucky fossil corals,—a monograph of the fossil corals of the Silurian and Devonian rocks of Kentucky: Kentucky Geol. Survey, pt. 2, 139 pls.

Dennison, J. M., 1961, Stratigraphy of Onesquethaw stage of Devonian in West Virginia and bordering states: West Virginia Geol. Survey Bull. 22, 87 p.

Dow, J. W., 1962, Lower and Middle Devonian limestones in northeastern Ohio and adjacent areas: Ohio Div. Geol. Survey Rept. Inv. 42, 67 p.

Dubatolov, V. N. and Spassky, N. J., 1970. [Corals of the principal Devonian palaeobiogeographical provinces], *in* Zakonomernosti rasprostraneiya paleozoyskikh korallov SSSR: Vses. Simp. [Papers of the Izuch. Iskop. Korallor SSSR, 2nd Tr., no. 3 II All-Union symposium on fossil corals of the USSR, v. 3], p. 15–31.

Dybowski, W. N., 1973a, Beschreibung einer neuen aus Nordamerika stammenden devonischen Art der zoantharia rugosa: Verhandl. Russ. kais. min. Gesellsch. St. Petersburg, (2), 8, p. 153–160, pl. 6.

——— 1873b–1874, Monographie der Zoantharia sclerodermata rugosa aus der Silurformationen Estlands, Nord-Livlands und der Insel Gotland: Archiv. Naturkunde Liv-Ehst- und Kurland; (1), v. 5, 1873, p. 257–414, pls. 1, 2; v. 5, 1874, p. 415–532, pls. 3–5.

Eardley, A. J., 1951, Structural geology of North America: New York, Harper & Bros., 624 p.

Easton, W. H., and Oliver, W. A., Jr., 1973, The Devonian tetracoral, *Acinophyllum stokesi* (Milne-Edwards and Haime, 1851): Jour. Paleontology, v. 47, p. 915–918, pl. 1.

Ehlers, G. M., 1945, Stratigraphy of the surface formations of the Mackinac Straits region, *in* Landes, K. K., Ehlers, G. M., and Stanley, G. M., Geology of the Mackinac Straits region and subsurface geology of northern Southern Peninsula: Michigan Geol. Survey Div., Pub. 44, p. 19–120.

Ehlers, G. M., Smith, J. E., and Sheldon, F. D., 1959, Surface stratigraphy of the Mackinac Straits region, *in* Michigan Basin Geol. Soc. Guidebook, Ann. Geol. Excursion, June 1959: p. 13–18.

Ehlers, G. M., and Stumm, E. C., 1949, Corals of the Devonian traverse group of Michigan; part 2, *Cylindrophyllum, Depasophyllum, Disphyllum, Eridophyllum,* and *Synaptophyllum*: Michigan Univ. Mus. Paleontology Contr., v. 8, no. 3, p. 21–41.

——— 1951a, *Billingsastraea*, pt. 4 *of* Corals of the Middle Devonian Traverse group of Michigan: Michigan Univ. Mus. Paleontology Contr., v. 9, no. 3, p. 83–92, pls. 1–3.

——— 1951b, Middle Devonian Columbus Limestone near Ingersoll, Ontario, Canada: Am. Assoc. Petroleum Geologists Bull., v. 35, no. 8, p. 1879–1888.

——— 1953, Species of the tetracoral genus *Billingsastraea* from the Middle Devonian of New York and other regions: Buffalo Soc. Nat. Sci. Bull., v. 21, no. 2, p. 1–11, pls. 1–6.

Ehlers, G. M., Stumm, E. C., and Kesling, R. V., 1951, Devonian rocks of southeastern Michigan and northwestern Ohio: Ann Arbor, Edwards Bros., 40 p.

Ehlers, G. M. and White, T. E., 1932, *Cylindrophyllum panicum* (Winchell) and *Cylindrophyllum hindshawi* sp. nov., Tetracoralla from the Traverse group of Michigan: Michigan Univ. Mus. Paleontology Contr., v. 4, no. 4, p. 93–100, 5 pls.

Fagerstrom, J. A., 1961, The fauna of the Middle Devonian Formosa reef limestone of southwestern Ontario: Jour. Paleontology, v. 35, no. 1, 48 p.

Fenton, C. L., and Fenton, M. A., 1924, The stratigraphy and fauna of the Hackberry Stage of the Upper Devonian: Michigan Univ. Mus. Paleontology Contr., v. 1, 260 p., 9 figs., 45 pls.

Fisher, R. A., 1946, Statistical methods for research workers: Edinburgh, 354 p.

Flint, R. F., and others, Glacial map of North America, 2 sheets, pt. 1; Bibliography and explanatory notes, pt. 2: Geol. Soc. America Spec. Paper 60, 37 p. illus. geol. map, 1945.

Flower, R. H., 1943, Middle Devonian nautiloids of New York [abs.]: Geol. Soc. America Bull., v. 54, p. 1830.

Flugel, Erik von, 1956, Revision der devonischen Hydrozoen der Karnischen Alpen: Carinthia II, v. 66, p. 41–60, pl. 1.

Fontaine, Henri, 1961, Les madréporaires paléozoïques du Viêt-Nam, du Laos et du Cambodge: Service Geol., Arch. Géol. Viêt-Nam no. 5, 276 p., 35 pls.

Fraunfelter, G. H., 1966, An occurrence of *Hexagonaria* in the Grand Tower Formation of southern Illinois and southeastern Missouri: Illinois Acad. Sci. Trans., v. 59, p. 347–351.

Fromental, E. de, 1861, Introduction à l'Etude des Polypiers fossiles: Paris, 357 p.

Goldfuss, G. A., 1826, Petrefacta Germaniae, Part I: Düsseldorf, 76 p., 25 pls.

Goldring, Winifred, and Flower, R. H., 1942, Restudy of the Schoharie and Esopus Formations in New York State: Am. Jour. Sci. v. 240, p. 673–694.

Grabau, A. W., 1898, The geology and paleontology of Eighteen-mile Creek and the lake-shore sections of Erie Co., New York: Buffalo Soc. Nat. Sci. Bull. 6, p. 1–403.

——— 1906, Guide to the geology and paleontology of the Schoharie Valley in eastern New York: New York State Mus. Bull. 92, p. 77–386.

——— 1910, Description of Monroe fossils, *in* Grabau, A. W., Sherzer, W. H., The Monroe Formation: Michigan Geol. Survey, pub. 2, p. 87–213.

——— 1917, Stratigraphic relationships of the Tully Limestone and the Genesee Shale in eastern North America: Geol. Soc. America Bull., v. 28, p. 945–958.

——— 1922, Paleozoic corals of China, Pt. 1,Tetraseptata: China Geol. Survey, Palaeontologia Sinica, ser. B, v. 2, fascicle 1, 76 p.

——— 1936, Early Permian fossils of China, pt. II, Fauna of the Maping Limestone of Kwangsi and Kweichow: China Geol. Survey, Palaeontologia Sinica, ser. B, v. 8, pt. 4, B, 441 p.

Grabau, A. W., and Shimer, H. W., 1906, North American index fossils: School Mines Quart., v. 27, p. 138–248.

——— 1909, North American index fossils—Invertebrates: New York, Seiler and Co., v. 1, 853 p.

Greene, G. K., 1898–1906, Contribution to Indiana paleontology: v. 1, pts. 1–20, 204 p., New Albany, Indiana, 1898–1904; v. 2, pts. 1–3, 38 p., New Albany, Indiana, 1906.

Hall, James, 1843, Geology of New York, part 4, comprising the survey of the fourth geological district: Albany, 683 p.

——— 1877, Illustrations of Devonian fossils,—corals of the upper Helderberg and Hamilton groups: New York Geol. Survey, Paleont., 39 pls. and explanations.

——— 1882, Fossil corals of the Niagara and upper Helderberg groups: Albany, 59 p.

——— 1883a, Descriptions of fossil corals from the Niagara and upper Helderberg groups of Indiana. Indiana, Dept. Geol. Nat. Hist., Ann. Rept. 12, p. 271–318.

——— 1883b, Van Cleve's fossil corals: Indiana, Dept. Geol. Nat. Hist., Ann. Rept. 12, p. 239–270.

——— 1884, Descriptions of fossil corals from the Niagara and upper Helderberg groups: New York State Mus. Ann. Rept. 35, p. 407–464.

Harrington, H. J., 1968, Devonian of South America: *in* Oswald, D. H., ed., Internat. Symposium on the Devonian System, Calgary, Alberta, 1967 [Proc]: Calgary, Alberta Soc. Petroleum Geologists, v. 1, p. 651–671 [1967].

Hill, Dorothy, 1935, British terminology for rugose corals: Geol. Mag., v. 72, no. 11, p. 481–519.

——— 1939, The Devonian rugose corals of Lilydale and Loyola, Victoria: Royal Soc. Victoria Proc., v. 51, p. 219–256, pls. 13–16.

——— 1941, The lower Middle Devonian rugose corals of the Murrumbidgee and Goodradigbee Rivers, New South Wales: Royal Soc. New South Wales, Jour. and Proc., v. 74, p. 247–276.

——— 1942a, The Devonian rugose corals of the Tamworth district, New South Wales: Royal Soc. New South Wales, Jour. and Proc., v. 76, pt. 3, p. 142–164.

——— 1942b, Middle Paleozoic rugose corals from the Wellington district, New South Wales: Royal Soc. New South Wales, Jour. and Proc., v. 76, pt. 3, p. 182–189.

——— 1942c, Some Tasmanian Palaeozoic corals: Royal Soc. Tasmania, Papers and Proc. 1941, p. 3–12.

——— 1956a, The Devonian corals of Reefton, New Zealand: New Zealand Geol. Survey Paleontological Bull. 25, p. 5–14.

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

——— 1957, The sequence and distribution of upper Palaeozoic coral faunas: Australian Jour. Sci., v. 19, no. 3a, p. P42–P61.

Hollard, Henri, 1962, Attribution au Givetian des calcaires coralligènes du Maïder (Moroc présaharien): Soc. Géol. Frances, C. R. Som. des. Séance, pt. 6, p. 175–177.

Holmes, M. E., 1887, The morphology of the carinae upon the septa of rugose corals: Dissert., Univ. of Michigan; Boston, Bradley Whidden, 31 p.

House, M. R., 1962, Observations on the ammonoid succession of the North American Devonian: Jour. Paleontology, v. 36 p. 247–284.

——— 1968, Devonian ammonoid zonation and correlations between North America and Europe, *in* Oswald, D. H., ed., Internat. Symposium on the Devonian System, Calgary, Alberta, 1967 [Proc]: Calgary, Alberta Soc. Petroleum Geologists, v. 2, p. 1061–1068 [1967].

Hüffner, E., 1916, Beitrage zur Kenntiss des Devons von Bithynien; Auf Grund der Aufsammlungen von Herrn Dr. Endriss: Jahrb. Preuss. Geol. Landesanstalt; v. 37, pt. 1, no. 2, p. 260–357; Anthozoa, p. 318–331.

Hussey, R. C., 1926, The Richmond Formation of Michigan: Michigan Univ. Mus. Geology Contr., v. 2, no. 8, p. 113–187, 11 pls.

Imbrie, John, 1956, Biometrical methods in the study of invertebrate fossils: Am. Mus. Nat. History Bull., v. 108, art. 2, p. 215–252.

Ivania, V. A., 1957, Devonian corals der Belyi Kamen' na r. Kara-Chumysh (ugo-zapadnyi Kuzbass): Uch. zap. Tomsk. Univ. gos. un.-ta, 1957, no. 28, p. 55–73.

Janssens, Arie, 1968, Stratigraphy of Silurian and pre-Olentangy Devonian rocks of the South Birmingham Pool area, Erie and Lorain Counties, Ohio: Ohio Div. Geol. Survey Rept. Inv. 70, 20 p.

——— 1970a, Guidebook to the Middle Devonian rocks of north-central Ohio: Geol. Soc. Ohio, 30 p.

——— 1970b, Middle Devonian formations in the subsurface of northwestern Ohio: Ohio Div. Geol. Survey Rept. Inv., v. 78, 22 p.

Jell, J. S., 1969, Septal microstructure and classification of the Phillipsastraeidae; *in* Campbell, K. S. W., ed., Stratigraphy and paleontology, Essays in honor of Dorothy Hill: Canberra, Australian Nat. Univ. Press, p. 50–73.

Jell, J. S., and Hill, Dorothy, 1969, Devonian corals from Ukalunda: Queensland Geol. Survey Pub. 340, 27 p.

Jell, J. S., and Pedder A. E. H., 1969, *Martinophyllum*, a new genus of Devonian rugose corals: Jour. Paleontology, v. 43, no. 3, p. 735–740.

Johnsen, J. H., and Southard, J. B., 1962, The Schoharie Formation in southeastern New York, *in* New York State Geological Association Guidebook, 34th Ann. Mtg. Port Jervis, 1962: p. A7–A15, A27, text figs.

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

Kindle, E. M., 1912, The Onondaga fauna of the Allegheny region: U.S. Geol. Survey Bull 508, 144 p, 13 pls

Klapper, Gilbert, and Ziegler, Willi, 1967, Evolutionary development of the *Icriodus latericrescens* group (Conodonta) in the Devionian of Europe and North America: Palaeontographica, v. 127A, pt. 1–2, p. 68-83.

Koninck, L. G., de, 1876, Récherches sur les fossiles paléozoiques de la Nouvelle-Galles du Sud (Australia): Mem. Soc. Royale Sci. Liege, ser. 2, v. 6, p. 1–140, pls. 1–4 (1877); v. 7, p. 1–235, pls. 5–24 (1878).

Kreidler, W. L., Van Tyne, A. M., and Jorgensen, K. M., 1972, Deep wells in New York State: New York State Mus. Sci. Serv. Bull. 418A, 335 p.

Krömmelbein, Karl, 1968, Devonian of the Amazonas Basin, Brazil: *in* Oswald, D. H., ed., Internat. Symposium on the Devonian System, Calgary, Alberta, 1967 [Proc.]: Calgary, Alberta Soc. Petroleum Geologists, v. 2, p. 201–208 [1967].

Lambe, L. M., 1899, On some species of Canadian Paleozoic corals: Ottawa Naturalist 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 Geol. Survey Contr. Canadian Paleontology v. 4, p. 97–197, pls. 6–18.

Lang, W. D., and Smith, Stanley, 1935a, *Cyathophyllum caespitosum* Goldfuss, and other Devonian corals considered in a revision of that species: Geol. Soc. London Quart. Jour., no. 364, v. 91, pt. 4, p. 538–590, pls. 35–37.

——— 1935b, On the genotype of *Columnaria* Goldfuss: Annals Mag. Nat. History ser. 10, v. 16, no. 94, p. 426–433.

Lang, W. D., Smith, Stanley, and Thomas, H. D., 1940, Index of Paleozoic coral genera: London, British Mus. (Nat. History), 231 p.

Lecompte, Marius, 1952, Madreporaires Paleozoiques, *in* Piveteau, Traité de Paleontologie, v. 1, p. 419–539.

LeMaître, Dorothée, 1947, Contribution à l'étude du dévonien du Tafilalet—II, Le Récif coralligène de Ouihalane: Morocco, Sérv. Geol., Notes et Mém. no. 67, 113 p.

Liddle, R. A., Harris, G. D., and Wills, J. W., 1943, The Rio Cachiri section in the Sierra de Perija, Venezuela, pt. 1, Geology: Bulls. Am. Paleontology, v. 27, no. 108, p. 5–53.

McGregor, D. C., Sandford, B. V., and Norris, A. W., 1970, Palynology and correlation of Devonian formations in the Moose River Basin, northern Ontario: Geol. Assoc. Canada Proc., v. 22, p. 45–54.

McLaren, D. J., 1959, A revision of the Devonian coral genus *Synaptophyllum* Simpson: Canada Geol. Survey Bull. 48, p. 15–33.

——— 1964, Corals of the Devonian Horn Plateau Formation, *in* McLaren, D. J., and Norris, A. W., Fauna of the Devonian Horn Plâteau Formation, District of Mackenzie: Canada Geol. Survey Bull. 114, p. 3–28, pls. 1–12.

Meents, W. F., and Swann, D. H., 1965, Grand Tower Limestone (Devonian) of southern Illinois: Illinois Geol. Survey Circ. 389, 34 p.

Miller, R. L., Harris, L. D., and Roen, J. B., 1964, The Wildcat Valley Sandstone (Devonian) of southwest Virginia: U.S. Geol. Survey Prof. Paper 501–B, p. B49–B52.

Miller, S. A., 1889, North American geology and paleontology: Cincinnati, Ohio, 664 p.

Milne-Edwards, Henri, 1860, Histoire naturelle des coralliaires de polypes proprement dits, v. 3: Paris, 560 p.

Milne-Edwards, Henri, and Haime, Jules, 1850, A monograph of the British fossil corals, Introduction: p. i-lxxxv (Monog. Paleont. Soc. London).

——— 1851, Monographie des polypiers fossiles des terraines palaeozoiques: Paris, Mus. Natl. d'histoire nat., Archives, v. 5, 502 p., 20 pls.

Mitchell, S. W., 1967, Stratigraphy of the Silica Formation of Ohio and the Hungry Hollow Formation of Ontario, with paleogeographic interpretations: Michigan Acad. Sci., Arts and Letters Papers 1966, v. 52, p. 175–196.

Moore, R. C., Hill, Dorothy, and Wells, J. W., 1956, Glossary of morphological terms applied to corals, *in* Moore, R. C., ed., Treatise on invertebrate paleontology, pt. F., Coelenterata: Geol. Soc. America and Kansas Univ. Press, p. F245–251.

Nelson, S. J., 1963, Ordovician paleontology of the northern Hudson Bay Lowland: Geol. Soc. America Mem. 90, 152 p.

Nicholson, H. A., 1874, Report upon the paleontology of the Province of Ontario: Toronto, 133 p.

——— 1874a, Descriptions of new fossils from the Devonian formations of Canada West: Geol. Mag., ser. 2 ,v. 1, p. 10–16, 54–60, 117–126, 159–165, 197–201.

——— 1875b, Report upon the paleontology of the Province of Ontario: Toronto, 96 p.

——— 1875a, Description of the corals of the Silurian and Devonian systems: Ohio Geol. Survey Rept. 2, pt. 2 Paleontology, p. 181–242.

——— 1878, On the minute structure of the corals of the genera *Heliophyllum* and *Crepidophyllum*: Annals and Mag. Nat. History. ser. 5, v. 1, p. 44–54.

Nicholson, H. A., Thompson, James, 1877, Descriptions of some new or imperfectly understood forms of Paleozoic corals [abs.]: Royal Soc. Edinburgh Proc. 9, p. 149–150.

Norris, A. W., and Sanford, B. V., 1969, Palaeozoic and Mesozoic geology of the Hudson Bay Lowlands, *in* Earth science symposium on Hudson Bay, Ottawa, 1968: Canada Geol. Survey Paper 68–53, p. 169–205.

Northrup, S. A., 1939, Paleontology and stratigraphy of the Silurian rocks of the Port Daniel-Black Cape region, Gaspé: Geol. Soc. America Spec. Paper 21, 302 p. 28 pls.

Oliver, W. A. Jr., 1951, Middle Devonian coral beds of central New York: Am. Jour. Sci., v. 249, p. 705–728.

——— 1954, Stratigraphy of the Onondaga Limestone (Devonian) in central New York: Geol. Soc. America Bull., v. 65, p. 621–652.

——— 1956a, *Tornoceras* from the Devonian Onondaga Limestone of New York: Jour. Paleontology 30, p. 402–405.

——— 1956b, Biostromes and bioherms of the Onondaga limestone in eastern New York: New York State Mus. and Sci. Service Circ. 45, 23 p.

——— 1956c, Stratigraphy of the Onondaga Limestone in eastern New York: Geol. Soc. America Bull., 67, p. 1441–1474.

——— 1960a, Coral faunas in the Onondaga Limestone of New York: U.S. Geol. Survey Prof. Paper 400–B, p. B172–B174.

——— 1960b, Devonian rugose corals from northern Maine: U.S. Geol. Survey Bull., 1111–A, p. 1–23, pls. 1–5.

——— 1960c, Rugose corals from reef limestones in the Lower Devonian of New York: Jour Paleontology, v. 34, p. 59–100, pls. 13–19, 34 figs.

——— 1962, The Onondaga Limestone in southeastern New York *in* Guidebook to field trips—New York State Geol., 34th Ann. Mtg., 1962: New York City College, Dept. Geol. p. A2–A6, A16–A20, A–25, 2 figs.

——— 1963a, The Onondaga Limestone, *in* Stratigraphy, facies changes and paleoecology of the Lower Devonian Helderberg limestones and Middle Devonian Onondaga Limestones, *in* Geological Society of America Guidebook, 76th Ann. Mtg., field trip no. 1, Mohawk and Central Hudson Valley, New York, 1963: p. 11–16, 20–21, 26–27, 29–33.

——— 1963b, Redescription of three species of corals from the Lockport Dolomite in New York: U.S. Geol. Survey Prof. Paper 414–G, p. G1–G9, 5 pls.

——— 1963c, Silurian rugose corals from the Lake Témiscouata area, Quebec U.S. Geol. Survey Prof. Paper 430–B, p. 11–20, pls. 5–8 [1962].

——— 1964, The Devonian colonial coral genus *Billingsastraea* and its earliest known species: U.S. Geol. Survey Prof. Paper 483–B, 5 p.

——— 1966a, Bois Blanc Formation, *in* Changes in stratigraphic nomenclature by the U.S. Geological Survey 1965: U.S. Geol. Survey Bull. 1244–A, p. A46–A48.

——— 1966b, Clarence Member of Onondaga Limestone, *in* Changes in stratigraphic nomenclature by the U.S. Geological Survey 1965: U.S. Geol. Survey Bull. 1244–A, p. A48–A49.

——— 1966c, The Bois Blanc and Onondaga Formations in western New York and adjacent Ontario, *in* New York State Geological Association Guidebook, 38th Ann. Mtg., Buffalo, 1966: p. 32–43.

——— 1967a, Stratigraphy of the Bois Blanc Formation in New York U.S. Geol. Survey Prof. Paper 584–A, 8 p.

——— 1967b, Contact of Delaware and Columbus Limestones in northern Ohio, *in* Geological Survey Research 1967: U.S. Geol. Survey Prof. Paper 575–A, p. A76.

——— 1968a, Succession of rugose coral faunas in the Lower and Middle Devonian of eastern North America, *in* Oswald, D. H., ed., Internat. Symposium on the Devonian System, Calgary, Alberta, 1967 [Proc.]: Calgary, Alberta Soc. Petroleum Geologists, p. 733–744.

——— 1968b, Some aspects of colony development in corals, *in* Paleobiological aspects of growth and development, a symposium: Paleontological Soc. Mem. 2 (Jour. Paleontology, v. 42, no. 5, supp.), p. 16–34.

——— 1971, The coral fauna and age of the Famine Limestone in Quebec: *in* Dutro, J. T., Jr., ed., Paleozoic Perspectives, a paleontological tribute to G. Arthur Cooper: Smithsonian Contr. Paleobiology, no. 3, p. 193–201.

——— 1973, Devonian coral endemism in eastern North America and its bearing on paleogeography, *in* Organisms and continents through time: Spec. Papers Palaeontology, no. 12, p. 318–319.

——— 1974, Classification and new genera of noncystimorph colonial rugose corals from the Onesquethaw Stage in New York and adjacent areas: U.S. Geol. Survey, Jour. Research, v. 2, p. 165–174.

——— 1975, Endemism and biogeography of Late Silurian to Middle Devonian rugose corals in eastern North America. (In press.)

Oliver, W. A. Jr., and Galle, Arnošt, 1971, "*Calceola*" (=*Rhizophyllum*) and "*Billingsastraea*" (=*Iowaphyllum*) in Bohemia: Věst. Úst. úst. geol. (Prague), v. 46, p. 209–216, pl. 1–4.

Oliver, W. A., Jr., deWitt, W., Jr., Dennison, J. M., Hoskins, D. M., and Huddle, J. W., 1968, Devonian of the Appalachian Basin, United States, *in* Oswald, D. H., ed., Internat. Symposium on the Devonian System, Calgary, Alberta, 1967 [Proc.]: Calgary, Alberta Soc. Petroleum Geologists, v. 1, p. 1001–1040 [1967].

——— 1969, Correlation of Devonian rock units in the Appalachian Basin: U.S. Geol. Survey Oil and Gas Inv. Chart OC–64, 1 sheet.

——— 1971, Isopach and lithofacies maps of the Devonian in the Appalachian Basin: Pennsylvania Geol. Survey Prog. Rept. 182, 7 sheets.

Orbigny, Alcide d', 1850, Prodrome de paléontologie stratigraphique universelle des animaux mollusques et rayonnés faisant suite au cours élémentaire de paléontologie et de géologie stratigraphiques, vol. 1: Paris, 384 p.

Owen, D. D., 1844, Descriptions of some organic remains figured in this work, supposed to be new, *in* Report of a géological exploration of part of Iowa, Wisconsin, and Illinois . . . in 1839: U.S. 28th Con. 1st. sess., Senate Executive Doc. 407, 197 p., illus.

Ozol, M. A., 1964, Alkali reactivity of cherts and stratigraphy and petrology of cherts and associated limestones of the Onondaga Formation of central and western New York: Dissert. Abs., v. 24, p. 4144–4145.

Pedder, A. E. H., 1964, Correlation of the Canadian Middle Devonian Hume and Nahanni formations by tetracorals: Palaeontology, v. 7, pt. 3, p. 430–451, pls. 62–73.

Perkins, R. D., 1963, Petrology of the Jeffersonville Limestone (Middle Devonian) of southeastern Indiana: Geol. Soc. America Bull., v. 74, no. 11, p. 1335–1354.

Pickett, John, 1967, Untersuchungen zur Familie Phillipsastreidae (Zoantharia rugosa): Senckenbergiana Lethaea, v. 48, no. 1, p. 1–89, pl. 7.

Pictet, F. J., 1857, Traité de Paleontologie: 2d ed., v. 4, p. 1–768, and Atlas: Paris.

Prantl, Ferdinand, 1951, On the supposed occurrence of the genus *Phillipsastraea* d'Orbigny, 1849, in the Devonian of Bohemia: Národní Mus. Prague, Sbornik, v. 7B (1951), no. 3, Geologia et Palaeontologia, no. 2, p. 3–17, pls. 1–4.

Quenstedt, F. A., 1878–1881, Petrefactenkunde Deutschlands, VI: Die Röhren—und Sternkorallen p. 1–144 (1878), p. 145–624 (1879), p. 625–912 (1880), p. 913–1094 (1881), Leipzig.

Ramsey, N. J., 1969, Conodonts from the Columbus and Delaware Limestones (Middle Devonian of central Ohio [abs.]: Geol. Soc. America Abs. with Programs for 1969, v. 1 pt. 6, p. 39.

Rexroad, C. B. and Orr, R. W., 1967, Silurian and Devonian stratigraphy of southeastern Indiana, field trip Z *in* Geologic tales along Hoosier trails— Geol. Soc. America, North-central Sec., 1st Ann. Mtg., 1967, Bloomington, Indiana, Indiana Field Trip Gdbk.: Univ. Dept. Geol. and Indiana Geol. Survey, p. 39–74.

Rickard, L. V., 1964, Correlation of the Devonian rocks in New York State: New York State Mus. and Sci. Service, Geol. Survey Map and Chart Ser., no. 4.

Roemer, F. A., 1855, Beitrage zur geologischen Kenntnis des nordwestlichen Harzgebirges. III: Palaeontolographica, 5, p. 1–44, pls. 1–8, Cassel.

——— 1883, (1880–1897), Lethaea geognostica, part 1; Lethaea palaeozoica. p. 325–544 (1–688), fig. 62–126 (226), pls. A, B.

Rominger, C. L., 1876, Palaeontology—fossil corals: Michigan Geol. Survey, v. 3, pt. 2, 161 p.

Różkowska, Maria, 1953, Pachyphyllinae et Phillipsastraea du Frasnien de Pologne: Palaeontologia Polonica, no. 5, p. 1–90, 8 pls.

Sanford, B. V., 1958, Geological map of southwestern Ontario: Canada Geol. Survey Map 1062A.

——— 1968, Devonian of Ontario and Michigan, *in* Oswald, D. H., ed., Internat. Symposium on the Devonian System, Calgary, Alberta, 1967 [Proc.]: Calgary. Alberta Soc. Petroleum Geologists v. 1, p. 973–999 [1967].

Sanford, B. V., Norris, A. W. and Bostock, H. H., 1968, Geology of the Hudson Bay Lowlands (Operation Winisk, 1967): Canada Geol. Survey Paper 67–60, p. 1–45.

Schindewolf, O. H., 1938, Zur Kenntnis der Gattung *Zaphrentis* und der sogenannten Zaphrentiden des Karbons: Jahrb. Preuss. Geol. Landesanstalt, v. 58, p. 439–454.

Schluter, Clemens, 1889, Anthozoen des rheinischen Mittel-Devon: Abhandlungen zur geol. Specialkarte von Preussen und den Thuringischen Statten, v. 8, no. 4, p. 258–465, 16 pls.

Schouppé, Alexander von, 1949, Die "Thamnophyllen" und ihre Beziehung zur Gruppe des "Cyathophyllum caespitosum": Palaeontographica, v. 97, pt. A, no. 4–6, p. 99–180, pls. 9–14.

——— 1958, Revision des Formenkreises um *Phillipsastraea* d'Orb., *"Pachyphyllum"* E. & H., Macgeea (Webst.), *"Thamnophyllum"* Pen., *Peneckiella* Soshk., und verwandter Formen Neues Jahrb. Geologie u. Paläontologie, Abh., v. 106, p. 139–244, pls. 5, 6.

Scrutton, C. T., 1967, Marisastridae (Rugosa) from southeast Devonshire, England: Palaeontology, v. 10, pt. 2, p. 266–279.

——— 1968, Colonial Phillipsastraeidae from the Devonian of southeast Devon, England: British Mus. (Nat. History) Bull., Geology, v. 15, no. 5, p. 183–281, 18 pls.

Sherzer, W. H., 1889, New characters of *Diphyphyllum simcoense* (Bill.) Rom.: Am. Geologist, v. 4, p. 93–95.

——— 1890, Some further corrections of "North American Geology and Paleontology": Am. Geologist, v. 6, p. 59–61.

——— 1891, A chart of rugose corals: Am. Geologist, v. 7, p. 273–301.

Shimer, H. W., and Shrock, R. R., 1944, Index fossils of North America: New York, John Wiley & Sons, 837 p., 303 pls.

Simpson, G. B., 1900, Preliminary descriptions of new genera of Paleozoic rugose corals: New York State Mus. Bull. 39, p. 199–222.

Simpson, G. G., Roe, Anne, and Lewontin, R. C., 1960, Quantitative zoology [revised edition]: New York, Harcourt, Brace, and Co., 440 p.

Sloss, L. L., 1939, Devonian rugose corals from the Traverse beds of Michigan. Jour. Paleontology, v. 13, no. 1, p. 52–73, 4 pls., 8 figs.

Smith, Stanley, 1933, On *Xylodes rugosus* sp. nov., a Niagaran coral: Am. Jour. Sci. 5th ser., v. 26, no. 155, p. 512–522, 1 pl.

——— 1945, Upper Devonian corals of the Mackenzie River region, Canada: Geol. Soc. America Spec. Paper 59, 126 p.

Smith, Stanley, and Lang, W. D., 1927, On the Silurian coral *Tryplasma rugosum* (E and H): Nat. History Ann. Mag., ser. 9, v. 20, p. 305–308.

Smith, Stanley, and Tremberth, Reginald, 1927, *Ptilophyllum* and *Rysodes*, gen. nov.: Nat. History, Ann. Mag., ser. 9, v. 20: p. 309–313.

Sokolov, B. S., 1948, [Commensalism in Favosites]: Akad. Nauk SSSR Izv. Ser. Biol., no. 1, p. 102–109, figs. 1–10.

Sorauf, J. E., 1967, Massive Devonian Rugosa of Belgium: Kansas Univ. Paleont. Contr., Paper 16, 41 p., 11 pls. (as figs.).

Soshkina, E. D., 1936, [Middle Devonian rugose corals from the Northern Urals]: Akad. Nauk SSSR, Trudy Polar Comm., no. 28, p. 15–76.

——— 1939, [Upper Devonian corals Rugosa of the Ural]: Akad. Nauk SSSR, Inst. Paléont., Trudy, v. 9, no. 2, 88 p., 14 pls.

——— 1951, [Upper Devonian Rugosa corals, their systematics and evolution]: Akad. Nauk SSSR, Paléont., Inst. Trudy, v. 34, 122 p., 24 pls.

——— 1952, [Determinative guide to Devonian four-rayed corals: composed of material from the Devonian of the Urals, Timan, Armenia and Middle Devonian field of the Russian Platform] (Russian): Akad. Nauk SSSR, Paléont. Inst., Trudy, v. 39, 126 p., 49 pls.

——— 1954, [Devonian four-rayed corals of the Russian Platform] (Russian): Akad. Nauk SSSR, Paleont. Inst. Trudy, v. 52, 74 p., 19 pls.

Soshkina, E. D., and Dobrolubova, T. A., 1962, Order Evenkiellida, Order Columnarida, *in* Sokolov, B. S., Osnovy Paleontologii, p. 333–345, pls. 17–23, ills. 84–108.

Sparling, D. R., 1971, Bedrock geology of Ottawa County, Ohio, *in* Geology of the Lake Erie islands and adjacent shores: Michigan Basin Geol. Soc., Guidebook for 1971, p. 19–29.

Spassky, N. J., 1960a, [Devonian tetracorals of the upper Amur and eastern Transbaikal]: Leningrad, Gornogo Inst., Zapiski, v. 37, pt. 2, p. 99–107.

——— 1960b, [Devonian tetracorals from the Rudny Altai]: Vses. aerogeologischeskii trest (VAGT)-Akad. Nauk Kazakh. SSR, vpy. 3, 143 p.

——— 1967, [The dispersion of Devonian tetracorals], *in* Stratigrafiya i Paleogeografiya: Leningrad, Gornogo Inst. Zapiski, v. 53, pt. 2, p. 51–68.

Stainbrook, M. A., 1940, *Prismatophyllum* in the Cedar Valley beds of Iowa: Jour. Paleontology, v. 14, no. 3, p. 270–284.

Stauffer, C R, 1907, The Hamilton in Ohio: Jour. Geology, v. 15, p. 590–596.

——— 1909, The Middle Devonian of Ohio: Ohio Geol. Survey, 4th ser. Bull 10, 204 p.

——— 1913, Geology of the region around Hagarsville [Ontario]: Internat. Geol. Cong., XII, Toronto, Canada, 1913, Guidebook 4, p. 82–99.

——— 1915, The Devonian of southwestern Ontario: Canada Geol. Survey Mem. 34, 341 p.

——— 1957, The Columbus Limestone: Jour. Geology, v. 65, p 376–383.

Stewart, G. A., 1927, Fauna of the Silica Shale of Lucas County: Ohio Geol. Survey, 4th ser., Bull. 32, 76 p., 1 fig., 5 pls.

——— 1938, Middle Devonian corals of Ohio: Geol. Soc. America Spec. Paper 8, 120 p., 20 pls., 2 figs.

Strusz, D. L., Disphyllidae and Phacellophyllidae from the Devonian Garra Formation of New South Wales: Palaeontology, v. 8, pt. 3, p. 518–571, pls. 72–78, figs.

Stumm, E. C., 1937, The lower Middle Devonian tetracorals of the Nevada Limestone: Jour. Paleontology, v. 11, no. 5, p. 423–443, 3 pls.

——— 1938, Upper Middle Devonian rugose corals of the Nevada Limestone: Jour. Paleontology, v. 12, no. 5, p. 478–485, 2 pls.

——— 1939, Upper Devonian rugose corals of the Nevada Limestone: Jour. Paleontology, v. 14, no. 1, p. 57–67, 2 pls.

——— 1948a, Lower Middle Devonian species of the tetracoral genus *Hexagonaria* of east-central North America: Michigan Univ. Mus. Paleontology Contr., v. 7, no. 2, p. 7–49.

——— 1948b, Upper Devonian compound tetracorals from the Martin Limestone [Ariz.]: Jour. Paleontology, v. 22, no. 1, p. 40–47.

——— 1949, Revision of the families and genera of the Devonian tetracorals: Geol. Soc. America Mem. 40, 92 p., 25 pls.

——— 1954, Four new species of rugose corals of the Middle Devonian genus *Eridophyllum* from New York, Michigan, and Ohio: Michigan Univ. Mus. Paleontology Contr., v. 12, no. 1, p. 1–11.

——— 1955, Tetracoralla, Division 1, Unit 1F, pt. C, *in* Type invertebrate fossils of North America (Devonian): Wagner Free Inst. Sci., Philadelphia, cards 128–337.

——— 1965, Silurian and Devonian corals of the Falls of the Ohio: Geol. Soc. America Mem. 93, 184 p., pls. 3–80.

——— 1967, Growth stages in the Middle Devonian rugose coral species *Hexagonaria anna* (Whitfield) from the Traverse Group of Michigan: Michigan Univ. Mus. Paleontology, Contr., v. 21, no. 5, p. 105–108, 1 pl.

——— 1968, The corals of the Middle Devonian Tenmile Creek Dolomite of northwestern Ohio: Michigan Univ. Mus. Paleontology Contr. 22, no. 3, p. 37–44, 3 pls.

——— 1969, Revision of R. P. Whitfield's types of rugose and tabulate corals in the Museum of Paleontology, University of California, and in the United States National Museum: Bulls. Am. Paleontology, v. 56, no. 250, p. 235–254, pls. 10–13.

——— 1970, Corals of the Traverse Group of Michigan, Part 13, *Hexagonaria:* Michigan Univ. Mus. Paleontology Contr., v. 23, no. 5, p. 81–91, 4 pls.

Stumm, E. C., Kellum, L. B. and Wright, J. D., 1956, Devonian strata of the London-Sarnia area, southwestern Ontario, Canada, *in* Michigan Geological Society Guidebook, ann. field trip, 1956, 21 p.

Tillman, J. R., 1970, The age, stratigraphic relationships, and correlation of the lower part of the Olentangy Shale of central Ohio: Ohio Jour. Sci., v. 70, no. 4, p. 202–217.

Troedsson, G. T., 1928, On the Middle and Upper Ordovician faunas of northern Greenland; pt. 2: Medd. Grönland, v. 72, 197 p.

Vanuxem, Lardner, 1842, Geology of New York, part 3, comprising the survey of the third geological district: Albany, Nat. History of New York 306 p.

Wang, H. C., 1948, The Middle Devonian rugose corals of eastern Yunnan: Peking Natl. Univ. Geol. Inst. Contr. no. 33, 45 p., pls. 1–5.

——— 1950, A revision of the Zoantharia Rugosa in the light of their minute skeletal structures: Royal Soc. London Philos. Trans., ser. B, no. 611, v. 234, p. 175–246.

Wedekind, R., 1922, Zur Kenntnis der Stringophyllen des oberen Mitteldevon: Sitz-ber. Gesellsch. Beford. gesamten Naturwiss. Marburg für 1921, v. 56, no. 1, p. 1–16.,

Weisbord, N. E., 1926, Venezuelan Devonian fossils: Bulls. Am. Paleontology, v. 11, no. 46, 52 p.

——— 1968, The Devonian System in western Venezuela, *in* Oswald, D. H., ed., Internat. Symposium on the Devonian System, Calgary, Alberta, 1967 [Proc.]: Calgary, Alberta Soc. Petroleum Geologists, v. 2, p. 215–226 [1967].

Wells, J. W., 1937, Individual variation in the rugose coral species *Heliophyllum halli* E & H: Palaeontographica Americana, v. 2, no. 6, 22 p., 1 pl., 31 figs.

——— 1943, The Rio Cachiri section in the Sierra de Perija, Venezuela, pt. 2b, Anthozoa: Bulls. Am. Paleontology, v. 27, no. 108, p. 95–100.

——— 1944, New tabulate corals from the Pennsylvanian of Texas: Jour. Paleontology, v. 18, no. 3, p. 259–262, pls. 40, 41.

——— 1947, Provisional paleoecological analysis of the Devonian rocks of the Columbus Region [Ohio]: Ohio Jour. Sci., v. 47, no. 3, p. 119–126.

White, C. A., 1882, Fossils of the Indiana rocks: Indiana Dept. Geol. Nat. History Ann. Rept. 11, p. 347–401.

Whiteaves, J. F., 1897, The fossils of the Galena-Trenton and Black River Formations of Lake Winnipeg and its vicinity: Canada Geol. Survey, Palaeozoic Fossils v. 3, no. 3, p. 129–242.

——— 1898, On some additional or imperfectly understood fossils from the Hamilton formation of Ontario, with a revised list of the species therefrom: Canada Geol. Survey, Contr. Canada Paleontology 1, p. 361–418.

——— 1906, Paleozoic fossils—Appendix—Errata et corrigenda: Canada Geol. Survey, Palaeozoic Fossils, v. 3, p. 341–345.

Whitfield, R. P., 1882, Palaeontology—Part 3 *in* Geology of Wisconsin, survey of 1873–1879: Wisconsin Geol. Survey, v. 4, p. 163–363.

——— 1891, Contributions to invertebrate paleontology [of Ohio]: New York Acad. Sci., Ann. 5, p. 505–620 (1891); or Ohio Geol. Survey, Rept. 7, p. 407–494 (1893).

——— 1899, List of fossils, types and figured specimens used in the paleontological work of R. P. Whitfield, showing where they are probably to be found at the present time: New York Acad. Sci. Annals 12, p. 139–186.

Williams, M. Y., 1919, The Silurian geology and faunas of Ontario Peninsula and Manitoulin and adjacent islands: Canada Geol. Survey Mem. 111, 195 p., 34 pls.

Winchell, Alexander, 1866, The Grand Traverse region—a report on the geological and industrial resources of the counties of Antrim, Grand Traverse, Benzie, and Leelanaw in the Lower Peninsula of Michigan: Ann Arbor, 97 p.

Yabe, H. and Hayasaka, I., 1915, Paleozoic corals from Japan, Korea and China: Tokyo, Geol. Soc. Japan Jour., XXII, p. 55–70, 79–92, 93–109, 127–142.

Yandell, L. P., and Shumard, B. F., 1847, Contributions to the Geology of Kentucky: Louisville, 36 p.

Zheltonogova, V. A., and Ivania, V. A., 1960, ed., [Subclass Tetracoralla (Rugosa)], *in* Khlafina, L. L., ed., [Biostratigraphy of the Paleozoic of the Sayano-Altai mountain area]: Sibir. Nauchno—Issled. Inst. Geologii, Geofizikii Mineral'nogo Syr'ya Trudy, v. 20, p. 360–408, pls. D27–D57.

INDEX

[Italic numbers indicate major references and descriptions]

☆U.S. GOVERNMENT PRINTING OFFICE: 1976 O—211-317/122

PLATES 1-108

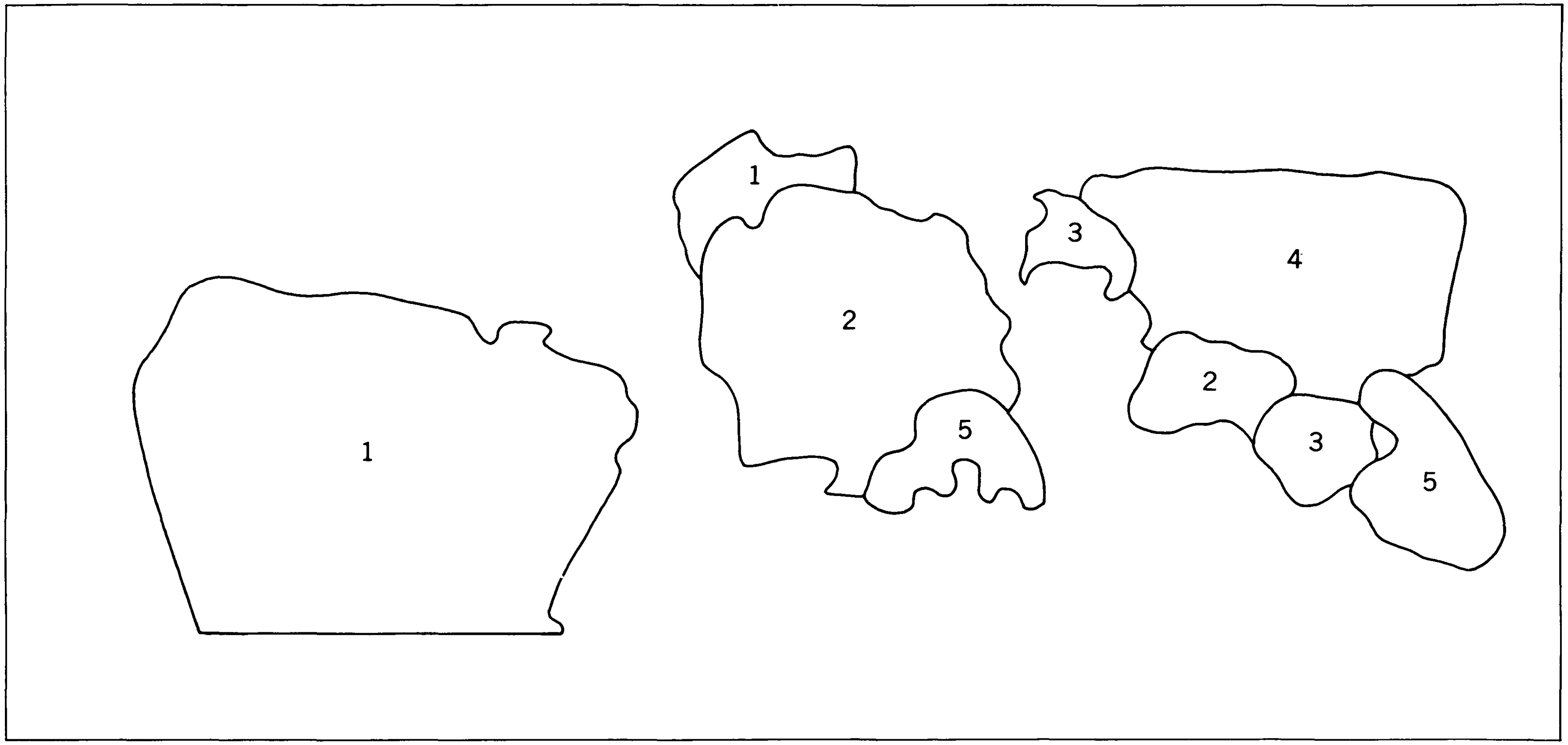
All figures on plates 2–108 are unretouched photographs of thin sections unless otherwise indicated.

Contact photographs of the plates in this report are available at cost, from the U.S. Geological Survey Library, Federal Center, Denver, Colorado 80225.

PLATE 1A

Reconstruction of Edgecliff bioherm scene based on fossils collected from bioherm near Buffalo, N.Y. (Old Fogelsanger quarry, loc. 108). Skeletalform is accurately shown as molds were prepared from actual specimens. Soft parts (polyps) are based on living forms in analogous environments and are, at best, reasonable guesses. A key to the colonial rugose corals represented is given below. See plate 1B for detail views and key to other invertebrates.

Models and diorama are by George Marchand in the Hall of Invertebrate Paleontology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. Photographed by Victor Krantz, Smithsonian Institution.

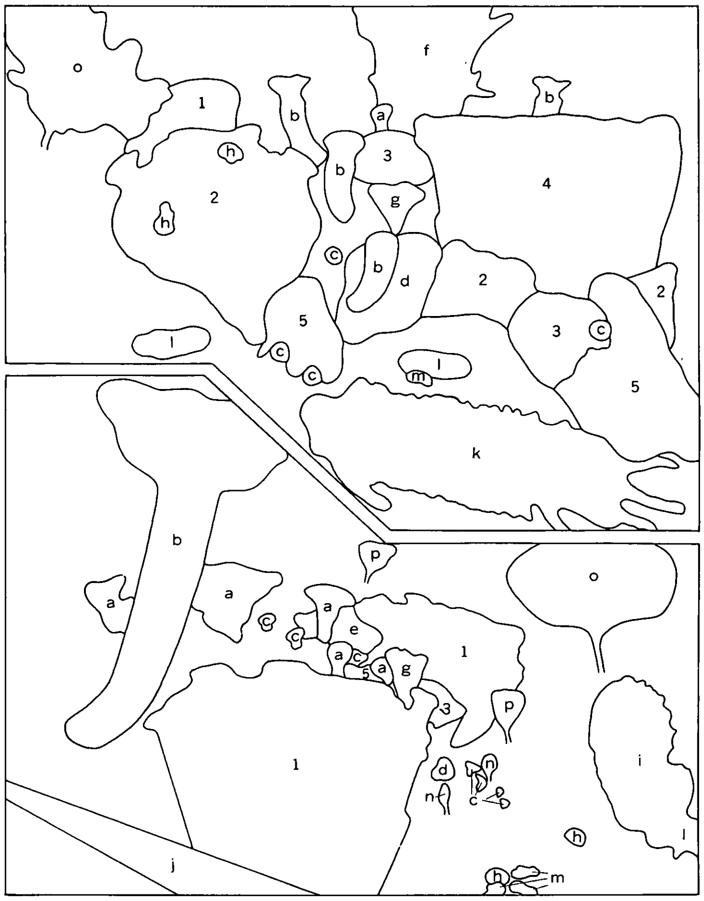


Key to colonial rugose corals: 1, *Cyathocylindrium gemmatum* (Hall); 2, *Heliophyllum monticulum* (Ehlers and Stumm); 3, *Prismatophyllum ovoideum* (Davis); 4, *Acinophyllum segregatum* (Simpson); 5, *Asterobillingsa magdisa* Oliver. Scale: diameter of *C. gemmatum* corallite (1 in key) is approximately 1 inch (2½ cm).

RECONSTRUCTION OF EDGECLIFF BIOHERM SCENE

PLATE 1B

Details of Edgecliff bioherm reconstruction shown in plate 1A. Models based on specmens from locality 108. A key to the colonial rugose corals and other fossils represented is given below. Photographs by Victor Krantz, Smithsonian Institution.



Key

COLONIAL RUGOSE CORALS: 1, *Cyathocylindrium gemmatum* (Hall); 2, *Heliophyllum monticulum* (Ehlers and Stumm); 3, *Prismatophyllum ovoideum* (Davis); 4, *Acinophyllum segregatum* (Simpson); 5, *Asterobillingsa magdisa* Oliver.

OTHER RUGOSE CORALS: a, *Heliophyllum halli* Milne-Edwards and Haime; b, *Siphonophrentis elongata* (Rafinesque and Clifford); c, *Zaphrentis*? sp.

TABULATE CORALS: d, *Alveolites mordax* Davis; e, *Emmonsia epidermata* (Rominger); f, *Trachypora* sp.; d and f are not known to occur in the Edgecliff Member.

BRYOZOAN: g, Fenestellate.

GASTROPOD: h, *Platyceras* (*Platyostoma*) *lineata* Conrad.

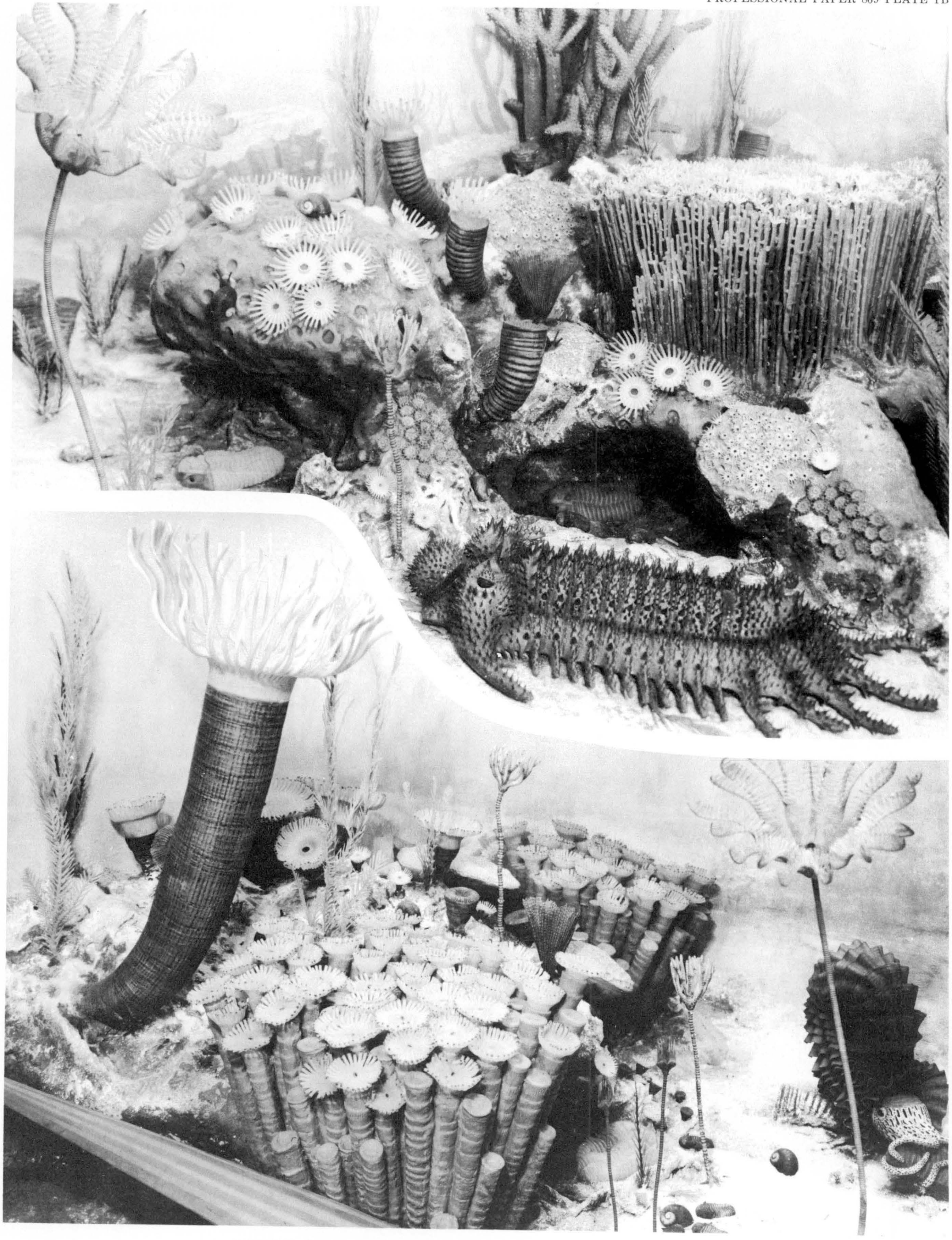
NAUTILOID CEPHALOPODS: i, "*Michelinoceras*" sp.; j, *Goldringia* sp.

TRILOBITES: k, *Terataspis grandis* (Hall); l, *Calymene ptatys* Green; m, *Phacops cristata* Hall; the trilobite in the center foreground of plate 1A is *Anchiopella anchiops* (Green). All four species are characteristic of the Schoharie and Bois Blanc Formations and are not certainly known from the Edgecliff Member.

BLASTOID: n, *Brachyschisma corrugatum* (Reimann).

CRINOIDS: o, *Dolatocrinus* sp.; p, *Arachnocrinus* sp.

(Identifications made or confirmed by E. L. Yochelson, gastropod; Mackenzie Gordon, Jr., *Goldringia;* M. E. Taylor, trilobites; D. B. Macurda, echinoderms; T. L. Chase, University of Michigan, kindly sent me a list prepared by I. G. Reimann, of the Marchand molds, which confirmed most of the identifications and added the *Michelinoceras* and *Arachnocrinus*.)



DETAILS OF EDGECLIFF BIOHERM RECONSTRUCTION

PLATE 2

FIGURES 1–8. *Synaptophyllum arundinaceum* (Billings) (p. 47).

Edgecliff Member, Onondaga Limestone, southwestern Ontario.

1–5. Lectotype, GSC 3602. Locality 3 miles (4.8 km) west of Cayuga.

1, 3. Longitudinal and transverse thin sections of two corallites (× 4).

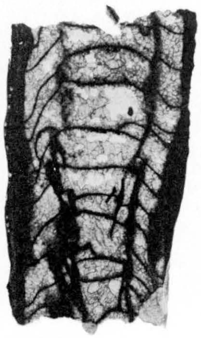
2, 4. Longitudinal and transverse thin sections of another corallite (× 4).

5. Exterior (× 1).

6. GSC 31151. Longitudinal thin section (× 5); see also pl. 4, fig. 10. Loc. GSC 22795.

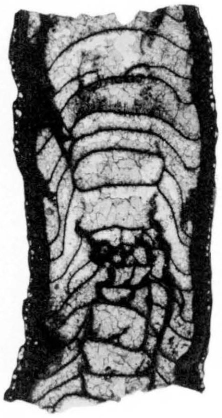
7. GSC 31152. Transverse thin section (× 2½). Loc. GSC 2645.

8. GSC 3422a. Exterior of fragment (× 1). Cayuga, Ontario.



1

5

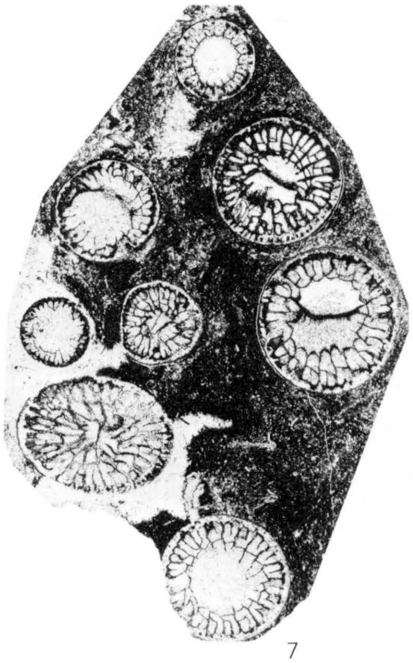


2

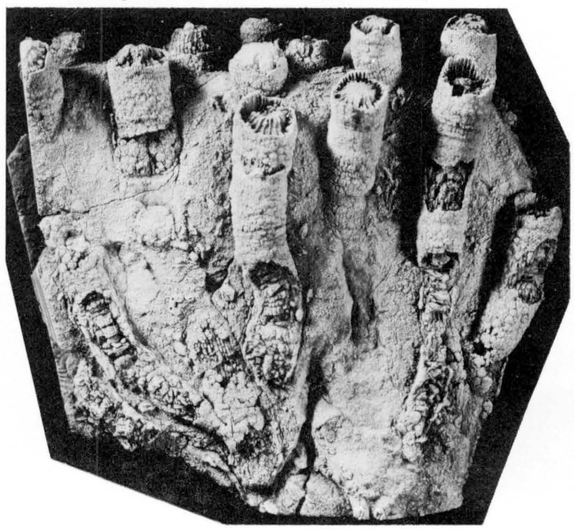
3

4

6



7



8

SYNAPTOPHYLLUM ARUNDINACEUM (BILLINGS)

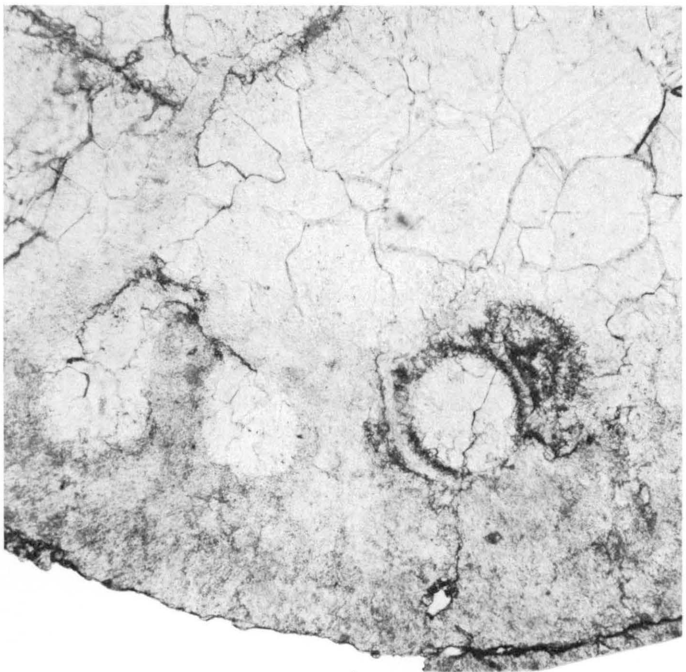
PLATE 3

FIGURES 1–5. *Synaptophyllum arundinaceum* (Billings) (p. 47).

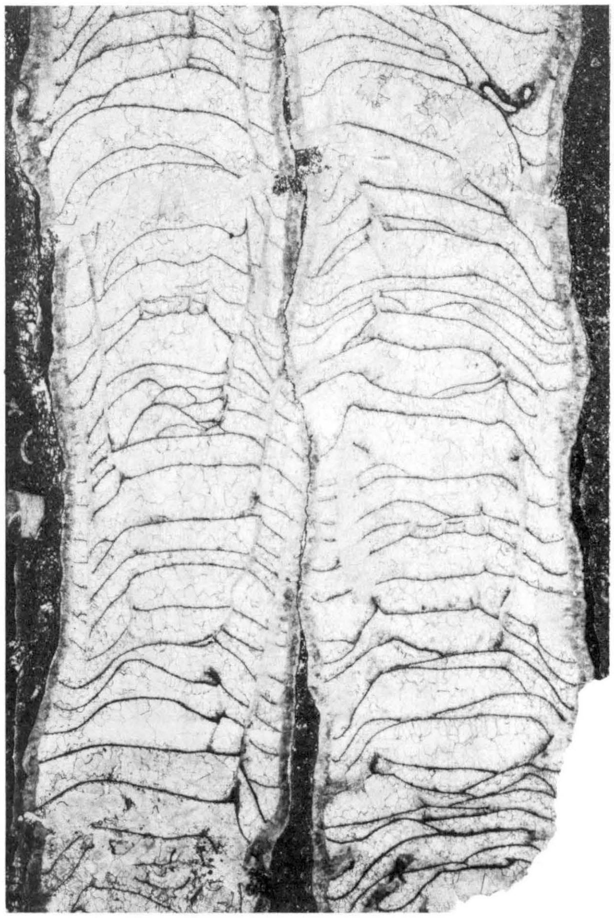
USNM 10719, Edgecliff bioherm facies; loc. 108. See also plate 4, figure 9.

1. Detail (× 50) of one corallite in upper right part of fig. 2.
2. Transverse thin section (× 2½).

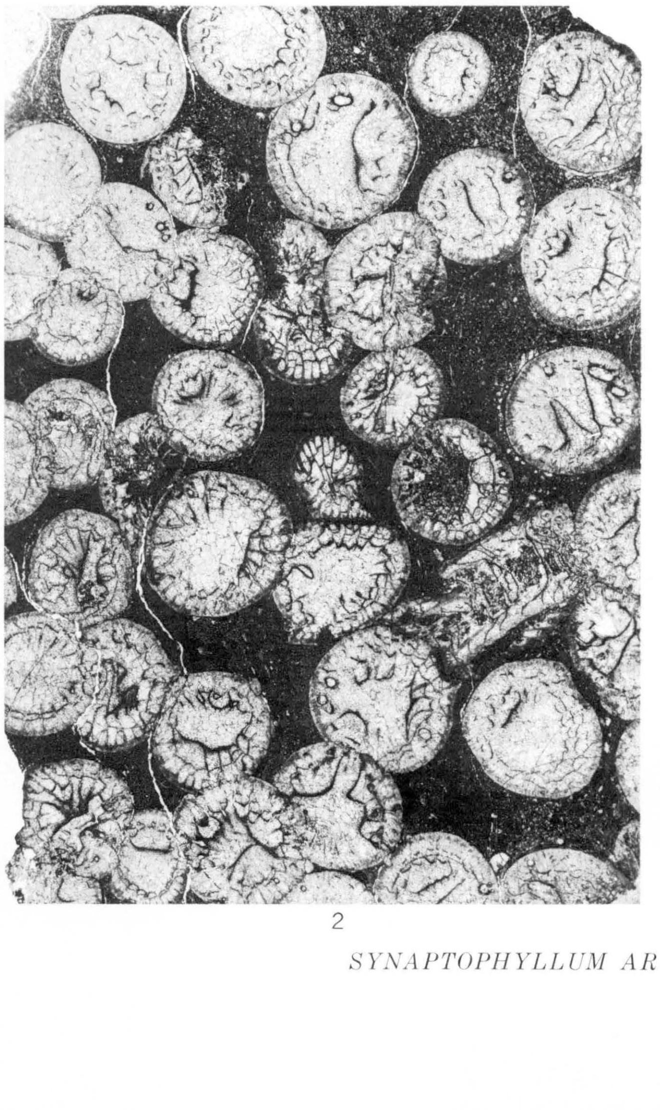
3–5. Longitudinal thin sections (× 5).



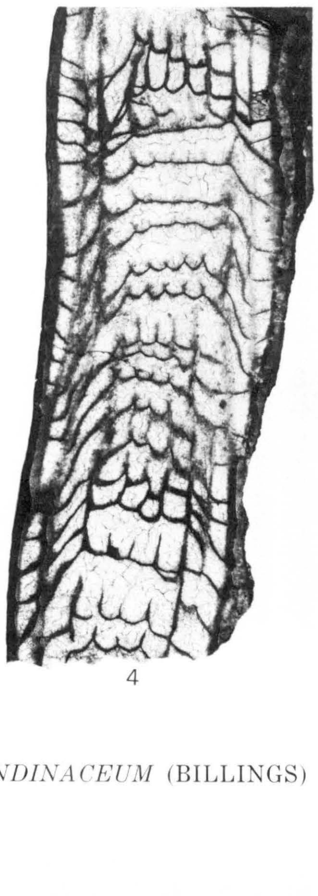
1



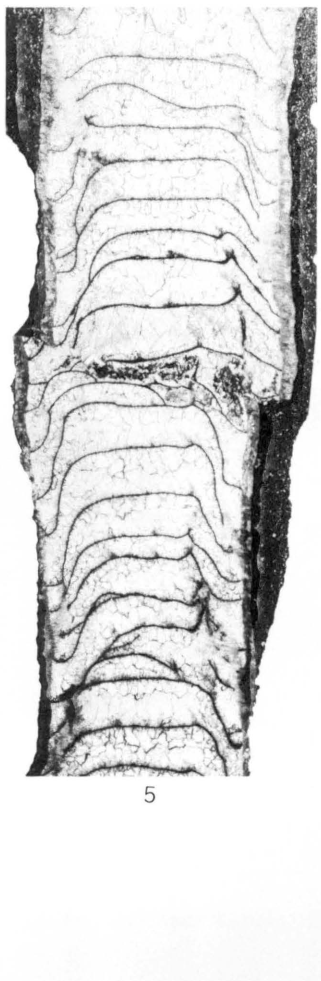
3



2



4



5

SYNAPTOPHYLLUM ARUNDINACEUM (BILLINGS)

PLATE 4

FIGURES 1–10. *Synaptophyllum arundinaceum* (Billings) (p. 47).

Edgecliff bioherm facies.

1. NYSM 12822. Longitudinal thin section (× 5). Loc. 81.

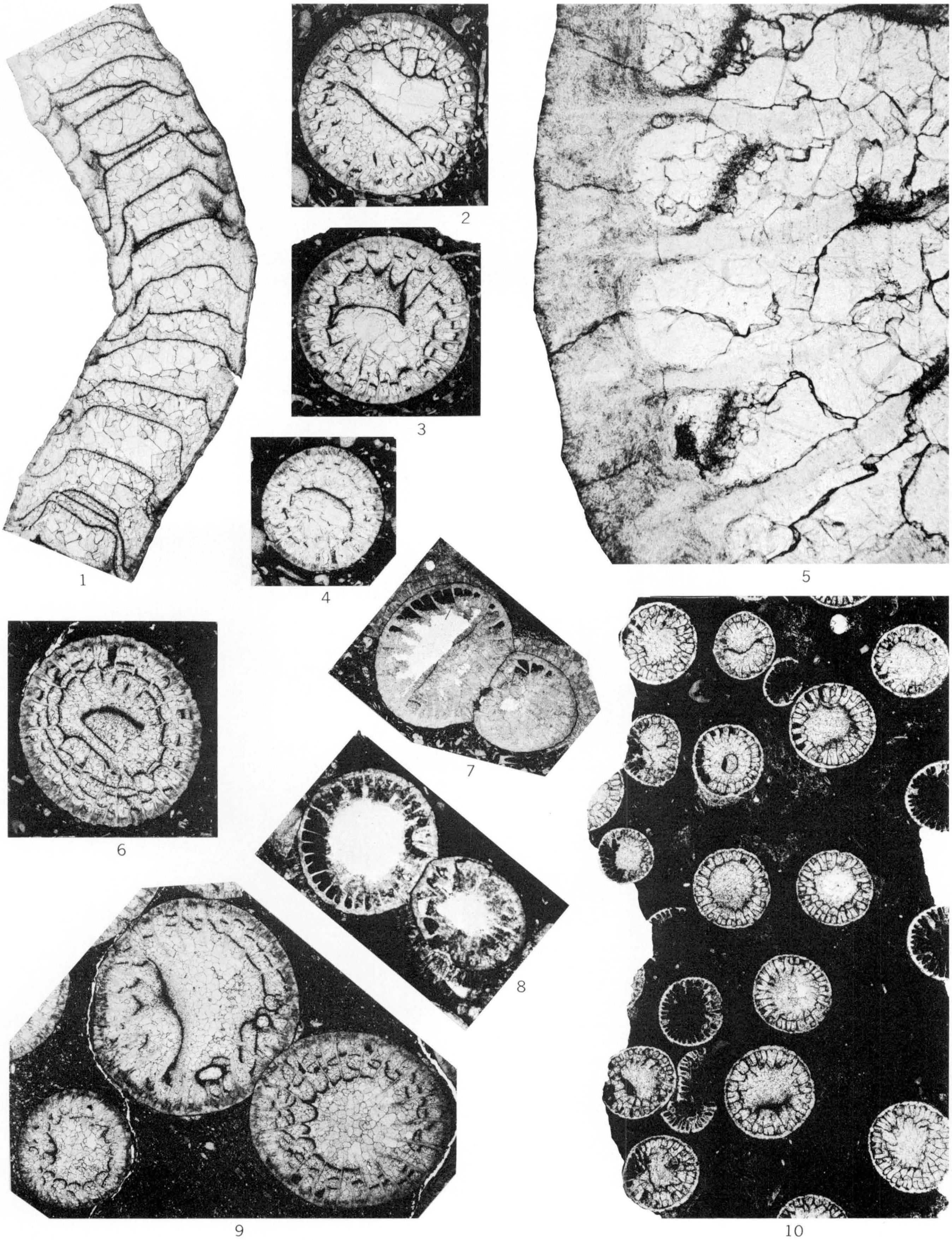
2–5. NYSM 12821. Transverse thin sections of three corallites (× 5) and part of corallite in fig. 2 (× 50). Loc. 108.

6. USNM 162577. Transverse thin section (× 5). Loc. 438. See also pl. 7, figs. 7–9.

7, 8. USNM 162576. Serial transverse sections of laterally offsetting corallite (× 5). Loc. 236.

9. USNM 10719. Transverse thin section (× 5). These three corallites are top center in pl. 3, fig. 2.

10. GSC 31151. Transverse thin section (× 2½). Same corallum as pl. 2, fig. 6.



SYNAPTOPHYLLUM ARUNDINACEUM (BILLINGS)

PLATE 5

FIGURES 1–8. *Synaptophyllum tabulatum* (Simpson). (p. 49).

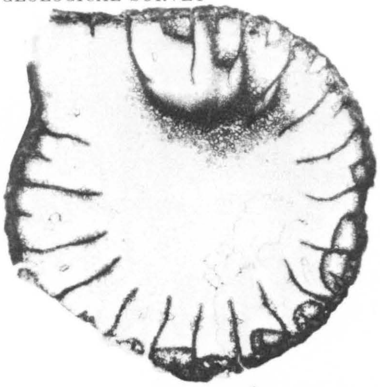
Edgecliff Member, Onondaga Limestone.

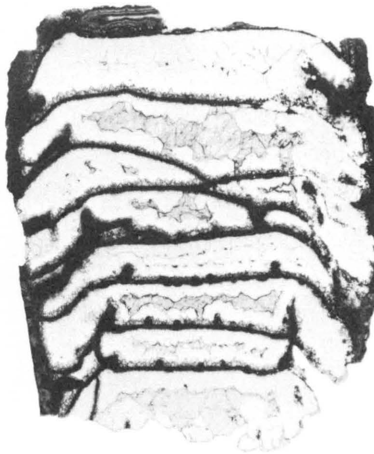
1–3. Holotype, NYSM 300 (and 12875, see text). Transverse and two longitudinal sections presumed to be from the same corallite or corallum (× 5). Walpole, Ontario.

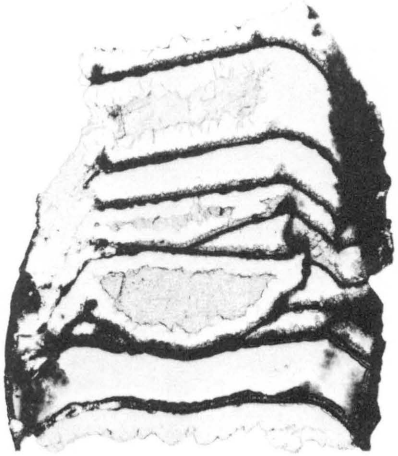
4–8. USNM 162607. Loc. 244.

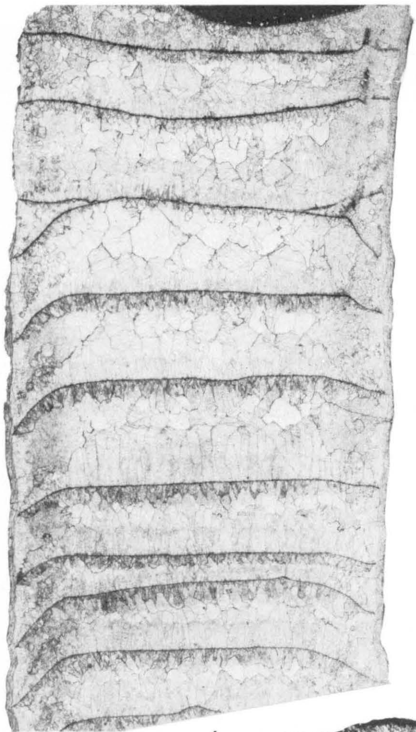
4–7. Longitudinal and transverse thin sections of different corallites (× 5).

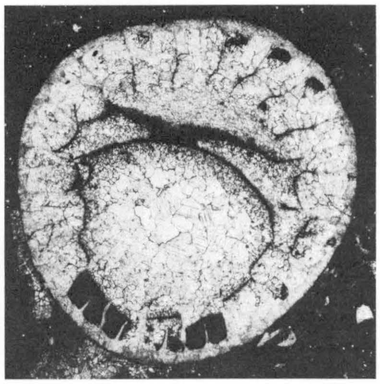
8. Part of corallite shown in fig. 7 (× 50).

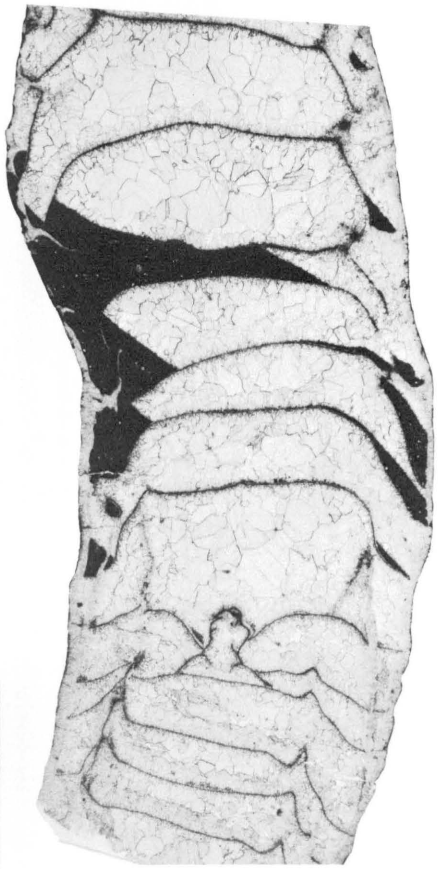

1

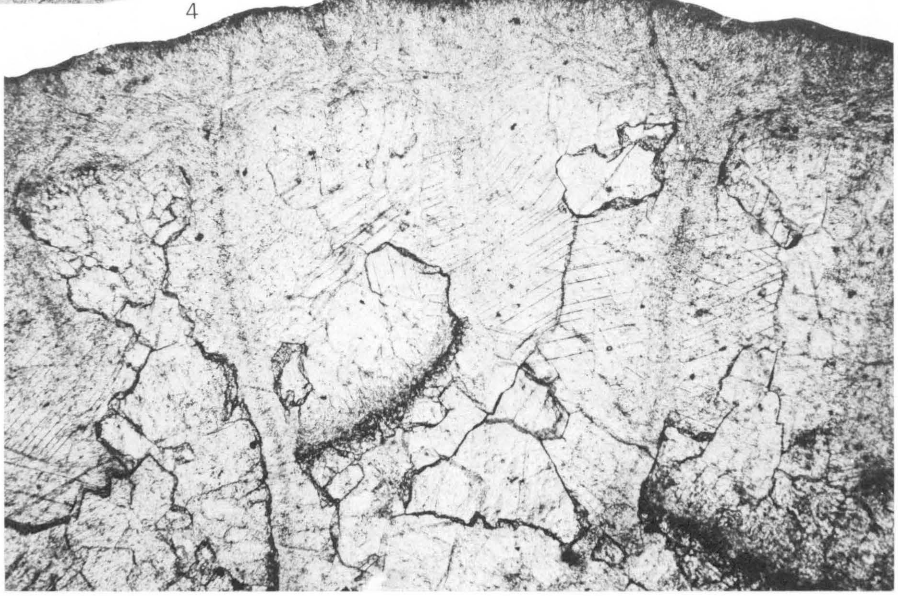

2

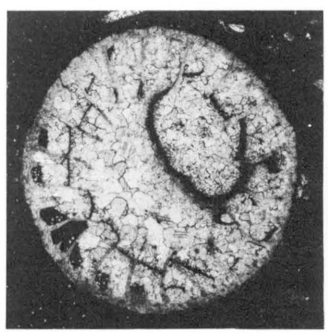

3


4


5


6


8


7

SYNAPTOPHYLLUM TABULATUM (SIMPSON)

PLATE 6

FIGURES 1–10. *Synaptophyllum kladion* n. sp. (p. 50).

Moorehouse Member, New York and Ontario.

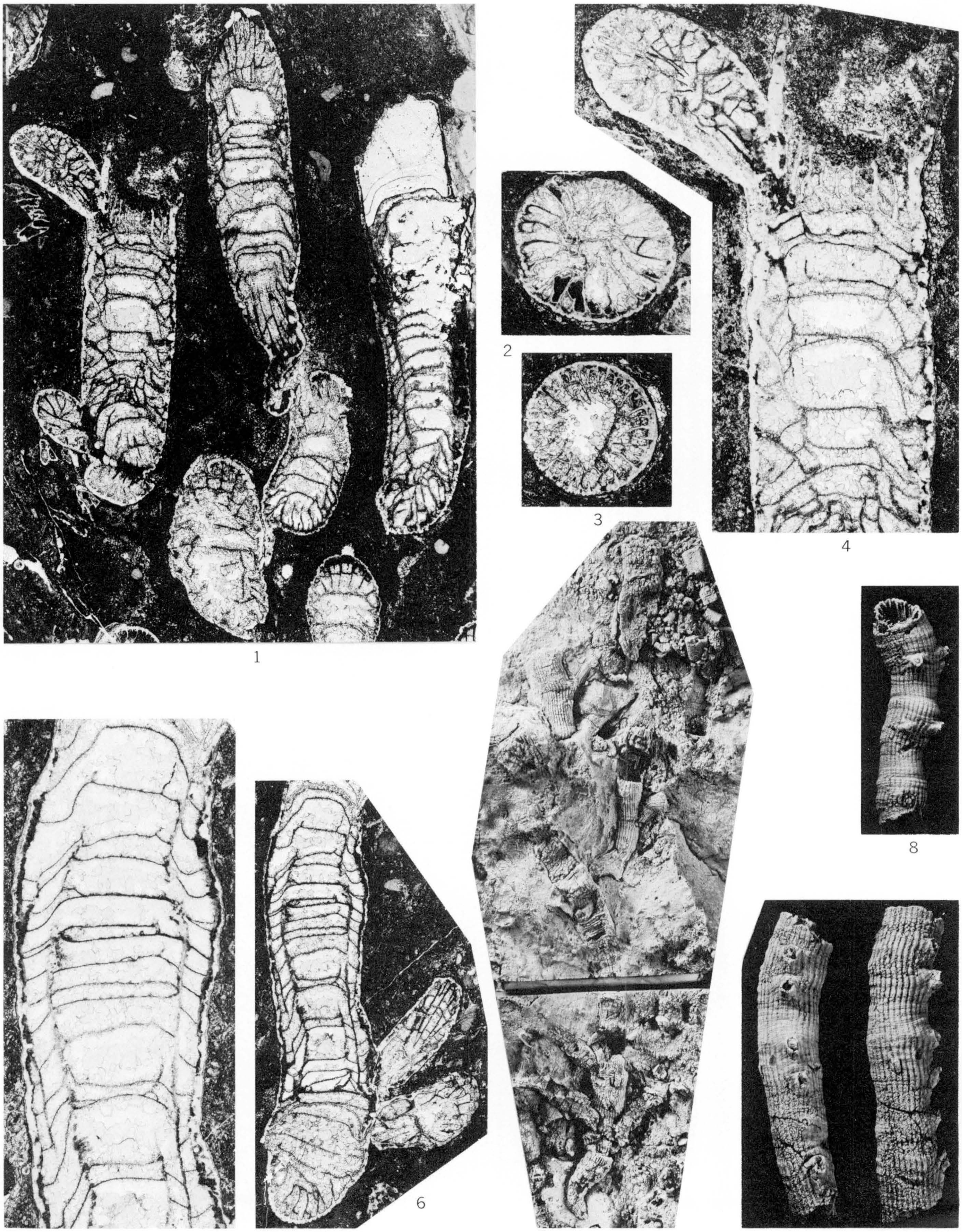
1–6. Holotype, GSC 31153. Loc. C18.

1, 6. Longitudinal thin sections (× 2½).

2–5. Transverse and Longtudinal thin sections (× 5).

7. Paratype, USNM 162592. Silicified and weathered specimen showing characteristic growth form (× 1). Loc. 120.

8–10. Two paratypes, USNM 162593. Silicified fragments showing shape and offset frequency (× 1½). Loc. 373.

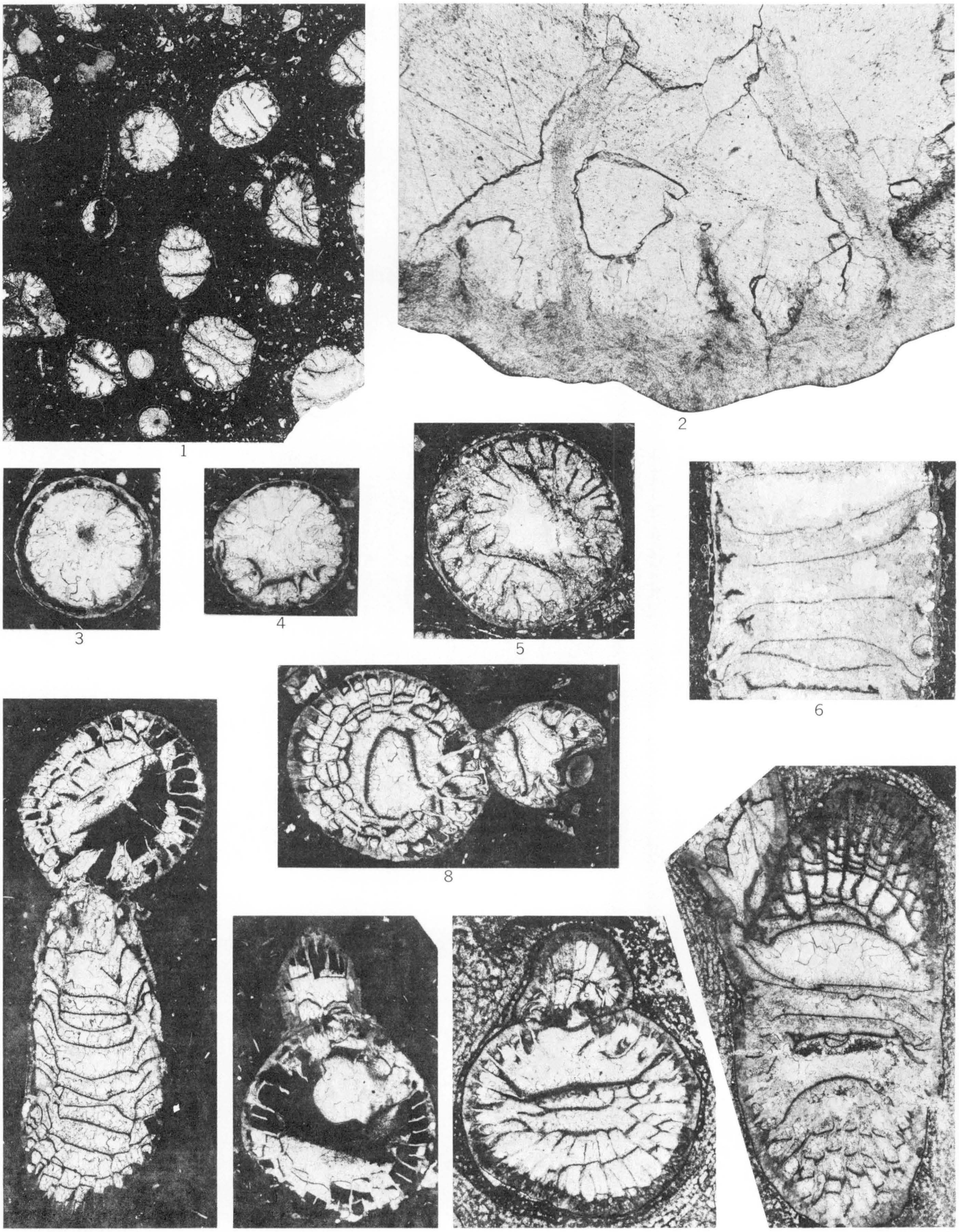


SYNAPTOPHYLLUM KLADION N. SP.

PLATE 7

FIGURES 1–6. *Synaptophyllum kladion* n. sp. (p. 50).
Moorehouse Member, New York.
1–4. Paratype, USNM 162589. Loc. 373.
1, 3, 4. Transverse thin sections (× 2½ and × 5).
2. Part of corallite in fig. 4 (× 50).
5, 6. Paratype, USNM 162590. Transverse and longitudinal thin sections (× 5). Loc. 120.

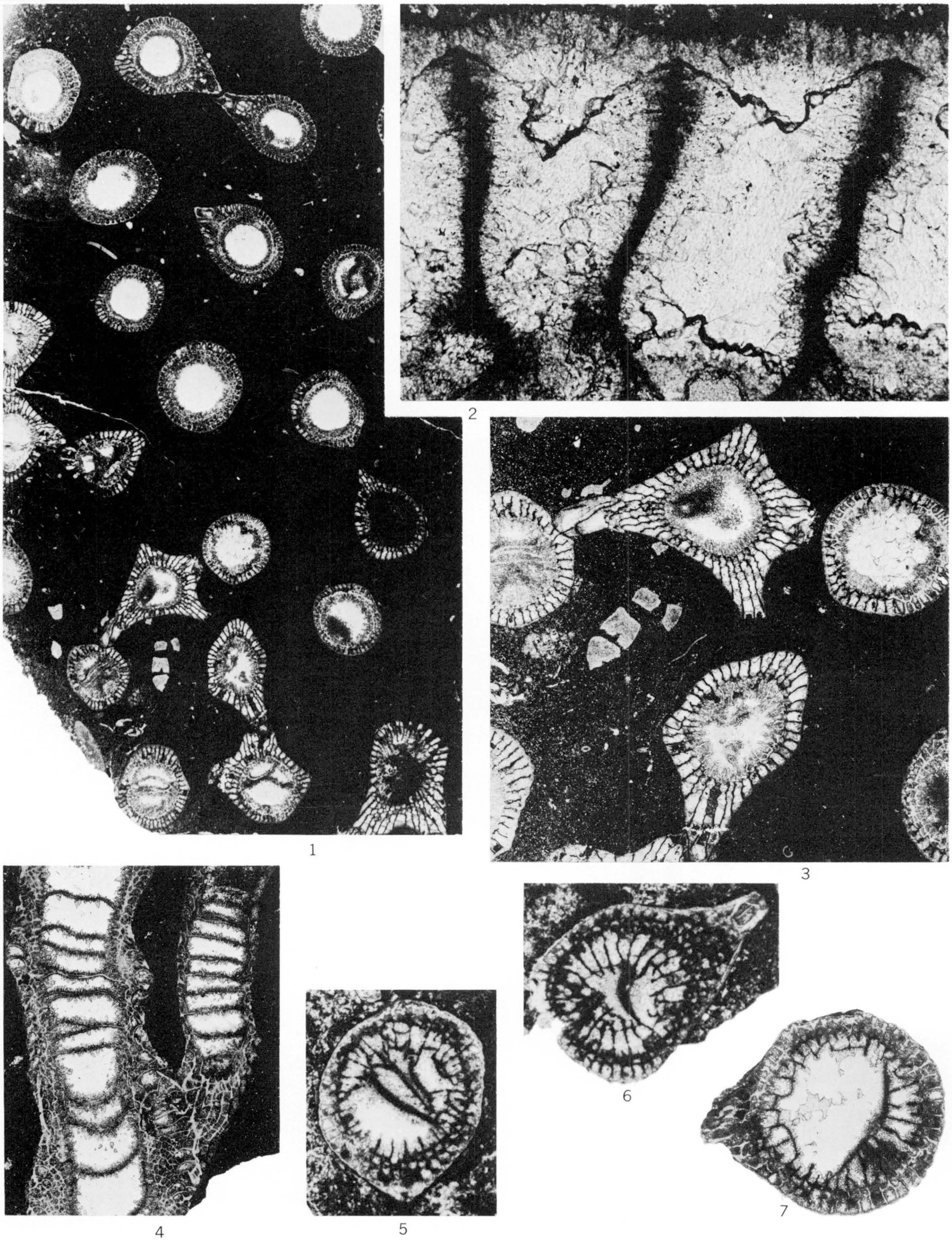
7–11. *Synaptophyllum arundinaceum* (Billings) (p. 47).
7–9. Paratype, USNM 162577. Three corallites with lateral offsets (× 5). See also pl. 4, fig. 6.
10, 11. USNM 162587. Transverse and semilongitudinal thin sections of corallites with lateral offsets (× 5). Columbus Limestone, USGS loc. 7807–SD.



SYNAPTOPHYLLUM KLADION N. SP. AND *S. ARUNDINACEUM* (BILLINGS)

PLATE 8

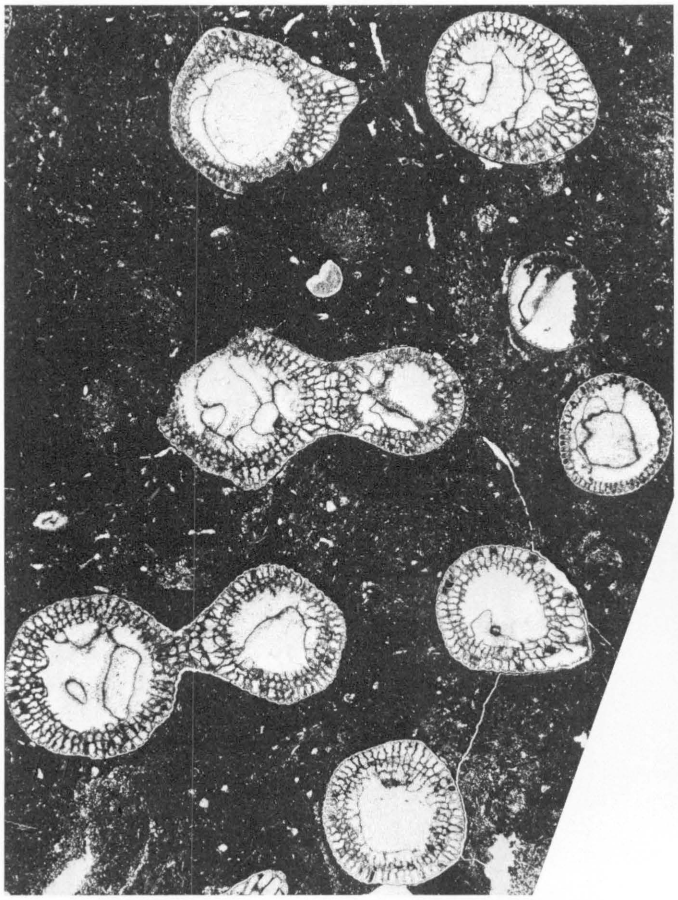
FIGURES 1–7. *Acinophyllum simcoense* (Billings) (p. 57).
Bois Blanc Formation.
1–4. Neotype, GSC 31144. Loc. C28.
1. Transverse thin section (× 2½).
2. Detail (× 100) of low-central corallite in fig. 3.
3. Part of fig. 1 (× 5).
4. Longtudinal thin section (× 5).
5–7. Holotype of *Synaptophyllum baculoideum* Simpson
NYSM 334, 335. Transverse thin sections of three corallites. Leroy, N.Y.



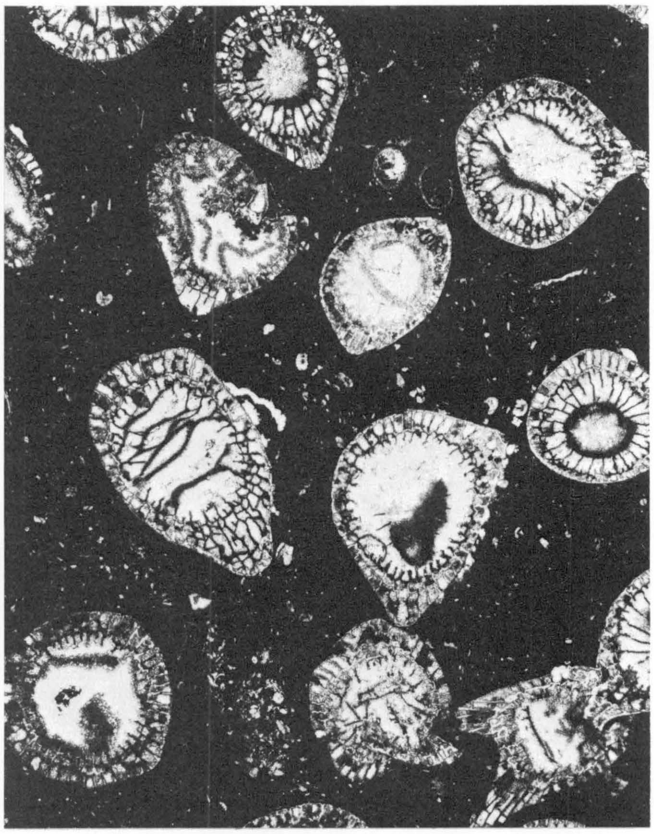
ACINOPHYLLUM SIMCOENSE (BILLINGS)

PLATE 9

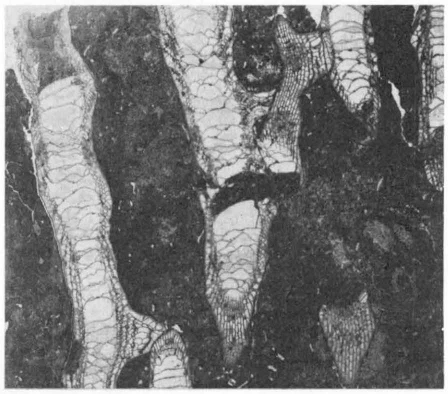
FIGURES 1–5. *Acinophyllum simcoense* (Billings) (p. 57).
Bois Blanc Formation.
1, 2. USNM 27961. Transverse and longitudinal thin sections (× 2½, × 1). Hagarsville, Ontario.
3–5. NYSM 12811. Transverse and two longitudinal thin sections (× 2½). Leroy, N.Y.



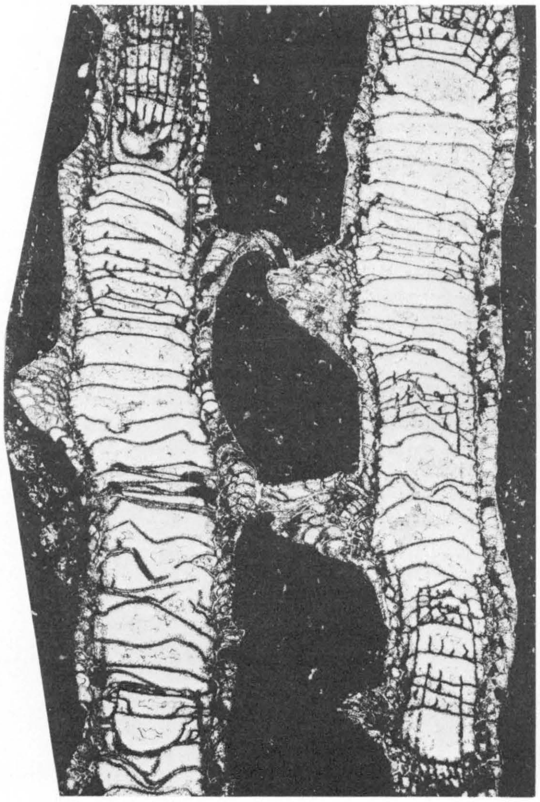
1



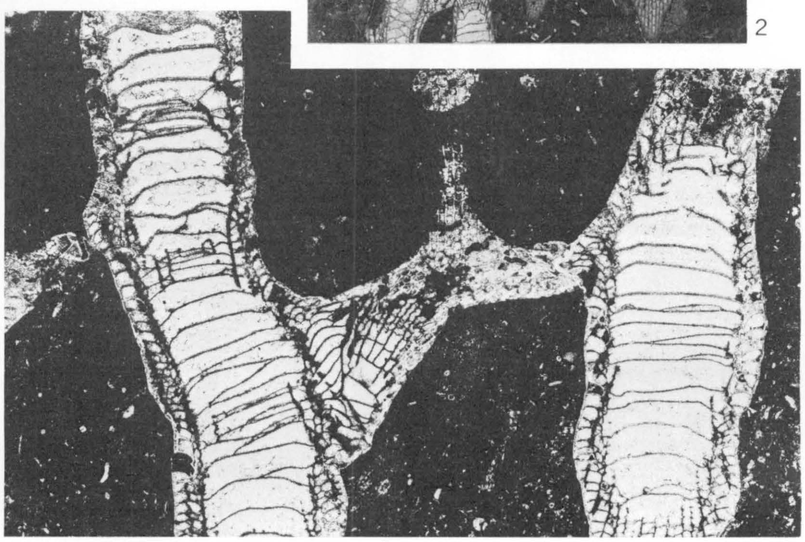
3



2



4



5

ACINOPHYLLUM SIMCOENSE (BILLINGS)

PLATE 10

FIGURES 1–7. *Acinophyllum simcoense* (Billings) (p. 57).

Bois Blanc Formation.

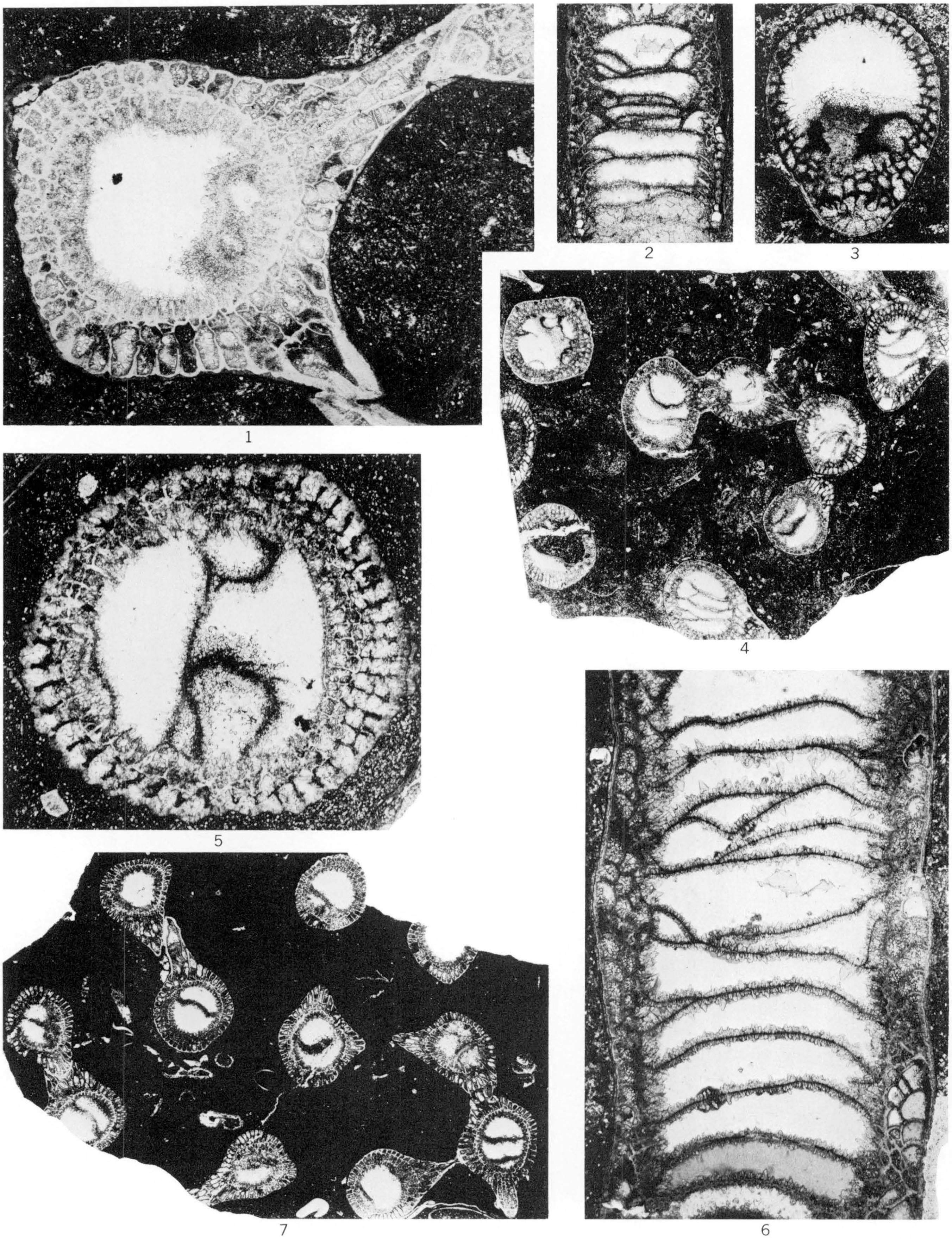
1. USNM 162596. Transverse thin section (× 10). Loc. C28.

2, 5. USNM 162595. Longtudinal (× 5) and transverse (× 10) thin sections. Loc. C28.

3. NYSM 12813. Transverse thin section (× 5). Leroy, N.Y.

4, 6. USNM 162597. Transverse (× 2½) and longitudinal (× 10) thin sections. Loc. C28.

7. USNM 162598. Transverse thin section (× 2½). Loc. C28.

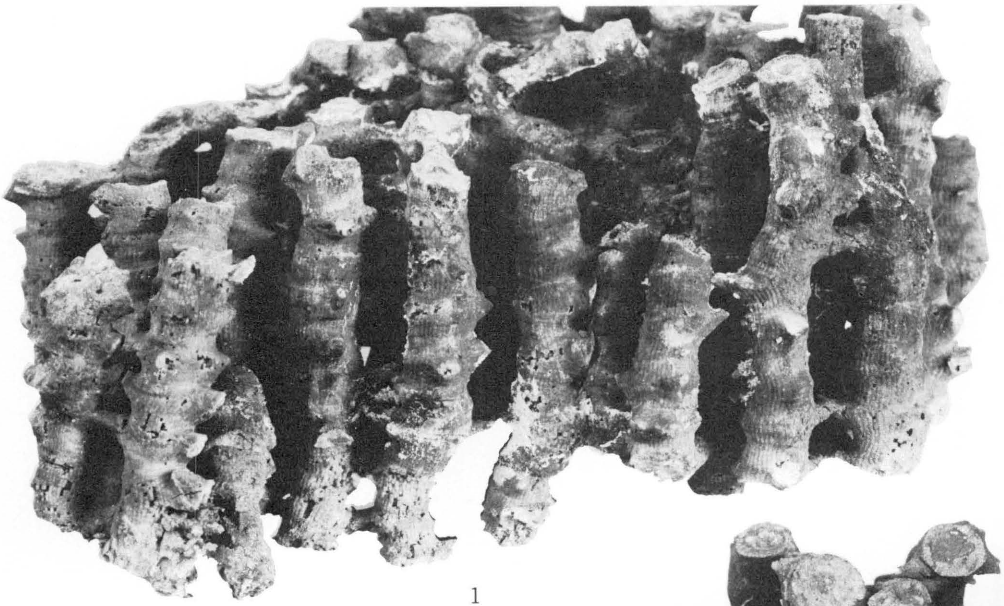


ACINOPHYLLUM SIMCOENSE (BILLINGS)

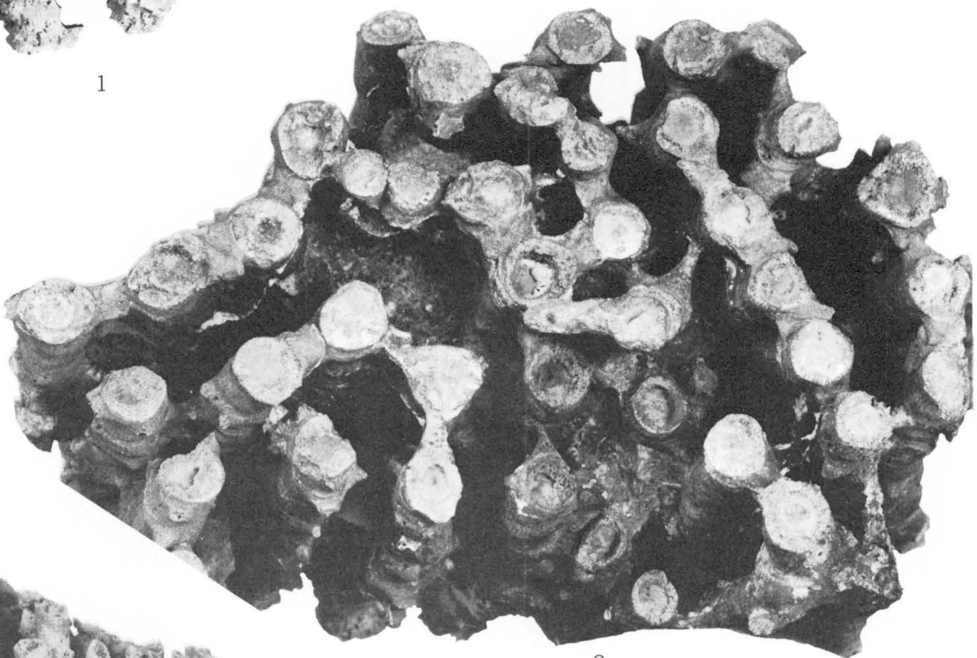
PLATE 11

FIGURES 1, 2. *Acinophyllum simcoense* (Billings) (p. 57).
Bois Blanc Formation. NYSM 12812. Lateral and distal views of silicified and etched corallum (× 1). Leroy, N.Y.

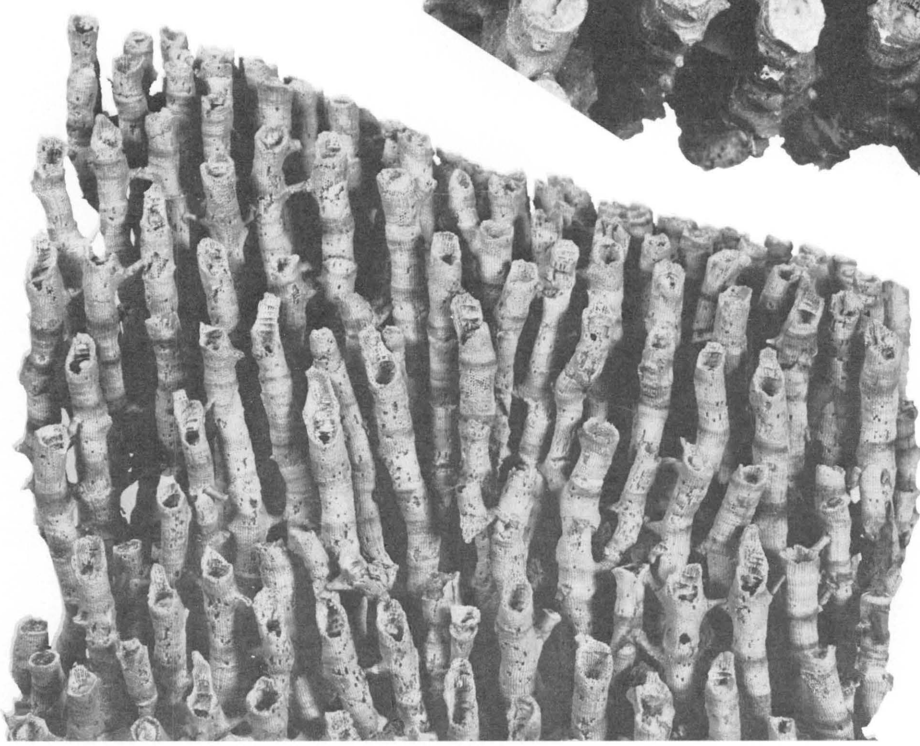
3. *Acinophyllum segregatum* (Simpson) (p. 61).
Onondaga Limestone. NYSM 12785. Lateral view of silicified and etched corallum (× 1). Leroy, N.Y.



1



2



3

ACINOPHYLLUM SIMCOENSE (BILLINGS) AND *A. SEGREGATUM* (SIMPSON)

PLATE 12

FIGURES 1–6. *Acinophyllum stramineum* (Billings) (p. 59).

Edgecliff Member.

1–3. Lectotype, GSC 3431. Wainfleet, Ontario. Photographs provided by the G.S.C.

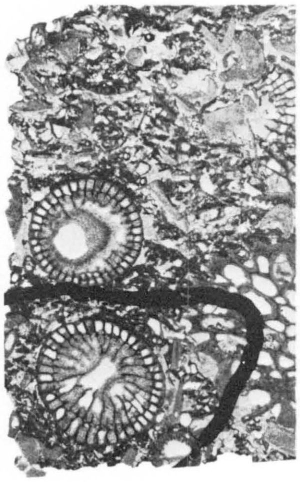
1, 2. Transverse and longitudinal thin sections (× 4).

3. Surface of lectotype fragment (× 1).

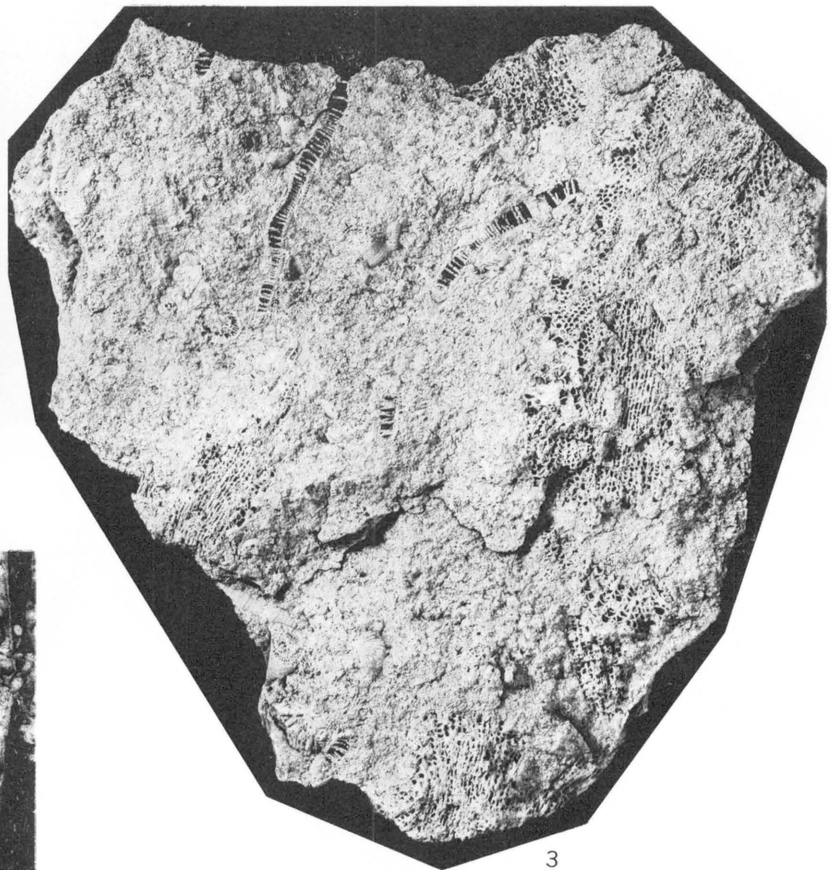
4. NYSM 12806. Longitudinal thin section (× 5). Loc. 108. See also pl. 13, fig. 1.

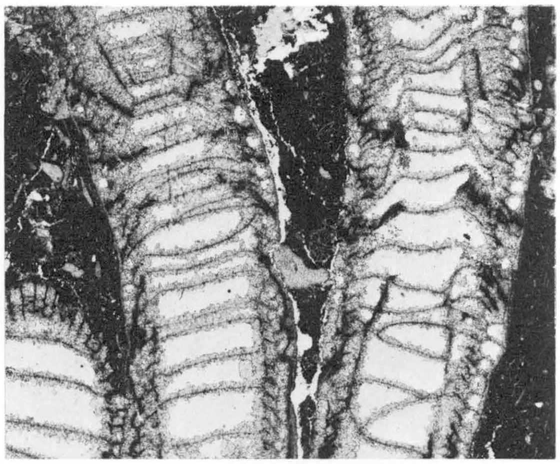
5. USNM 162608. Transverse thin section (× 2½). Loc. 108. See also pl. 13, figs. 6, 7, and pl. 14, figs. 8–10.

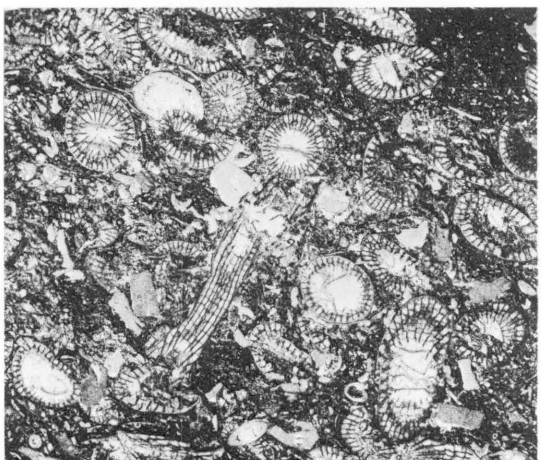
6. NYSM 12807. Thin section through broken corallum (× 2½). Loc. 108.

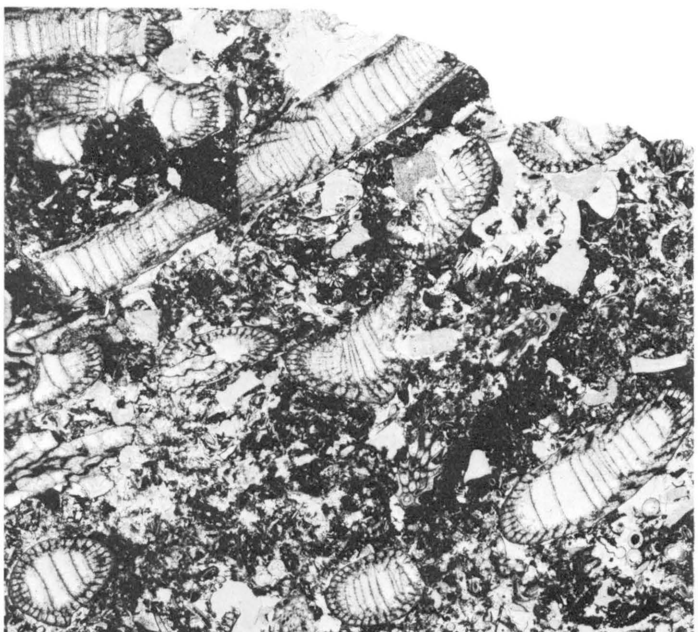

1


2


3


4


5


6

ACINOPHYLLUM STRAMINEUM (BILLINGS)

PLATE 13

FIGURES. 1–8. *Acinophyllum stramineum* (Billings) (p. 59).

Edgecliff bioherm facies, New York.

1. NYSM 12806. Transverse section of two corallites (× 10). See also pl. 12, fig. 4.

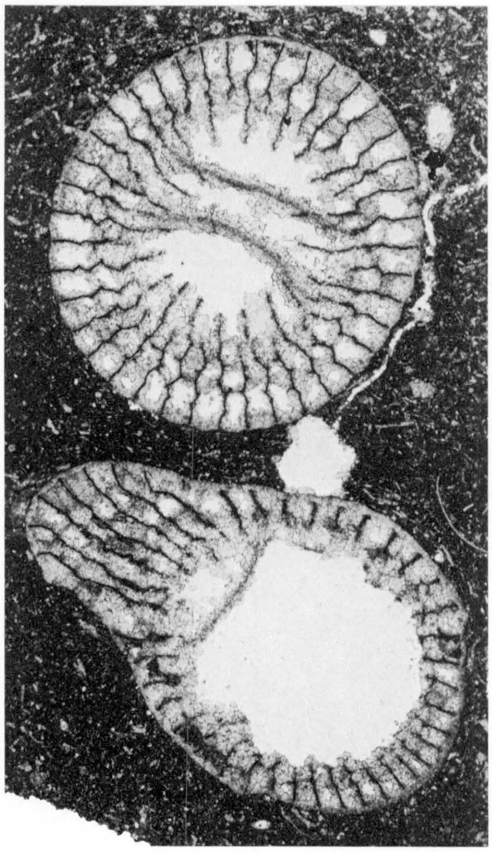
2–5. USNM 162609. Transverse thin sections of several corallites (× 10). Loc. 135. See also pl. 14, figs. 1–7

6, 7. USNM 162608. See also pl. 12, fig. 5, and pl. 14, figs. 8–10.

6. Detail of section shown in fig. 7 (× 50).

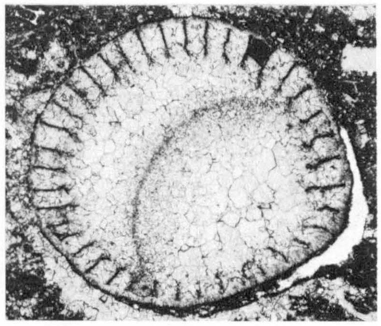
7. Longitudinal thin section (× 10).

8. NYSM 12808. Longitudinal thin section (× 10). Loc. 108.

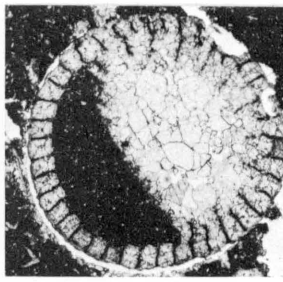


1

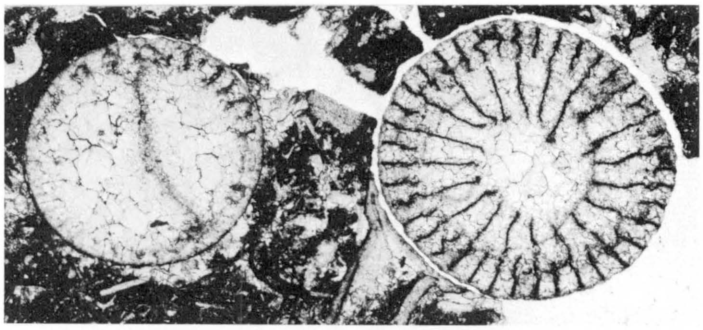
2



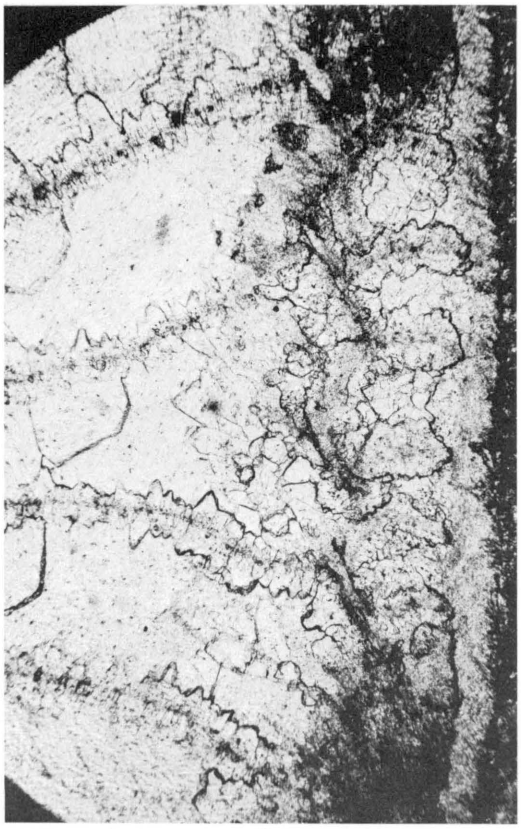
3



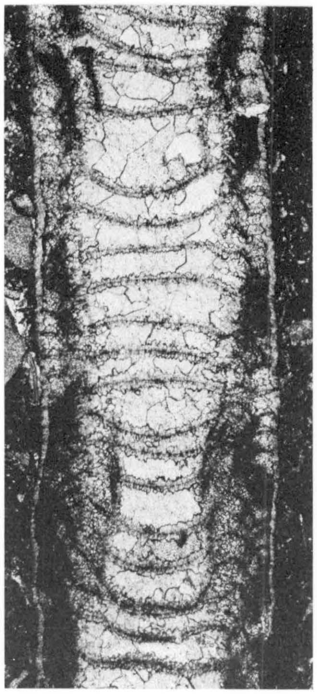
4



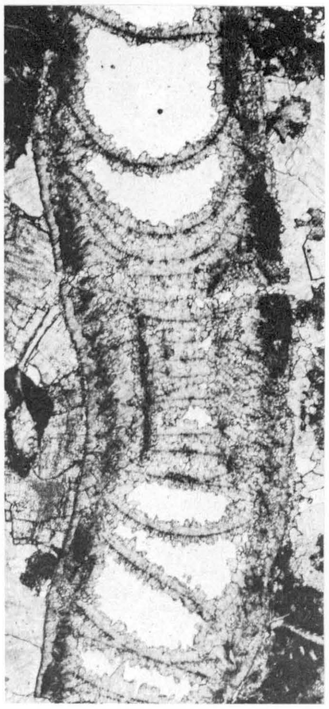
5



6



7



8

ACINOPHYLLUM STRAMINEUM (BILLINGS)

PLATE 14

FIGURES 1–10. *Acinophyllum stramineum* (Billings) (p. 59).

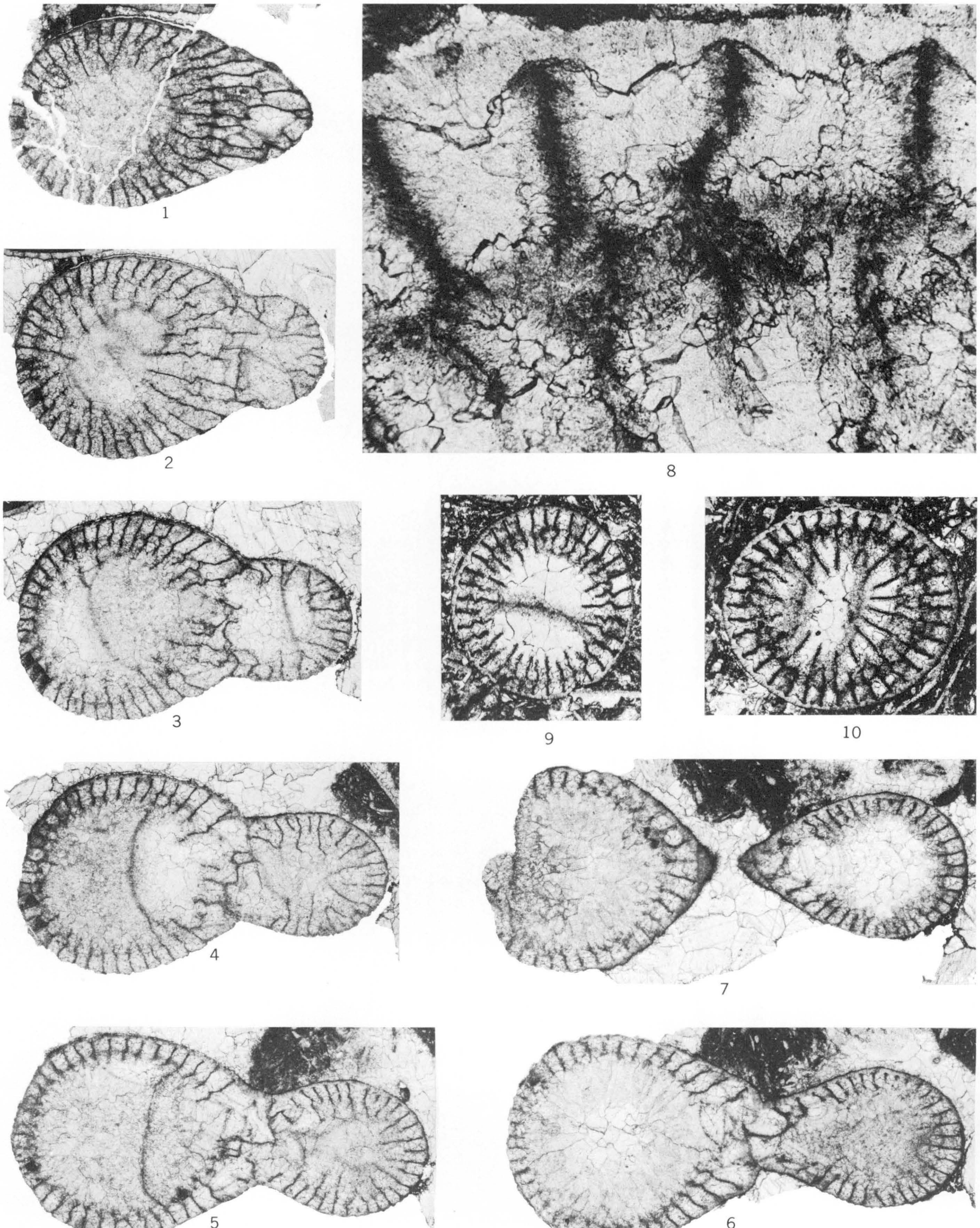
Edgecliff bioherm facies, New York. Loc. 108.

1–7. USNM 162609. Serial transverse sections of lateral offsetting ($\times$ 10). Average distance between successive sections <1 mm (range, 0.8–1.4 mm); total distance from lowest to highest section, 5.8 mm. See also pl. 13, figs. 2–5.

8–10. USNM 162608. See also pl. 12, fig. 5, and pl. 13, figs. 6, 7.

8. Detail of left upper part of corallite in fig. 10 ($\times$ 100).

9, 10. Transverse thin sections of two corallites ($\times$ 10).



ACINOPHYLLUM STRAMINEUM (BILLINGS)

PLATE 15

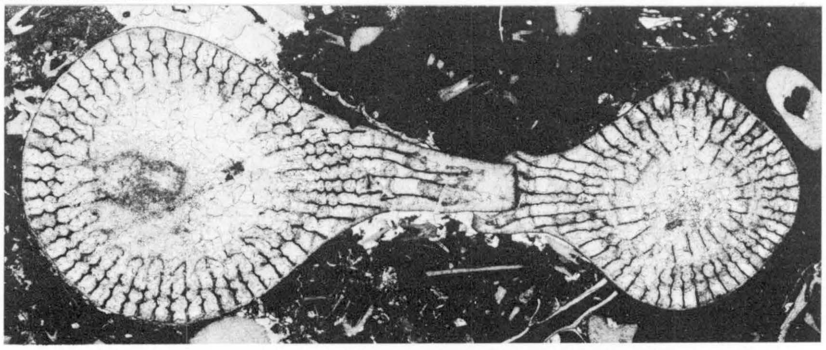
FIGURES 1–6. *Acinophyllum segregatum* Simpson (p. 61).

Onondaga Limestone, New York.

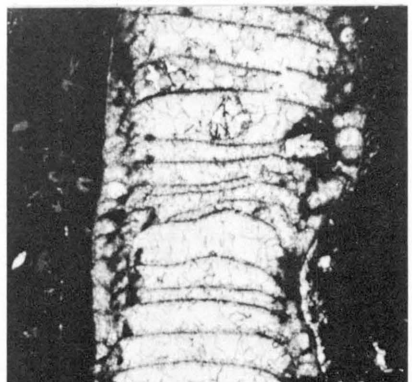
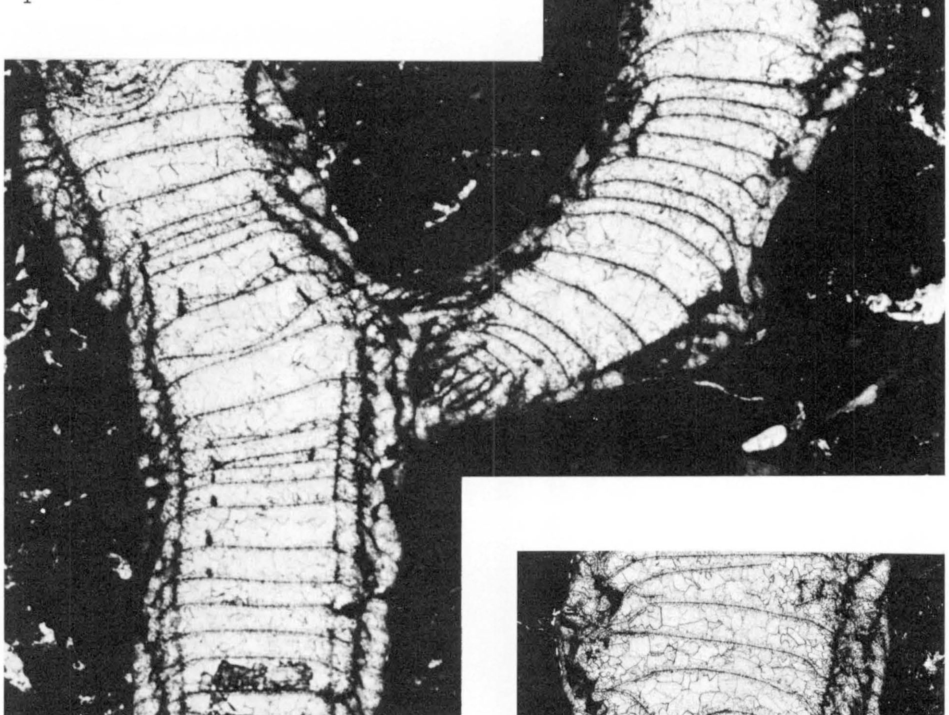
1–3. USNM 162615. Edgecliff bioherm facies. Loc. 269. See also pl. 16, fig. 1

1. Transverse thin section of two corallites and lateral support (× 5).
2. Longitudinal thin section of parent and lateral offset (× 5).
3. Longitudinal thin section of another corallite (× 5).

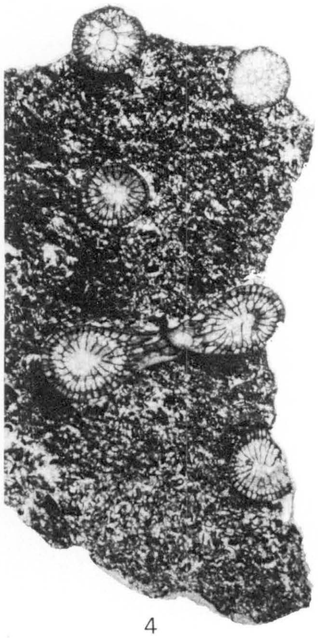
4–6. Holotype, NYSM 336. Successive enlargements of single thin section (× 2½, × 5, × 20). Clarksville, N.Y.



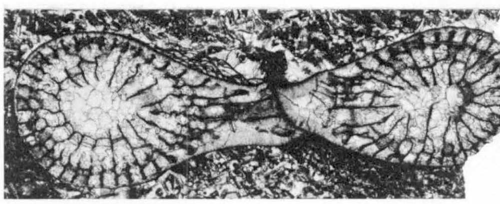
1

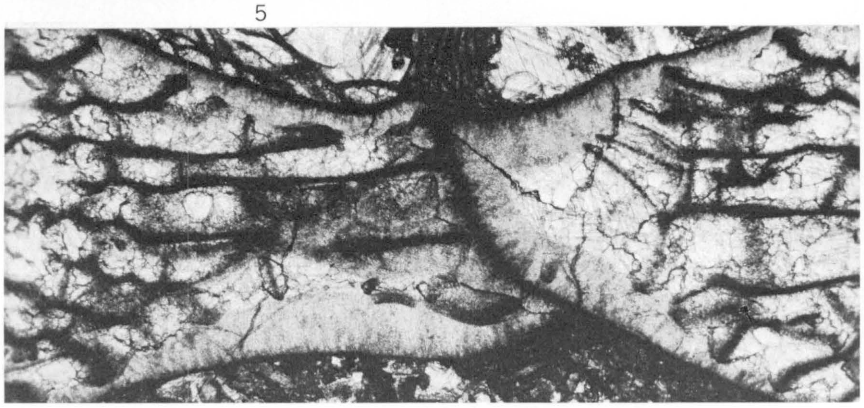
2



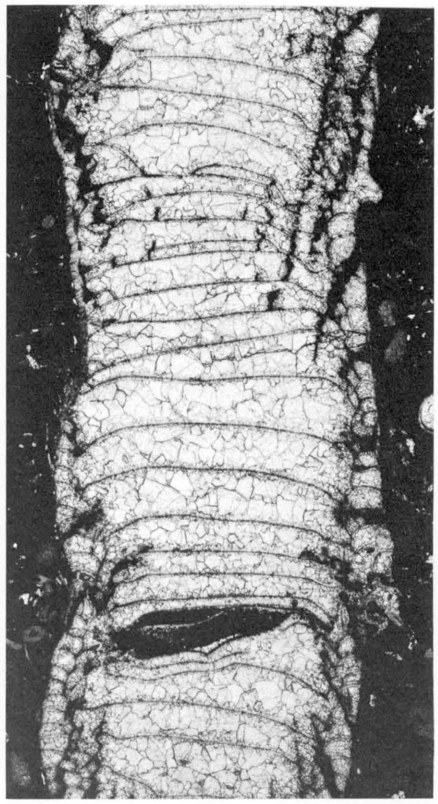
4



5



6



3

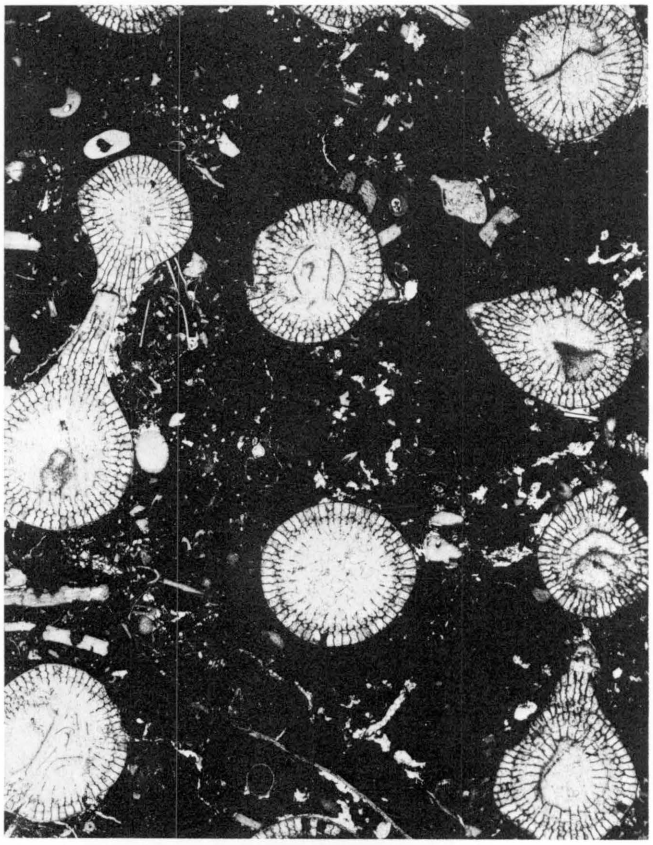
ACINOPHYLLUM SEGREGATUM (SIMPSON)

PLATE 16

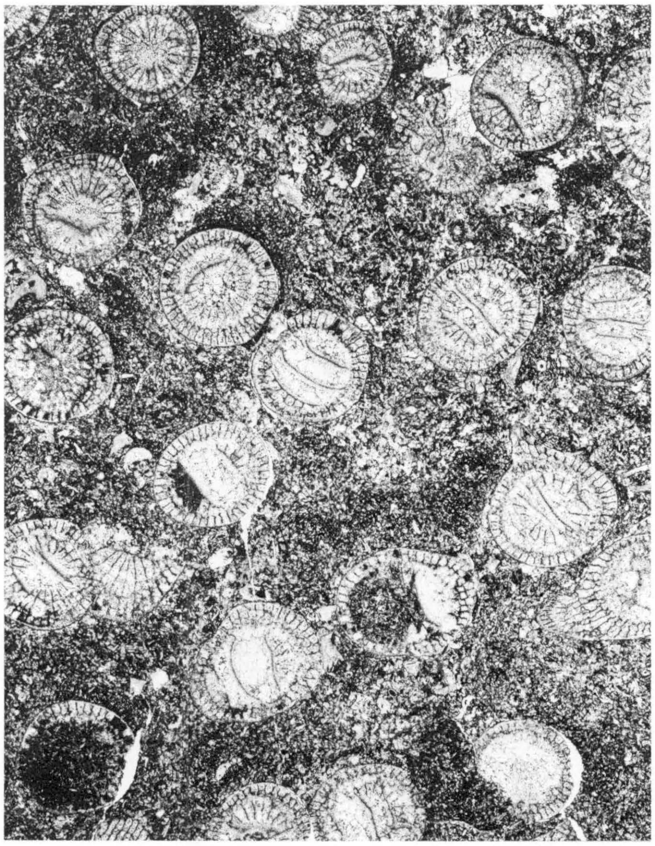
FIGURES 1–4. *Acinophyllum segregatum* Simpson (p. 61).

Four transverse thin sections to show intercolony variation in corallite diameter and spacing (× 2½). Edgecliff Member, New York.

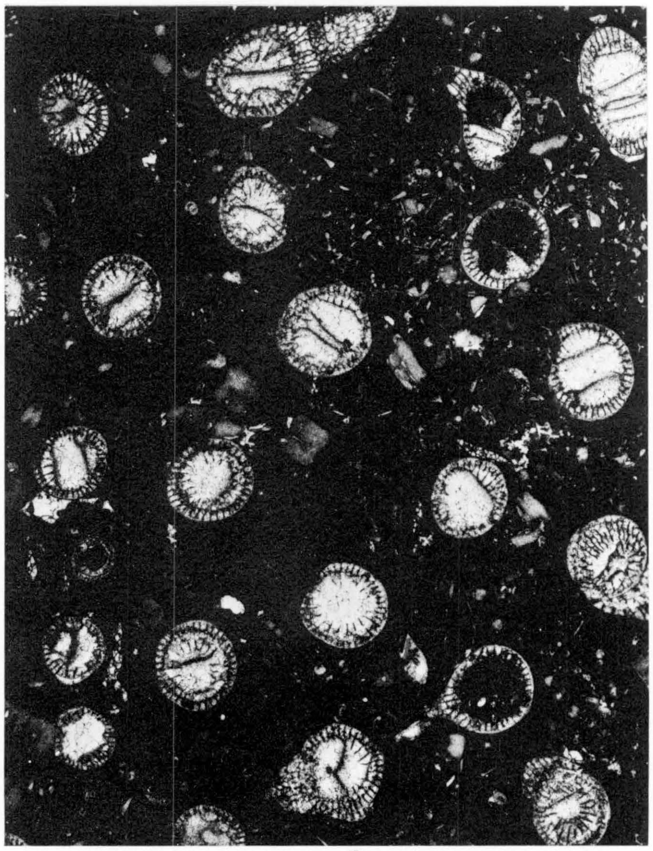
1. USNM 162615. Bioherm facies. Loc. 269. See also pl. 15, figs. 1–3.
2. NYSM 12780. Biostrome facies. Loc 164.
3. USNM 162617. Bioherm facies. Loc. 269.
4. USNM 162620. Fine-grained facies. Loc. 198.



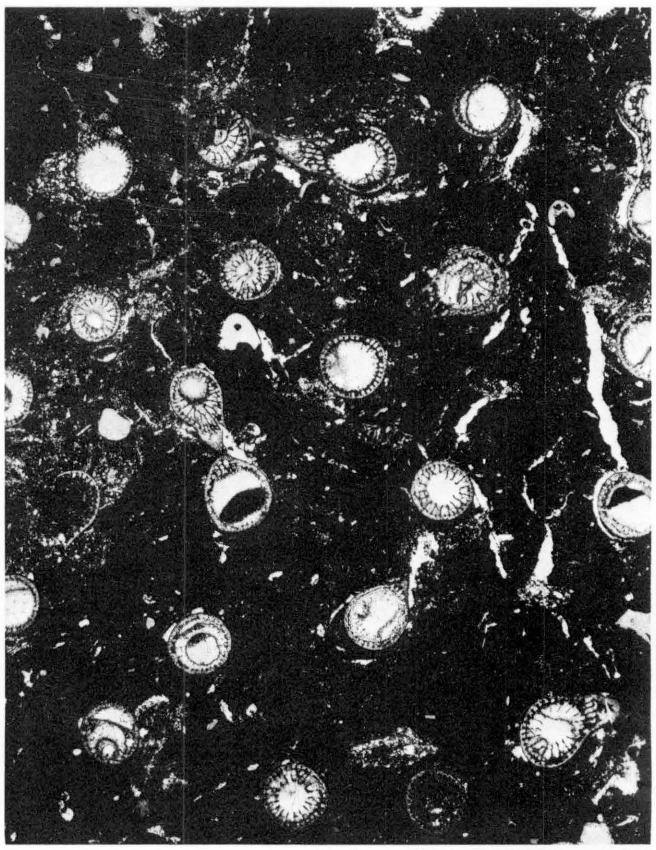
1



2



3



4

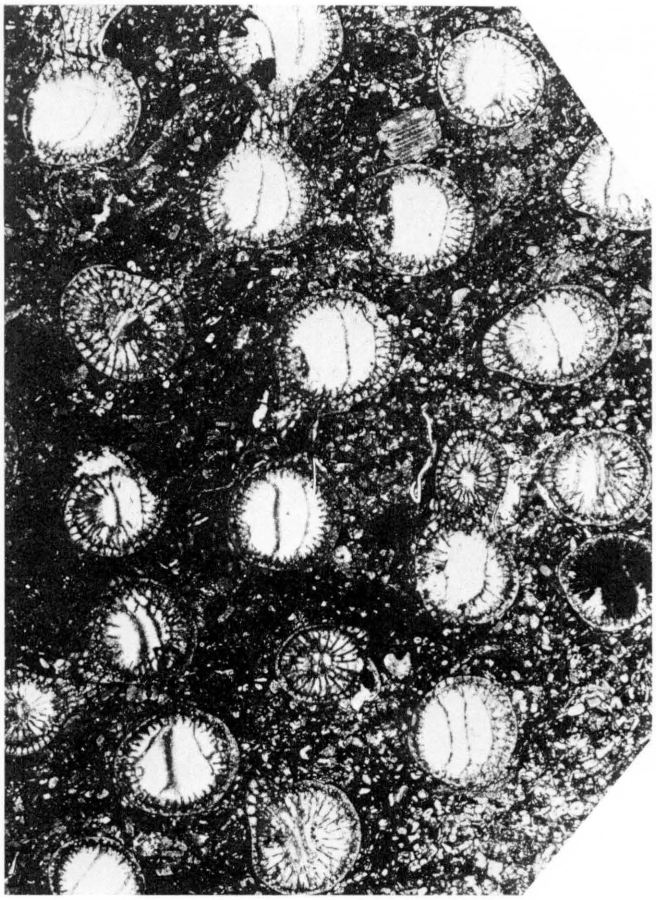
ACINOPHYLLUM SEGREGATUM (SIMPSON)

PLATE 17

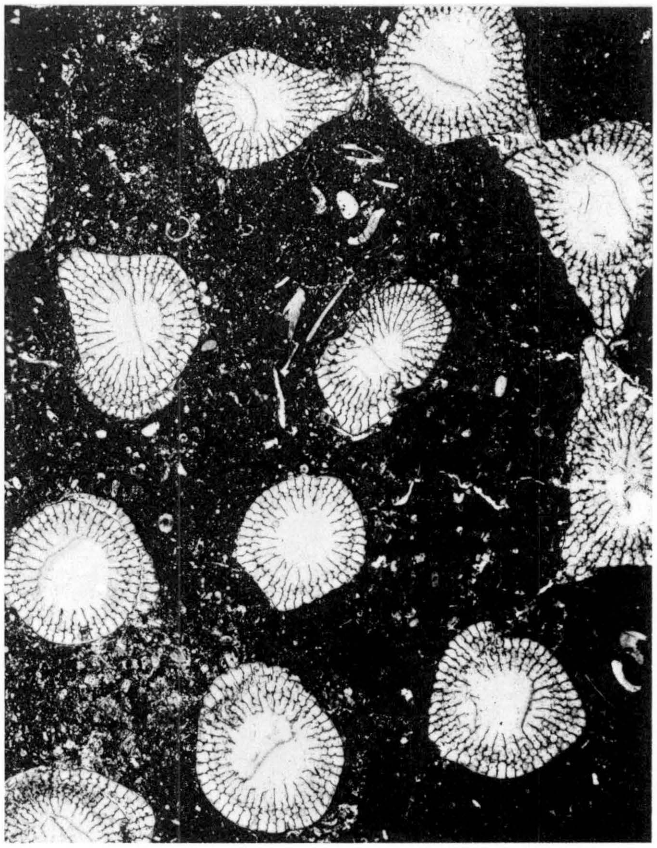
FIGURES 1–5. *Acinophyllum segregatum* Simpson (p. 61).

Transverse sections through five coralla (× 2½). Moorehouse Member and equivalent part of Detroit River Group.

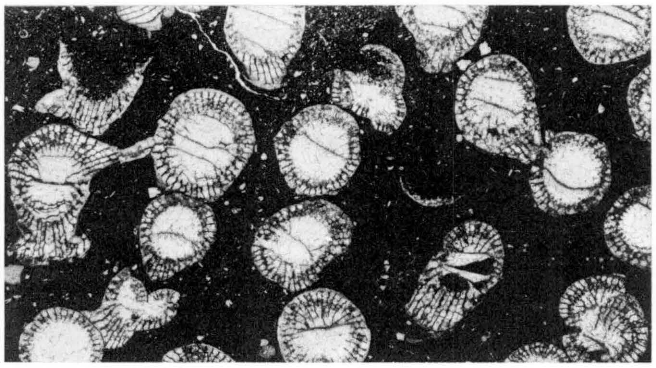
1. GSC 31164. Detroit River Group, Chepstow, Ontario. Loc. GSC 23657.
2. NYSM 12784. Moorehouse Member, Loc. 112.
3. GSC 31162. Moorehouse Member, Port Dover, Ontario. Loc. GSC 23521.
4. GSC 31163. Moorehouse Member, Naticoke, Ontario. Loc. GSC 22978.
5. USNM 162621. Moorehouse Member, *Acinophyllum-Eridophyllum* bed. Loc. 118.



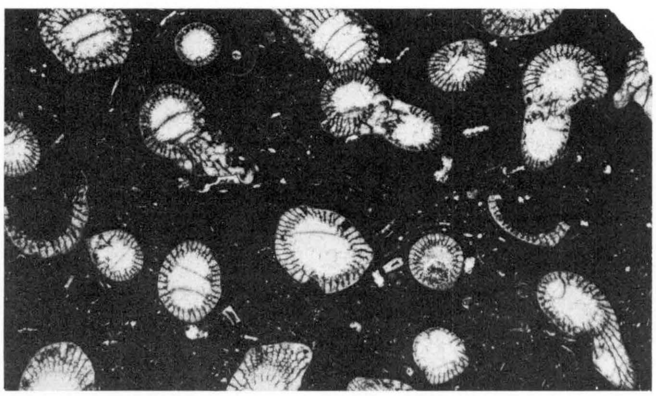
1



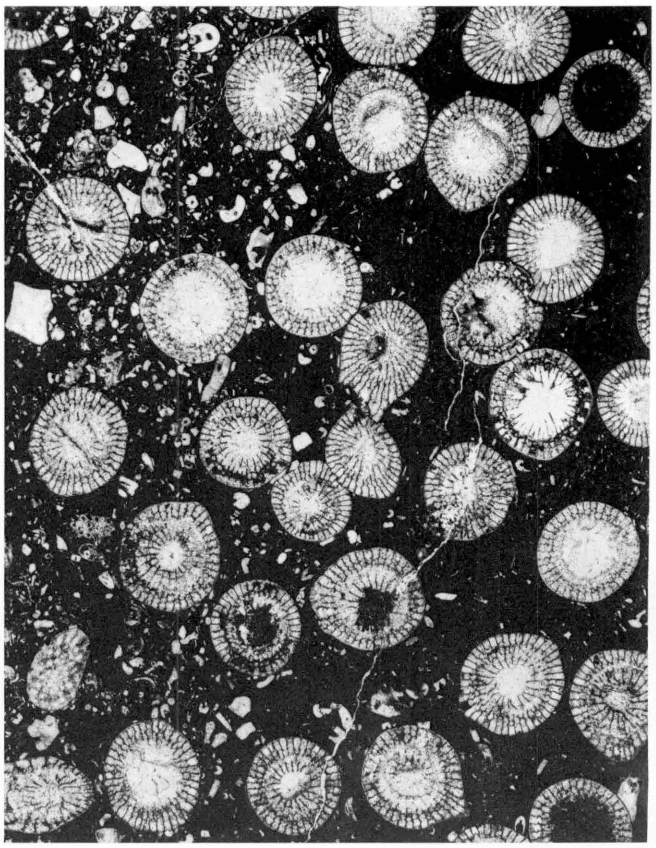
2



3



4



5

ACINOPHYLLUM SEGREGATUM (SIMPSON)

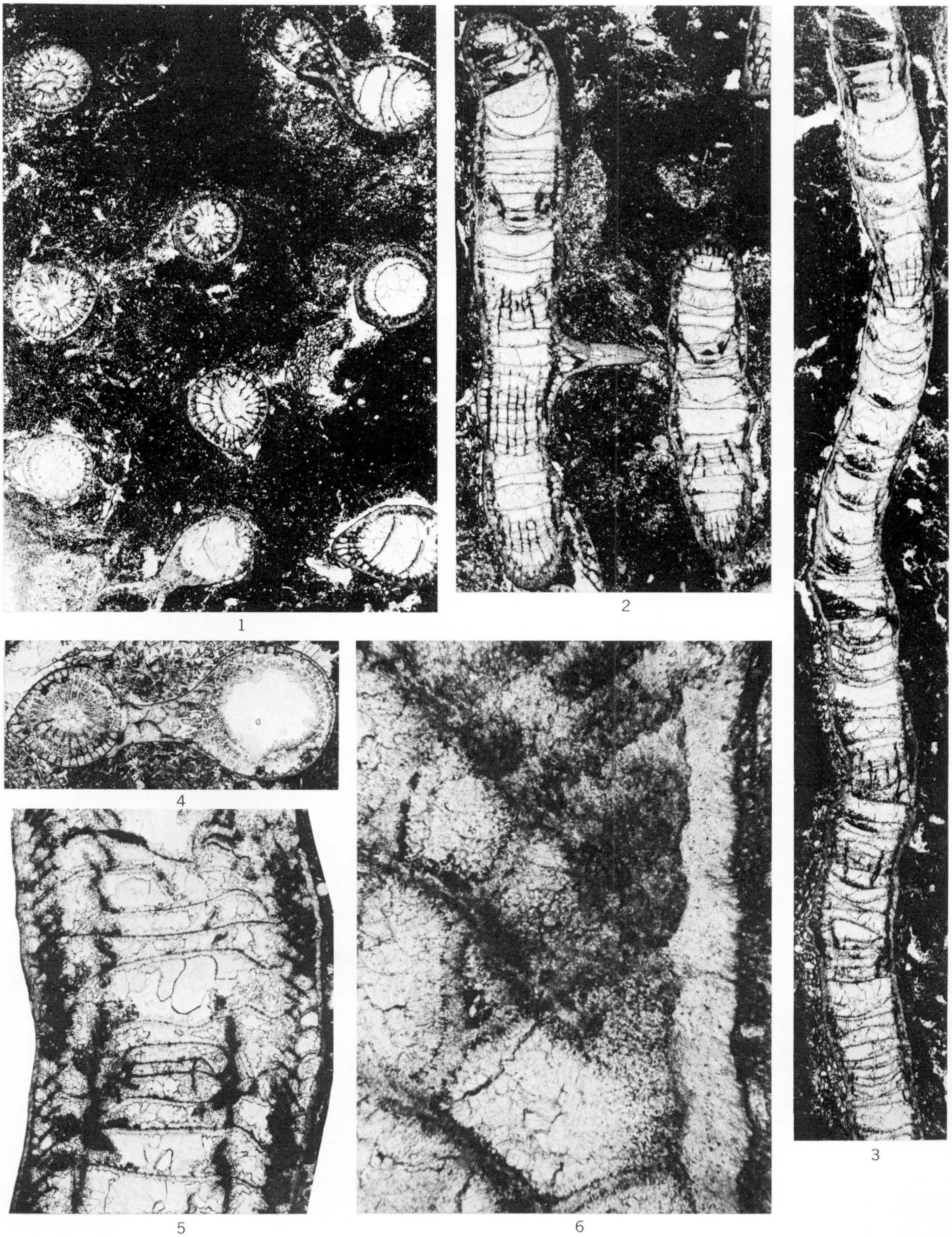
PLATE 18

FIGURES 1–6. *Acinophyllum segregatum* Simpson (p. 61).
Edgecliff Member, New York.

1–3. USNM 162619. Transverse and two longitudinal thin sections; note lateral connections in figs. 1 and 2 (× 5). Fine-grained facies. Loc. 198.

4. NYSM 12782. Transverse section of two corallites and lateral connection (× 5). Biostrome facies. Loc. 286.

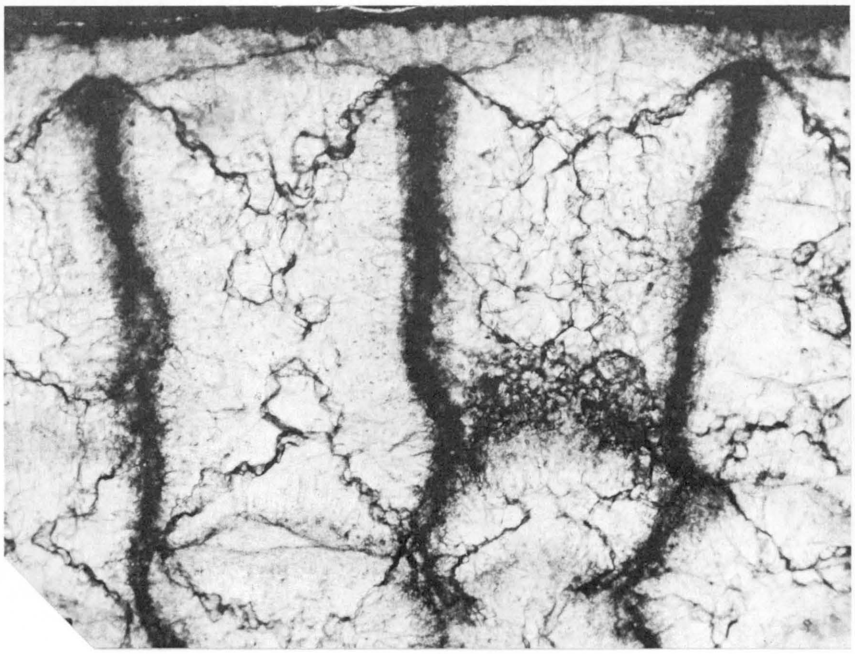
5, 6. NYSM 12786. Longitudinal thin section (× 10) and detail (× 100). Bioherm facies. Loc. 108.

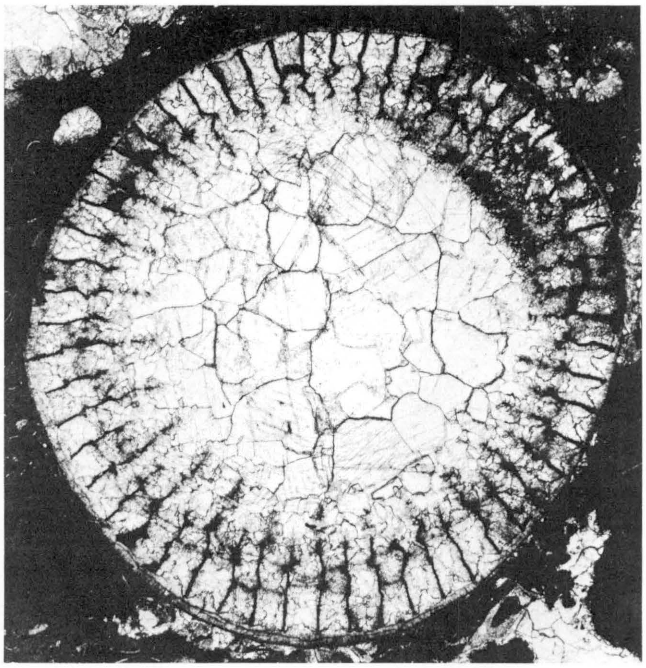


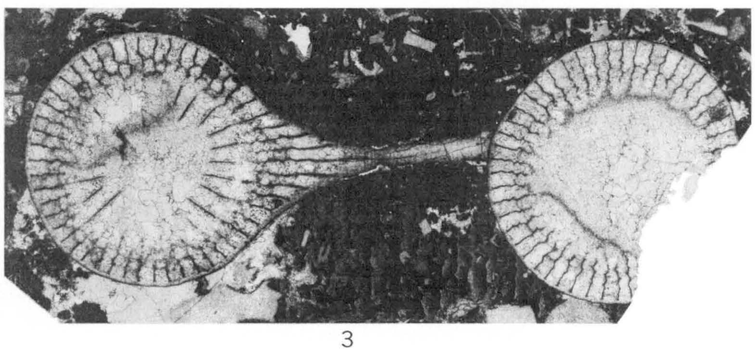
ACINOPHYLLUM SEGREGATUM (SIMPSON)

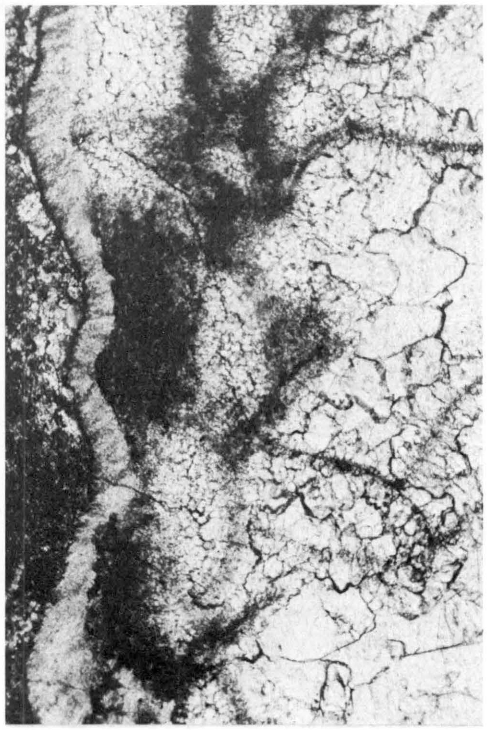
PLATE 19

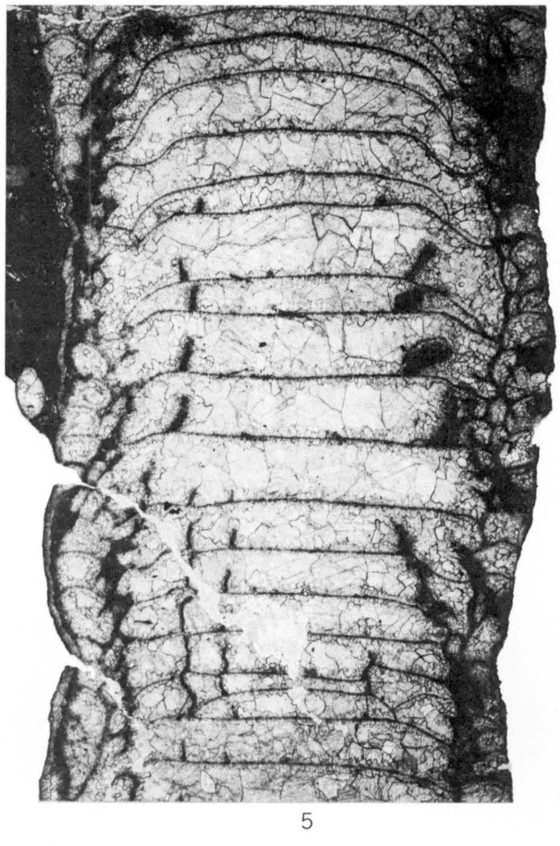
FIGURES 1–5. *Acinophyllum segregatum* Simpson (p. 61).
Edgecliff Member, New York.
1, 2. USNM 162618. Transverse thin section; detail (× 100) and corallite (× 10); detail is from upper margin as corallite is oriented in fig. 2. Loc. 188.
3–5. NYSM 12787. Bioherm facies. Loc. 269.
3. Transverse thin section of two corallites and lateral connection (× 5).
4, 5. Longitudinal thin section; detail (× 50) and corallite (× 10).


1


2


3


4


5

ACINOPHYLLUM SEGREGATUM (SIMPSON)

PLATE 20

FIGURES 1–11. *Acinophyllum segregatum* Simpson (p. 61).

Onondaga Limestone, New York.

1, 2. NYSM 337, 338. Illustrated thin sections of *Synaptophyllum simcoense of Simpson* (1900) not Billings (× 2). Leroy, N.Y.

3. NYSM 12790. Longitudinal thin section of parent and offset (× 5). Edgecliff fine-grained facies. Loc. 337.

4. NYSM 12789. Transverse thin section of lateral connection (× 10). Edgecliff bioherm facies. Loc. 236.

5, 6. NYSM 12783. Transverse thin sections showing three corallites with lateral connections (× 5). Edgecliff biostrome facies. Loc. 90.

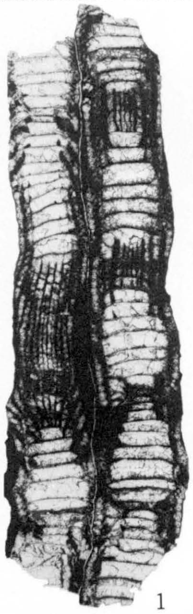
7. NYSM 12788. Longitudinal thin section (× 5). Moorehouse Member, *Acinophyllum-Eridophyllum* bed. Loc. 120.

8. NYSM 12792. Longitudinal thin section of lateral connections meeting midway between corallites (× 10). Edgecliff biostrome faces. Loc. 206.

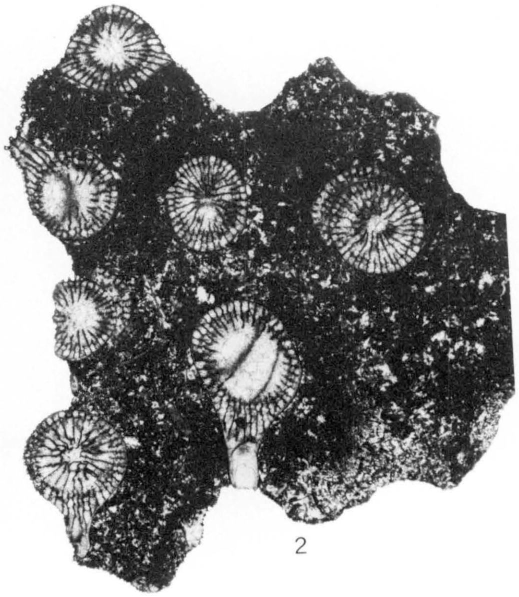
9. NYSM 12791. Transverse section of three corallites with lateral connections (× 5). Edgecliff fine-grained facies. Loc. 337.

10. USNM 162616. Longitudinal thin section of offsetting (× 5). Edgecliff bioherm facies. Loc. 329.

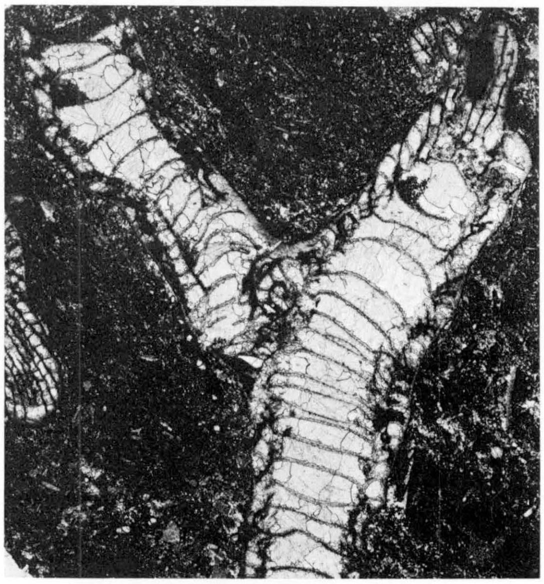
11. USNM 162623. Longitudinal thin section of corallite and offset (× 5). Edgecliff bioherm facies. Loc. 233.



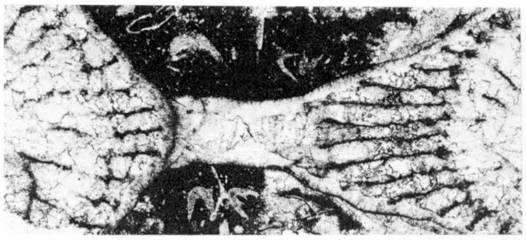
1



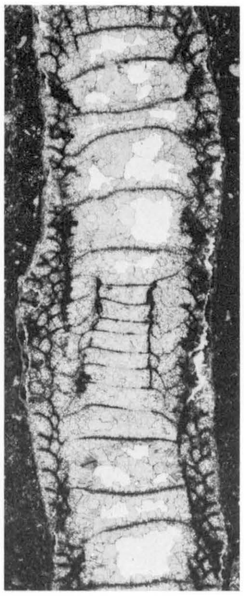
2



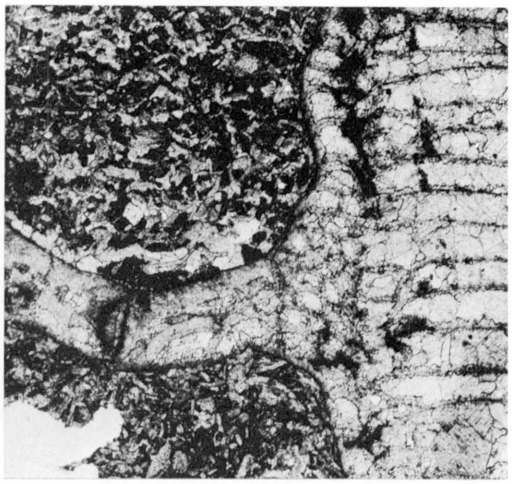
3



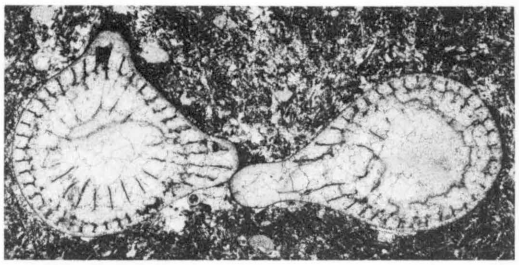
4



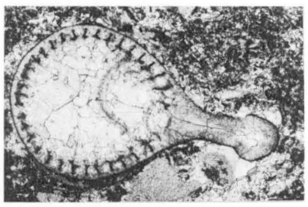
7



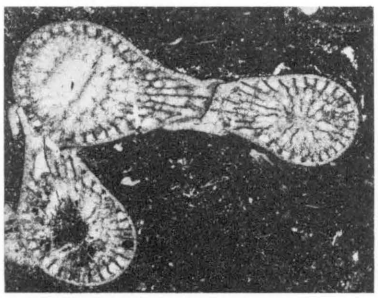
8



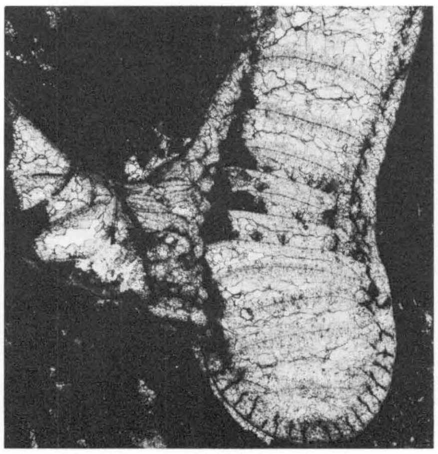
5



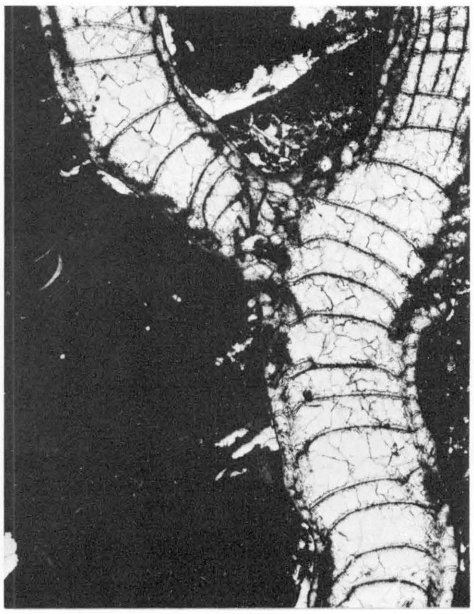
6



9



10



11

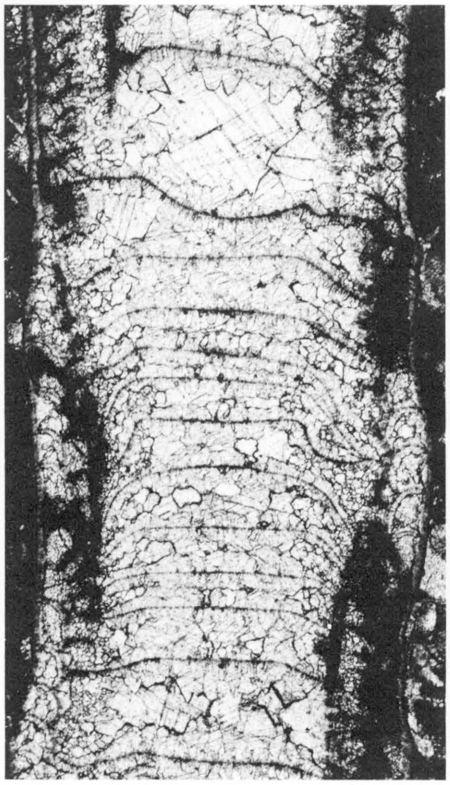
ACINOPHYLLUM SEGREGATUM (SIMPSON)

PLATE 21

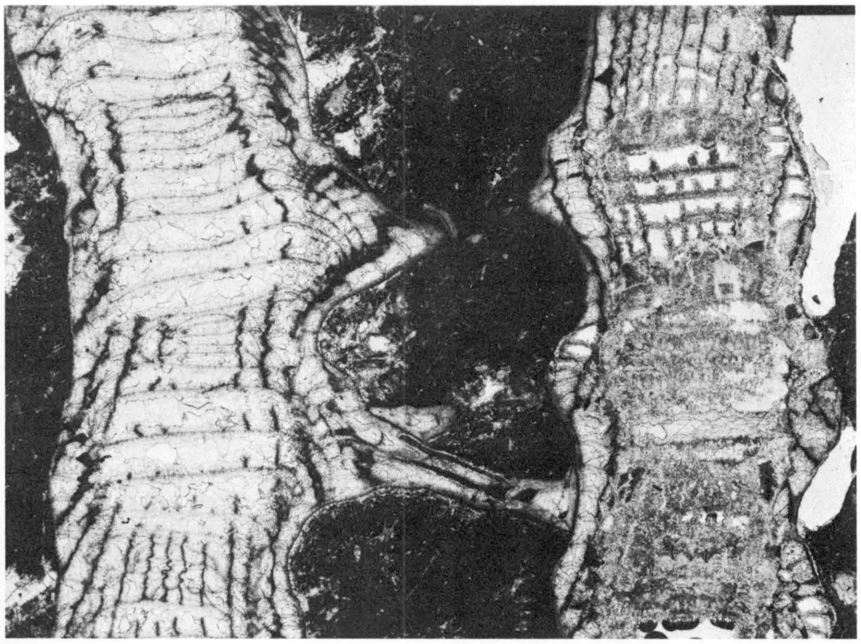
FIGURES 1–6. *Acinophyllum segregatum* Simpson (p. 61).

Edgecliff Member, New York.

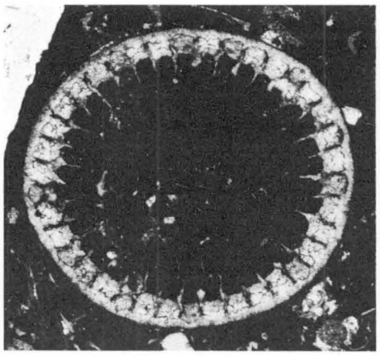
1. USNM 162626. Longitudinal thin section (× 10). Bioherm facies. Loc. 329.
2. NYSM 12781. Longitudinal thin section of two corallites showing coarse rugae and lateral connections (× 5). Biostrome facies. Loc. 188.
3. USNM 162628. Longitudinal thin section (× 10). Bioherm facies. Loc. 108.
4. USNM 162625. Transverse thin section through calice (× 10). Bioherm facies. Loc. 269.
5. USNM 162624. Transverse thin section (× 10). Bioherm facies. Loc. 233.
6. USNM 162627. Longitudinal thin section of two corallites with lateral connections (× 5). Bioherm facies. Loc. 135.



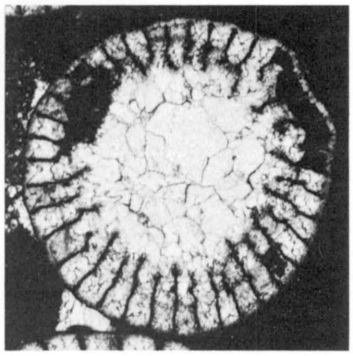
1



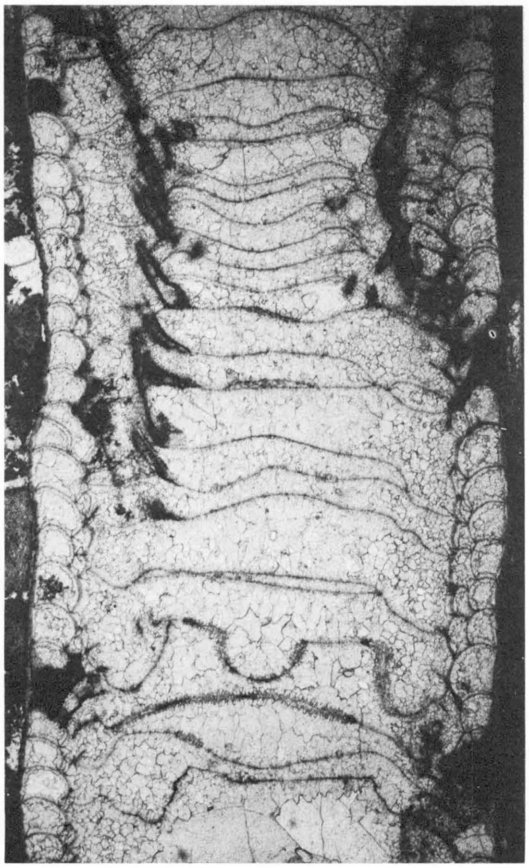
2



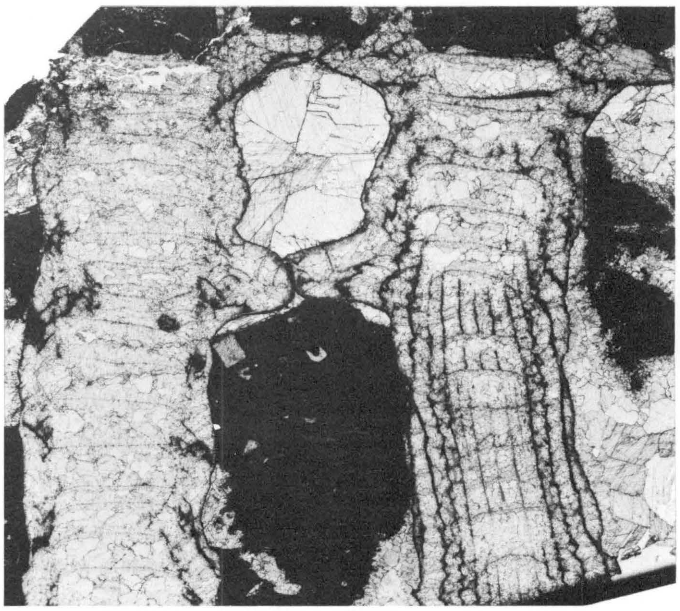
4



5



3



6

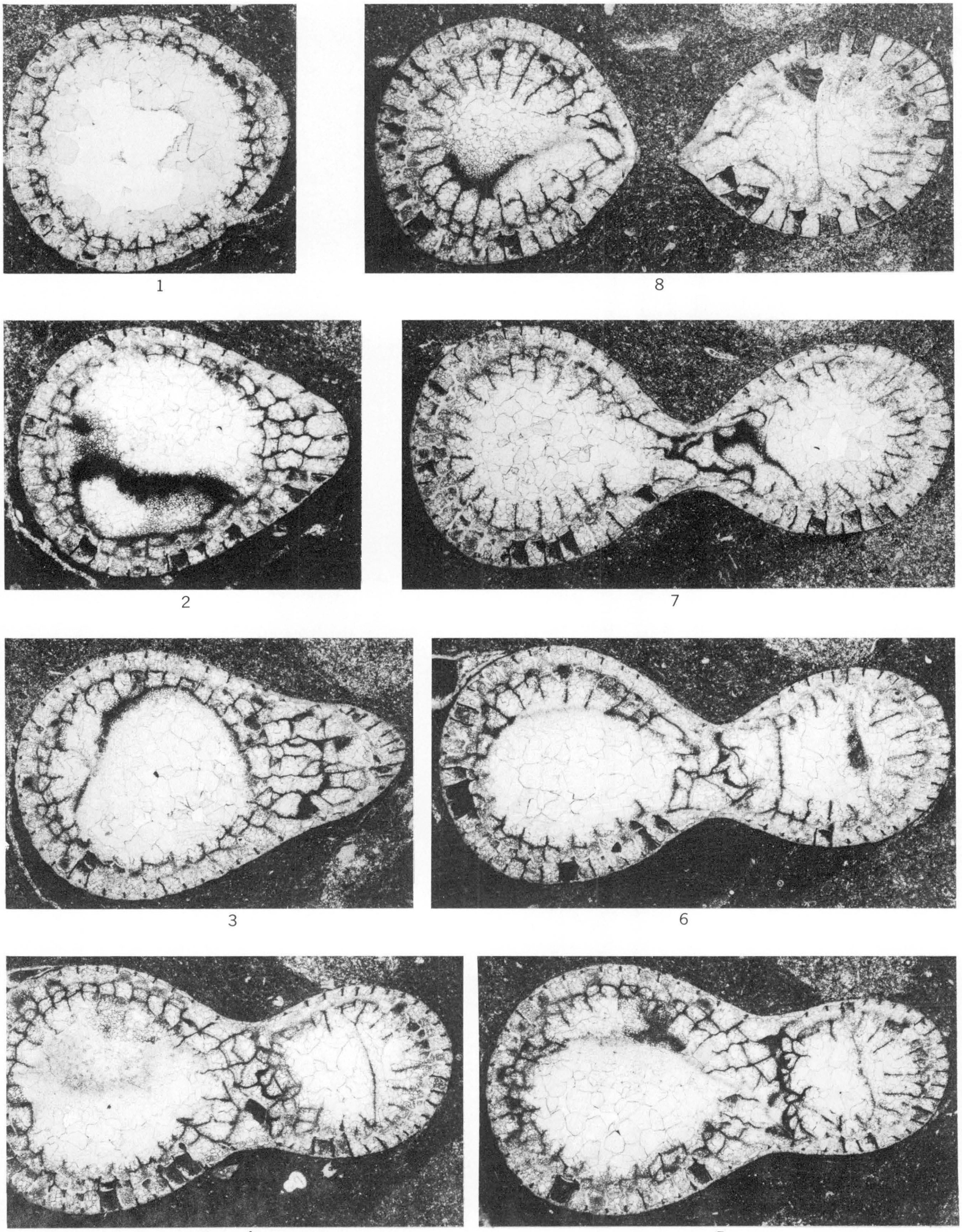
ACINOPHYLLUM SEGREGATUM (SIMPSON)

PLATE 22

FIGURES 1–8. *Acinophyllum segregatum* Simpson (p. 61).

USNM 162622. Serial transverse thin sections through offsetting corallite.

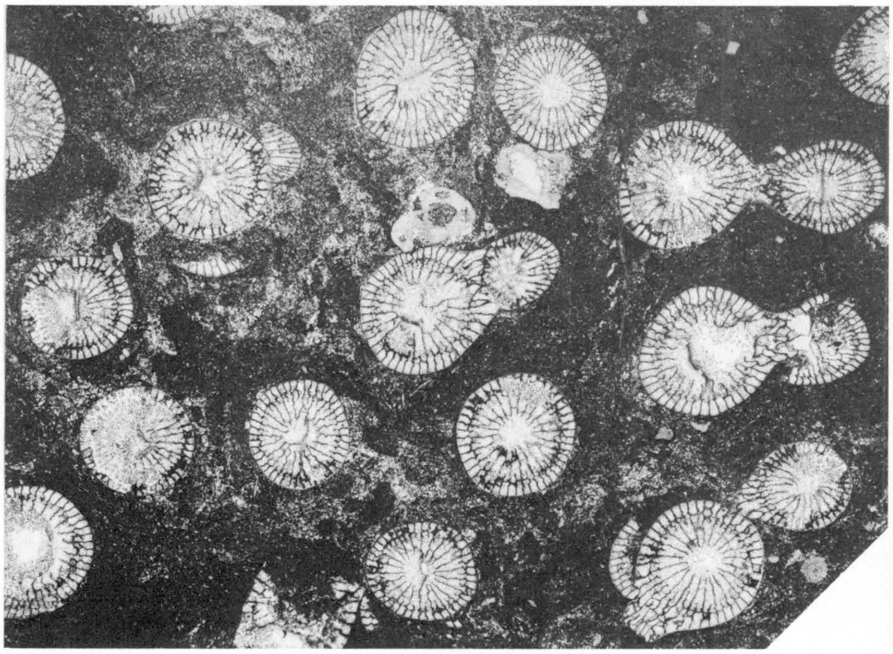
Total distance from lowest to highest section in sequence, approximately 8 mm; sections 1–3 represent 1.7 mm; 4–8 represent 3.4 mm; sections 3 and 4 are separated by approximately 2 mm; all measurements perpendicular to axis of parent.

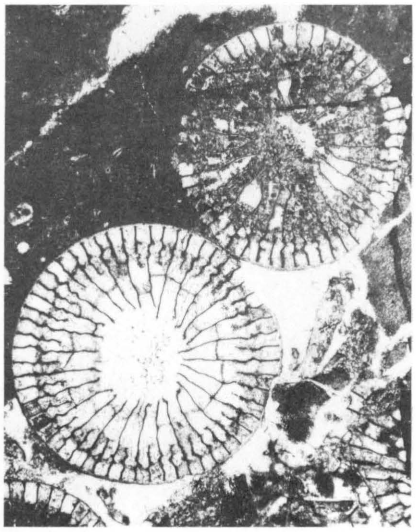


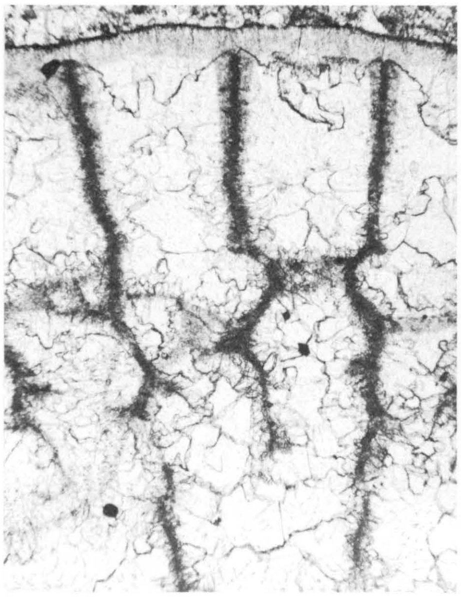
ACINOPHYLLUM SEGREGATUM SIMPSON

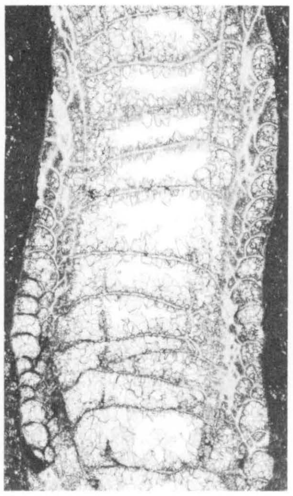
PLATE 23

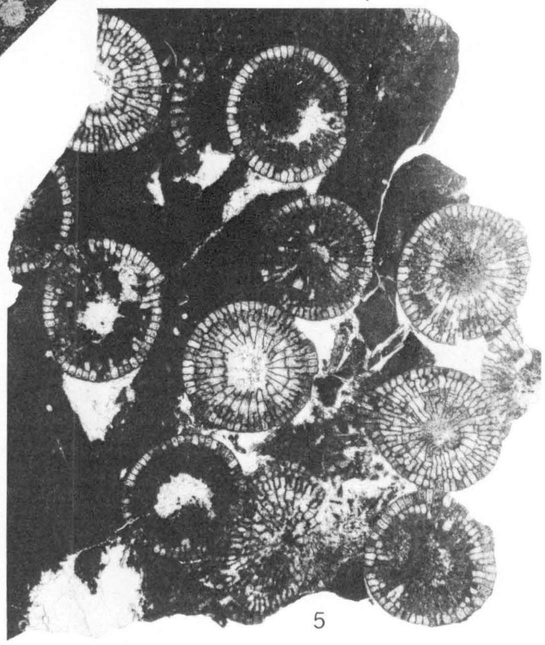
FIGURES 1–8. *Acinophyllum mclareni* Fagerstrom (p. 63).
Ontario.
1–3. USNM 162662. Moorehouse Member. Loc. C18.
1. Transverse thin section (× 2½).
2. Detail of corallite nearest to center of fig. 1 (× 50).
3. Longitudinal thin section (× 5).
4–7. Holotype, UMMP 36120. Formosa reef facies of Detroit River Group, Formosa, Ontario.
4, 5. Transverse thin section (× 5, × 2½).
6, 7. Longitudinal thin sections of two corallites (× 5).
8. USNM 162661. Transverse thin section of two corallites with lateral offsets (× 5). Loc. C36.

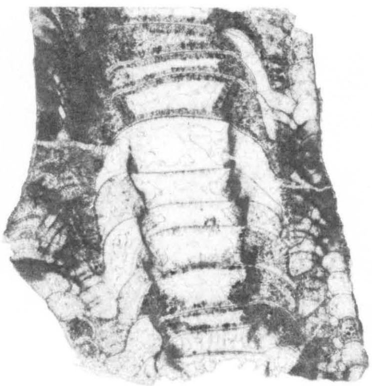

1

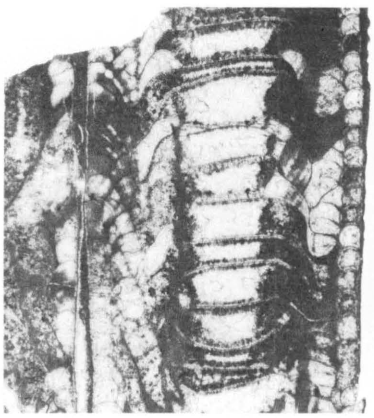

4

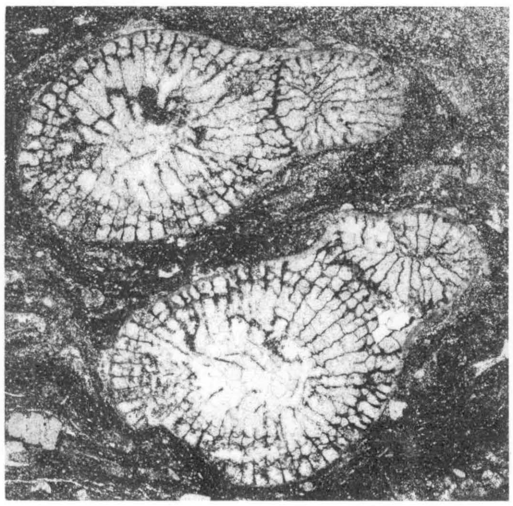

2


3


5


6


7


8

ACINOPHYLLUM MCLARENI FAGERSTROM

PLATE 24

FIGURES 1–7. *Acinophyllum mclareni* Fagerstrom (p. 63).

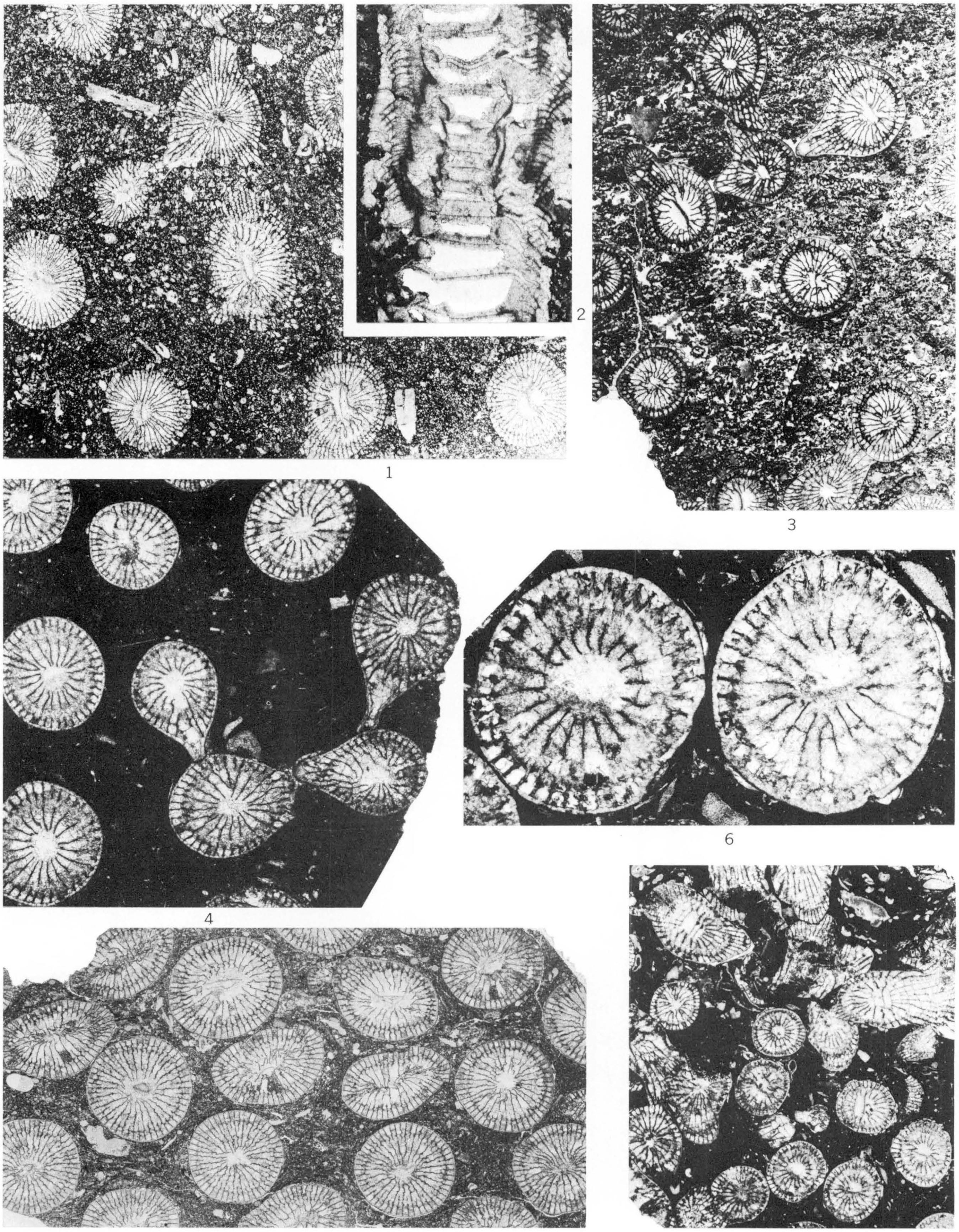
1, 2. USNM 162664. Transverse (× 2½) and longitudinal (× 5) thin sections. Boyle Limestone, Flax Creek, Ky.

3. USNM 162663. Transverse thin section (× 2½). Jeffersonville Limestone, Zone C, Falls of the Ohio, Ky.

4. OSU 17735. Illustrated specimen of *Synaptophyllum simcoense* Stewart (1938) not Billings. Transverse view (× 5) of thin section illustrated by Stewart. Columbus Limestone, Ohio.

5. USNM 162660. Transverse thin section (× 2½). Amherstberg Formation, Beachville, Ontario.

6, 7. UMMP 60484. Transverse thin section (× 2½), and two corallites from same (× 10). Upper part of Columbus Limestone, Loraine County, Ohio. Core from Nagel No. 1 at 1,097 ft. (See Janssens, 1970, pl. 21, for general discussion.)



ACINOPHYLLUM MCLARENI FAGERSTROM

PLATE 25

FIGURE 1–8. *Acinophyllum stokesi* (Milne-Edwards and Haime) (p. 65).

1–5. Holotype of *A. davisi* Stumm, MCZ 7827. Jeffersonville Limestone, Zone A (lower coral zone, Schoharie equivalent, Falls of the Ohio).

1–3. Transverse thin section (× 2½) and parts of same section (× 5).

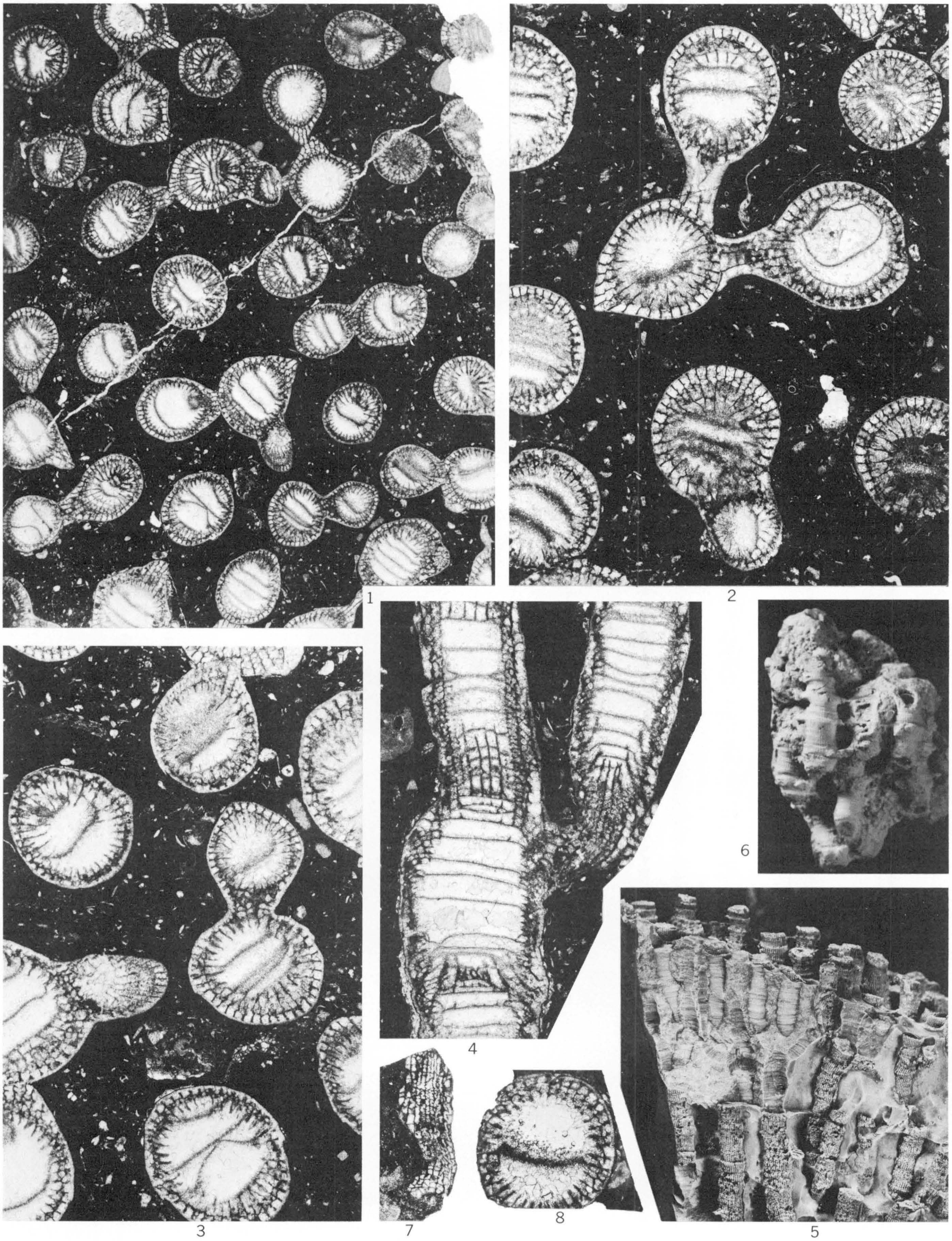
4. Longitudinal thin section (× 5).

5. Exterior (× 1).

6–8. Holotype, original of Milne-Edwards and Haime, 1851, pl. 20, fig. 2. Paris Museum No. 497a.

6. Exterior (× 1).

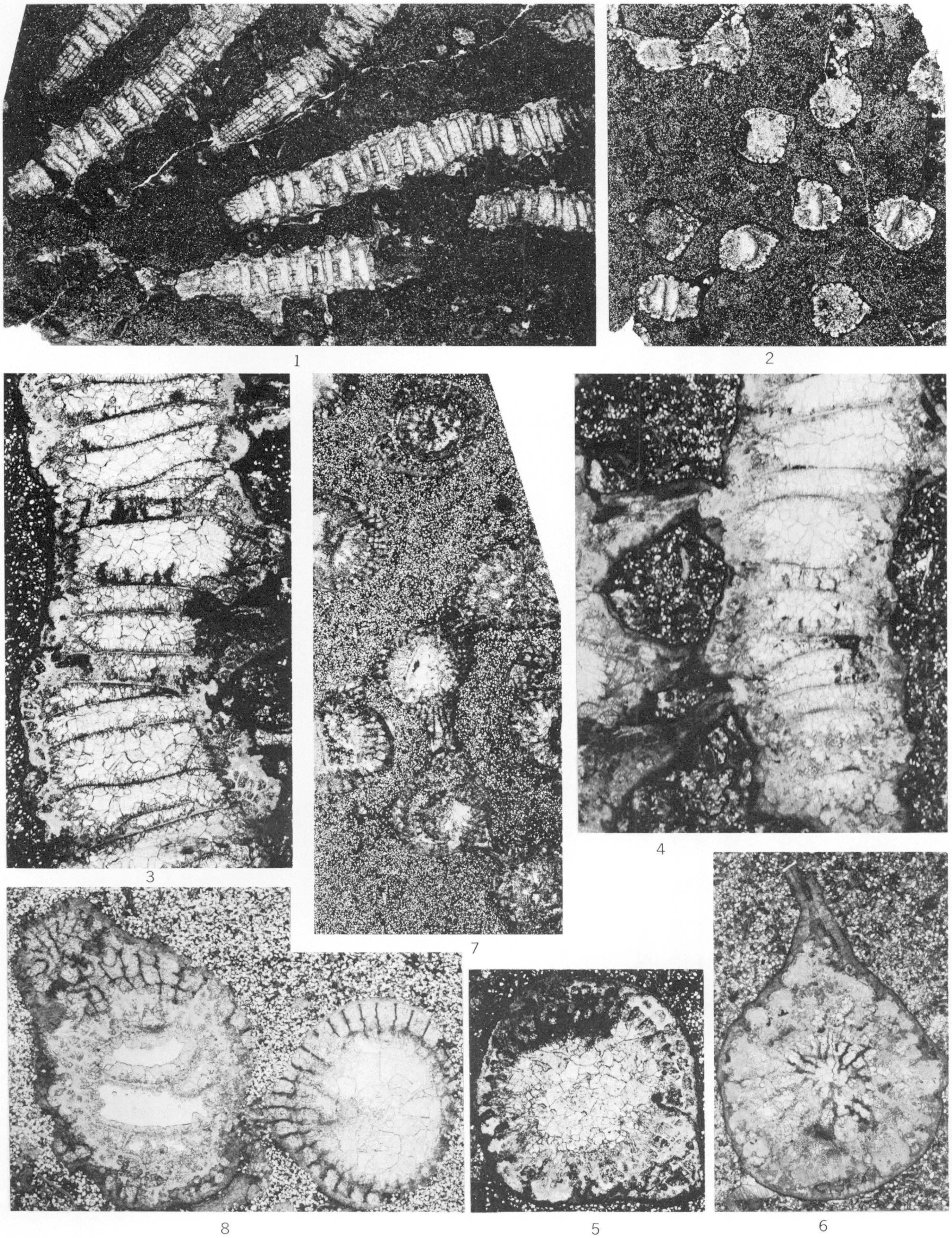
7, 8. Tangential and transverse thin sections (× 5).



ACINOPHYLLUM STOKESI (MILNE-EDWARDS AND HAIME)

PLATE 26

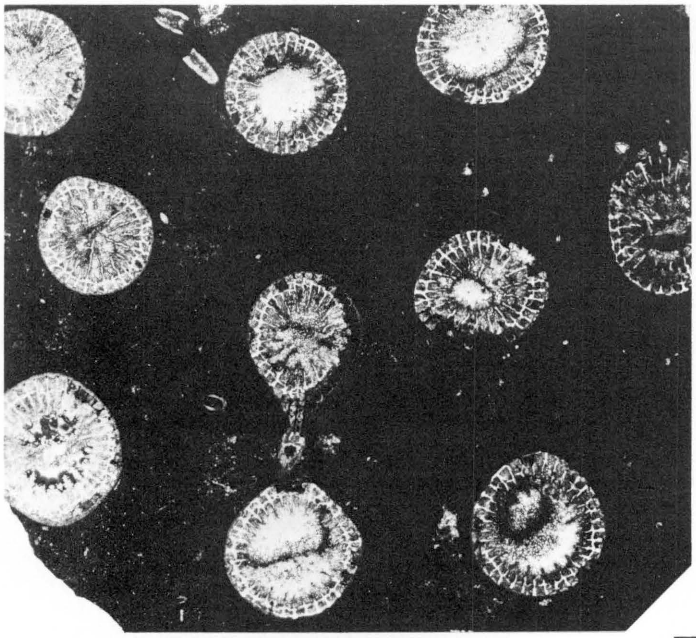
FIGURES 1–8. *Acinophyllum stokesi* (Milne-Edwards and Haime) (p. 65).
Schoharie Formation New York.
1–6. NYSM 12810. Clarksville, N.Y.
1, 2. Longitudinal and transverse thin sections (× 2½).
3–6. Individual corallites of sections shown in figs. 1 and 2 (× 10).
7. USNM 162675. Transverse thin section (× 5). Loc. 79.
8. USNM 162674. Transverse thin section of two corallites (× 10). Loc. 505.

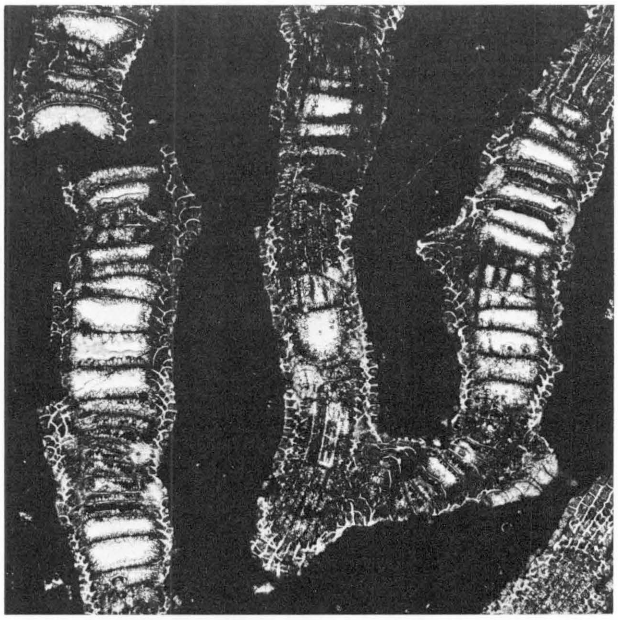


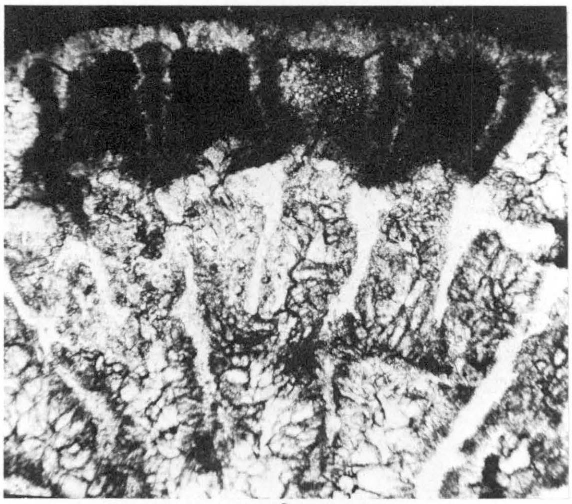
ACINOPHYLLUM STOKESI (MILNE-EDWARDS AND HAIME)

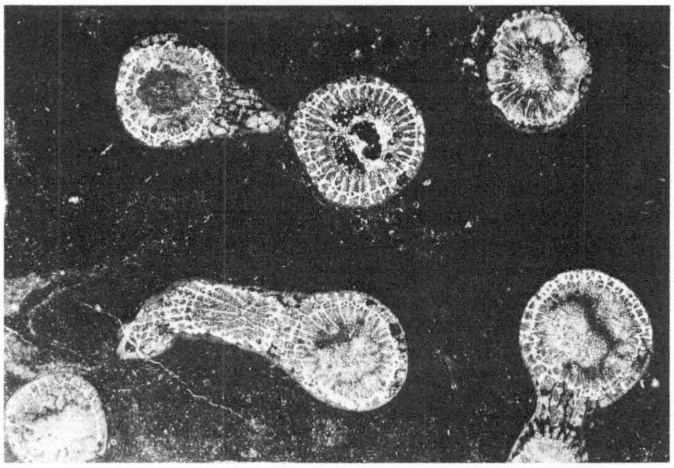
PLATE 27

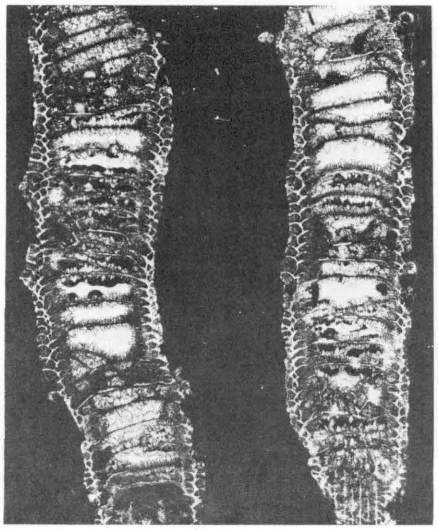
FIGURES 1–6. *Acinophyllum stokesi* (Milne-Edwards and Haime) (p. 65).
Bois Blanc Formation, Ontario.
1–5. USNM 162670. Loc. C10.
1, 4. Two parts of one transverse thin section (× 5).
2, 5. Two parts of one longitudinal thin section (× 5).
3. Detail of corallite from another part of same transverse thin section (× 50).
6. GSC 31143. Basal view of partly etched corallum (× 1). Oxford, Ontario. Loc. GSC 2596.

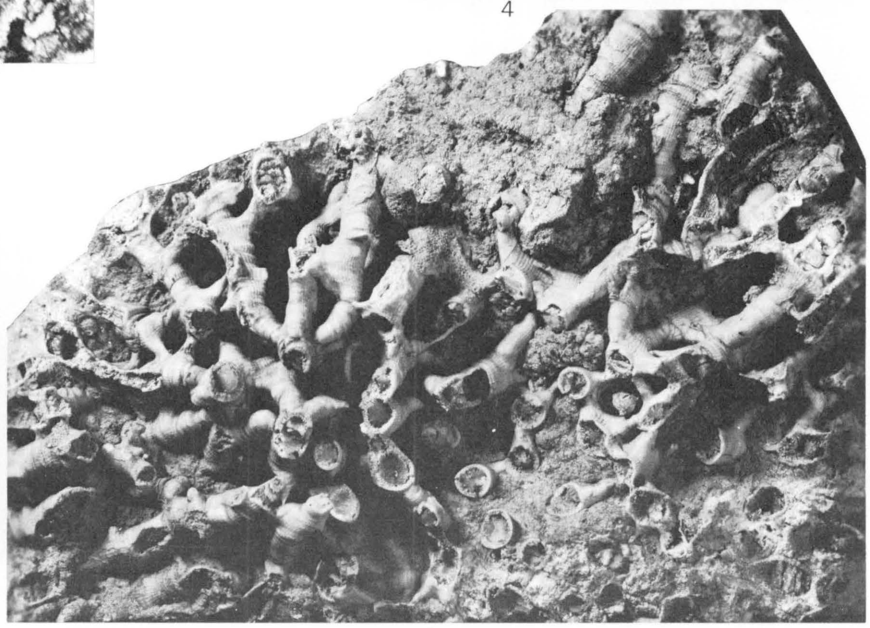

1


2


3


4


5


6

ACINOPHYLLUM STOKESI (MILNE-EDWARDS AND HAIME)

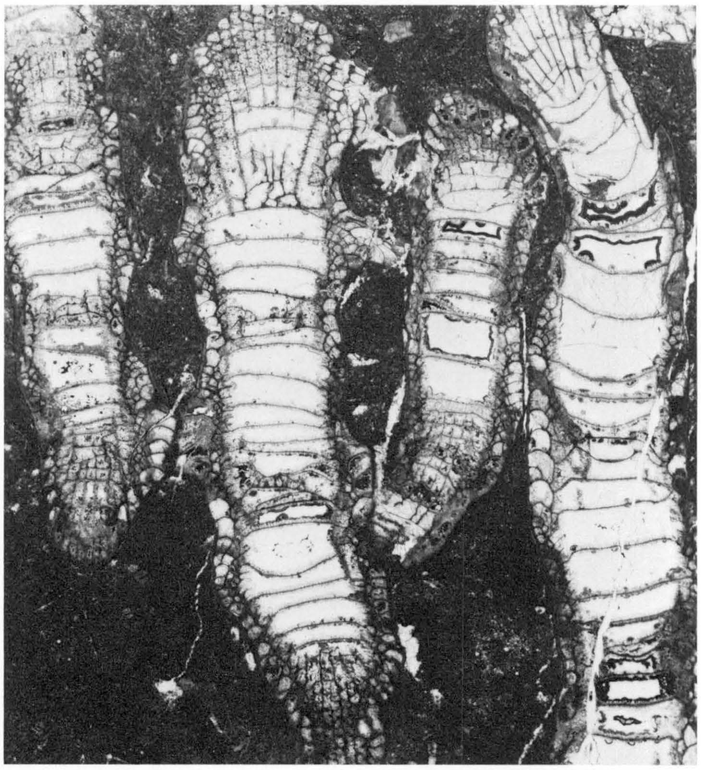
PLATE 28

FIGURES 1–5. *Acinophyllum stokesi* (Milne-Edwards and Haime) (p. 65).
Bois Blanc Formation, Ontario. Loc. C22.

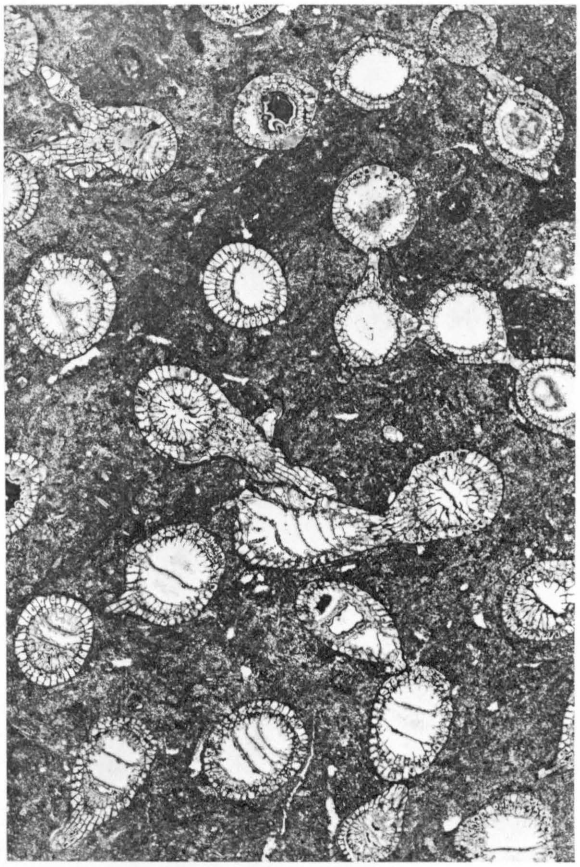
1, 2. USNM 162671. Longitudinal (× 5) and transverse (× 2½) thin sections.

3, 4. USNM 162673. Longitudinal and transverse thin sections (× 2½).

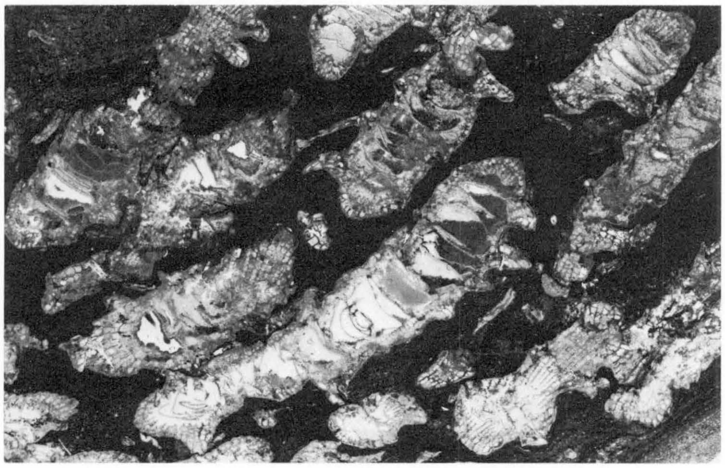
5. USNM 162672. Transverse thin section (× 2½).



1

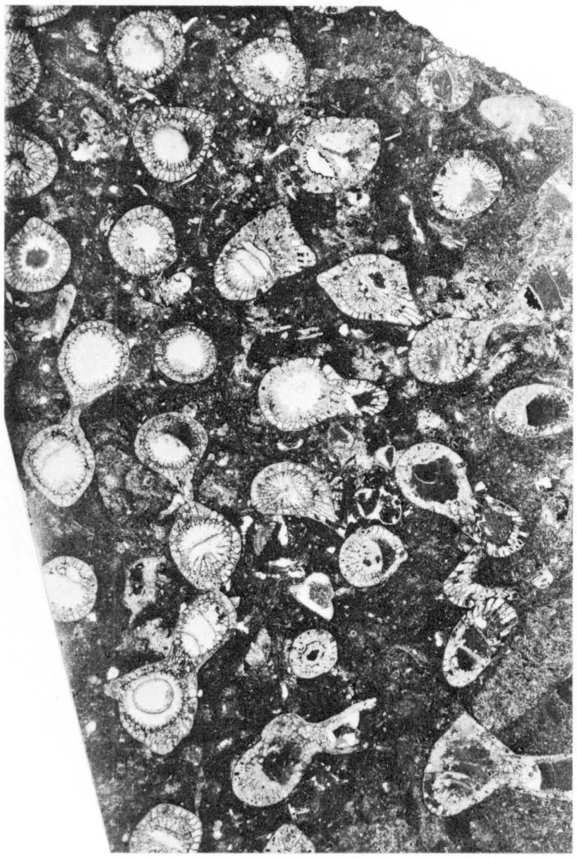


2



3

4



5

ACINOPHYLLUM STOKESI (MILNE-EDWARDS AND HAIME)

PLATE 29

FIGURES 1–10. *Acinophyllum vermetum* (Weisbord) (p. 57).
Caño Grande Formation, northern Venezuela.

1–4. Lectotype, PRI 21598.

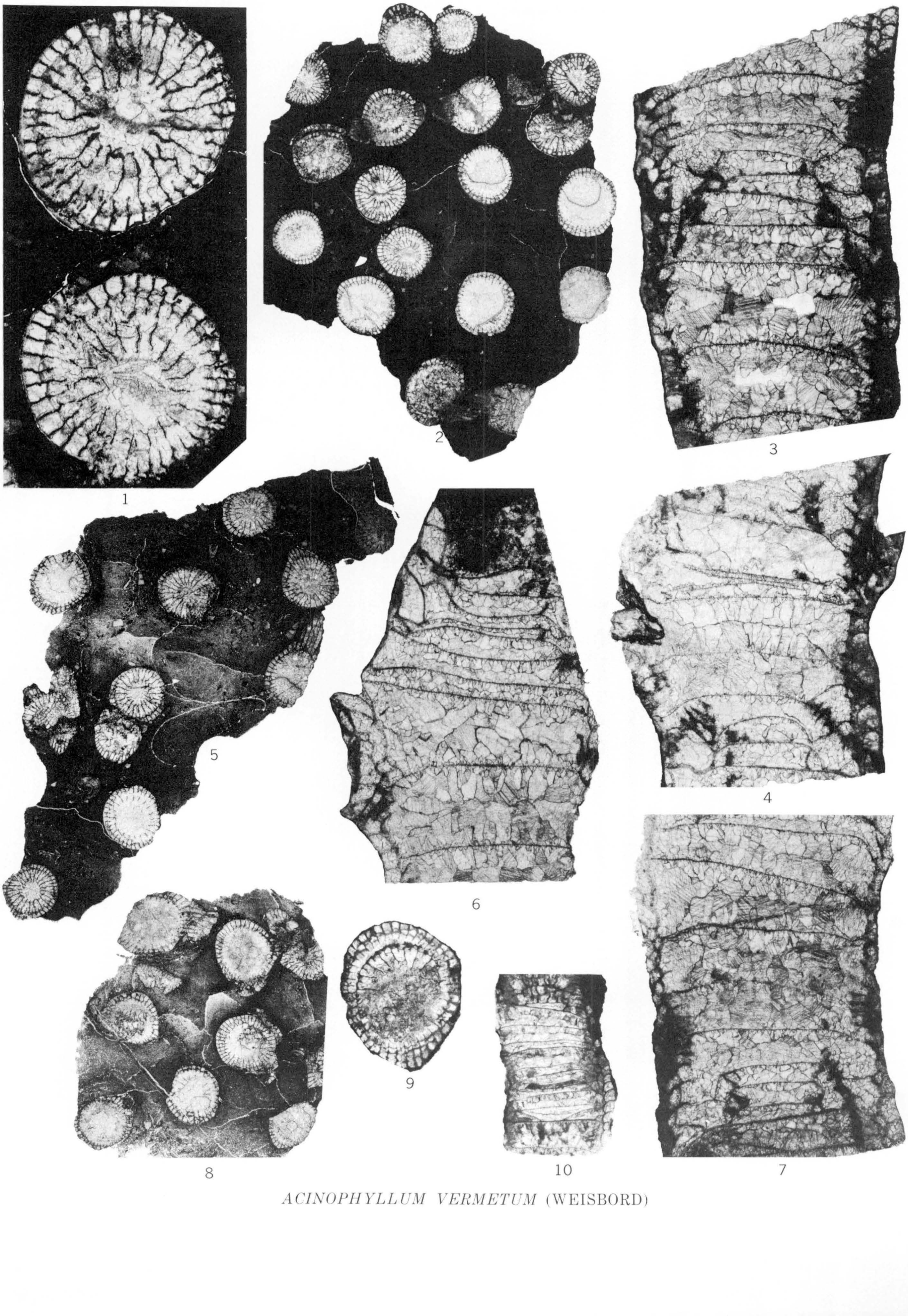
1, 2. Transverse thin section (× 2½) and two of the corallites (× 10).

3, 4. Longitudinal thin sections of two corallites (× 10).

5–7. PRI 27637. Transverse (× 2½) and two longitudinal (× 10) thin sections.

8. PRI 27638. Transverse thin section (× 2½).

9, 10. Paralectotype, PRI 21595. Transverse and longitudinal thin sections (× 5).



ACINOPHYLLUM VERMETUM (WEISBORD)

PLATE 30

FIGURES 1–7. *Disphyllum? rectiseptatum* (Rominger) (p. 112).

Dundee Limestone, Michigan.

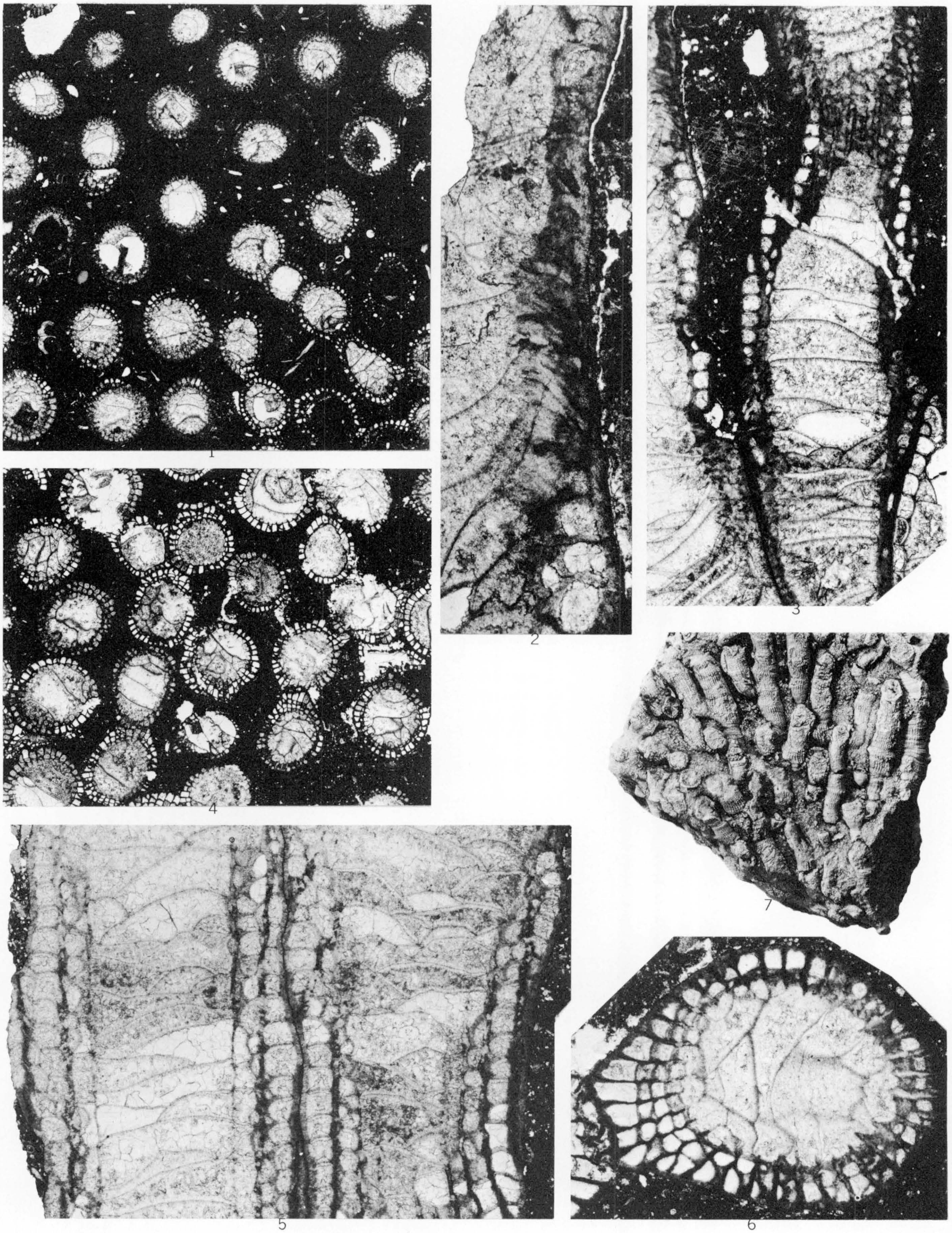
1–3. Syntype, UMMP 14378.

1. Transverse thin section (× 2½).

2, 3. Longitudinal thin section, detail (× 25) and general (× 10).

4–6. UMMP 14380. Transverse thin section (× 2½); longitudinal and transverse thin sections (× 10). Corallite in fig. 6 is in lower right quarter of fig. 4.

7. Syntype, UMMP 14379. Fragment (× 1).



DISPHYLLUM? RECTISEPTATUM (ROMINGER)

PLATE 31

FIGURES 1–9. *Cylindrophyllum elongatum* Simpson (p. 71).

Edgecliff Member, New York.

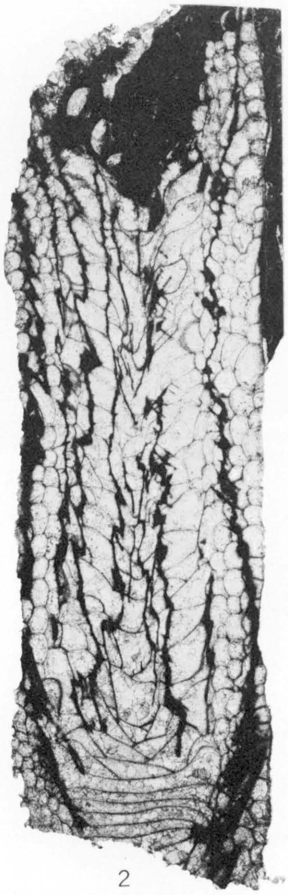
1, 2. Holotype, NYSM 246. Two longitudinal thin sections (× 2½) that together are the original of Simpson's single drawing. Clarksville, N.Y.

3–9. USNM 163382. Loc. 108. See also pl. 32, figs. 4, 5.

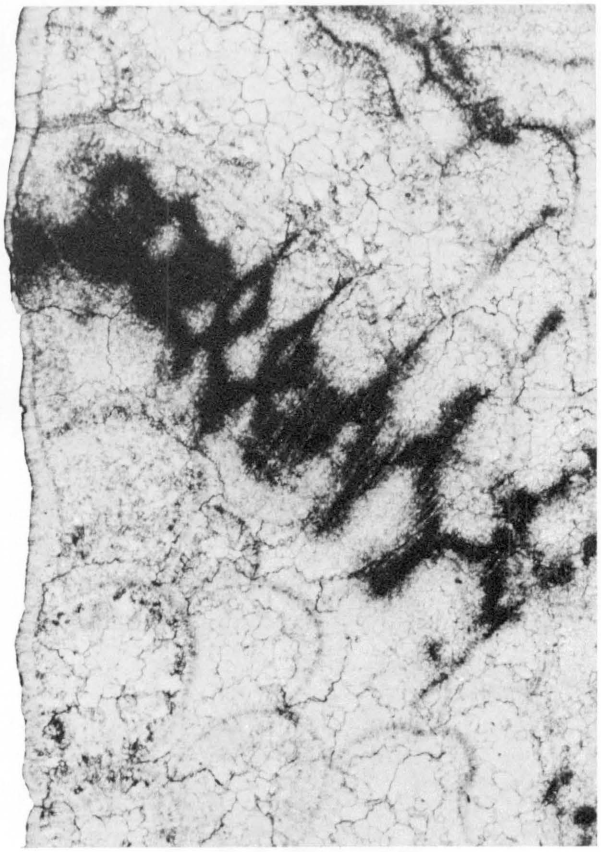
3, 9. Longitudinal thin section (× 2½) and detail (× 25).

4–8. Serial transverse thin sections through one corallite, showing peripheral increase. Total distance (parallel to corallite axis) from lowest to highest section is 7.0 mm. Sections in figs. 5 and 6 are separated by approximately 3 mm; other intervals are 1.2–1.4 mm.

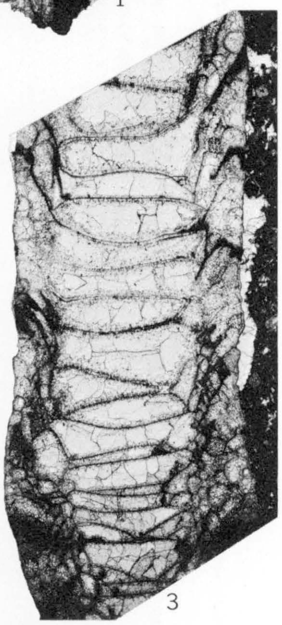
1



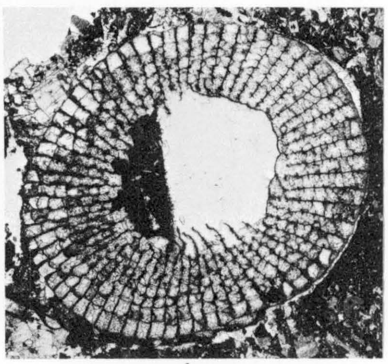
2



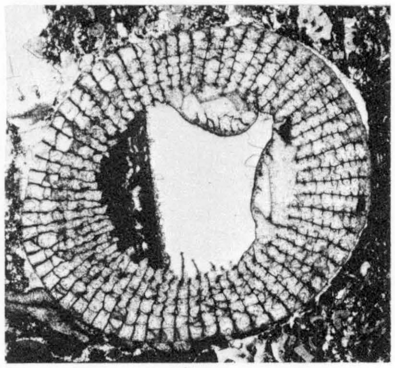
9



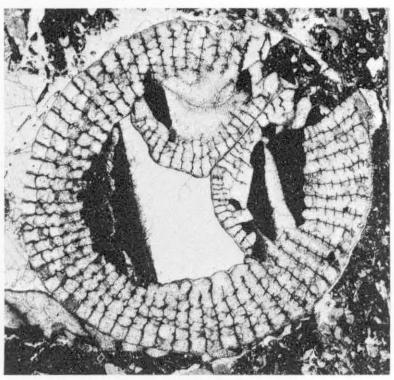
3



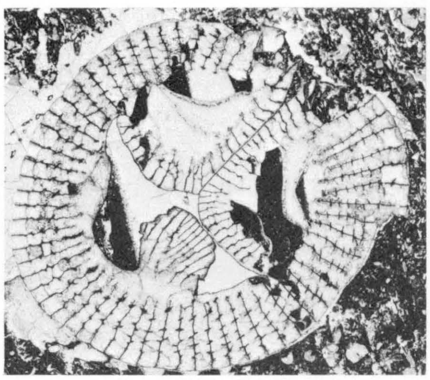
4



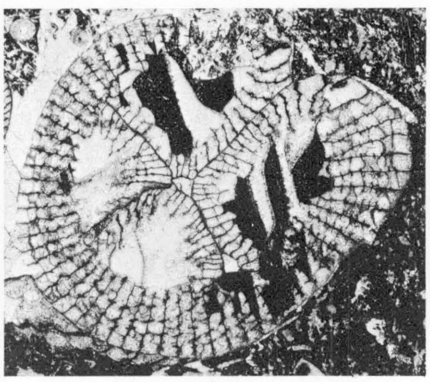
5



6



7



8

CYLINDROPHYLLUM ELONGATUM SIMPSON

PLATE 32

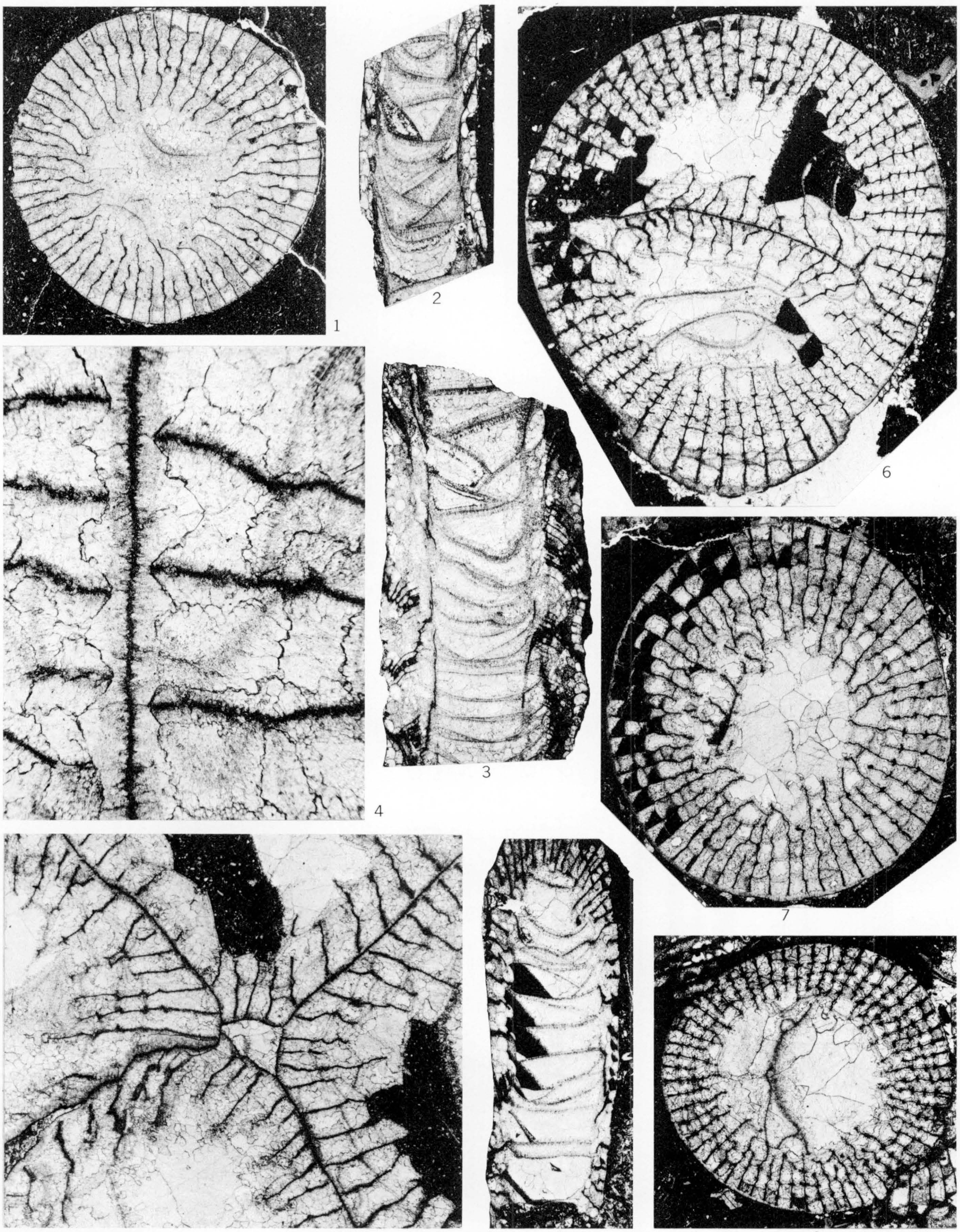
FIGURES 1–9. *Cylindrophyllum elongatum* Simpson (p. 71).

Edgecliff bioherm facies, New York.

1–3. USNM 163384. Transverse (× 5) and two longitudinal (× 2½) thin sections. Loc. 233.

4, 5. USNM 163382. Details of corallites illustrated in pl. 31, fig. 6 (× 50) and fig. 8 (× 10) respectively.

6–9. USNM 163383. Three transverse (× 5) and a longitudinal (× 2½) thin sections. The corallite in fig. 6 shows a single peripheral offset. Figs. 8 and 9 are of the same corallite. Loc. 108.



CYLINDROPHYLLUM ELONGATUM SIMPSON

PLATE 33

FIGURES 1–11. *Cylindrophyllum elongatum* Simpson (p. 71).
Edgecliff bioherm facies, New York.

1–5. USNM 163388. Loc. 296.

1–4. Serial transverse thin sections (× 2½) showing stages in development of peripheral offsets. The lowest and highest sections shown are separated by 4.0 mm (measured parallel to corallite axis); distance between adjacent sections ranges from 1.0 to 1.8 mm.

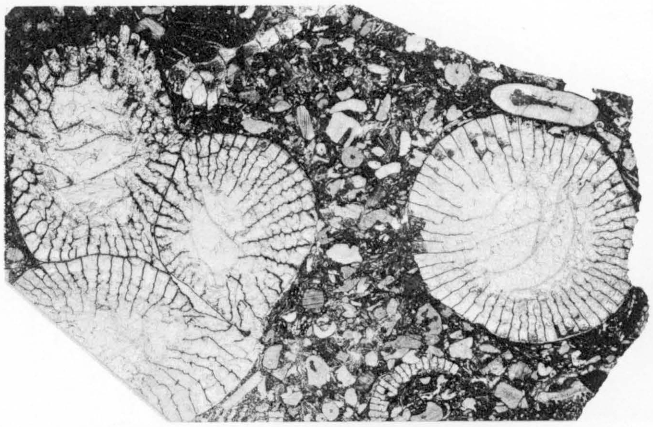
5. Longitudinal thin section of another corallite (× 2½).

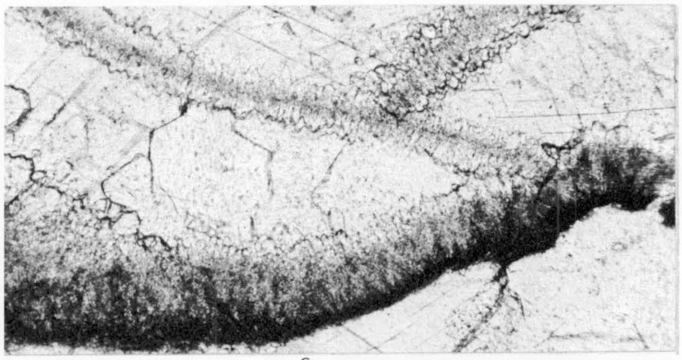
6, 7. USNM 172241. Longitudinal thin section of perpheral offset (fig. 7, × 2½) and detail of basal plate (× 50).

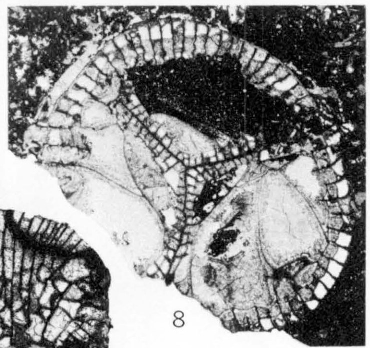
8–11. USNM 163387. Loc. 108.

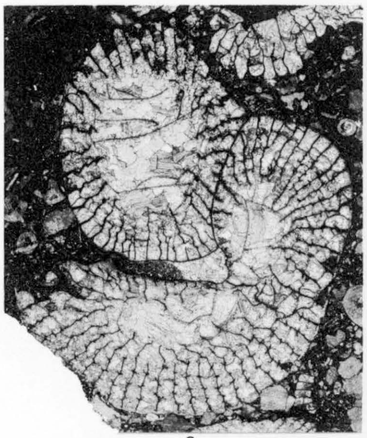
8–10. Serial transverse sections showing stages in peripheral offsetting. Distance between lowest and highest sections is approximately 12 mm (measured parallel to corallite axis). Section in fig. 9 is approximately midway between other two.

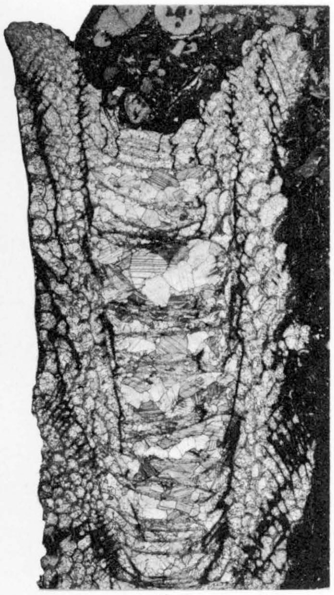
11. Detail of section in fig. 8 (× 25).


1

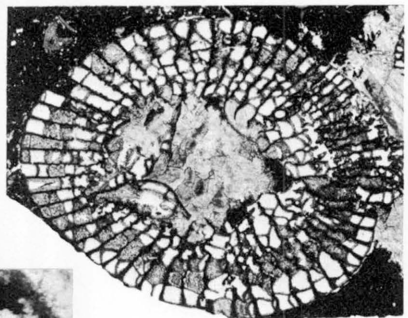

6

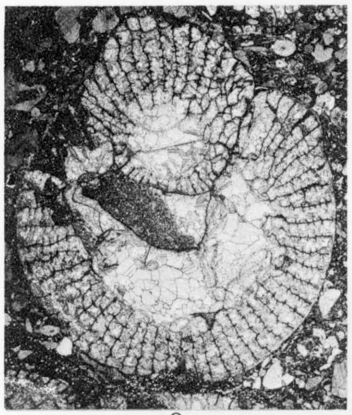

8

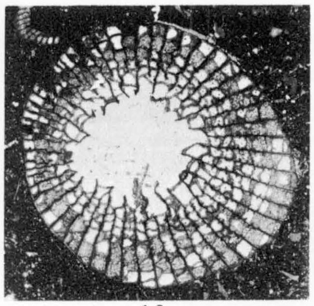

2

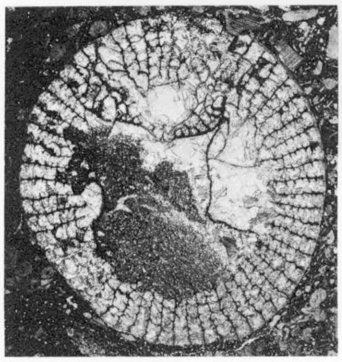

5

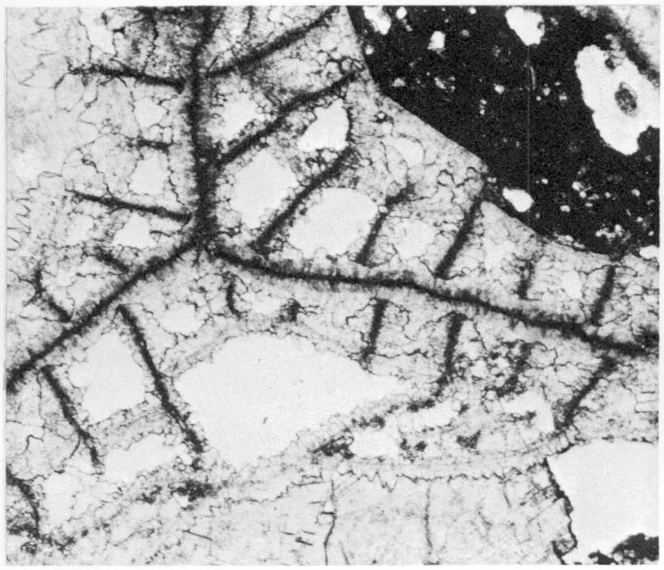

7


9


3


10


4

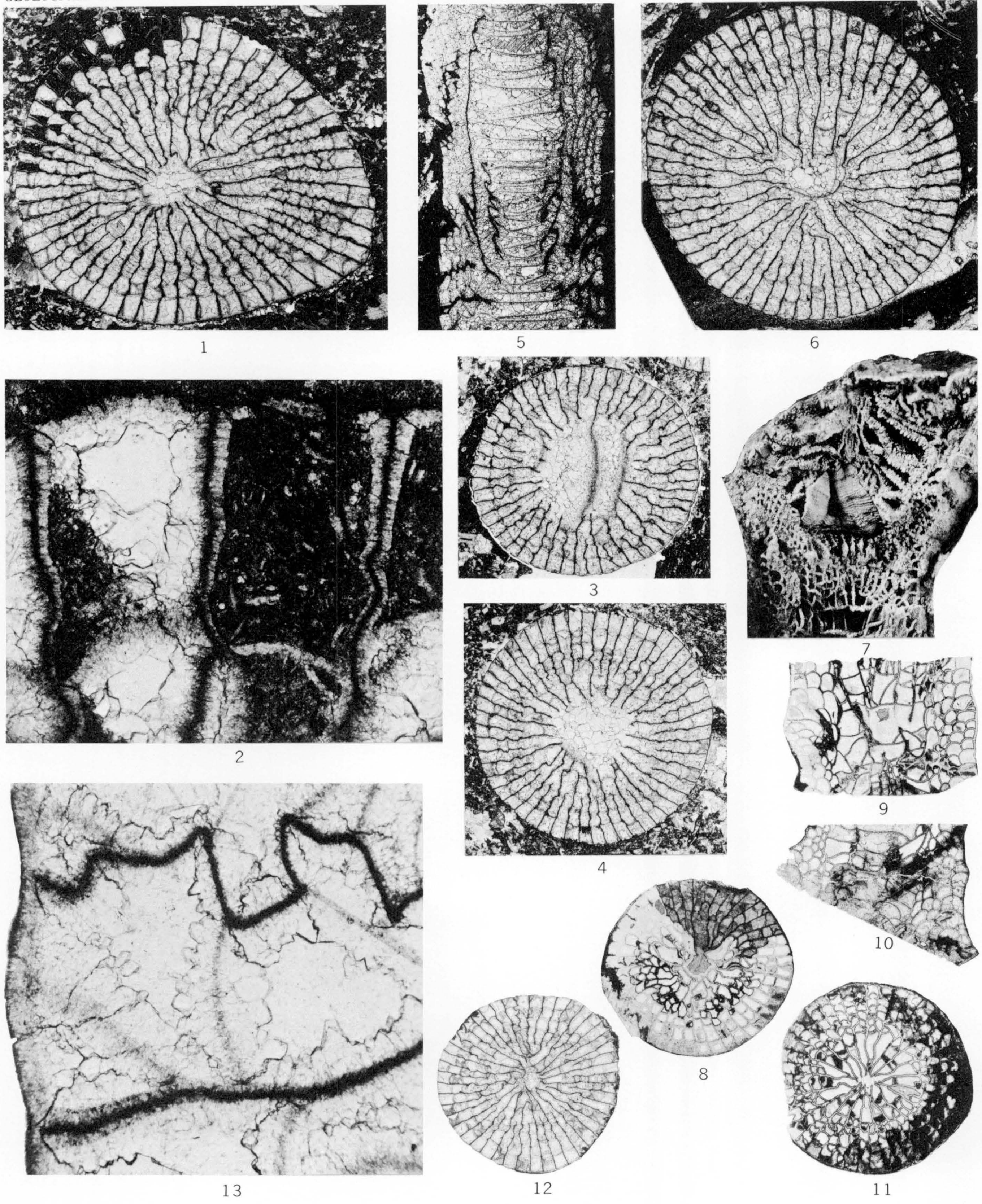

11

CYLINDROPHYLLUM ELONGATUM SIMPSON

PLATE 34

FIGURES 1–7. *Cylindrophyllum elongatum* Simpson (p. 71).
Edgecliff Member, New York.
1–4. NYSM 12814. Clarksville.
1, 3, 4. Transverse thin sections of three corallites (× 5).
2. Detail of section in fig. 1 (× 50).
5, 6. USNM 163386. Longitudinal (× 2½) and transverse (× 5) thin sections. Bioherm facies. Loc. 329.
7. USNM 172242. Specimen broken to show surface (with growth lines) of base of two peripheral offsets (× 2½). Bioherm facies. Loc. 108.

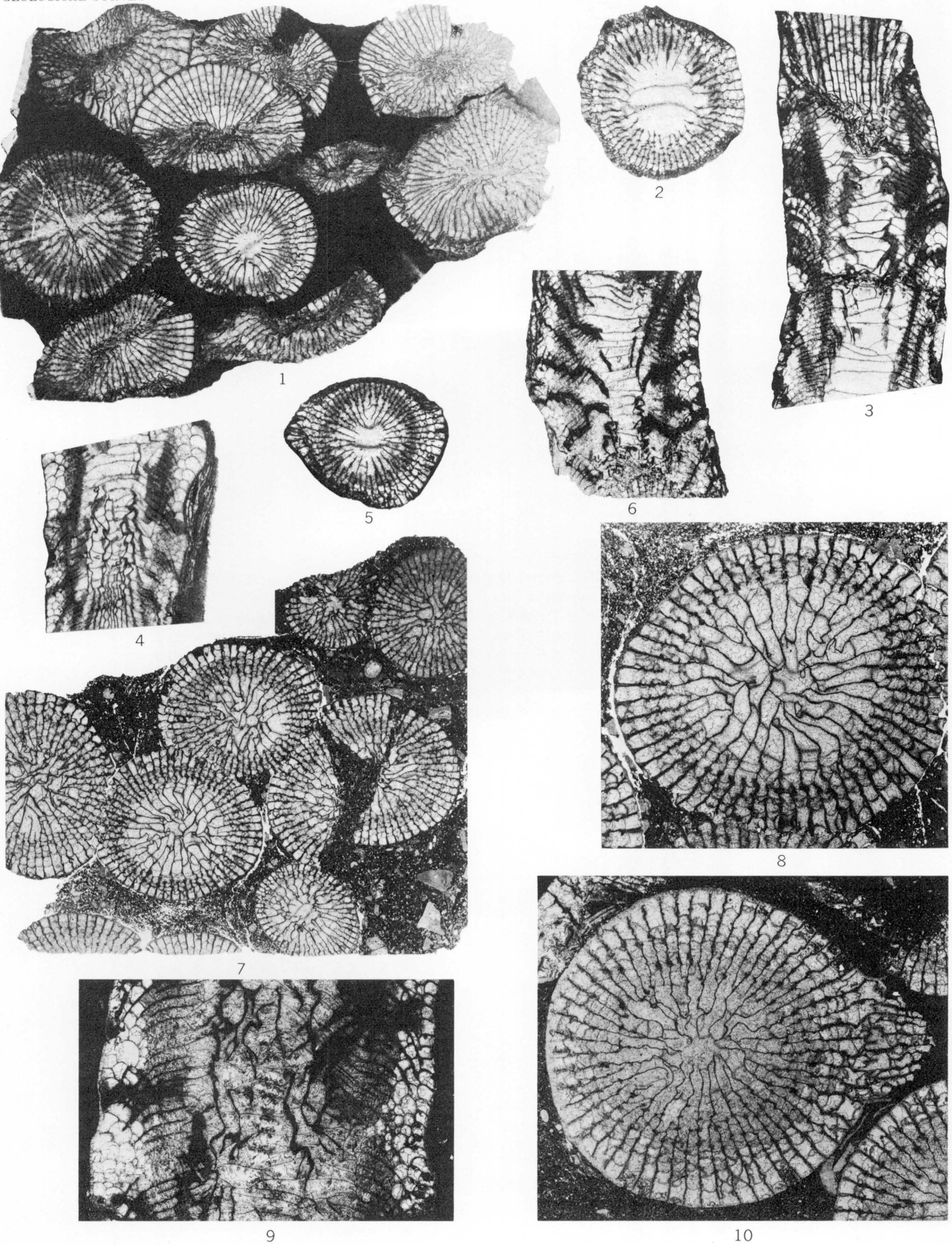
8–13. *Cylindrophyllum* sp. A (p. 77).
Edgecliff bioherm facies, New York. Loc. 108.
8, 9. NYSM 12817. Transverse and longitudinal thin sections of same corallite (× 2½).
10–13. USNM 163395.
10, 11. Longitudinal and transverse thin sections of one corallite (× 2½).
12, 13. Transverse thin section of another corallite (× 2½) and detail (× 50).



CYLINDROPHYLLUM ELONGATUM SIMPSON AND *C.* SP. A

PLATE 35

FIGURES 1–10. *Cylindrophyllum propinquum* Stewart (p. 73).
Columbus Limestone, Zone C, Ohio.
- 1–6. Holotype, OSU 17779. Various transverse and longitudinal thin sections (all × 2½). Dublin quarry.
- 7, 8. USNM 172188. Transverse thin section (× 2½) and one corallite (× 5). USGS loc. 8289–SD.
- 9, 10. USNM 172187. Longitudinal and transverse thin sections of different corallites (× 5). USGS loc. 7808–SD.



CYLINDROPHYLLUM PROPINQUUM STEWART

PLATE 36

FIGURES 1–7. *Cylindrophyllum propinquum* Stewart (p. 73).

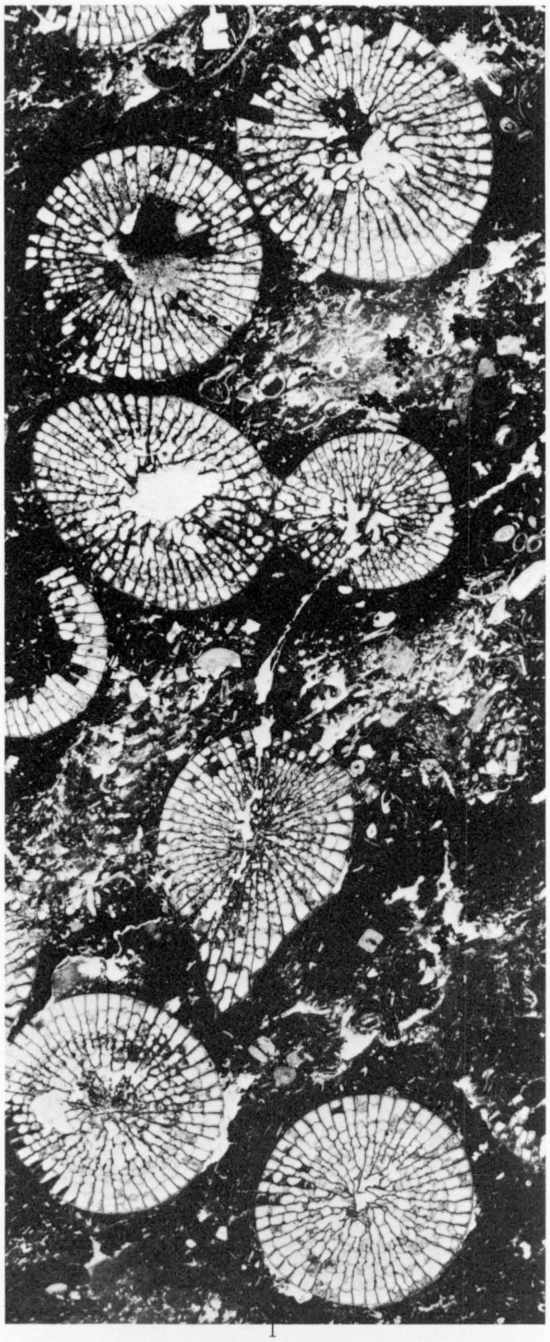
USNM 172182. Edgecliff bioherm facies, New York. Loc. 269.

1. Transverse thin section (× 2½).

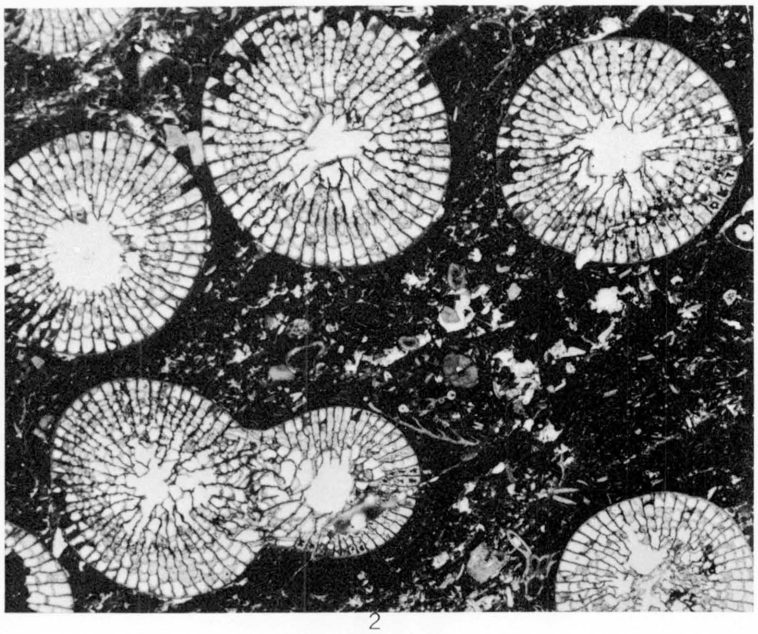
2, 4, 5. Serial transverse thin sections (× 2½) showing formation of lateral offset. Distance between lowest and highest section is 6.6 mm (measured parallel to parental axis). Intermediate section is 4.4 mm above lowest section.

3. Detail of upper right corallite in fig. 2 (× 50).

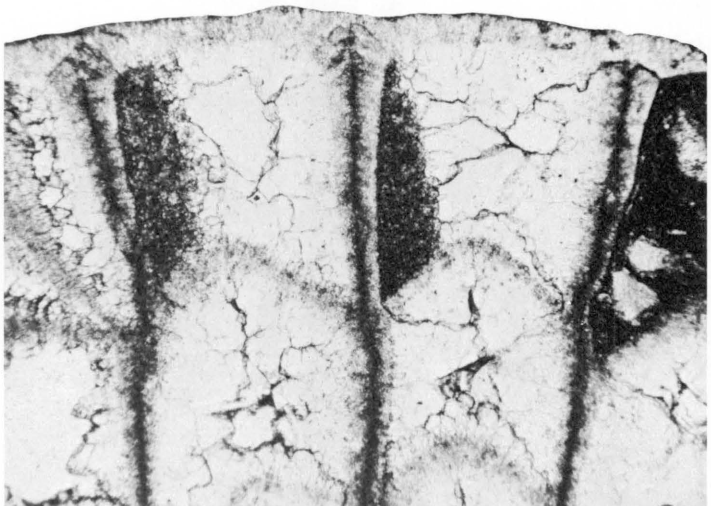
6, 7. Longitudinal thin sections of two corallites (× 2½).



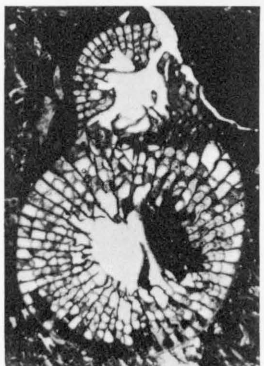
1



2

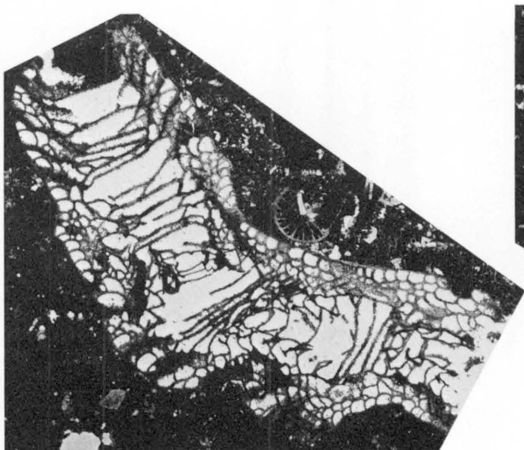


3

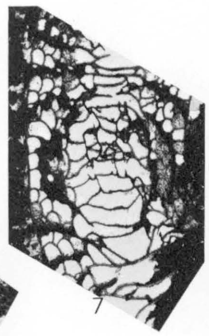


4

5



6



7

CYLINDROPHYLLUM PROPINQUUM STEWART

PLATE 37

FIGURES 1–9. *Cylindrophyllum propinquum* Stewart (p. 73).

Edgecliff bioherm facies, New York.

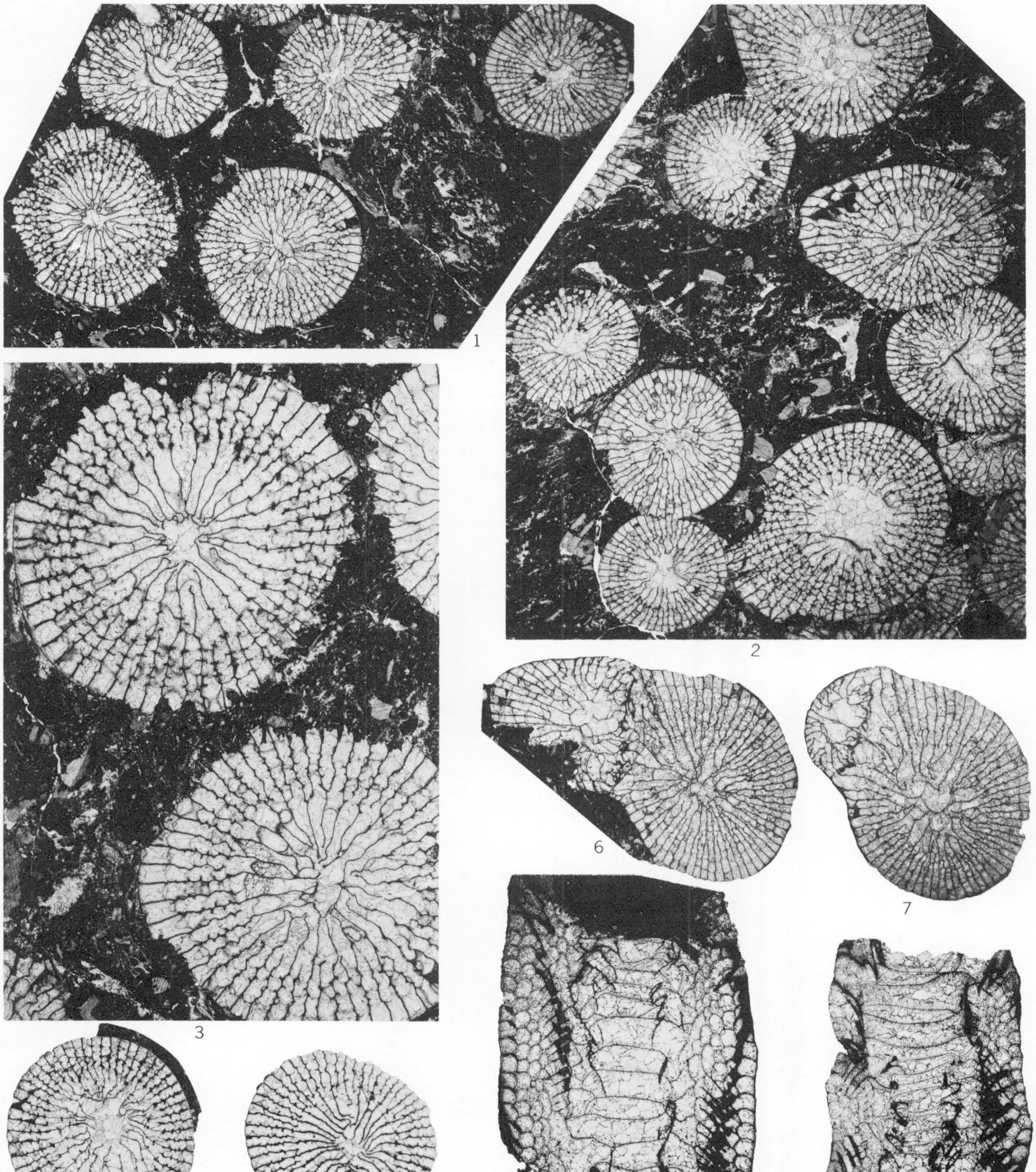
1–3. USNM 172180. Two parts of one thin section through colony (× 2½) and two corallites from fig. 1 (× 5). Loc. 296.

4, 5. USNM 172181. Two transverse thin sections (× 2½) through same corallite. Loc. 296.

6–9. NYSM 12818. Loc. 135.

6, 7. Transverse thin sections through one corallite showing two stages of same lateral offset (× 2½).

8, 9. Longitudinal thin sections of two corallites (× 2½).



CYLINDROPHYLLUM PROPINQUUM STEWART

PLATE 38

FIGURES 1–12. *Cylindrophyllum propinquum* Stewart (p. 73).

USNM 172184. Edgecliff biostrome facies, New York. Loc. 188.

1–3. Wide-spaced aerial sections of corallite with offset in advanced and very early stages and below same offset (× 2½). Total distance between lower and higher sections estimated at 15 mm.

4, 5. Longitudinal thin sections of two other corallites (× 2½).

6, 7. Transverse and longitudinal thin sections of another corallite (× 2½).

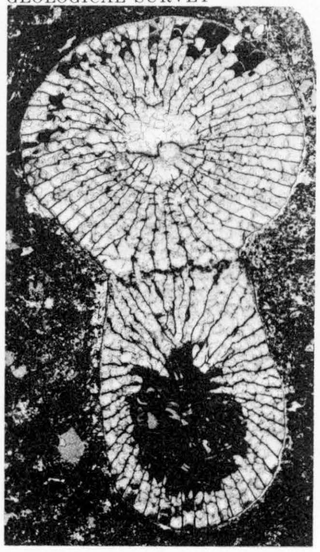
8. Transverse thin section of another corallite (× 2½).

9, 10. Longitudinal and transverse thin sections of another corallite (× 2½).

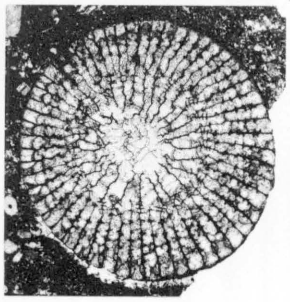
11. Detail of central part of corallite in fig. 10 (× 10).

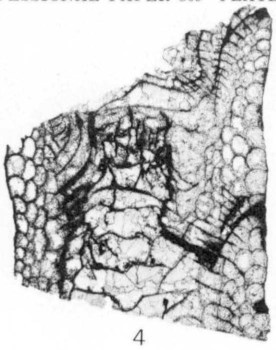
12. Exterior of corallite and offset (× 1½).

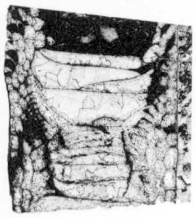
Note carinae in tabularium of several of the corallites.

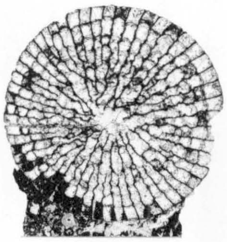

1

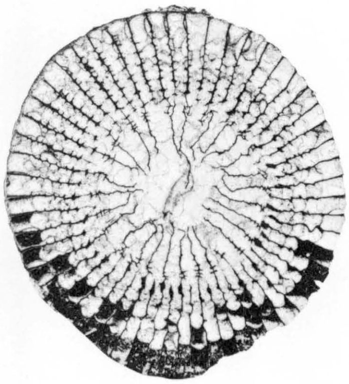

2

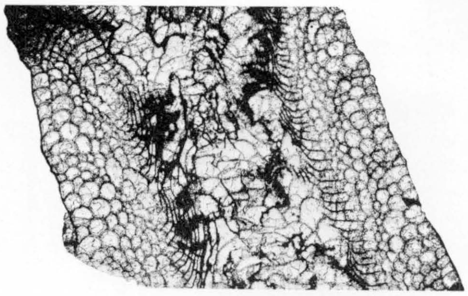

3

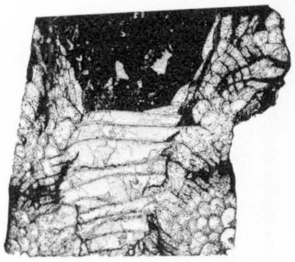

4

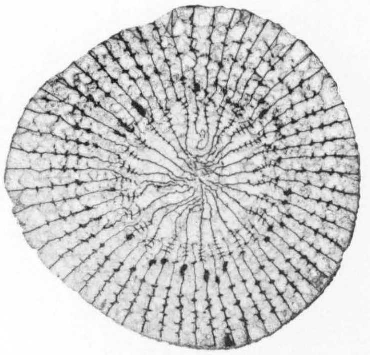

5

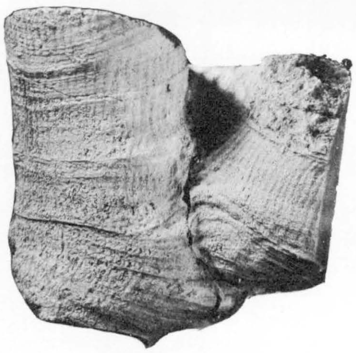

6

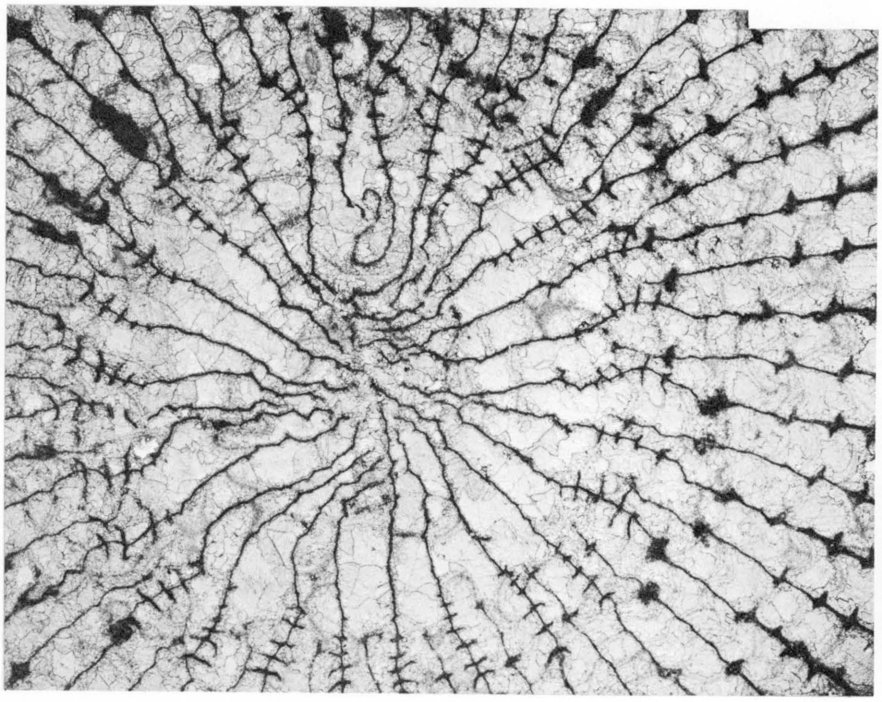

8


9


7


10


12


11

CYLINDROPHYLLUM PROPINQUUM STEWART

PLATE 39

FIGURES 1–8. *Cylindrophyllum laxtensum* n. sp. (p. 75).

Bois Blanc and Schoharie Formations, New York and Ontario.

1–4. Holotype, GSC 31146. Bois Blanc Formation. Loc. C19.

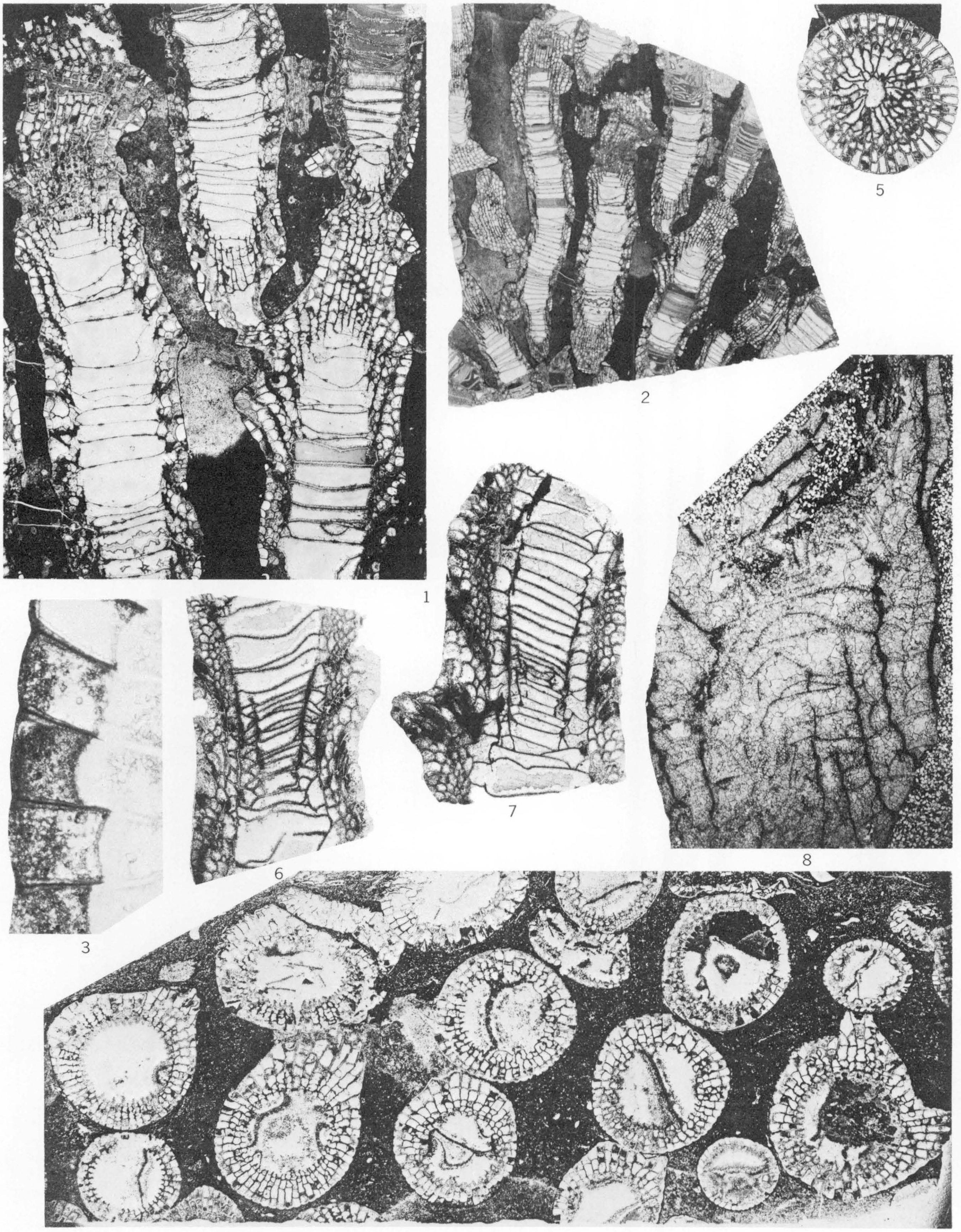
1, 2. Longitudinal thin section; three corallites (× 2½), the same and additional corallites (× 1).

3, 4. Transverse thin section; fig. 4, several corallites (× 2½) and fig. 3, detail of lower-middle corallite in fig. 4 (× 25).

5. Paratype, USNM 163391. Transverse thin section (× 2½). Bois Blanc Formation. Loc. C28.

6, 7. Paratype, GSC 31147. Longitudinal thin sections of two corallites (× 2½). Bois Blanc Formation. Innerkip, Ontario, GSC loc. 23676.

8. Paratype, USNM 163393. Longitudinal thin section (× 5). Schoharie Grit. Loc. 505.



4

CYLINDROPHYLLUM LAXTENSUM N. SP.

PLATE 40

FIGURES 1–6. *Cylindrophyllum laxtensum* n. sp. (p. 75).

Bois Blanc Formation, Ontario.

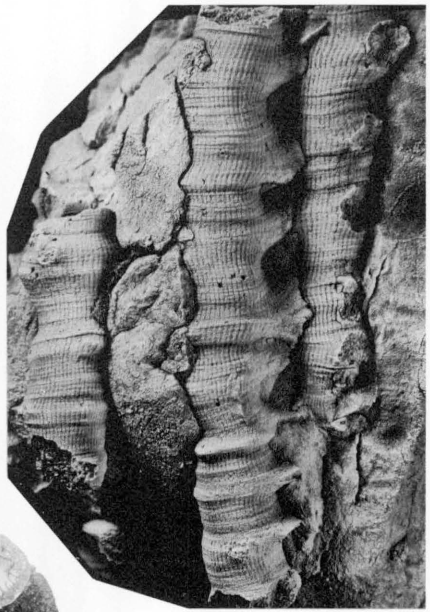
1–2. Paratype, USNM 182813. Transverse thin section: fig. 2, (× 2½); fig. 1, detail of parts of two corallites in center left of fig. 2 (× 50); horizontal structure in fig. 1 is wall between two lateral connections; other structures are parts of four septa (with dark center lines) and two dissepiments. Woodstock Ontario.

3–6. Paratype, GSC 3585a. Walpole, Ontario.

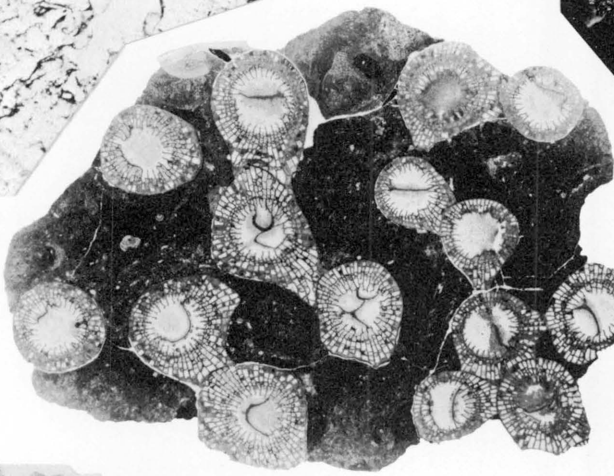
3. Exterior of corallites (× 1).
4. Transverse thin section (× 1).

5, 6. Longitudinal thin sections (× 2½). Section in fig. 5 shows two lateral connections and part of adjacent corallite.

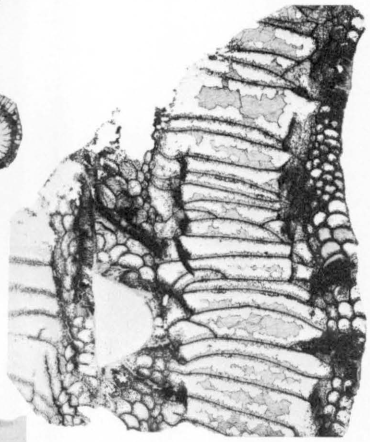
1



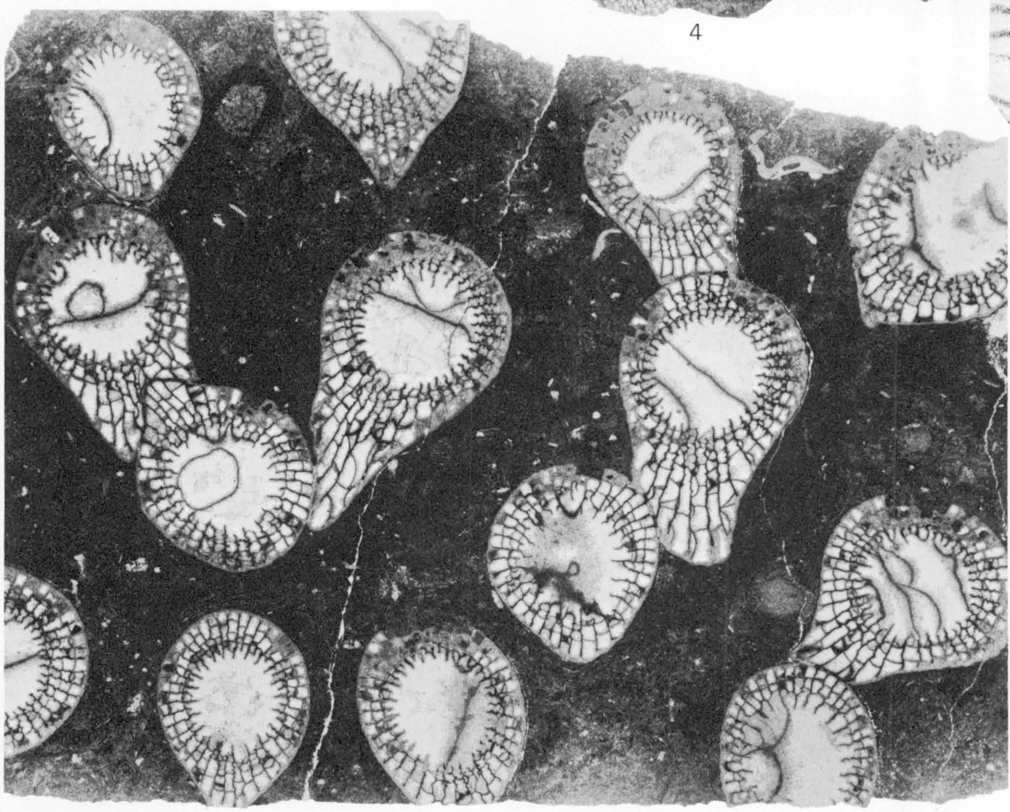
3



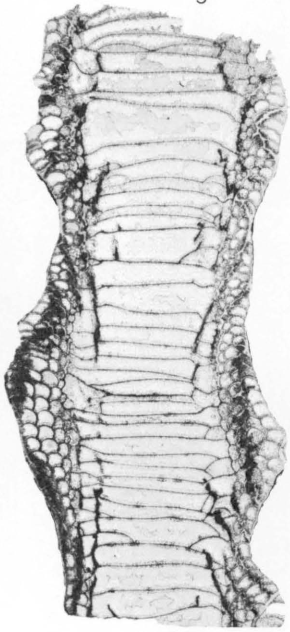
4



5



2



6

CYLINDROPHYLLUM LAXTENSUM N. SP.

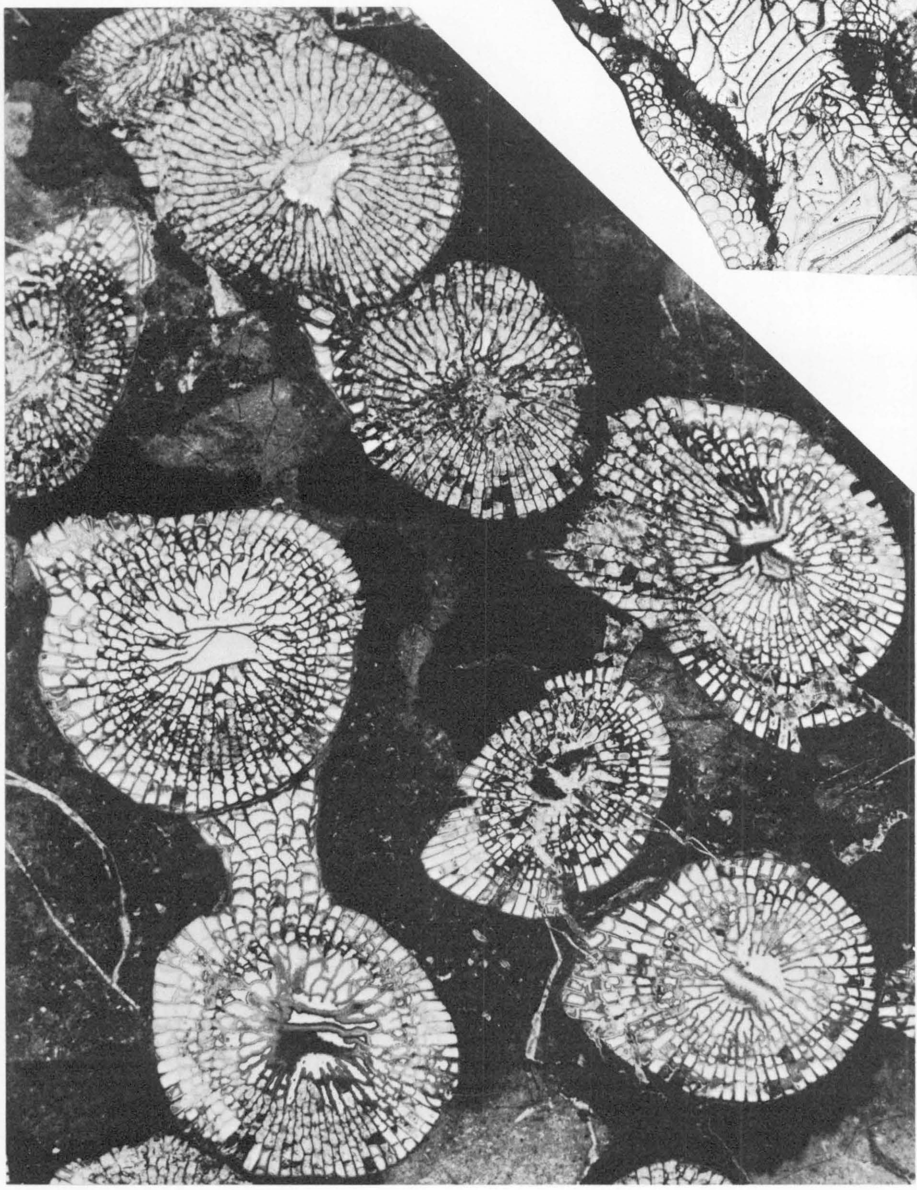
PLATE 41

FIGURES 1–5. *Cylindrophyllum deearium* n. sp. (p. 76).

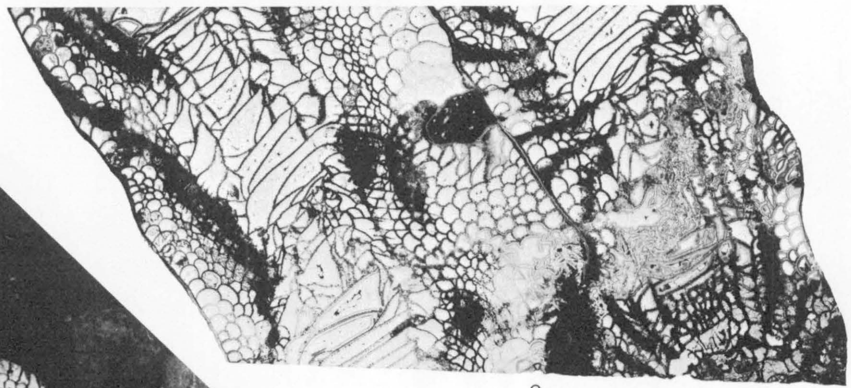
Edgecliff bioherm facies, New York.

1–3. Holotype, USNM 172190. Transverse and longitudinal thin sections (× 2½). Loc. 360.

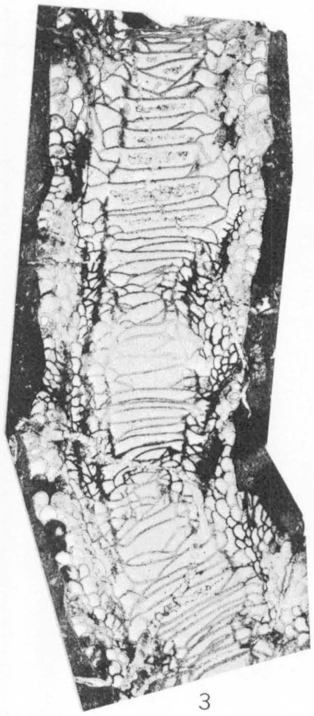
4, 5. Paratype, NYSM 12819. Longitudinal and transverse thin sections (× 2½). Loc. 296.



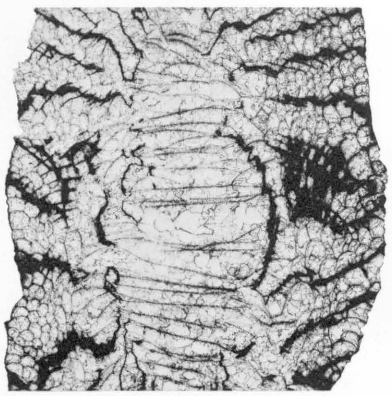
1



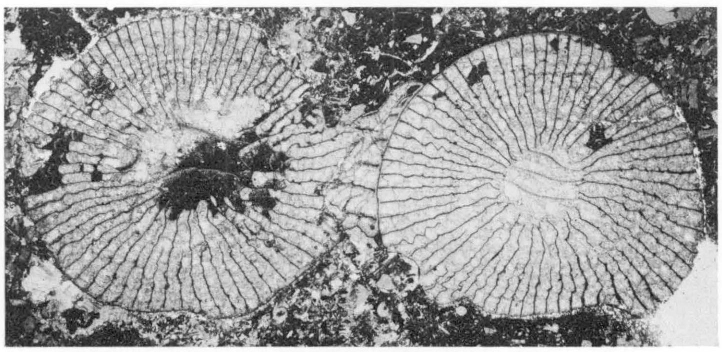
2



3



4



5

CYLINDROPHYLLUM DEEARIUM N. SP.

PLATE 42

FIGURES 1–7. *Cylindrophyllum deearium* n. sp. (p. 76).

Edgecliff Member, New York.

1–4. Paratype, NYSM 12820. Bioherm facies. Loc. 81.

1, 2. Transverse and longitudinal thin sections (× 2½).

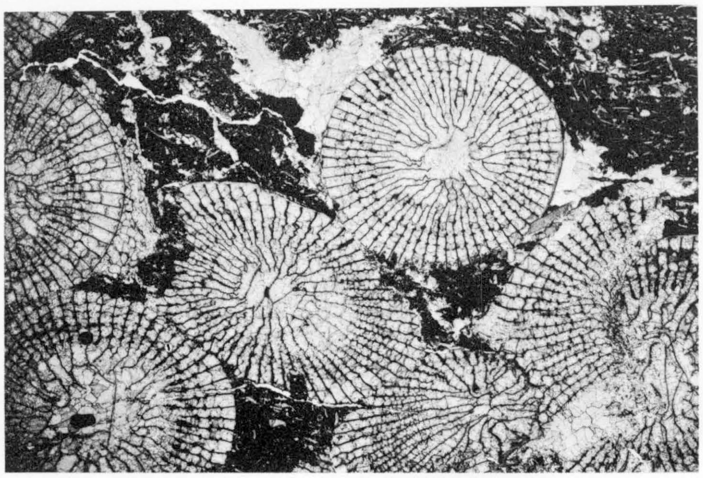
3. Longitudinal thin section of another corallite (× 5).

4. Detail of section in fig. 3 (× 25).

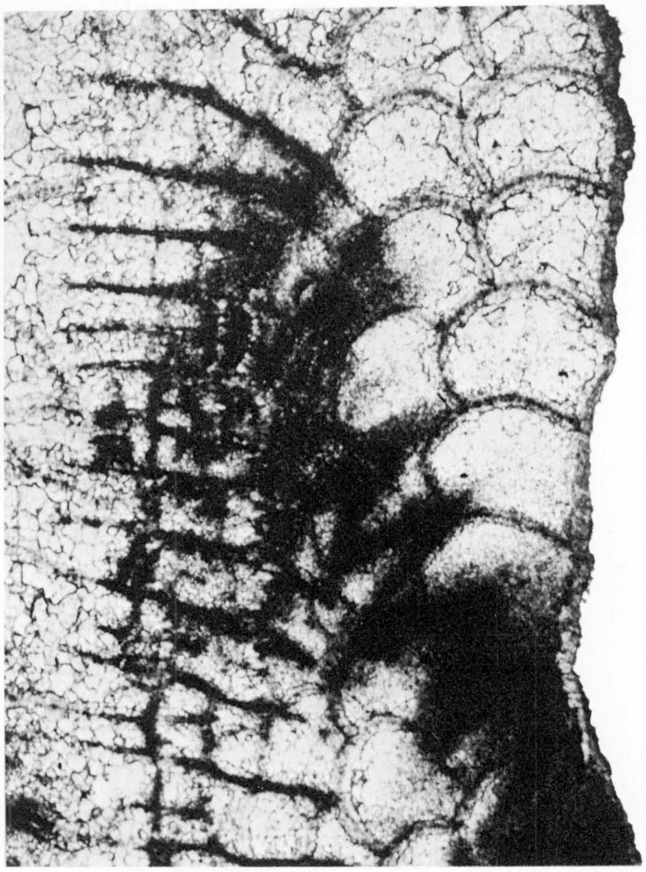
5. USNM 172243. Longitudinal thin section of fragment only tentatively identified as this species (× 2½); shows peripheral offsets. Bioherm facies. Loc. 207.

6. Paratype, NYSM 12871. Exteriors of several corallites and offset (× 1). Leroy, N.Y.

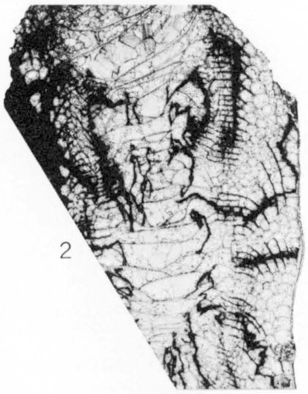
7. Paratype, USNM 172191. Longitudinal thin section including peripheral offsets (× 2½). Bioherm facies. Loc. 81.



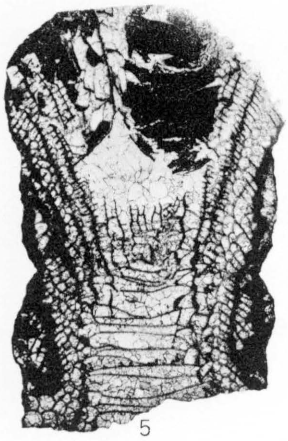
1



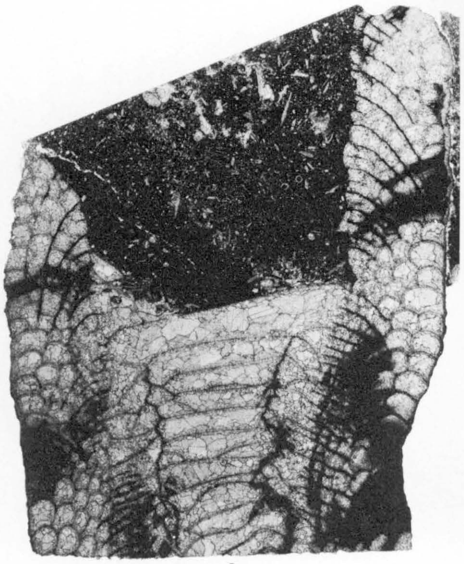
4



2

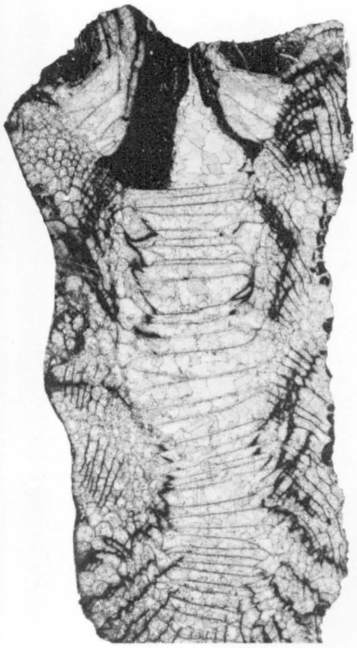


5



3

6



7

CYLINDROPHYLLUM DEEARIUM N. SP.

PLATE 43

FIGURES 1–11. *Cylindrophyllum deearium* n. sp. (p. 76).

Edgecliff Member, New York and Ontario.

1, 2. Paratype, USNM 25870. Longitudinal and transverse thin sections (× 2½). Leroy, N.Y.

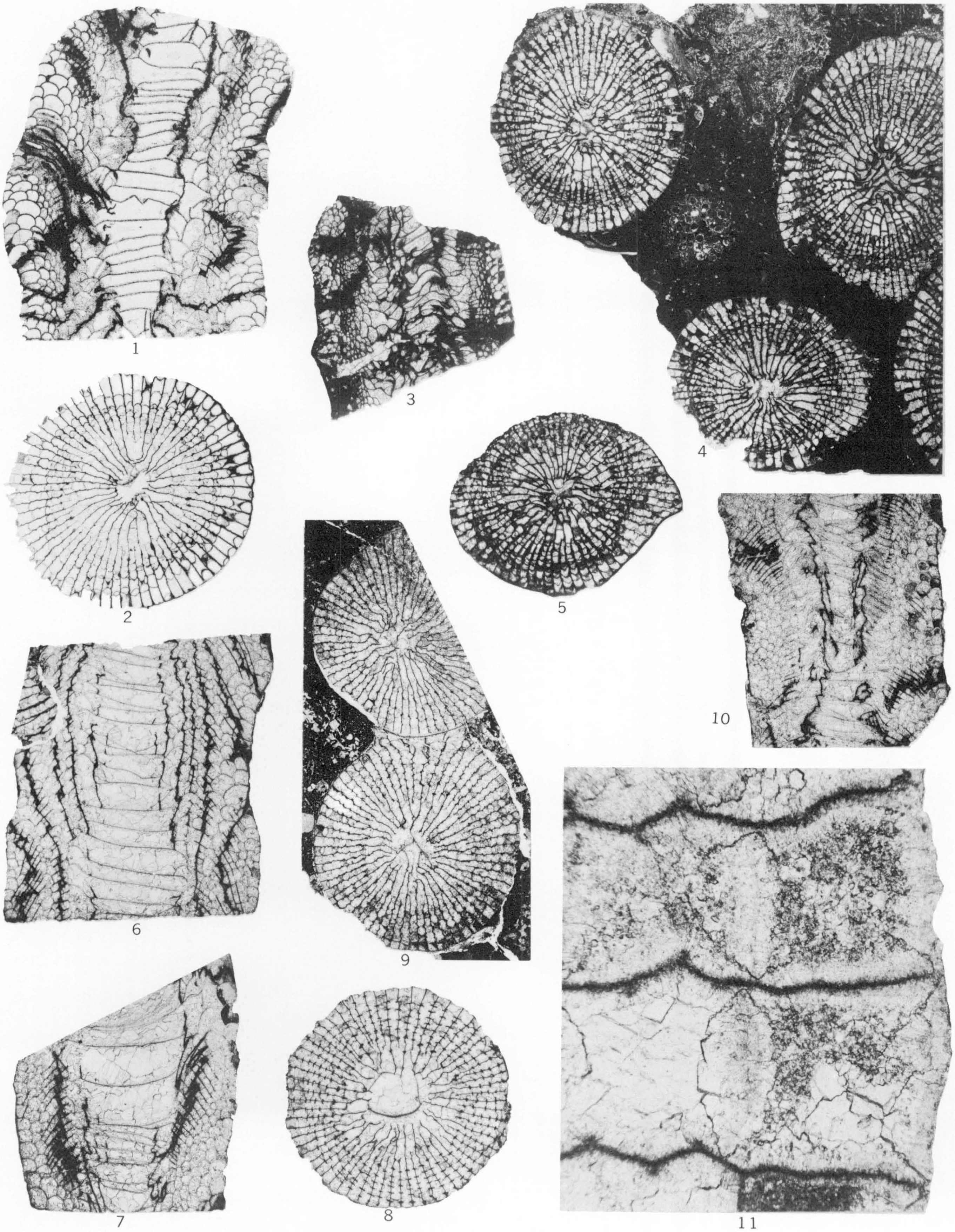
3–5. Paratype, UMMP 50576. Longitudinal and transverse thin sections (× 2½). Cheapside, Ontario.

6–8. Paratype, USNM 172192. Longitudinal and transverse thin sections (× 2½). Bioherm facies. Loc. 81.

9–11. Paratype, USNM 172193. Bioherm facies. Loc. 244.

9–10. Transverse and longitudinal thin sections (× 2½).

11. Detail of lower end of transverse section as oriented in fig. 9 (× 50).



CYLINDROPHYLLUM DEEARIUM N. SP.

PLATE 44

FIGURES 1–8. *Disphyllum*? *stummi* (Oliver) (p. 113).

Famine Limestone, St. George, Quebec.

1–5. Paratype, GSC 24639.

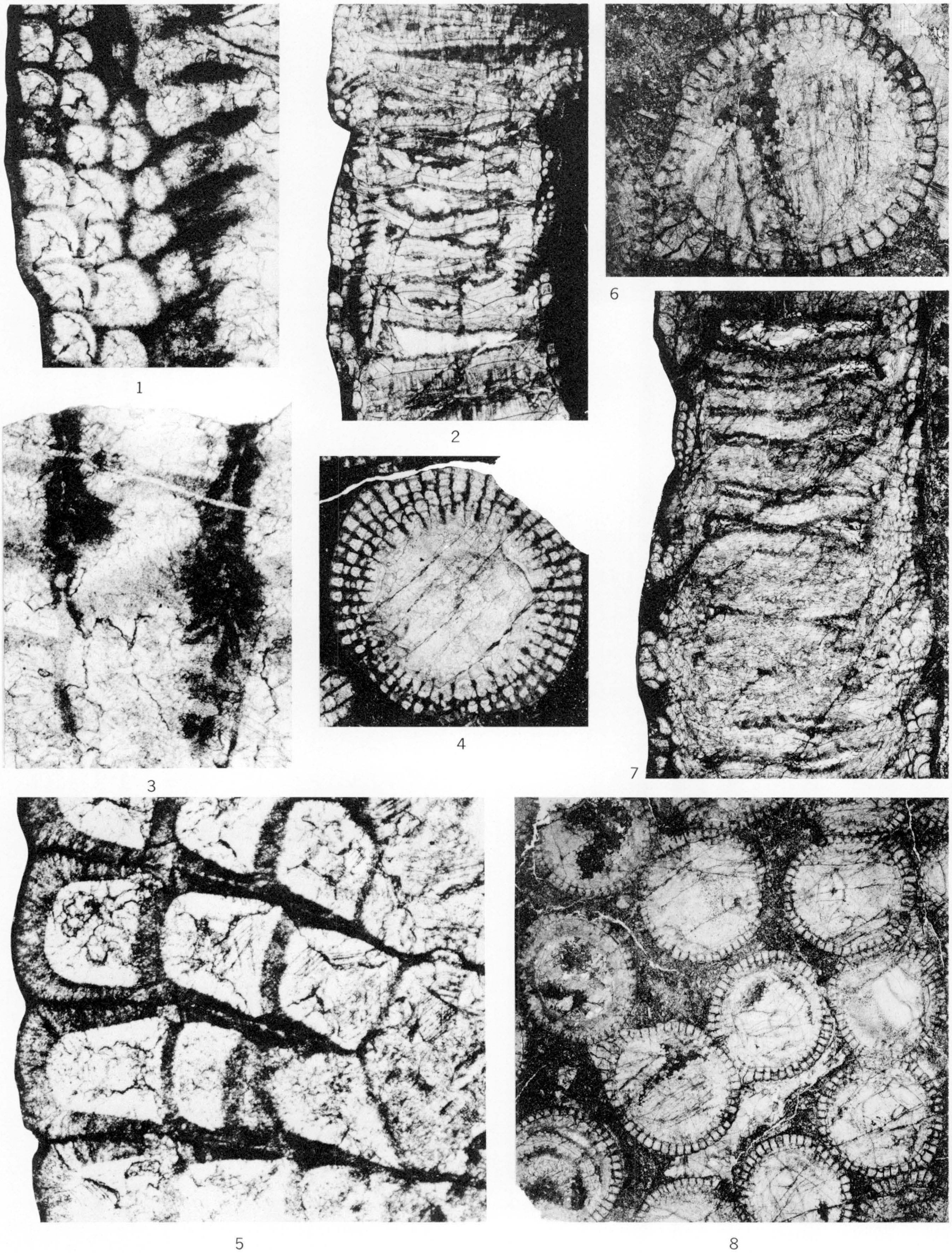
1, 2. Detail (× 25) and general view (× 5) of longitudinal thin section.

3–5. Detail (× 50), general view (× 5), and second detail (× 50) from same transverse thin section.

6–8. Holotype, USNM 163236.

6, 7. Transverse and longitudinal thin sections (× 5).

8. Transverse thin section (× 2½); corallite in fig. 6 is in low left center.

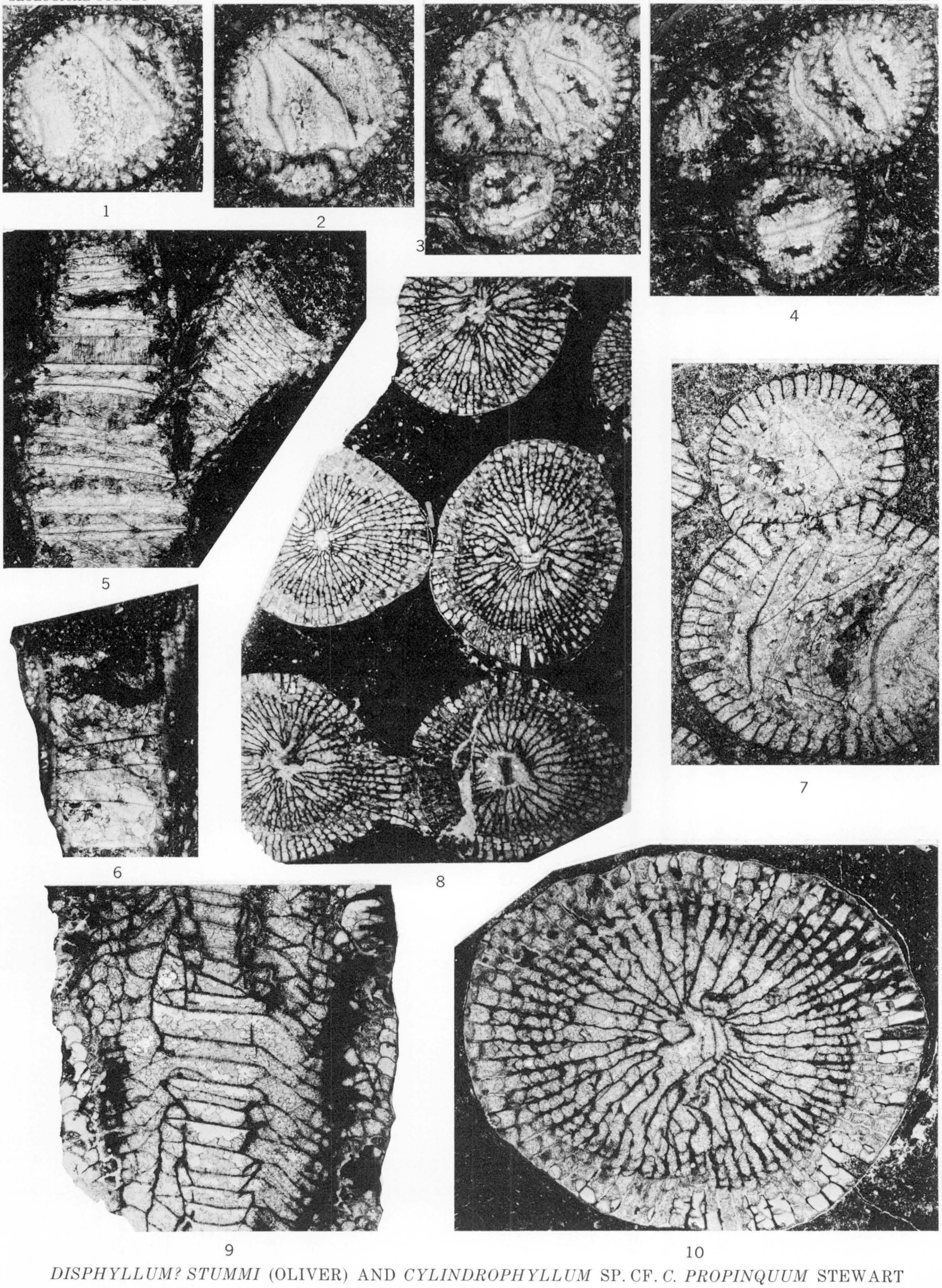


DISPHYLLUM? STUMMI (OLIVER)

PLATE 45

FIGURES 1–7. *Disphyllum*? *stummi* (Oliver) (p. 113).
Famine Limestone, St. George, Quebec.
1–4. Paratype, GSC 24797. Serial transverse thin sections showing stages of lateral increase (× 5).
5. Paratype, GSC 24798. Longitudinal thin section of corallite and lateral offset (× 5).
6. Paratype, USNM 163398. Longitudinal thin section (× 5).
7. Paratype, USNM 163237. Transverse thin section of corallite and lateral offset (× 5).

8–10. *Cylindrophyllum* sp. cf. *C. propinquum* Stewart
Edgecliff Member(?), Ontario. USNM 172185. Loc. C45.
8. Transverse thin section of several corallites (× 2½).
9, 10. Longitudinal and transverse thin sections (× 5). Fig. 10 corallite is right center in fig. 8.



DISPHYLLUM? STUMMI (OLIVER) AND *CYLINDROPHYLLUM* SP. CF. *C. PROPINQUUM* STEWART

PLATE 46

FIGURES 1–7. *Prismatophyllum prisma* Lang and Smith (p. 79).

Jeffersonville Limestone, Zone B.

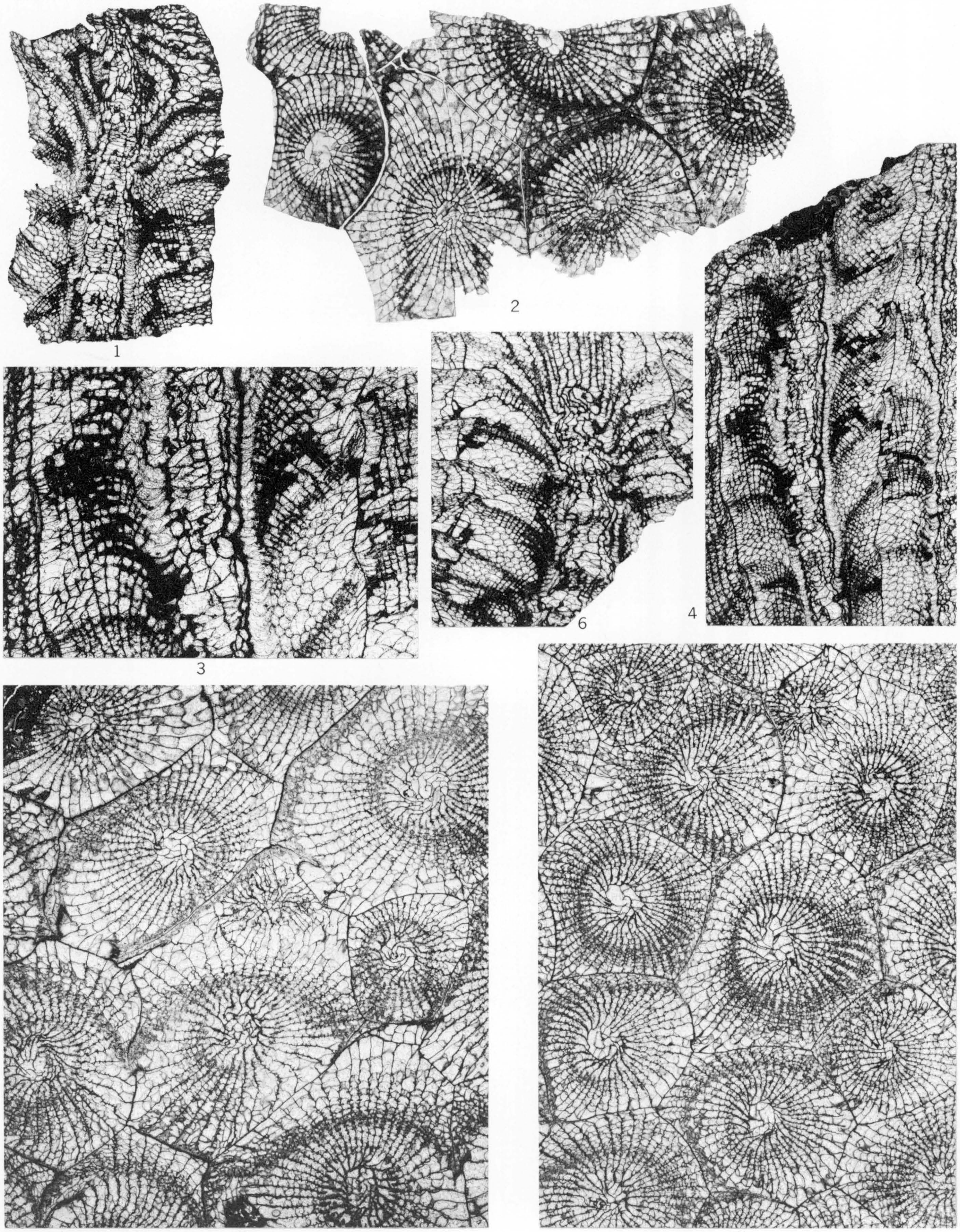
1, 2. Holotype, BMNH R31730, 31. Longitudinal and transverse thin sections (× 2½). Charleston Landing, Ind.

3–5. USNM 163401. Falls of the Ohio, Kentucky-Indiana.

3, 4. Longitudinal thin section (× 5, × 2½).

5. Transverse thin section (× 2½).

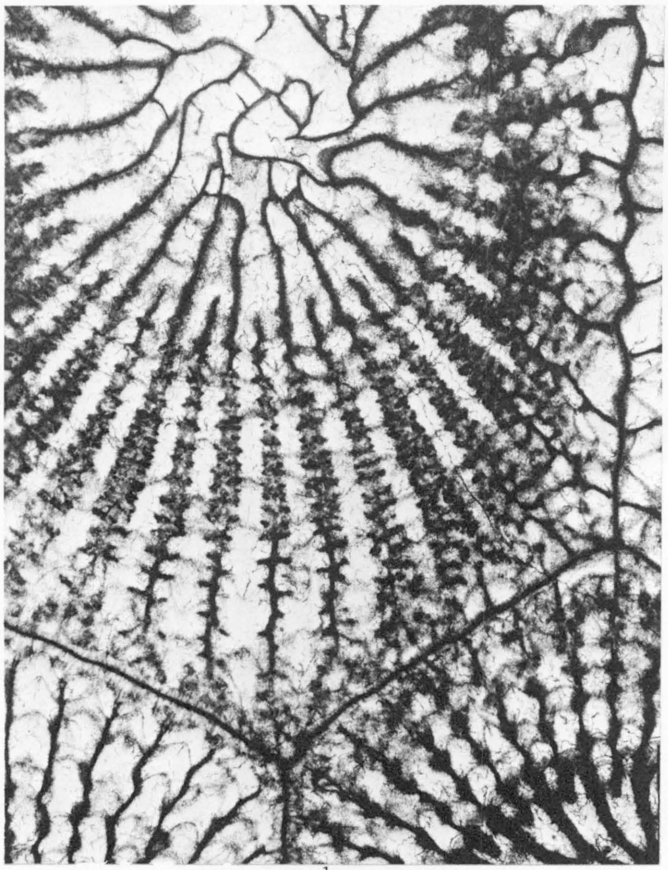
6, 7. USNM 163400. Falls of the Ohio, Kentucky-Indiana. Longitudinal and transverse thin sections (× 2½).



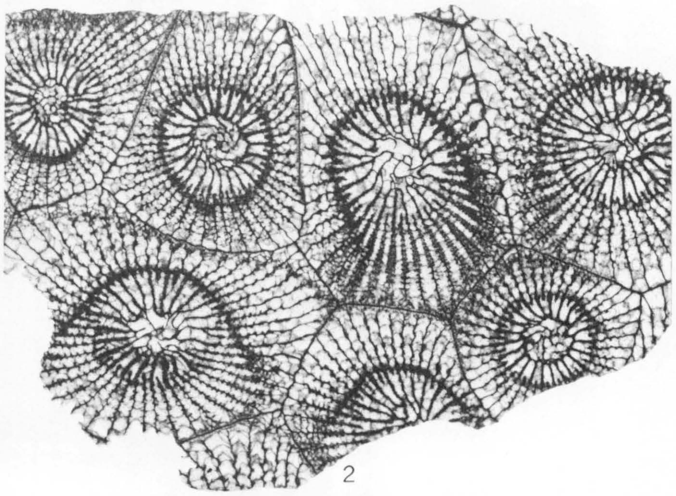
PRISMATOPHYLLUM PRISMA LANG AND SMITH

PLATE 47

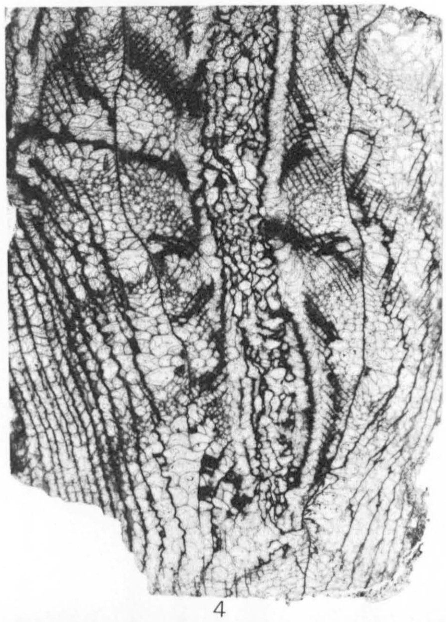
FIGURES 1–5. *Prismatophyllum prisma* Lang and Smith (p. 79).
SUI 21198. Holotype of *P. cinctum* Stainbrook. Falls of the Ohio.
1–3. Transverse section (× 10, × 2½, × 25).
4, 5. Longitudinal section (× 2½, × 5).



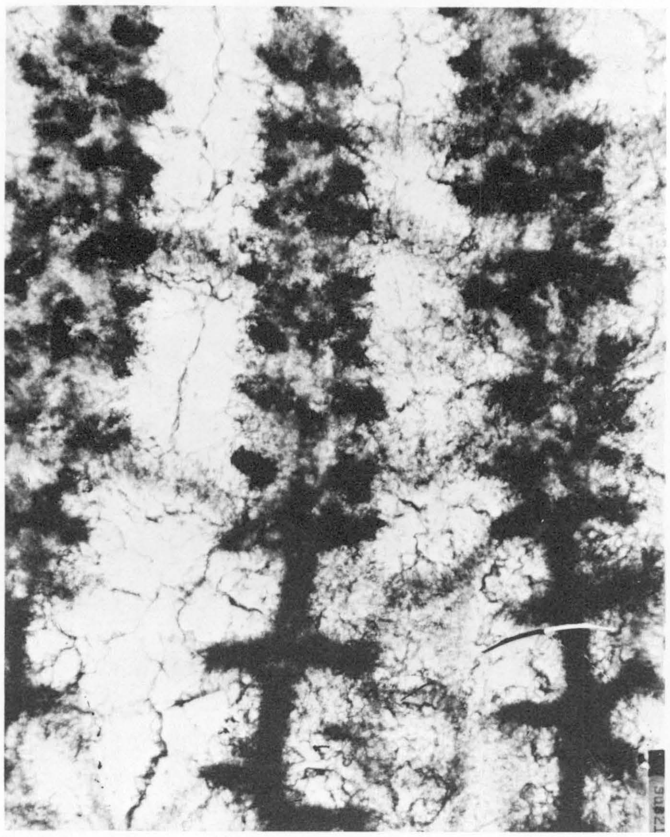
1



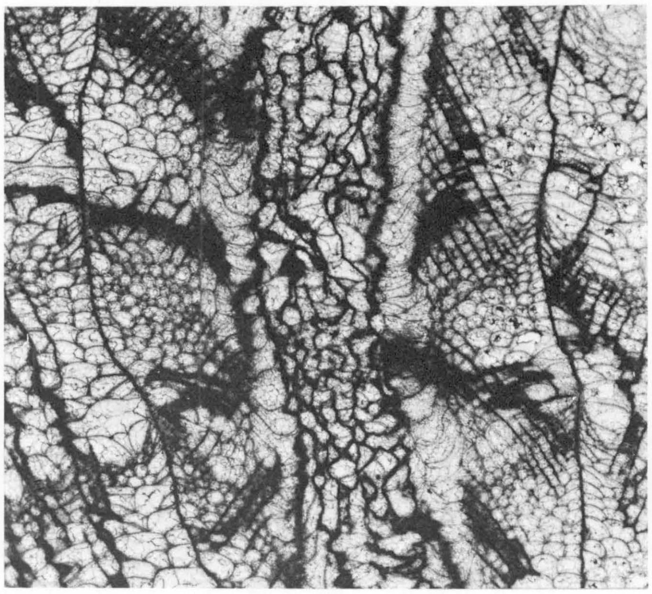
2



4



3

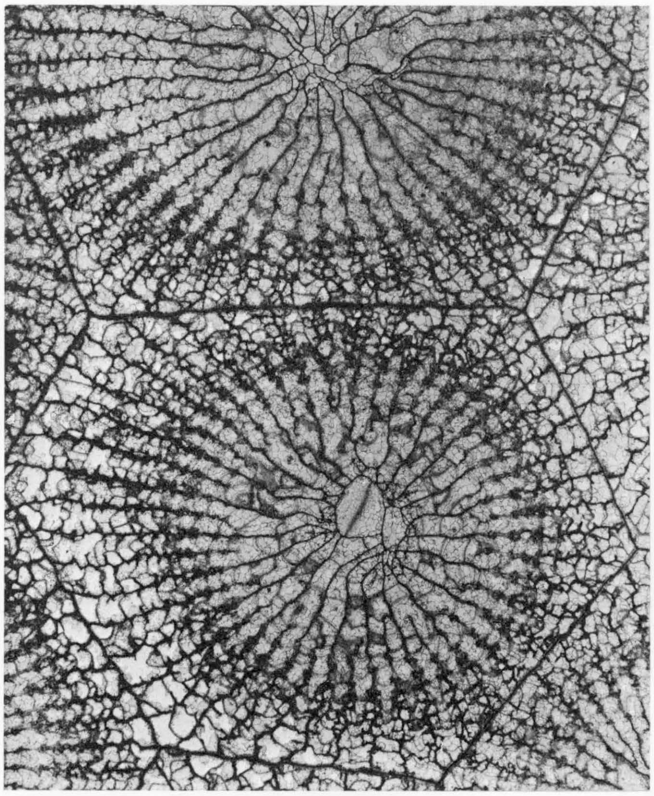


5

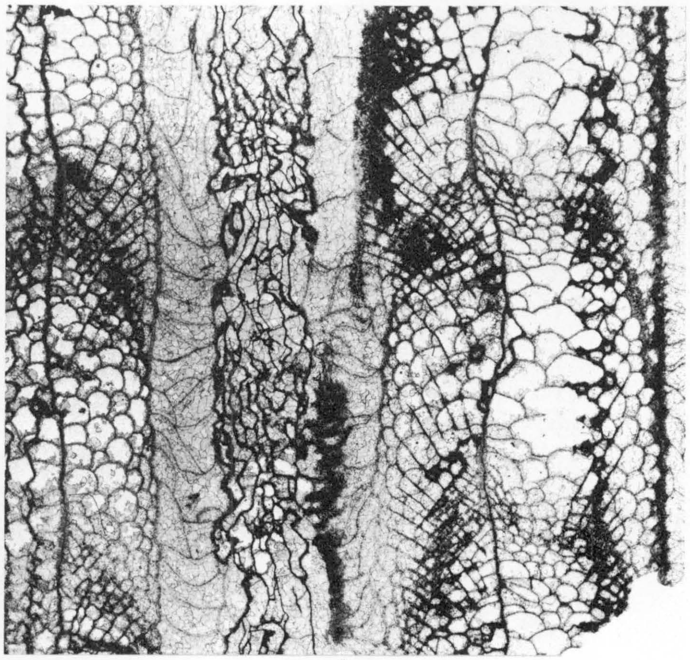
PRISMATOPHYLLUM PRISMA LANG AND SMITH

PLATE 48

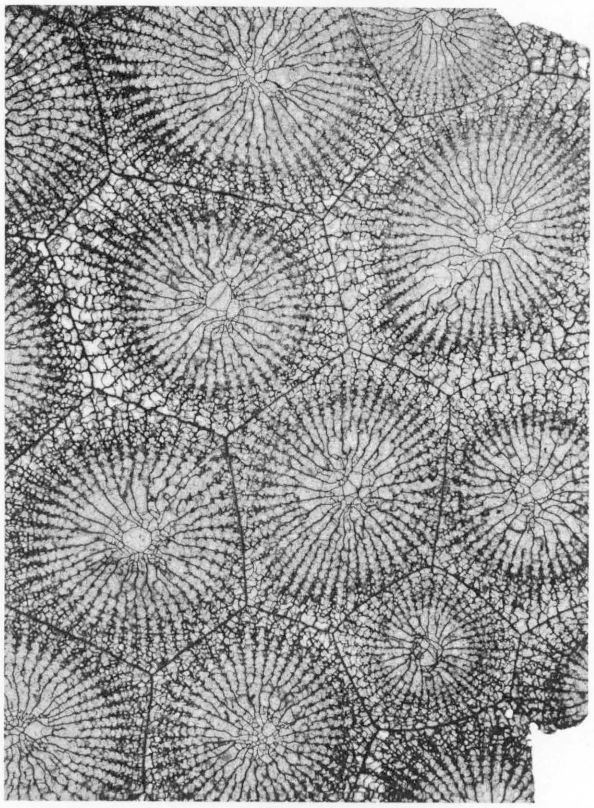
FIGURES 1–4. *Prismatophyllum prisma* Lang and Smith (p. 79).
USNM 163405. Jeffersonville Limestone, Zone B, Falls of the Ohio, Ky.-Ind.
1, 3, 4. Transverse thin section (× 5, × 2½, × 25).
2. Longitudinal thin section (× 5).



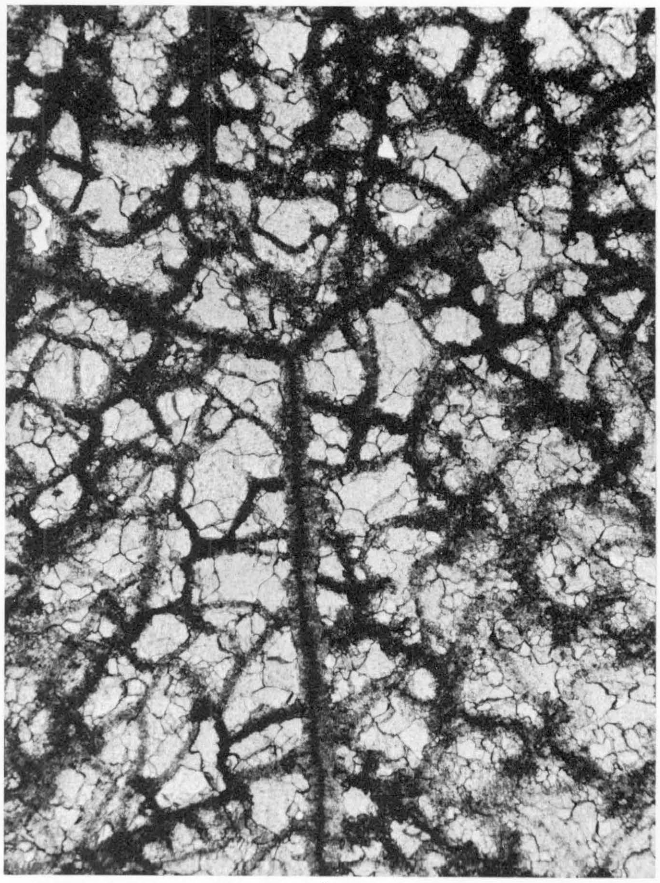
1



2



3



4

PRISMATOPHYLLUM PRISMA LANG AND SMITH

PLATE 49

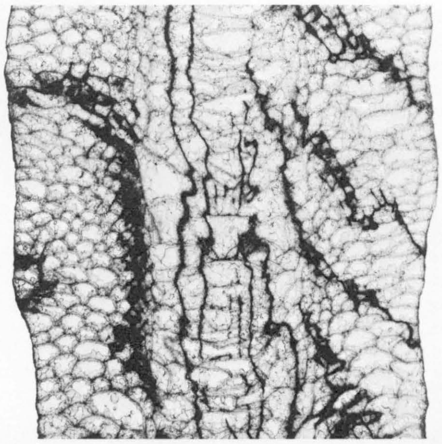
FIGURES. 1–5. *Prismatophyllum ovoideum* (Davis) (p. 83).

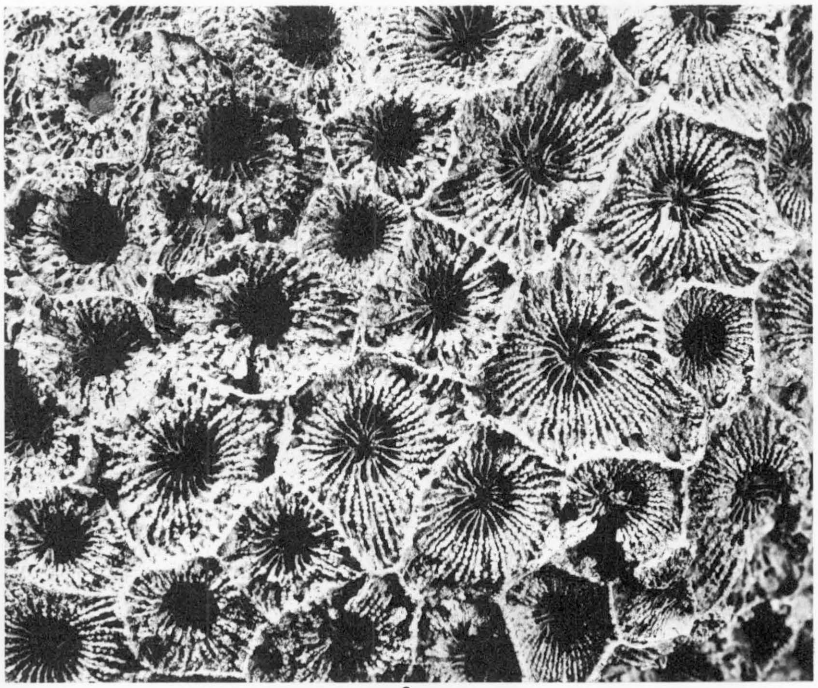
Jeffersonville Limestone, Falls of the Ohio, Ky.-Ind.

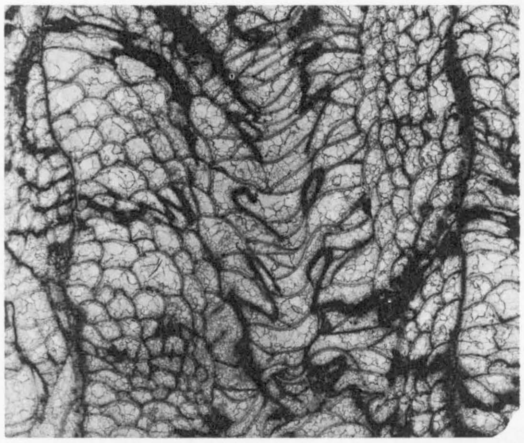
1. USNM 163413. Longitudinal thin section (× 5).
2. Holotype, MCZ 7910. Surface of silicified corallum (× 2½).

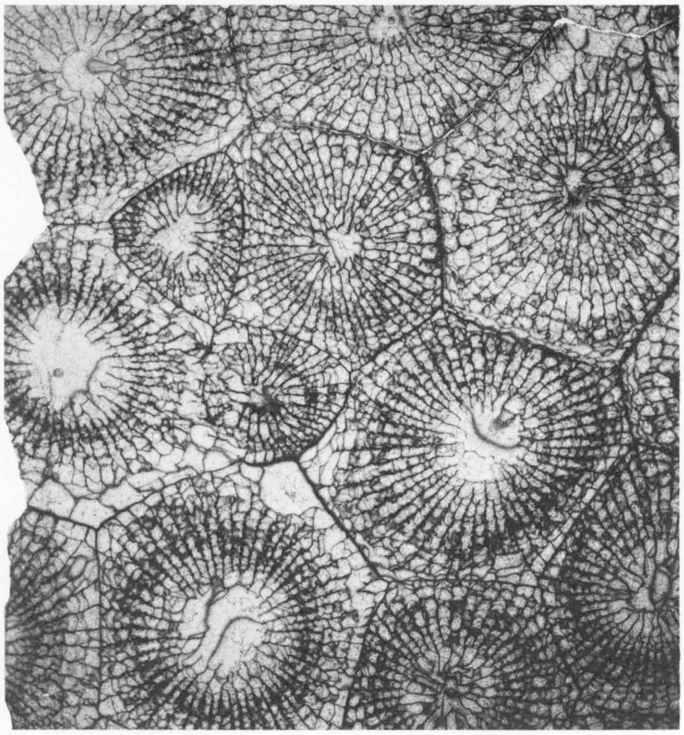
3–5. USNM 163407. Zone C.

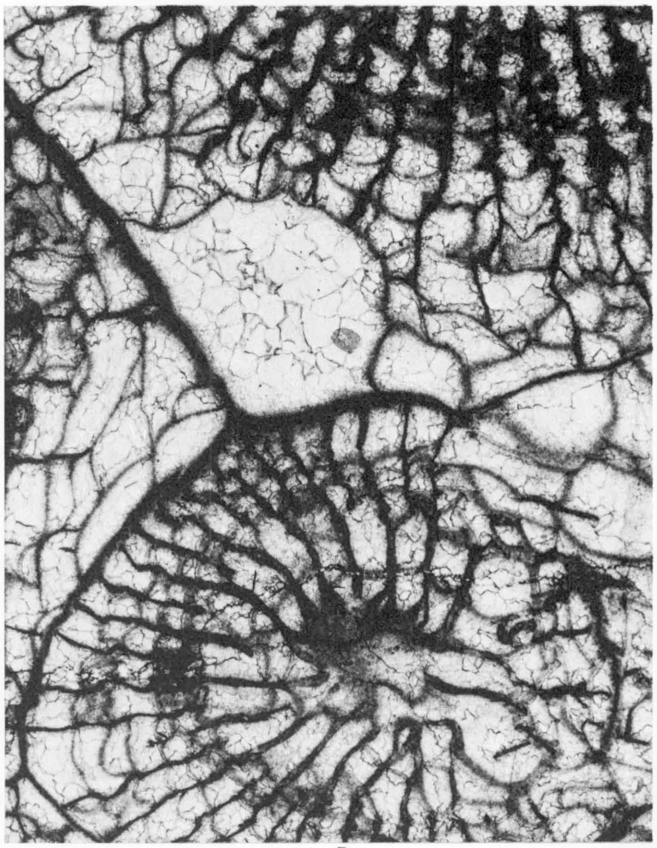
- 3. Longitudinal thin section (× 5).
- 4, 5. Transverse thin section (× 2½) and part of same (× 10).


1


2


3


4


5

PRISMATOPHYLLUM OVOIDEUM (DAVIS)

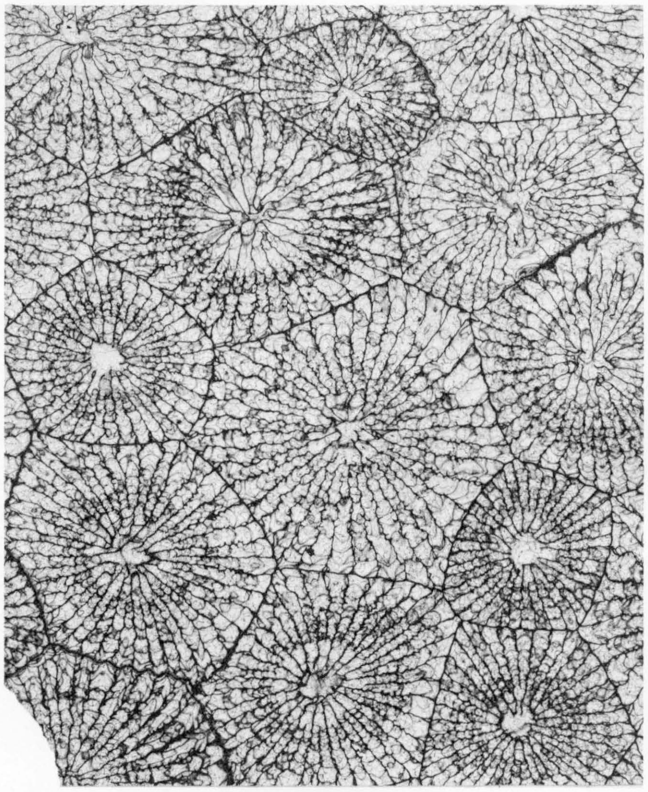
PLATE 50

FIGURES 1–5. *Prismatophyllum ovoideum* (Davis) (p. 83).

USNM 163408. Jeffersonville Limestone, Zone C, Falls of the Ohio, Ky.-Ind.

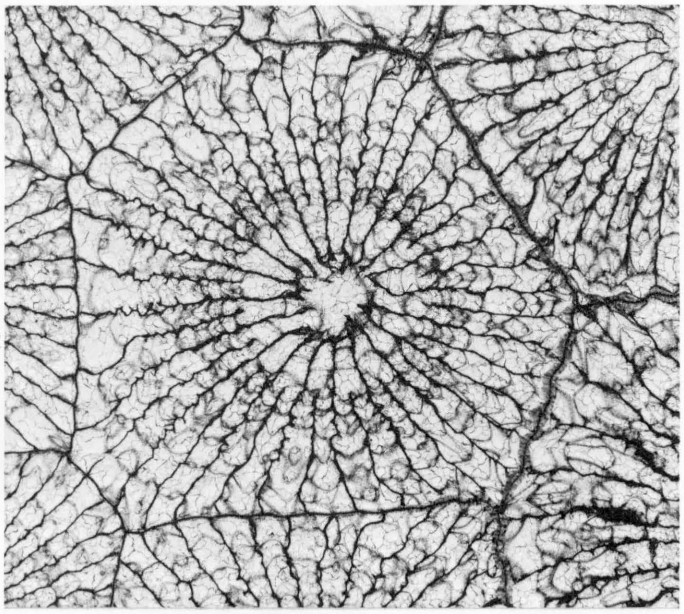
1, 2, 5. Transverse thin section (× 2½), one corallite from another part of same (× 5), and detail of wall and septa of same corallite (× 25).

3, 4. Longitudinal thin section (× 2½, × 5).

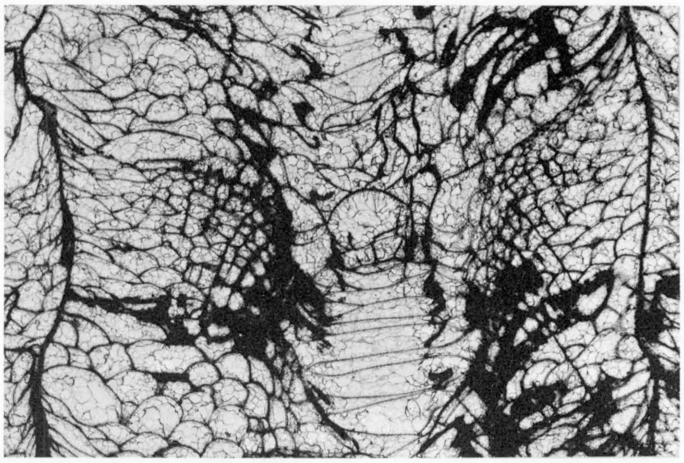


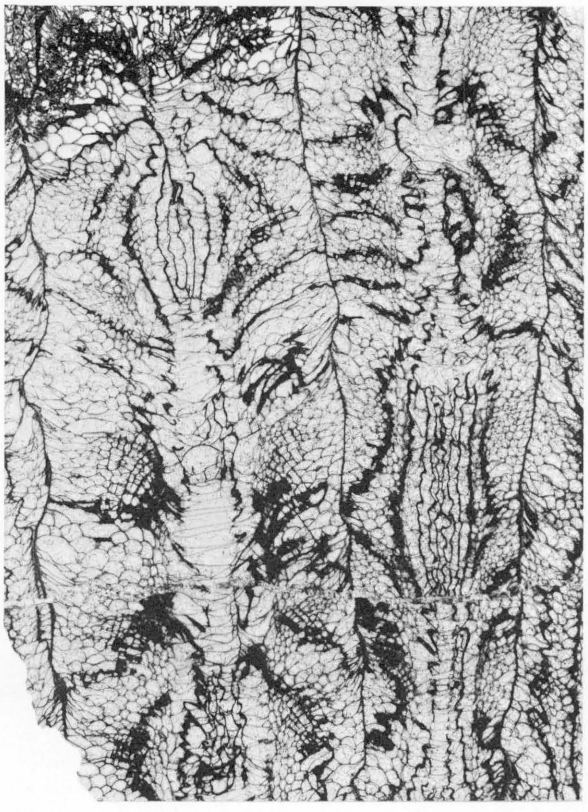
1

2

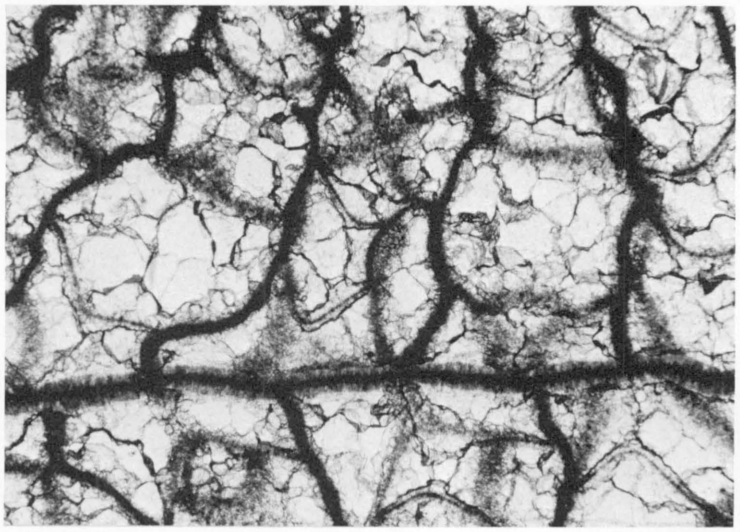


4





3

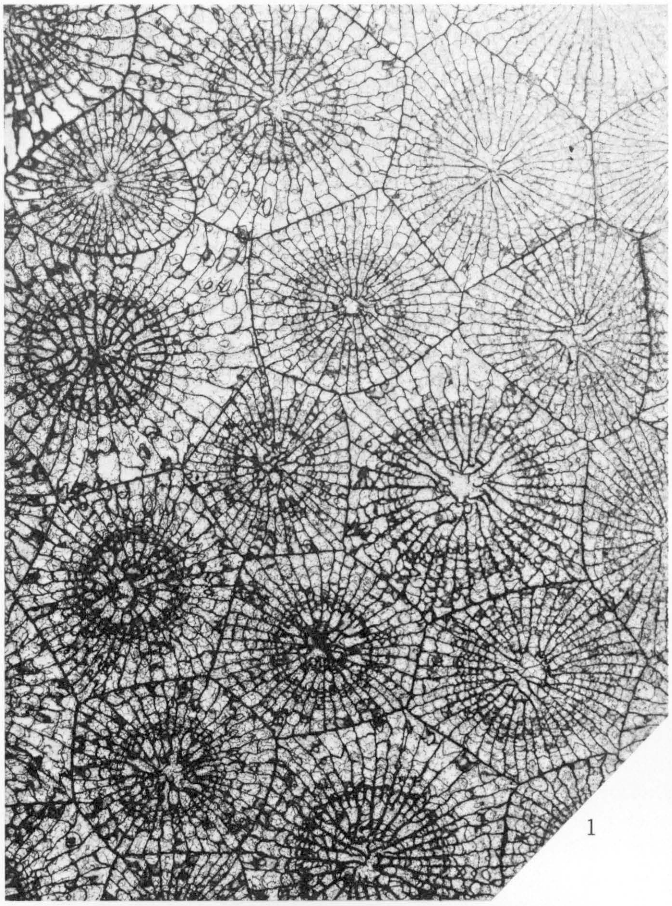


5

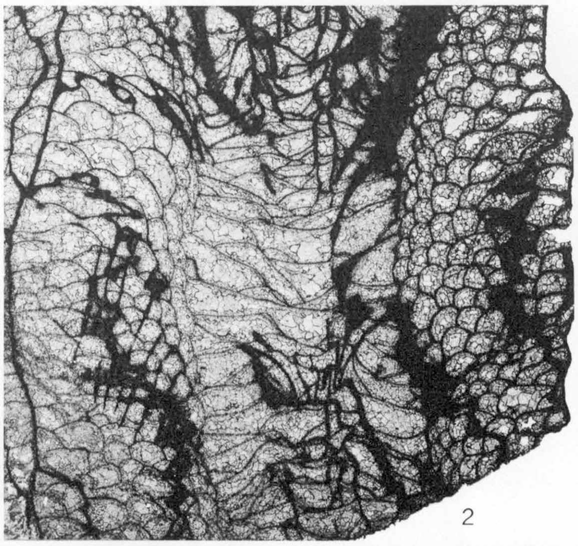
PRISMATOPHYLLUM OVOIDEUM (DAVIS)

PLATE 51

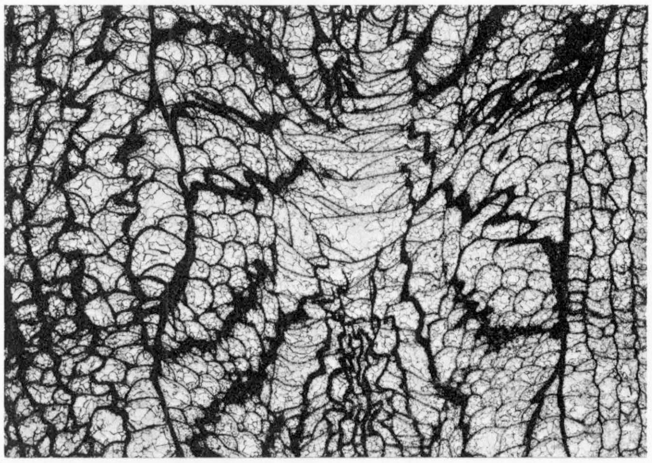
FIGURES 1–5. *Prismatophyllum ovoideum* (Davis) (p. 83).
NYSM 12829. Onondaga Limestone, western New York.
1, 4, 5. Transverse thin section (× 2½), two corallites (× 5), and detail from margin of smaller corallite (× 50).
2, 3. Longitudinal thin sections (× 5).



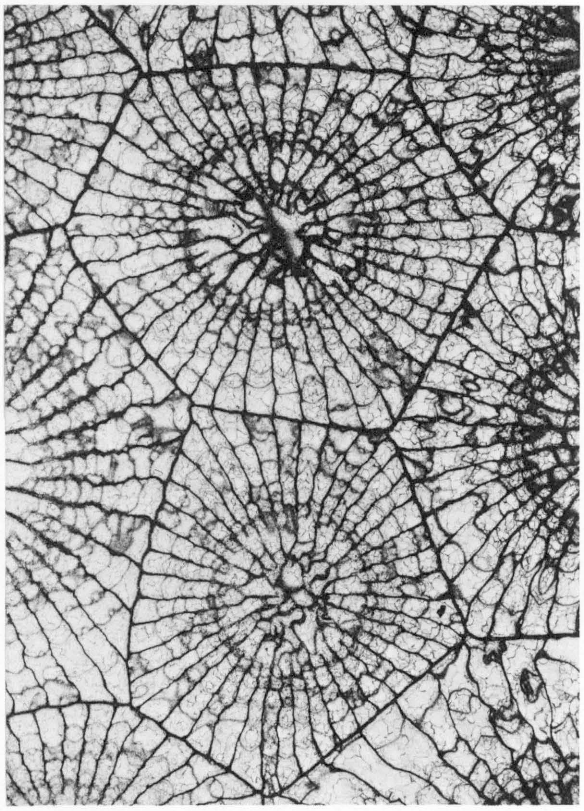
1



2



3



4

5

PRISMATOPHYLLUM OVOIDEUM (DAVIS)

PLATE 52

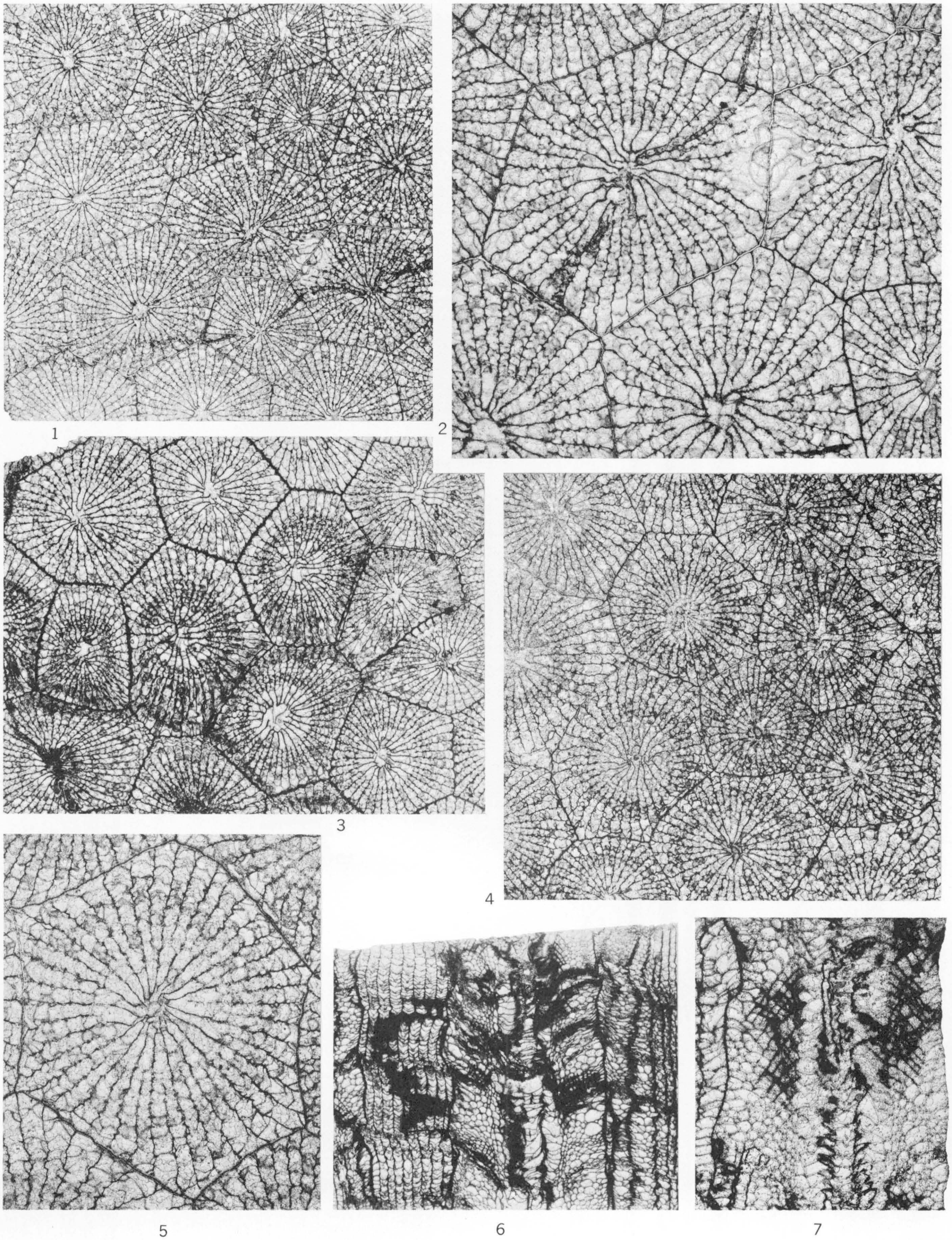
FIGURES 1–7. *Prismatophyllum ovoideum* (Davis) (p. 83).

Edgecliff Member and equivalents, Ontario and New York.

1, 2, 7. USNM 163414. Transverse thin section (× 2½, × 5) and longitudinal thin section (× 5). Amherstburg Formation. Loc. C27.

3, 6. UMMP 24178. Transverse and longitudinal thin sections (× 2½). Amherstburg Formation. Beachville, Ontario.

4, 5. NYSM 12830. Transverse thin section (× 2½, × 5). Onondaga Limestone, western New York.



PRISMATOPHYLLUM OVOIDEUM (DAVIS)

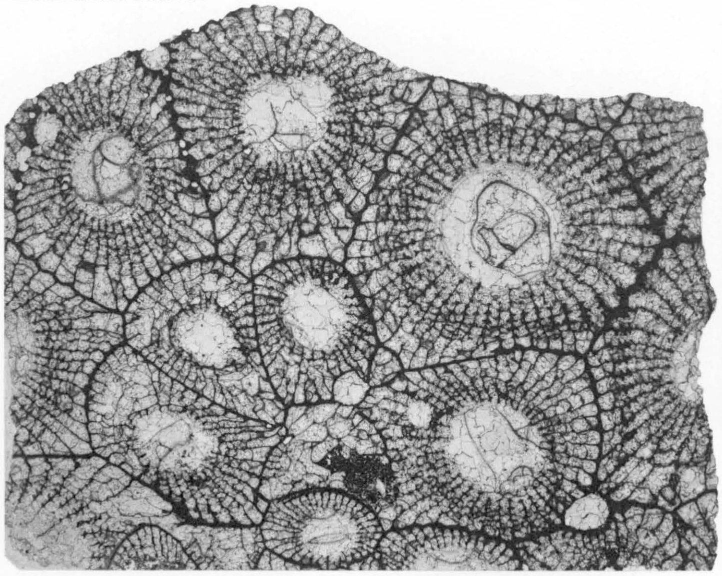
PLATE 53

FIGURES 1–6. *Prismatophyllum truncata* Stewart (p. 85).

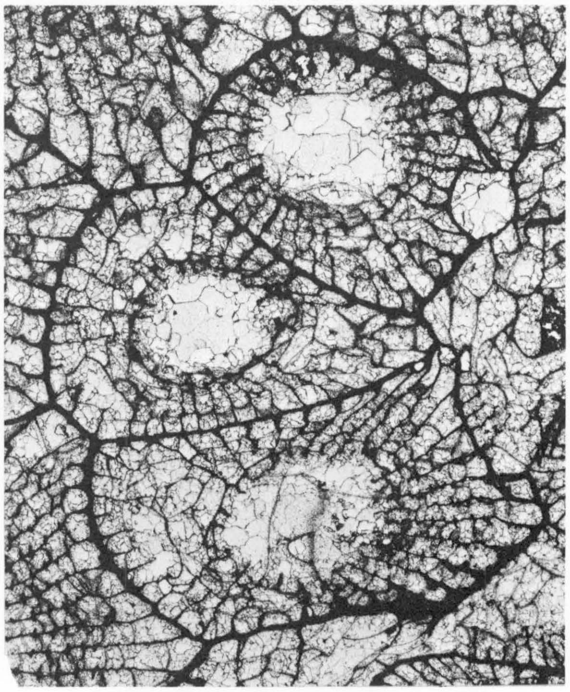
Holotype, OSU 17786. Upper Columbus or Dundee Limestone, Ohio.

1–4. Transverse thin section (× 2½) and details of three parts of same section (× 5).

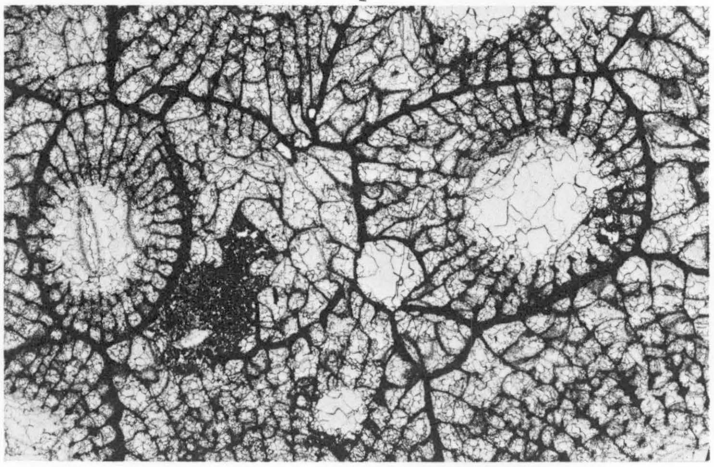
5, 6. Longitudinal thin sections (× 2½, × 5).



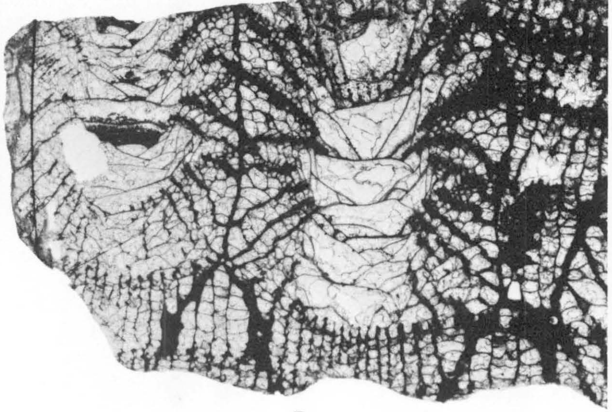
1



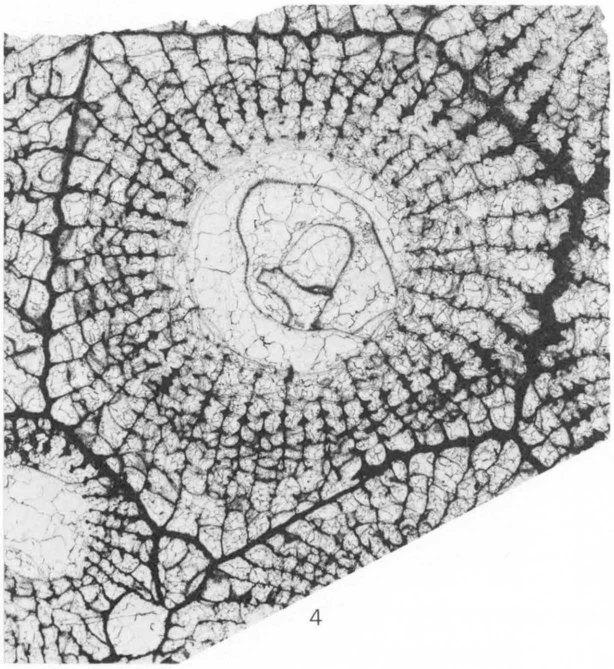
2



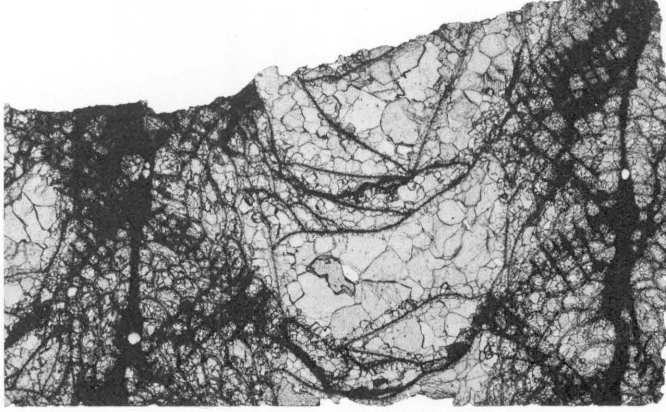
3



5



4



6

PRISMATOPHYLLUM TRUNCATA STEWART

PLATE 54

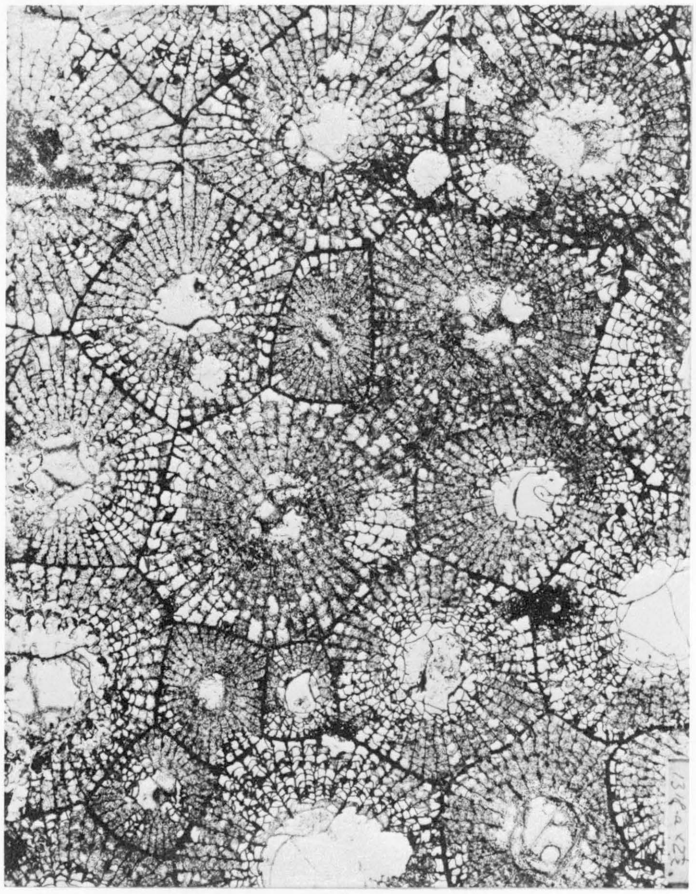
FIGURES 1–4. *Prismatophyllum truncata* Stewart (p. 85).

USNM 163418. Seneca Member, New York. Loc 46.

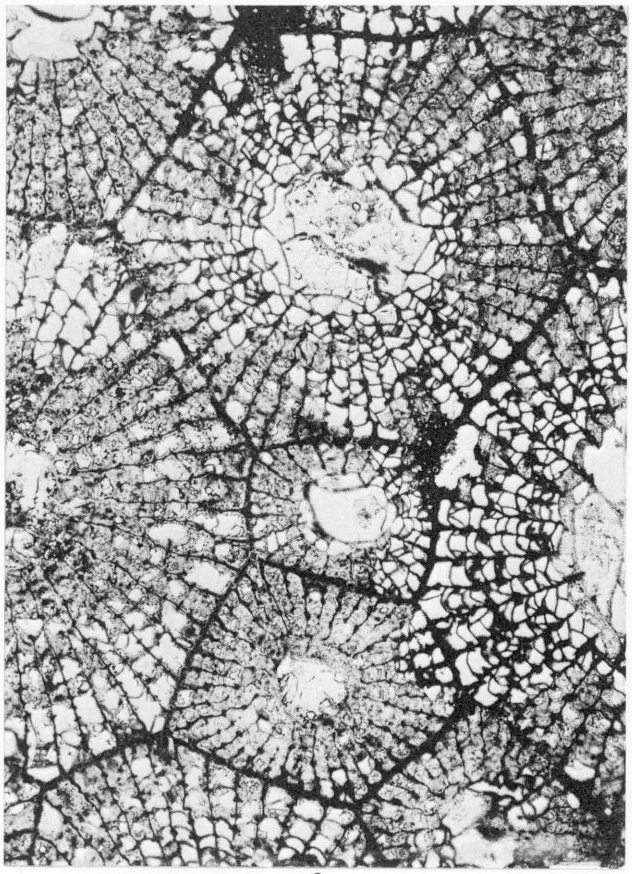
1, 2. Transverse thin section (× 2½) and three corallites in same (× 5).

3. Longitudinal thin section (× 2½).

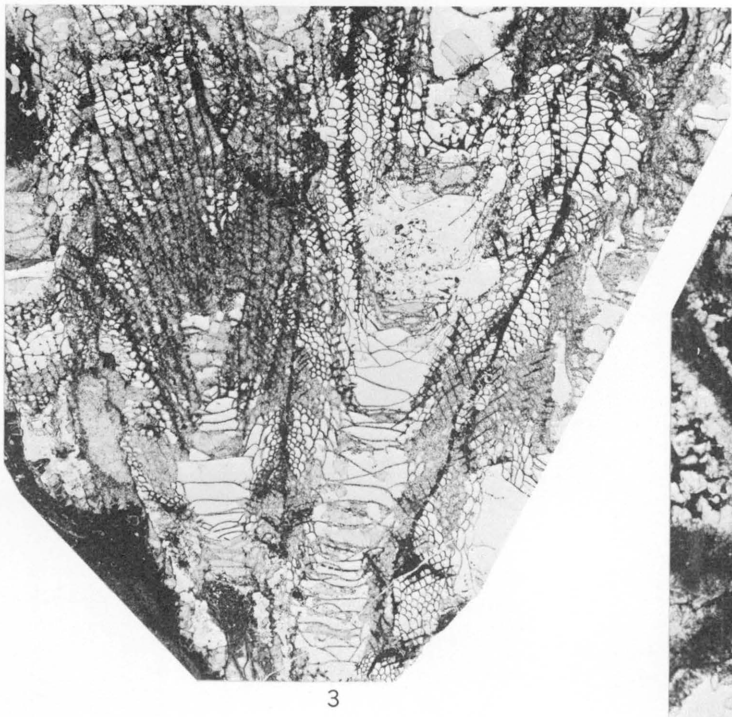
4. Detail of wall and septa of two small corallites shown in fig. 2 (× 50).



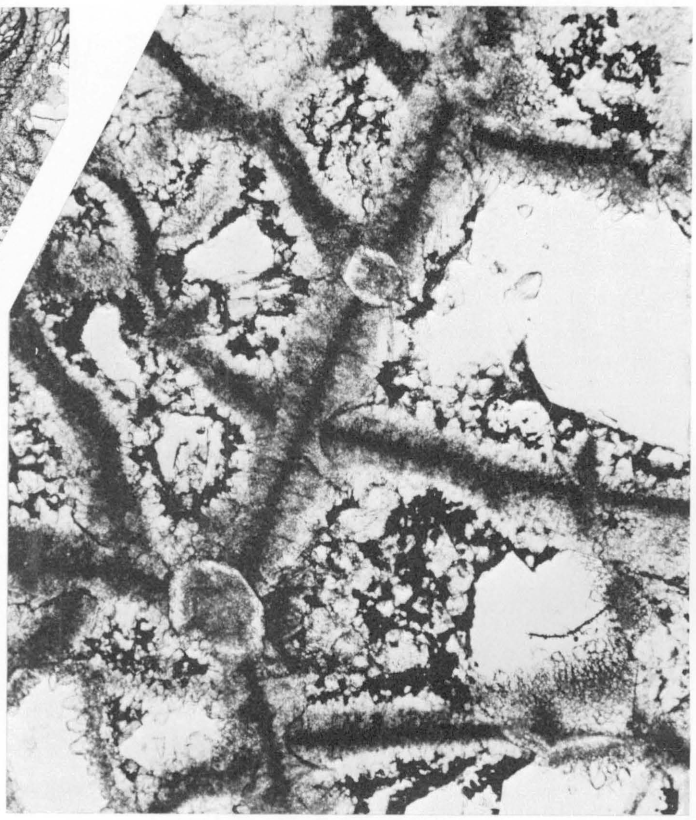
1



2



3



4

PRISMATOPHYLLUM TRUNCATA STEWART

PLATE 55

FIGURES 1–7. *Prismatophyllum anna* (Whitfield) (p. 87).

Lectotype, UCMP 34218. Dundee or "Blue" Limestone, Paulding County, Ohio. See also plate 56, figure 7.

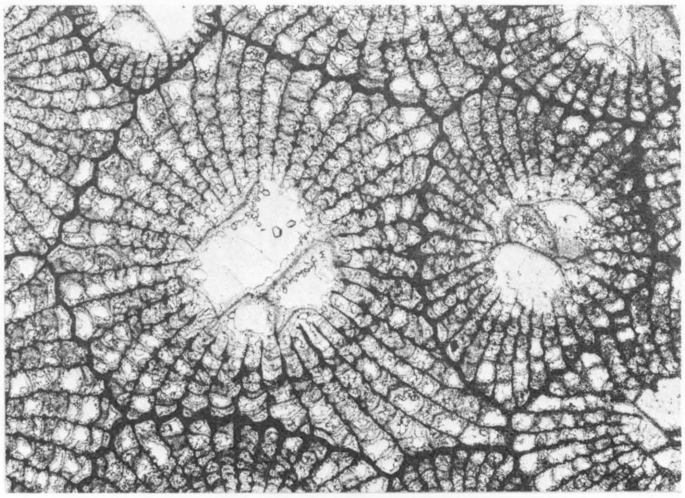
1, 2. Two views of lectotype fragment (× 1). Whitfield's fig. 4 is from the face in fig. 2.

3, 5, 7. Transverse thin section (× 5, × 5, × 2½).

4. Detail of wall and septa in same transverse thin section (× 50).

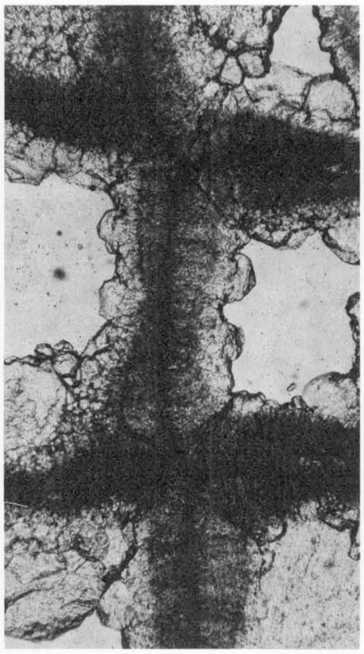
6. Longitudinal thin section (× 5).

1

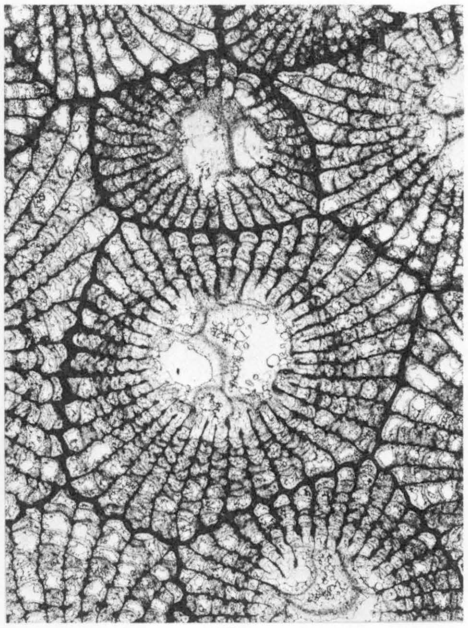


3

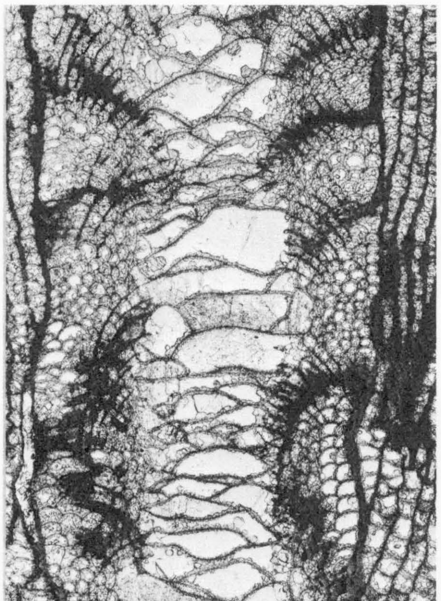
2



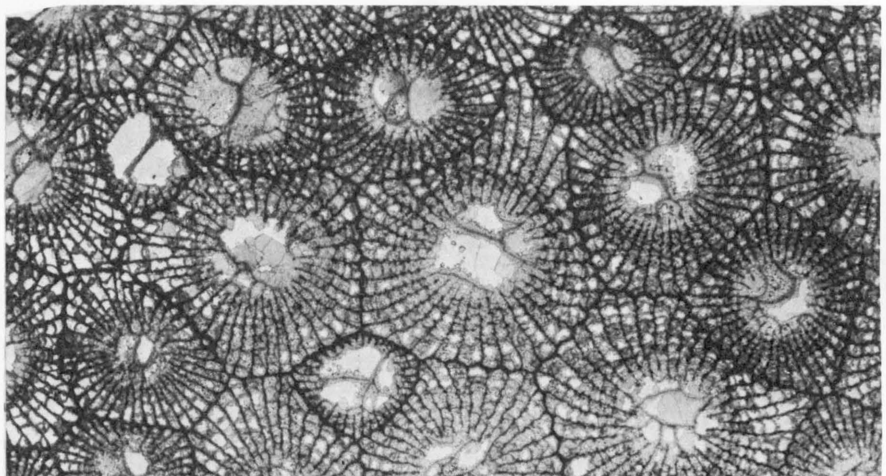
4



5



6



7

PRISMATOPHYLLUM ANNA (WHITFIELD)

PLATE 56

FIGURES 1–7. *Prismatophyllum anna* (Whitfield) (p. 87).

"Blue" (?) Limestone, Ohio.

1–3, 6. Paralectotype, OSU 3743–2.

1, 2. Transverse thin section (× 2½) and part of same (× 5).

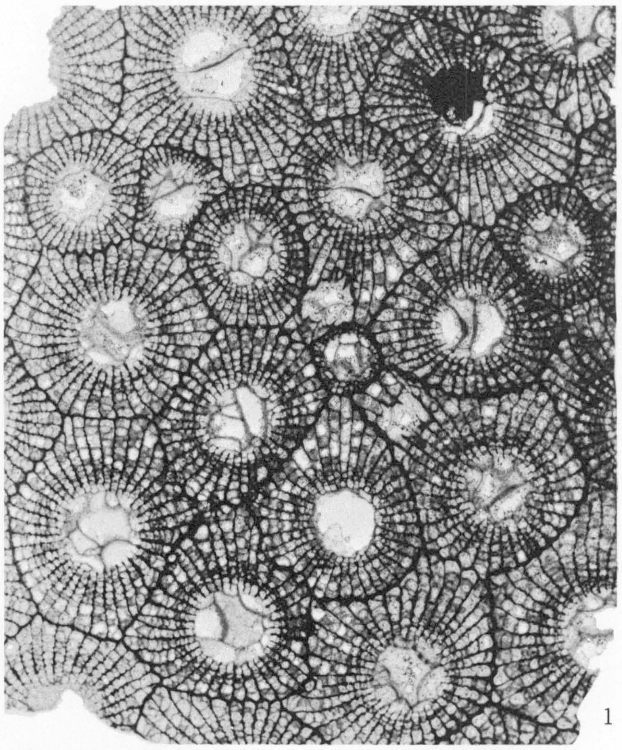
3. Part of longitudinal thin section shown in fig. 6 (× 5).

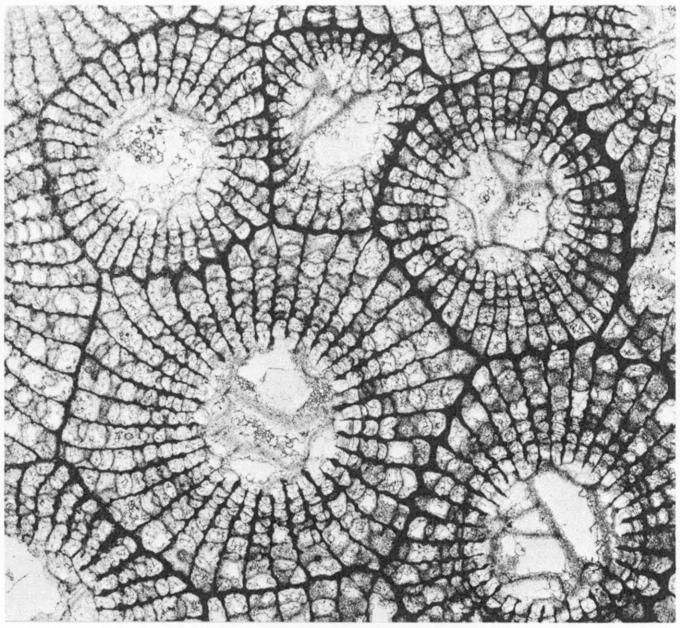
6. Longitudinal thin section (× 2½).

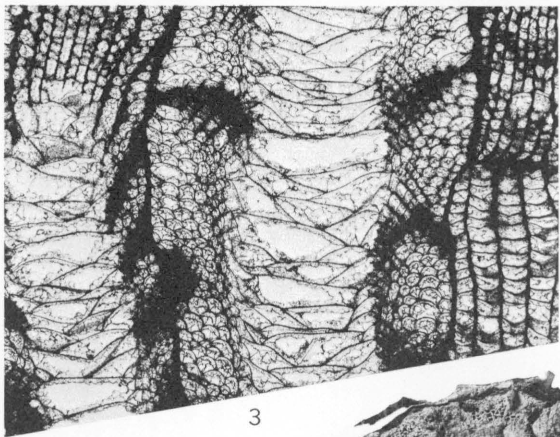
4. Paralectotype, UCMP 34216. Transverse thin section (× 5).

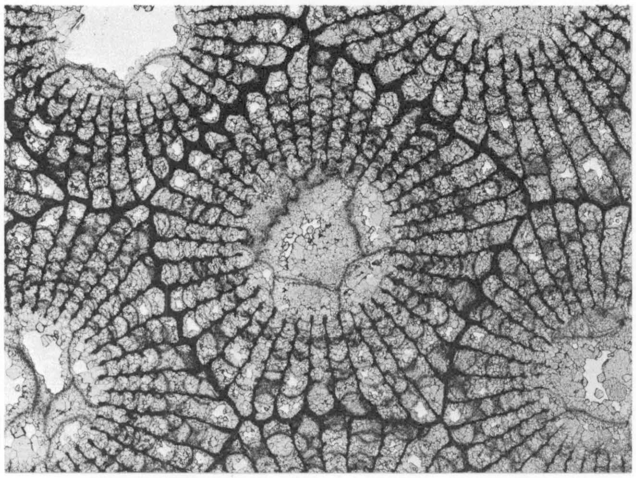
5. Paralectotype, UCMP 34217. The original of Whitfield's fig. 2.

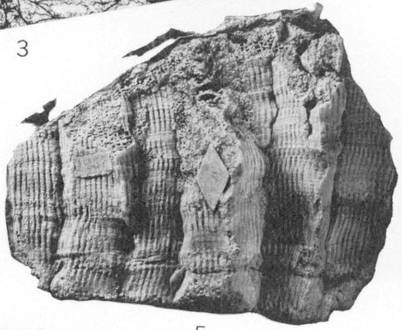
7. Lectotype, UCMP 34218. Part of section illustrated in pl. 55, fig. 7 (× 5).

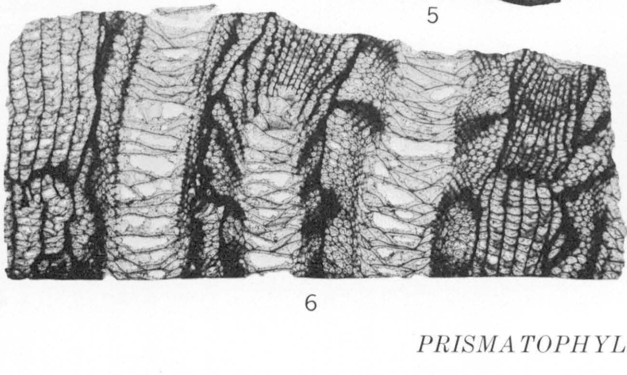

1

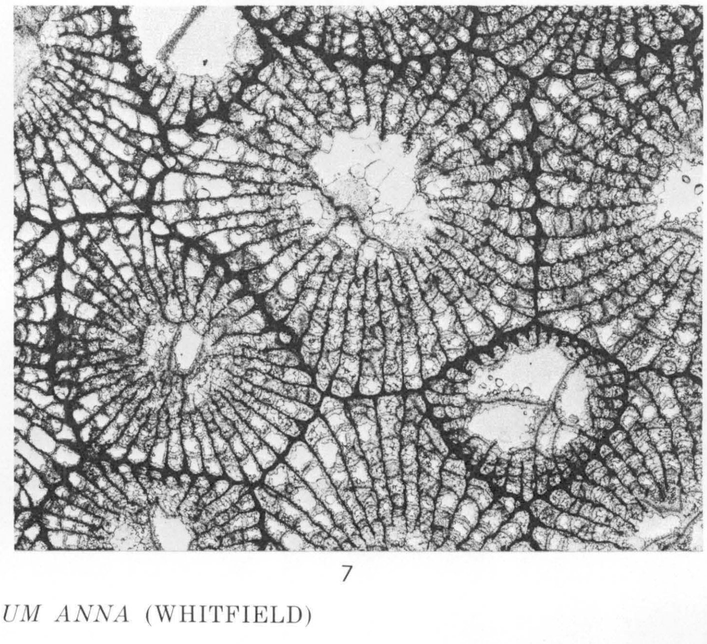

2


3


4


5

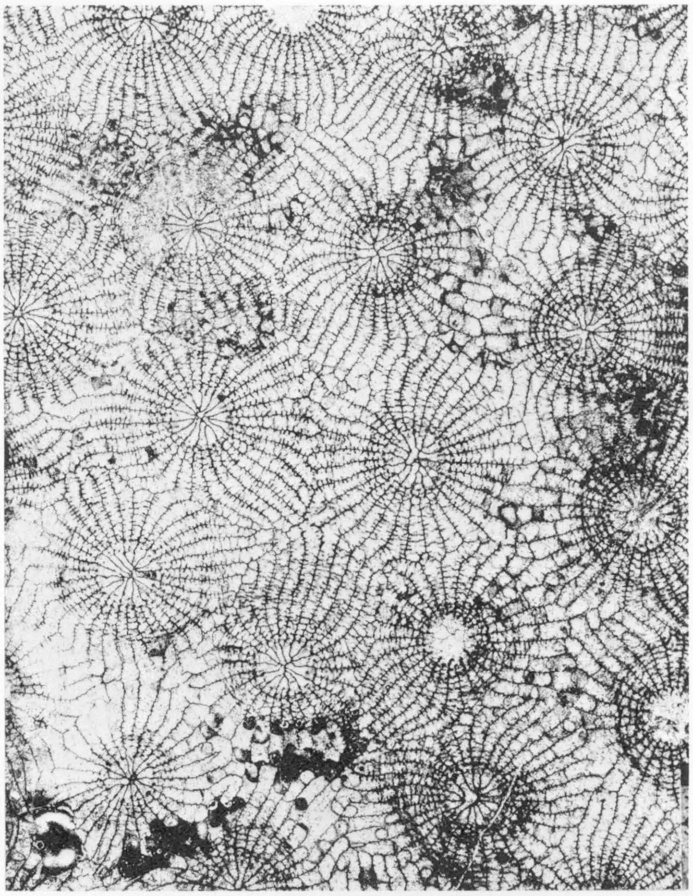

6


7

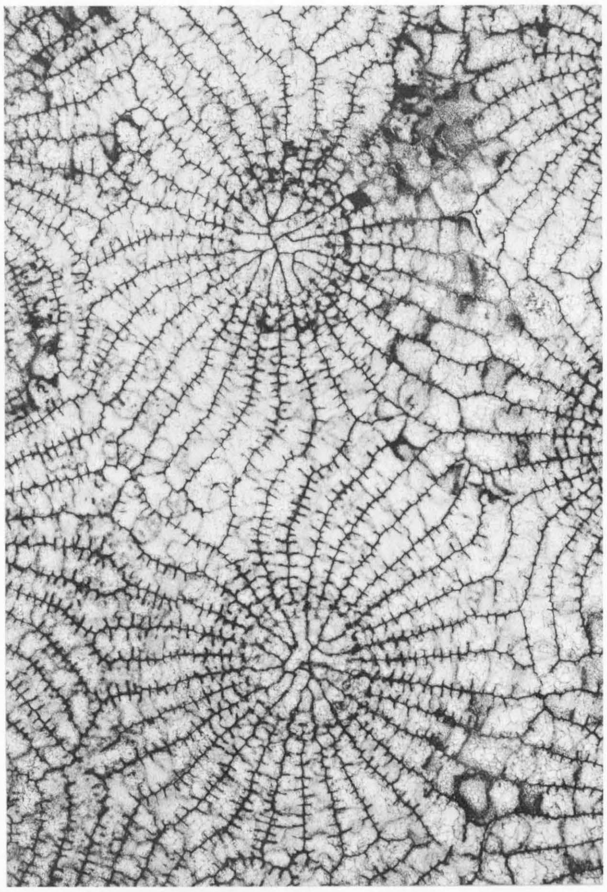
PRISMATOPHYLLUM ANNA (WHITFIELD)

PLATE 57

FIGURES 1–5. *Asterobillingsa magdisa magdisa* Oliver (p. 93).
Schoharie Formation, New York.
1, 2, 5. Holotype, USNM 163419. Loc. 73.
1, 2. Transverse thin section (× 2½) and two corallites of same (× 5).
5. Longitudinal thin section (× 5).
3, 4. Paratype, NYSM 12828. Transverse and longitudinal thin sections. Schoharie County.

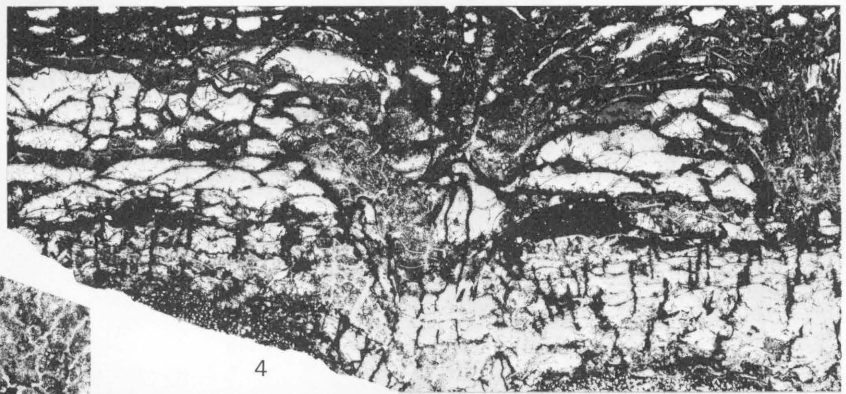


1

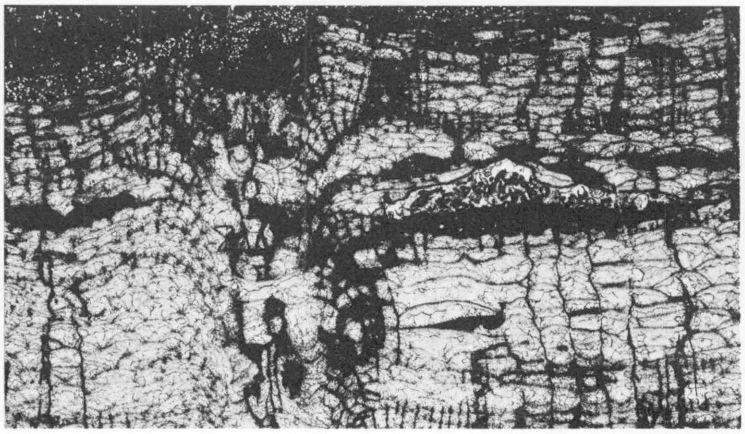


2

3



4



5

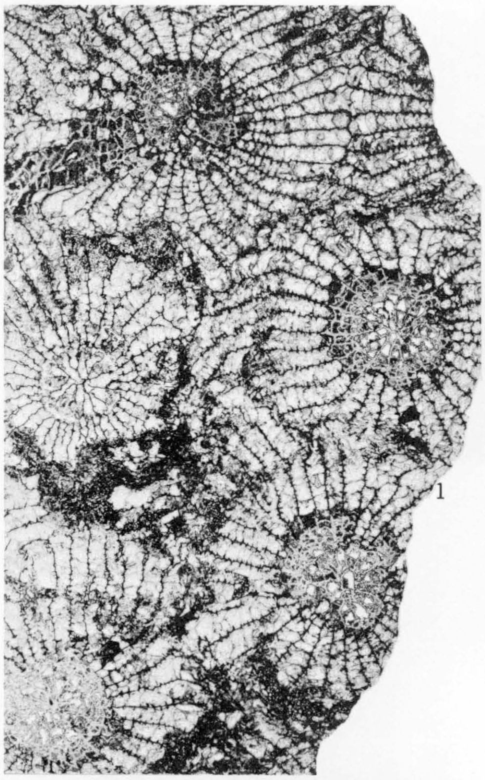
ASTEROBILLINGSA MAGDISA MAGDISA OLIVER

PLATE 58

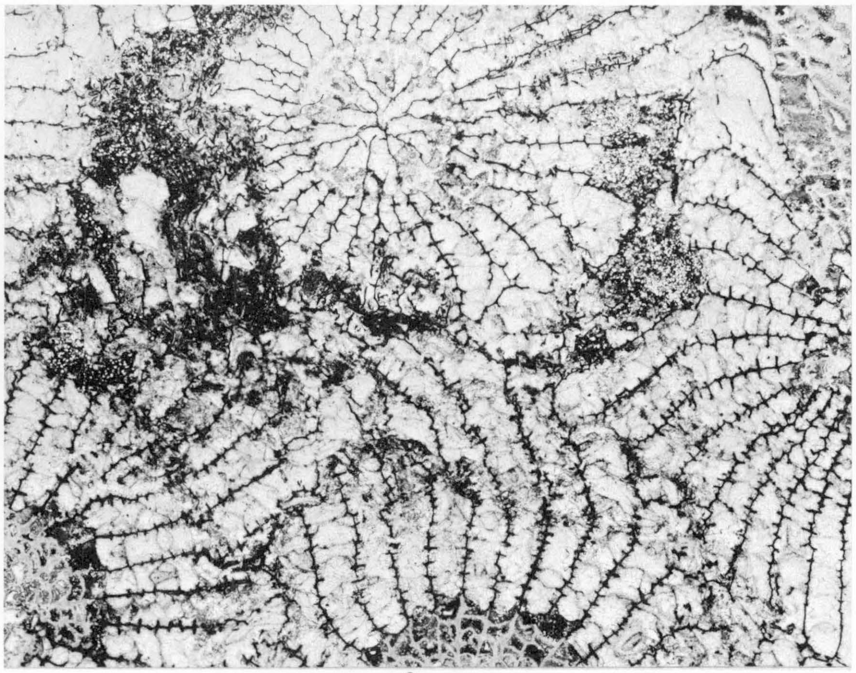
FIGURES 1–6. *Asterobillingsa magdisa magdisa* Oliver (p. 93).

1–3. Paratype AMNH 641. Transverse (× 2½, × 5) and longitudinal (× 2½) thin sections. Schoharie Grit, Schoharie, N.Y.

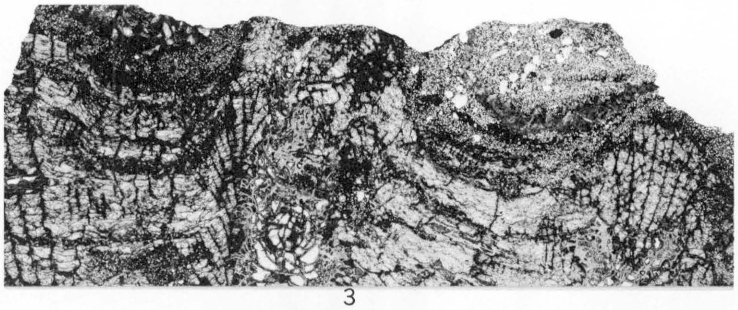
4–6. Paratype, USNM 128016. Two longitudinal and one transverse thin sections (× 2½). Bois Blanc Formation, Port Colborne, Ontario. This is original of Ehlers and Stumm, 1953, pl. 1, figs. 2–3, as *Billingsastraea verneuili*.



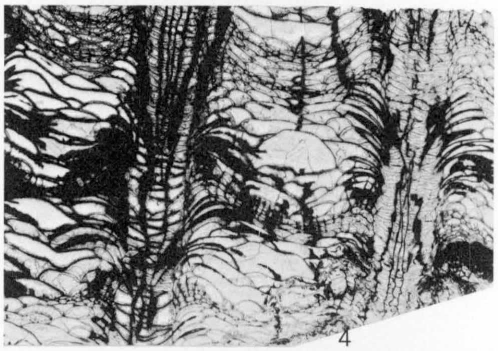
1



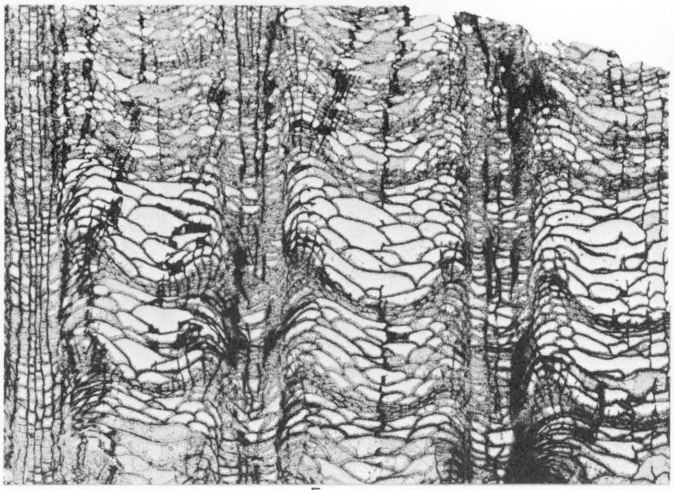
2



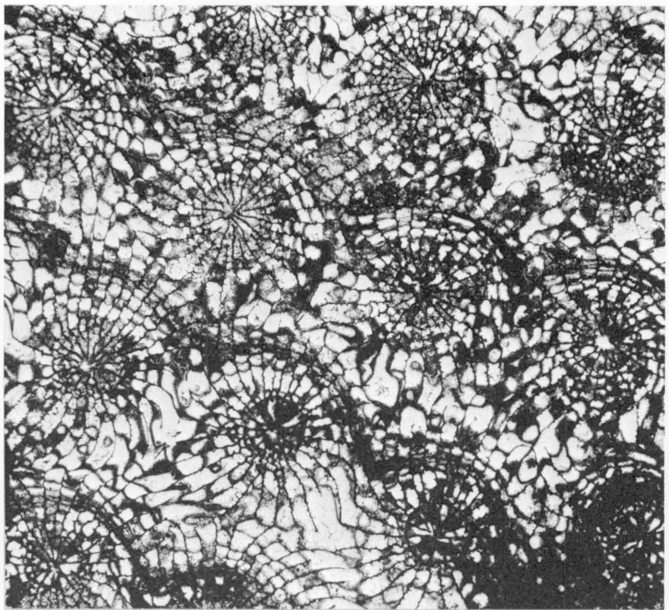
3



4



5



6

ASTEROBILLINGSA MAGDISA MAGDISA OLIVER

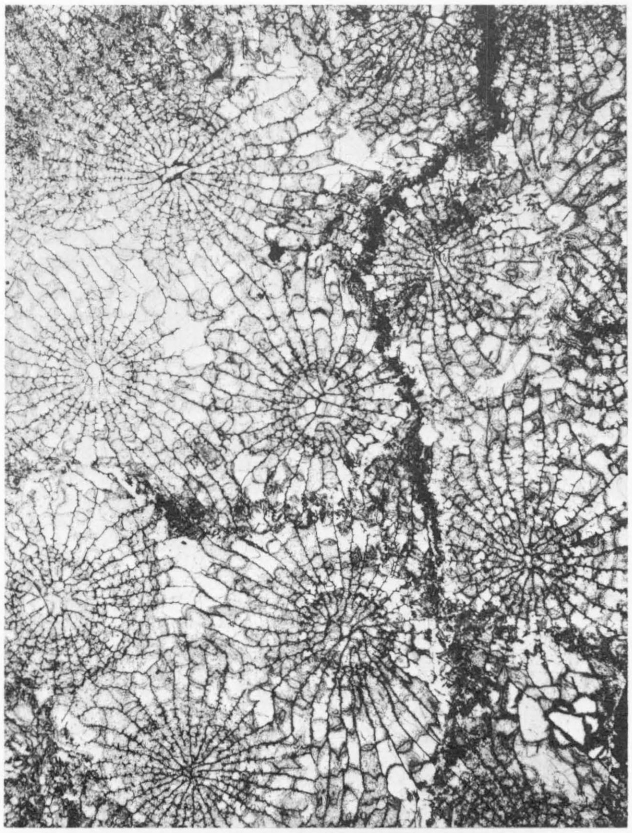
PLATE 59

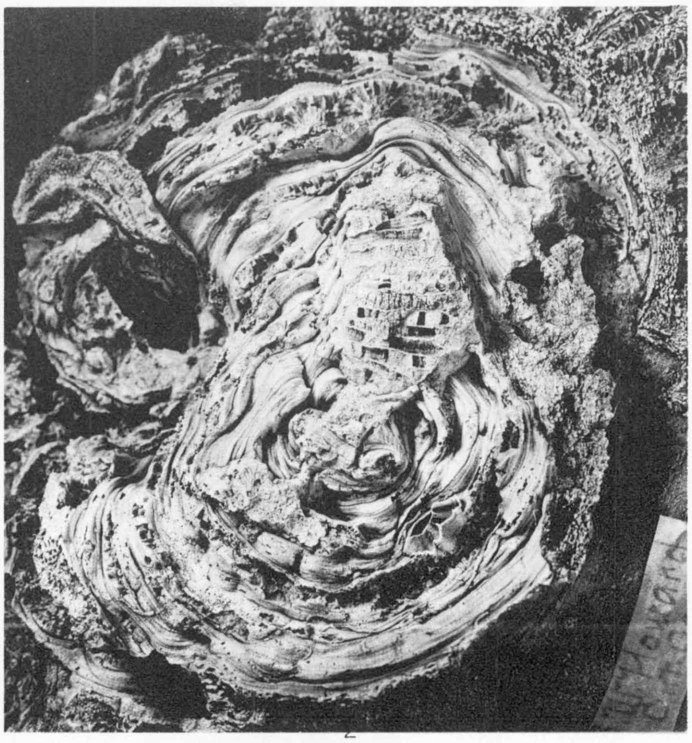
FIGURES 1–5. *Asterobillingsa magdisa magdisa* Oliver (p. 93).

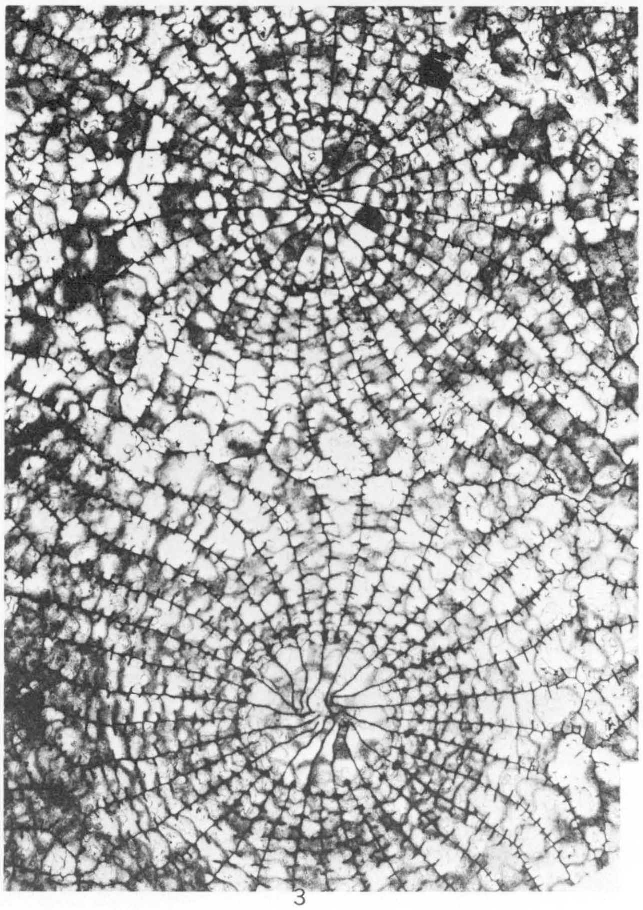
Bois Blanc Formation, Ontario.

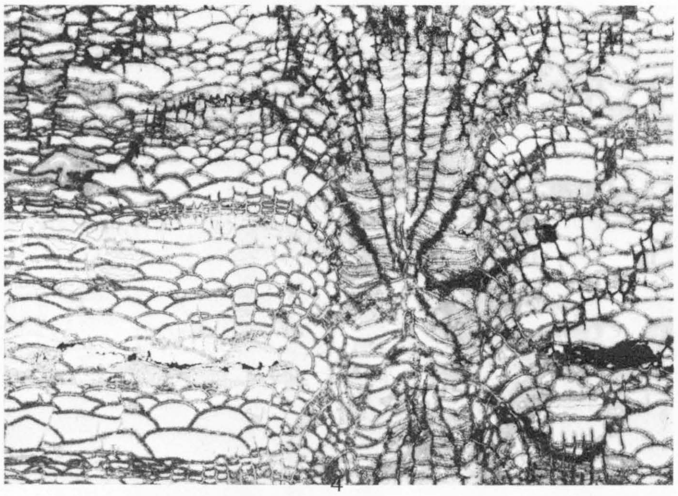
1. Paratype, USNM 113264. Transverse thin section (× 2½). Port Colborne.
2. Paratype, USNM 163423. Base of silicified corallum, to show holotheca (× 1). Hagarsville.

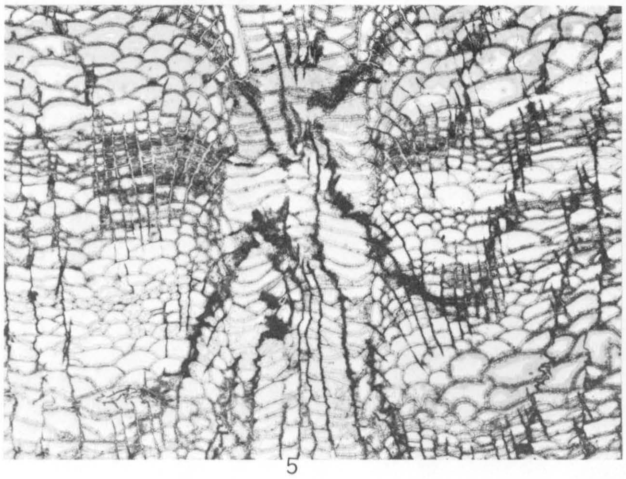
3–5. Paratype, USNM 163420. Transverse thin section (× 5) and two parts of one longitudinal thin section (× 5). Loc. C20.


1


2


3

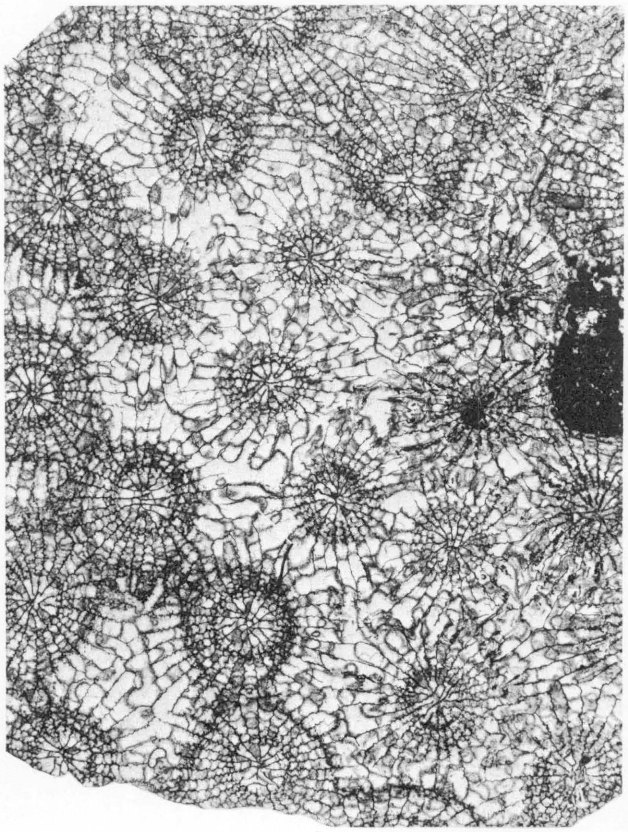

4


5

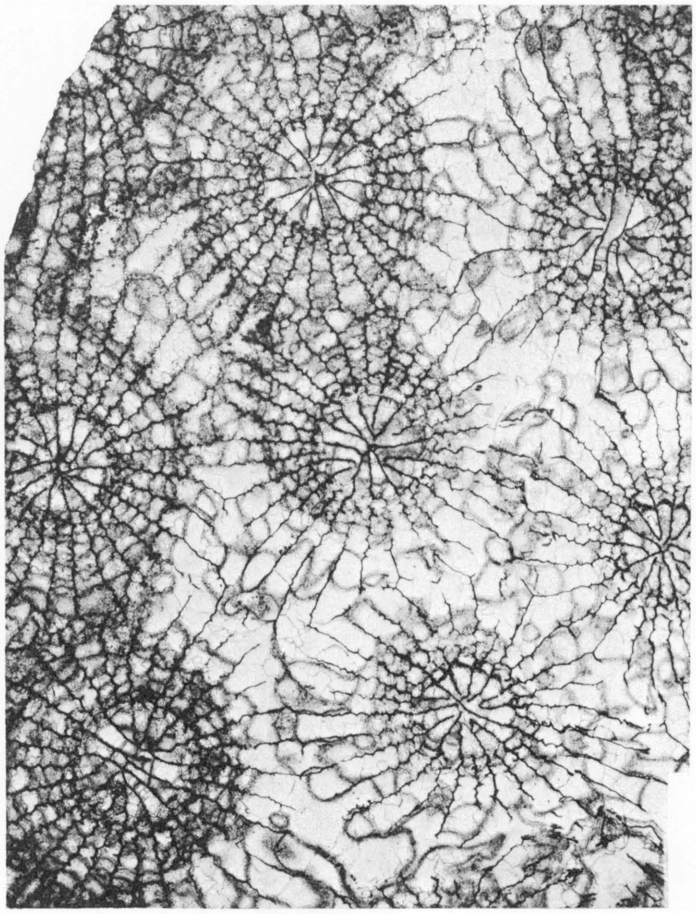
ASTEROBILLINGSA MAGDISA MAGDISA OLIVER

PLATE 60

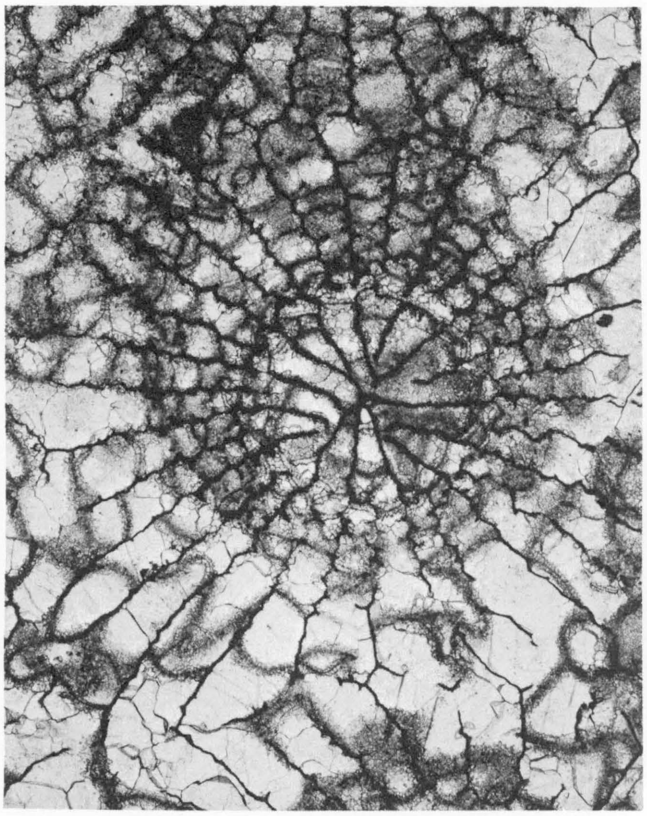
FIGURES 1–4. *Asterobillingsa magdisa magdisa* Oliver (p. 93).
Paratype, USNM 163422. Edgeciff bioherm facies. Loc. 108.
1–3. Transverse thin section (× 2½) and parts (× 5, × 10).
4. Longitudinal thin section (× 5).



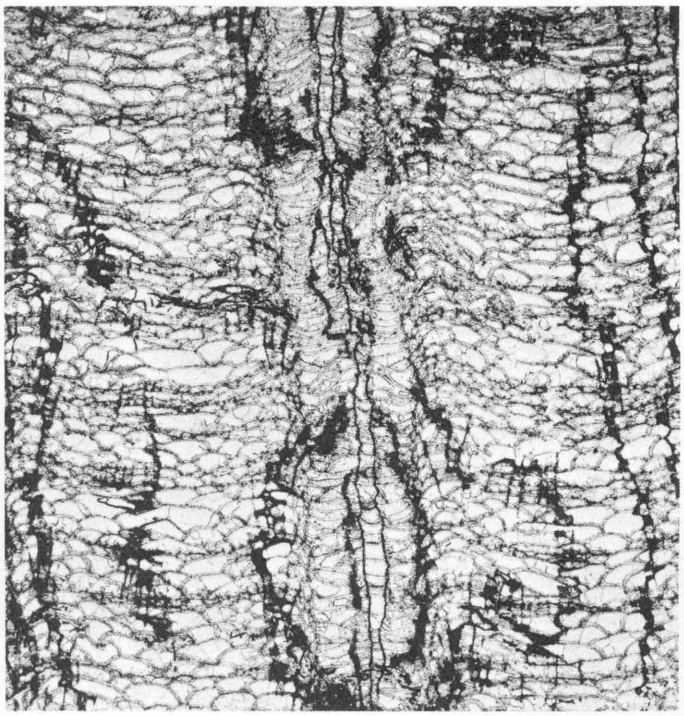
1



2



3

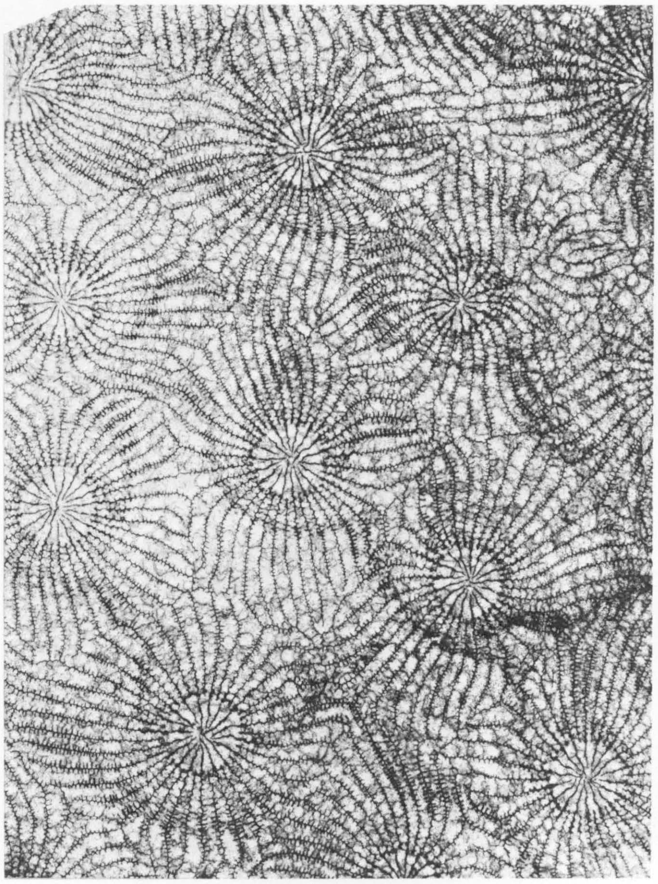


4

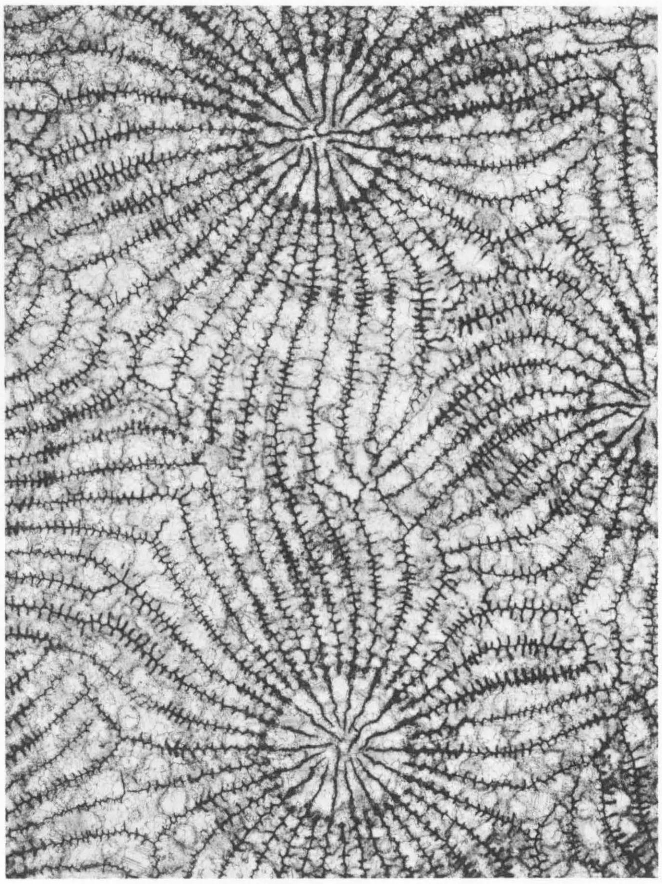
ASTEROBILLINGSA MAGDISA MAGDISA OLIVER

PLATE 61

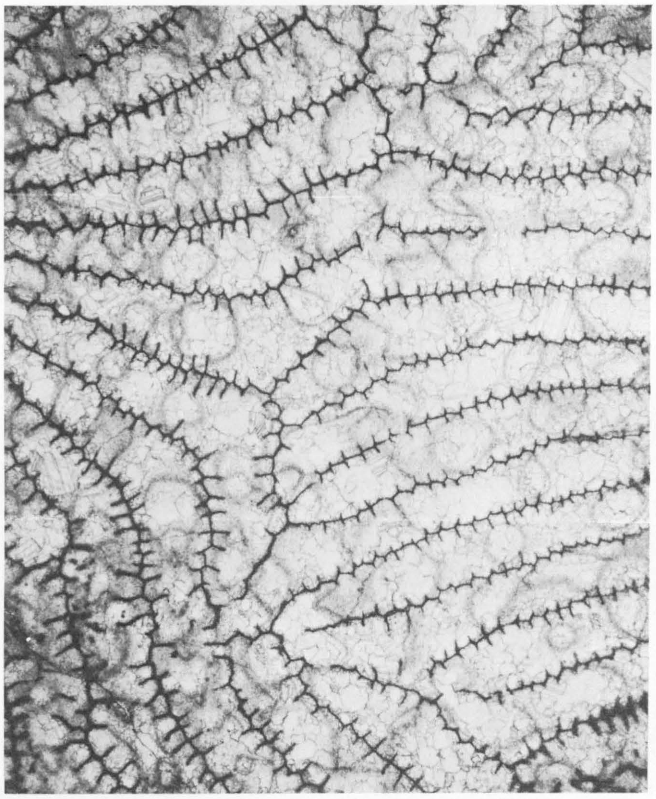
FIGURES 1–4. *Asterobillingsa magdisa steorra* Oliver (p. 94).
Holotype, NYSM 12824. Onondaga Limestone, Clarksville, N.Y. Four photographs of one transverse thin section to show morphology of septa and carinae (× 2½, × 5, × 10, × 50). See also pl. 62.



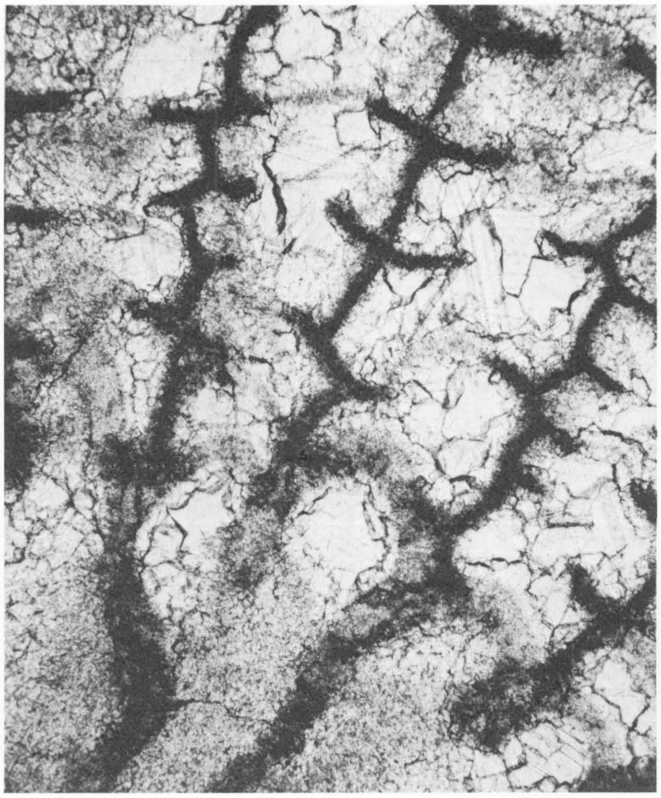
1



2



3

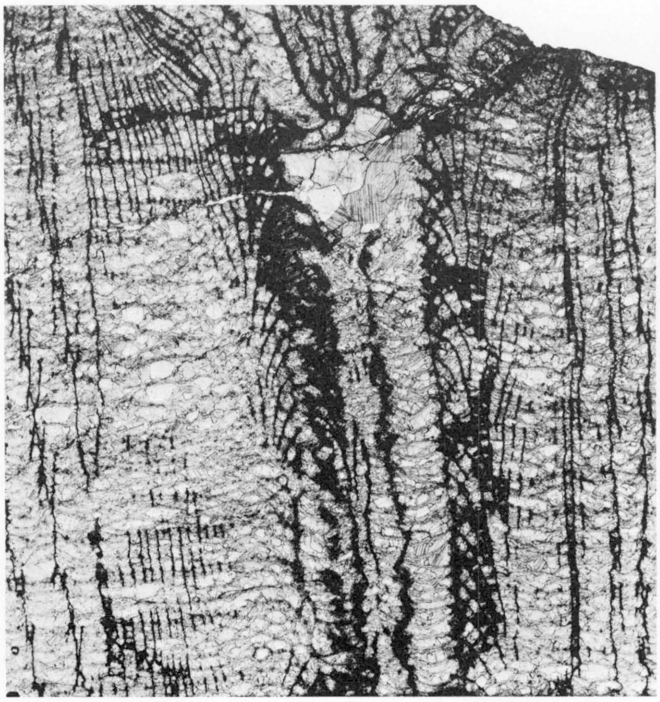


4

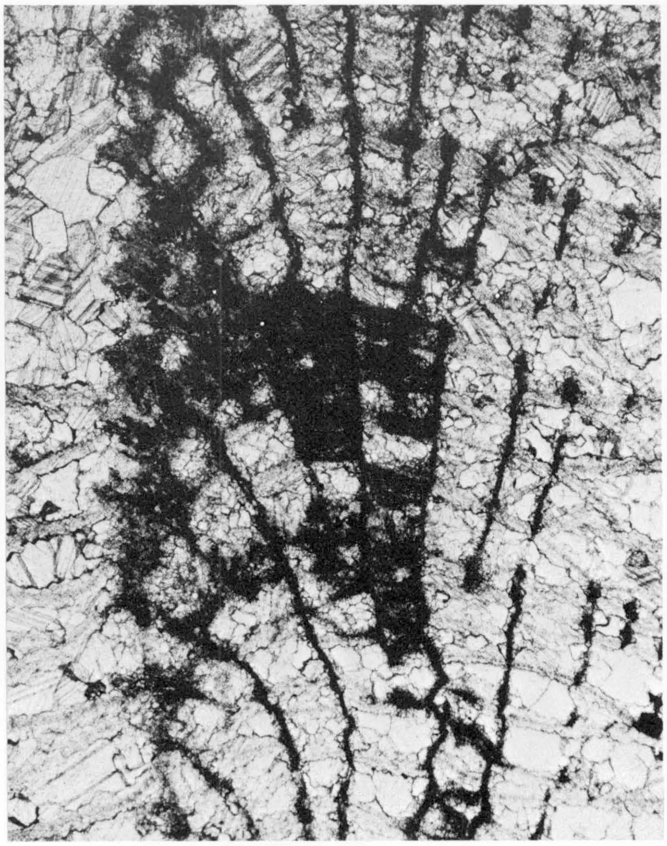
ASTEROBILLINGSA MAGDISA STEORRA OLIVER

PLATE 62

FIGURES 1–4. *Asterobillingsa magdisa steorra* Oliver (p. 94).
Holotype, NYSM 12824. Onondaga Limestone, Clarksville, N.Y. Four photographs of one longitudinal thin section to show general morphology and details of carinae and trabeculae (× 5, × 25, × 25, × 50). See also pl. 61.

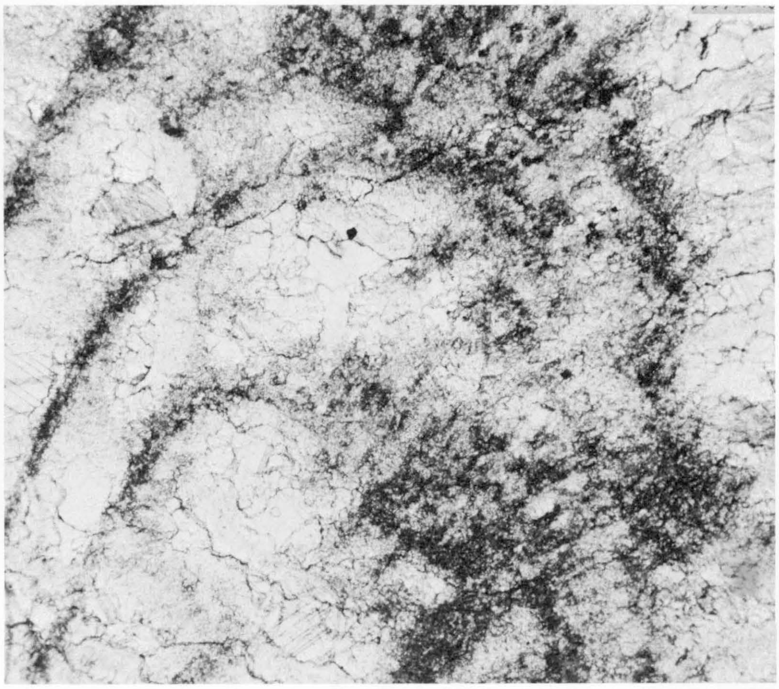


1



2

3



4

ASTEROBILLINGSA MAGDISA STEORRA OLIVER

PLATE 63

FIGURES 1–5. *Asterobillingsa magdisa steorra* Oliver (p. 94).

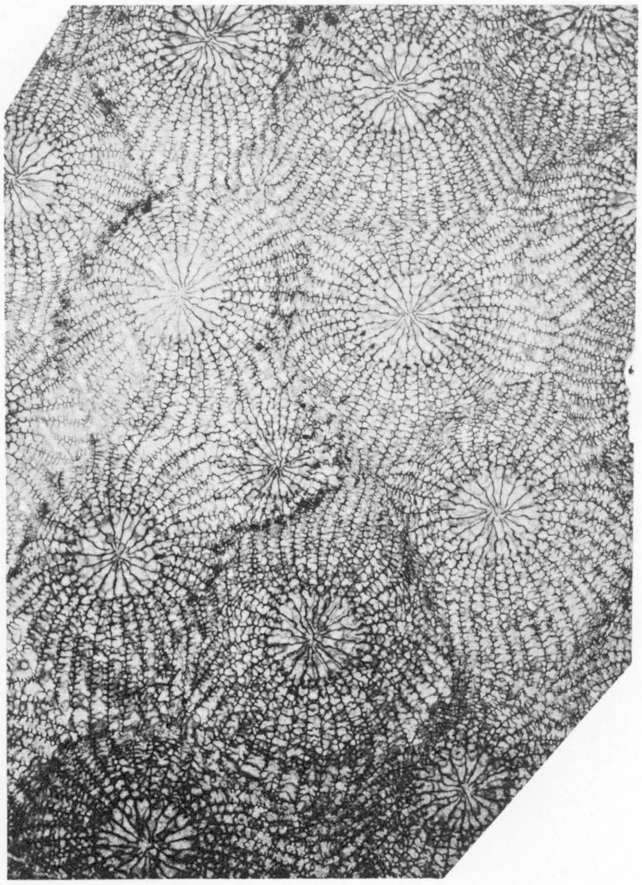
1–3. Paratype, GSC 31155. Woodstock, Ontario.

1, 2. Transverse thin section (× 2½, × 5).

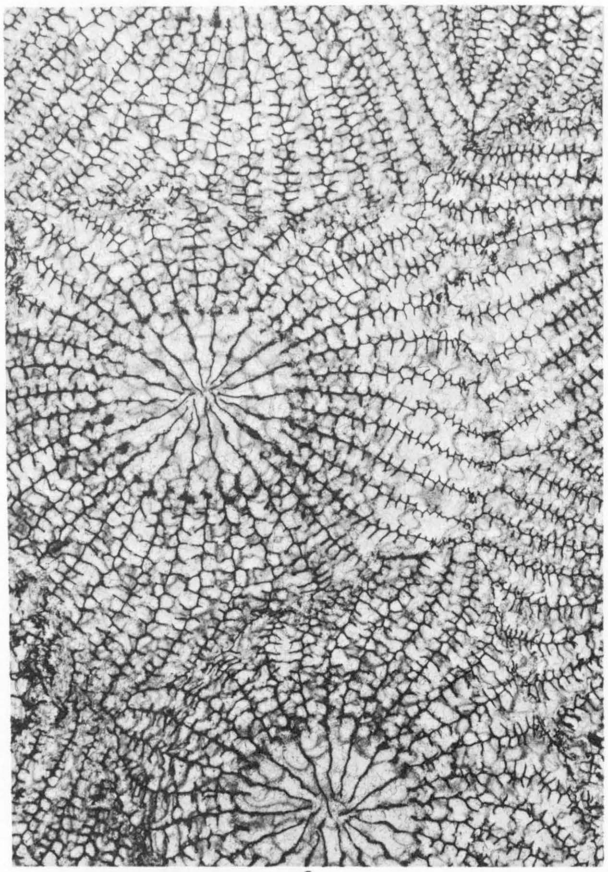
3. Longitudinal thin section (× 5).

4. Paratype, USNM 172167. Longitudinal thin section (× 5). Edgecliff bioherm facies. Loc. 108.

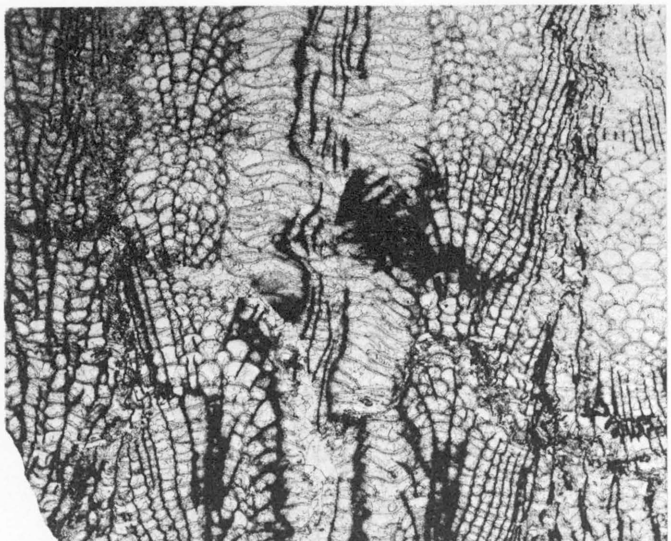
5. Paratype, USNM 172168. Longitudinal thin section (× 5). Edgecliff bioherm facies. Loc. 108.



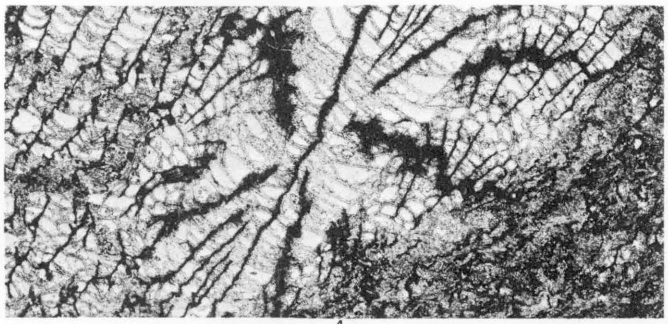
1



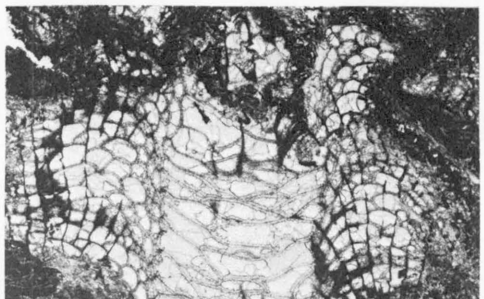
2



3



4

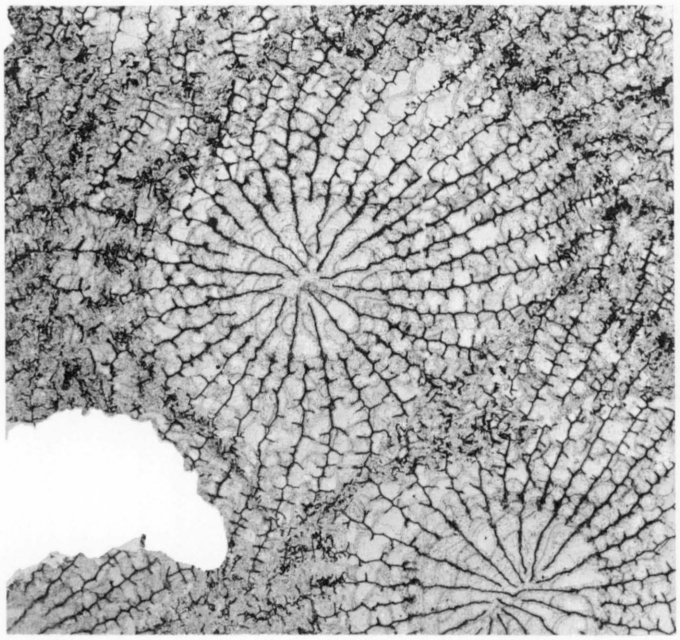


5

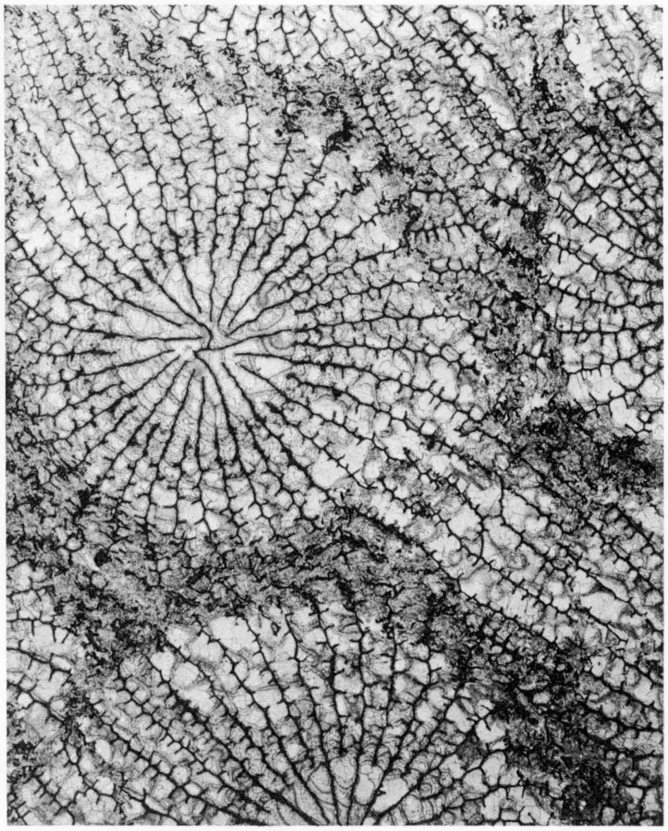
ASTEROBILLINGSA MAGDISA STEORRA OLIVER

PLATE 64

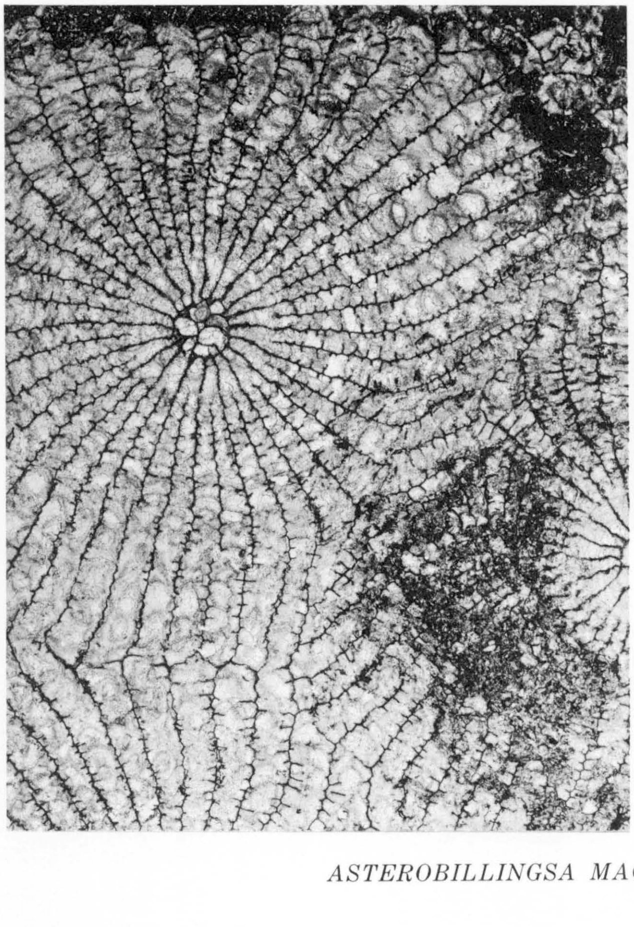
FIGURES 1–4. *Asterobillingsa magdisa steorra* Oliver (p. 94).
Edgecliff bioherm facies, New York.
1, 2. Paratype, USNM 172166. Two corallites from same transverse section (× 5). Loc. 108.
3, 4. Paratype, NYSM 12826. Two corallites from same transverse section (× 5). Loc. 269.



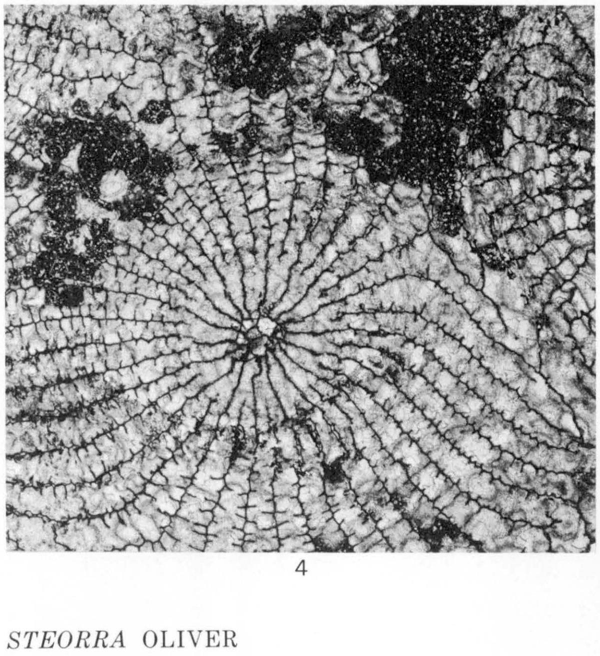
1



2



3



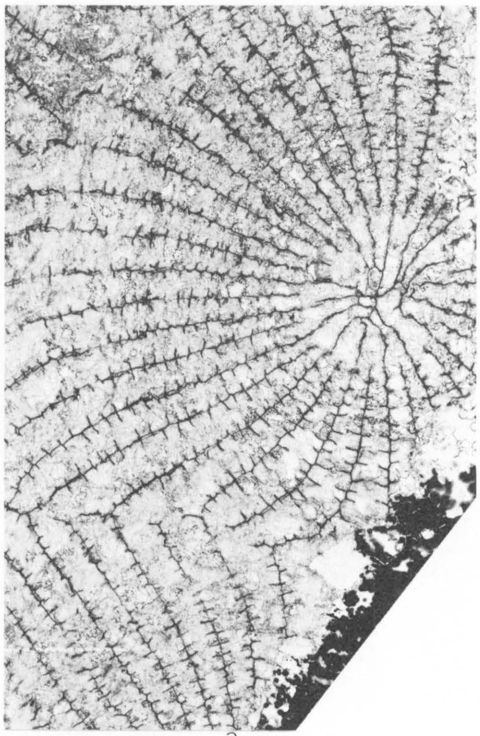
4

ASTEROBILLINGSA MAGDISA STEORRA OLIVER

PLATE 65

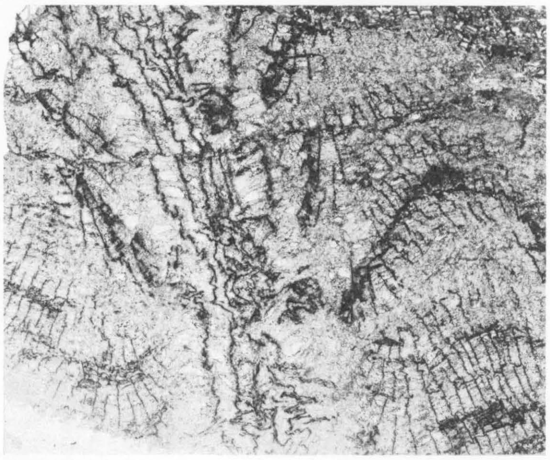
FIGURES 1–5. *Asterobillingsa rugosa* (Hall) (p. 94).
Holotype, NYSM 299. Leroy, N.Y.
1, 2. Longitudinal thin section (× 10, × 5).
3–5. Transverse thin section (× 5, × 5, × 2½).

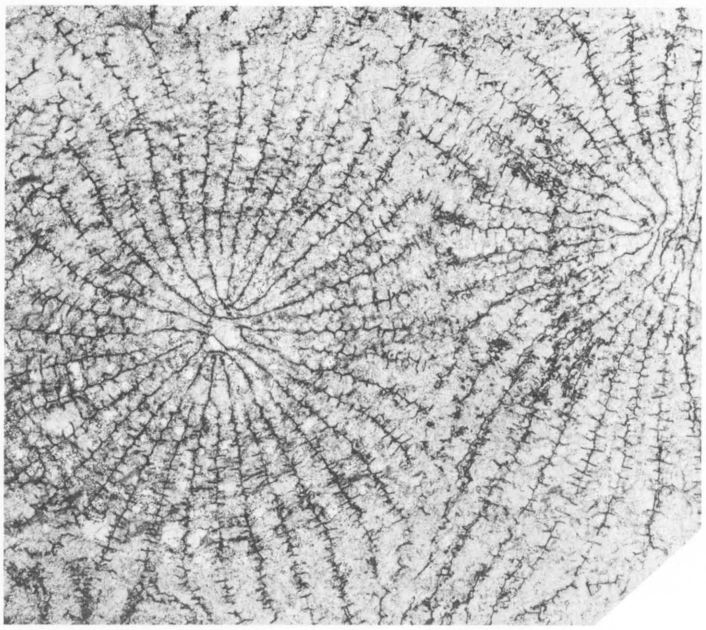
1



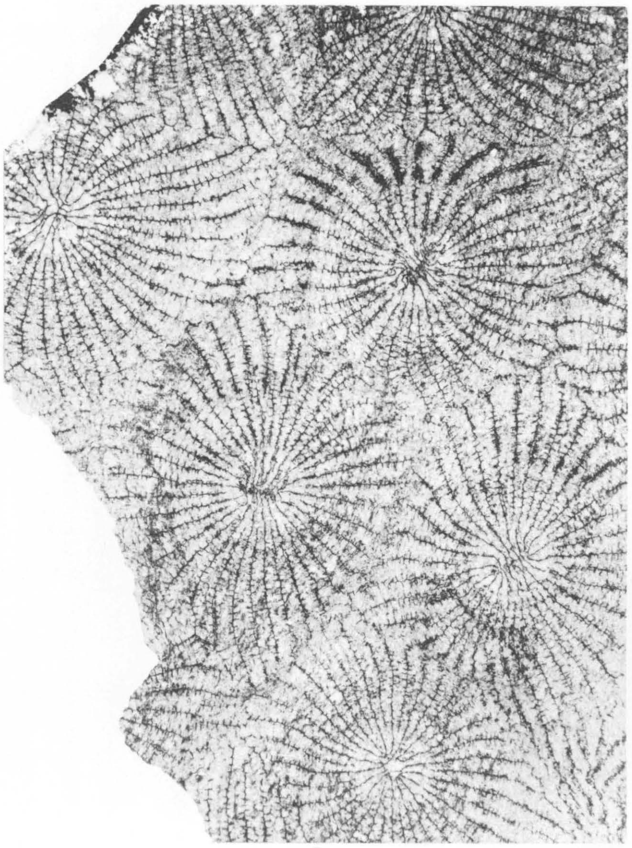
3

2





4



5

ASTEROBILLINGSA RUGOSA (HALL)

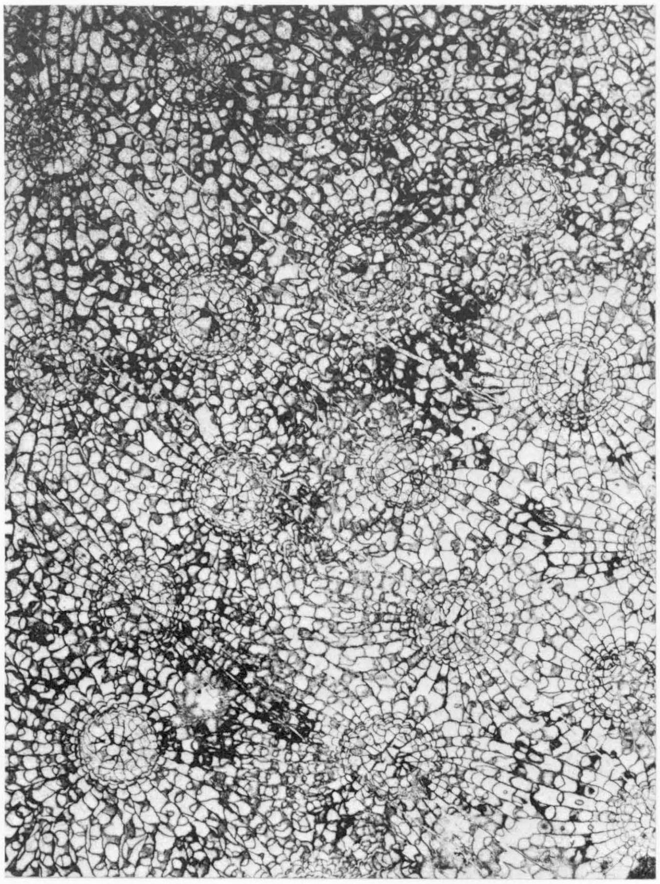
PLATE 66

FIGURES 1–4. *Radiastraea arachne* Stumm (p. 90).

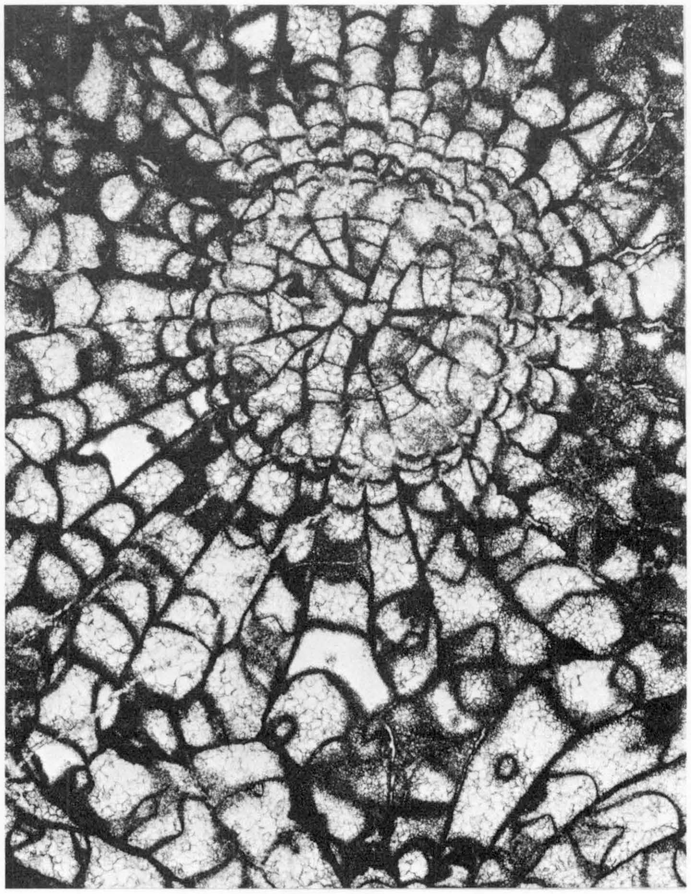
Holotype, USNM 94458. Lower part of Nevada Formation, Nevada. Illustrated here for comparison with *Asterobillingsa* spp.

1–3. Transverse thin section (× 2½, × 5, and × 10).

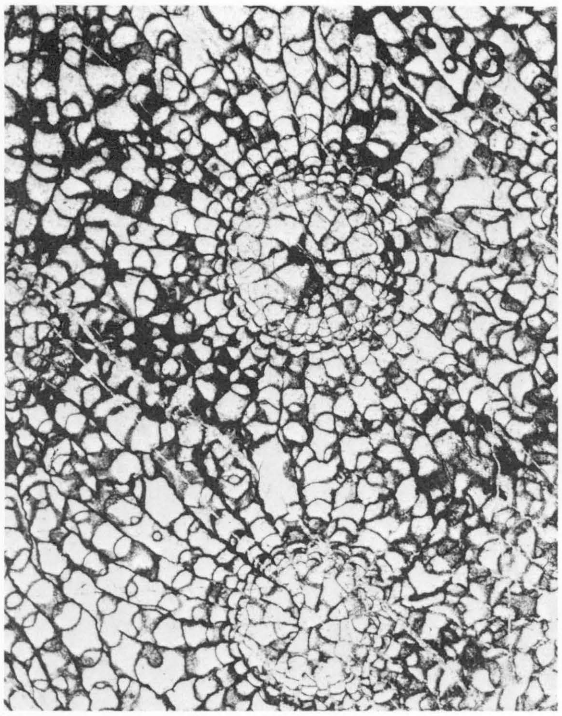
4. Longitudinal thin section (× 10).



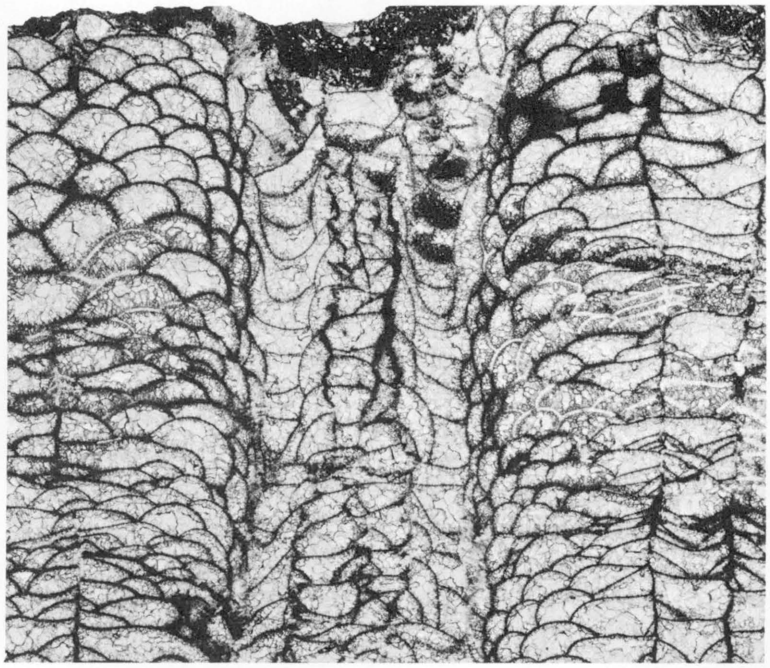
1



3



2



4

RADIASTRAEA ARACHNE STUMM

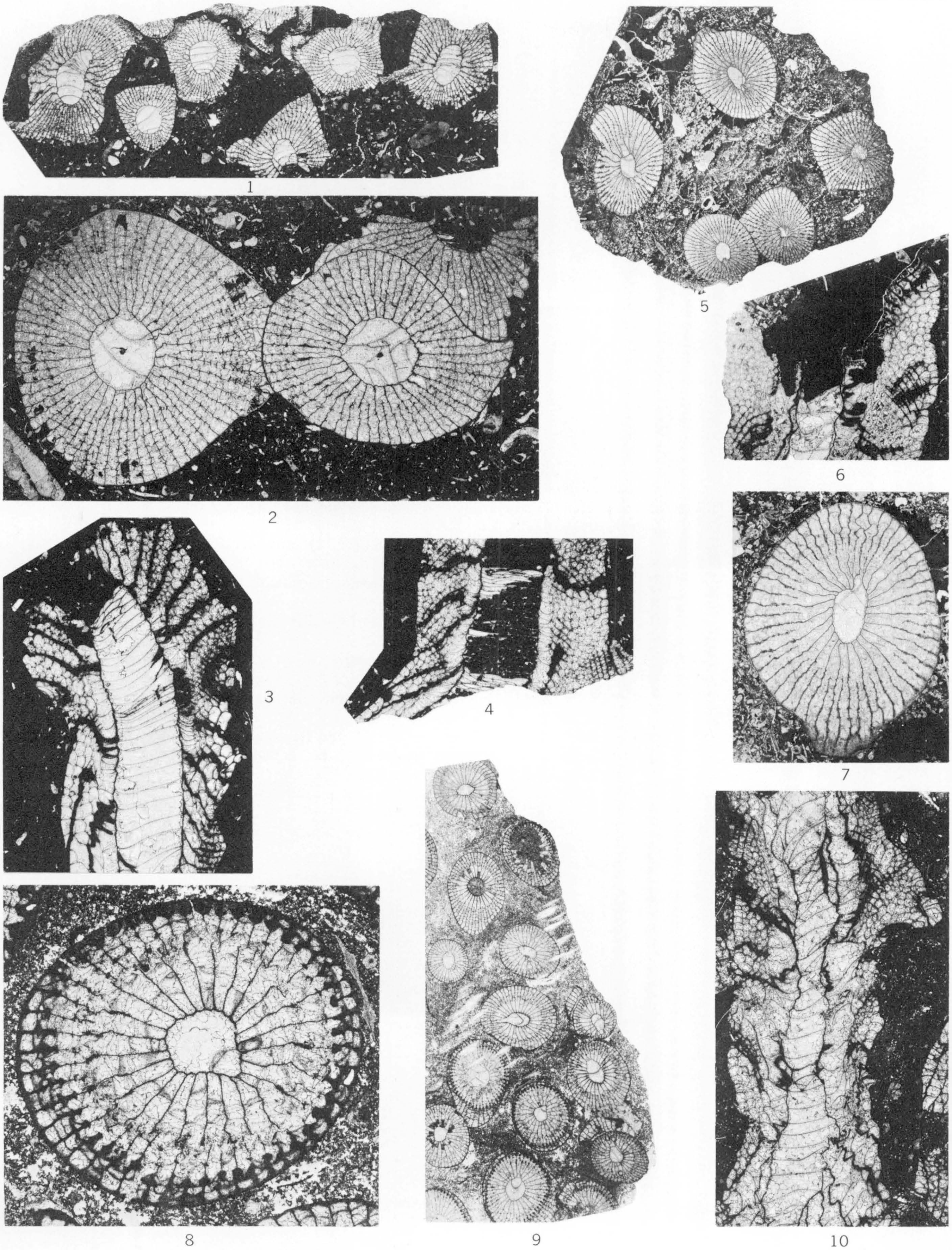
PLATE 67

FIGURES 1–10. *Eridophyllum seriale* Milne-Edwards and Haime (p. 99).
New York and Ohio.

1–4. USNM 163424. Moorehouse Member. Loc. 497.
- 1, 2. Two transverse thin sections (× 1, × 2½).
- 3, 4. Two longitudinal thin sections (× 2½).

5–7. USNM 10721. Onondaga Limestone, Albany, N.Y.
- 5, 7. Transverse thin section (× 1) and one corallite from same (× 2½).
- 6. Longitudinal thin section (× 2½).

8–10. USNM 163425. Columbus Limestone, Zone H, Marblehead, Ohio (USGS loc. 7786–SD).
- 8, 9. Transverse thin section, one corallite (× 5) and section (× 1).
- 10. Longitudinal thin section (× 2½).



ERIDOPHYLLUM SERIALE MILNE-EDWARDS AND HAIME

PLATE 68

FIGURES 1–10. *Eridophyllum seriale* Milne-Edwards and Haime, population B (p. 99).
Moorehouse Member, *Acinophyllum-Eridophyllum* bed, New York.

1–7. USNM 163426. Loc. 118.

1, 4. Transverse thin section (× 1) and corallite with offsets (× 2½).

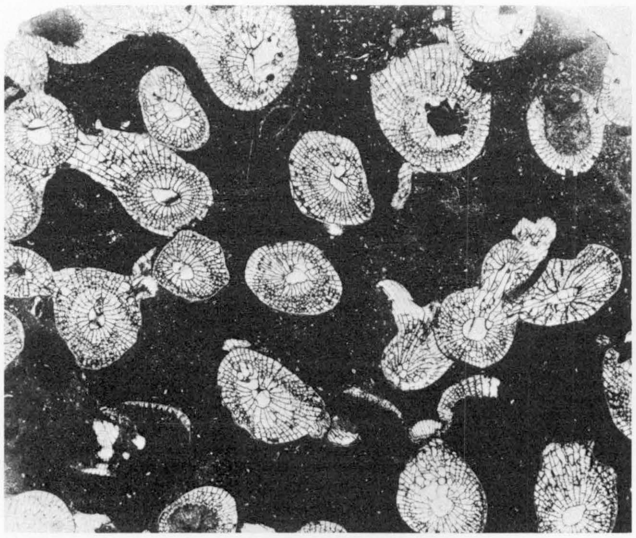
2, 3, 5. Corallites from second transverse thin section (× 2½, × 5, × 2½).

6. Detail of wall and septa of corallite illustrated in fig. 3 (× 50).

7. Longitudinal thin section of corallite with lateral offset (× 2½).

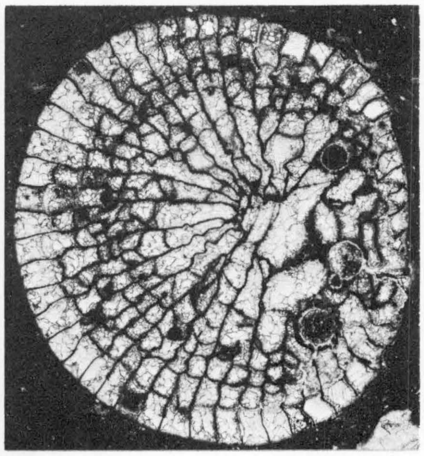
8. NYSM 12831. Longitudinal thin section showing lateral support (× 2½). Loc. 120.

9, 10. USNM 163428. Transverse (× 5) and longitudinal (× 2½) thin sections. Note parasite tubes in fig. 9 and the resulting interruptions of the aulos. Loc. 118.

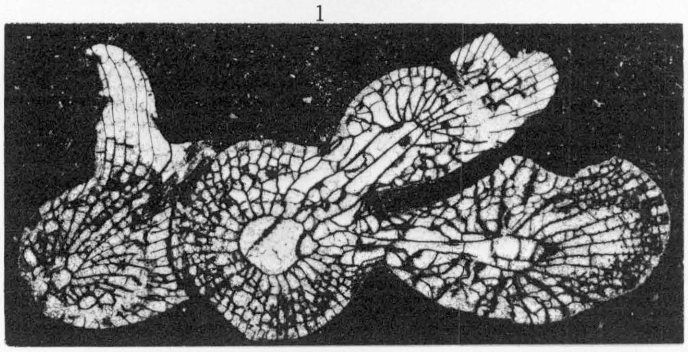


1

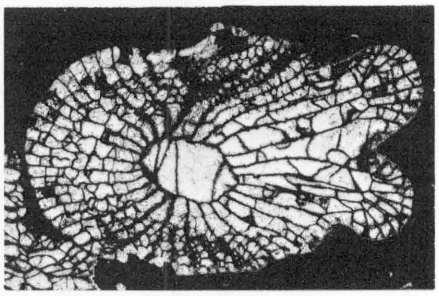
2



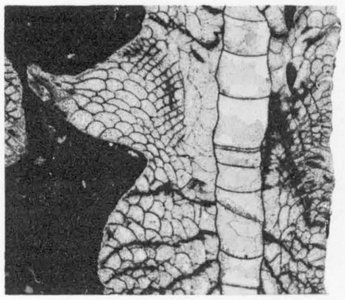
3



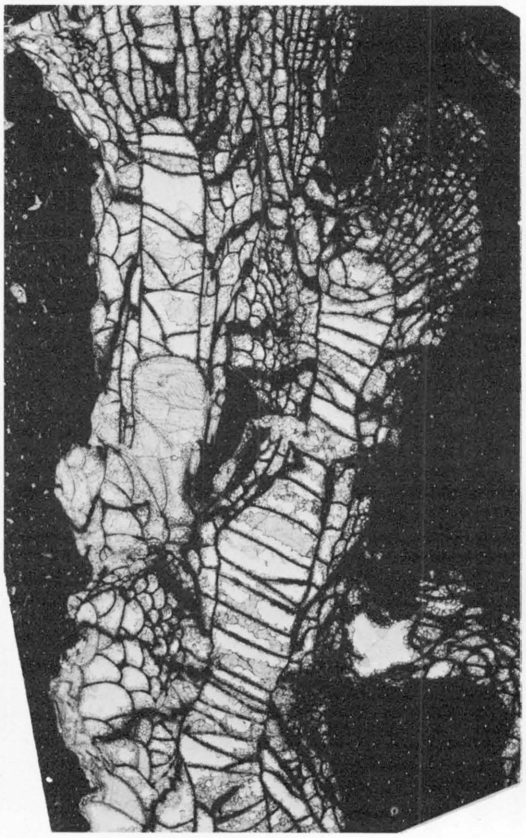
4



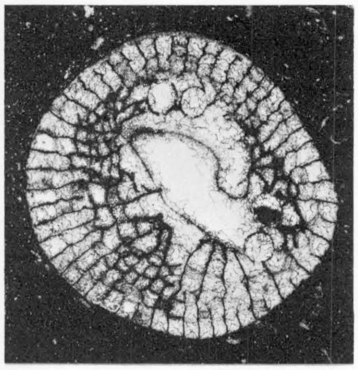
5



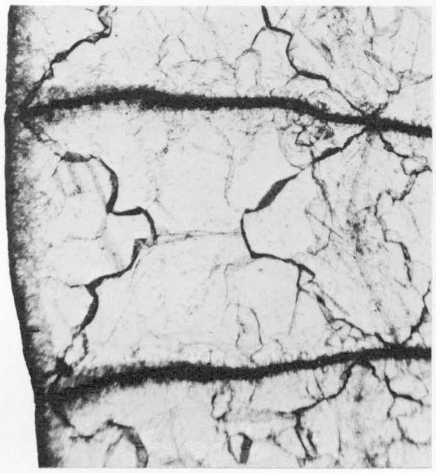
8



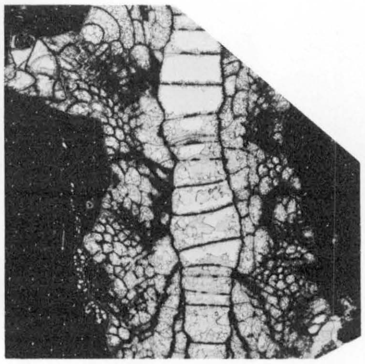
7



9



6



10

ERIDOPHYLLUM SERIALE MILNE-EDWARDS AND HAIME, POPULATION B

PLATE 69

FIGURES 1–10. *Eridophyllum seriale* Milne-Edwards and Haime, population B (p. 99). Moorehouse Member, *Acinophyllum-Eridophyllum* bed, New York.

1–5. USNM 163427. Loc. 118.

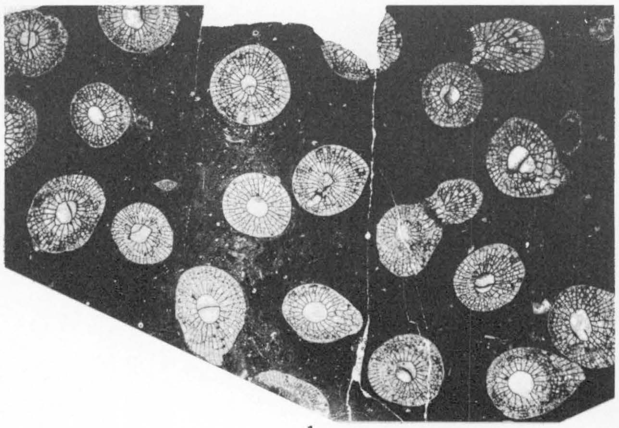
1–4. Transverse thin section (× 1), two corallites from same (× 5), and detail of corallite in fig. 3 (× 25).

5. Longitudinal thin section (× 5).

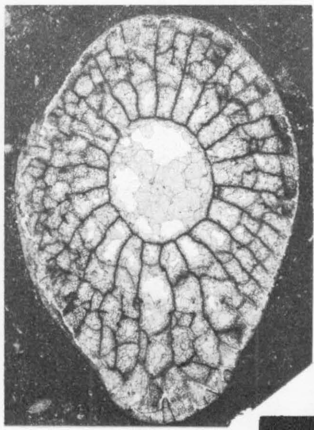
6–10. USNM 163429. Loc. 120.

6, 7. Longitudinal thin sections including parasite tubes (× 5).

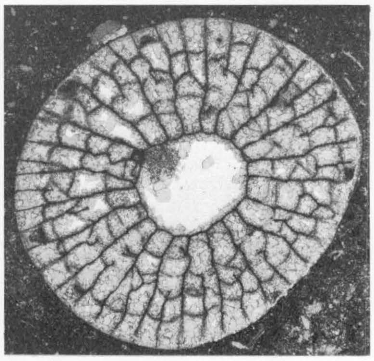
8–10. Three corallites from one transverse section (× 5). Parasite tubes in first two have caused disruption of the aulos; the third is "normal."



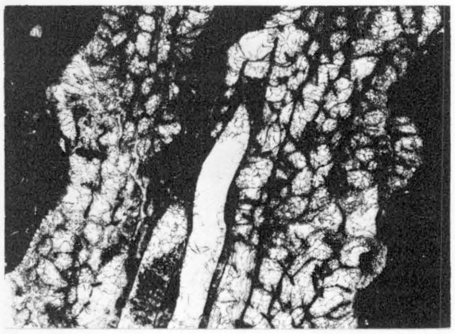
1



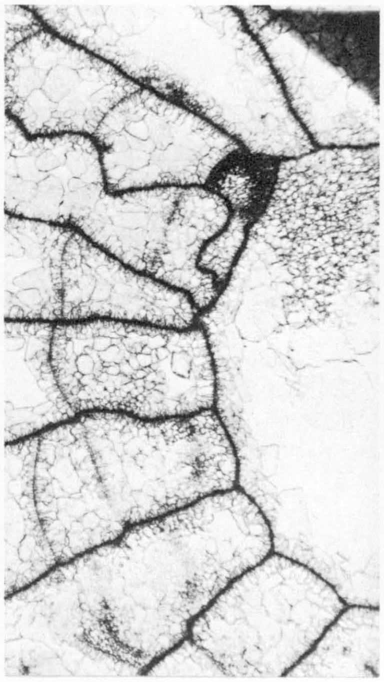
2



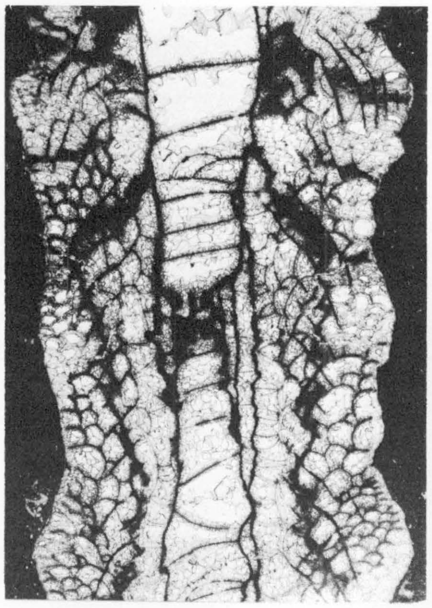
3



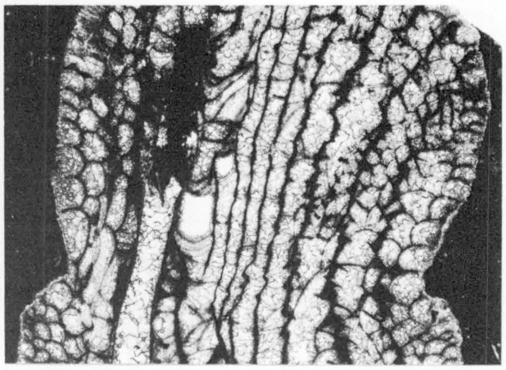
6



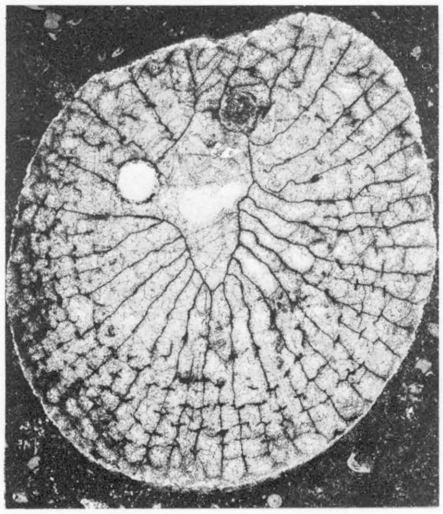
4



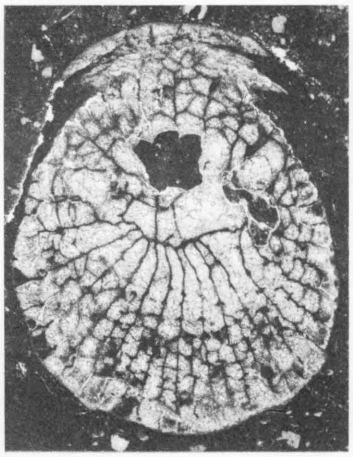
5



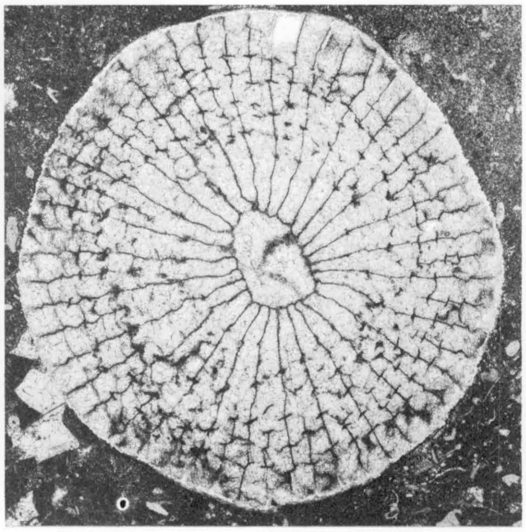
7



8



9



10

ERIDOPHYLLUM SERIALE MILNE-EDWARDS AND HAIME, POPULATION B

PLATE 70

FIGURES 1–11. *Eridophyllum subseriale* Stumm (p. 103).

Edgecliff Member and equivalents, New York and Ontario.

1, 2. USNM 163456. Longitudinal thin sections of two corallites (× 2½). Edgecliff bioherm facies. Loc. 329. See also pl. 71, figs. 6–8 and pl. 72, figs. 1–7.

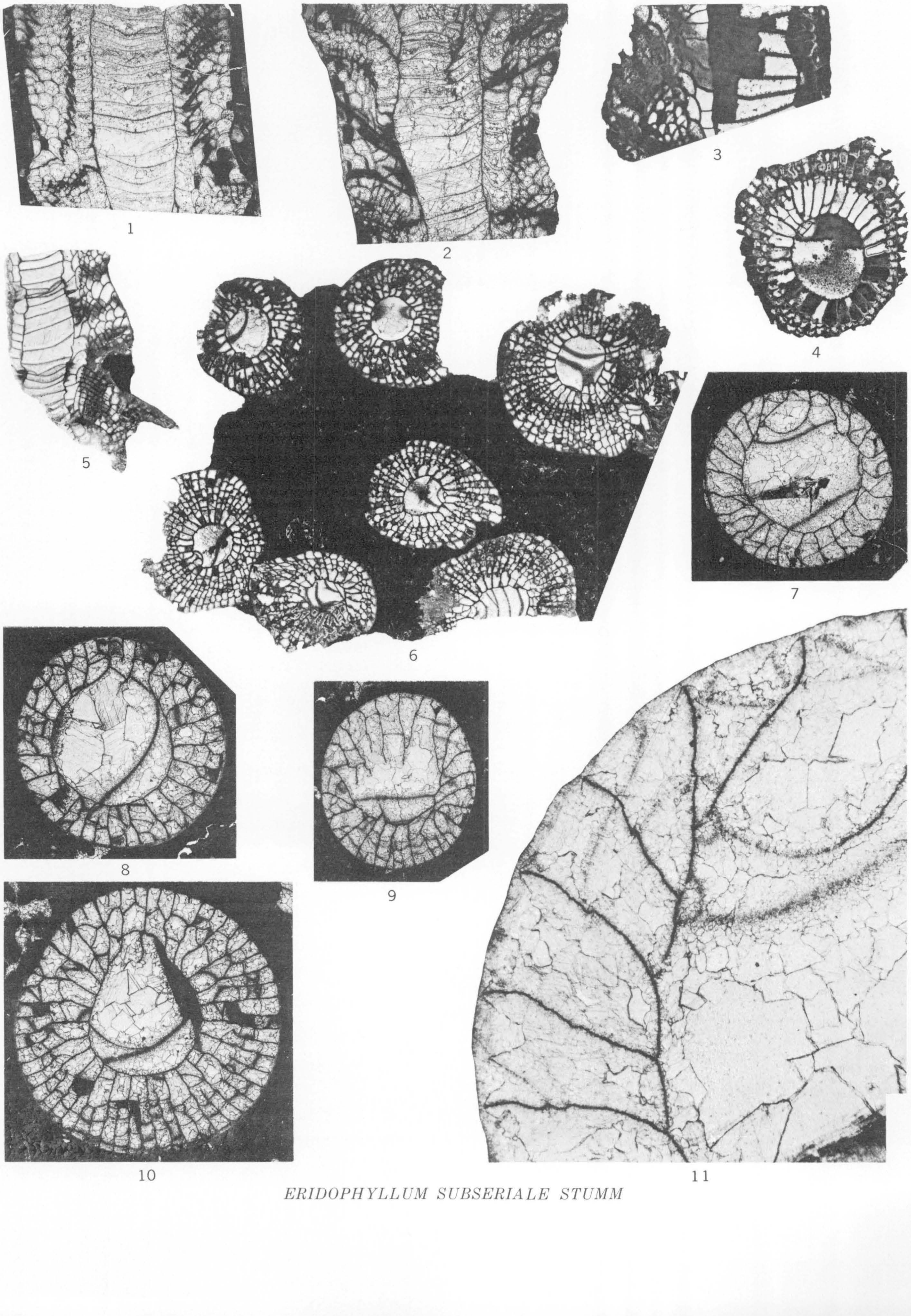
3, 4. UMMP 36122. Specimens illustrated as *E. seriale* by Fagerstrom, 1961 (pl. 3, figs. 15, 16) and here questionably assigned to *E. subseriale*. Longitudinal and transverse thin sections (× 2½). Formasa reef facies, Detroit River Group, Ontario.

5, 6. Holotype, UMMP 5272. Longitudinal and transverse thin sections (× 2½). Edgecliff Member, Caledonia, N.Y. See also pl. 72, fig. 8.

7–11. NYSM 12833. Edgecliff bioherm facies. Loc. 285.

7–10. Four corallites from one transverse thin section (× 5).

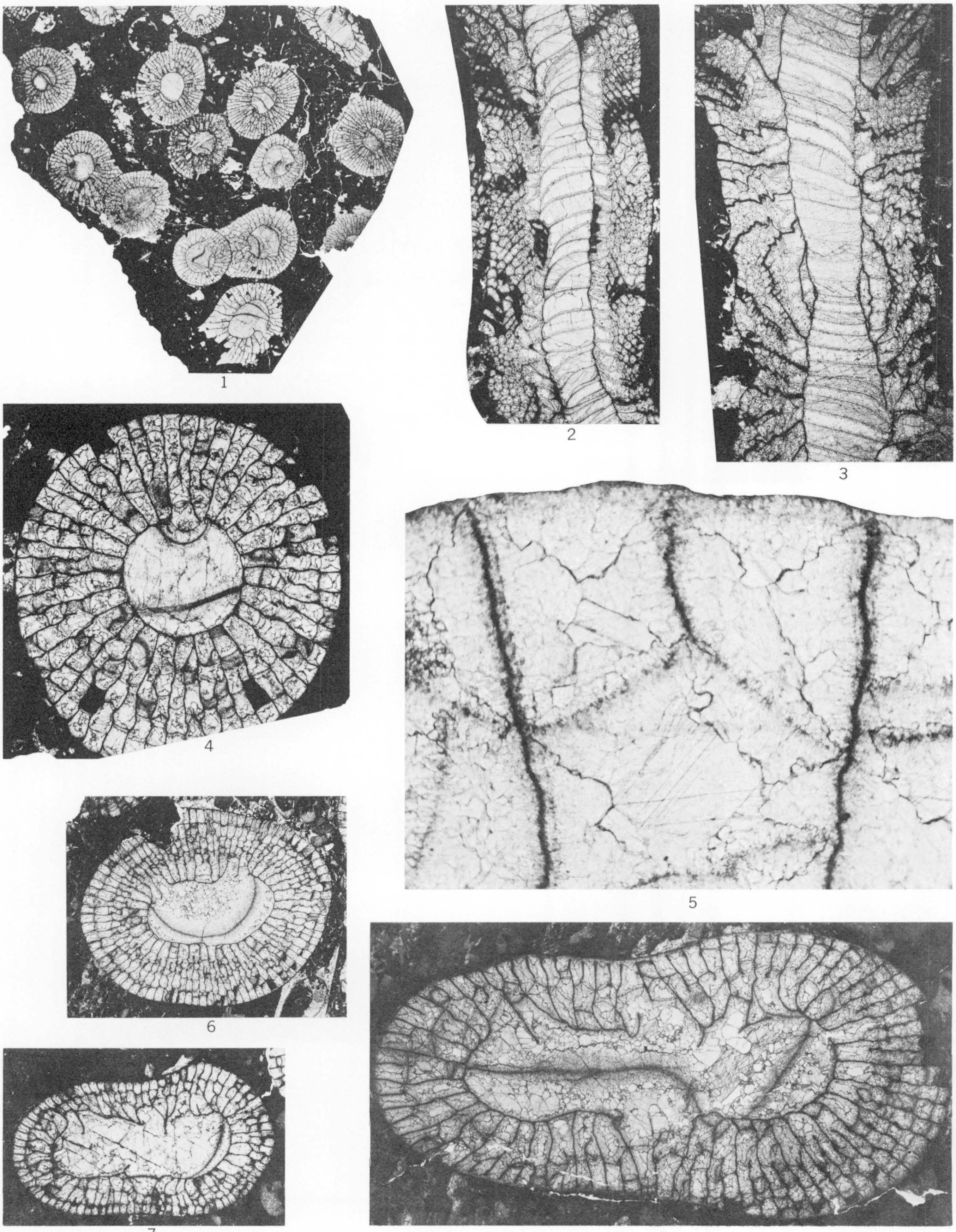
11. Detail of corallite in fig. 7 (× 25).



ERIDOPHYLLUM SUBSERIALE STUMM

PLATE 71

FIGURES 1–8. *Eridophyllum subseriale* Stumm (p. 103).
Edgecliff bioherm facies, New York.
1, 3, 4. USNM 163455. Loc. 360.
1. Transverse thin section (× 1).
3. Longitudinal thin section (× 2½).
4. One corallite from a second transverse thin section (× 5).
2. USNM 163457. Longitudinal thin section (× 2½). Loc. 360.
5. NYSM 12834. Detail of transverse thin section not otherwise illustrated (× 50). Loc. 329.
6–8. USNM 163456. Serial transverse thin sections of corallite that apparently started to increase axially (× 2½). Lower and upper sections are approximately 2 cm apart (measured parallel to axis). See text discussion and illustrations of "normal corallites" in same corallum on pl. 70, figs. 1, 2 and pl. 72, figs. 1–7.



ERIDOPHYLLUM SUBSERIALE STUMM

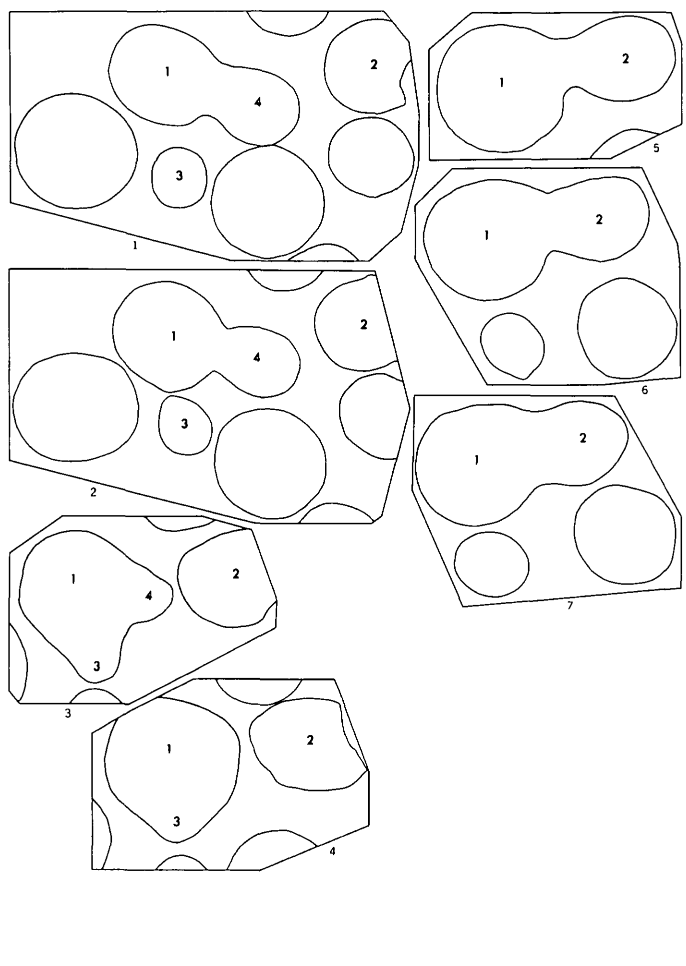
PLATE 72

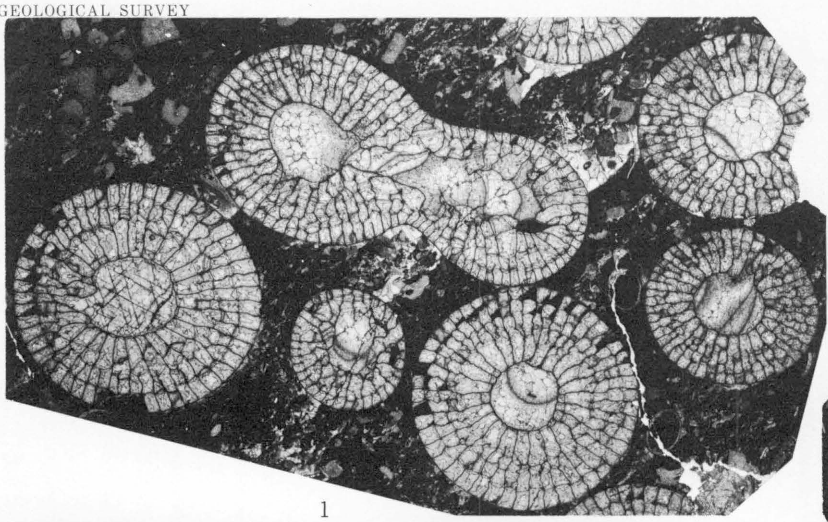
FIGURES 1–8. *Eridophyllum subseriale* Stumm (p. 103).

Edgecliff Member, New York.

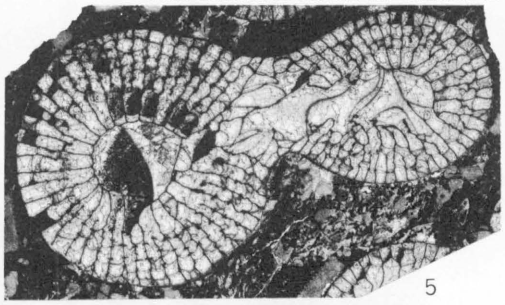
1–7. USNM 163456. Bioherm facies. See also pl. 70, figs. 1, 2 and pl. 71, figs. 6–8. Serial transverse thin sections (× 2½) from highest to lowest showing development and separation of several offsets. Spacing of sections ranges from 3 to 5 mm; total separation of upper (fig. 1) and lower (fig. 7) sections approximately 25 mm. Individual corallites are identified in tracing below.

8. Holotype, UMMP 5272. Exterior (× 1). See also pl. 70, figs. 5, 6.

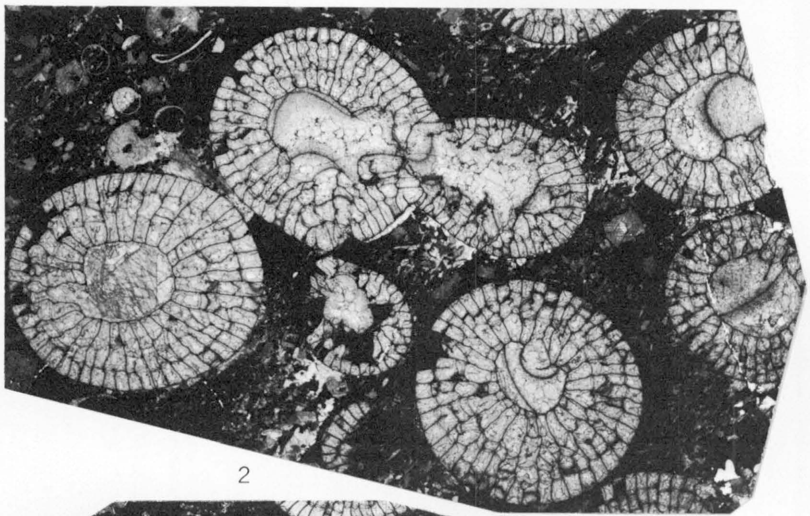




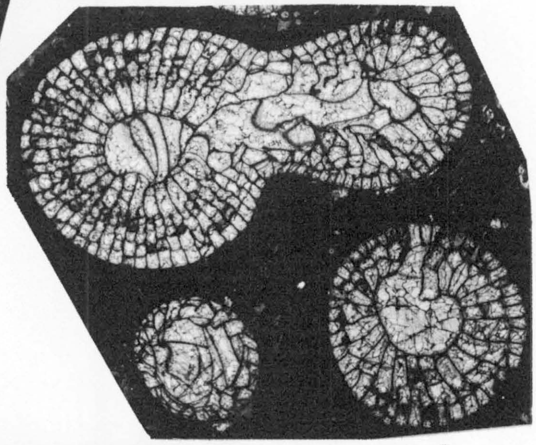
1



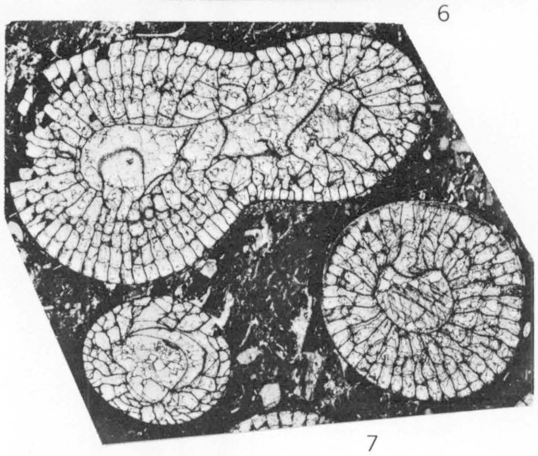
5



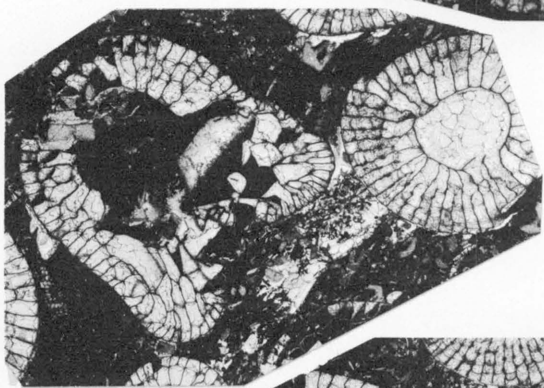
2



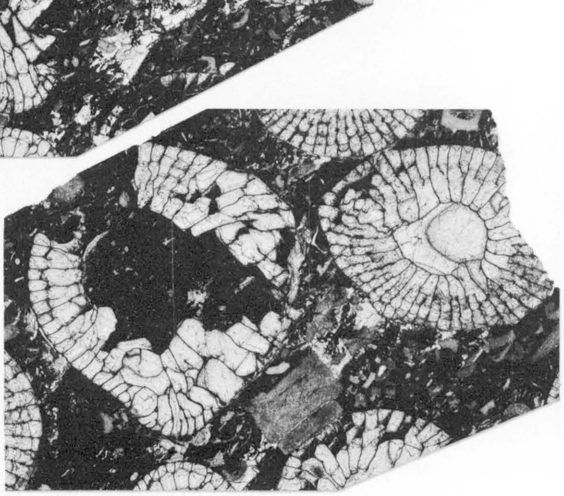
6



7



3



4

8

ERIDOPHYLLUM SUBSERIALE STUMM

PLATE 73

FIGURES 1–9. *Eridophyllum aulodokum* n. sp. (p. 106).

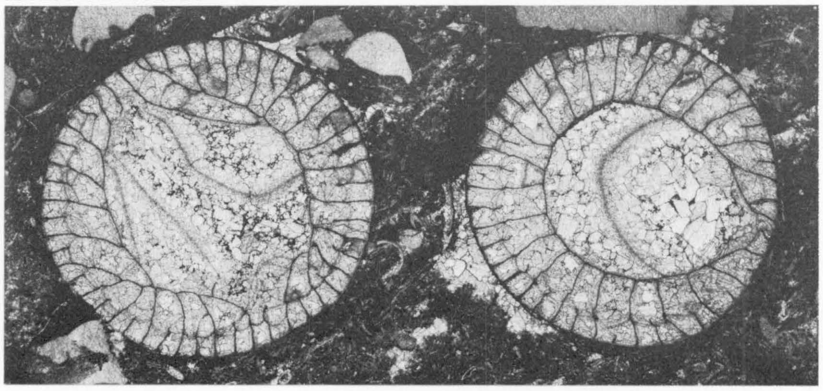
Holotype, USNM 163436. Moorehouse (?) or Seneca (?) Member. Loc. 112.

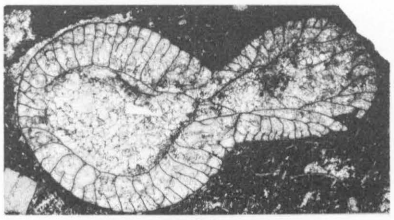
1, 2, 5–7. Various corrallites from one transverse thin section (fig. 1, × 5; others, × 2½).

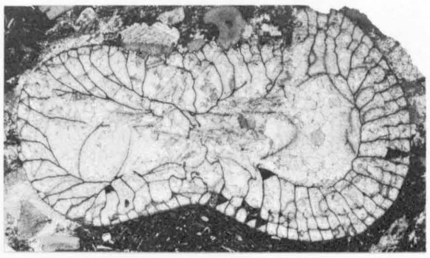
3. Corallite and offset from another transverse thin section (× 2½).

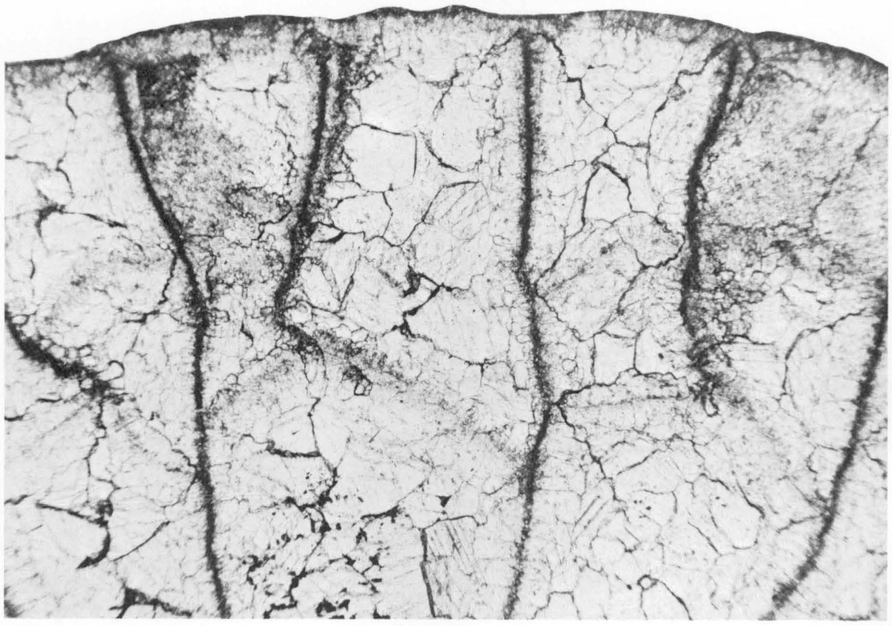
4. Detail of left corallite in fig. 1 (× 50).

8, 9. Longitudinal thin section (× 10, × 5).

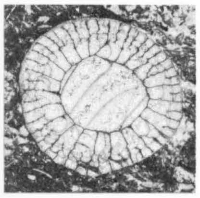

1

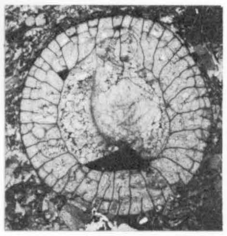

2

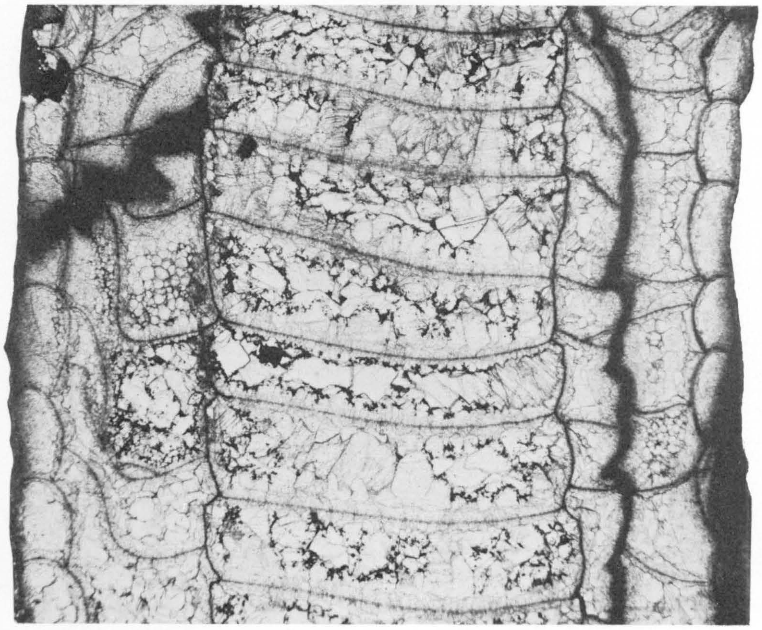

3

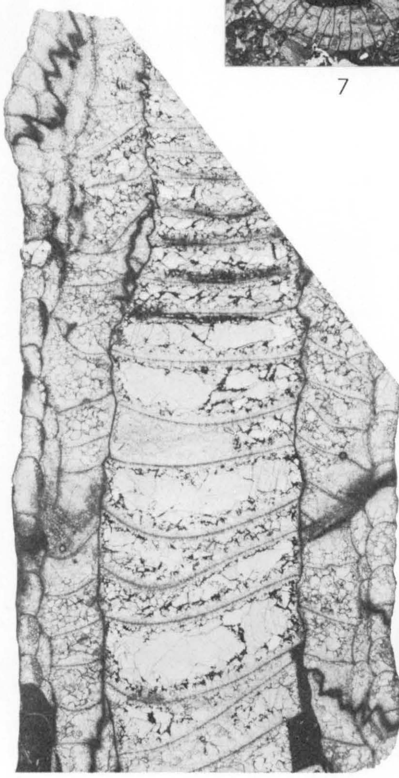

4


5


6


7


8


9

ERIDOPHYLLUM AULODOKUM N. SP.

PLATE 74

FIGURES 1–8. *Eridophyllum corniculum* n. sp. (p. 106).

Moorehouse Member, western New York.

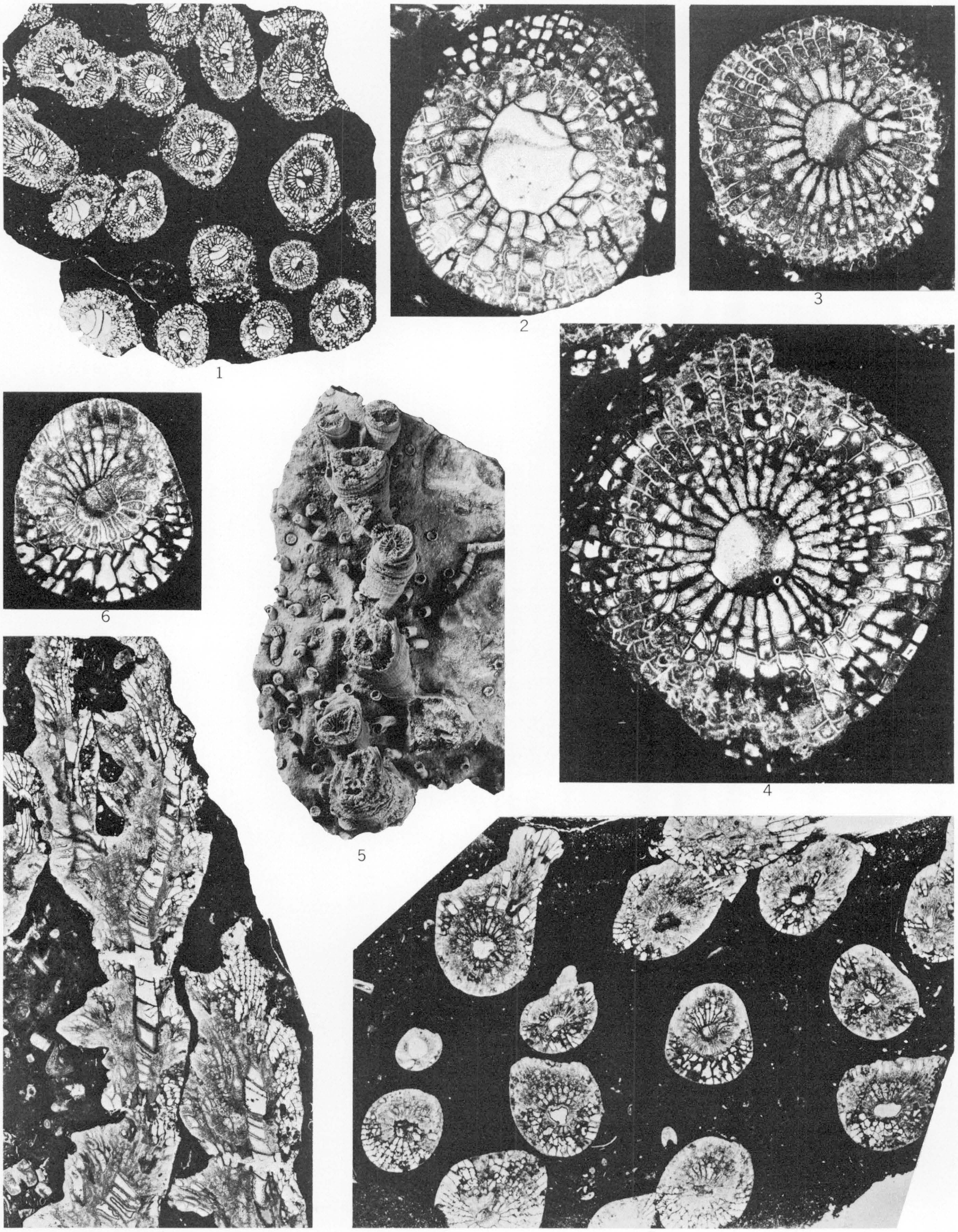
1–4. Paratype, USNM 163448. Transverse thin section (× 1) and three corallites from same (× 5). Loc. 112.

5. Paratype, USNM 163449. View of reptant colony from above (× 1). Loc. 393.

6–8. Holotype, USNM 163438. Loc. 112.

6, 8. One corallite (× 5) and general view of same transverse thin section (× 1).

7. Longitudinal thin section (× 2½).



ERIDOPHYLLUM CORNICULUM N. SP.

PLATE 75

FIGURES 1–11. *Eridophyllum corniculum* n. sp. (p. 106).

Moorehouse Member, western New York.

1, 2. Paratype, USNM 163450. Transverse thin sections of corallites with lateral offsets (× 5). Loc. 112.

3–6. Paratype, USNM 163441. Loc. 112.

3–5. Transverse thin sections of corallites (× 5).

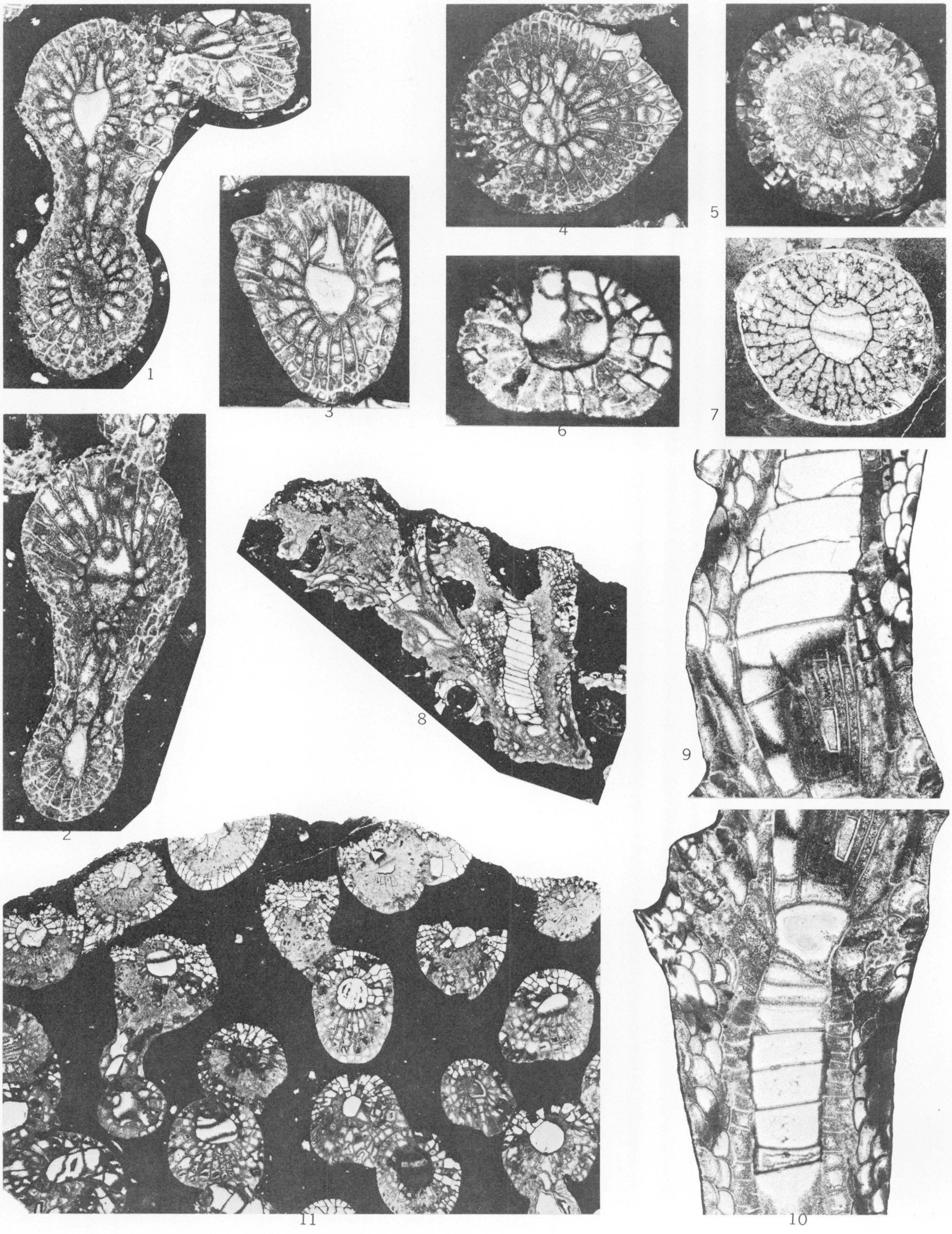
6. Transverse thin section of immature part of another corallite (× 10).

7. Paratype, USNM 163446. Transverse thin sections of one corallite (× 5). Loc. 393.

8. Paratype, NYSM 12835. Longitudinal thin section of corallite and offset (× 2½). Loc. 112.

9, 10. Paratype, USNM 163444. Longitudinal thin sections of two corallites (× 5). Loc. 112.

11. Paratype, USNM 163442. Transverse thin section (× 2½). Loc. 112.



ERIDOPHYLLUM CORNICULUM N. SP.

PLATE 76

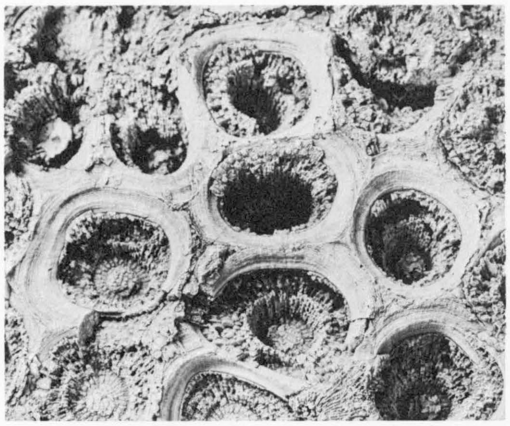
FIGURES 1–5. *Grewgiphyllum colligatum* (Billings) (p. 109).

Neotype, GSC 31158. Bois Blanc Formation, Walpole, Ontario.

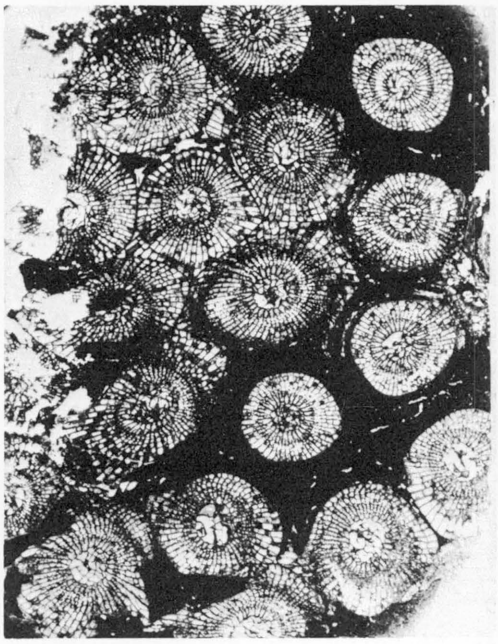
1. Part of weathered top of corallum (× 1), showing lower sides of corallite expansions to the cerioid stages.
2. Part of weathered base (× 1), showing cylindrical stages and expansions.

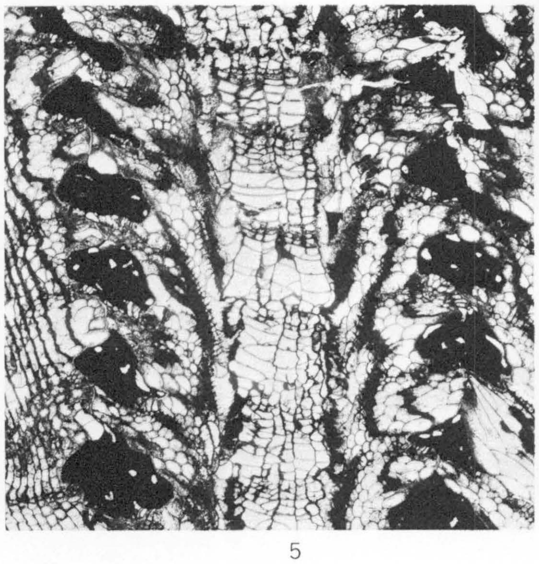
3, 4. Transverse thin section (× 1) and part of same (× 2½).

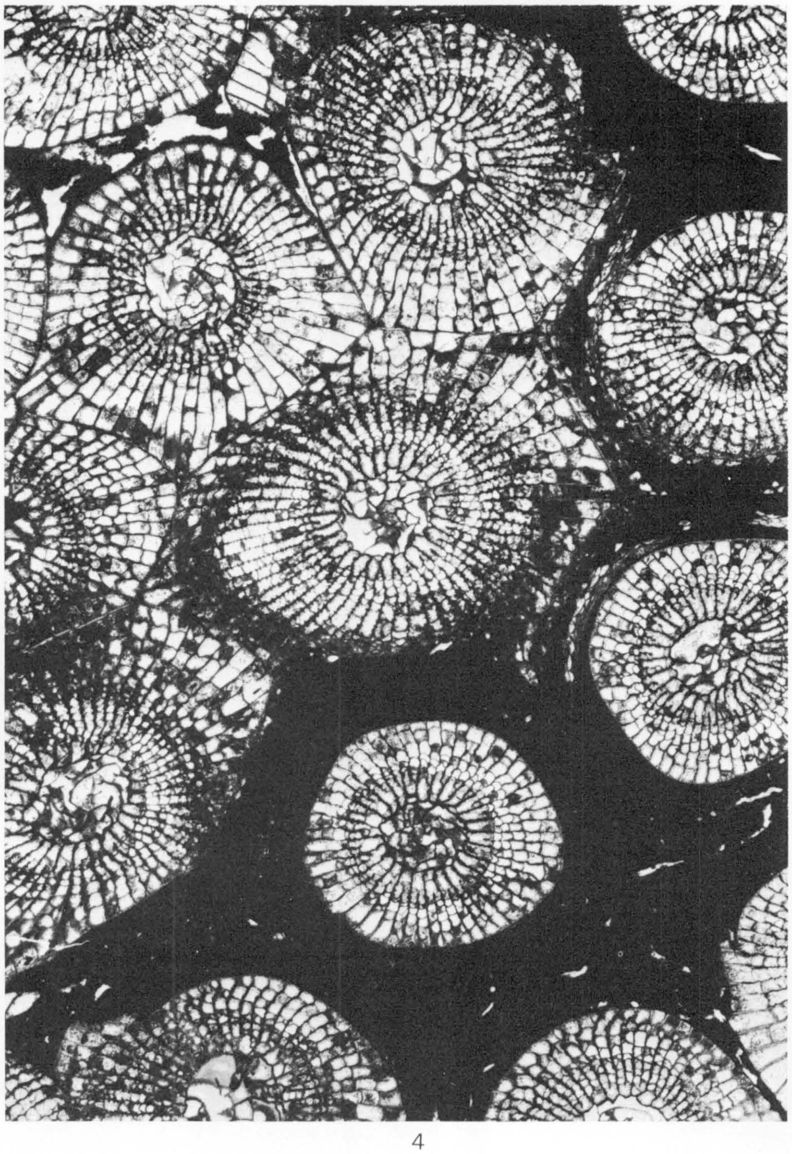
5. Longitudinal thin section (× 2½).


1


2


3


5


4

GREWGIPHYLLUM COLLIGATUM (BILLINGS)

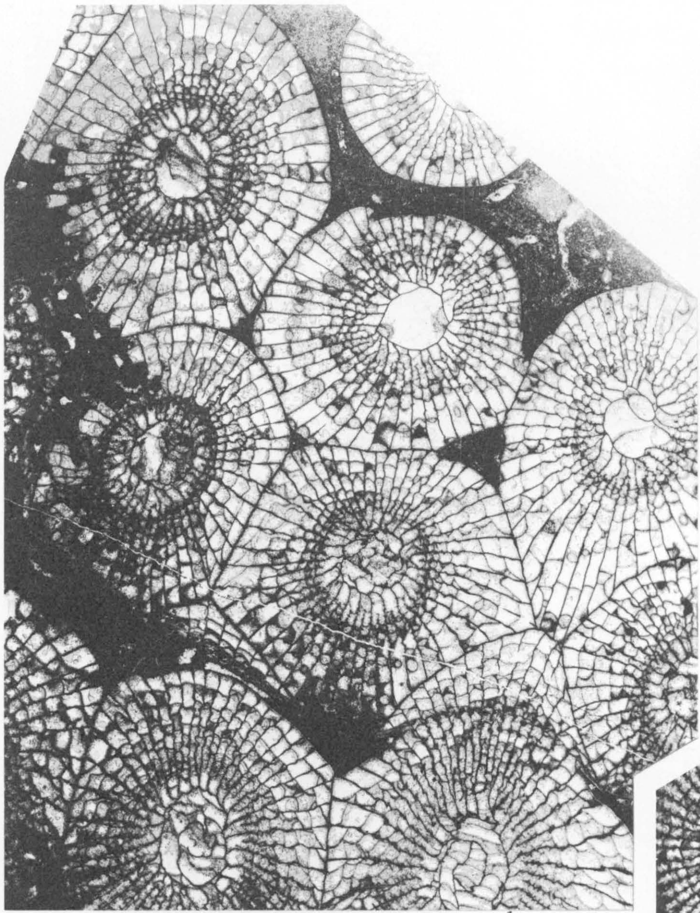
PLATE 77

FIGURES 1–5. *Grewgiphyllum colligatum* (Billings) (p. 109).

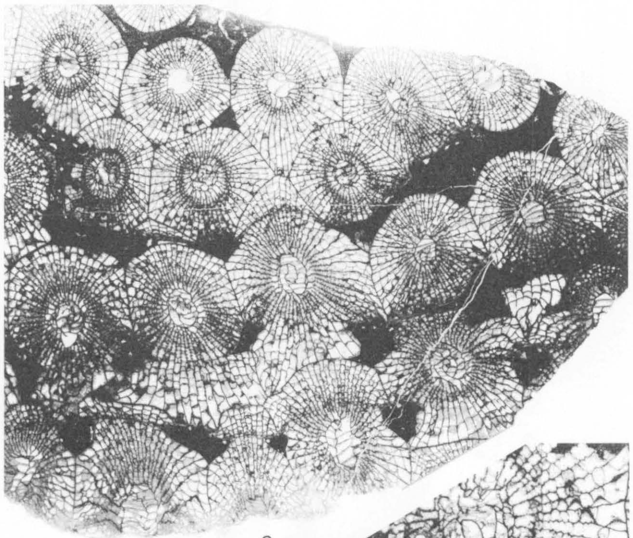
Bois Blanc Formation, Ontario.

1–3. USNM 163464. Transverse thin section, part (× 2½) and whole (× 1); and longitudinal thin section (× 2½). Loc. C19.

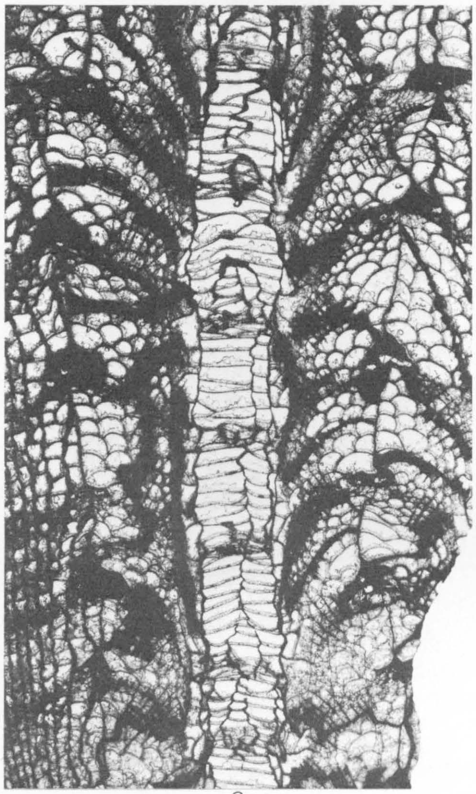
4, 5. USNM 163463. Transverse and longitudinal thin sections (× 2½, × 1). Loc. C19.



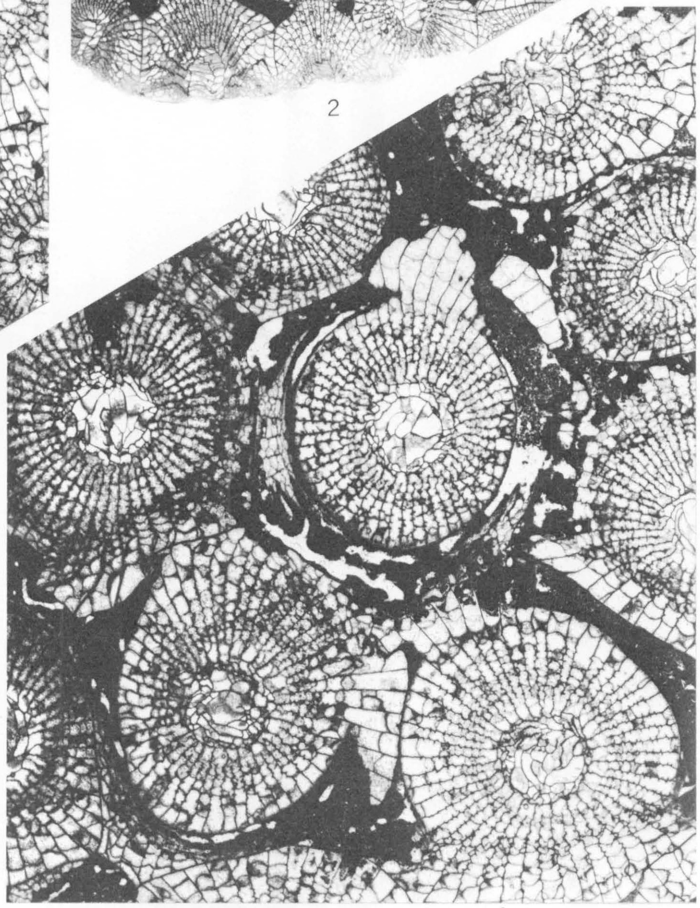
1



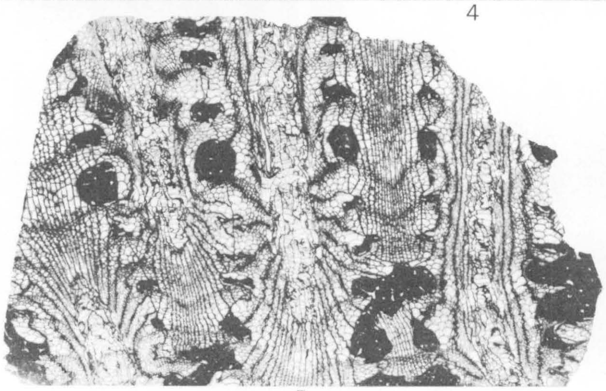
2



3



4



5

GREWGIPHYLLUM COLLIGATUM (BILLINGS)

PLATE 78

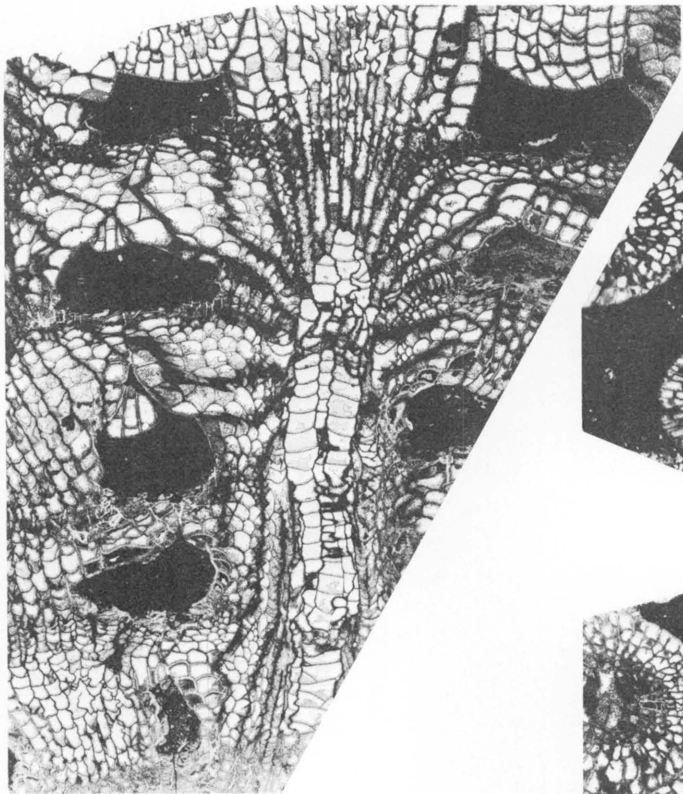
FIGURES 1–6. *Grewgiphyllum colligatum* (Billings) (p. 109).

Ontario.

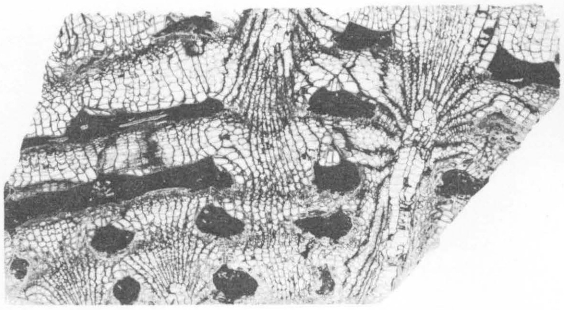
1, 2. USNM 163465. Longitudinal thin section, part (× 2½) and whole (× 1). Green beds, Edgecliff (?) age. Loc. C10.

3. USNM 163466. Transverse thin section (× 1). Green beds, Edgecliff (?) age. Loc. C10.

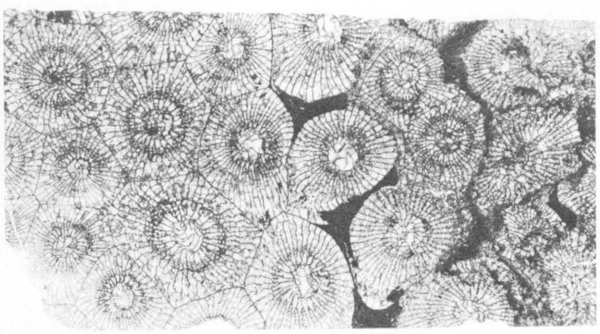
4–6. GSC 31157. Parts of two transverse and one longitudinal thin sections (× 2½). Bois Blanc (?) Formation, Woodstock.



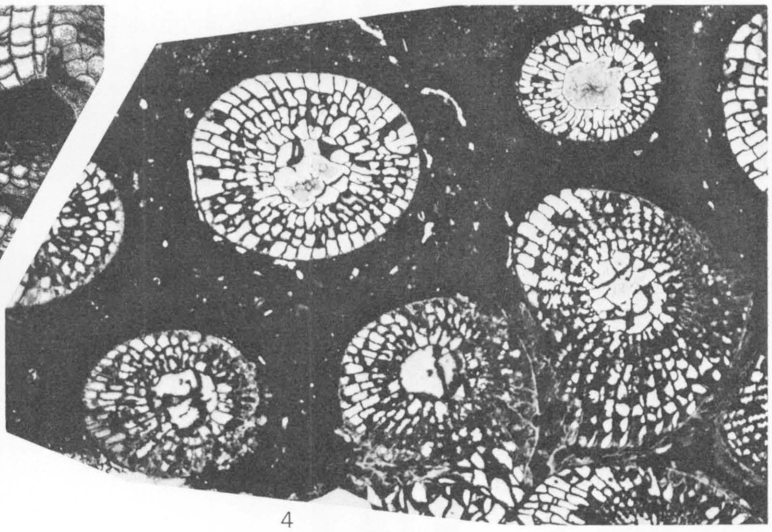
1



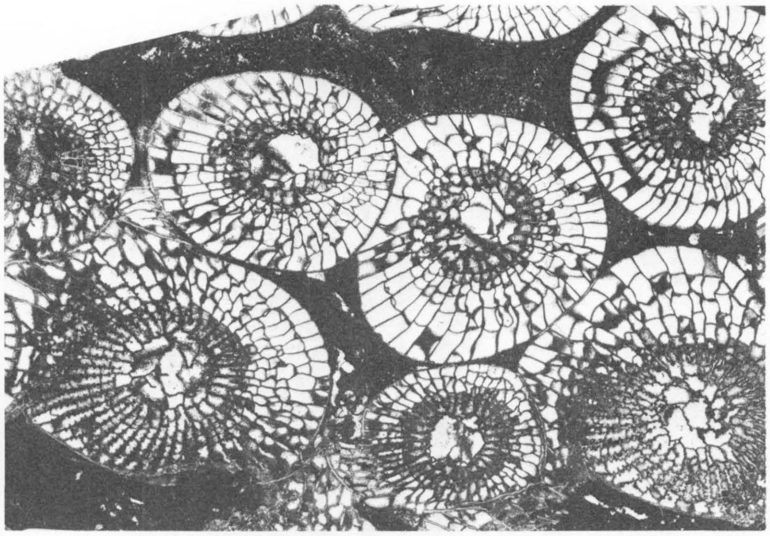
2



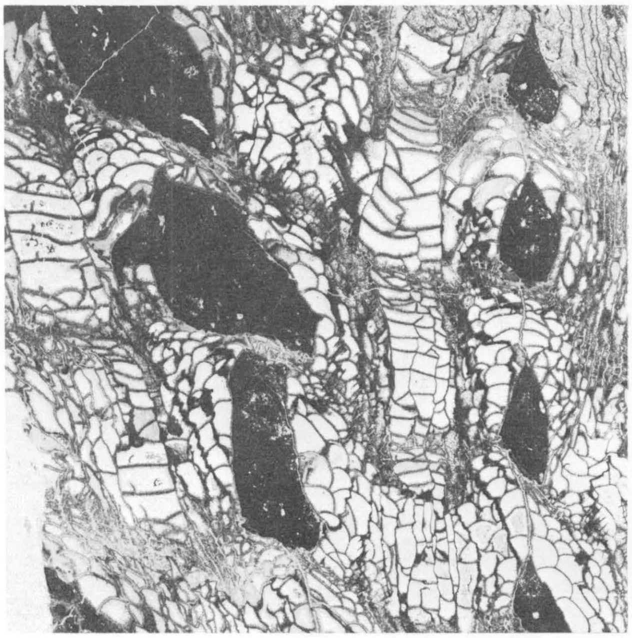
3



4



5



6

GREWGIPHYLLUM COLLIGATUM (BILLINGS)

PLATE 79

FIGURES 1–7. *Grewgiphyllum colligatum* Billings (p. 109).

1–5. USNM 172162. Edgecliff bioherm facies. Loc. 108.

1, 2. Two longitudinal thin sections (× 2½).

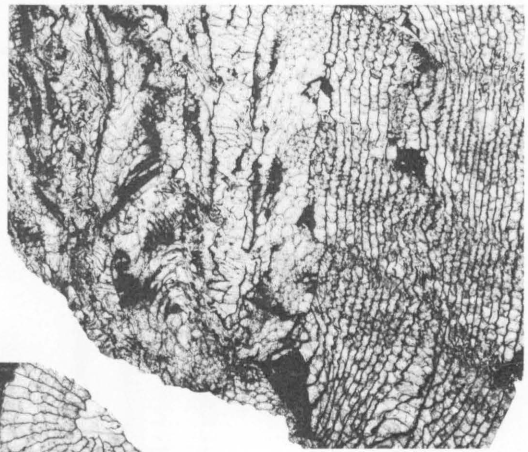
3. Transverse thin section (× 1).

4. Part of same section (× 2½).

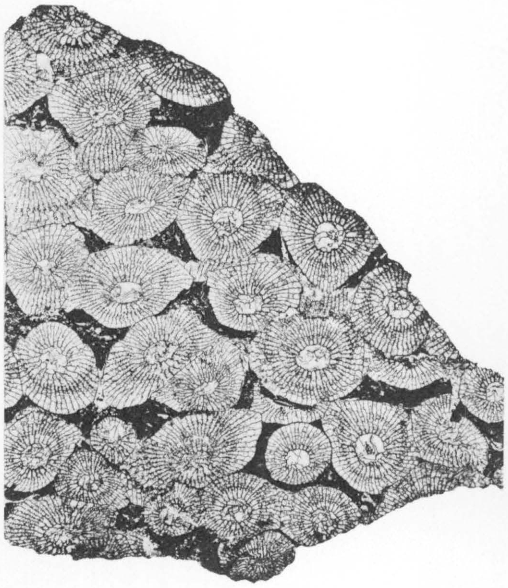
5. Detail of corallite that is right-middle in fig. 4 (× 50).

6, 7. USNM 113556. Parallel transverse thin sections, of same corallites, taken approximately 5 mm apart (× 1). Bois Blanc (?) Formation, Hagarsville, Ontario.

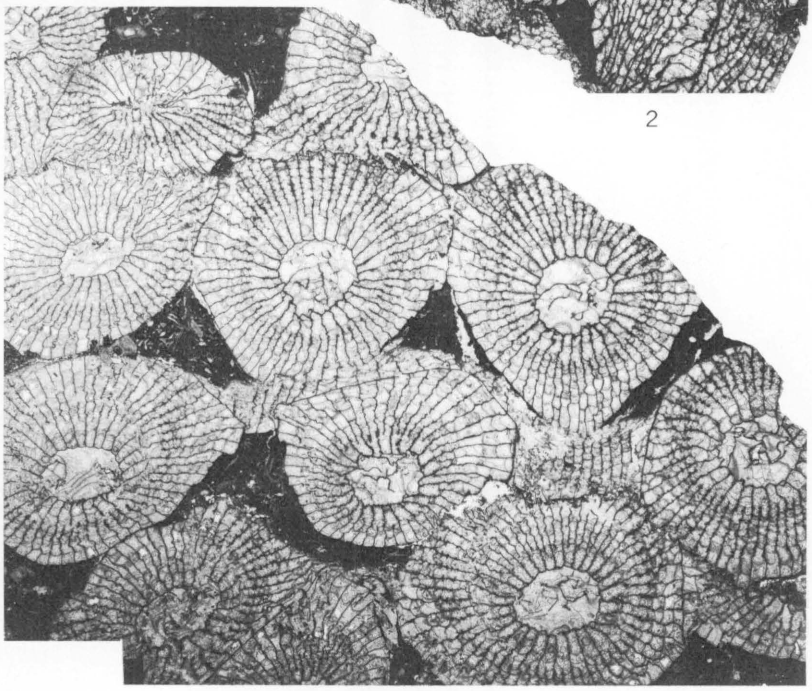
1



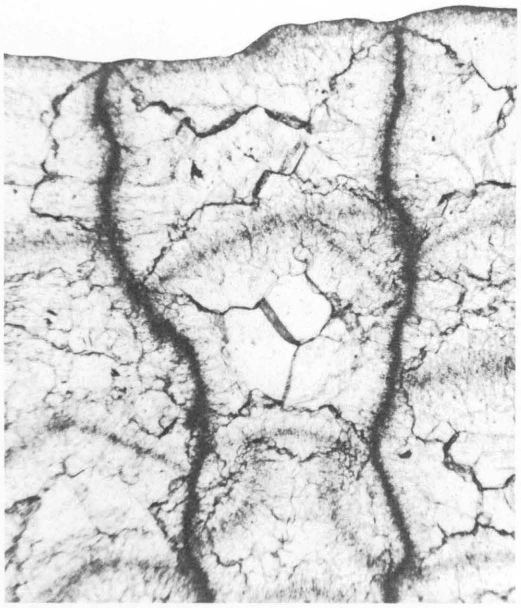
2



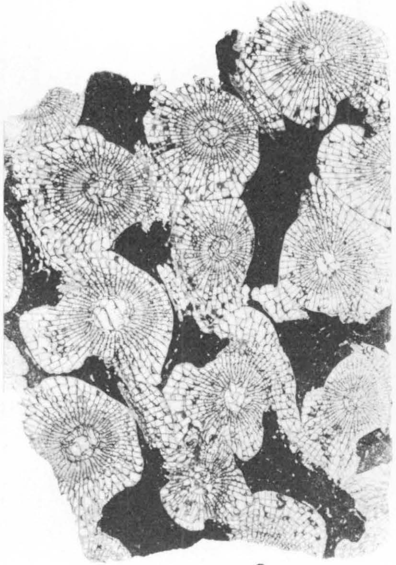
3



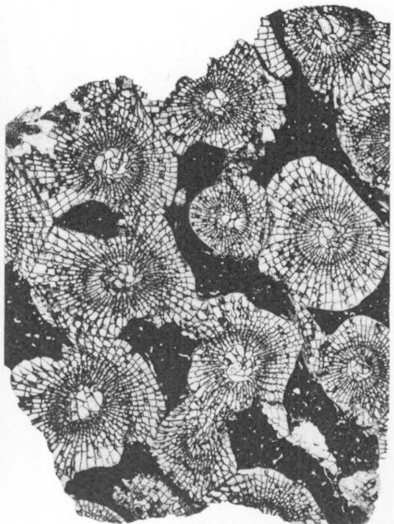
4



5



6

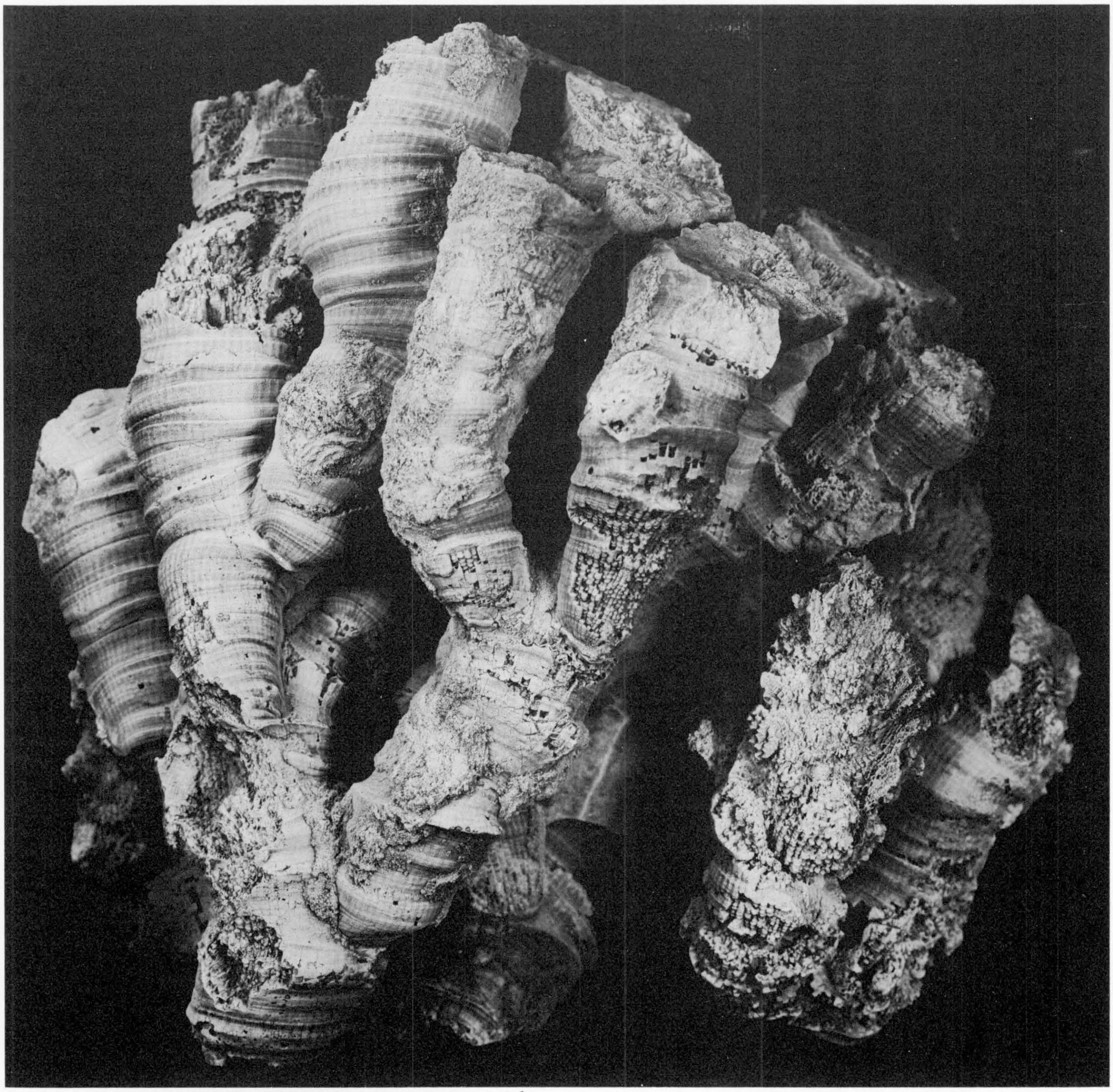


7

GREWGIPHYLLUM COLLIGATUM BILLINGS

PLATE 80

Cyathocylindrium opulens Oliver (p. 117).
Paratype, NYSM 12844.
Growth form and exterior of silicified specimen of form with lateral offsets (× 1).
Leroy, N.Y. Probably Edgecliff Member.



1

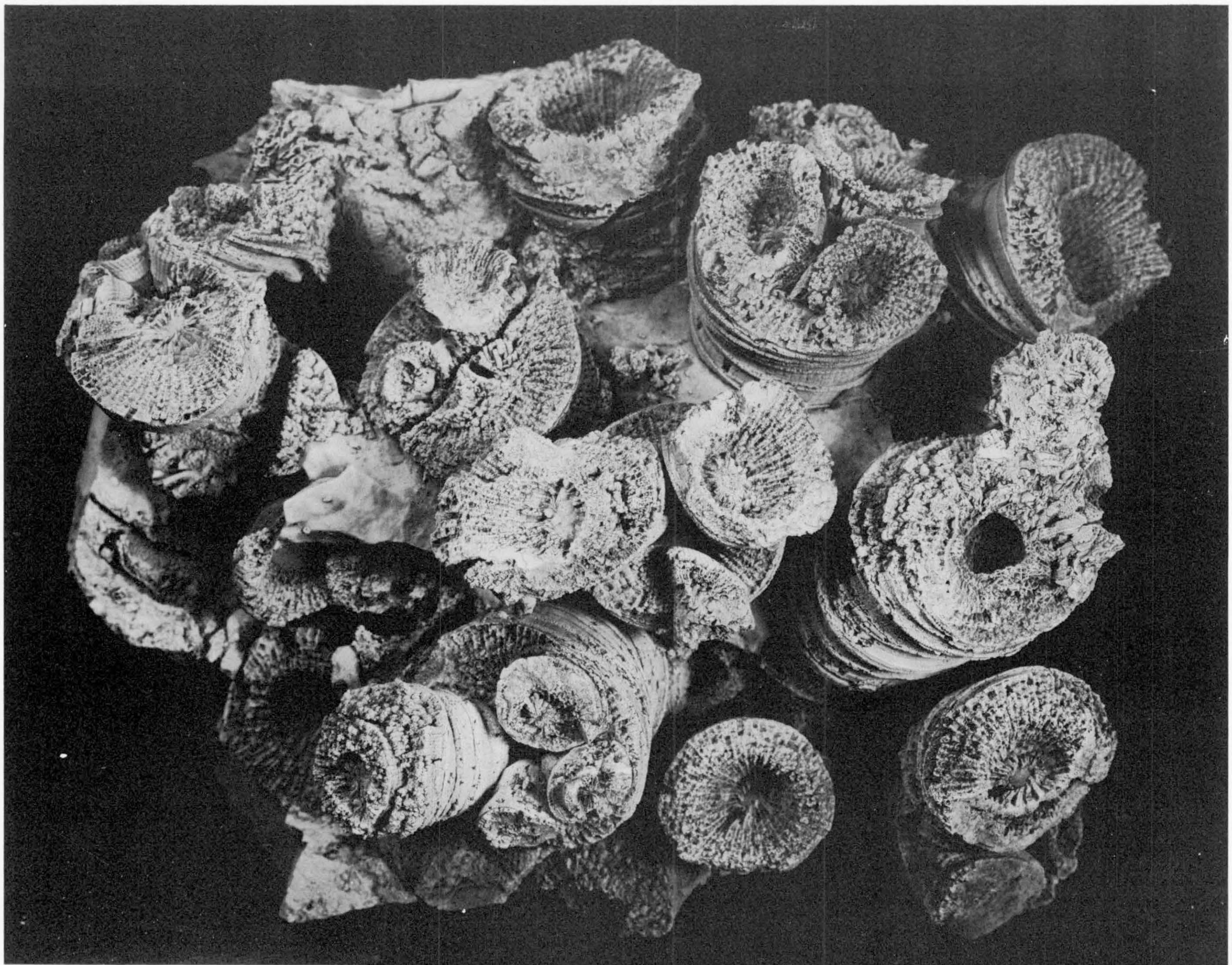
CYATHOCYLINDRIUM OPULENS OLIVER

PLATE 81

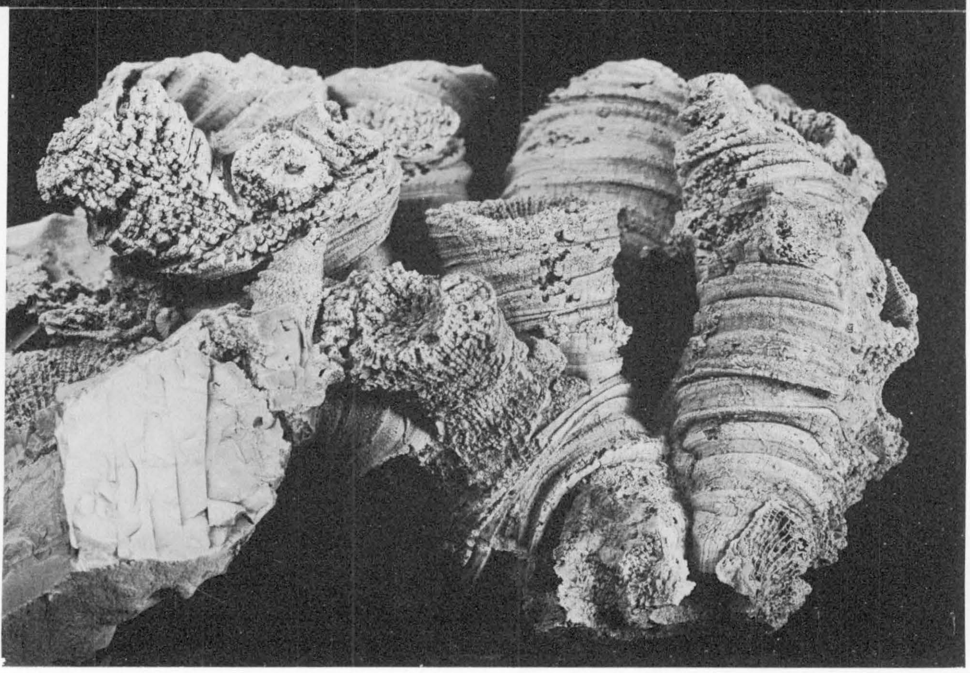
FIGURES 1, 2. *Cyathocylindrium opulens* Oliver (p. 117).

Paratype NYSM 12845.

Top and lateral views of part of silicified corallum of form with peripheral offsets (× 1). Leroy, N.Y. Probably Edgecliff Member.



1



2

CYATHOCYLINDRIUM OPULENS OLIVER

PLATE 82

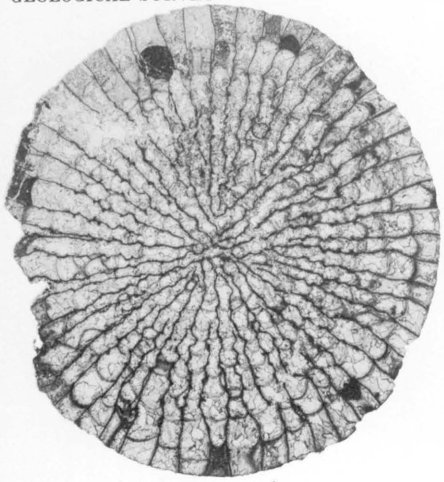
FIGURES 1–9. *Cyathocylindrium opulens* Oliver (p. 117).

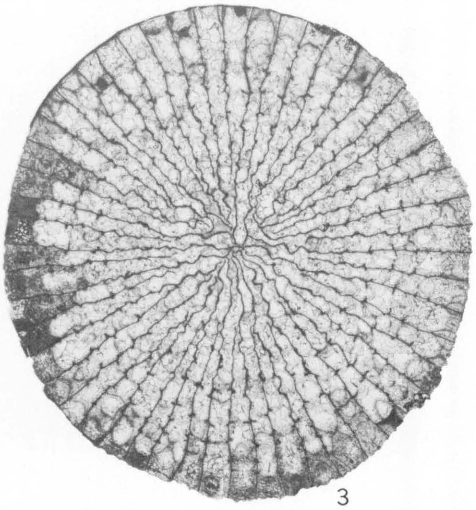
Holotype, USNM 172197. Edgecliff bioherm facies. Loc. 81.

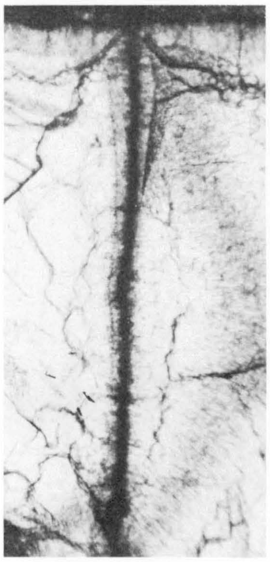
1, 2. Transverse and longitudinal thin sections of one corallite (× 2½).

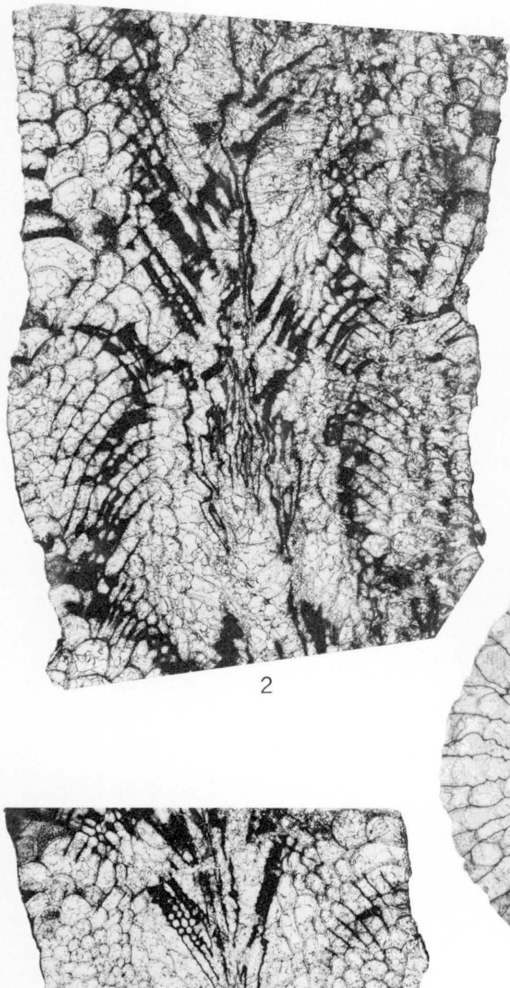
3–6. Transverse thin section of another corallite (× 2½) and details (× 50, figs. 4 and 5; × 10, fig. 6). Septum in fig. 4 is second from right in fig. 6. Area of fig. 6 is upper left in fig. 3. Area of fig. 4 is just left of the axis in fig. 3 and reversed.

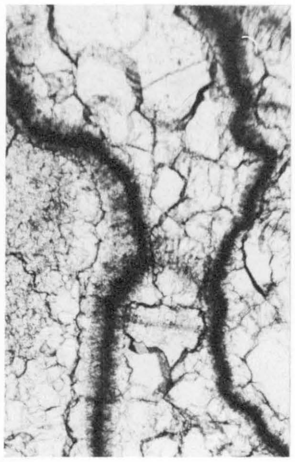
7–9. Longitudinal and transverse thin sections of additional corallites (× 2½).

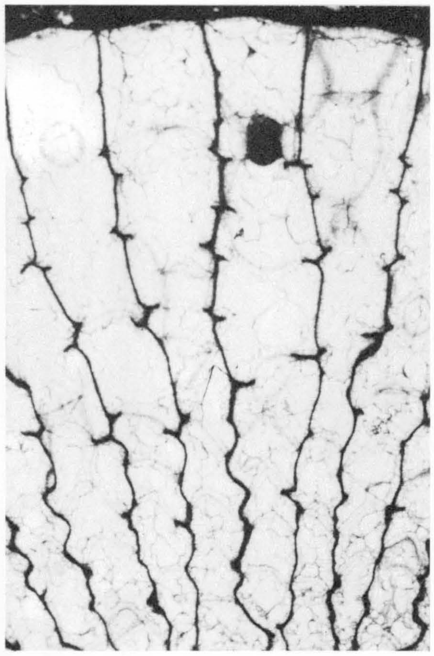

1

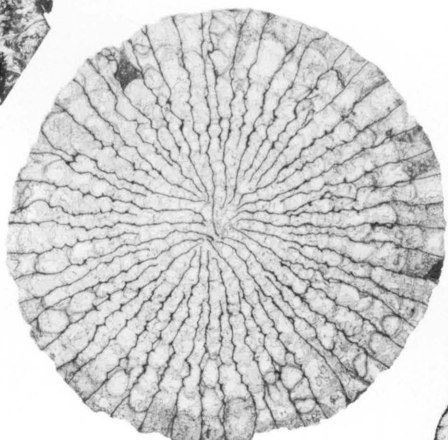

3

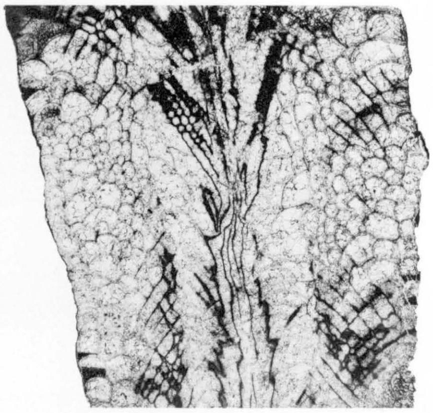

4

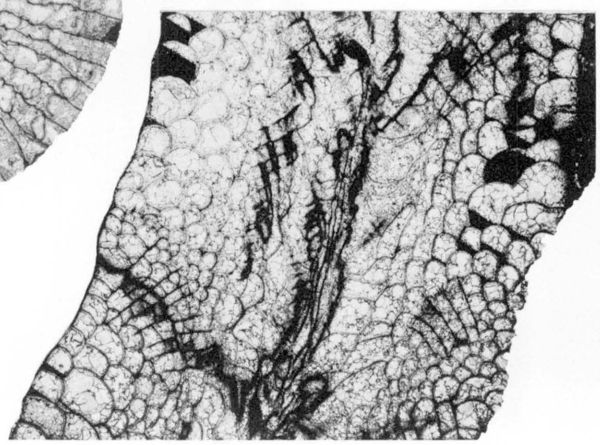

2


5


6


8


7


9

CYATHOCYLINDRIUM OPULENS OLIVER

PLATE 83

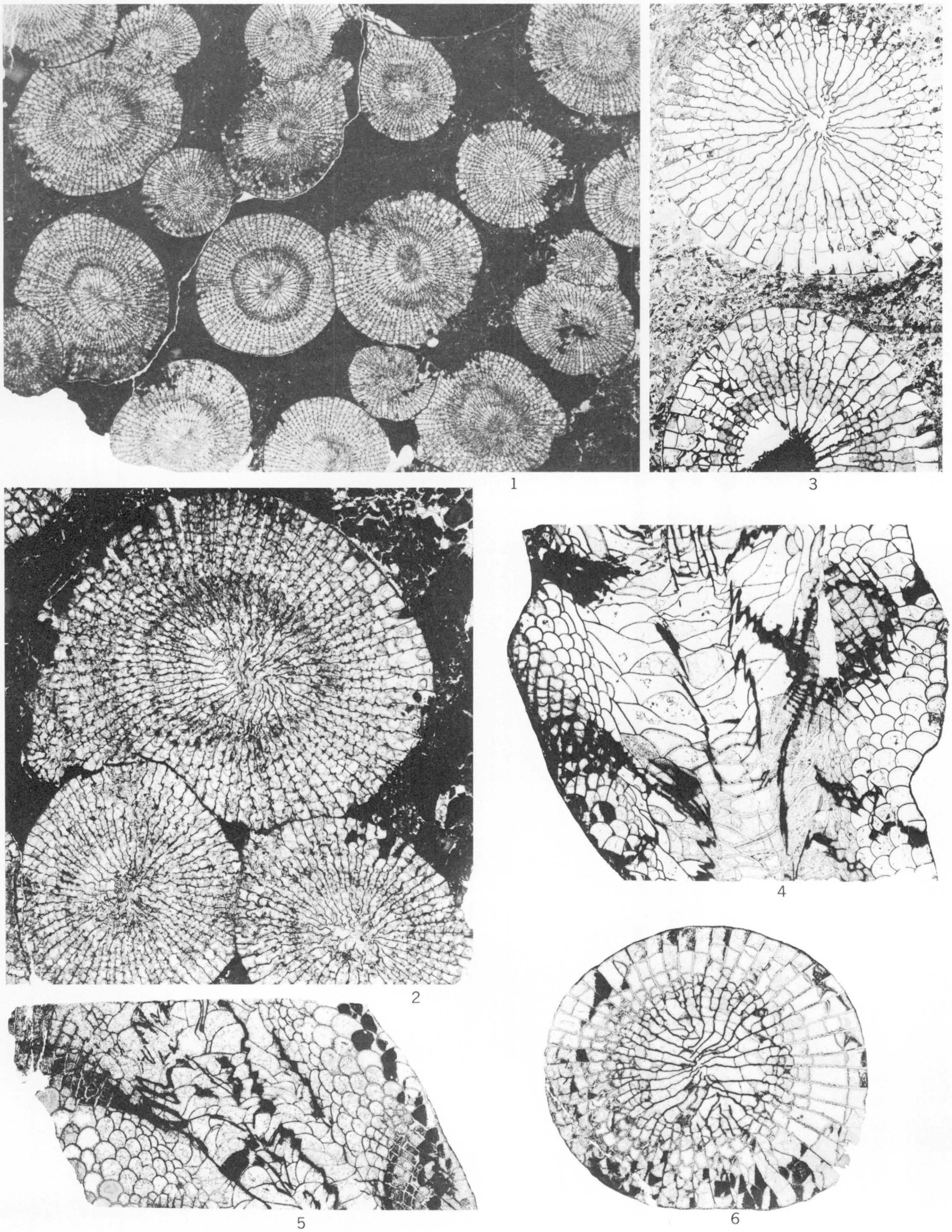
[All figures × 2½ except fig. 1, × 1]

FIGURES 1–6. *Cyathocylindrium opulens* Oliver (p. 117).
Edgecliff Member, New York and Ontario.

1, 2. Paratype, USNM 172198. Two transverse thin sections. Bioherm facies. Loc. 233.

3, 4. Paratype, GSC 31159. Transverse and longitudinal thin sections of same corallite. Bioherm facies. Loc. C7.

5, 6. Paratype, USNM 172199. Longitudinal and transverse thin sections of one corallite. Nonbioherm facies. Loc. C22.



CYATHOCYLINDRIUM OPULENS OLIVER

PLATE 84

FIGURES 1–6. *Cyathocylindrium opulens* Oliver (p. 117).

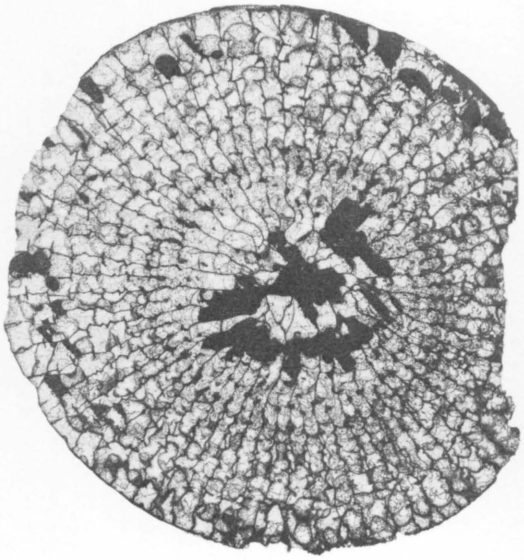
Edgecliff bioherm facies, New York and Ontario.

1–4. Paratype, NYSM 12843. Loc. 233.

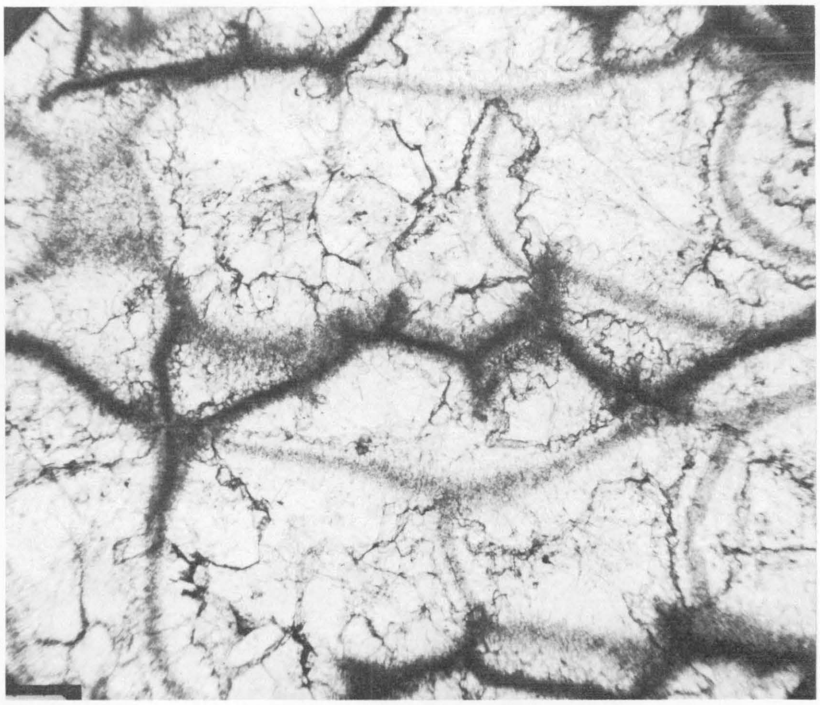
1, 2. Transverse thin section (× 2½) and detail (× 50).

3, 4. Longitudinal thin section of same corallite (× 2½) and detail (× 25).

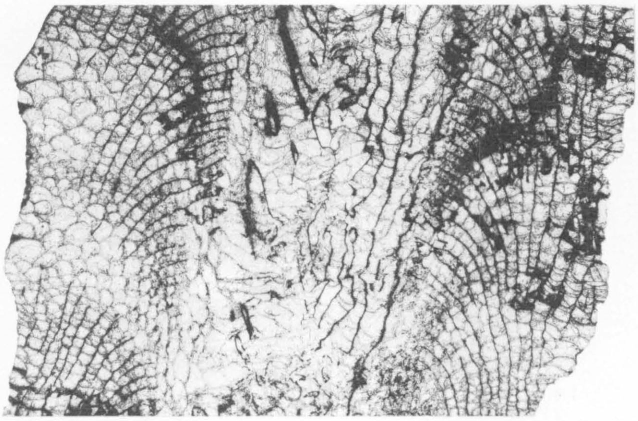
5, 6. Paratype, USNM 172200. Longitudinal and transverse thin sections of different corallites. Fig. 6 shows single peripheral offset in colony that otherwise has only lateral offsets. This is the only example known in this species of the occurrence of both lateral and peripheral offsets in the same colony.



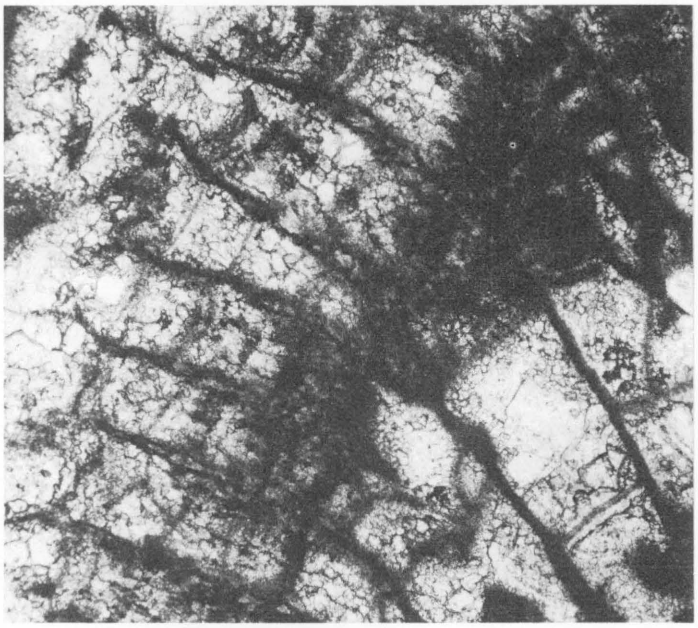
1



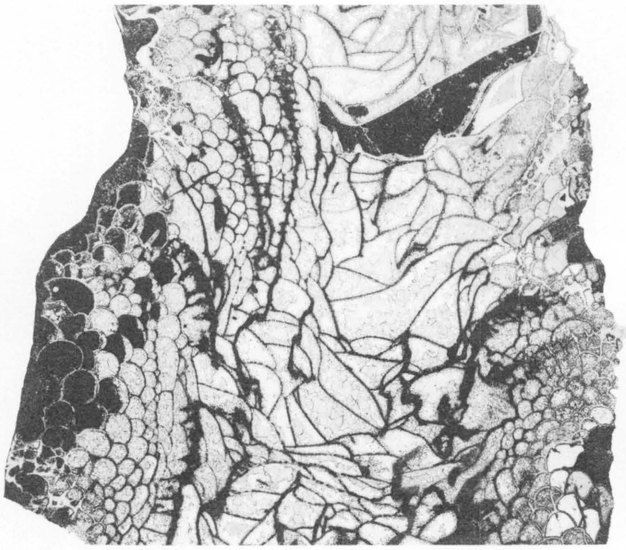
2
X 2½



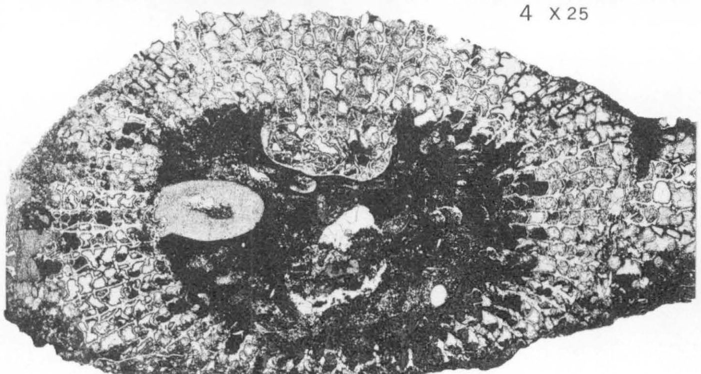
3



4 X 25



5



6

CYATHOCYLINDRIUM OPULENS OLIVER

PLATE 85

[All figures × 2½]

FIGURES 1–9. *Cyathocylindrium opulens* Oliver (p. 117).

Edgecliff bioherm facies, New York.

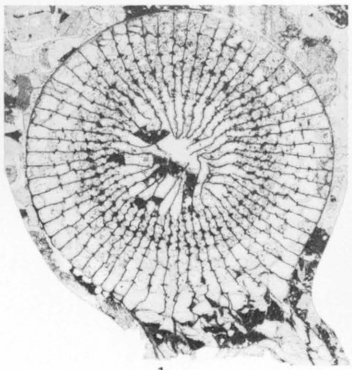
1–4. Paratype, USNM 172201. Three transverse and one longitudinal thin sections of four different corallites. Loc. 233.

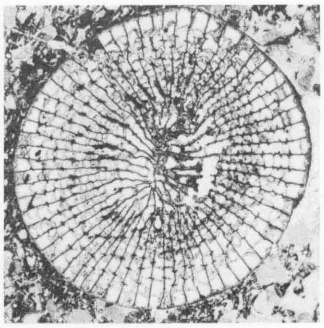
5, 6. Paratype, USNM 172204. Transverse and longitudinal thin sections of two corallites. Loc. 329.

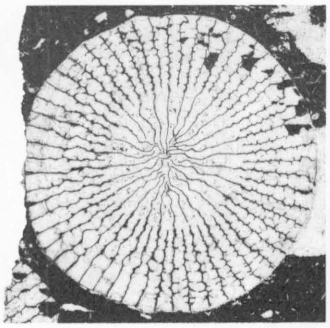
7. Paratype, USNM 172203. Longitudinal thin section. Loc. 233.

8. Paratype, NYSM 12846. Transverse thin section of two corallites. Loc. 329.

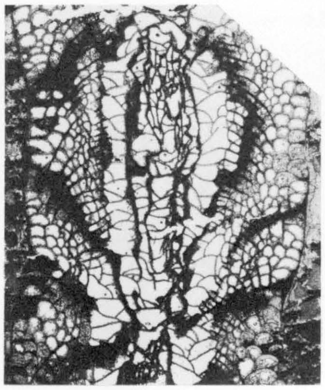
9. Paratype, USNM 172202. Transverse thin section of corallite showing two generations of peripheral offsets. Loc. 329.

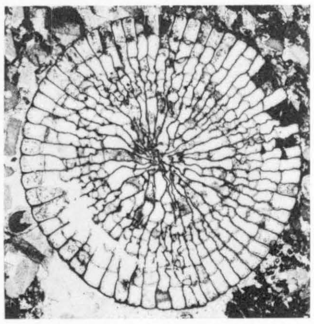

1

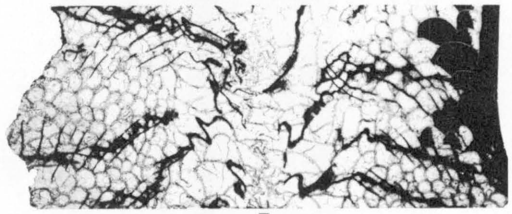

2

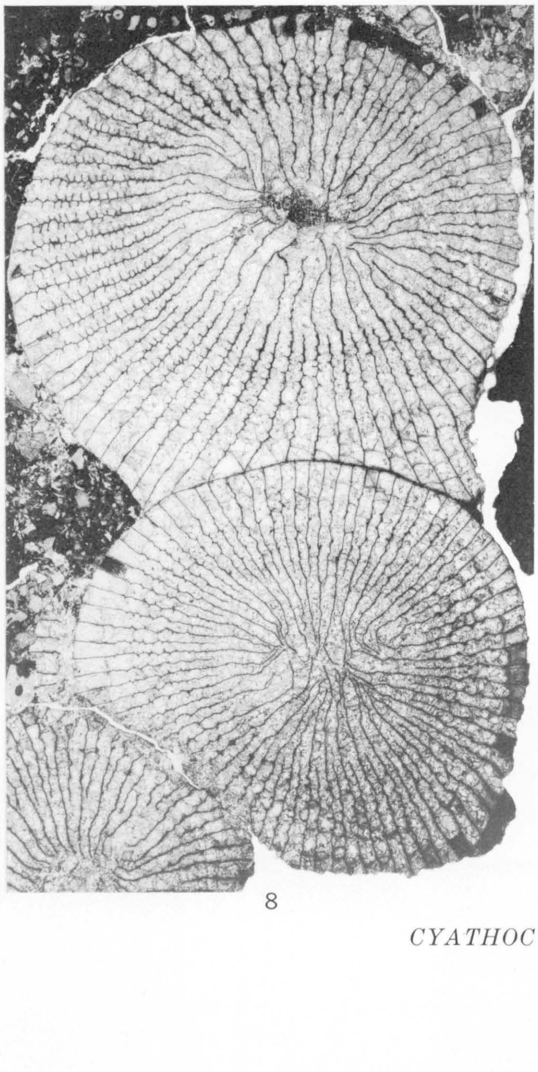

5

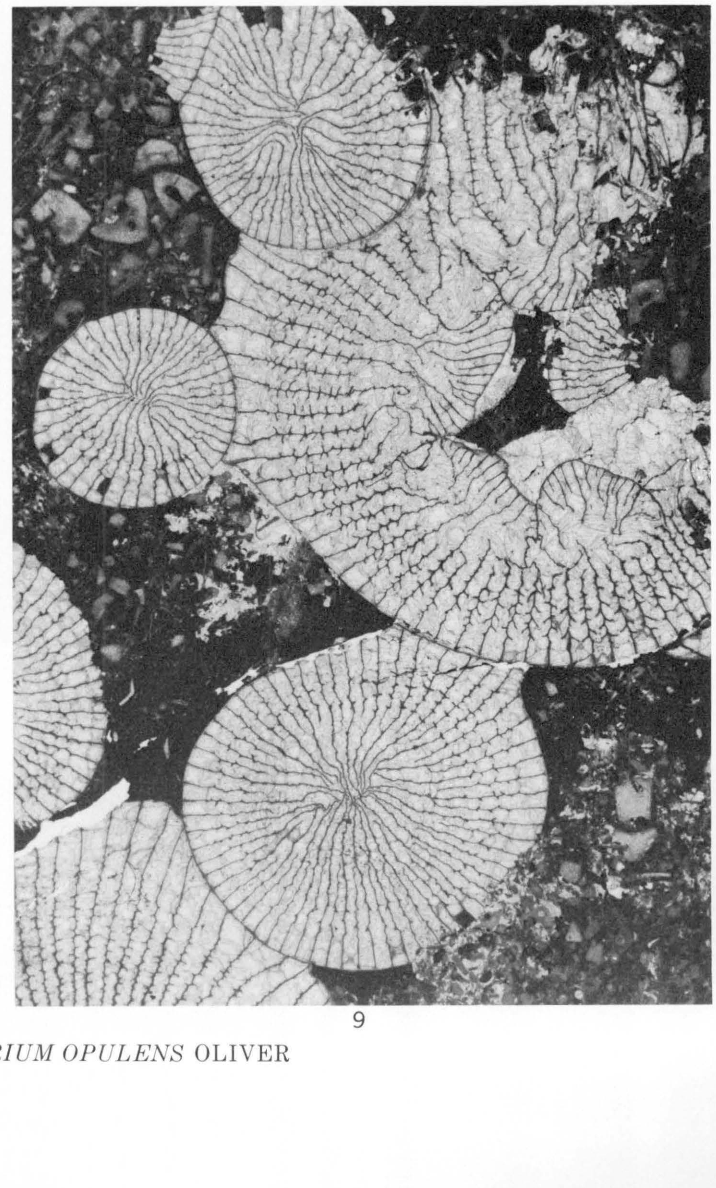

6


3


4


7


8


9

CYATHOCYLINDRIUM OPULENS OLIVER

PLATE 86

[All figures × 2½]

FIGURES 1–4. *Cyathocylindrium opulens* Oliver

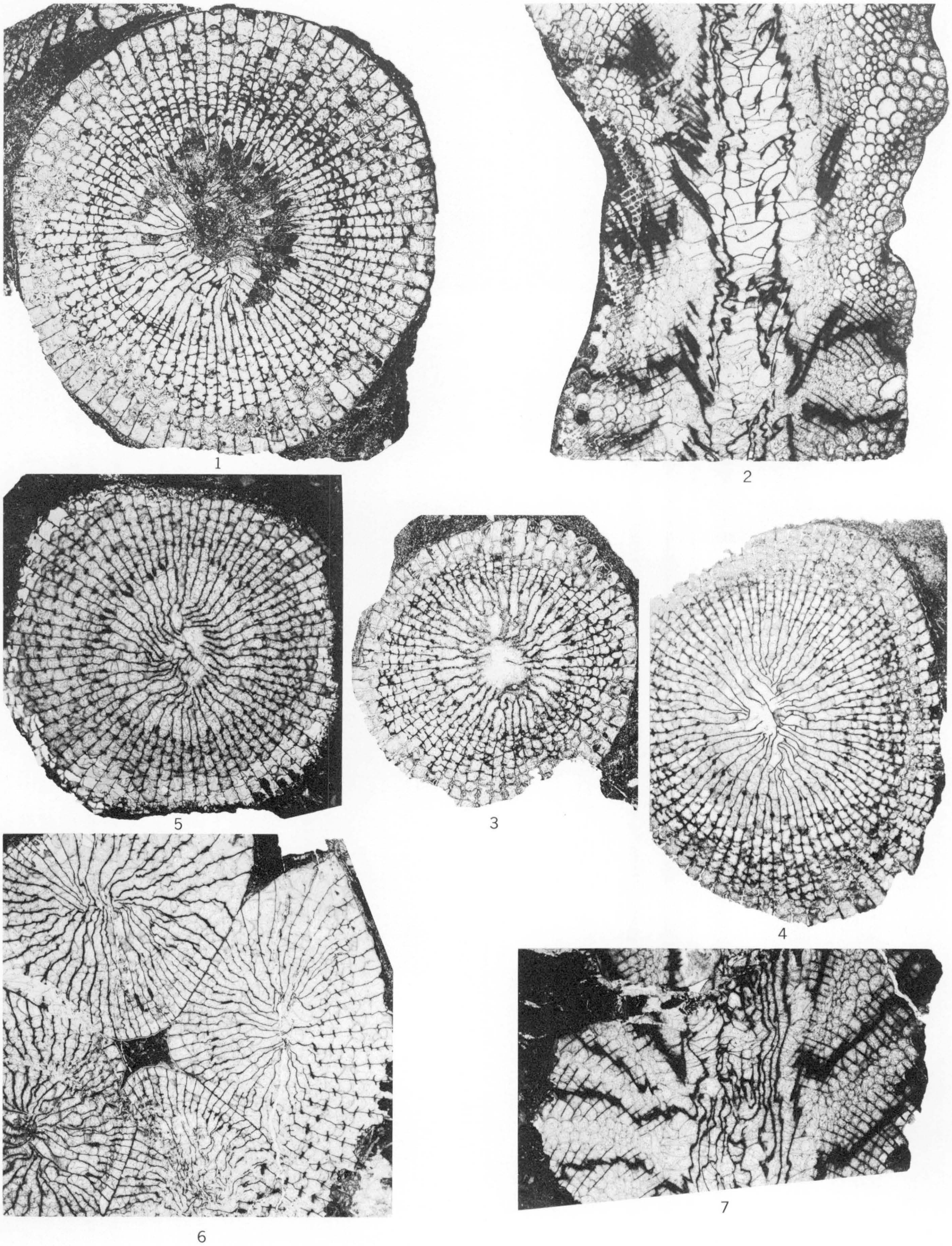
Paratype, USNM 172205. Edgecliff nonbiostrome facies. Loc. C23.

1, 2, 4. Two transverse and one longitudinal thin section of one corallite.

3. Transverse thin section of another corallite.

5–7. *Cyathocylindrium* sp. cf. *C. opulens* Oliver.

UMMP 60485. Transverse and longitudinal thin sections. Fig. 6 shows peripheral offsets in advanced stage. Upper Columbus Limestone, Ashtabula County core, Ohio.

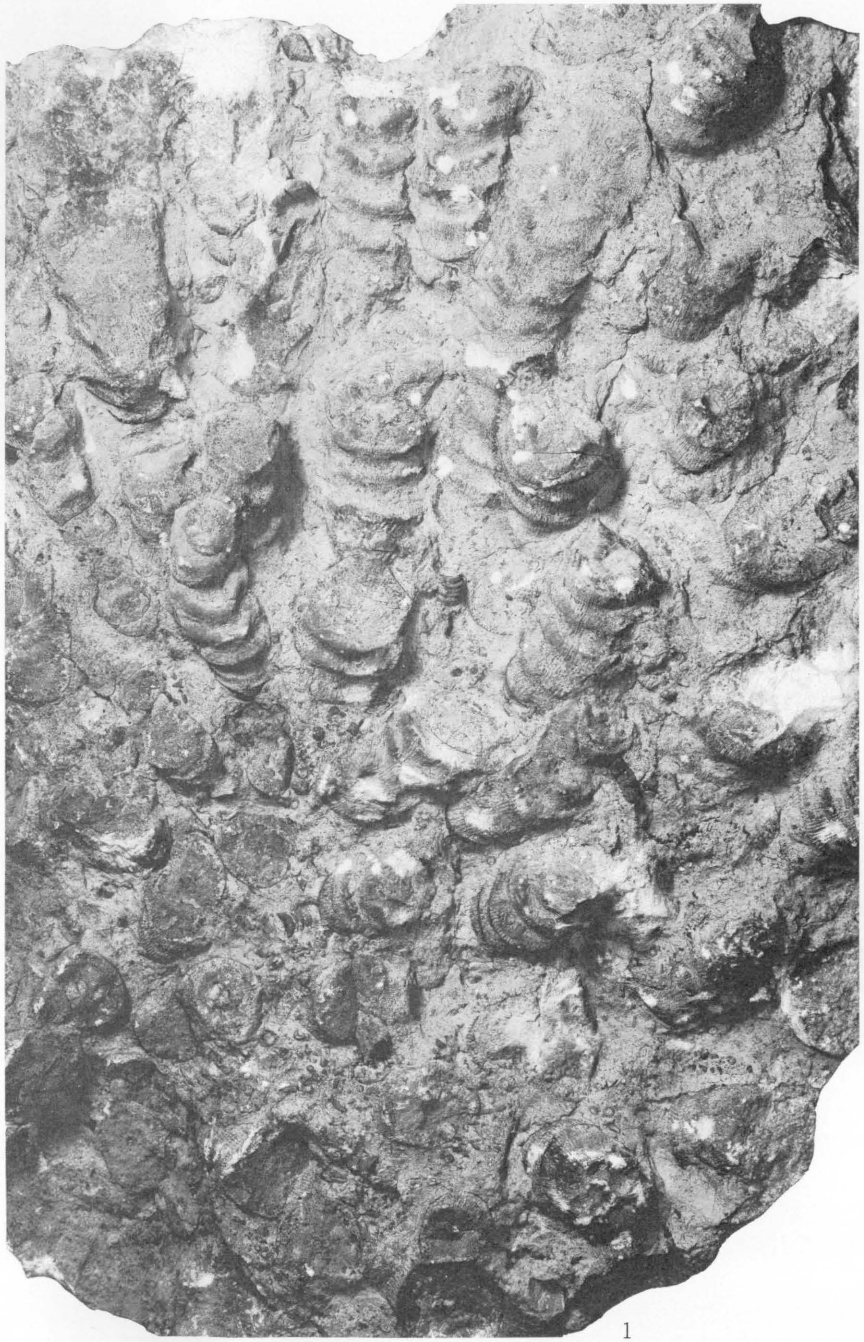


CYATHOCYLINDRIUM OPULENS OLIVER AND *C.* SP. CF. *C. OPULENS*

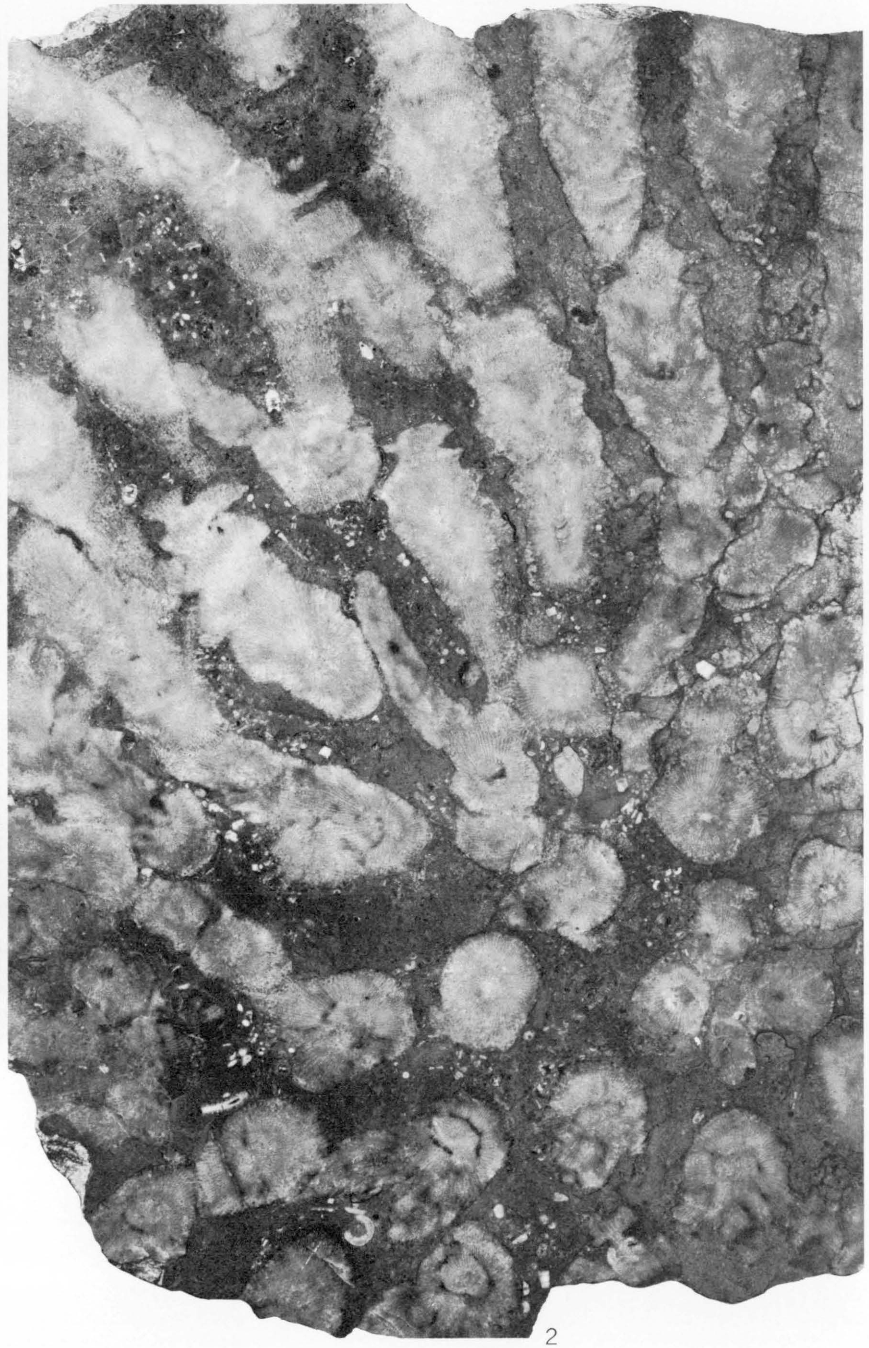
PLATE 87

FIGURES 1, 2. *Cyathocylindrium gemmatum* (Hall) (p. 120).

USNM 172213. Polished base and weathered upper surface of same part of rock slab approximately 5 cm thick (× ½). Shows profuse growth with peripheral increase near center of corallum. Edgecliff bioherm facies. Loc. 108. See also pl. 88, figs. 4–6.



1



2

CYATHOCYLINDRIUM GEMMATUM (HALL)

PLATE 88

FIGURES 1–8. *Cyathocylindrium gemmatum* (Hall) (p. 120).
Edgecliff Member, New York and Ontario.

1, 2. USNM 172217. Transverse (× 1) and longitudinal (× 2½) thin sections. Edgecliff "'green beds." Loc. C10.

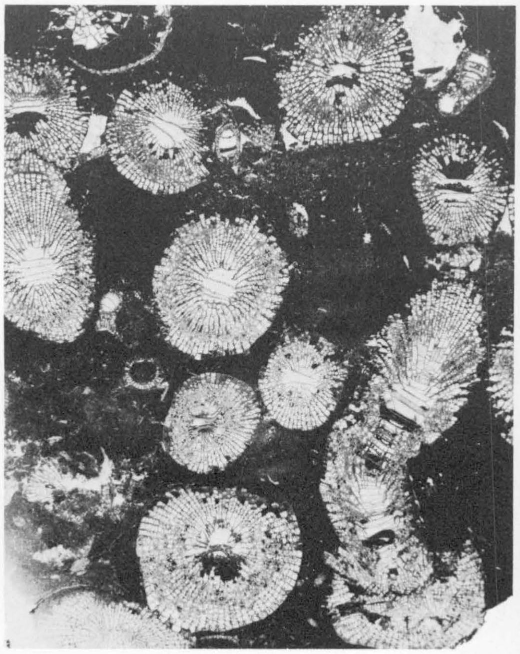
3. USNM 172215. Longitudinal thin section (× 2½). Bioherm facies. Loc. 108. See also pl. 90, figs. 4–7.

4–6. USNM 172213. Bioherm facies. Loc. 108. See also pl. 87, figs. 1, 2.

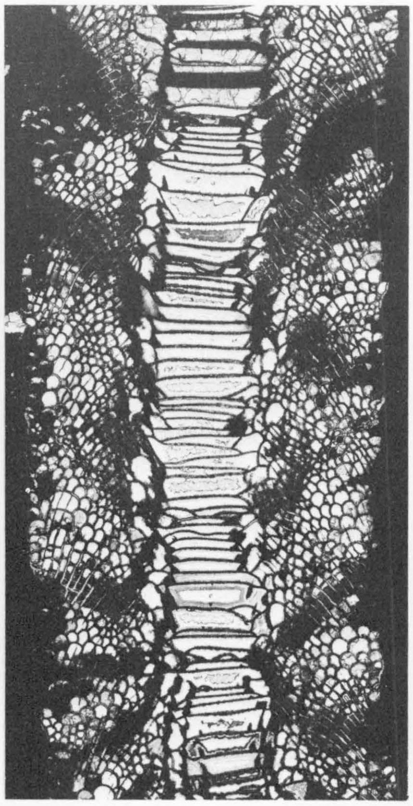
4. Transverse thin section (× 2½).

5, 6. Longitudinal thin section of another corallite. Detail (× 50) of wall from left-center area of section in fig. 6 (× 2½).

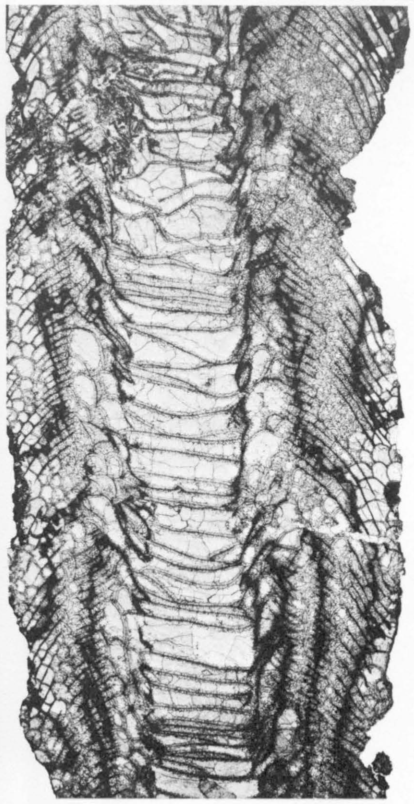
7, 8. USNM 172212. Transverse and longitudinal thin sections of one corallite (× 2½). Bioherm facies. Loc. 108.



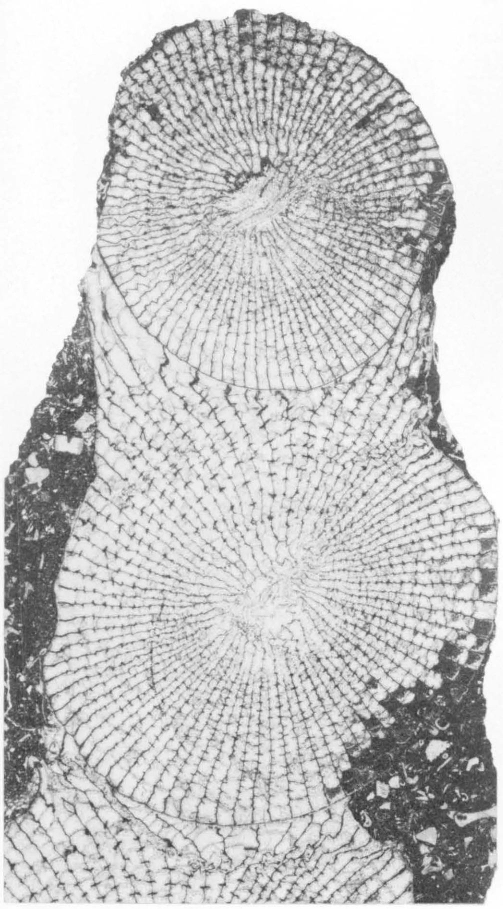
1



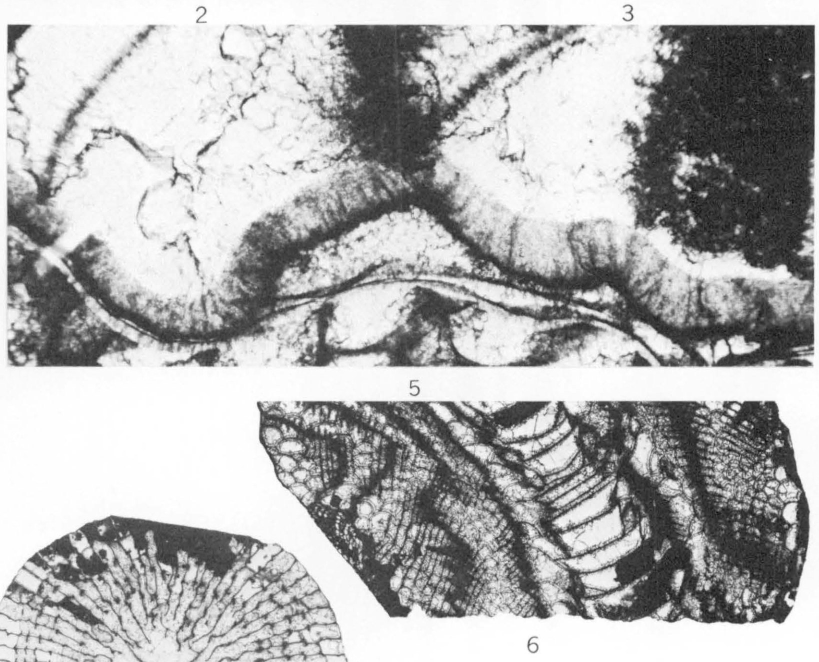
2



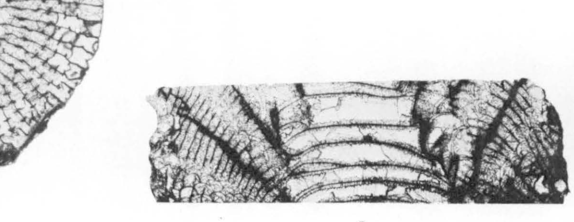
3



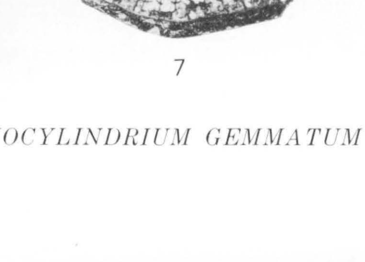
4



5



6



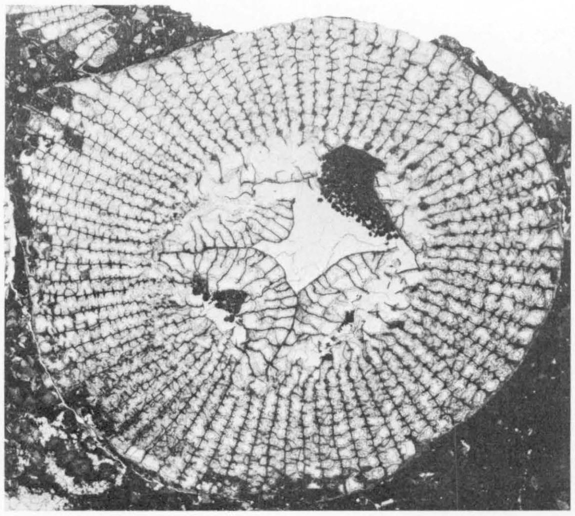
7

8

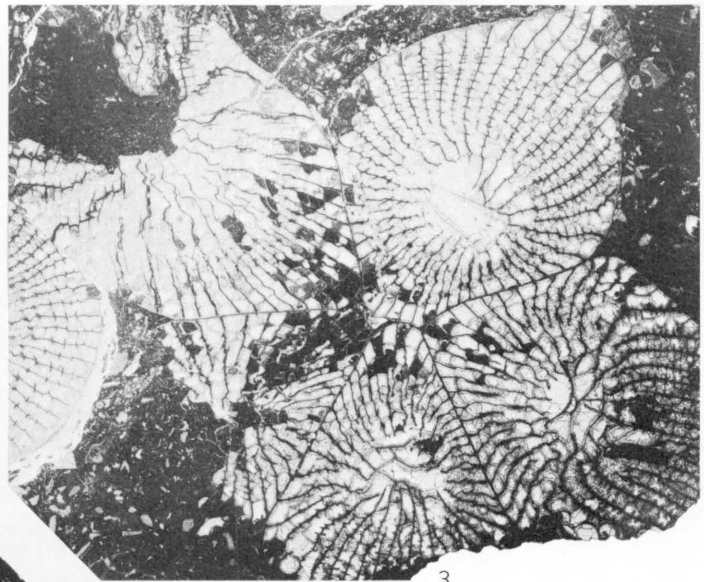
CYATHOCYLINDRIUM GEMMATUM (HALL)

PLATE 89

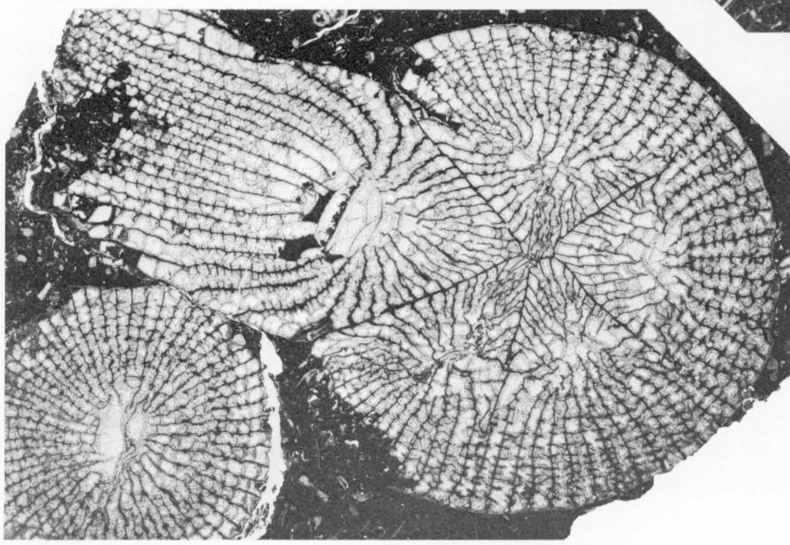
FIGURES 1–6. *Cyathocylindrium gemmatum* (Hall) (p. 120).
Edgecliff bioherm facies. Loc. 108.
1–5. USNM 172214.
1–3. Serial transverse thin sections of axial increase (× 2½). Distance between upper and lower section, estimated at 1 cm.
4. Detail of section in fig. 3 (× 10).
5. Detail of section in fig. 2 (× 50).
6. NYSM 12860. Transverse thin section (× 2½).



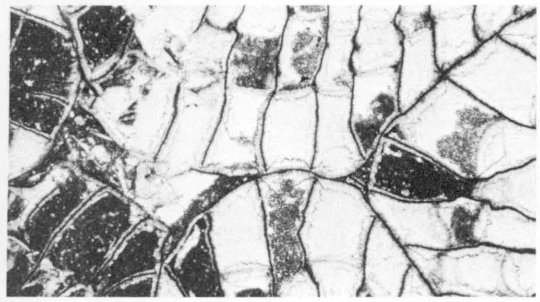
1



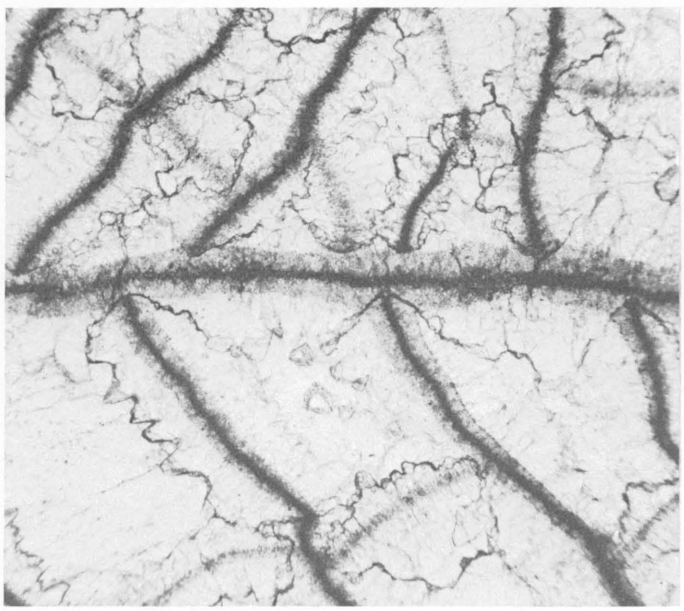
3



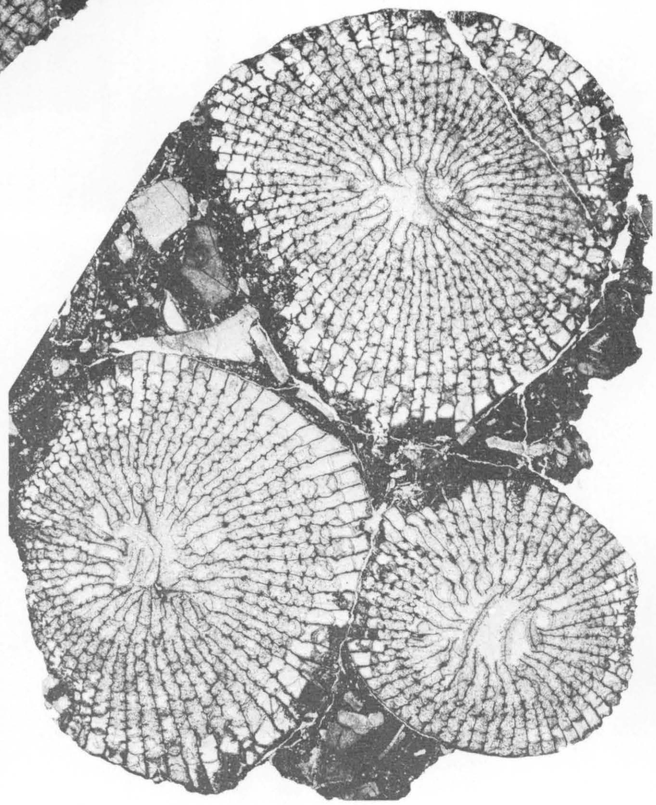
2



4



5



6

CYATHOCYLINDRIUM GEMMATUM (HALL)

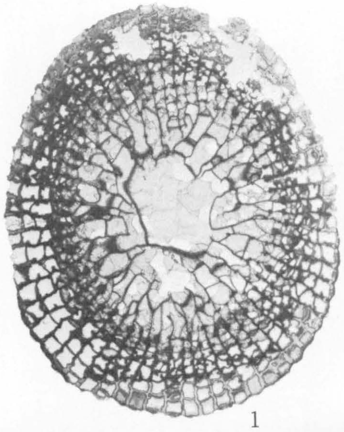
PLATE 90

FIGURES 1–7. *Cyathocylindrium gemmatum* (Hall) (p. 120).

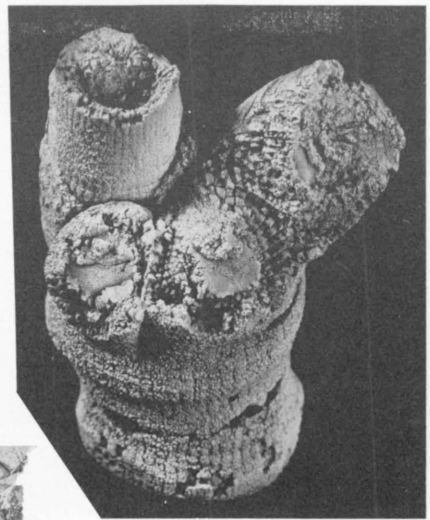
1–3. Holotype, FMNH 35872WM. Transverse thin section (× 2½) and two views of specimen (× 1½). Jeffersonville Limestone, Falls of the Ohio.

4–7. USNM 172215. Edgecliff bioherm facies. Loc. 108. See also pl. 88, fig. 3.

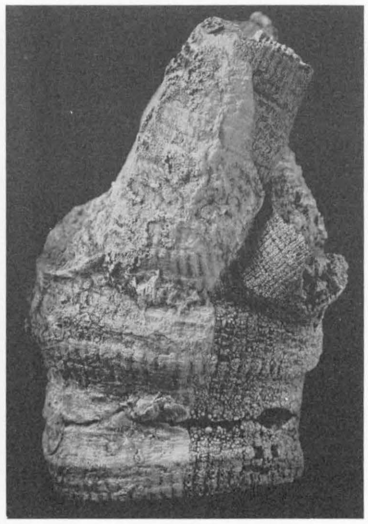
- 4, 5. Transverse thin section (× 5, × 2½).
- 6, 7. Longitudinal thin section of partial corallite in fig. 5.
  - 6. Part of section shown on pl. 88, fig. 3 (× 5).
  - 7. Detail of same section (× 50).



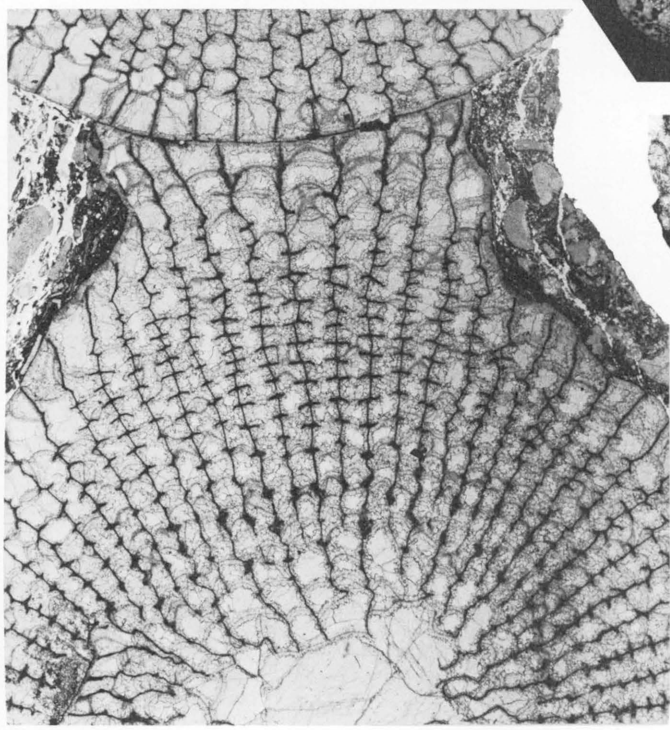
1



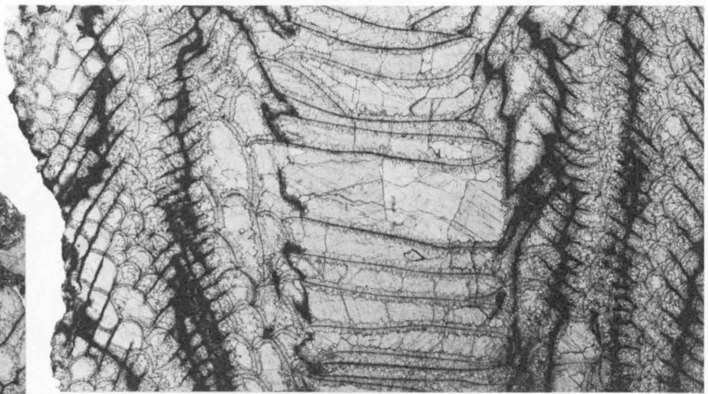
2



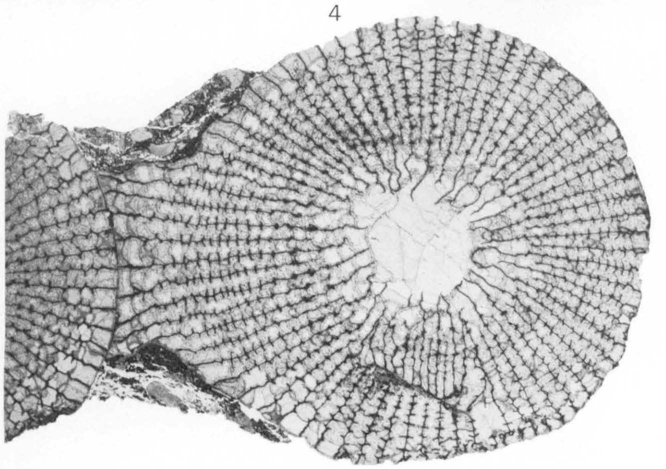
3



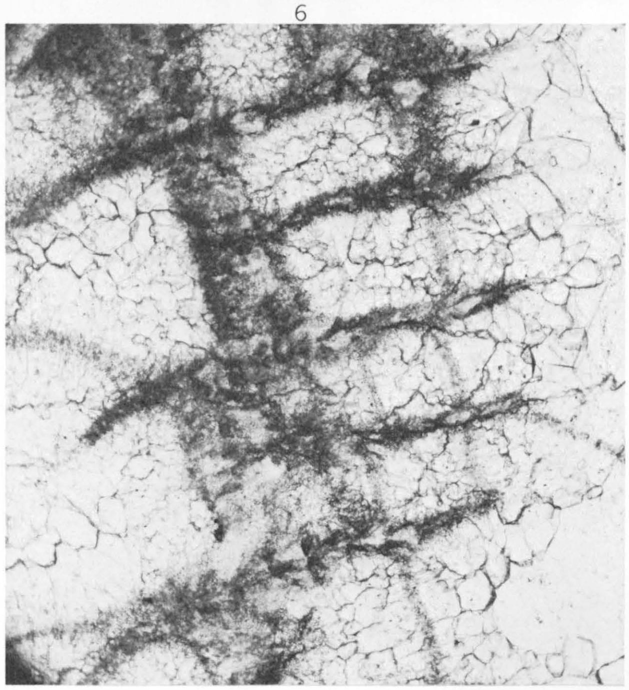
4



6



5



7

CYATHOCYLINDRIUM GEMMATUM (HALL)

PLATE 91

FIGURES 1–7. *Cyathocylindrium* n. sp. A (p. 122).

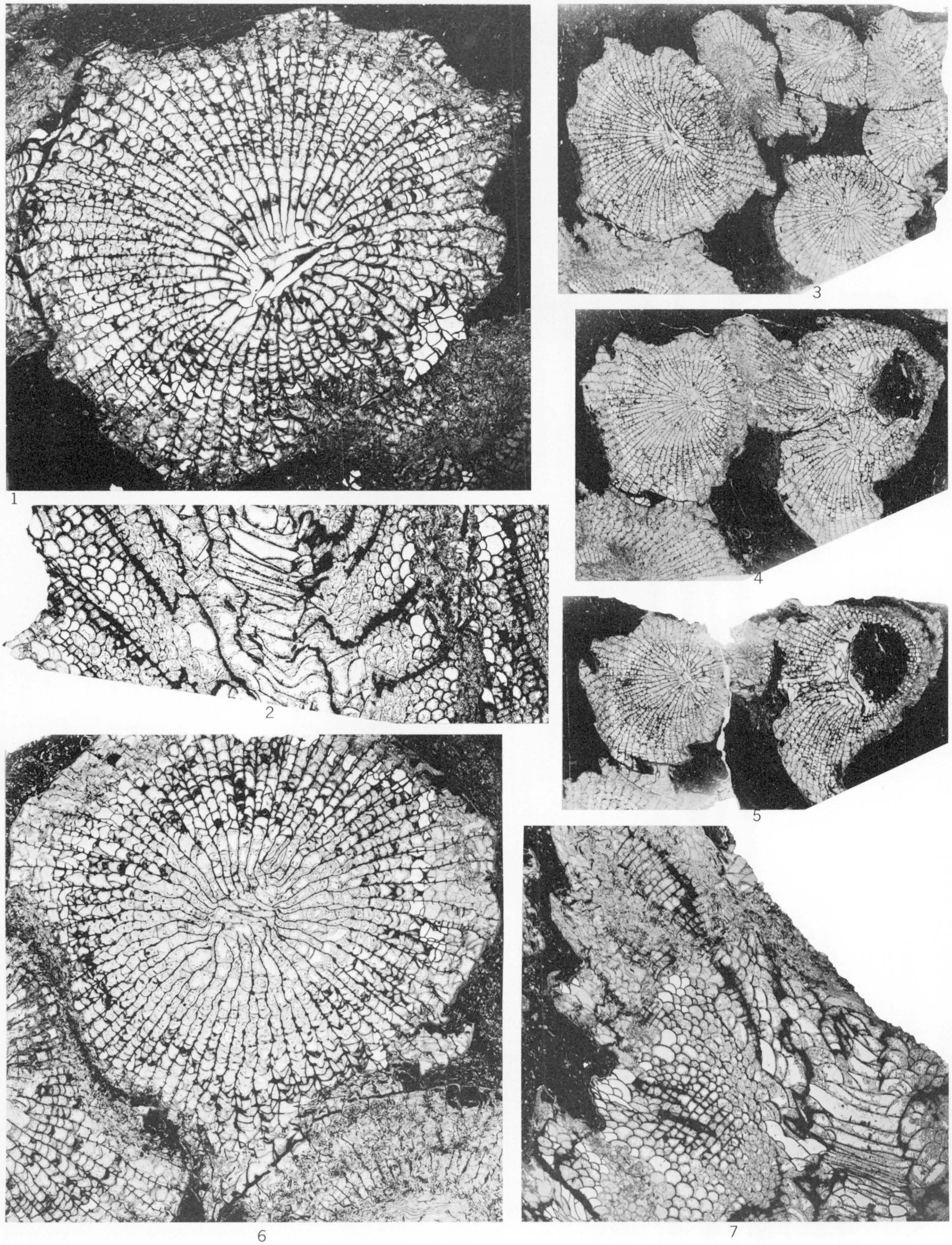
Moorehouse Member. Loc. 373.

1–5. USNM 172220.

1, 2. Transverse and longitudinal thin sections of different corallites (× 2½).

3–5. Serial transverse thin sections showing axial increase. Upper section (fig. 3) is approximately 17 mm above lower section. Middle section (fig. 4) is 5 to 6 mm above lower section. Corallite to left in fig. 3 is enlarged in fig. 1.

6, 7. NYSM 12864. Transverse and longitudinal thin sections (× 2½).



CYATHOCYLINDRIUM N. SP. A

PLATE 92

FIGURES 1–5. *Heliophyllum megaproliferum* n. sp. (p. 124).

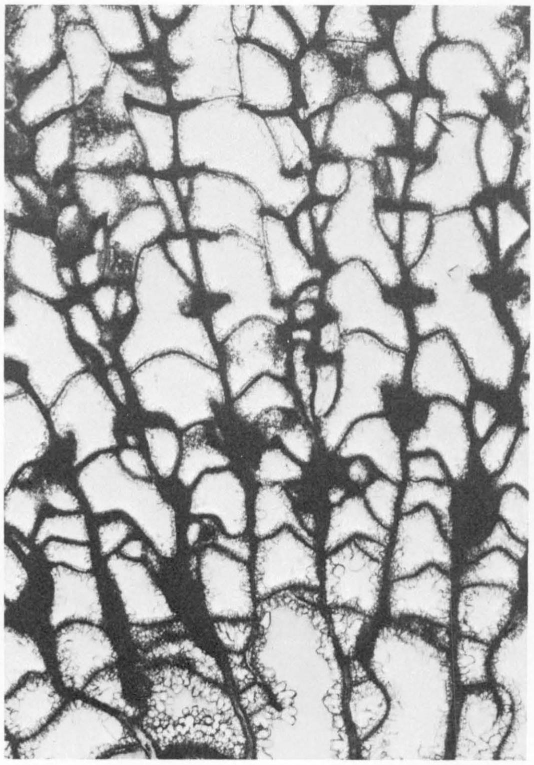
Edgecliff bioherm facies. Loc. C3.

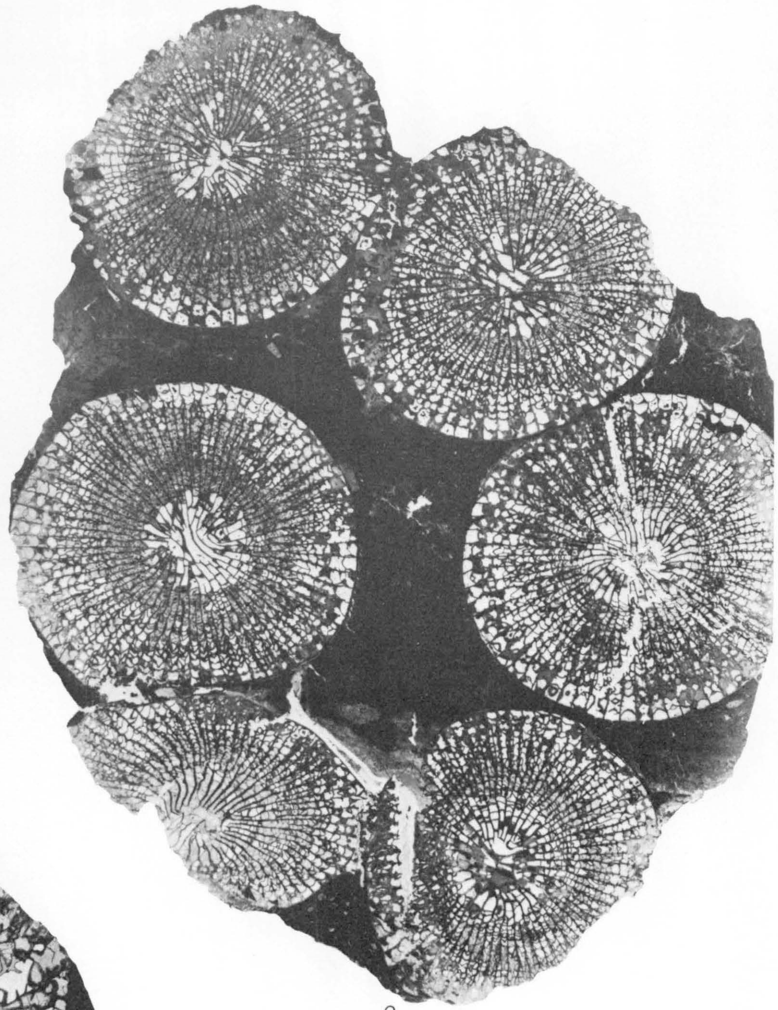
1, 3, 5. Paratype USNM 172221.

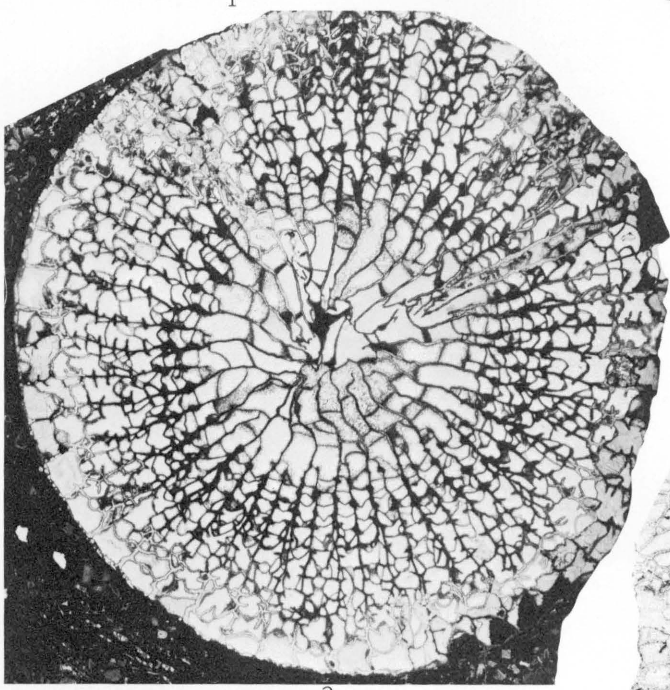
1, 3. Transverse thin section: detail (× 10) and general (× 2½). Detail is of inner dissepimentarium, above center in fig. 3.

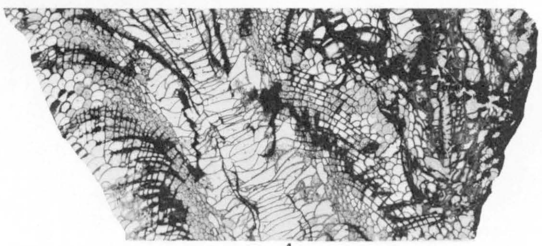
5. Longitudinal thin section of same corallite (× 2½).

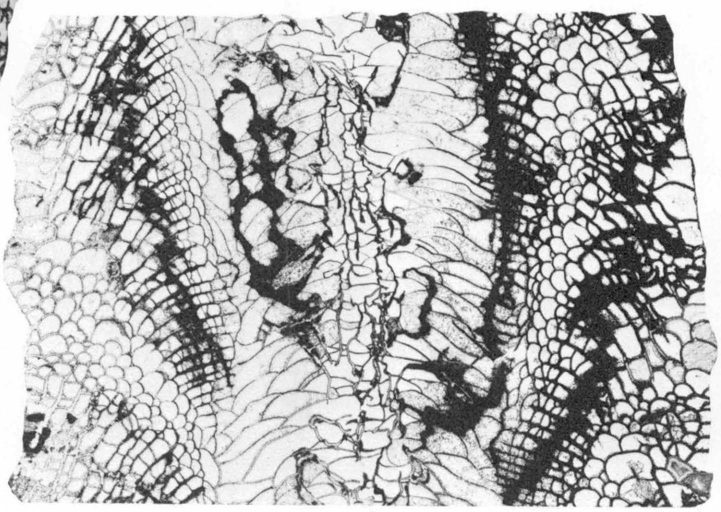
2, 4. Holotype, GSC 31161. Transverse and logitudinal thin sections (× 1).


1


2


3


4


5

HELIOPHYLLUM MEGAPROLIFERUM N. SP.

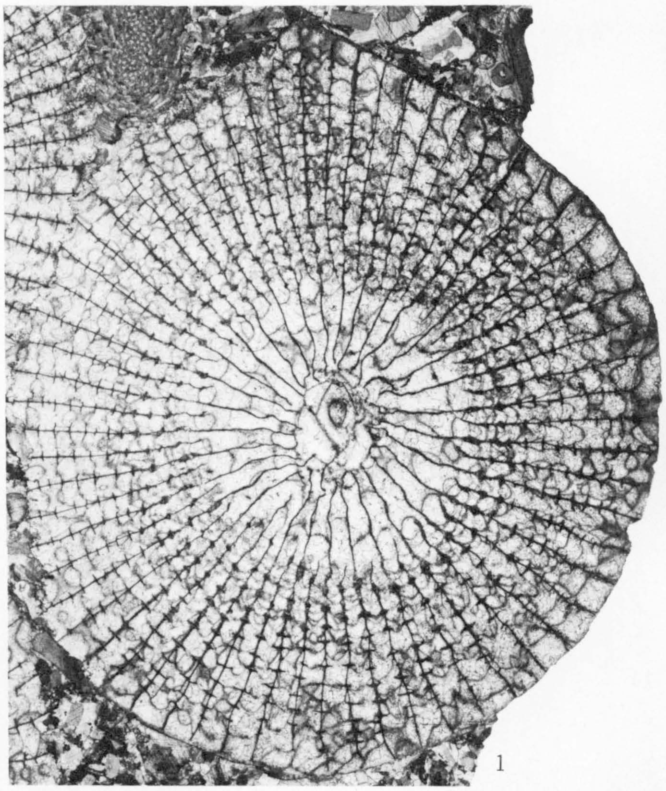
PLATE 93

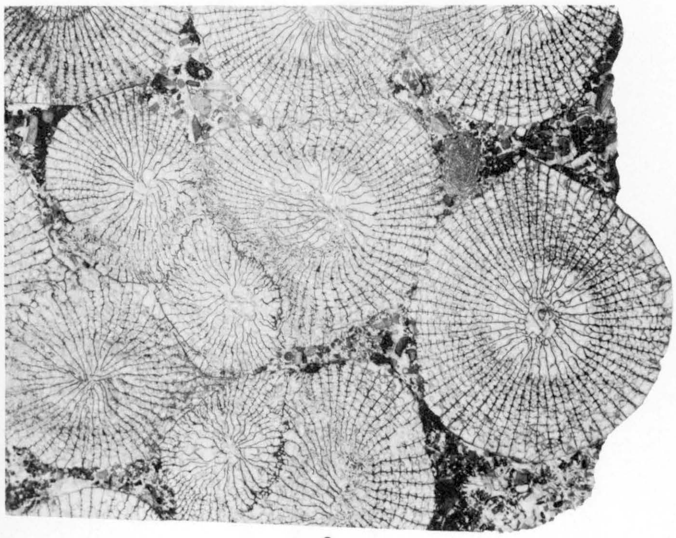
FIGURES 1–6. *Heliophyllum megaproliferum* n. sp. (p. 124).

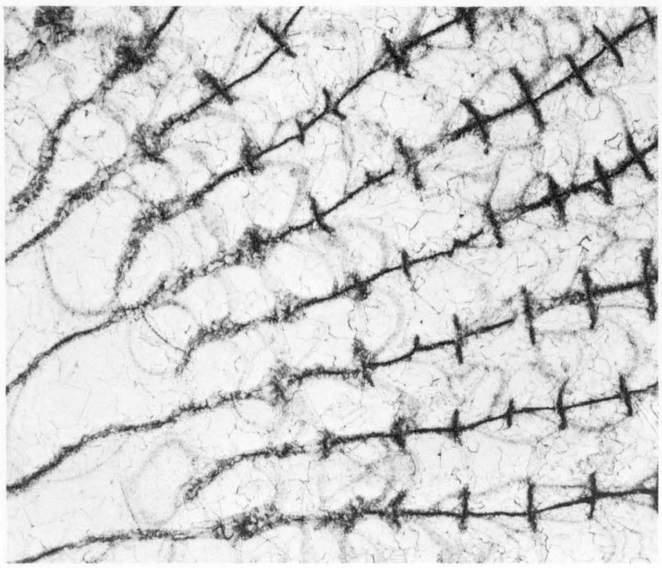
Edgecliff bioherm facies, New York.

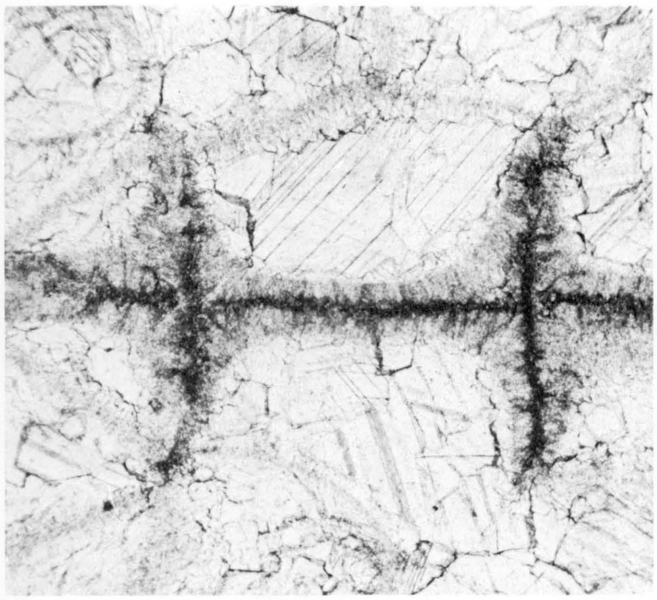
1–4. Paratype, USNM 172223. Transverse thin section (× 2½, × 1) and details (× 10, × 50). Fig. 3 is right center part of corallite in fig. 1 (reversed). Loc. 248.

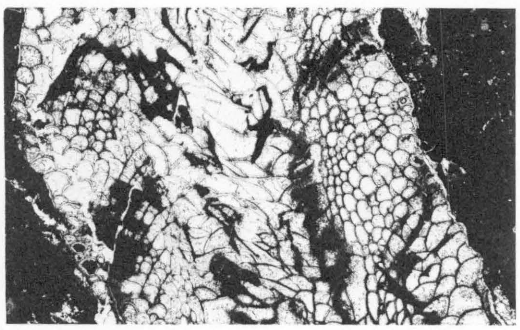
5, 6. Paratype, USNM 172222. Longitudinal and transverse thin sections (× 2½). Fig. 5 is of partial corallite (parent) in fig. 6. Fig. 6 shows lateral offset.

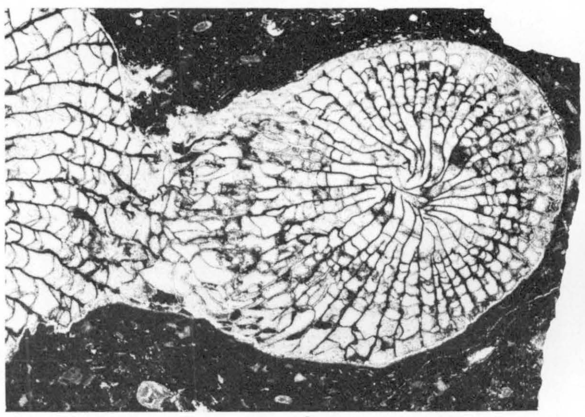

1


2


3


4


5


6

HELIOPHYLLUM MEGAPROLIFERUM N. SP.

PLATE 94

FIGURES 1–9. *Heliophyllum* n. sp. B (p. 125).

Edgecliff bioherm facies. Loc. 329.

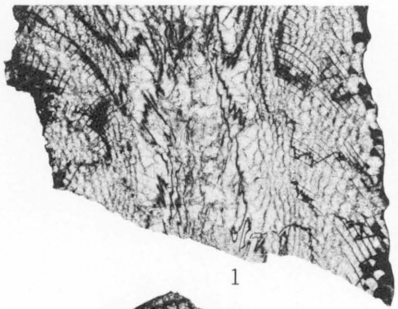
1, 2, 8, 9. USNM 172225.

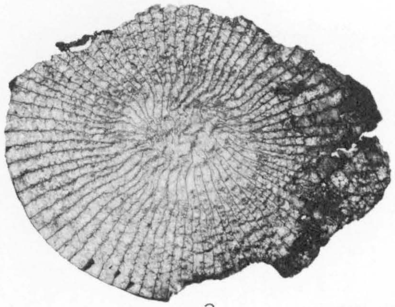
1, 2. Transverse and longitudinal thin sections of one corallite (× 1).

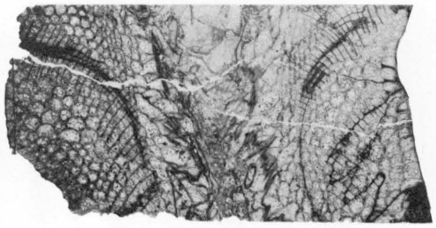
8, 9. Details of septal morphology in section shown in fig. 2 (× 10).

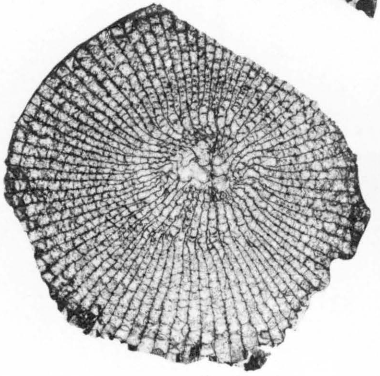
3–5. USNM 172224. Transverse and longitudinal thin sections of different corallites (× 1) and detail of transverse section (× 50).

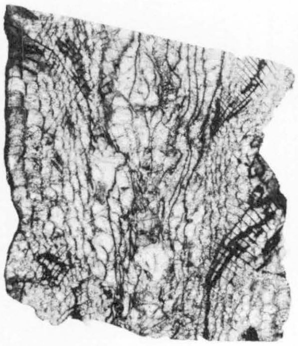
6, 7. NYSM 12865. Longitudinal thin section (× 1) and detail of same (× 5).

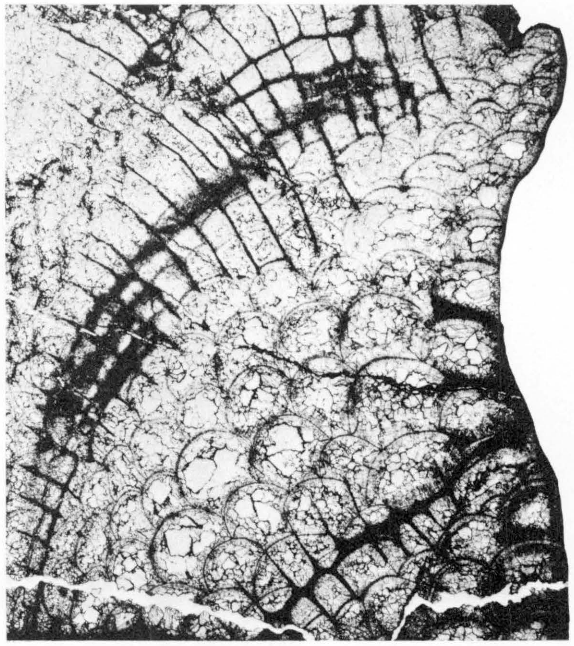

1

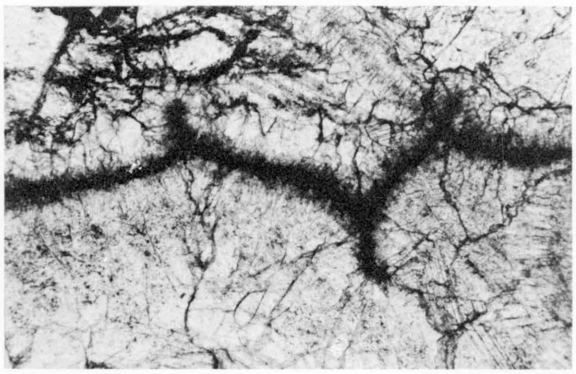

3

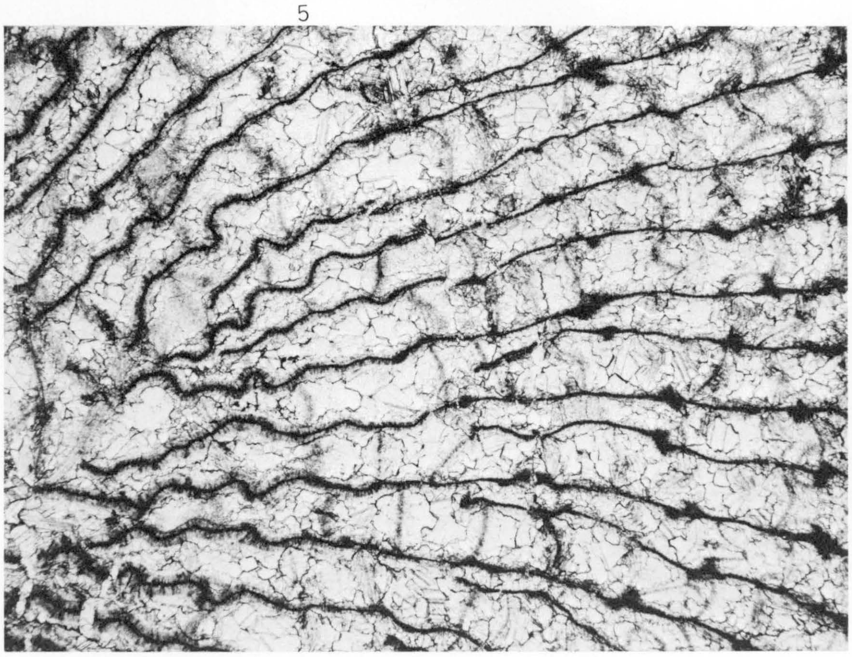

6

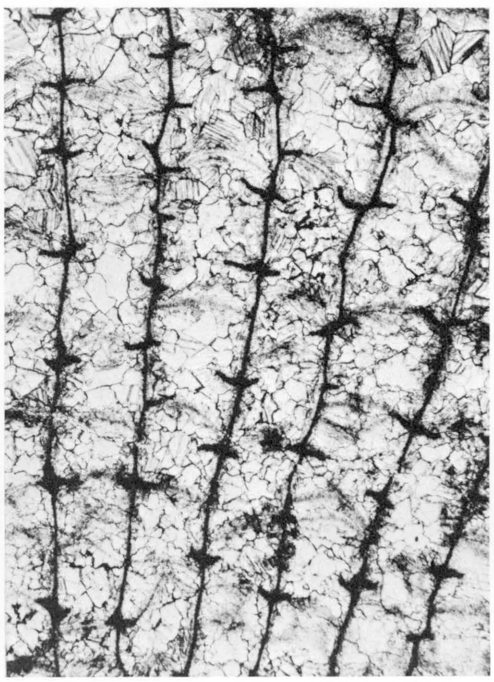

2


4


7


5


8


9

HELIOPHYLLUM N. SP. B

PLATE 95

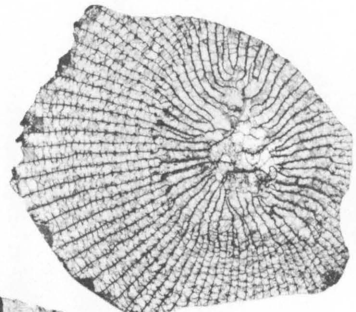
FIGURES 1–6. *Heliophyllum* n. sp. C (p. 126).

USNM 172227. Edgecliff bioherm facies. Loc. 297.

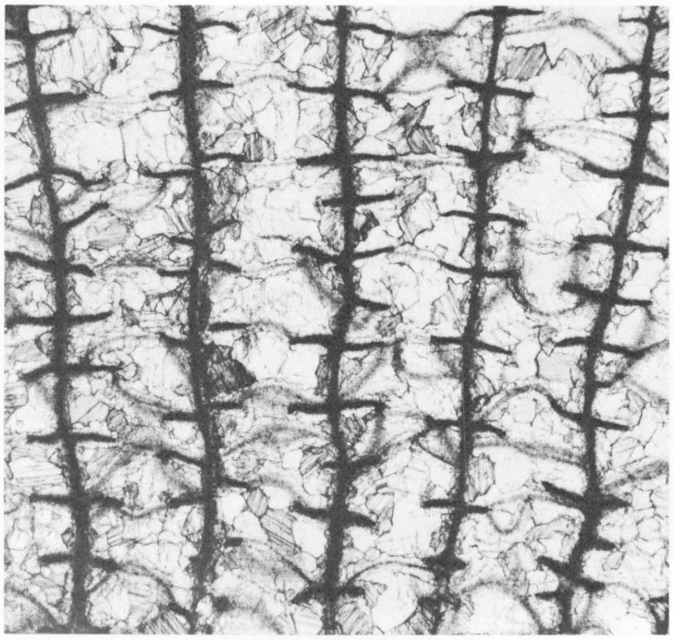
1, 2. Transverse thin section (× 1) and part of same (× 5).

3, 4. Details of septal morphology in same section (× 10, × 25).

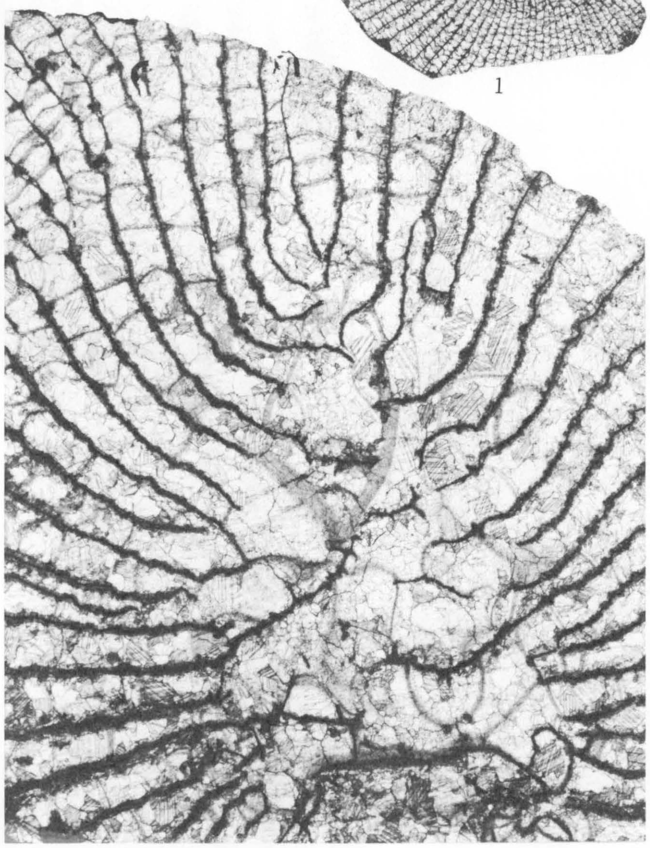
5, 6. Longitudinal thin section of another corallite (× 1) and detail of same (× 5).



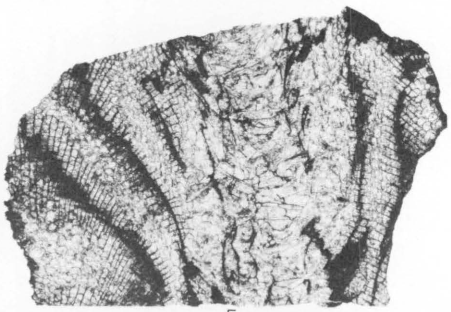
1



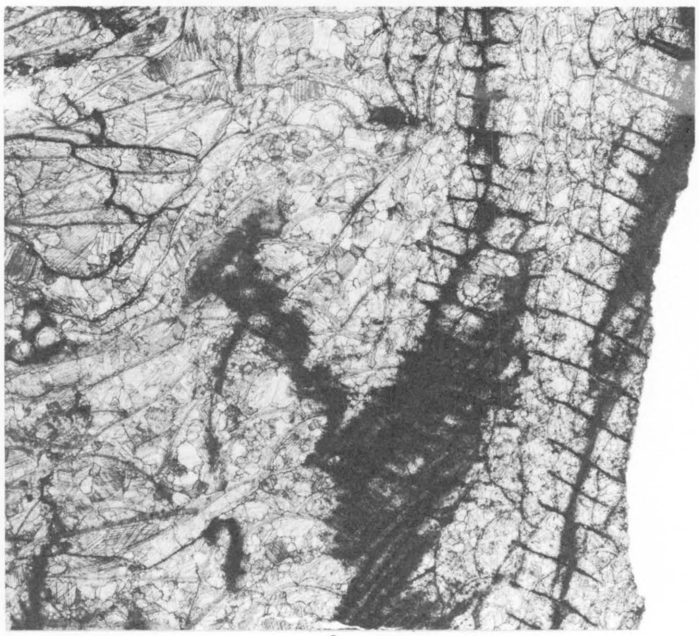
3



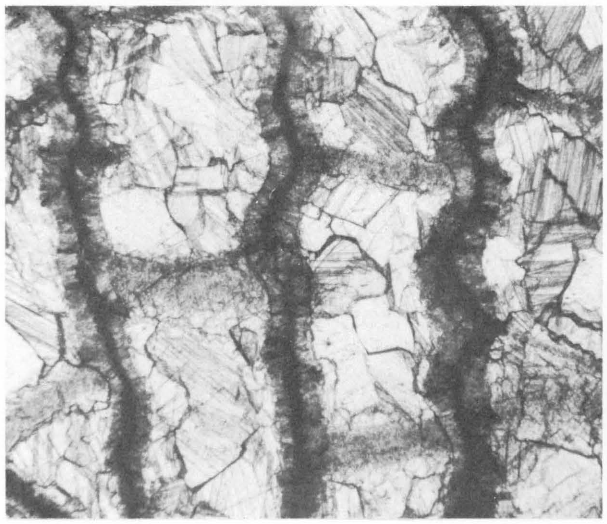
2



5



6



4

HELIOPHYLLUM N. SP. C

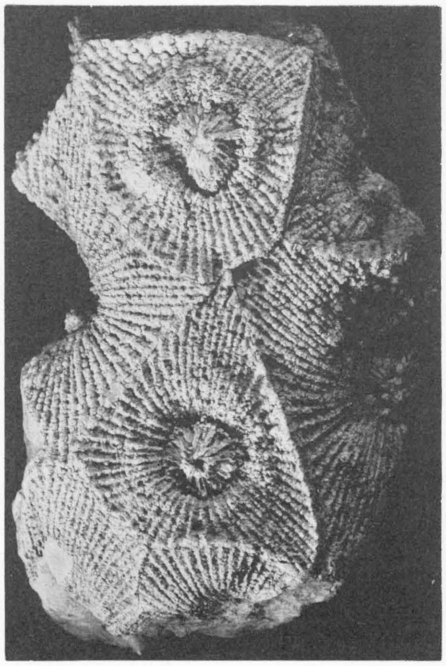
PLATE 96

FIGURES 1–4. *Heliophyllum coalitum* (Rominger) (p. 127).

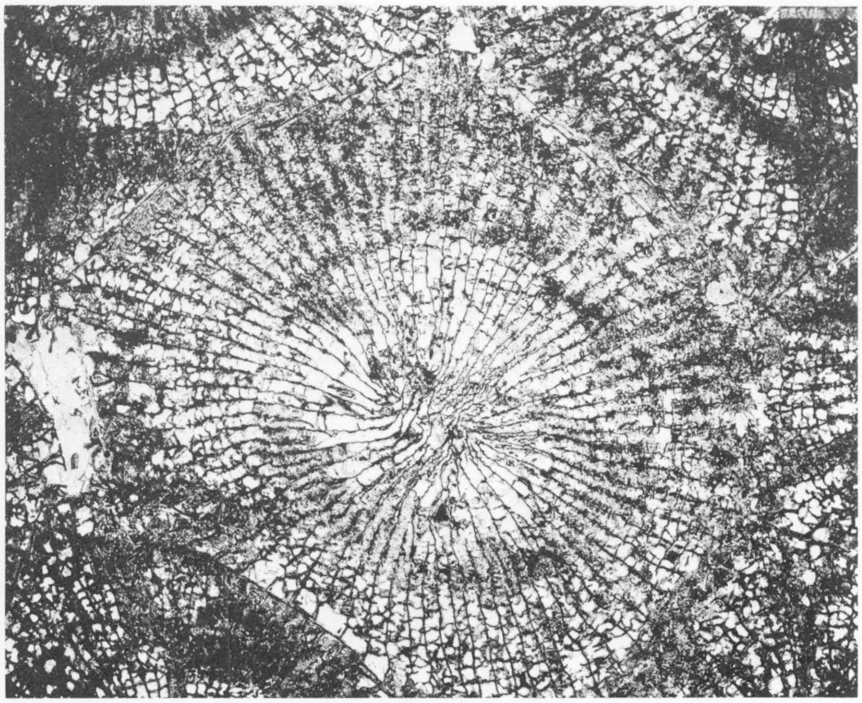
1. Holotype, UMMP 8579. Top surface of fragment (× 1). Drift, Ann Arbor, Mich.

2, 3. USNM 172229. Transverse thin section: one corallite (× 2½) and several (× 1). Edgecliff bioherm facies. Loc. 438.

4. USNM 172228. Transverse thin section (× 1). Edgecliff bioherm facies. Loc. 296.

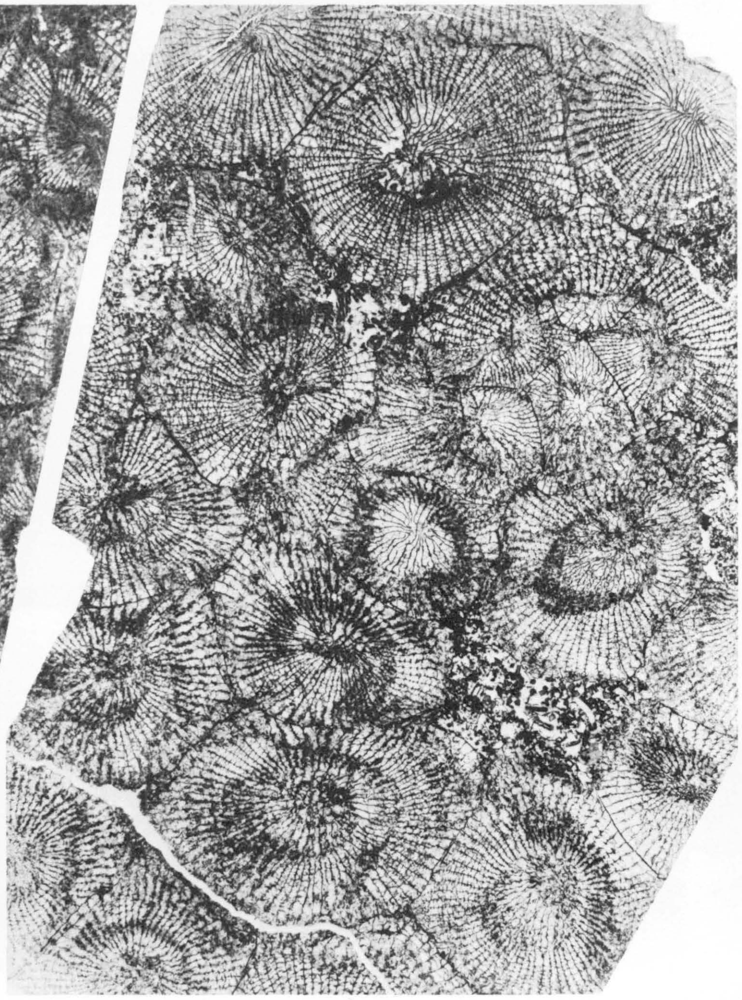


1



2

3



4

HELIOPHYLLUM COALITUM (ROMINGER)

PLATE 97

FIGURES 1–7. *Heliophyllum coalitum* (Rominger) (p. 127).

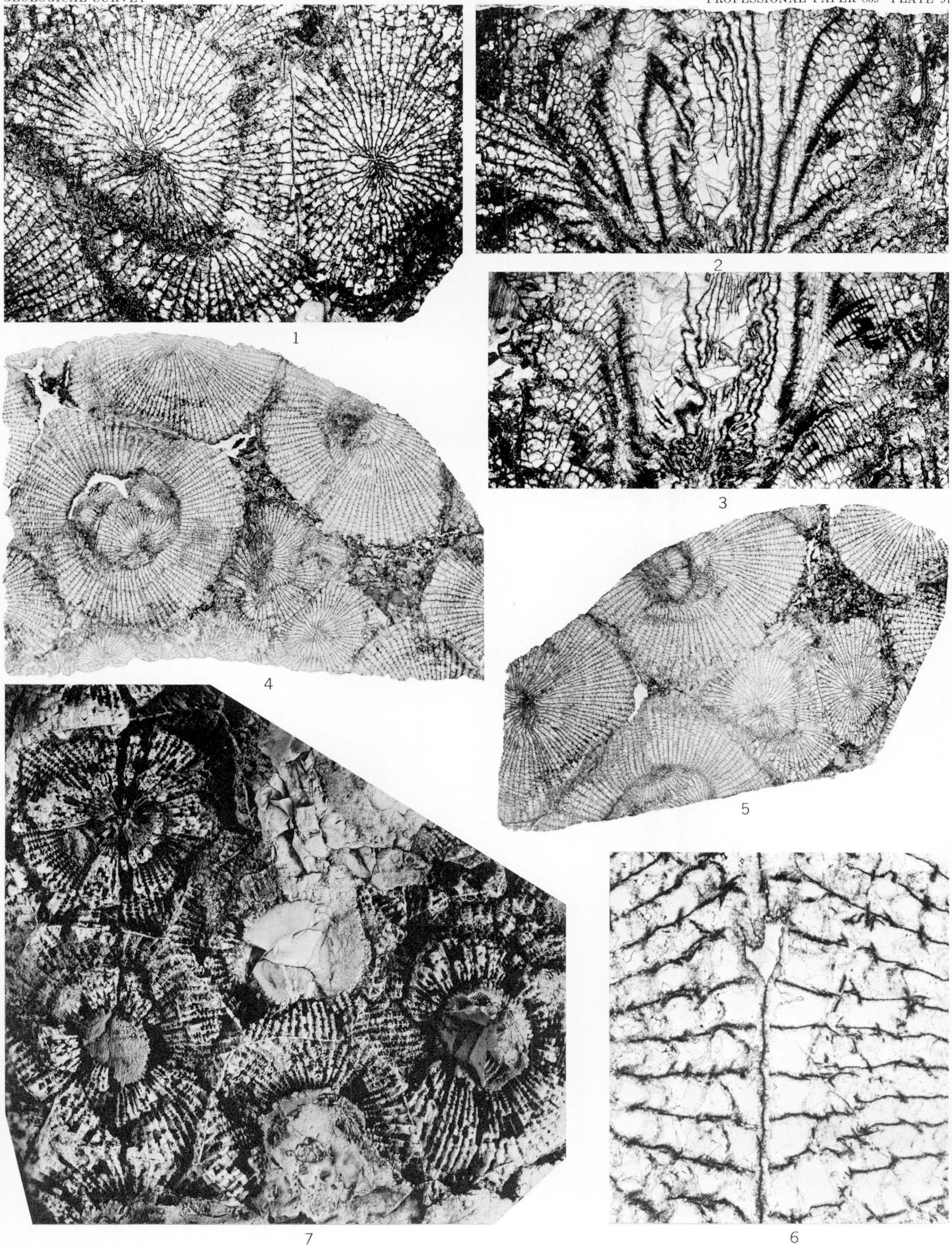
1–6. USNM 172230. Edgecliff bioherm facies. Loc. 438.

1, 5, 6. Transverse thin section (× 2½, × 1) and detail of wall and septa (× 10).

2, 3. Longitudinal thin sections (× 2½).

4. Second transverse thin section (× 1).

7. GSC 3586. Weathered surface of silicified colony. North Oxford Township, Ontario.



HELIOPHYLLUM COALITUM (ROMINGER)

PLATE 98

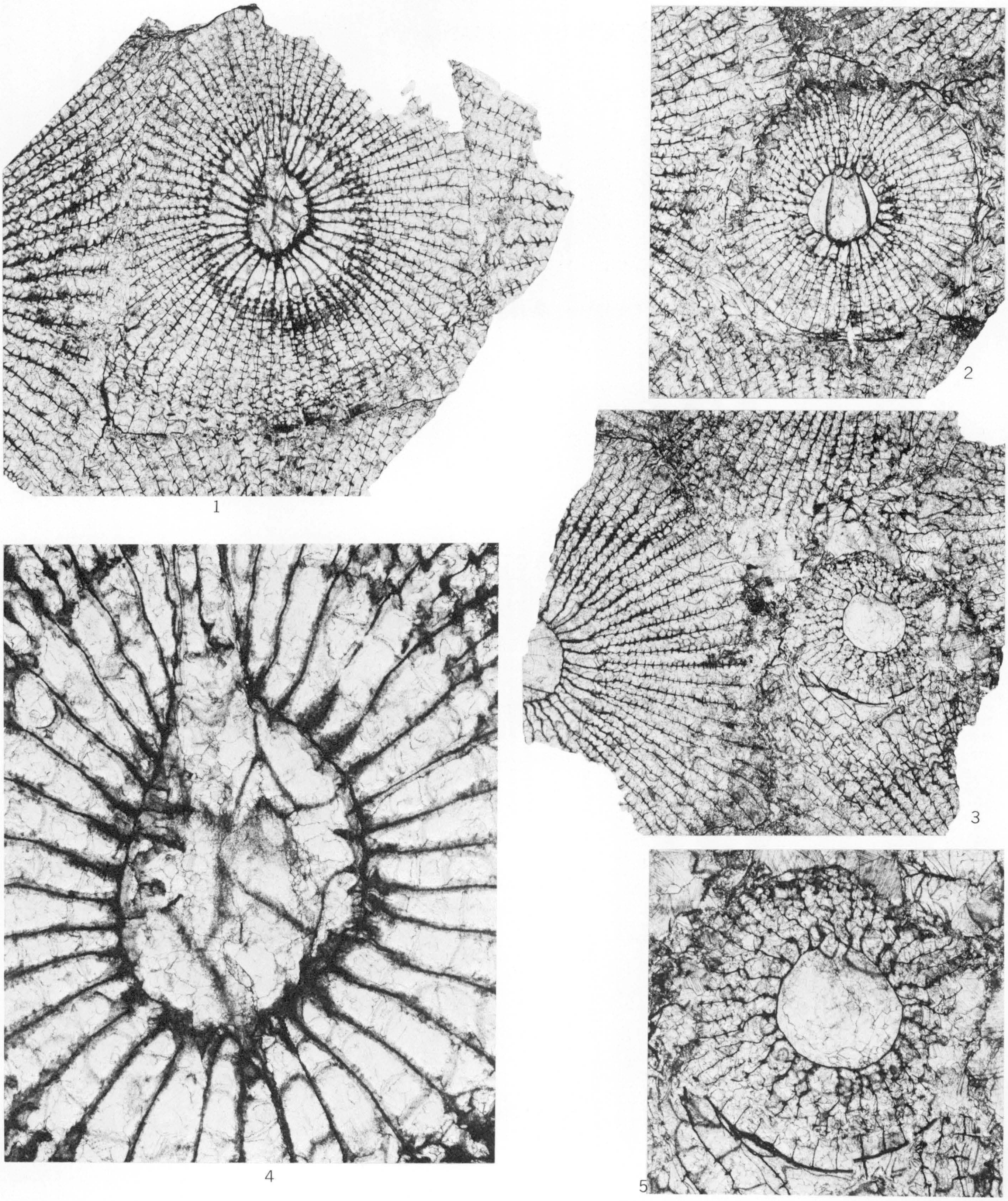
FIGURES 1–5. *Heliophyllum coalitum* (Rominger) (p. 127).

USNM 172231. Edgecliff bioherm facies. Loc. 296. Morphology of aulos known only in this one corallum.

1–3. Serial transverse sections of lateral offset with aulos (descending order; sections in figs. 2 and 3 were taken 9 mm and 15 mm below that in fig. 1) (× 2½).

4. Detail of aulos in fig. 1 (× 10).

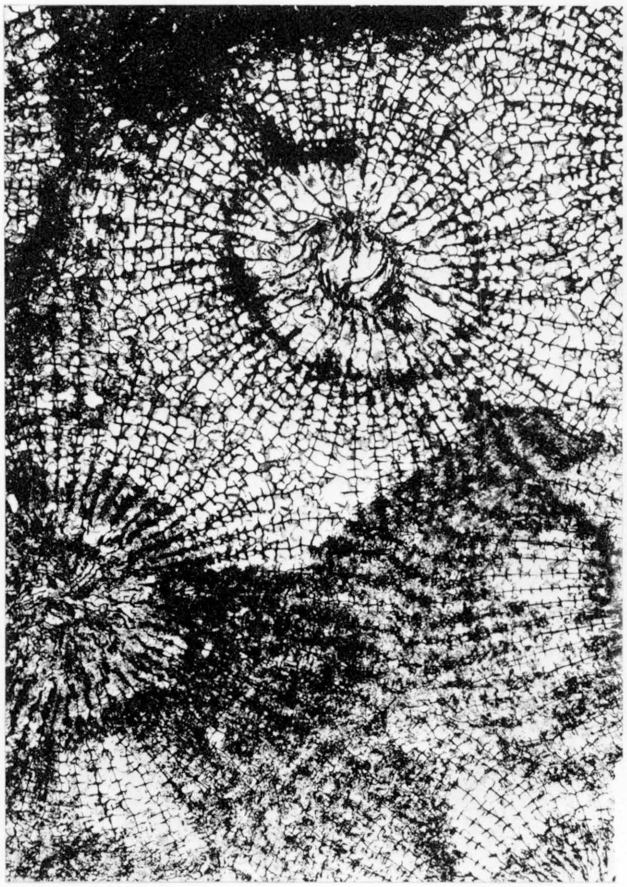
5. Detail of earliest stage of offset and aulos in section seen in fig. 3 (× 5).



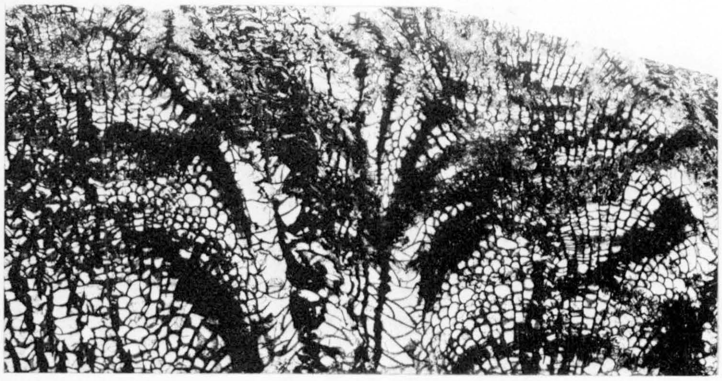
HELIOPHYLLUM COALITUM (ROMINGER)

PLATE 99

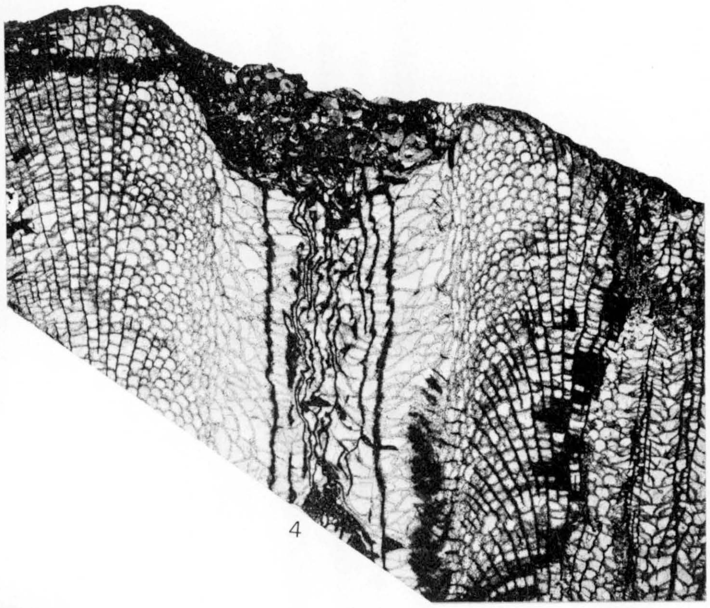
FIGURES 1–5. *Heliophyllum monticulum* (Ehlers and Stumm) (p. 129).
Edgecliff bioherm facies. Loc. 108 (Williamsville), New York.
1–3. Holotype, UMMP 28519 and USNM 128015. Transverse and longitudinal thin sections (× 2½) and upper surface of corallum (× 1).
4, 5. USNM 172234. Longitudinal and transverse thin sections (× 2½, × 1).



1

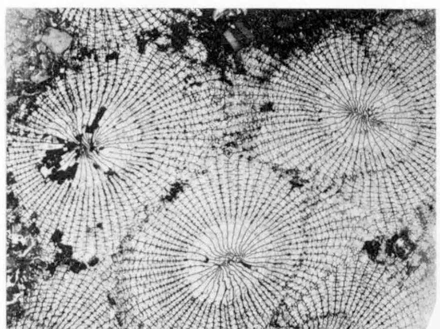


2



4

3



5

HELIOPHYLLUM MONTICULUM (EHLERS AND STUMM)

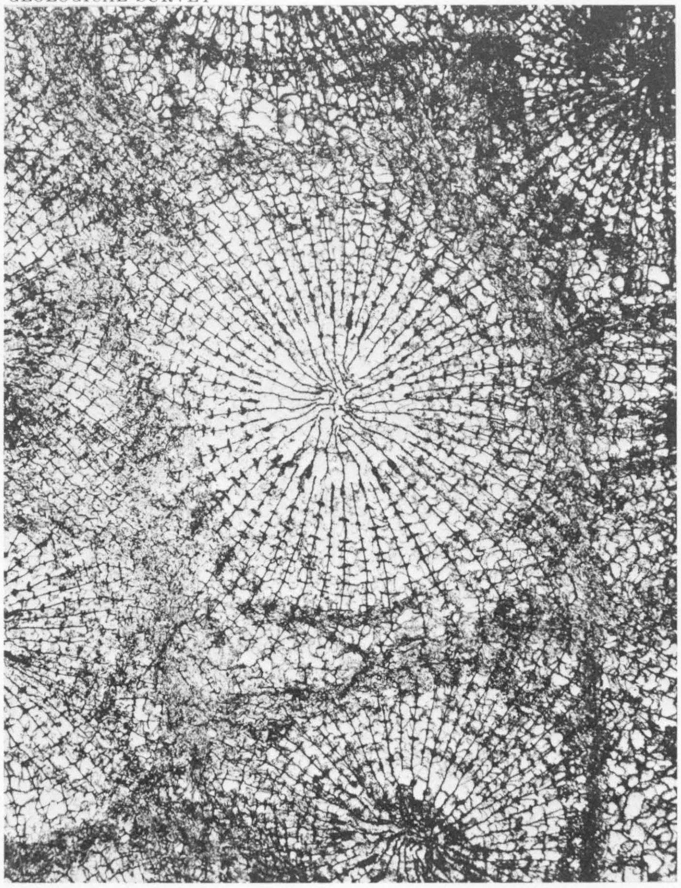
PLATE 100

FIGURES 1–5. *Heliophyllum monticulum* (Ehlers and Stumm) (p. 129).

USNM 172232. Edgecliff bioherm facies. Loc. 108.

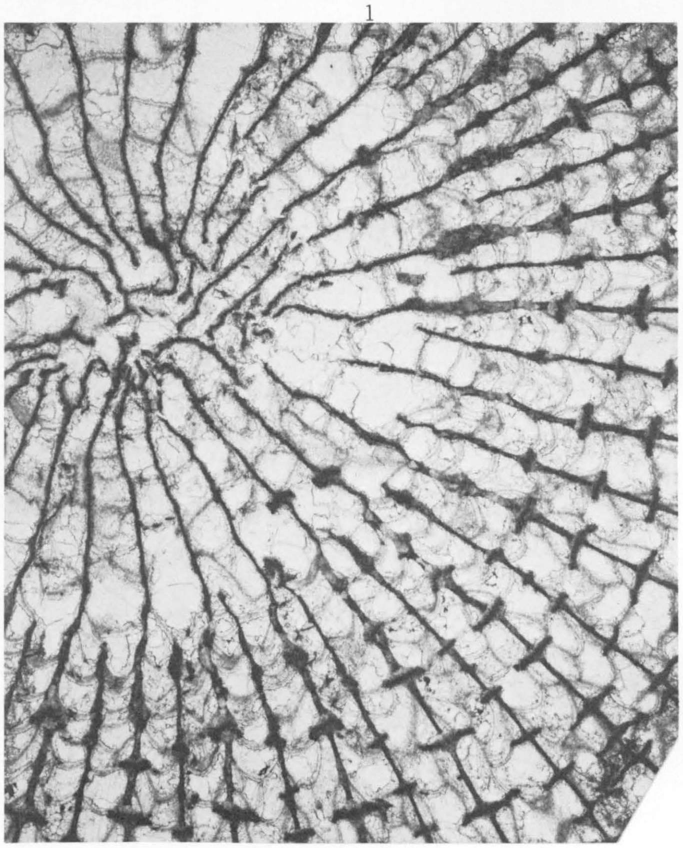
1–3. Transverse thin section: general view (× 2½); detail of inner ends of septa of same corallite (× 50) and its axial area (× 10). The three figures are similarly oriented.

4, 5. Longitudinal thin section (× 5) and detail (× 50).

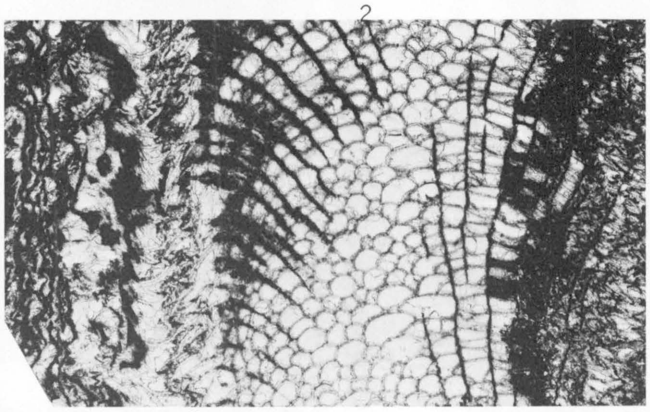


1

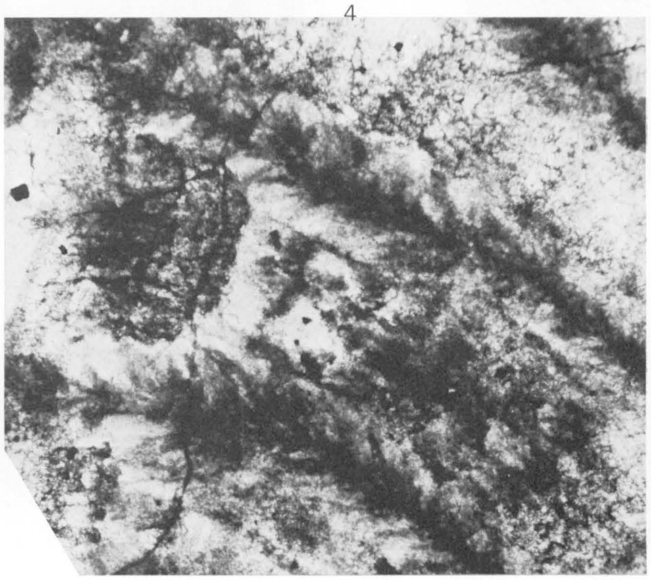
2



3



4

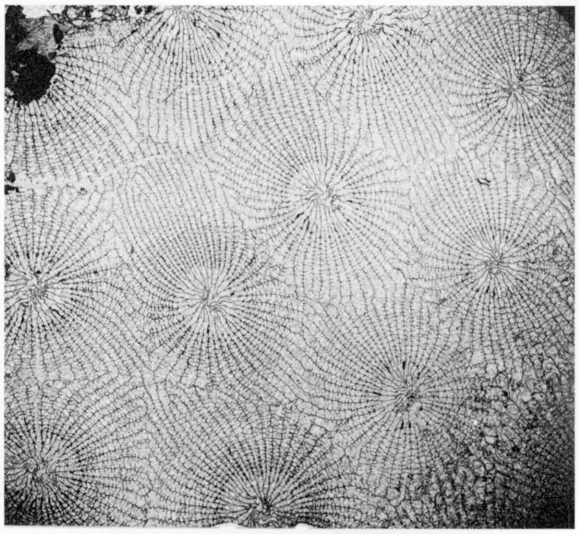


5

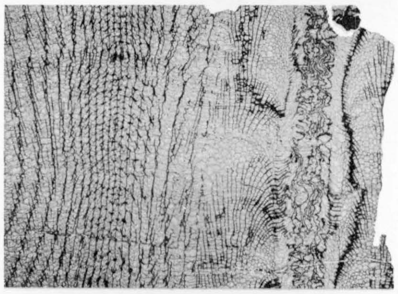
HELIOPHYLLUM MONTICULUM (EHLERS AND STUMM)

PLATE 101

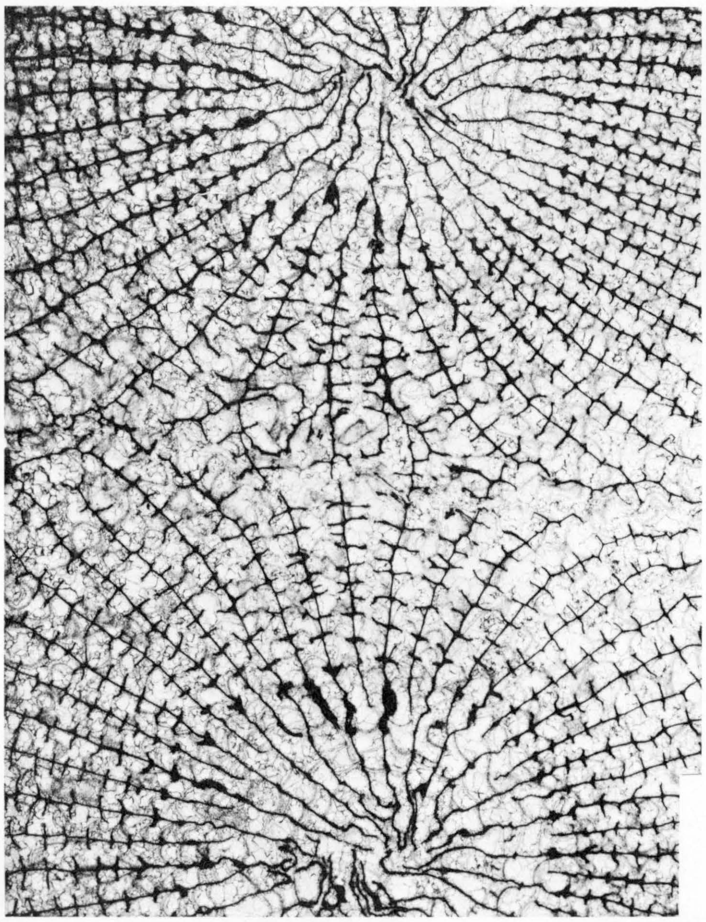
FIGURES 1–4. *Heliophyllum monticulum* (Ehlers and Stumm) (p. 129).
Edgecliff bioherm facies, New York
1–3. USNM 172233. Loc. 81.
1, 2. Transverse and longitudinal thin sections (× 1).
3. Detail of parts of two corallites in center of fig. 1 (× 5).
4. USNM 136711. Upper surface of corallum (× 1). Loc. 108.
See also pl. 102, figs. 1, 2.



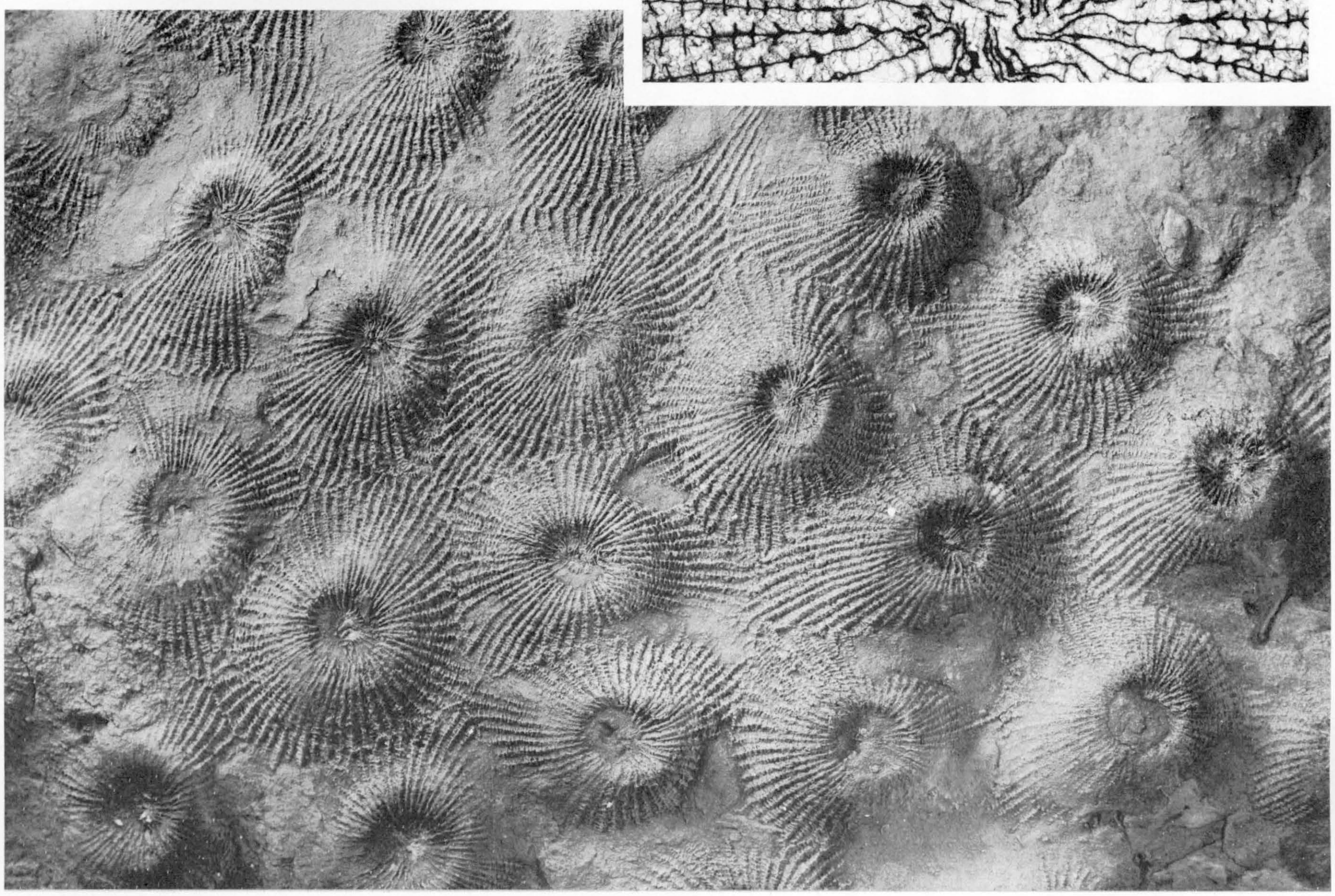
1



2



3



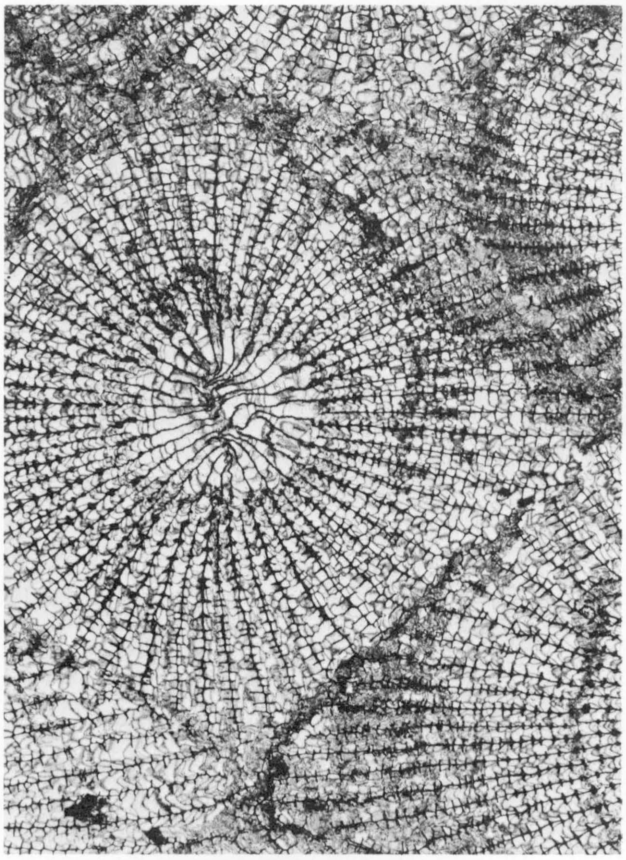
4

HELIOPHYLLUM MONTICULUM (EHLERS AND STUMM)

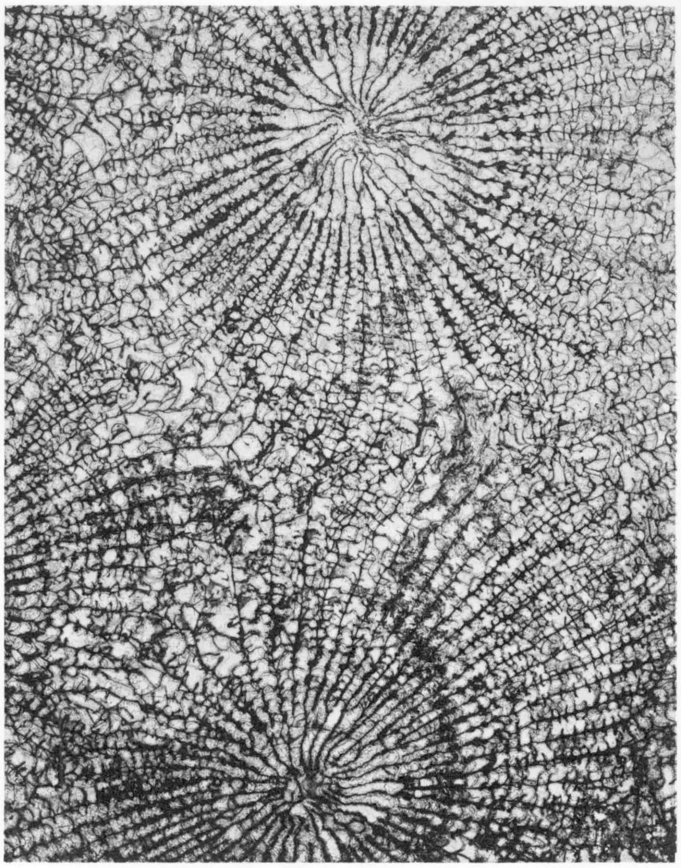
PLATE 102

[All figures × 2½]

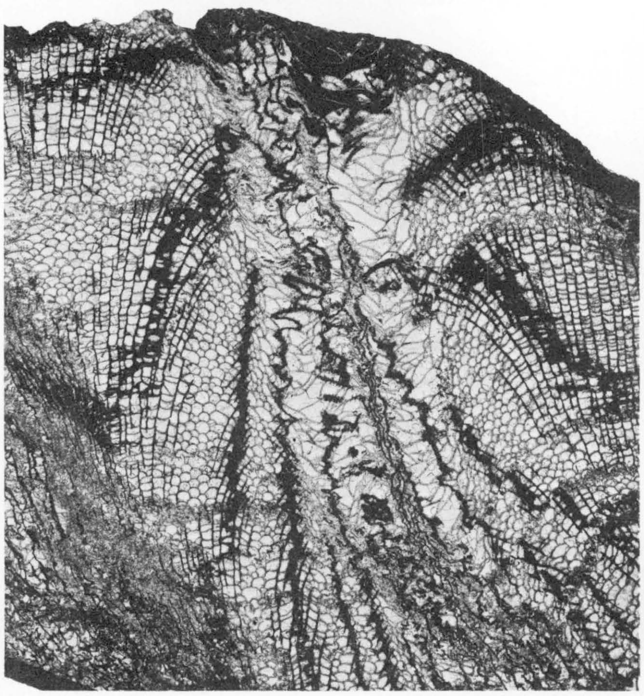
FIGURES 1–4. *Heliophyllum monticulum* (Ehlers and Stumm) (p. 129).
Edgecliff bioherm facies, New York and Ontario.
1, 2. USNM 136711. Transverse and longitudinal thin sections. Loc. 108. See also pl. 101, fig. 4.
3. USNM 172235. Transverse thin section. Loc. C10.
4. USNM 136692. Transverse thin section. Loc. 108.



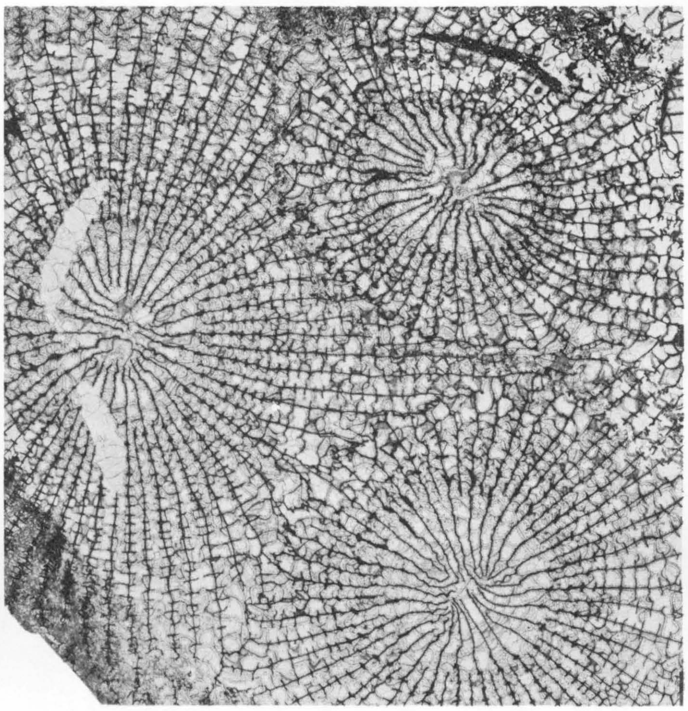
1



3



2



4

HELIOPHYLLUM MONTICULUM (EHLERS AND STUMM)

PLATE 103

[All figures × 2½]

FIGURES 1–5. *Heliophyllum cassum* n. sp. (p. 130).

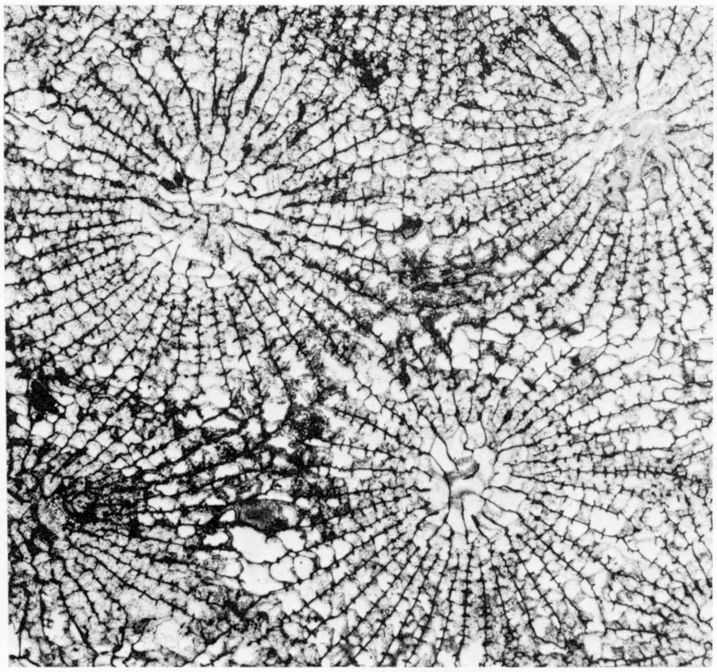
Bois Blanc Formation, Ontario.

1, 3, 5. Holotype, USNM 172244. Loc. C19.

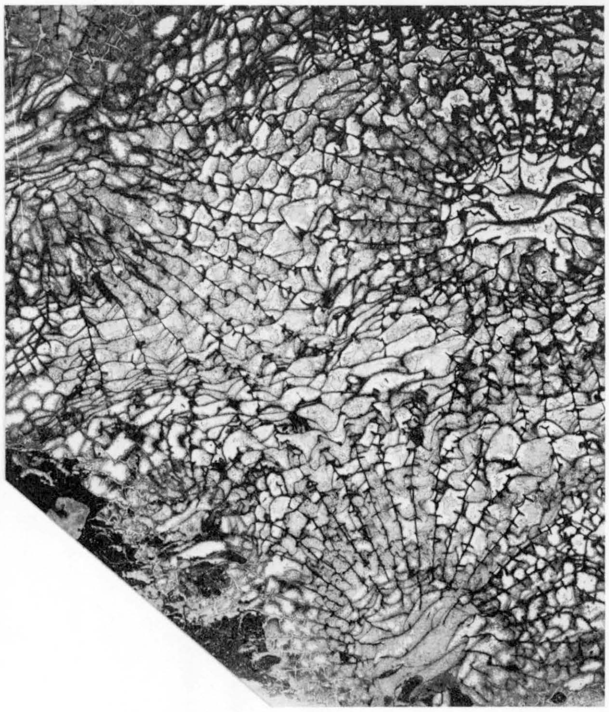
1, 5. Different parts of one transverse thin section. Fig. 5 shows several offsets.

3. Longitudinal thin section.

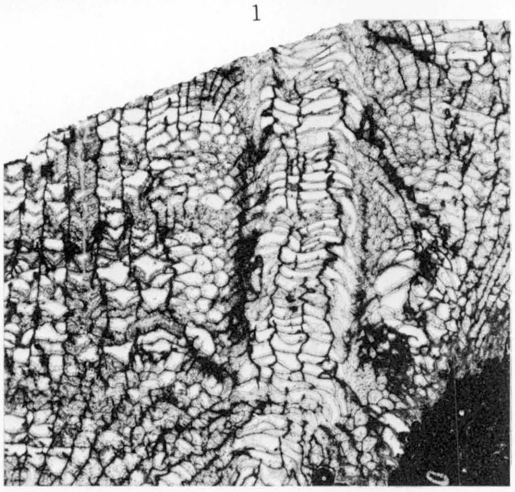
2, 4. Paratype, UMMP 31601. Transverse and longitudinal thin sections. Innerkip.



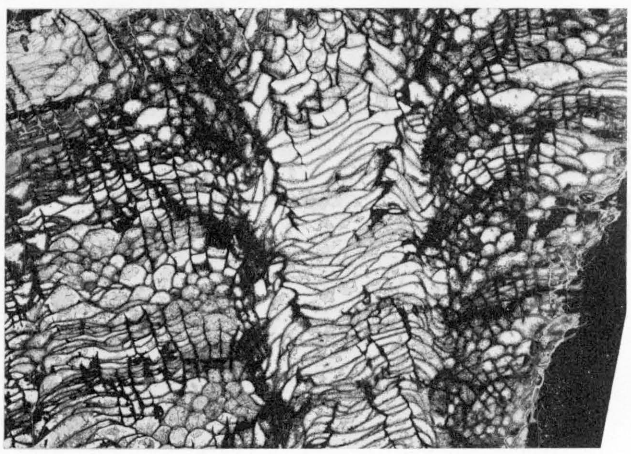
1



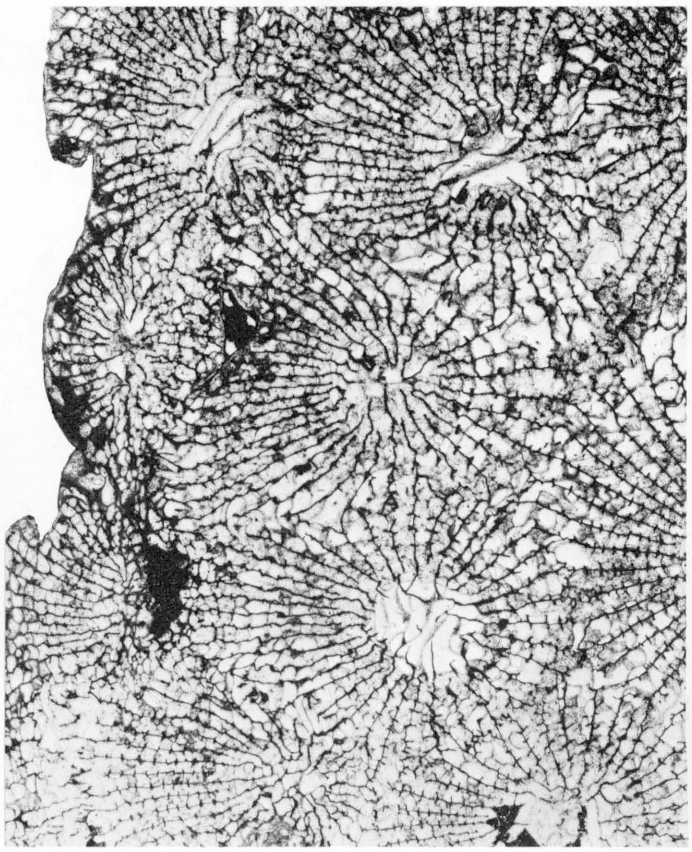
2



3



4



5

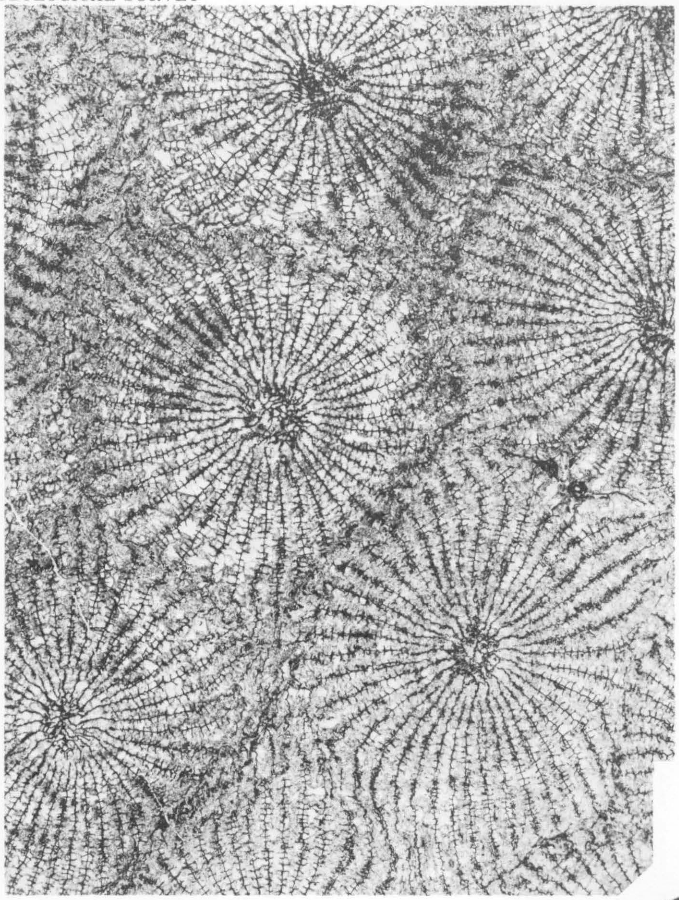
HELIOPHYLLUM CASSUM N. SP.

PLATE 104

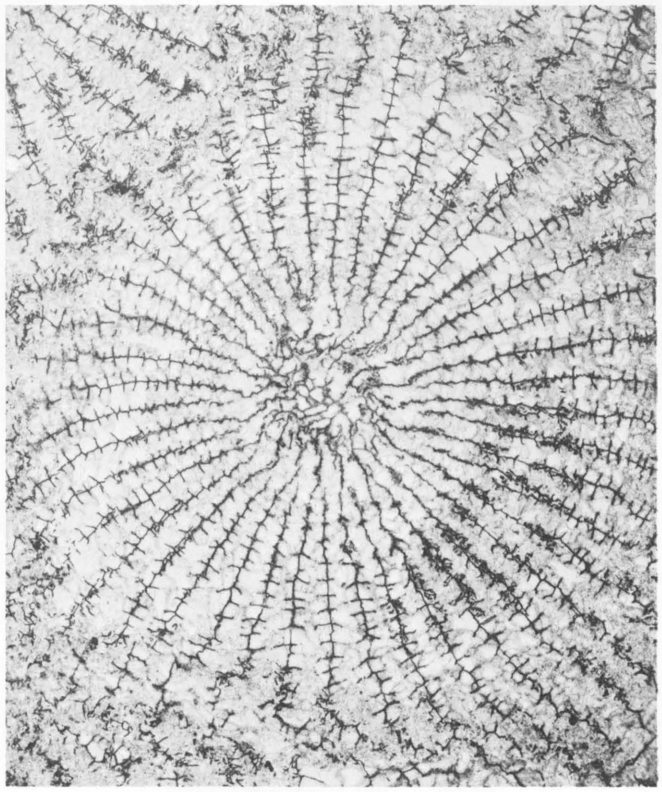
FIGURES 1–4. *Heliophyllum procellatum* n. sp. (p. 131).

Holotype, NYSM 12872. Bois Blanc (?) Formation, Falkirk, N.Y.

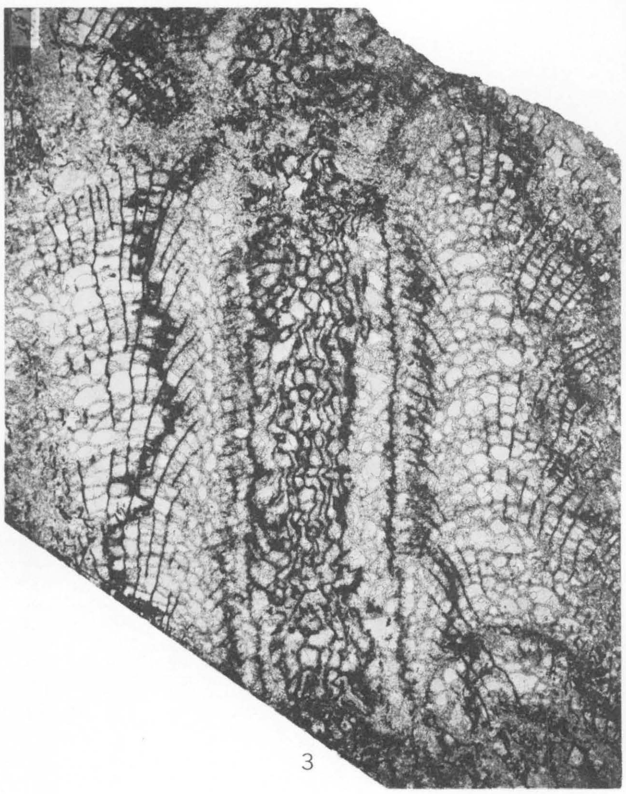
1. Transverse thin section (× 2½).
2. Central corallite in fig. 1 (× 5).
3. Longitudinal thin section (× 5).
4. Top surface of corallum (× 1).



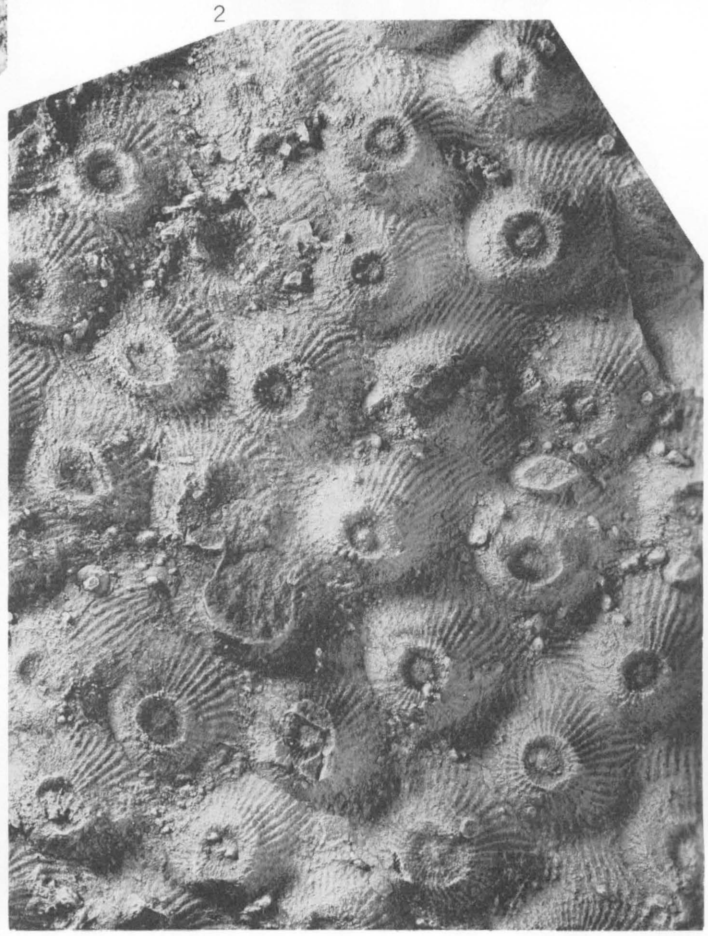
1



2



3



4

HELIOPHYLLUM PROCELLATUM N. SP.

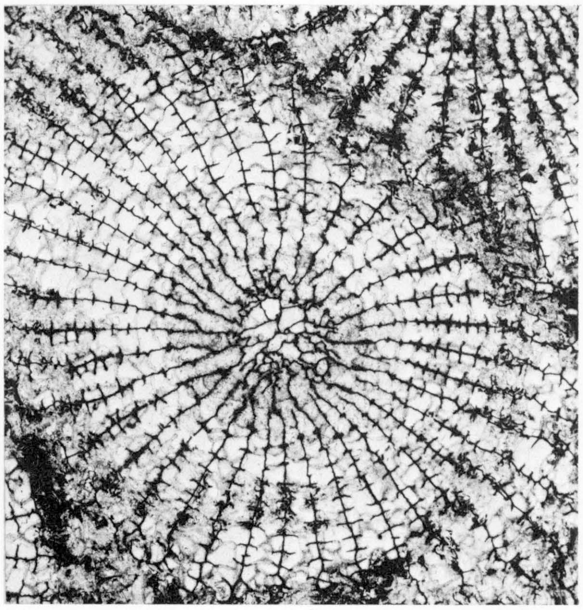
PLATE 105

FIGURES 1–5. *Heliophyllum procellatum* n. sp. (p. 131).
Bois Blanc (?) Formation, Falkirk, N.Y.

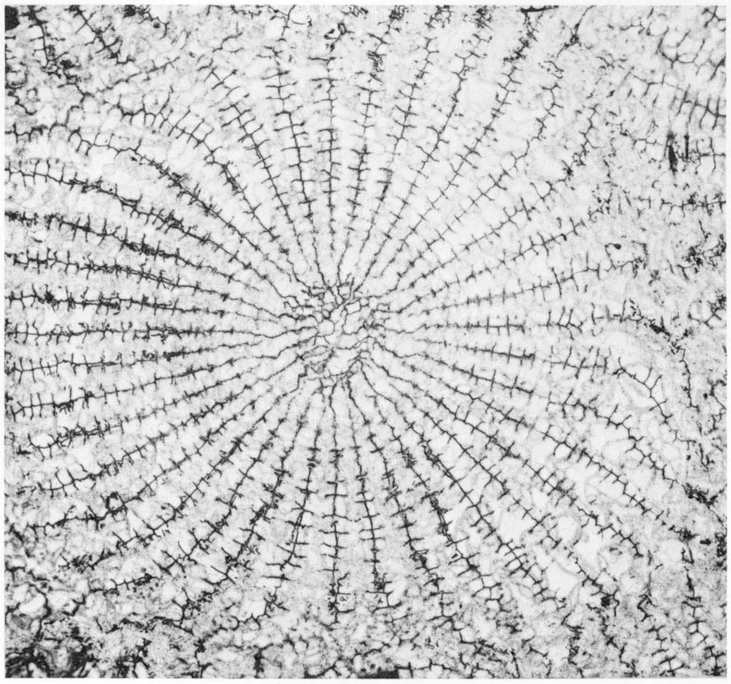
1, 2. NYSM 12874; thin sections of either NYSM 12872 or 12873. Transverse thin sections (× 5).

3–5. Paratype, NYSM 12873.

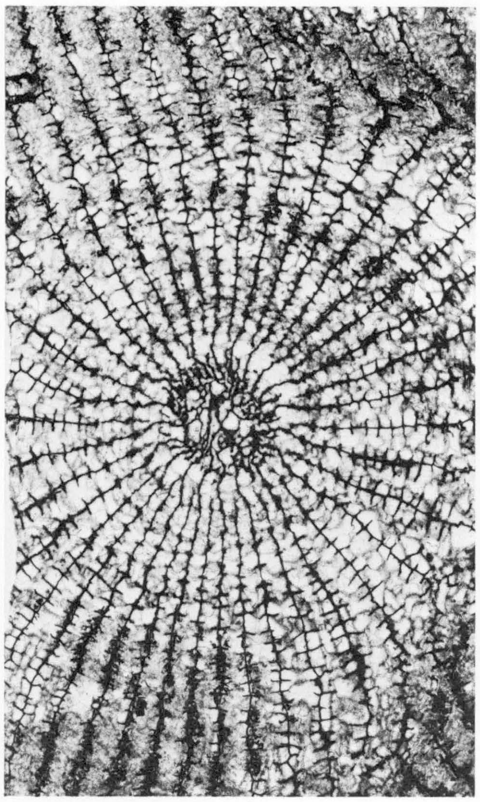
3. Transverse thin section of corallite in lower left of fig. 5 (× 5).
4. Longitudinal thin section (× 5).
5. Transverse thin section (× 2½).



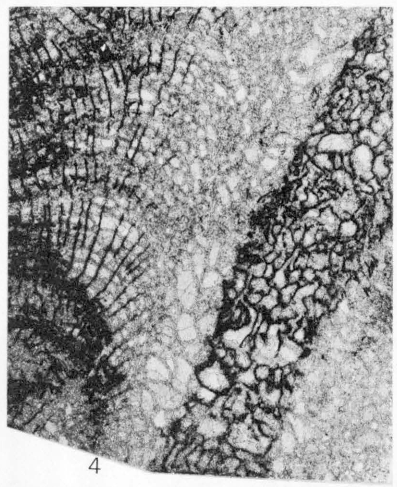
1



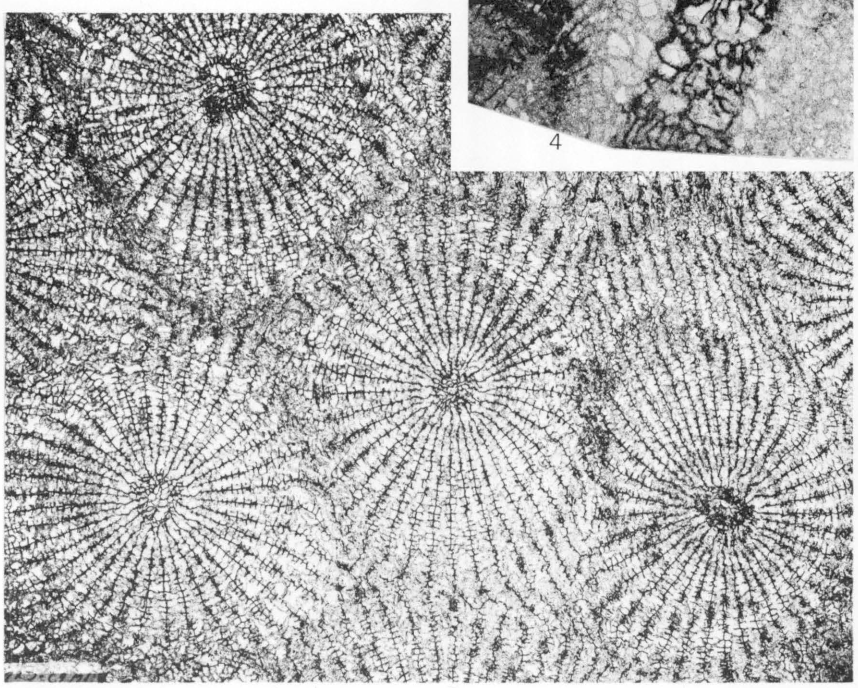
2



3



4

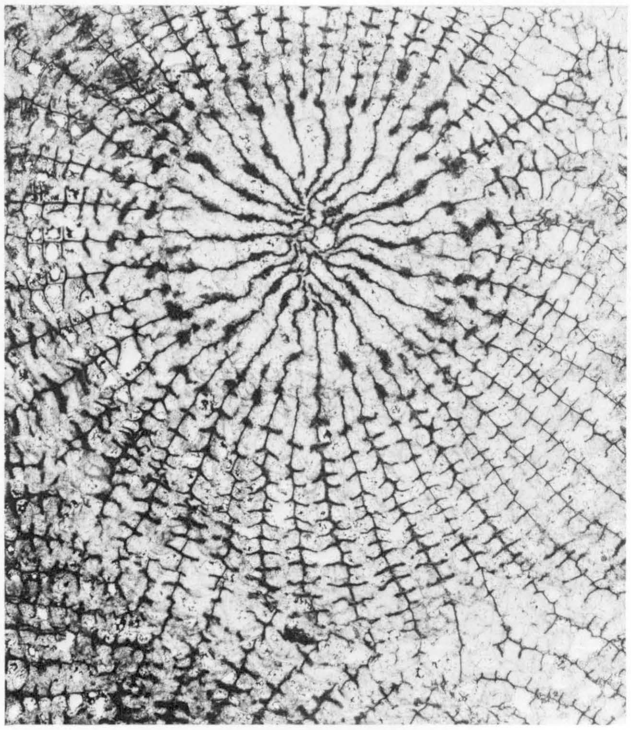


5

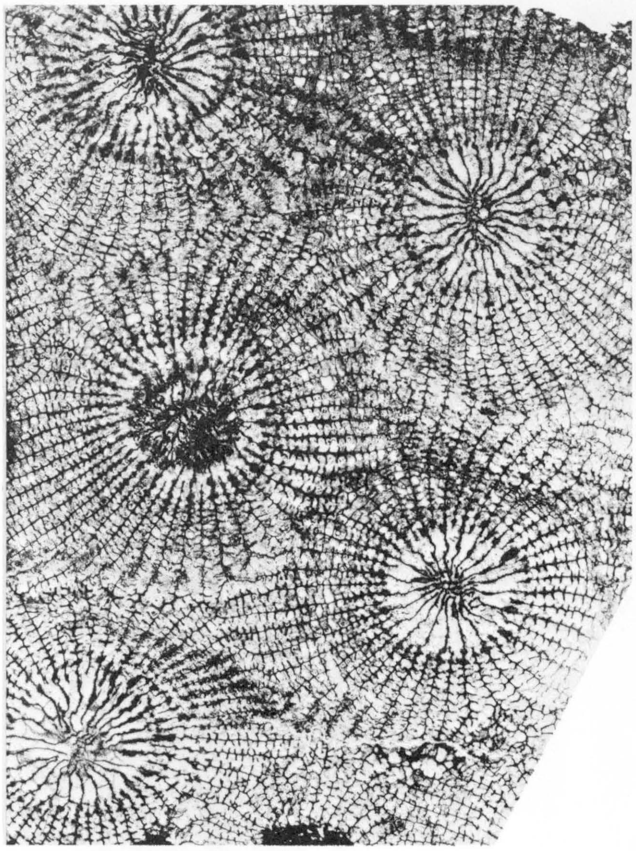
HELIOPHYLLUM PROCELLATUM N. SP.

PLATE 106

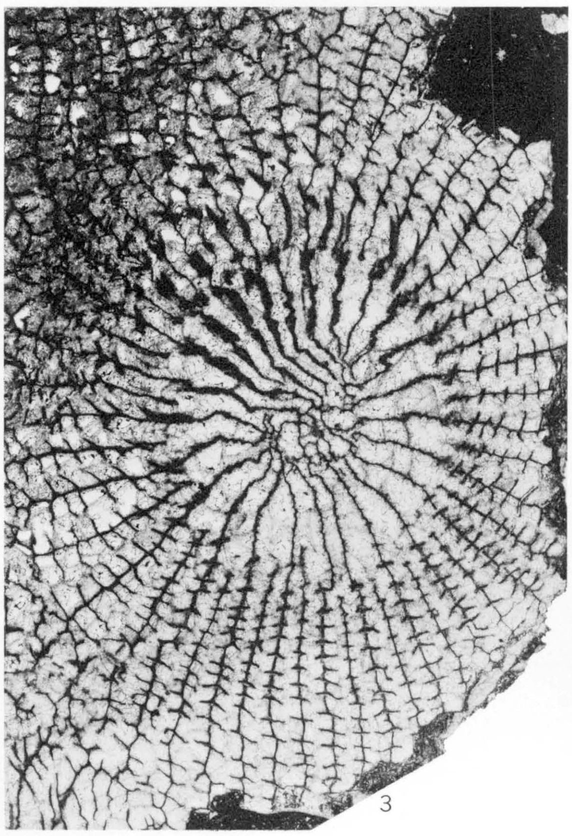
FIGURES 1–4. *Heliophyllum* sp. cf. *H. procellatum* n. sp. (p. 131).
UMMP 18804. Bois Blanc Formation, Mackinac County, Michigan.
1, 2. Transverse thin section (× 5, × 2½).
3. Another transverse thin section (× 2½).
4. Longitudinal thin section (× 4).



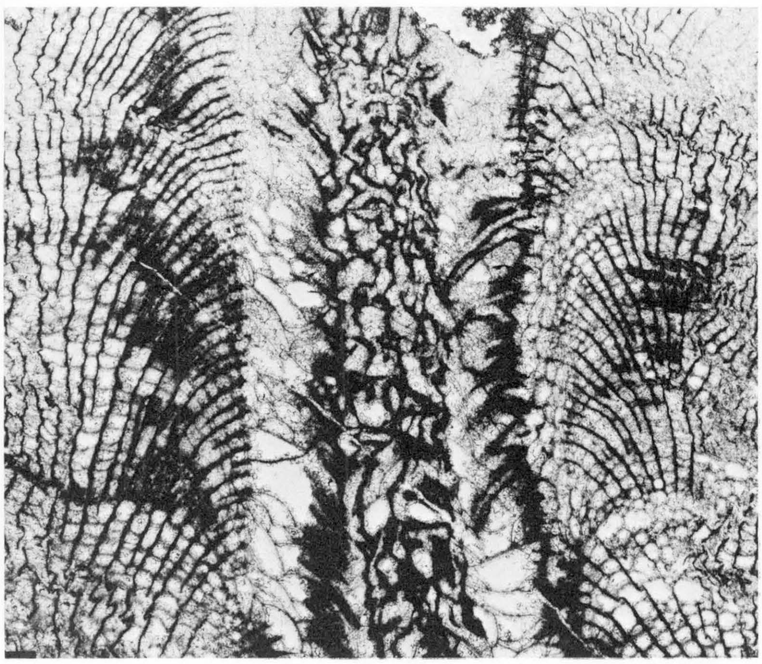
1



2



3



4

HELIOPHYLLUM SP. CF. *H. PROCELLATUM* N. SP.

PLATE 107

FIGURES 1–6. *Eridophyllum conjunctum* (Davis) (p. 108).

USNM 172245. Moorehouse Member, New York. Loc. 118.

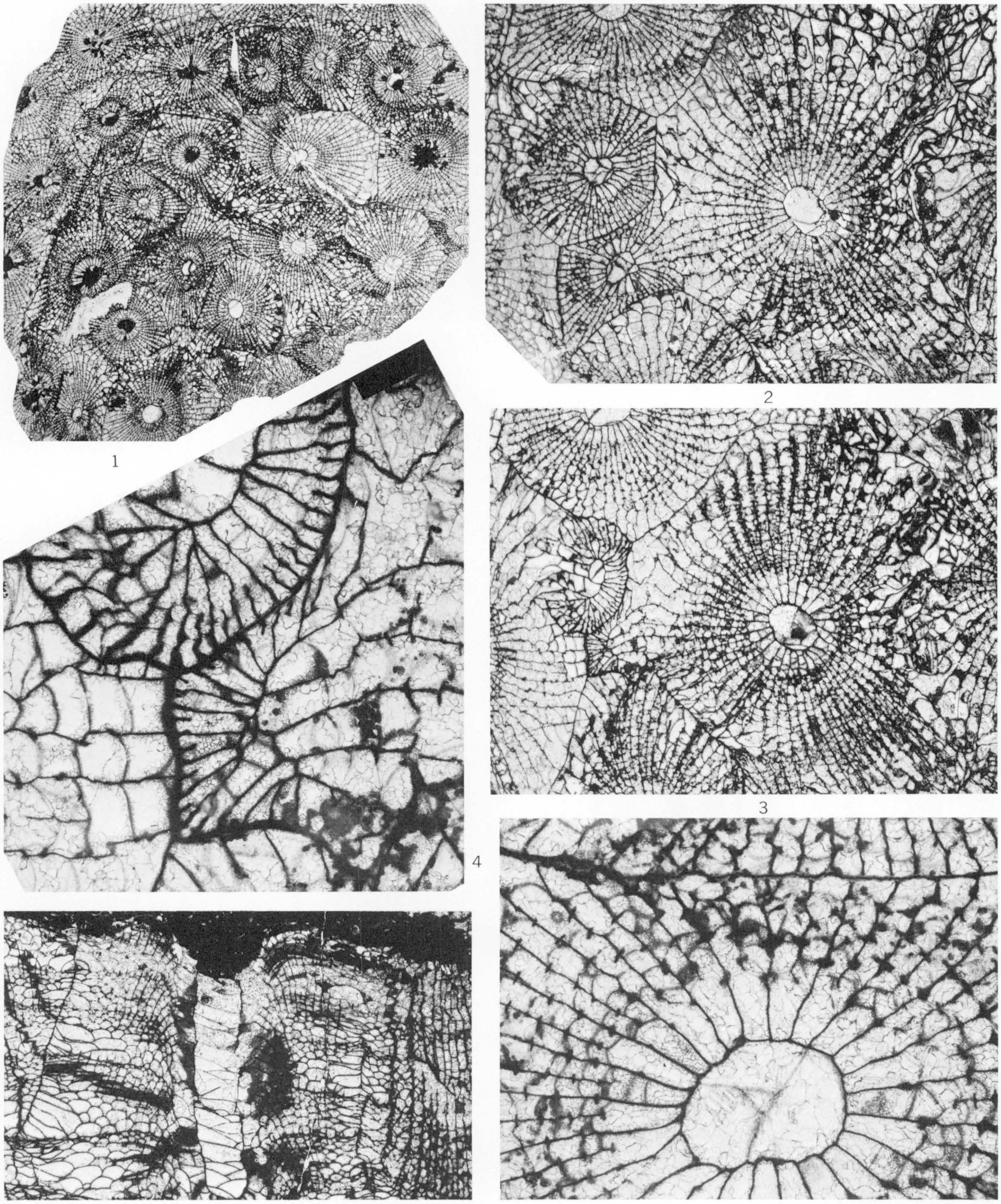
1. Transverse thin section (× 1). Upper right-center corallite with upward projecting offset; same corallite as in figs. 2 and 3.

2, 3. Upper and lower transverse thin section (× 2½), showing early and middle stages of lateral offset to left of large corallite and another lateral offset from large left corallite that is only partly shown. Two sections are parallel and 4 mm apart. Section in fig. 1 is parallel and approximately 8 mm higher than section in fig. 2.

4. Detail of offsets in fig. 3 (× 10).

5. Longitudinal thin section (× 2½).

6. Detail of aulos in offset shown in figs. 1–3 but in additional transverse section taken between sections shown in figs. 1 and 2 (× 10).



ERIDOPHYLLUM CONJUNCTUM (DAVIS)

PLATE 108

FIGURES 1–3. *Eridophyllum conjunctum* (Davis) (p. 108).

Jeffersonville Limestone (above coral zone), Falls of the Ohio (× 2½).

1. Lectotype of *Diphyphyllum conjunctum* Davis, MCZ 7859. Transverse thin section.

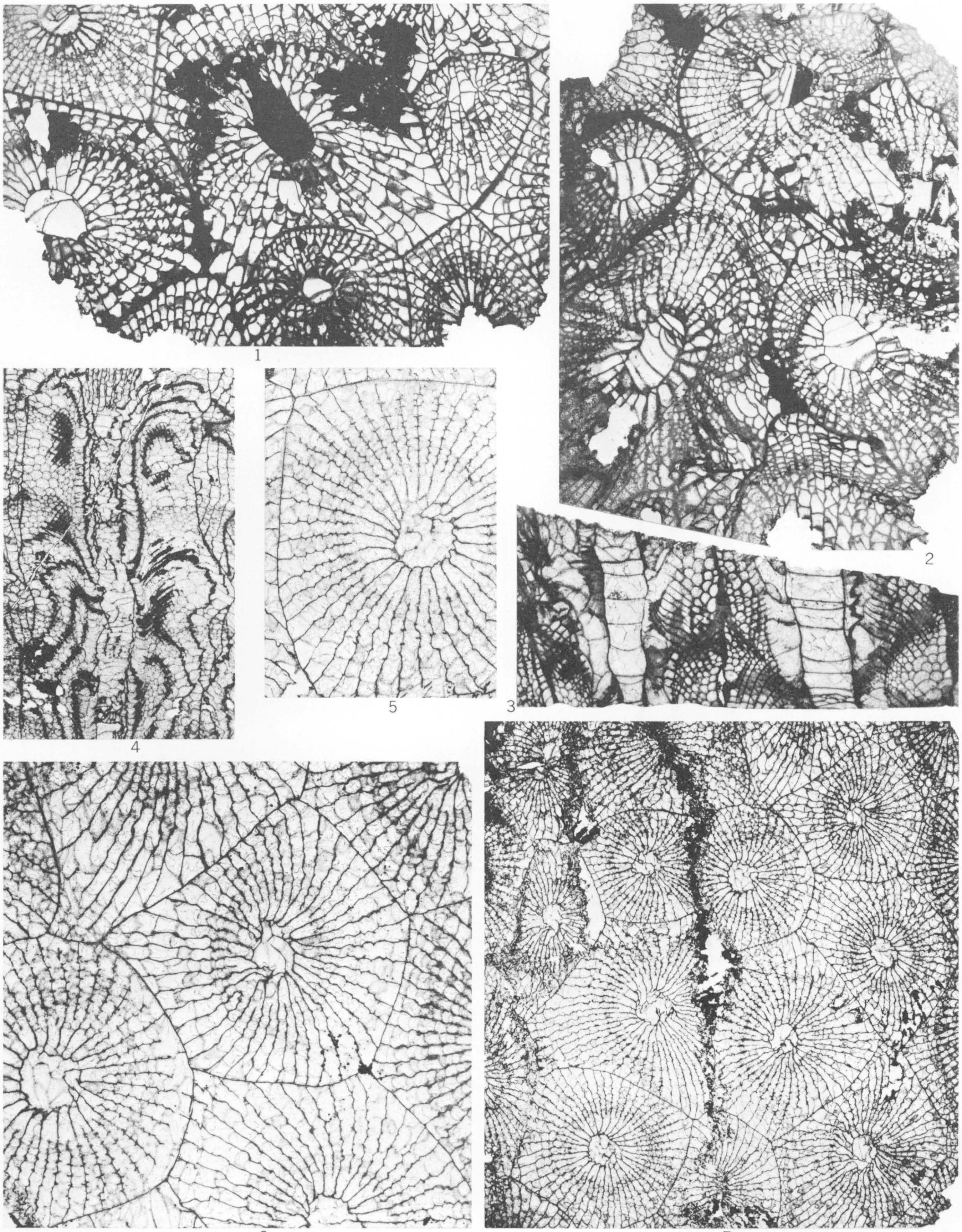
2, 3. Holotype of *Diphyphyllum coalescens* Davis, MCZ 7877. Transverse and longitudinal thin sections.

4–7. *Eridophyllum* sp. cf. *E. conjunctum* (Davis)

Columbus Limestone, Chillicothe, Ohio core, OSU 21336.

4. Longitudinal thin section (× 2½).

5–7. Transverse thin sections (× 5, × 5, × 2½).



ERIDOPHYLLUM CONJUNCTUM (DAVIS) AND *E.* SP. CF. *E. CONJUNCTUM* (DAVIS)