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Bulletin 339

**STROMATOPOROIDS OF THE DETROIT RIVER
GROUP AND ADJACENT ROCKS (DEVONIAN)
IN THE VICINITY OF THE MICHIGAN BASIN**

J.A. Fagerstrom



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Preface

In many parts of the world, including western Canada, large quantities of petroleum are found in close association with reef structures of Devonian age. Recent studies indicate that stromatoporoids, extinct sponge-like organisms, were the chief "frame-builders" for these reefs. Much of the pioneering research on the detailed morphology and biological affinities of the stromatoporoids was undertaken more than a century ago by Canadian paleontologists and was based on specimens from southwestern Ontario and northern Ohio. It is thus appropriate that the Geological Survey should publish the results of this recent comprehensive study of this important group.

This report refines the basis for species level stromatoporoid taxonomy using large samples and relatively simple measuring and statistical techniques and evaluates the importance of these species for determining the geologic age of the enclosing rocks. Comparisons are also made of the species distributions in such varied environments as reefs, biostromes, and sedimentary carbonate substrates.

OTTAWA, January 1982

R.A. Price
Director General
Geological Survey of Canada

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STROMATOPOROIDS OF THE DETROIT RIVER GROUP AND ADJACENT ROCKS (DEVONIAN) IN THE VICINITY OF THE MICHIGAN BASIN

Abstract

The Appalachian Faunal Province stromatoporoid acme zone occurs in a succession of Lower (Emsian) and Middle (Eifelian) Devonian carbonate rocks exposed along the margin of the Michigan Basin in southwestern Ontario (including the Niagara Peninsula) and adjacent areas of Michigan, Ohio and Indiana. These rocks include (from older to younger) the upper Bois Blanc Limestone, the entire Detroit River Group, the upper Columbus Limestone and the lower Dundee/Delaware Limestone. Stromatoporoids are typically much more abundant and diverse in limestones, especially reefs and biostromes, but locally the Detroit River dolomites also contain notable assemblages.

Systematic studies of Michigan Basin Emsian and Eifelian stromatoporoids began in 1873 and specimens from these rocks were important in the pioneering research of H.A. Nicholson and W.A. Parks. The species described herein are based on examination of thin-sections from over 500 *coenostea* collected from about 35 outcrops in an area exceeding 12 000 square km. Cellular/microlaminar forms belonging to the genera *Syringostroma* and *Habrostroma* (new genus) dominate most of the fossil assemblages in both abundance and diversity. The entire stromatoporoid fauna includes 26 (possibly 31) species distributed among 7 (possibly 9) genera; three species (*Habrostroma formosensis*, *H. beachvillensis*, *Pseudoactinodictyon stearni*) are new. Results of the taxonomic aspects of this study include the clarification of the levels of morphological variation of most species based on large samples and the recognition of several synonymous previously described species.

The faunas of the Bois Blanc, Columbus and Dundee/Delaware Limestone consist chiefly of long-ranging species also found in adjacent rock units whereas about half of the Detroit River Group species are absent from the adjacent rocks. Greatest faunal similarities exist among outcrops within the Detroit River but even here the levels of similarity are very low, even among samples from rocks of the same age and environmental setting.

Comparison of the Detroit River stromatoporoid species with other Appalachian Province faunas outside the Michigan Basin indicates greatest similarity to the Kwatabohegan Formation in the Hudson Bay Lowlands and lesser similarities to the Columbus Limestone in central Ohio and the Jeffersonville Limestone in southeastern Indiana and north-central Kentucky. Thus, the value of individual stromatoporoid species in local and regional chronostratigraphy and as indicators of particular paleoenvironments appears to be severely limited.

Résumé

La zone de développement maximum des stromatoporoidés de la province faunique des Appalaches se situe dans une succession de roches carbonatées du Dévonien inférieur (Emsien) et moyen (Eifélien), exposées le long du rebord du bassin du Michigan, dans le sud-ouest de l'Ontario (y compris dans la péninsule de Niagara), et dans des zones adjacentes du Michigan, de l'Ohio et de l'Indiana. Ces roches comprennent (des terrains les plus anciens aux plus récents) les calcaires supérieurs de Bois Blanc, tout le groupe de Detroit River, les calcaires supérieurs de Columbus et les calcaires inférieurs de Dundee et Delaware. Généralement, les stromatoporoidés sont beaucoup plus abondants et diversifiés dans les calcaires, en particulier dans les récifs et biostromes, mais localement, les dolomites de la rivière Detroit contiennent aussi des assemblages intéressants.

Dès 1873, ont été entreprises des études systématiques des stromatoporoidés de l'Emsien et de l'Eifélien du bassin du Michigan, et des spécimens provenant de ces roches ont joué un rôle important dans les travaux de recherche initiaux de H.A. Nicholson et W.A. Parks. La description de l'espèce mentionnée ici est basée sur l'examen de lames minces de plus de 500 *coenostea* recueillis dans environ 35 affleurements, sur une superficie de plus de 12 000 km². Les formes cellulaires et microlaminées appartenant aux genres *Syringostroma* et *Habrostroma* (gen. nov.) dominent la majeure partie des assemblages fossiles, du point de vue à la fois de l'abondance et de la diversité. La faune entière de stromatoporoidés comprend 26 (peut-être 31) espèces réparties entre 7 (peut-être 9) genres; trois espèces (*Habrostroma formosensis*, *H. beachvillensis*, *Pseudoactinodictyon stearni*) sont nouvelles. Du point de vue taxonomique, dans la présente étude, on est parvenu à mieux expliquer les niveaux de variation morphologique de la plupart des espèces, en examinant des échantillons de grande taille, et à reconnaître la synonymie de plusieurs espèces déjà décrites.

Les faunes des calcaires de Bois Blanc, de Columbus, et de Dundee et Delaware consistent principalement en espèces de grande longévité, aussi rencontrées dans les unités rocheuses adjacentes, tandis que presque la moitié des espèces du groupe de Detroit River ne sont pas représentées dans les terrains adjacents. C'est parmi les affleurements du secteur de la rivière Detroit que l'on observe la plus grande similarité entre les faunes, mais même là, le degré de ressemblance est très faible, même pour les échantillons prélevés dans des roches du même âge et formées dans les mêmes conditions paléocéologiques.

En comparant les espèces de stromatoporoidés de la rivière Detroit avec d'autres faunes de la province des Appalaches, à l'extérieur du bassin du Michigan, on constate une très nette ressemblance avec celles de la formation de Kwataboahagan dans les basses-terres de la baie d'Hudson, et une beaucoup moins grande ressemblance avec celles des calcaires de Columbus dans le centre de l'Ohio, et les calcaires de Jeffersonville, dans le sud-est de l'Indiana et le secteur centre-nord du Kentucky. Ainsi, il semble que les diverses espèces de stromatoporoidés puissent difficilement aider à élucider la chronostratigraphie locale et régionale, ou servir d'indicateurs de paléoenvironnements particuliers.

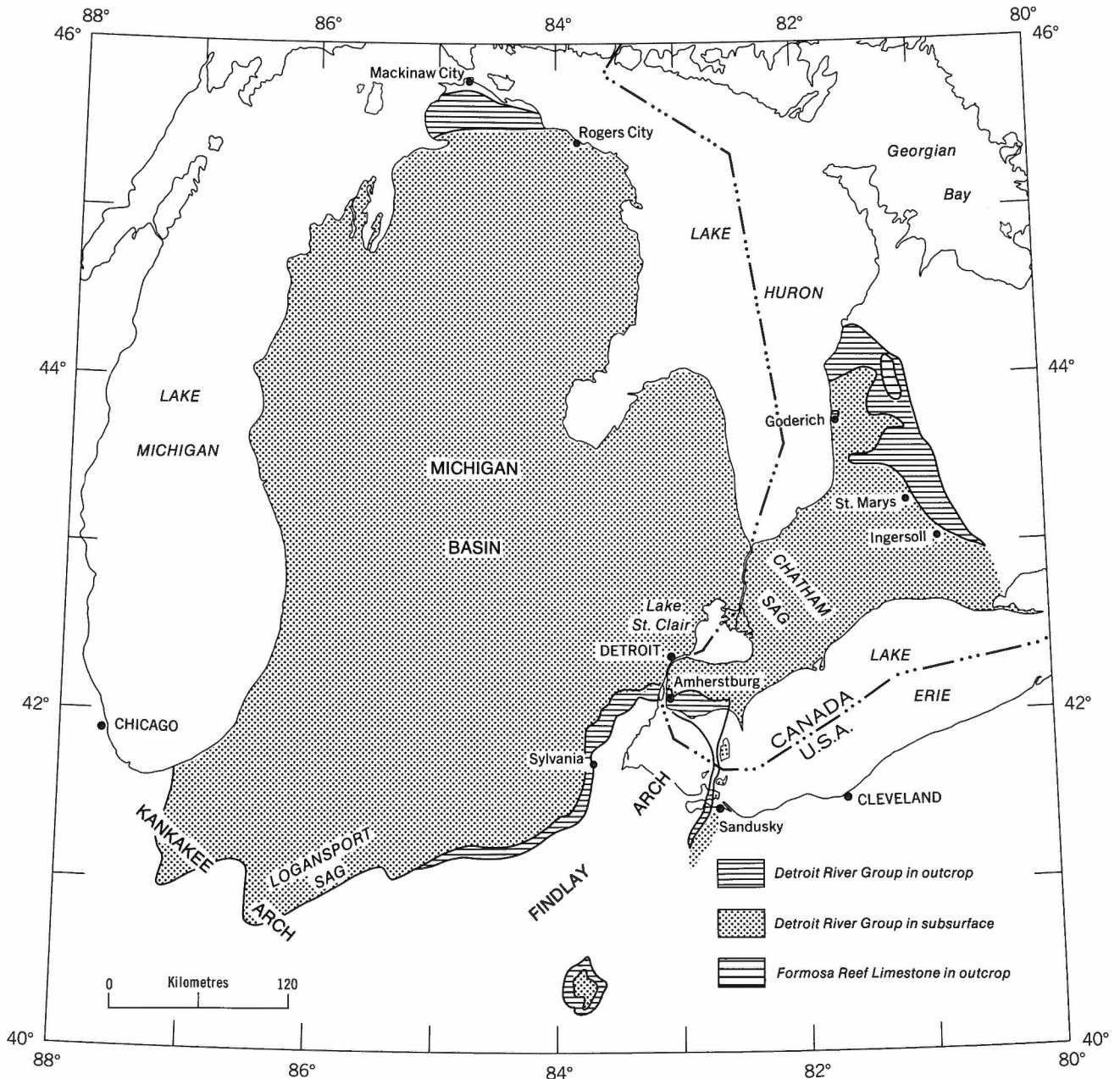


FIGURE 1A. Index map of Michigan Basin and adjacent areas showing distribution of the Detroit River Group.

STROMATOPOROIDS OF THE DETROIT RIVER GROUP AND ADJACENT ROCKS (DEVONIAN) IN THE VICINITY OF THE MICHIGAN BASIN

INTRODUCTION

The carbonate rocks of the Detroit River Group along the eastern and southern margins of the Michigan Basin (Fig. 1A) contain a very unusual fossil assemblage. Locally, in quarries and road cuts, fossils are abundant, diverse and moderately well-preserved and yet after nearly 75 years of study, the geologic age and stratigraphic relationships of these rocks are still uncertain (Fig. 1B).

In southwestern Ontario stromatoporoids are especially important in both the Detroit River Group and the adjacent rocks. This rich fauna attracted the attention of some of Canada's earliest paleontologists; they described many newly recognized genera and species and used specimens from these rocks to attempt to determine the biological affinities of these extinct organisms. Subsequent collecting by many geologists, including several members of the Geological Survey of Canada, has greatly enlarged the sample sizes, led to the discovery of one heretofore unrecognized genus and several species and refined the data upon which the determination of their value as indicators of geologic age is based.

Modern laboratory techniques have made it possible to postulate a possible course of alteration that some stromatoporoid skeletons have undergone in the millions of years since the death of the organism. The large sample sizes have provided the basis for applying statistics to assess and compare levels of morphologic variation within single specimens and among localized collections of contemporaneous individuals of the same species. Statistics also indicate that for most species there were no continuous evolutionary trends of morphologic change during the several million years of earth history required for deposition of the Detroit River Group and adjacent rocks.

Previous Work

The earliest work on the systematics of Michigan Basin stromatoporoids was the description of four species from the Traverse Group (Givetian age) near Grand Traverse Bay in northern Michigan by Alexander Winchell (1866). In 1873 H.A. Nicholson published the first of a long succession of classical papers and monographs on all aspects of stromatoporoid research (morphology, systematics, biological affinities and diagenesis) based in part on material from the Columbus and Bois Blanc Limestones in northern Ohio and the Niagara Peninsula, Ontario. The culmination of Nicholson's research was a four-part monograph published between 1886 and 1892; the fourth part was his final work on stromatoporoids.

The earliest work on undoubted Detroit River stromatoporoids (the geologic source of some of Nicholson's material is uncertain) was by A.W. Grabau (1910) who described six species from the vicinity of Amherstburg, Ontario and Detroit, Michigan. His report was largely ignored by most subsequent workers but Galloway and Ehlers (1960) and Fagerstrom (1961a; 1962) redescribed some of Grabau's material (see also herein for further revision).

Most of the stromatoporoid research by W.A. Parks dealt with pre-Devonian forms but his final monograph (1936) was a major revision and clarification of numerous Devonian taxa based largely on material from Ontario. In 1957 two major works on stromatoporoids appeared almost simultaneously; one (Galloway, 1957) was a detailed treatment of their structure and classification (mostly genera) and the other (Galloway and St. Jean, 1957) consisted primarily of the systematic description of many species (most of them new) from the Columbus Limestone in Ohio and the correlative Jeffersonville Limestone in southern Indiana and northern Kentucky.

Although the emphasis in the papers by Stearn (1966a) and St. Jean (1962, 1967) was on detailed micromorphology (rather than systematics) both authors described and illustrated many examples of microstructures in type and other material from the same outcrops as the materials described in the present report. Thus, most of the taxa were originally described many years ago on the basis of small samples; a few of these taxa have been subsequently revised. Revision, however, has been based on small samples of very restricted geographic and stratigraphic occurrence.

The chief contributions of this report are: (a) the revised description of taxa based on large samples, mostly from the Detroit River Group, (b) analysis of the varied effects of resorption and/or diagenesis on micromorphology, especially of the cellular/microlaminar forms, (c) morphometric analysis of intracoenosteal and intraspecific macromorphologic variation, especially of the genus *Syringostroma* and (d) detailed analysis of the occurrence of each species and its relative value in local and regional correlation of Early (Emsian) and Middle (Eifelian) Devonian age rocks.

Acknowledgments

Study of the rocks and fossils of the Detroit River Group by the author began in 1956 and has included parts of twelve field seasons in the Michigan Basin area. This field work has benefitted from the able assistance of former graduate students at the University of Nebraska (R. Diffendal, P. Roper, C. Mayo, R. Blodgett), financial support from the American Philosophical Society, Sigma Xi and Geological Society of America and discussions of stratigraphic relations with R. Linsley, W. Oliver, C. Kahle, A. Janssens and the late G.M. Ehlers who first showed me these rocks near Sylvania, Ohio. R. Pabian prepared most of the thin-sections.

The following curators either loaned type material or made them available when I visited their institutions: Brian Rosen (British Museum, Natural History, London), Paul Sartenaer (Institut Royal des Sciences Naturelles de Belgique, Brussels), Brad Macurda (University of Michigan, Ann Arbor), May Dasch (Yale University, New Haven, Connecticut), John Monteith and Janet Waddington (Royal Ontario Museum, Toronto) and Bruce Bell (New York State Museum, Albany). Other museum curators also responded

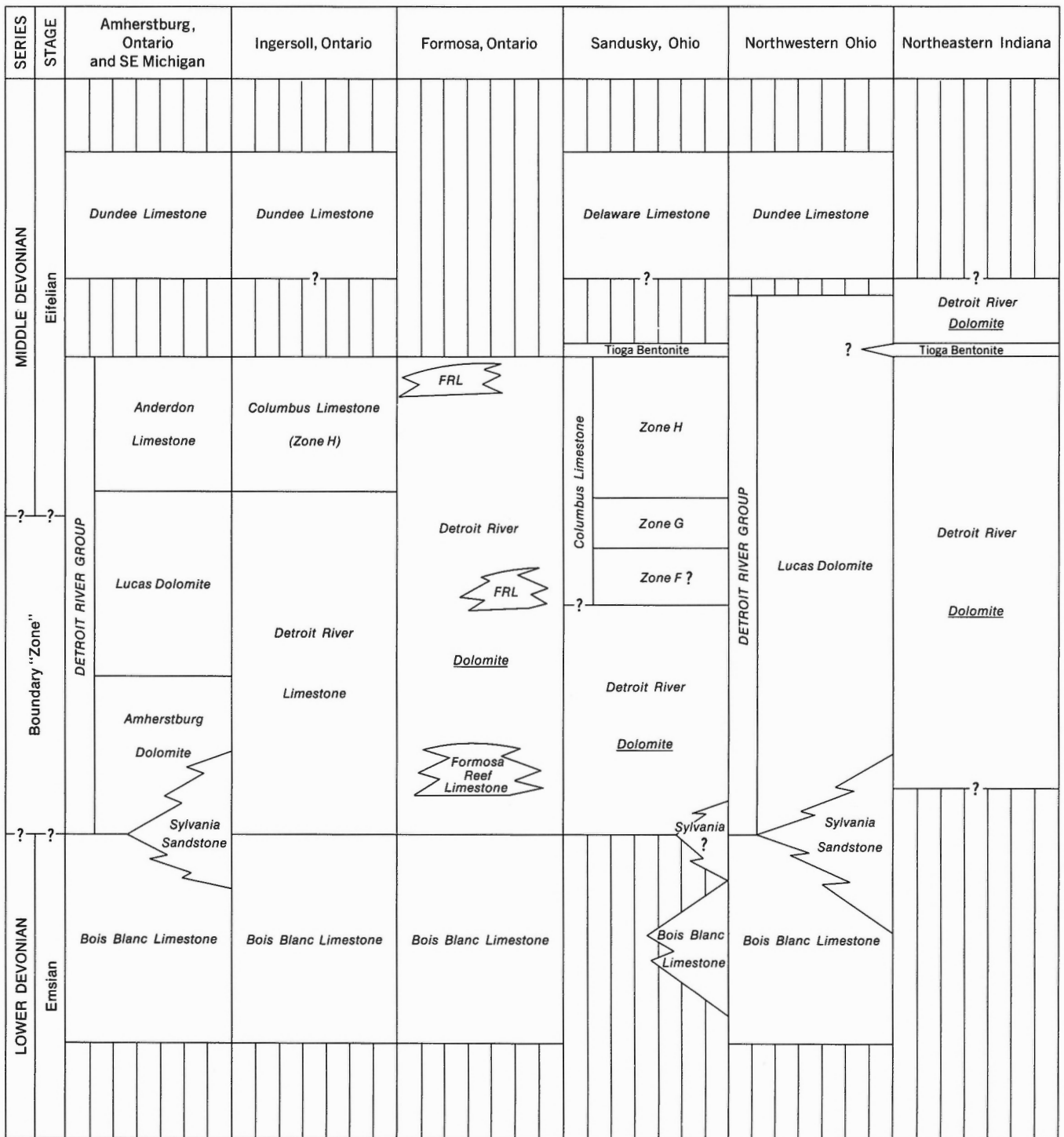


FIGURE 1B. Correlation of the Detroit River Group and adjacent rocks in the vicinity of the Michigan Basin. The lithology of the Detroit River Group varies from dolomite to limestone; the chief lithology in each area is underlined. FRL = Formosa Reef Limestone.

GSC

(negatively, unfortunately) to my request for the loan of Nicholson's types for *Stromatopora ponderosa* and *S. substriatella*; these specimens must be presumed lost.

In June 1969 the author spent two weeks in the laboratory of C.W. Stearn (McGill University). During this visit the generic identification of most of the Detroit River material was patiently discussed and in several subsequent meetings I benefitted enormously from Dr. Stearn's willingness to share his knowledge and enthusiasm for the stromatoporoids with me. In correspondence, Joseph St. Jean, Jr. (University of N. Carolina) called my attention to the Genus *Parallelostroma* Nestor and shared with me his notes on the type material of *Ferestromatopora* Yavorsky as well as his ideas on the nomenclatural status of *Stictostroma* Parks and *Stromatoporella* Nicholson. Colin Stearn also called my attention to the Genus *Climacostroma* Yang and Dong.

A.E. Cockbain reviewed an early version of Appendix 2 on "Stromatopoid Morphometrics" and C.W. Stearn reviewed a draft of the sections dealing with diagenesis. The manuscript was greatly improved in its final form by incorporation of their thoughtful suggestions.

I am deeply indebted to all of the above persons and institutions for their interest in this project; without their help its completion in the present form would have been impossible.

STRATIGRAPHY

Lithostratigraphic Units

The emphasis in the present report is on the stromatoporoids of the Detroit River Group (Fig. 1) with lesser attention given to those from the adjacent rocks which have been included chiefly for purposes of comparison with the Detroit River fauna. Therefore, in this discussion of the stratigraphy, emphasis will also be on the Detroit River, especially in areas where these rocks contain abundant stromatoporoids.

General stratigraphic and faunal studies of the Devonian of the Michigan Basin and adjacent areas began well over 100 years ago and have continued at an accelerating pace to the present. The history of Devonian stratigraphic nomenclature, distribution of outcropping lithostratigraphic units and lithofacies variation have most recently been reviewed by Best (1953), Sanford (1967), Fagerstrom (1967), Liberty (1966) and Liberty and Bolton (1971). Landes (1951) and Gardner (1974) studied the subsurface stratigraphy of most of these same units and their correlatives in the central Michigan Basin; Sanford and Brady (1955), Shearrow (1957), Dow (1962), Janssens (1968; 1970), Doheny et al. (1975), Shaver (1974) and Orr (1971) reported surface and subsurface relations on the adjacent platform.

In the type region between Amherstburg, Ontario (Fig. 1B) and Sylvania, Ohio (Fagerstrom, 1971, p. 86-90) the rocks of the Detroit River Group are almost entirely dolomite except for the upper formation (Anderdon Limestone; Ehlers, Stumm and Kesling, 1951). This preponderance of dolomite is typical of the Detroit River elsewhere except in the small limestone reefs near Formosa (Fagerstrom, 1961b), the thick sequence of very pure limestone near Ingersoll and Beachville, Ontario, and in the subsurface of the central Michigan Basin where the group includes important interbedded units of evaporites and sandstones. The chief areas of abundant and diverse stromatoporoids coincide with the occurrence of limestone,

in both the Detroit River and adjacent rocks, but they are also locally present where the rocks are dolomite. Thus, the bulk of the specimens described below are from southwestern Ontario (Fig. 1).

Throughout the Michigan Basin and adjacent areas of the platform, the Detroit River Group is underlain by the Bois Blanc Limestone except in southeastern Michigan, near Sylvania, Ohio and the Amherstburg-Windsor, Ontario area where the Sylvania Sandstone intervenes and in northern and central Ohio and northern Indiana where it is unconformably underlain by Upper Silurian rocks (Fig. 1B). The Bois Blanc-Detroit River contact is nowhere exposed but is presumably conformable; the Sylvania-Detroit River contact is exposed in southeastern Michigan and northwestern Ohio and is conformable (Fagerstrom, 1967; 1971, p. 5-6). In Michigan, northwestern Ohio and Ontario the Dundee Limestone (Liberty and Bolton, 1971, p. 65) overlies the Detroit River (Fagerstrom, 1971, p. 6); in central Ohio the rocks correlative with the Dundee are named the Delaware Limestone but there the Columbus Limestone intervenes between the Detroit River and Delaware.

Near Ingersoll and on Pelee Island, Ontario and near Sandusky, Ohio the upper Columbus Limestone (Zone H of Stauffer, 1909) conformably overlies the Detroit River and is in turn unconformably (?) overlain by the Delaware (Ohio) or Dundee (Ontario). In all these areas both the Columbus and the Detroit River are fossiliferous and there is a strong similarity in their stromatoporoid faunas. The numerous large quarry exposures near both Ingersoll and Sandusky have yielded particularly important stromatoporoid materials including many specimens studied by Nicholson (1873), Parks (1936) and Galloway and St. Jean (1957). In contrast, stromatoporoids are absent in the Sylvania and comparatively uncommon in the Bois Blanc and Dundee/Delaware.

In northwestern Ohio and northern Indiana the Detroit River consists predominantly of dolomite, with minor interbedded evaporites, and contains a sparse stromatoporoid fauna; in northern Indiana the Dundee/Delaware Limestone is absent and the Detroit River is unconformably overlain by very fossiliferous rocks of the Traverse Formation (undifferentiated; Doheny et al., 1975).

Although the rocks of the Detroit River Group in outcrop are everywhere carbonate (excluding the Sylvania and Pendleton Sandstones; cf. Carman, 1936; see Fagerstrom, 1971, p. 3) there is a rather complex inter-fingering of dolomite and limestone that can be briefly summarized as follows (see Fig. 1B and Fagerstrom, 1971, p. 4):

- a. On both flanks of the Findlay Arch the Detroit River consists of varied shades of brown and grey dolomite except locally near Amherstburg, Ontario and Trenton, Michigan (directly across the river from Amherstburg) where the upper formation (Anderdon) is grey high calcium limestone. The subjacent brown dolomite in this area has been subdivided into the Amherstburg (basal) and Lucas (above) Dolomites (Fagerstrom, 1971, p. 3-5, 88-90).
- b. Near Ingersoll the entire exposed thickness of the Detroit River is grey limestone.
- c. At St. Marys the Detroit River is predominantly tan dolomite with some interbeds of grey limestone.
- d. North of St. Marys and in northern Michigan the Detroit River is entirely tan dolomite except for a localized cluster of small, grey limestone reefs near Formosa, Ontario (Fagerstrom, 1961b; Liberty and Bolton, 1971, p. 59-65).

In contrast, the adjacent Bois Blanc, Columbus and Dundee are much more uniform grey limestones virtually throughout their areas of occurrence except for the basal few metres of the Columbus near Ingersoll (Ehlers and Stumm, 1951) and the basal Bois Blanc near Hagersville, Ontario (approximately 65 kilometres east of Ingersoll, Fig. 1; Hewitt, 1960) which are sandstone or sandy limestone (formerly called the Springvale Sandstone).

Biostratigraphic Units

Near Amherstburg, Ontario

Fagerstrom (1971, p. 6-8) reviewed the history and nomenclature of biostratigraphic subdivision in the type region of the Detroit River Group. In this region he recognized three biostratigraphic subzones (modified from Lane, Prosser, Sherzer and Grabau, 1909, p. 555, 556): a basal informal "coral-mixed brachiopod subzone", the middle **Acanthonema holopiforme** Subzone, and an upper **Amphipora nattressi** Subzone. These subzones are also coincident with the three formations recognized in the Amherstburg area (in ascending order the Amherstburg and Lucas Dolomites and the Anderdon Limestone). Fagerstrom (1971, p. 57-74) described the range-zones and biostratigraphic significance of the brachiopod taxa in these rocks.

In the type region fossiliferous rocks of the "coral-mixed brachiopod subzone" are not presently exposed so that information on the stromatoporoids from this subzone is based on: (a) six specimens collected in the early 1900's from the "coral bed" of the Oakwood salt shaft (Loc. H¹, Fig. 31) by W.H. Sherzer; these rocks are presumed to be of Amherstburg age (see Fagerstrom, 1971, p. 88) and (b) six specimens collected by Fagerstrom in 1963 from blocks dredged from the Livingstone Channel (Loc. I, Fig. 31; see also Fagerstrom, 1971, p. 88-89); both the Amherstburg and Lucas Dolomites were exposed in the channel from 1908 to 1912 but because stromatoporoids are exceedingly rare in present exposures of the Lucas it is here presumed that all six specimens came from the Amherstburg. The twelve specimens collected by Sherzer and Fagerstrom are taxonomically distributed as follows:

?**Habrostroma** sp.; 1 specimen, UMMP 14062
Syringostroma sherzeri (?); 1 specimen, UMMP 13093
S. pustulosum; 2 specimens, GSC 60305, 60306
S. densum; 1 specimen, GSC 60381
Anostylostroma laxum; 2 specimens, GSC 60420, 60421
A. sp.; 2 specimens, UMMP 36077B, 36078
Amphipora ramosa(?); 1 specimen, UMMP 14040
Stictostroma anomalum; 1 specimen, UMMP 36085
S. sp.; 1 specimen, GSC 60306

In the **Acanthonema holopiforme** Subzone stromatoporoids are very rare and complete silicification of all specimens known to the writer makes generic identification impossible.

Stromatoporoid-bearing rocks of the **Amphipora nattressi** Subzone are presently exposed in three large quarries (Localities G, K, 76000, Appendix 1) and although specimens are abundant and diverse (14 species) at each, **A. nattressi** appears to be a poor subzonal index because it is not particularly abundant or widespread in the subzone. However, because its designation as the subzonal index by Lane, Prosser, Sherzer and Grabau (1909) has priority the name should be retained for the subzone; furthermore, near Ingersoll, Ontario (see below) **A. nattressi** is characteristic of the upper Detroit River Group.

Near Beachville, Ontario

In the large quarries near Beachville, the Detroit River Group consists of a total exposed thickness of about 35 m of uniform grey limestone that contains abundant and moderately well-preserved stromatoporoids through almost the entire section (see Fig. 27). The vertical faunal succession may be conveniently subdivided into three local biostratigraphic zones: a lower stromatoporoid - coral rich biostrome here named the **Anostylostroma columnare** Zone, a middle unit of less diverse and more dispersed stromatoporoids here named the **Syringostroma sherzeri**(?) Zone and an upper unit of recurrent thin dendroidal stromatoporoid biostromes that include large numbers of **Amphipora nattressi** and so is here referred to the **A. nattressi** Subzone of the Amherstburg area (described above).

The overlying sandy grey Columbus Limestone belongs to Zone H or the **Paraspirifer acuminatus** Zone (Ehlers and Stumm, 1951).

The local and regional biostratigraphic significance of these Detroit River and Columbus zones and subzones as well as the stromatoporoids of the underlying Bois Blanc and the overlying Dundee Limestones are discussed below in the chapter on "Biostratigraphy and Correlation".

SPECIES OF THE GENUS SYRINGOSTROMA

The Detroit River Group and Columbus Limestone contain at least six, and perhaps eight, clearly separable species of **Syringostroma** (see also "Systematic Descriptions" below for the genus as well as the species). Species differences are based on aspects of both external and internal coenosteal morphology (Table 1; Figs. 2-4) from large collections (see below for exceptions) near Amherstburg, Formosa and Ingersoll, Ontario and Sandusky, Ohio (Fig. 1). (For general glossary of morphologic terms see Galloway, 1957.)

Syringostroma cylindricum differs from all other species in coenosteal shape. Only **S. nodulatum** and **S. probicrenulatum** have mamelons and this species pair is easily separated on the basis of the size and spacing of their megapillars (Table 1; see also "Remarks" for the Systematic Description of the Genus **Syringostroma** for discussion of the nature of megapillars and Fagerstrom and Saxena, 1973, for definition and description of techniques for measuring megapillar size and spacing). In addition, **S. probicrenulatum** differs from all the other species in having the most poorly formed and organized (non-persistent, irregularly arranged) megapillars (Fig. 3).

The univariate data of Fig. 2, supplemented by appropriate F- and t-tests, indicate that **S. densum**, **S. pustulosum**, and **S. sherzeri**(?) are clearly separable on the basis of the size and spacing of the megapillars. The remarkable clustering of points for these species into non-overlapping "fields" in Fig. 3 confirms this conclusion despite the general high level of inter-coenosteal variation within each species.

In coenostea of species of **Syringostroma** having relatively widely spaced megapillars, the microlaminae (defined herein; see "Remarks", Systematic Paleontology, Group I) tend to rise steeply as they approach the megapillar margins and the galleries appear elongate in vertical thin-sections. Tangential thin-sections of such coenostea typically are marked by a prominent ring of galleries encircling each megapillar (Fagerstrom and Saxena, 1973).

¹Capital letters for localities in the type region of the Detroit River Group (see Fagerstrom, 1971, p. 86-90).

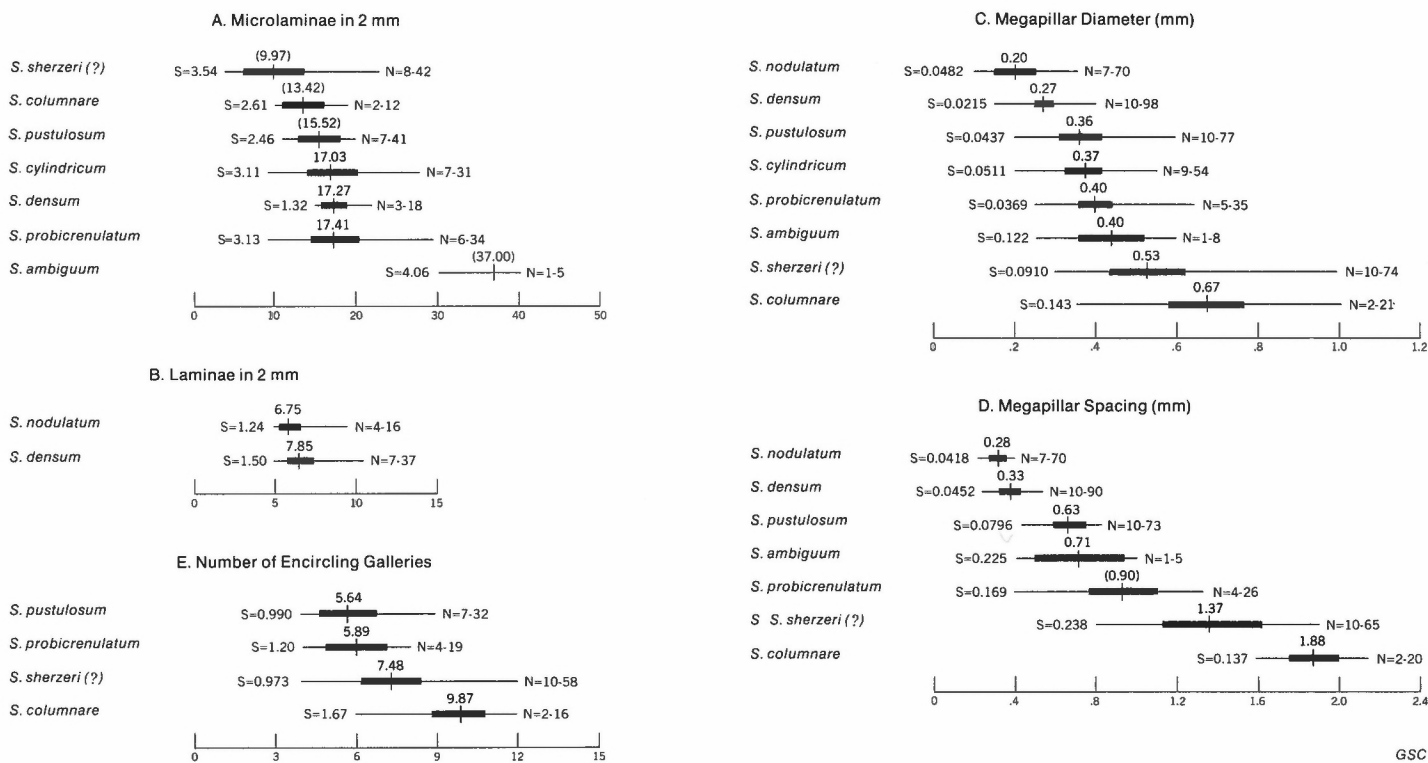


FIGURE 2. Comparison of univariate statistics for five morphologic features for species of *Syringostroma* from the Detroit River Group and Columbus Limestone. The long, thin line spans the absolute observed range for all coenostea measured; the heavy horizontal bar spans the standard deviation; the vertical thin line with the number above marks the location of the mean. N = number of coenostea measured - total number of measurements used to calculate mean and s. s = standard deviation. Mean values in parentheses indicate those species for which F- and t-tests indicate that they differ from all other species at the 0.05 level of significance.

However, the number of encircling galleries is less useful in differentiating among the species of *Syringostroma* than either megapillar diameter or megapillar spacing (Fig. 2) and is only moderately well correlated with megapillar diameter (Fig. 4). In fact, the data of Figs. 2-4 strongly suggest that there is a hierarchy of taxonomic criteria (in contrast to one of the basic tenets of numerical taxonomy) based on internal morphology that proceeds from the most useful, megapillar spacing (not used to identify either *S. cylindricum* or *S. ambiguum*) to megapillar diameter, microlaminar/laminar spacing to the least useful, number of encircling galleries (of no value for identification of species with closely spaced microlaminae/laminae, e.g. *S. ambiguum*, *S. nodulatum*, *S. densum*, *S. cylindricum*).

The size and spacing of the megapillars can also be combined into an important expression of the percentage of the centre-to-centre distance between adjacent megapillars that is occupied by the megapillars themselves, here termed the megapillar ratio: $(100)(\text{mean or median megapillar diameter}) \div (\text{mean or median megapillar spacing})$. The megapillar ratio can be computed for individual coenostea (Fig. 3), or for a sample of the members of the hypodigm for each species; for example, megapillar ratios based on the data in Fig. 2 are: *S. columnare* = 35.6; *S. sherzeri*(?) = 38.7; *S. pustulosum* = 57.2; *S. densum* = 81.8; *S. nodulatum* = 87.8.

Megapillar ratios are simple mathematical expressions of what appear to be fundamental attributes of the coenostea of *Syringostroma* spp. that can be effectively used in the presentation and interpretation of data regarding degrees of taxonomic difference, morphologic change (if any) due to evolution, clinal variation, functional morphology, etc.

In order to test the value of megapillar size and spacing as taxonomic criteria, the author measured and plotted (Fig. 3) data on these same variates for species not present in the Michigan Basin (*S. reticulata*, *S. ristigouchense*) or that were suspected synonyms of basal species (*S. sanduskyense*). These data strongly suggest that *S. sherzeri*(?) and *S. reticulata* are synonyms as are *S. densum* and *S. sanduskyense* but leave in doubt the taxonomic relations between *S. nodulatum*, *S. ristigouchense*, and *S. densum*. Although the sample size for *S. ristigouchense* (from Lower Devonian rocks, Cap Bon Ami, New Brunswick) is rather small, replotting of joint mean values for megapillar size and spacing (Fig. 5) of the data for the species in Figs. 2C and 2D together with the data for *S. ristigouchense*, suggests that the latter species is intermediate between *S. nodulatum* and *S. densum*. In fact, *S. ristigouchense* may have been the ancestor to *S. densum*; a significant stratigraphic gap between the known range-zones of *S. ristigouchense* and *S. nodulatum* and the presence of

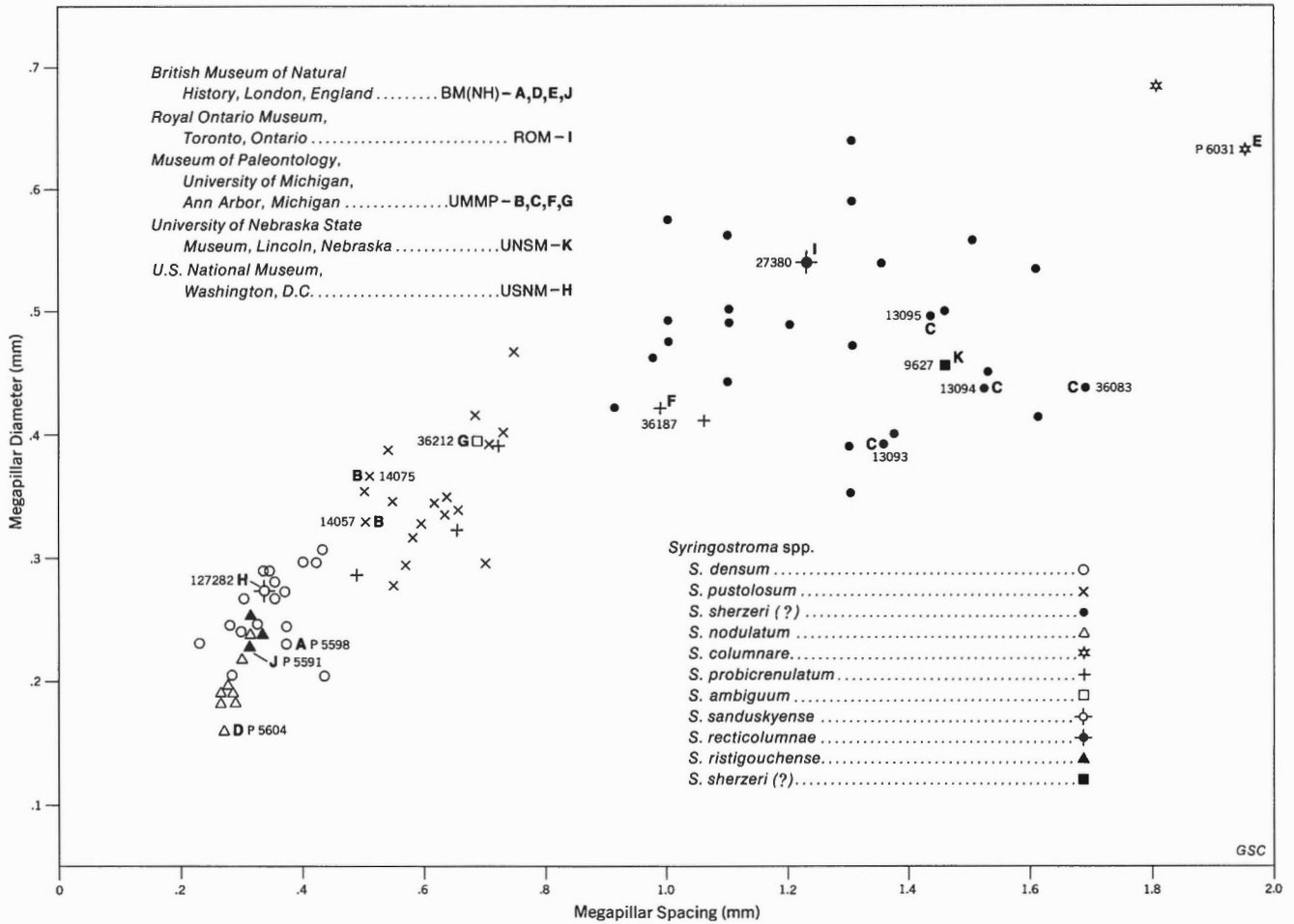
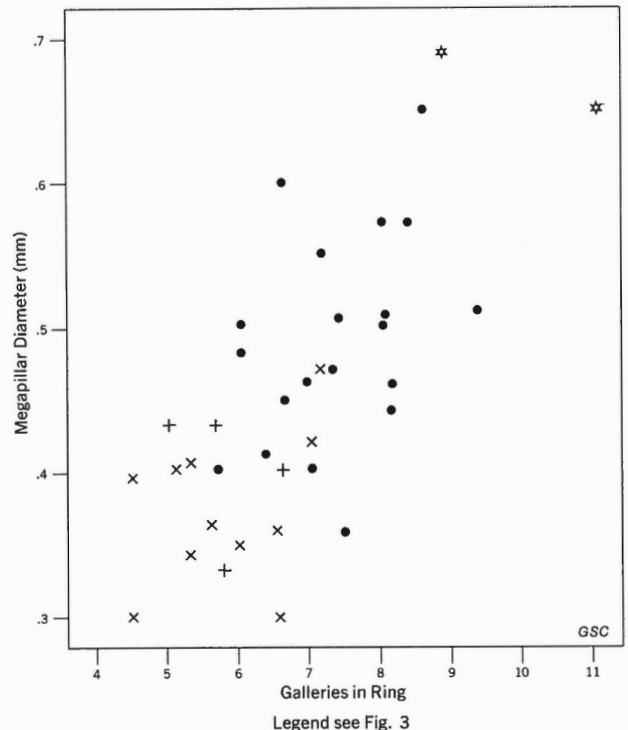
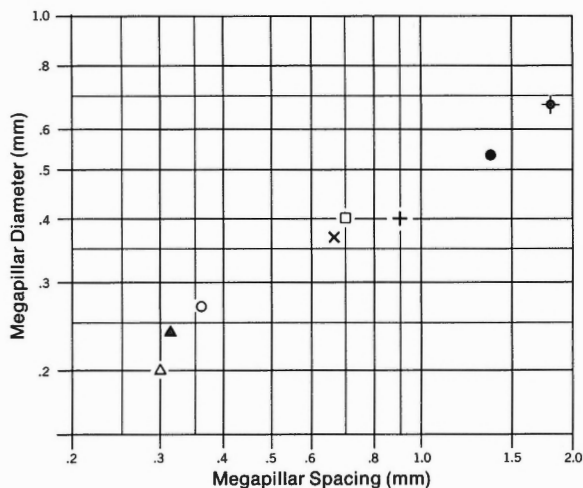


FIGURE 3. Relations between size and proximity of megapillars (based on median values) in *Syringostroma* spp. Type specimens indicated by letters as follows: A = BM(NH) P5598, holotype, *S. densum*; B = UMMP 14057, 14075, syntypes, *S. pustulosum*; C = UMMP 13093-13095, 36083, syntypes, *S. sherzeri* (?); D = BM(NH) P5604, holotype, *S. nodulatum*; E = BM(NH) P6031, holotype, *S. columnare*; F = UMMP 36187, holotype, *S. probicrenulatum*; G = UMMP 36212, holotype, *S. ambiguum*; H = USNM 127282, holotype, *S. sanduskyense*; I = ROM 27380, holotype, *S. recticolumnae*; J = BM(NH) P5591, holotype, *S. ristigouchense*. Note the clear separation of the clusters of points representing coenostea of *S. densum*, *S. pustulosum*, *S. sherzeri* (?) and *S. columnare* (see text). Point K = UNSM 9627, hypotype, *S. sherzeri* (?) used by Fagerstrom and Saxena (1973); compare with Figure 33.

FIGURE 4. Relations between megapillar size and number of galleries in innermost ring of galleries around megapillars (based on median values) for *Syringostroma* spp. Intermixing of points indicates relation between variates is not a good taxonomic criterion.





Legend see Fig. 3

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FIGURE 5. Allometric relation between mean values (from Figure 2) for megapillar size and spacing for *Syringostroma* spp. Symbols same as for Figure 3.

well-developed mamelons in the latter species (mamelons are absent in *S. ristigouchense* and *S. densum*) both mitigate against *S. ristigouchense* as the direct ancestor to *S. nodulatum*.

The taxonomic significance of the apparent differences in megapillar size and spacing between *S. columnare* (has priority) and *S. sherzeri*(?) a possible junior synonym, is uncertain due to the small sample size and large variance for coenostea tentatively assigned to the former species. F-tests for comparison of differences in the variances for microlaminar spacing and megapillar diameter and spacing for *S. columnare* and *S. sherzeri*(?) indicate that t-test comparisons for the separation of these species are only valid

TABLE 1

Key to Identification of Species of *Syringostroma* in the Detroit River Group and Columbus Limestone in the vicinity of Michigan Basin

- I Coenosteam sub-cylindrical; axial tissue amalgamated *S. cylindricum*
- II Coenosteam flat, undulatory, or sub-hemispherical
 - A. Mamelons present; megapillars poorly formed
 - 1. Megapillars very small (0.15-0.25 mm in diameter) and very closely spaced (0.2-0.3 mm apart). Mamelons well-developed *S. nodulatum*
 - 2. Megapillars moderately large (0.35-0.6 mm in diameter) and moderately far apart (0.4-1.3 mm). Mamelons poorly developed *S. probicrenulatum*
 - B. Mamelons absent, megapillars prominent, well formed
 - 1. Microlaminae very closely spaced (30-40 in 2 mm) *S. ambiguum*
 - 2. Microlaminae moderately closely spaced (5-30 in 2 mm)
 - a. Megapillars very small (0.15-0.35 mm in diameter) and very closely spaced (0.2-0.5 mm apart) *S. densum*
 - b. Megapillars moderately large (0.25-0.5 mm in diameter) and moderately far apart (0.4-0.8 mm) *S. pustulosum*
 - c. Megapillars large (0.3-0.7 mm in diameter) and widely spaced (0.9-1.8 mm apart) *S. sherzeri* (?)
 - d. Megapillars very large (0.4-1.0 mm in diameter) and very widely spaced (1.6-2.1 mm apart) *S. columnare*

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for the mean values for microlaminar spacing. Biometrical comparisons of microlaminar spacing strongly suggest that *S. columnare* is intermediate between *S. sherzeri* and *S. pustulosum* and that these differences are indeed significant. However, in view of the small sample size for *S. columnare*, the taxonomic significance of these differences in microlaminar spacing remains uncertain. Repeated attempts to increase the sample size for *S. columnare* have proven unsuccessful and the present uncertainties are likely to persist.

In coenostea that appear to be well-preserved, the microlaminae are individually distinct and the closeness of their spacing is easily measured and compared. In other coenostea, the clarity of the individual microlaminae is variable from place to place and two or more microlaminae may be fused into one lamina. The tendency toward fusion is generally directly proportional to the closeness of the microlaminar spacing (e.g. *S. nodulatum* and *S. densum*, Fig. 2). However, the only known coenosteam of *S. ambiguum* is clearly an exception to this generalization; the microlaminae are individually distinct and yet are the closest spaced in any coenosteam of any cellular/microlaminar stromatoporoid observed by this author. In all features, except for microlaminar spacing, *S. ambiguum* closely resembles *S. pustulosum* and thus could be regarded as an unusual variant of *S. pustulosum*. Again, efforts to collect more coenostea of *S. ambiguum* have been unrewarded.

In summary, the six (or eight) species of *Syringostroma* in the Detroit River Group and Columbus Limestone (in northern Ohio) can be clearly distinguished by use of a combination of five quantitative internal coenosteal features and two non-quantitative external features (Table 1 and Fig. 2). The size and spacing of the megapillars has proven to be particularly useful for distinguishing between three (or four) of the most similar species (Figs. 2, 3). The present data are inadequate to confidently establish the morphological differences (if any) between *S. columnare* and *S. sherzeri*(?) and between *S. ambiguum* and *S. pustulosum*.

SYSTEMATIC PALEONTOLOGY

Introduction

Morphologic Terminology

The relatively large and conflicting array of morphologic terms used to describe stromatoporoids has undoubtedly contributed to the general lack of interest among paleontologists in stromatoporoid systematics. The attempts of Galloway (1957), Galloway and St. Jean (1957), Stearn (1966a) and Abbott (1973) to stabilize terminology (in English) have met with general acceptance and their usages have been followed in the present report.

Morphologic features may be conveniently subdivided into those easily visible with the unaided eye or a 10 power hand lens here termed macrostructures, and those visible only in thin-section using a compound microscope, here termed microstructures. Both macrostructures and microstructures can in turn be characterized as to their size, shape (size + shape = form) and arrangement.

The coenosteal shape (macrostructure) terminology of Abbott (1973) is generally adequate, except for the following omission that applies to many forms from the Detroit River Group and related rocks:

Ellipsoidal

Vertically compressed ("loaf-shaped") coenostea having unequally long horizontal axes, the longest of which exceeds the vertical axis in length.

The term "megapillar" was first used for an internal macrostructural feature by Fagerstrom and Saxena (1973) and is discussed in detail below under the heading "Remarks" for the systematic description of the Genus *Syringostroma*. Papillae on the coenosteal surface (Galloway, 1957, p. 356) are commonly the upper ends of megapillars.

Macrostructures (e.g. coenosteal shape; presence/absence and form of latilaminae, laminae, pillars, dissepiments, mamelons, astrophorae) are generally less useful taxonomic criteria at the genus level than microstructures (cf. Lecompte, 1956, p. F120). The microstructural terminology of Stearn (1966a) has been followed in the present report.

In keeping with this subdivision into macrostructures and microstructures, the following systematic descriptions of species begin with the macrostructures and continue to the microstructures taking up, in order, the latilaminae/laminae/microlaminae, megapillars/pillars, galleries and dissepiments; the astrophoral canals and mamelons are discussed both as macro- and as microstructures.

Preservation and Diagenesis

Although stromatoporoids are present in the dolomitic rocks of the Detroit River Group they are not as abundant, diverse or as well-preserved as in the relatively pure limestones of the reefs near Formosa and the biostromes near Ingersoll and Amherstburg, Ontario. Locally, coenostea in dolomite have been wholly or partially replaced by chert which has destroyed the original microstructure and made identification at the genus and species levels impossible.

The original mineralogy of Paleozoic stromatoporoid coenostea is uncertain but the work of Wendt (1975) and Stearn (1975; 1977) suggests that for many species it was aragonite. Thus, the probability is great that all of the calcite coenostea described below have undergone diagenetic alteration and that some of the microstructural differences here regarded as having prime taxonomic significance at the genus level may be merely differences in the kind and degree of diagenesis that the coenostea have undergone.

The problems posed by variable degrees of diagenetic alteration of stromatoporoids have concerned taxonomists for many years (e.g. Nicholson began to consider them in the late 1800's) but answers regarding original microstructures are still largely speculative (Stearn, 1975). In the present report, the subject of diagenesis has generally not been treated in detail except in the "Remarks" preceding the systematic description of the genera having cellular/microlaminar microstructure. However, it has been assumed that among the non-cellular forms, coenostea having clearly defined (sharp borders) laminae, pillars and dissepiments and galleries containing clear (spar) calcite crystals (Pl. 5, figs. 2, 8) have undergone less alteration than coenostea with diffuse borders (Pl. 5, fig. 7) of the macrostructural elements (cf. Riding, 1974). Thus, the spacing of macrostructural elements is far less subject to diagenetic alteration than is their size or thickness and so has been used as an important taxonomic criterion for distinguishing among some closely similar species (e.g. *Syringostroma* spp.). However, among other taxa the spacing of macrostructural elements is exceedingly variable and may have been more related to such aspects of paleoecology as turbulence, temperature and solar period than to genetic aspects of the assumed sexually reproducing population (e.g. *Anostylostroma laxum*). Furthermore, coenostea in which detailed microstructural features (cellules, ordincells, microreticulate and tripartite

laminae) are well-developed and assumed to have been altered less by diagenesis than coenostea having flocculent, melanospheric or vacuolate microstructures (Stearn, 1966a). Of particular concern is the presence of two (or even three) different microstructures in different parts of the same thin-section which according to presently used taxonomic criteria are indicative of two or more genera. Such coenostea strongly suggest that some of the presently recognized microstructures that are presumed to be diagnostic of particular genera may be at least partly the result of diagenesis and thus of uncertain taxonomic significance.

The fact that diagenesis is a surface related phenomenon is readily apparent among Detroit River stromatoporoids. Coenostea having high surface area/volume ratios are more altered (e.g. the fragile cylindrical/dendroidal coenostea of *Amphipora* and *Stachyodes*, Pl. 6, figs. 5, 9), than coenostea having lower ratios (e.g. the thick, lamellar coenostea of *Anostylostroma* and *Habrostroma*) or the central parts of hemispherical or ellipsoidal coenostea.

In summary, determination of the nature and degree of diagenesis is and will probably continue to be for some time, the most difficult unsolved problem in stromatoporoid taxonomy. Until these aspects of diagenesis can be recognized, the original microstructural features will remain partly an enigma and some of the currently accepted taxonomic criteria for the identification of stromatoporoid genera are of uncertain validity. However, some coenosteal features have proven to be remarkably stable and thus of great value in distinguishing among several closely related genera and species. (For supporting examples of this last statement see the chapter entitled "Species of the Genus *Syringostroma*" and "Remarks" for the systematic descriptions of the genera *Habrostroma* and *Syringostroma*).

Stromatoporoid Classification

The position of the Stromatoporoidea (most workers regard it as an order) in the animal (or plant; Kazmierczak, 1976) kingdom has been uncertain and controversial almost from the time of their first description as fossils (Goldfuss, 1826). The history of this controversy has been reviewed by Lecompte (1951), Galloway (1957) and other authors and its most recent comprehensive analysis was by Stearn (1972) who, along with Hartman and Goreau (1970), pointed out the similarities between the Stromatoporoidea and the living Sclerospongia (Phylum Porifera).

Similarly, the subdivision of the Stromatoporoidea at the family level has not found general acceptance so rather than arranging the genera and species described below into a complete and formal hierarchical scheme (including families) they are arranged in four informal "groups" of genera and species having similar microstructures of the laminae as follows:

Group I: Genera having cellular/microlaminar microstructure (*Habrostroma*; *Syringostroma*)

Group II: Genera having compact, transversely porous/transversely fibrous microstructure (*Anostylostroma*; *Pseudoactinodictyon*; *Amphipora*)

Group III: Genera having tripartite/ordincellular microstructure (*Stictostroma*; *Stromatoporella*; *Trupetostroma*)

Group IV: Genus with striate microstructure (*Stachyodes*)

In addition to the presence in one thin-section of microstructures characteristic of two or more genera (as noted above), a single thin-section may also contain arrangements of macrostructural elements characteristic of more than one genus. In such cases the "genera" are often very closely related and unequivocal decisions regarding the generic assignment of these coenostea may be impossible to make. To resolve this problem, the author has used an informal category, herein called the "Genus Group" (e.g. Anostylostroma – Pseudoactinodictyon "Genus Group") in the following systematic descriptions (see Mayr, 1970, p. 424 for definition of his comparable term "species group").

Similarly, the very high levels of both intracoenosteal and intraspecific variation (Appendix 2) have made the distinctions among some closely related species very difficult to determine. This problem is most apparent among large samples from the same locality and has led in some cases to the placement of two or more species in synonymy. Again, the author has used Mayr's (1970, p. 424) concept of "Species Group" (= Formenkreis of Flügel and Flügel-Kahler, 1975) to indicate that closely related species of the same genus are intergradational.

Prior to the present study, the chief work on Detroit River stromatoporoids was by A.W. Grabau (1910, p. 87-94). All of Grabau's material was collected either from the Amherstburg Dolomite? ("coral bed"; see Fagerstrom, 1971, p. 88) at Locality H or from the type Anderdon Limestone at Locality K and was deposited in the Museum of Paleontology at the University of Michigan (UMMP). These same specimens later became part of the material used by Galloway and Ehlers (1960) in their revision of some Michigan Basin stromatoporoids and were also examined in the course of the present study. The following specimens, originally described by Grabau and revised by Galloway and Ehlers, are here revised again for the reasons indicated:

1. ***Stromatopora galtense*** Grabau (= ***S. gallowayi*** of Galloway and Ehlers) based on UMMP 14062 is probably a species of ***Habrostroma*** but the sample is too small for satisfactory identification.
2. ***Stromatopora (Coenostroma) pustulosum*** Grabau (partim) (= ***Syringostroma aurora*** of Galloway and Ehlers) based on UMMP 14075 is here regarded as ***Syringostroma pustulosum*** (Grabau).
3. ***S. (Coenostroma) pustulosum*** Grabau (partim) (= ***Syringostroma aurella*** of Galloway and Ehlers) based on UMMP 14057 is here regarded as ***Syringostroma pustulosum*** (Grabau).
4. ***Clathrodictyon ostiolatum*** Grabau (partim) (= ***Anostylostroma arvense*** of Galloway and Ehlers) based on UMMP 13069 is too poorly preserved for identification.
5. ***Idiostroma nattressi*** Grabau (partim) (= ***Amphipora nattressi*** of Galloway and Ehlers) based on UMMP 14038, 14039, 14042 is too poorly preserved for identification.
6. ***Stictostroma anomalum*** Galloway and Ehlers based on UMMP 36077B and 36078 is probably a species of ***Anostylostroma***; in fact, Galloway and Ehlers (1960, p. 91) indicate that such is the case for UMMP 36078.

Galloway and Ehlers (1960, p. 102-104) described only two species from the Bois Blanc Limestone. The author has examined their material, regards all of it as belonging to the Genus ***Stachyodes*** and has collected no comparable material from the Bois Blanc elsewhere in the vicinity of the Michigan Basin.

The abundant and diverse stromatoporoid fauna of the Columbus Limestone was described by Galloway and St. Jean (1957). The present author has examined only selected material studied by them from northern Ohio; these specimens are referred to in the following systematic descriptions and the hypodemes (Simpson, 1940) to which they belong have been expanded in size and range by the author's own collecting. Similarly, the author has compared the Michigan Basin material described below with selected type specimens of Nicholson (1873 and numerous subsequent papers), Girty (1897), Parks (1904; 1936), Fritz and Waines (1956) and Lecompte (1951, 1952) for the purposes of checking suspected synonymous species and expanding the sizes and ranges of their hypodemes.

Systematic Descriptions

All type and figured specimens listed below under the heading "Material and Occurrence" for each species were examined by the author who also collected all of the material unless otherwise indicated. Occurrences of the biostratigraphically more important taxa in rocks beyond the limits of the Michigan Basin are discussed in the chapter on "Biostratigraphy and Correlation".

The repositories of the type and figured specimens are as follows:

- GSC – Geological Survey of Canada, Ottawa, Ontario
- BM(NH) – British Museum. Natural History, London, England.
- UMMP – Museum of Paleontology, University of Michigan, Ann Arbor, Michigan
- MRHN – Musée Royal d'Histoire Naturelle, Brussels, Belgium
- UNSM – University of Nebraska State Museum, Lincoln, Nebraska
- USNM – U.S. National Museum, Washington, D.C.
- ROM – Royal Ontario Museum, Toronto, Ontario
- NYSM – New York State Museum, Albany, New York
- YPM – Yale Peabody Museum, Yale University, New Haven, Connecticut

Duplicate specimens of nearly all type and figured material have also been deposited in the Invertebrate Paleontology Division, University of Nebraska State Museum, Lincoln.

Group I: Genera Having Cellular/Microlaminar Microstructure

Remarks: Spar-filled vacuities or voids are present in the stromatoporoid coenosteum on both the macrostructural and microstructural scales. Such macrostructural vacuities are presumed to have originally been filled with soft tissues and consist of galleries, pseudozooidal tubes, astrorhizal canals and vesicles (see Galloway, 1957 for discussion of these terms). They are present between the macrostructural elements consisting generally of laminae, pillars, dissepiments (or cysts), walls and tabulae arranged in either a reticulate (laminae and pillars about equally well-developed), amalgamate (neither laminae nor pillars well-defined and persistent) or vesicular (dissepiments predominant) pattern.

In thin-sections viewed at magnifications of X10-X50 several forms of microstructural vacuities (Nicholson, 1886, p. 36) are present within the macrostructural elements (chiefly the laminae and pillars). They range in shape from circular (presumably spherical in three dimensions) to elongate (tubular), range in size (minimum diameter or cross-section) from about 0.01-0.06 mm and may be randomly arranged or in a regular network (microreticulate) or laterally continuous "bead-like" pattern (ordincellular) that give the laminae a tri-partite appearance (Pl. 8, fig. 6). The elongate vacuities may be arranged either parallel or perpendicular to the laminae and their margins or walls range from well-defined (a thin layer of dense, opaque specks about 0.001-0.005 mm in diameter; compare Stearn, 1966a, p. 77, 79) to diffuse. Typically, the smaller vacuities (here termed cellules) are more circular, more randomly arranged (a uniformly speckled appearance) and have better defined margins (Pl. 1, fig. 1; Pl. 2, fig. 5) than the larger ones; coenostea containing abundant randomly arranged cellules are here regarded as most closely approaching the original microstructure.

Previous authors (e.g. Galloway, 1957; Lecompte, 1951, 1952; Stearn, 1966a; St. Jean, 1967) have not agreed on their varied usages of the term cellular (\cong maculate) in reference to coenosteal microstructure or in their interpretations of the changes undergone by cellules during diagenesis. The present author here restricts the term "cellule" to sub-circular to sub-elliptical spar-filled vacuities 0.01-0.04 mm in minimum diameter that are present in macrostructural elements and uses the term "vacuole" for similar but larger vacuities (0.04-0.06 mm in diameter) of the same shapes (Pl. 1, fig. 3). It is quite common for cellules and vacuoles to occur together in the same thin-section and for reasons discussed below the author believes that in some situations cellules may enlarge to vacuoles or even tubules. In cases of extreme enlargement (e.g. *Syringostroma nodulatum* described below) vacuoles may be nearly as large as small galleries. Cellules occur among the smaller specks and clusters of specks in the microlaminae and laminae as well as in the less dense and lighter colored tissue that covers these macrostructures (clothing tissue of Stearn, 1966a).

Although both Galloway (1957) and Stearn (1966a) use the term "microlamina(e)" neither of them clearly defines it: a very thin (about 0.01-0.03 mm) and laterally continuous major horizontal or concentric macrostructure composed of a marked concentration of dark individual specks or small clusters of specks; cellules may be present between adjacent specks or clusters but are of less importance than the specks. There is no comparable vertical macrostructure; in coenostea with cellules and microlaminae the pillars commonly have rather poorly defined margins and the specks are much less densely arranged, i.e. the microlaminae are more prominent than the pillars (Pl. 1, fig. 4). However, if megapillars are present, they may be at least as prominent as the microlaminae, especially in tangential sections (Pl. 2, figs. 7, 8).

Cellules and microlaminae occur together in a great many coenostea of the genera *Syringostroma* and *Habrostroma* in the Detroit River Group and adjacent rocks and in these coenostea the cellules are commonly larger in the vertical macrostructures (especially mamelon columns) and the specks are more dense and uniformly distributed in the horizontal (Pl. 3, fig. 1) macrostructures. Thus, it is not uncommon for cellules and vacuoles to be larger and more prominent in pillars and megapillars measured in tangential sections than in microlaminae and laminae of the same coenosteum measured in vertical sections (see Table 3) suggesting that the cellules and vacuoles are horizontally elongate ellipsoids and ovoids.

The present author regards the microlaminae as original structures secreted by the stromatoporoid organism. Subsequently, the microlaminae may possibly have been partially resorbed during later astogeny (or ontogeny) or variously altered or even destroyed during diagenesis. Thus, by resorption and/or diagenesis the result was the conversion of microlaminae to laminae by alteration and/or rearrangement of the original specks. After secretion of the microlaminae the organism was probably also able to strengthen them by adding variable thicknesses of cellular clothing tissue (= secondary tissue of Galloway, 1957) which in turn may have been either resorbed or added to during astogeny or diagenesis.

In the cellular/microlaminar stromatoporoids there is a general similarity in the microstructure of the clothing tissue of the microlaminae and the tissue of the pillars; the specks are more diffuse than in the microlaminae and are commonly enlarged to flocs and melanospheres (Stearn, 1966a, p. 82-83) and the cellules are larger and more numerous in the clothing and pillar tissue than in the microlaminae. These features suggest that the pillars and clothing tissue have had a similar origin and diagenetic history.

The major changes involved in resorption and diagenesis are due to variable degrees of enlargement and diffusion of some specks from the axial parts of the thin microlaminae into the adjacent cellular clothing tissue and in extreme cases into the galleries. This diffusion of specks results in loss of clarity in the boundaries between microlaminae, clothing tissue and galleries, loss of identity of individual microlaminae (especially if they are closely spaced) and fusion of 2-6 microlaminae into one more or less diffuse lamina (Pl. 2, fig. 7). Laminae formed by fusion of microlaminae are usually much thicker (about 0.05-0.1 mm) than microlaminae and the density and darkness of the laminae specks is less than in the microlaminae from which they were formed.

As noted above, these alterations in the arrangement of the microlaminar specks are commonly accompanied by increased cellule diameter, change in cellule shape from circular to elliptical or irregular and may result in the formation of vacuolate or microreticulate microstructures in which only parts of the coenosteum still retain traces of the original cellules and microlaminae. Even after enlargement as postulated here, cellules are generally far more numerous than vacuoles and appear to be more prominent in the clothing tissue than in the microlaminae; the converse is true of the specks.

Although the origin of tripartite/ordincellular microstructure is uncertain, it is not present in coenostea having microlaminae and the ordincells are commonly larger than typical cellules and vacuoles. Therefore, most authors do not regard the cellular/microlaminar stromatoporoids as closely related to the tripartite/ordincellular stromatoporoids. Furthermore, the pillars of stromatoporoids having tripartite/ordincellular laminae generally lack cellules; instead, the specks are very densely arranged (compact), the pillar margins are well-defined (Pl. 7, fig. 1) and the pillars may contain scattered vacuoles (as in *Trupetostroma* or *Stictostroma*) which probably do not represent the enlargement of cellules.

Alterations in the size and shape of the specks and cellules in the pillars and megapillars of the cellular/microlaminar stromatoporoids may also produce changes in their arrangement. Thus, the clumping of specks into flocs and melanospheres not only enlarges the adjacent cellules (Stearn, 1966a, p. 82-83) but may also alter their arrangement from random (as in *Habrostroma* and

Syringostroma) to vertically aligned (as in **Parallelopora**) or microreticulate (as in **Parallelostroma**) by processes similar to those described by Stearn (1966a, p. 82-83) but also involving differential diffusion of specks. Differential diffusion of specks may also alter their own arrangement from random (uniformly speckled) to striated, water jet or vertically aligned (Pl. 3, fig. 3). Thus, the cellules, vacuoles, flocs and melanospheres in **Syringostroma** (Pl. 2, fig. 2) are commonly larger, darker and arranged in microreticulate or water jet patterns in the megapillars in contrast to their smaller size, lighter appearance and random arrangement in the adjacent normal sized pillars in the same thin-section; these differences suggest that differential diffusion of the megapillar specks may have taken place.

If the above postulated differences in both the size and arrangement of specks, flocs, melanospheres, cellules and vacuoles is indeed correct, then the microstructural differences presently used to distinguish among such similar genera as **Habrostroma**, **Parallelostroma** and **Parallelopora** are of doubtful validity and the former two genera may be junior synonyms of **Parallelopora** Bargatsky.

In summary, the presumed resorptive and/or diagenetic alterations that may occur in cellular/microlaminar stromatoporoids are as follows (recognizable only in thin-sections):

1. Two or more microlaminae may become fused into one lamina; traces of the former microlaminae are usually locally recognizable except in cases of considerable alteration.
2. Cellules may be enlarged, their shape changed from circular (spherical) to elliptical, tubular or irregular and their arrangement altered from random to horizontal (microreticulate) or vertical alignment in two or more rows or columns by differential diffusion of the adjacent specks.
3. Specks may undergo clumping to form flocs or melanospheres which in turn may be randomly arranged or aligned in horizontal or vertical (water jet) rows or columns.

Thus, resorption and diagenesis presumably have very profound effects in altering the size, shape and arrangement of microstructures whereas their effects on macrostructures are much less apparent and largely confined to changes in size (or thickness), to a lesser degree, shape (cf. Riding, 1974) and only in extreme cases is the arrangement of macrostructures altered. Pillars are not enlarged to megapillars, laminae do not become latilaminae, nor do pillars and galleries become superposed as a result of resorption and diagenesis.

In the following systematic descriptions and comparisons of the Group I (cellular/microlaminar) genera the author has emphasized those morphologic features that he believes have undergone minimal diagenetic alteration (e.g. the relative prominence and shape of the microlaminae, and pillars; presence/absence of megapillars) rather than the sizes, shapes and arrangements of the cellules, vacuoles, specks, flocs, and melanospheres. It is also important to note that only cellules and microlaminae are unique to the Group I genera; all of the other macrostructural and microstructural forms and arrangements may also occur in the non-cellular/microlaminar genera (Groups II, III, and perhaps IV) described below (see also Stearn, 1966a).

Genus **Habrostroma** n. gen.

Type species: **Stromatopora proxilaminata** Fagerstrom, 1961a, p. 8, Pl. 1, figs. 4-6.

Description. Coenostea of variable sizes and shapes from thin, flat to gently undulant crusts to large hemispherical to subellipsoidal masses; surface smooth, papillate, or with well-developed mamelons. Tissue reticulate; composed of very prominent, clearly defined, thin persistent microlaminae (Pl. 1, figs. 2, 7) and/or thicker, less clearly defined laminae (Pl. 2, figs. 3, 5), and pillars. Pillars variably developed; range from thin, non-persistent structures (Pl. 1, figs. 1, 2, 7) that expand upwards and coalesce along undersides of microlaminae and laminae to thick, prominent structures that are superposed through several microlaminae and/or two to four laminae (Pl. 2, figs. 3, 5). Tissue microstructure cellular (with rare vacuoles in some coenostea) and flocculent to melanospheric; in thick pillars there may be a variably prominent vertical "grain or fibre" due to alternating light and dark columns of aligned cellules and aligned specks, flocs and melanospheres. Galleries range from large, laterally elongate to small, subellipsoidal to subspherical vacuities. Astorhizae present in some species. Dissepiments rare to absent. (This genus comprises many species assigned by most previous authors to **Stromatopora**, e.g. Stearn, 1966a, p. 111).

Remarks. The diagnostic features of **Habrostroma** are the cellular tissue, the very prominent, relatively closely spaced, dark, continuous microlaminae, and the thicker, much less prominent, less continuous, and less dense pillars. During resorption and/or diagenesis two or more microlaminae may fuse, lose their individual identities, and form a single, less dense lamina; coenostea in intermediate stages of alteration may contain both microlaminae and laminae (Pl. 2, fig. 5). Such laminae may closely resemble the poorly preserved laminae of some stromatoporoids lacking cellular microstructure. Thus, the thickness and spacing of laminae has much less taxonomic significance than the thickness and spacing of microlaminae.

Similarly, the pillars in **Habrostroma** may also undergo resorptive or diagenetic modification involving enlargement of the pillars themselves as well as their included specks and cellules. In addition, the enlarged specks may alter their arrangement from random (uniformly speckled) to water jet melanospheric. Such pillars may resemble the megapillars of **Syringostroma**; the differences between the enlarged pillars of **Habrostroma** and true megapillars are discussed below in the "Remarks" for the Genus **Syringostroma**.

Microreticulate microstructure (Stearn, 1966a, p. 78, 83, 111, pl. 18, fig. 3) is not present in either the microlaminae or pillars of the very well-preserved material of **Habrostroma** from the Detroit River Group.

Comparisons. The presence of cellular tissue in **Habrostroma** indicates that this genus is most closely related to **Stromatopora**, **Ferestromatopora**, **Syringostroma**, **Parallelopora**, **Parallelostroma**, and **Climacostroma**. Comparison of **Habrostroma** and **Syringostroma** is made below under "Remarks" for the Genus **Syringostroma** and comparisons of **Habrostroma** with the other genera follow here.

The chief difference between **Habrostroma** and **Stromatopora** Goldfuss (as restricted herein) is the presence of closely spaced (up to about 35 in 2 mm), thin, continuous microlaminae as the dominant structural elements of the coenosteam in **Habrostroma** (Pl. 1, fig. 1). In coenostea where diagenesis has completely destroyed the microlaminae, the resulting laminae are the dominant structural elements

whereas in *Stromatopora* the tissue is either amalgamate (neither microlaminae, laminae, dissepiments, nor pillars dominate; e.g. Lecompte, 1952, pl. 54, fig. 1) or the pillars and dissepiments are the dominant structures (e.g. Lecompte, 1952, pl. 54, figs. 2-5) and the laminae appear like dissepiments (as short cusps) joining adjacent pillars.

The present author is unaware of any species of *Stromatopora* (*sensu stricto*) in which pillars and dissepiments are the dominant skeletal elements that also contain continuous, well-developed microlaminae. However, examination of the type material of *Syringostroma vesiculosum* Lecompte (the absence of megapillars clearly indicates that this is not a species of *Syringostroma*) demonstrates the very great similarity between *Habrostroma* and *Stromatopora*. In Lecompte's (1952, pl. 32, fig. 3b) very large vertical sections of *S. vesiculosum* there are alternating "bands" or layers (latilaminae). In some latilaminae the microlaminae and laminae dominate (as in *Habrostroma*) whereas in others they have been replaced by dissepiments spanning the gap between adjacent, less well-developed pillars (as in *Stromatopora*). Because the overall appearance suggests that the dissepiments are generally more abundant than the microlaminae and laminae in *S. vesiculosum* and because dissepiments are relatively uncommon in *Habrostroma* the author interprets this as a species of *Stromatopora*.

Such uncertainties and subjective judgements in the identification of stromatoporoids at both the generic and specific levels are not at all uncommon even in well-preserved material and serve to emphasize the need for additional study of the present bases of classification as well as tolerance among stromatoporoid taxonomists for opinions and identifications based on material having different modes of preservation.

Previous authors (e.g. Galloway, 1957, 1960; Stearn, 1966a, 1966b; Kaźmierczak, 1971) who have redescribed the genus *Ferestromatopora* Yavorsky (1955, p. 109) have disagreed with regard to its basic morphology and the importance to be given to various features; even Yavorsky was inconsistent in his interpretation of the microstructure (Flügel and Flügel-Kahler, 1968, p. 544). Nonetheless, there has been general agreement that *Ferestromatopora* is similar to *Stromatopora* (*sensu lato*); it appears also to be very similar to *Habrostroma*.

In both *Ferestromatopora* and *Habrostroma* the microstructure is cellular and the horizontal structural elements are more prominent and continuous than the vertical ones. Although the author has not examined the type specimens of species assigned to *Ferestromatopora* by Yavorsky (1955), study of the descriptions and illustrations of this material suggests that *Habrostroma* differs from *Ferestromatopora* as indicated in Table 2.

Galloway (1957; 1960) and Stearn (1966a and 1966b) stressed the absence of superposed galleries and pseudozoidal tubes in *Ferestromatopora*; in *Habrostroma* the degree of

superposition of both galleries and pillars is highly varied and of minor significance for the identification of this genus. In the opinion of the present author, the chief features that distinguish *Ferestromatopora* are its cellular microstructure, well-developed continuous microlaminae/laminae, numerous obliquely stacked galleries and dissepiments in each interlaminar space, laterally joined dissepiments forming discontinuous subhorizontal structures, and very poorly developed or missing pillars.

The chief difference between *Habrostroma* and *Parallelostroma* Nestor (1966) appears to be the presence of very thick, microreticulate laminae in the latter in contrast to the thinner microlaminae and laminae with randomly arranged small cellules in *Habrostroma*. Similarly, the arrangement of the pillar cellules, vacuoles, flocs and melanospheres in vertical columns in *Parallelopora* Bargatsky contrasts with their random arrangement and generally smaller sizes in *Habrostroma*. However, as suggested above, these differences in the sizes, shapes and arrangements of microstructures could possibly be the result of differences in the degree of resorption and/or diagenesis that the coenostea have undergone. Until this possibility has been tested by examination of the type material of the species originally assigned to *Parallelostroma* and *Parallelopora*, it is best to regard these genera as well as *Habrostroma* as valid rather than as synonyms.

The closest affinities of *Habrostroma* presently appear to be with *Climacostroma* Yang and Dong (1979). The presumed differences between these genera (the author has not examined any of the type material of *Climacostroma* spp.) are the much greater degree of superposition of pillars and the absence of astrorhizae in some species of *Habrostroma* and the presence of small, vertical tubules and rods in *Climacostroma*. However, as noted in the description of *Habrostroma*, in coenostea where many of the microlaminae have been converted to laminae and the pillars appear thickened by addition of clothing tissue, both the laminae and pillars may have a vaguely developed vertical alignment of specks and cellules that might be similar to the vertical tubules and rods of Yang and Dong. Detailed comparison of the type material of *Climacostroma* spp. and *Habrostroma* spp. may indicate that the latter is an invalid junior synonym. Until such time it is better not to use the name *Climacostroma* for the material here ascribed to *Habrostroma*; to do so would extend both the geographic and stratigraphic ranges of *Climacostroma* far beyond their present limits.

Species assigned. The Detroit River Group and Columbus Limestone contain the following species here assigned to the Genus *Habrostroma*:

Stromatopora proxilaminata Fagerstrom, 1961a, p. 8, pl. 1, figs. 4-6.

TABLE 2

Major morphologic differences between *Ferestromatopora* Yavorsky (1955) and *Habrostroma*

	<i>Ferestromatopora</i>	<i>Habrostroma</i>
Galleries (size; shape; arrangement)	Large; oval; formed beneath dissepiments; in obliquely vertical stacks between adjacent microlaminae/laminae; not superposed to form pseudozoidal tubes.	Small; round, oval, subrectangular; only one level of galleries in each interlaminar space; may be superposed to form short pseudozoidal tubes.
Dissepiments	Abundant; tops may be laterally joined to form discontinuous, subhorizontal structures.	Rare to absent.
Pillars	Absent to poorly developed; short, not generally superposed.	Thick, with diffuse borders; may be superposed through two or more microlaminae/laminae.

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Stromatopora densilaminata Fagerstrom, 1961a, p. 9, pl. 1, figs. 7, 10.

H. formosensis n. sp.

H. beachvillensis n. sp.

Stromatopora larocquei Galloway and St. Jean, 1957, p. 171-173, pl. 13, fig. 3. (= *S. eumaculosa* Galloway and St. Jean, 1957, p. 177-178, pl. 14, figs. 4a, b)

The author has examined the type material for each of the following species previously assigned by other authors to other genera and here reassigns them to the Genus **Habrostroma**:

Syringostroma foveolatum Girty, 1897, p. 295-296, pl. 6, figs. 8, 9; Parks, 1909, p. 20-22, pl. 17, figs. 5-7, ? pl. 18, fig. 10 (as *Stromatopora foveolata*). Syntypes, YPM 22451 and NYSM 6822, 6823.

Syringostroma centrotum Girty, 1897, p. 293-295, pl. 7, figs. 1, 2; Parks, 1909, p. 12-14, pl. 16, figs. 6-9, ? pl. 18, figs. 6, 11. Syntypes, YPM 22449 and NYSM 6828, 6829.

Syringostroma consimile Girty, 1897, p. 297-298, pl. 7, figs. 3, 4; Parks, 1909, p. 14-16, pl. 16, figs. 10-12, ? pl. 18, fig. 14. Syntype, YPM 5527.

Syringostroma barretti Girty, 1897, p. 296-297, pl. 7, figs. 5, 6; Parks, 1909, p. 16-18, pl. 17, figs. 1, 2, ? pl. 18, fig. 5. The primary types are apparently lost. YPM 22454, labelled *Syringostroma barretti* (not type) in Girty's handwriting belongs in the Genus **Habrostroma**. Parks' hypotypes, NYSM 6825-6827 are too poorly preserved to determine whether or not they belong to **Habrostroma**; however, they almost surely lack megapillars and so are not a species of *Syringostroma*.

Stromatopora divergens Galloway and St. Jean, 1957.

Syringostroma percaniculata Lecompte, 1951.

Stromatopora saintjeani Fritz and Waines, 1956.

The author also examined the type material for the following other species and found it to be too poorly preserved for certain assignment to **Habrostroma**. However, future study of additional topotypic material will probably indicate they belong to **Habrostroma**.

Stromatopora marpleae Galloway and St. Jean, 1957

S. dubia Lecompte, 1951

S. laminosa Lecompte, 1951

S. stricta Lecompte, 1951

S. lensiformis Lecompte, 1951

The author has not examined the type material for *Stromatopora* sp. St. Jean, 1967 but on the basis of the published descriptions and illustrations suggests it belongs to **Habrostroma**.

The generic assignment of the following species is uncertain for the reasons indicated below. However, future detailed study may indicate that they also belong to the Genus **Habrostroma**.

Stromatopora obscura Galloway and St. Jean, 1957, p. 170-171, pl. 13, fig. 2. Galloway and St. Jean described the laminae as "thick" but the illustrations suggest that they may be thickened microlaminae. Galloway (1957, p. 447) assigned this species to **Ferestromatopora**.

Stromatopora mononensis Galloway and St. Jean, 1957, p. 178-179, pl. 15, fig. 1. The taxonomic significance, if any, of the tissue reversal in the single coenosteum on which this species was based is uncertain (Stearn, 1966a, p. 84). All other features suggest that this species belongs to **Habrostroma** and may be conspecific with *H. proxilaminata* as described below (see also Fagerstrom, 1961a, p. 8).

Stromatopora submixta Galloway and St. Jean, 1957, p. 180-181, pl. 15, fig. 2. The authors of this species described the tissue as "vaguely microlaminate" which suggests that the tissue originally may have been truly microlaminar as in **Habrostroma**.

Stromatopora cumingsi Galloway and St. Jean, 1957, p. 182-184, pl. 15, fig. 4; *Stromatopora conicomamillata* Galloway and St. Jean, 1957, p. 184-185, pl. 16, fig. 1; *Stromatopora magnimamillata* Galloway and St. Jean, 1957, p. 185-186, pl. 16, fig. 2; *Stromatopora gallowayi* Fritz and Waines, 1956, p. 98-100, pl. 2, figs. 3, 4. Poor preservation and relative prominence of microlaminae, laminae and pillars makes assignment of these species to **Habrostroma** uncertain.

Finally, the author has examined the type material of the following species assigned by Lecompte (1951) to **Stromatopora** and agrees with his generic assignment:

Stromatopora concentrica

S. cooperi

S. hupschi

S. maculata

In summary, the Genus **Habrostroma** is remarkably abundant and diverse in the Detroit River Group and Columbus Limestone and also appears to be highly diverse and widely distributed in rocks of Middle Silurian to Middle Devonian age.

Habrostroma densilaminata* – *Habrostroma proxilaminata* – *Habrostroma formosensis
"Species Group"

Plate 1, figures 1, 2, 4-8

Stromatopora densilaminata Fagerstrom, 1961a, p. 9, pl. 1, figs. 7, 10.

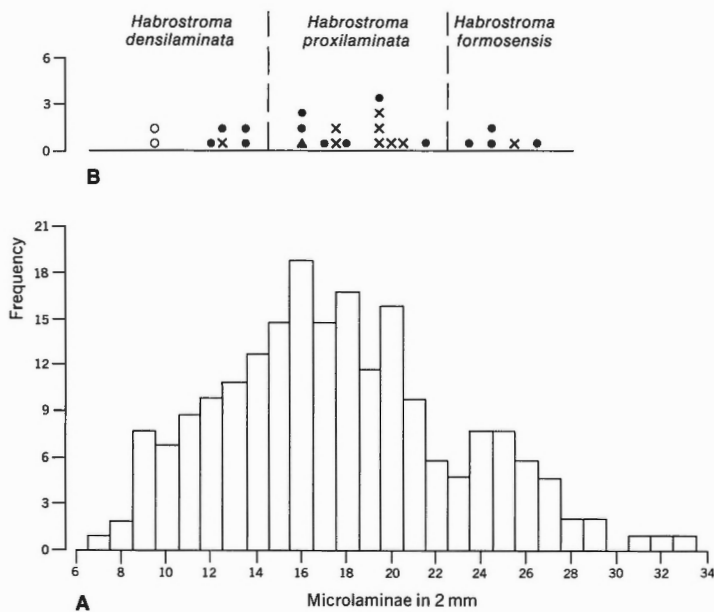
Stromatopora proxilaminata Fagerstrom, 1961a, p. 8, pl. 1, figs. 4-6.

Remarks. Detailed examination of an assemblage of 26 coenostea from Localities 23635, 97216 and 97212¹ belonging to the Genus **Habrostroma** indicates that the spacing of microlaminae is highly varied and of uncertain taxonomic value at the species level. For each coenosteum eight counts of the number of microlaminae in 2 mm were made and their frequency distribution plotted in Figure 6A.

¹Arabic numbers for localities in Ontario, assigned by the Geological Survey of Canada and on file in Ottawa (see Fig. 30). Precise locations of many of these quarries and outcrops are indicated on the maps accompanying Caley (1941, 1943), Liberty (1966) and Liberty and Bolton (1971).

These raw data indicate that there is a continuous spread of values (except for 30) from 7 to 33. Although these data have a polymodal distribution there is no apparent objective criterion for subdivision of the continuum into reasonably discreet species. One of the chief obstacles to such a subdivision is the very high level of variation in microlaminar spacing in a single thin-section. For example, the spacing of microlaminae in hypotype UNSM 4777 varies from 16 to 33 whereas in hypotype UNSM 4768 the range is only 7 to 17.

In order to further explore the possibility of subdividing this assemblage, median values (Fagerstrom and Saxena, 1973) for the number of microlaminae in 2 mm were determined for each of the 26 coenostea and their frequency distribution plotted in Figure 6B. Three "general groups" of values emerged: (1) a "group" of coenostea having closely spaced microlaminae, i.e. median values of at least 23 in 2 mm, (2) another "group" with median values of no more than about 14 in 2 mm, and (3) an "intermediate group" having median values of about 16 to 22 microlaminae in 2 mm. On the basis of the data presently available, each of these "groups" is distinctly different from the others so far as the spacing of microlaminae is concerned.



Stromatopora proxilaminata paratypes (Fagerstrom, 1961a) x
S. proxilaminata holotype ▲
S. densilaminata holotype and a paratype (Fagerstrom, 1961a) ○
 Coenostea from localities 23635, 97211 and 97216 ●

Note. Same scale is used on the abscissa for both figures.

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FIGURE 6A. Frequency distribution for microlaminar spacing from 26 coenostea of the *Habrostroma densilaminata*-*Habrostroma proxilaminata*-*Habrostroma formosensis* "Species Group" from the Formosa area, Ontario. N = 208.

FIGURE 6B. Frequency distribution of median values for microlaminar spacing for the same coenostea used in Fig. 6A. Crosses indicate paratypes of *Stromatopora proxilaminata* (Fagerstrom, 1961a) and the triangle indicates the holotype. Open circles indicate the holotype and a paratype of *S. densilaminata* (Fagerstrom, 1961a) and dots indicate non-type coenostea. Note that the same scale is used on the abscissa for both figures.

The next step in subdivision of the assemblage was to relate the spacing of microlaminae to the size, spacing, and height of the mamelons since mamelons are present in varying degrees of development in all of the coenostea. As shown in Figure 7, despite the rather high level of variability in both these variates there is a relation between them. Thus, in the "group" with widely spaced microlaminae noted above, the mamelons are the most closely spaced. Although the differences between the other two "groups" are less clear, the data of Figure 7 suggest that maximum values for mamelon spacing occur in the "group" having intermediate values for microlaminar spacing; nonetheless, mamelon spacing is of very limited value for distinguishing between members of these two "groups".

Five coenostea (two from the "group" with the most closely spaced microlaminae and three from the "group" with the most widely spaced microlaminae) were selected to investigate the possibility of establishing a relation between the spacing of microlaminae and the diameter of the astrorhizal canals. Six measurements of the canal diameter were made for each coenosteam. The median value (0.20 mm) for all 30 measurements occurred at least twice in four of the five coenostea. The remaining coenosteam, from the "group" with widely spaced microlaminae, had consistently smaller canals but the taxonomic significance of this difference is uncertain because of the small sizes of the samples compared. However, when considering the data from all five coenostea it appears as if microlaminar spacing and astrorhizal canal diameter are independent and that canal diameter is of very limited value as a taxonomic criterion for subdivision of the assemblage.

Thus, for those features of coenosteal morphology most amenable to biometrical study (microlaminar spacing, mamelon spacing, and astrorhizal canal diameter) it appears as if microlaminar spacing is the most suitable criterion for subdivision of the assemblage of 26 coenostea. On this basis, the "group" of seven coenostea (Fig. 6B) with relatively widely spaced microlaminae (median values of 14 microlaminae in 2 mm or less) generally conforms to the description of *Stromatopora densilaminata* Fagerstrom and

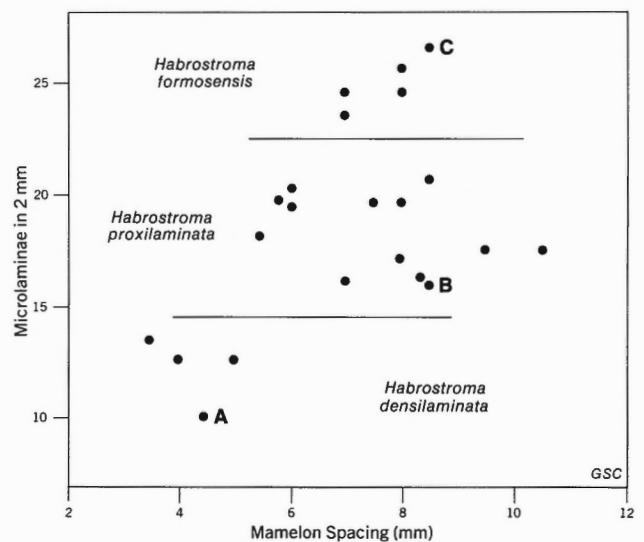


FIGURE 7. Relations between closeness of microlaminae and mamelons (based on median values) for 22 of the coenostea used in Figure 6. Points A, B and C indicate holotypes.

includes both of the primary type specimens. The "group" of 14 coenostea having median values of from 16 to 21.5 microlaminae generally conforms to the description of *Stromatopora proxilaminata* Fagerstrom and includes the holotype and 7 of the paratypes. The original descriptions of both these species are adequate and need not be repeated here; both species are here reassigned to the Genus *Habrostroma*.

The "group" of five coenostea (Fig. 6B) with relatively closely spaced microlaminae (median values of at least 23 microlaminae in 2 mm) is here assigned to the new species *Habrostroma formosensis* which is formally described below.

Detailed information on the precise location of ten coenostea in the *H. densilaminata* - *H. proxilaminata* - *H. formosensis* "Species Group" in the Formosa Reef Limestone at Location 23635 rather clearly indicates that each of the three species recognized in Figure 6B and noted above is randomly distributed both laterally and vertically in the reef. Thus, there is no apparent concentration of the forms in any particular part of the reef nor was any form characteristic of any particular stage in the geomorphic or ecologic development of the reef. Furthermore, the presence of this "Species Group" at localities that are not reefs, indicates that it is not restricted to the reef environment.

Material and Occurrence.

A. The following coenostea are here assigned to *Habrostroma densilaminata* (Fagerstrom): holotype, UMMP 36175, Formosa Reef Limestone, Loc. 97216; paratypes, UMMP 36184 and 36176, Formosa Reef Limestone, Loc. 23635; hypotypes, UNSM 4724, 4765, and 4794, Formosa Reef Limestone, Loc. 23635, collected by Paul R. Roper; hypotype, GSC 60233, lower Detroit River Group, Loc. 97211; hypotype, GSC 60234, lower 1.6 metres Anderdon Limestone, Loc. 76000; hypotype, GSC 20635; Formosa Reef Limestone, Loc. 97214.

B. The following coenostea are here assigned to *Habrostroma proxilaminata* (Fagerstrom): holotype, UMMP 36177, Formosa Reef Limestone, Loc. 23635; paratypes, UMMP 36178-36182 and 36186, Formosa Reef Limestone, Loc. 23635; paratype, UMMP 36185, Formosa Reef Limestone, Loc. 97216, collected by G.M. Ehlers; hypotypes, UNSM 4725, 4753, 4780, and 4786, Formosa Reef Limestone, Loc. 23635, collected by P.J. Roper; hypotype, GSC 60236, Formosa Reef Limestone, Loc. 23635; hypotype, GSC 60237, Bois Blanc Limestone or Detroit River Group, Loc. 97212; hypotype, GSC 60238, upper Dundee Limestone, Loc. III¹; hypotypes, GSC 60239, 60240, lower Dundee Limestone, Loc. III.

Habrostroma formosensis n. sp.

Plate 1, figures 4-6

Description. Coenosteam flat to gently undulating. Mamelons well-developed, 4 to 5 mm in diameter, 2 to 3 mm high, and spaced 7-9 mm apart centre to centre. Astrorhizae present but inconspicuous, radiating with branched canals from centres of mamelon columns. Latilaminae present but not well-defined; 0.5 to 2 mm thick. Peritheca apparently absent.

Vertical section: Tissue minutely cellular but not microreticulate, consisting of a network of clearly defined microlaminae and more diffuse pillars. Microlaminae undulose, very thin (0.01-0.02 mm), very closely spaced (median values of at least 23 microlaminae in 2 mm; Fig. 6B)

and consisting of a continuous central layer of dense dark material ("specks") covered by varying thicknesses of less dense, cellular clothing tissue. The abundance of clothing tissue increases in mamelon columns to almost completely fill the entire interlamellar space and obscure the microlaminae. Pillars typically spool-shaped, consisting of clothing tissue with borders poorly defined, 0.1-0.2 mm thick, spaced about 6 to 8 in 2 mm, and commonly superposed through 2 to 5 microlaminae. Galleries abundant, round to oval, 0.05-0.2 mm in maximum diameter, and commonly superposed to form poorly defined pseudozooidal tubes. Astrorhizal canals round to oval, large (about 0.20 mm in diameter), becoming abundant and conspicuous toward mamelon columns where they commonly appear as abnormally large, laterally elongate galleries. Dissepiments absent.

Tangential section: About 70 per cent of the area consists of diffuse, cellular, clothing tissue of the laminae and pillars. Microlaminae inconspicuous except near mamelon columns where they may form 1 or 2 complete rings around columns. Pillars appear as diffuse to well-defined isolated dots 0.1-0.2 mm in diameter or may be joined in short vermicular chains. Galleries generally appear as irregular, elongate open areas, or as small (0.05-0.1 mm), round openings in the lamellar tissue. Mamelon columns conspicuous, 2 to 5 mm in diameter, spaced about 7 to 9 mm apart centre-to-centre, and surrounded by numerous radiating straight, curved, and branching non-tabulate astrorhizal canals up to about 0.3 mm in diameter.

Remarks. This species differs from most other Detroit River species of *Habrostroma* by having very closely spaced microlaminae (Fig. 6B). The spacing of the mamelons is intermediate between *H. densilaminata* and *H. proxilaminata* (see Fagerstrom, 1961a, p. 8, 9). Astrorhizal canals appear to be less numerous in *H. formosensis* than in *H. densilaminata*.

Material and Occurrence. Holotype, GSC 60241, Formosa Reef Limestone, Loc. 23635; paratypes UMMP 36183, UNSM 4757, 4761, and 4777, Formosa Reef Limestone, Loc. 23635, collected by P.J. Roper; paratype, GSC 60242, Formosa Reef Limestone, Loc. 97215.

Habrostroma beachvillensis n. sp.

Plate 2, figures 5, 6

Description. Coenosteam flat and encrusting, gently undulose or large, subhemispherical masses up to about 30 cm in diameter. Mamelons well-developed, 4 to 6 mm in diameter, 2 to 3 mm high, and spaced 4 to 6 mm apart centre-to-centre. Astrorhizal systems poorly developed on surface; canals short, narrow. Latilaminae variably developed to absent, 1 to 4 mm thick. Peritheca apparently absent.

Vertical section: Tissue cellular to microreticulate, consisting of a network of microlaminae, laminae, and pillars; laminae more prominent than pillars, 3 to 9 in 2 mm, and 0.1 to 0.5 mm thick.

Pillars large (up to 0.25 mm in diameter), well-developed, about 6-11 in 2 mm, upwardly divergent in mamelon columns, and superposed through several laminae. Galleries small (0.1-0.15 mm), round to vertically elongate, with clearly defined borders, and typically superposed through several laminae. Mamelon columns prominent, may contain large (up to 0.25 mm), vertical astrorhizal canals extending for several mm along the axis and short, laterally elongate, narrower canals between the laminae. Laminae and microlaminae undulate steeply between mamelons and

¹Roman numerals for localities in the United States but not in the type region of the Detroit River Group (Fig. 31). (Roman numeral I has been omitted to avoid confusion with capital letter I.)

commonly lose their individual identity by amalgamation with pillars and abundant clothing tissue near axes of mamelon columns. Dissepiments absent.

Tangential section: About 90 per cent of the area consists of cellular tissue of laminae, pillars, and clearly defined, prominent mamelon columns 4 to 5 mm in diameter and spaced 4 to 5 mm apart centre-to-centre. Microlaminae indistinct to absent. Pillars locally isolated between mamelon columns, 0.1 to 0.25 mm in diameter, spaced 0.2 to 0.25 mm apart centre-to-centre or joined in short vermicular chains, or completely coalesced into a mass of very coarsely cellular tissue. Astorhizal canals very short, non-tabulate, confined to mamelon columns; axial canals 0.2 to 0.25 mm in diameter and commonly arranged as a ring of "holes" near margin of mamelon columns.

Remarks. Although microlaminae are clearly present in nearly every coenosteum of *Habrostroma beachvillensis*, they are not well enough preserved to warrant a biometrical study of their spacing as was done for the *H. densilaminata*-*H. proxilaminata*-*H. formosensis* "Species Group" (see above). In the coenosteum having the best preserved microlaminae (paratype GSC 60252) their spacing is most similar to *H. proxilaminata*. However, the relatively close spacing of the mamelons in *H. beachvillensis* is most similar to their spacing in *H. densilaminata*.

Material and Occurrence. Holotype, GSC 60243, approximately 5.5 m below top of lower Detroit River Group, Loc. 97210; paratypes, GSC 60244-60247, approximately 3.5, 5.5, 1.6 and 5.5 m respectively below top of lower Detroit River Group, Loc. 97210; paratypes, GSC 60248-60251, approximately 32.4, 32, 29.4 and 32.4 m respectively below top of Detroit River Group, Loc. 15114; paratypes, GSC 60252-60255, approximately 2, 2, 2.3 and 2.6 m respectively below top of lower Detroit River Group, Loc. 23566; hypotypes, GSC 60256, 60257 and 60261, lower Detroit River Group, Loc. 97211; hypotypes, GSC 60258-60260, upper Detroit River Group, Loc. V.

Habrostroma larocquei Galloway and St. Jean

Plate 2, figures 3, 4

Stromatopora larocquei Galloway and St. Jean, 1957, p. 171-173, pl. 13, fig. 3.

Ferestromatopora larocquei (Galloway and St. Jean). Galloway, 1957, pl. 36, fig. 4.

Clathrocoilon larocquei (Galloway and St. Jean). Stearn, 1966a, p. 111.

Stromatopora eumaculosa Galloway and St. Jean, 1957, p. 177-178, pl. 14, fig. 4.

Description. Coenosteum flat to gently undulating; up to at least 5 cm thick. Mamelons absent; surface papillate, papillae 0.1-0.25 mm in diameter. Astorhizae large (up to 17 mm in diameter), numerous and with prominent canals that may join ends of canals from adjacent astorhizal systems; generally without central vertical axial canal. Latilaminae 1-3 mm thick. Perithea variably developed; consisting of a layer of amalgamate tissue up to about 2 mm thick.

Vertical section: Tissue minutely cellular, consisting of a reticulate network of microlaminae, laminae, and pillars. Microlaminae undulant, very thin (0.015 to 0.02 mm), very closely spaced (about 25-40 in 2 mm), and consisting of either a dark or light central layer with variable thicknesses of

cellular clothing tissue. Laminae prominent, from 0.1 to 0.3 mm thick, gently and broadly undulant, spaced about 6 to 14 in 2 mm; each lamina composed of about 4 to 6 microlaminae. Pillars less prominent than laminae, flaring upward and broadly spreading along undersides of superjacent laminae, superposed through 2 to 5 laminae, and composed of cellular and darkly speckled dense tissue. Pillars spaced 0 to 8 in 2 mm and about 0.05 to .20 mm in minimum diameter. Galleries about 0.07 mm high and vary in width from 0.05 to over 2 mm; rarely superposed to form pseudozooidal tubes. Astorhizal canals round, abundant, and much larger than galleries (0.15 to 0.30 mm in diameter). Dissepiments absent.

Tangential section: About 75 per cent of the area, consists of diffuse, cellular tissue of the irregularly arranged laminae and pillars. Microlaminae inconspicuous. Pillars abundant and closely spaced between laminae, round to oval, 0.05 to 0.2 mm in minimum diameter, and not joined in vermicular chains. Astorhizae appear as short, irregularly arranged, non-tabulate, bent tubes 0.15 to 0.25 mm in maximum diameter.

Remarks. The diagenetic conversion of microlaminae to laminae (up to 6 microlaminae may fuse to form one lamina) can be clearly demonstrated among the coenostea of *H. larocquei*. Thus, the thickness and spacing of the microlaminae and/or laminae is highly dependent on the stage in this conversion reached in each thin-section. Furthermore, the density of clothing tissue may mask the internal structure of the laminae or make the laminar borders appear diffuse and gradational with the adjacent laminae.

The degree of superposition of the pillars is also variable and where particularly prominent they may resemble the megapillars of *Syringostroma* (Pl. 2, fig. 3; cf. Pl. 3, fig. 1). However, the superposed pillars of *H. larocquei* do not internally obliterate the microlaminae and laminae which pass through the superposed pillars with only minor change in their appearance and horizontal continuity. Nonetheless, the general similarity between the large superposed pillars of *H. larocquei* and true megapillars of *Syringostroma* lends additional support to the suggestion made under "Remarks" for the Genus *Habrostroma* that these genera are very closely related.

In their description of the holotype of *H. larocquei* Galloway and St. Jean (1957, p. 171-172) noted the presence of large, low, and widely spaced mamelons. Examination of thin-sections of the holotype indicates that regularly spaced mamelons are not present and that these irregularities of the surface are merely low undulations of variable sizes and shapes. Thus, the material here assigned to *H. larocquei* differs from all other Detroit River and Columbus species of *Habrostroma* in lacking mamelons.

Material and Occurrence. Holotype, USNM 127286, Columbus Limestone, Marblecliff Quarry near Columbus, Ohio, collected by A. Larocque; hypotype, USNM 127268, Jeffersonville Limestone, Falls of the Ohio River, Jeffersonville, Indiana, collected by J.W. Huddle; hypotype, GSC 60262, Detroit River Group, Loc. 76001; hypotype, GSC 60263, upper Columbus Limestone (Zone H), Loc. VII.

Genus *Syringostroma* Nicholson

Syringostroma Nicholson, 1875, p. 251; Nicholson, 1886, p. 97; Galloway, 1957, p. 449; Galloway and St. Jean, 1957, p. 186-188; Stearn, 1966a, p. 113-114; St. Jean, 1967, p. 426; Fischbuch, 1970b, p. 1078; Lecompte, 1951, p. 195 (partim); ? Kaźmierczak, 1971, p. 116; Zukalova, 1971, p. 70 (partim).

Stylodictyon Nicholson and Murie, 1878, p. 221-222; Nicholson, 1886, p. 79-80; Galloway, 1957, p. 449-450; Stearn, 1966a, p. 116.

Type species: **Syringostroma densa** (Nicholson, 1875, p. 251-252) by subsequent designation (Nicholson, 1886, p. 98).

Description. Coenostea of variable shapes and sizes from thin undulous crusts to large hemispherical, ellipsoidal, or cylindrical masses; surface papillate to mamillate, with or without mamelons. Tissue reticulate; composed of clearly defined, thin, persistent microlaminae and/or thicker, less well-defined laminae, thick, vertically continuous megapillars, and short, non-persistent pillars. Tissue microstructure cellular, microreticulate (in megapillars), or melanospheric. Astorhizae variably present. Dissepiments rare to absent.

Remarks. The term "megapillar" was first used by Fagerstrom and Saxena (1973) for the numerous, relatively thick, round to irregularly oval, vertically continuous rod-like structures unique to the Genus **Syringostroma**. In vertical sections megapillars appear as prominent, thick vertically continuous rods or columns generally several times as thick as microlaminae (Pl. 2, fig. 2) and two or three times as thick as laminae (Pl. 3, fig. 1). They are also much larger than the typically more numerous normal-sized pillars and differ from superposed pillars by having much more clearly defined borders, more uniform thickness, and they extend vertically through a much greater thickness of the coenosteum; many megapillars traverse nearly the entire thickness of the coenosteum and their upper ends mark the centers of the surficial papillae (Fagerstrom, 1962, Pl. 67, fig. 2). Within the megapillars are commonly found the largest cellules, dark specks, and the melanospheres of the coenosteum (Pl. 3, fig. 8). The arrangement of these cellules, specks and melanospheres is partly size dependent; the smallest are typically randomly arranged (Pl. 4, fig. 1) whereas the largest may show marked vertical alignment or water jet microstructure (Pl. 3, figs. 3, 8).

Many previous authors have described the megapillars of **Syringostroma** using such terms as "rods" (Grabau, 1910), "rod-like pillars" (Stearn, 1966a), "columns" or "pseudocolumns" (Nicholson and Murie, 1878; Nicholson, 1875; Fritz and Waines, 1956), "mamelon columns" (Galloway and Ehlers, 1960), mamillae (Birkhead and Fraunfelder, 1973), or merely as "large pillars" (Galloway, 1957; Fagerstrom, 1961a; St. Jean, 1967). Because each of these terms has been used for other stromatoporoid morphological features or is too general or cumbersome, the present author suggests that "megapillars" should be recognized as major features unique to **Syringostroma** in lieu of the above-noted synonymous terms.

The presence of microlaminae is another important characteristic of well-preserved coenostea of **Syringostroma**. Their spacing ranges from 4 to 40 in 2 mm in vertical section (Fig. 2) and they range in form from nearly flat between adjacent megapillars (Pl. 3, fig. 1), to slightly deflected at the megapillar margins (Pl. 4, fig. 2), to steeply drooped (Pl. 2, fig. 7). In species with drooped microlaminae between megapillars (e.g., **S. sherzeri**, **S. columnare**, **S. pustulosum**), the galleries adjacent to the megapillars appear in tangential sections in 1 to 2 rings or circles around the central megapillar (Pl. 2, fig. 8) whereas species with nearly flat microlaminae (e.g. **S. densum**, **S. nodulatum**, **S. probicrenulatum**) lack such rings of galleries and instead may have a single moat-like gallery encircling the entire megapillar (Pl. 3, fig. 7).

Among moderately well-preserved coenostea of some species of **Syringostroma** (e.g. **S. nodulatum**, **S. densum**) both microlaminae and laminae are present (Fig. 2). Furthermore, in such specimens it is generally possible to demonstrate that laminae result from the fusion of 2-5 microlaminae (Pl. 3, fig. 6). Thus, well-preserved coenostea of **Syringostroma** are characterized by the absence of laminae and poorly preserved coenostea by the absence of microlaminae. Even in well-preserved coenostea of **Syringostroma** it is rare for the microlaminae to maintain their individual identities in the central parts of the megapillars whereas in comparably preserved material of **Habrostroma** with superposed pillars the microlaminae generally pass through the pillars without deflection or loss of individual identity.

Comparisons. As noted above, the cellular-microreticulate-melanospheric microstructure of **Syringostroma** suggests that its closest relatives are **Stromatopora**, **Habrostroma** and **Parallelopora**. Comparison of **Stromatopora** (*sensu stricto*) and **Habrostroma** was made above in the "Remarks" for the latter genus and the comparison of **Syringostroma** to **Parallelopora** will be found below in the "Remarks" for the species **Syringostroma nodulatum**.

The chief differences between **Syringostroma** and **Habrostroma** are the presence of uniformly sized and spaced megapillars and the general orderly arrangement of the encircling gallery or galleries in **Syringostroma**. In well-preserved material these differences are readily apparent but in less well-preserved coenostea of **Habrostroma** the presence of superposed pillars enlarged by clothing cellular tissue that may also obscure some of the galleries, may make these distinctions difficult to determine. Furthermore, in some species of **Syringostroma** (e.g. **S. probicrenulatum**, **S. nodulatum**) the megapillars may be very small, poorly formed, or irregularly arranged and therefore easily overlooked. Finally, the superposition of pillars and the vertical alignment of cellules, dark specks, and melanospheres in the pillars of some vertical sections of **Habrostroma** may be suggestive of **Syringostroma**; careful study of tangential sections from the same coenostea will disprove the presence of true megapillars. Conversely, coenostea of **Syringostroma** having widely spaced and irregularly arranged megapillars (e.g. **S. probicrenulatum**) may appear in some vertical sections to lack megapillars and thus may be identical to **Habrostroma**; in such cases careful study of tangential sections is necessary to determine the presence of the megapillars.

In summary, the genera **Habrostroma** and **Syringostroma** are morphologically so similar that it is reasonable to assume they are also phylogenetically closely related. The somewhat simpler morphology of **Habrostroma** (no megapillars) suggests that it was ancestral to **Syringostroma** but this relation has not been proven as yet; the range-zones of both genera appear to begin in the Lower Devonian (Helderbergian) in North America.

Syringostroma differs from **Stromatopora** (*sensu stricto*, see "Remarks" for Genus **Habrostroma**) in having true megapillars and prominent, continuous microlaminae and/or laminae; **Stromatopora** lacks megapillars and the general structure of the tissue is amalgamate (neither the vertical nor the horizontal elements are easily distinguished; see Lecompte, 1952, pl. 54, fig. 1). Nicholson (1886, p. 2, 3) and Stearn (1966a, p. 110) emphasized the presence of pseudozoidal tubes accompanied by superposition of the adjacent pillars which imparts a marked vertical "grain" to some vertical sections of **Stromatopora** (Pl. 4, fig. 4) and makes the pillars appear more prominent and continuous than the microlaminae and/or laminae (Lecompte, 1952, pl. 54,

figs. 2, 3). Conversely migration of dark specks from the microlaminae and/or laminae into the adjacent galleries in horizontally arranged bands or zones during diagenesis may make the laminae appear more prominent than the pillars (Lecompte, 1952, pl. 53, figs. 2, 3).

Thus, vertical sections from coenostea of *Stromatopora* having strongly superposed pillars with abundant clothing tissue (Lecompte, 1952, pl. 52, figs. 1a, 2a and pl. 60, fig. 1) may closely resemble *Syringostroma*. However, tangential sections from the same coenostea (Lecompte, 1952, pl. 52, fig. 2b and pl. 60, fig. 1a) lack true megapillars with well-defined encircling galleries. In addition, the superposed pillars of *Stromatopora* are generally not as vertically continuous as the megapillars of *Syringostroma*.

Some of the difficulties previous workers have encountered in identifying the Genus *Syringostroma* may be more easily understood by review of the early history of species assignment to *Syringostroma*, its synonym *Stylodictyon* and to *Stromatopora* (*sensu lato*). In his original description of *Syringostroma*, Nicholson (1875) included two species, *S. densum* and *S. columnare*, and assigned his new species *S. nodulatum* to the genus *Stromatopora*. All three of these species are present in the Detroit River Group and/or Columbus Limestone, redescribed below, and assigned to *Syringostroma*.

Nicholson's original description of *Syringostroma* mentioned the presence of thickened and fused laminae and pillars but in subsequent discussion of the genus he emphasized the close spacing of the skeletal elements and the abundance and arrangement of the astrorhizae. In fact, his illustrations (Nicholson, 1875, pl. 24, figs. 2, 2a, 2b) of the species he later (Nicholson, 1886, p. 98) designated the type of *Syringostroma* unfortunately show no evidence of the thickened pillars (megapillars) now regarded as the chief features for identification of the genus.

It is readily apparent that Nicholson never regarded the thickened pillars (megapillars) as important for the identification of *Syringostroma* because in 1878 he and Murie established the genus *Stylodictyon* and in the original description and subsequent discussion repeatedly emphasized the importance of the vertical columns (megapillars). They designated *S. columnare* as the type species of *Stylodictyon*, thus removing this species from *Syringostroma* where it had been placed originally. It was not until 1891 (p. 325) that Nicholson formally recognized the very close similarity between *S. densum* and *S. nodulatum* when he finally placed the latter species in the genus *Syringostroma* and noted the presence of "strong radial pillars" (presumably megapillars).

The reasons for some of Nicholson's difficulties become apparent from the relationships between megapillar size and spacing among the various species of *Syringostroma* shown in Figs. 2 and 3. Thus, Nicholson's choice of *S. densum* as the type species of *Syringostroma* and *S. columnare* as the type of *Stylodictyon* nearly represent the extremes in megapillar size and spacing among the species present in the rocks from which his material was collected. The very conspicuous megapillars and encircling galleries of *S. columnare* (Fagerstrom, 1961a, Pl. 1, figs. 9, 12) stand in marked contrast to the very small and almost inconspicuous megapillars and galleries of *S. densum* and *S. nodulatum* (Pl. 3, figs. 1-5) which probably explains why Nicholson never recognized *Syringostroma* and *Stylodictyon* as synonyms nor placed sufficient emphasis on the presence of megapillars in his conception of *Syringostroma*. These uncertainties and inconsistencies on the part of Nicholson undoubtedly partly explain the difficulties subsequent workers (e.g. Lecompte, 1951; Kaźmierczak, 1971; Zúkalova, 1971; Girty, 1895) have encountered in assignment of species to this genus.

Species Assigned. The abundance and diversity of *Syringostroma* in the Detroit River Group and Columbus Limestone clearly establish these rocks as the acme zone for the genus in North America. Six (possibly eight) clearly distinguished species are described below and nine others were described by Galloway and St. Jean (1957) but have not been examined by the present author.

The author has examined the type specimens of the following other species and recognizes them as belonging to the Genus *Syringostroma*:

Coenostroma ristigouchense Spencer, 1884

Syringostroma baccatum Lecompte, 1951

Parallelopora bucheliensis Lecompte, 1951

Parallelopora dartingtonensis Lecompte, 1952

Parallelopora paucicaniculata Lecompte, 1952

Stromatopora pachytexta Lecompte, 1952

Syringostroma recticolumnae Fritz and Wainnes, 1956

Syringostroma crebricolumnae Fritz and Wainnes, 1956

Syringostroma distincticolumnae Fritz and Wainnes, 1956

Actinostroma parksi Fritz and Wainnes, 1956

Syringostroma aureorella Fritz and Wainnes, 1956

Stromatopora gallowayi Fritz and Wainnes, 1956

The author has not examined the type specimens of the following other species and subspecies but on the basis of published descriptions and illustrations believes they belong to *Syringostroma*:

Syringostroma astrorhizoides Birkhead, 1967

Syringostroma vesiculosum tenuilaminatum
Zúkalova, 1971

Species Rejected. The author has examined the type specimens of the following other species assigned to *Syringostroma* or *Stylodictyon* by previous workers, rejects them from these genera and assigns them to the genera indicated:

Stylodictyon robustum Fritz and Wainnes, 1956; a species of either *Stictostroma* or *Pseudoactinodictyon*.

Stylodictyon retiforme Nicholson and Murie, 1878; a species of *Anostylostroma*.

Syringostroma capitatum Lecompte, 1951; a species of either *Habrostroma* or *Stromatopora* (*sensu stricto*).

Syringostroma microfibrosum Lecompte, 1951; probably a species of *Habrostroma*.

Syringostroma microfibrosum mut. *latum*
Lecompte, 1951; probably a species of *Habrostroma*.

Syringostroma micropertusum Lecompte, 1951; probably a species of *Habrostroma*.

Syringostroma minutitextum Lecompte, 1951; probably a species of *Habrostroma*.

Syringostroma percaniculatum Lecompte, 1951; a species of *Habrostroma*.

Syringostroma vesiculosum Lecompte, 1951; probably a species of *Stromatopora* (*sensu stricto*; see Pl. 1, fig. 3 herein).

Syringostroma microporum Girty, 1897, p. 296, pl. 6, fig. 7; Parks, 1909, p. 19-20, pl. 17, figs. 3, 4; probably a species of *Habrostroma*.

The generic identification of all other species assigned to *Syringostroma* by previous authors (see Flügel and Flügel-Kahler, 1968, p. 577-578) is uncertain for one or more of the following reasons: (1) poor preservation of the type material, (2) poor illustrations, (3) unavailability of original descriptions to the present author, or (4) in the case of Yavorsky's numerous species, the inability of the present author to read or have translated the original descriptions.

Syringostroma columnare Nicholson

Syringostroma columnaris Nicholson, 1875, p. 253, pl. 24, figs. 1, la.

Styloctyon (*Syringostroma*) *columnare* (Nicholson). Nicholson and Murie, 1878, p. 221, 222, pl. 3, figs. 4-8.

Styloctyon columnare (Nicholson). Nicholson, 1886, pl. 7, figs. 7-11; *non* Parks, 1908, p. 29, pl. 12, figs. 1, 2 (see Galloway and St. Jean, 1957, p. 101, 102).

Syringostroma sherzeri (Grabau). Fagerstrom, 1961a (*partim*), pl. 1, figs. 9, 12; ? Birkhead and Fraunfelter, 1973, p. 1074, pl. 3, figs. 5, 6.

Emended description. Coenosteum large, flat to hemispherical; surface undulatory, ends of megapillars appear as low, rounded mamillae 1-1.5 mm in diameter and spaced 1.5 to 3 mm centre-to-centre; mamelons absent. Latilaminae 1.5 to 2 mm thick. Astorhizae uncertain; possibly well-developed. Peritheca unknown.

Vertical section. Skeleton composed of a reticulate network of microlaminae, megapillars and pillars; microstructure cellular. Microlaminae thin (approximately 0.025 mm), not notably joined to form continuous laminae; deeply drooped between megapillars where they are spaced 10 to 19 in 2 mm (mean = approximately 14) more closely spaced near ends and margins of megapillars; variably persistent through megapillars. Megapillars thick, straight, persistent through several microlaminae, with relatively uniform, parallel sides; composed of abundant relatively large, irregularly arranged cellules having poorly defined borders and dark specks in melanospheric to water jet microstructure. Pillars indistinct, composed of diffuse cellular tissue upwardly flared to spindle-shaped and commonly superposed in short divergent columns near megapillar margins. Galleries near megapillar margins also superposed to form short, upwardly divergent pseudozooidal tubes. Astorhizal canals round to oval, prominent between megapillars, 0.18 to 0.35 mm in minimum diameter (mean = approximately 0.27 mm). Dissepiments and mamelon columns absent.

Tangential section. Approximately 70 to 90 per cent of area consists of coarsely cellular tissue confluent among microlaminae, prominent megapillars, and poorly defined pillars; clothing tissue abundant. Megapillars abundant, 0.35 to 1.0 mm in diameter, subcircular, uniformly spaced 1.6 to 2.15 mm apart centre-to-centre, and typically enclosed by one or two microlaminae and one or two circlets of clearly

defined holes 0.15 to 0.2 mm in diameter marking locations of galleries and pseudozooidal tubes peripheral to megapillars. Other galleries irregular in size, shape, and distribution between megapillars. Megapillar tissue coarsely cellular; cellules 0.015 to 0.02 mm in diameter. Astorhizal canals variably developed from locally absent to large, non-tabulate tubes between megapillars.

Remarks. *Syringostroma columnare* most closely resembles *S. sherzeri* (?) but appears to differ significantly in the closer spacing of the microlaminae, the more distant spacing of the megapillars, and the greater number of galleries in the innermost ring enclosing the megapillars (see Figs. 2-5). The relatively large cellules in the megapillars are similar to those of *S. nodulata* but in nearly all other features these two species differ markedly. The cellules in *S. columnare* are neither so large nor are they arranged in vertical columns like the cellules of *Parallelopora ostiolata* Bargatsky (see Lecompte, 1952, pl. 51, fig. 3).

The specimen described as *Syringostroma sherzeri* by Birkhead and Fraunfelter (1973, p. 1074) appears to have megapillars intermediate in size and spacing between those of *S. sherzeri* (?) and *S. columnare*.

Material and Occurrence. Holotype, BM(NH) P6031, a moderately well-preserved coenosteum, upper Columbus Limestone, Zone H of Stauffer (1909), Sandusky, Ohio; hypotype, UMMP 36190, a very well-preserved coenosteum, Formosa Reef Limestone, Loc. 97215.

Syringostroma sherzeri (?) (Grabau)

Plate 2, figures 7-9

Styloctyon sherzeri Grabau, 1910, p. 92-94, pl. 8, figs. 4, 5.

Syringostroma recticolumnae Fritz and Waines, 1956, p. 109-111, pl. 3, figs. 2, 3, 5, 6; St. Jean, 1967, p. 427, pl. 3, figs. 4, 5.

Syringostroma sherzeri (Grabau). Galloway and Ehlers, 1960, p. 95-97, pl. 10, figs. 3, 4a, 4b; Fagerstrom, 1961a (*partim*), p. 10, *non* pl. 1, figs. 9, 12; Fagerstrom, 1962, p. 428 (*partim*), pl. 67, fig. 8, *non* pl. 65, figs. 9, 10, pl. 67, fig. 7; ? Birkhead and Fraunfelter, 1973, p. 1074, pl. 3, figs. 5, 6.

Revised Description. Coenosteum flat to hemispherical or ellipsoidal; large (up to 20 cm in diameter and 30 cm long). Ends of megapillars appear at surface as depressed pits or low, rounded mamillae 1 to 1.5 mm in diameter and spaced 1.5 to 3 mm centre-to-centre. Latilaminae prominent to obscure; up to 5 mm thick. Mamelons and peritheca absent. Astorhizae absent to poorly developed.

Vertical section. Skeleton composed of a reticulate network of microlaminae, laminae, megapillars, and pillars; microstructure cellular. Laminae composed of 2 to 5 dense, dark microlaminae generally with varying amounts of clothing tissue. Microlaminae thin (approximately 0.025 mm), deeply drooped between megapillars as if in festoons (except nearly straight where megapillars are widely spaced), and spaced 4 to 23 in 2 mm except near ends and margins of megapillars where spacing is closer; microlaminae typically not persistent through megapillars. Megapillars thick, straight, persistent through several laminae, with relatively uniform, parallel sides, and composed of moderately coarse cellular tissue, commonly in water jet microstructure. Pillars indistinct, composed of diffuse cellular tissue, spindle-shaped to parallel-sided,

approximately 0.1 to 0.3 mm thick, spaced 3 to 5 in 1 mm, and commonly superposed in upwardly divergent columns, especially near upper ends of megapillars. Galleries of two types: (a) large, laterally elongate galleries best developed around margins and ends of megapillars and commonly swept upward into long, non-tabulate pseudozooidal tubes bordering the megapillars, and (b) smaller (approximately 0.15 mm in diameter), more numerous, round to oval galleries. Astrorhizal canals conspicuous but not common, round to oval, and 0.4 to 0.6 mm in minimum diameter. Dissepiments and melon columns absent.

Tangential section. Approximately 60 to 80 per cent of area consists of blotchy, coarsely cellular tissue confluent among poorly defined laminae and pillars, very conspicuous megapillars, and abundant clothing tissue. Megapillars abundant, 0.3 to 1 mm in diameter, subcircular, uniformly spaced 0.8 to 1.9 mm apart centre-to-centre and typically enclosed by one or two microlaminae and one or two circlets of clearly defined holes 0.15 to 0.2 mm in diameter marking locations of upswept larger galleries and pseudozooidal tubes peripheral to megapillars. Smaller galleries irregular in size, shape, and distribution. Astrorhizal canals absent to rare, locally large, conspicuous, non-tabulate, and tending to wrap around megapillars.

Remarks. This species is the most abundant and widely distributed of all Detroit River species of the Genus *Syringostroma* and the quality of preservation of microstructure and the degree of infiltration of the galleries is generally good. The cellular microstructure is particularly well-developed in the megapillars of tangential sections. Because of the festoon arrangement of the microlaminae and the tendency for crowding and loss of microlaminae near the megapillars, measurements of microlaminar spacing were made approximately midway between adjacent megapillars where the microlaminae approach horizontality and mutual parallelism.

The chief criteria for the identification of *Syringostroma sherzeri* (?) are the deeply drooped microlaminae between relatively large and widely spaced megapillars and the relatively large, laterally elongate galleries that are commonly swept upward at the margins of the megapillars to form one or two circlets of holes surrounding the megapillars in tangential sections.

Syringostroma columnare Nicholson (1875; with various emendations in spelling, etc. noted above in synonymy for the species) is very similar to, if not conspecific with *Syringostroma sherzeri* (Grabau, 1910). The chief distinctions appear to be closer spacing of the microlaminae and the greater size and spacing of the megapillars in *S. columnare* (Figs. 2 to 5); however, the sample size is too small and variable to adequately assess the biometrical significance of these apparent differences (see chapter, present report titled "Species of the Genus *Syringostroma*", p. 4).

There seems to be little doubt that *S. sherzeri* (Grabau) and *S. recticolumnae* Fritz and Wainnes are synonymous. The chief difference may be in the generally closer spacing of microlaminae (approximately 18 in 2 mm) in *S. recticolumnae*; however, spacing this close is also present in a few specimens of *S. sherzeri* (e.g., UNSM 1687).

Syringostroma sherzeri (?) is also similar to *S. tuberosum* Galloway and St. Jean; both species have deeply drooped microlaminae and circlets of holes surrounding the megapillars. However, the microlaminae are more closely spaced and the megapillars are both larger (0.9 to 1.1 mm) and more closely spaced (0.2 to 0.4 mm) in *S. tuberosum* than in *S. sherzeri* (?). Similarly, *S. sherzeri* (?) and *S. superdensum*

Galloway and St. Jean bear strong resemblances with regard to the shape of the large galleries and the circlets of holes around the megapillars in tangential sections; however, the microlaminae in *S. sherzeri* (?) are more deeply drooped and the megapillars in *S. superdensum* are somewhat larger (0.6 mm) and more closely spaced (0.8-1.2 mm).

As noted above in the "Remarks" for *Syringostroma columnare*, the specimen described by Birkhead and Fraunfelter (1973) from the upper Grand Tower Limestone of Missouri appears to be intermediate between *S. sherzeri* (?) and *S. columnare* with regard to megapillar size and spacing. Unfortunately, Birkhead and Fraunfelter (1973, p. 1074) did not provide information on microlaminar spacing in their specimen for comparison with samples of *S. sherzeri* (?) and *S. columnare* described herein.

Material and Occurrence. Lectotype, UMMP 13093, selected by Galloway and Ehlers (1960, p. 97), probably from Amherstburg Dolomite, Loc. H, collected by W.H. Sherzer; paralectotypes, UMMP 13094, 13095 and 36083, probably from Amherstburg Dolomite, Loc. H, collected by W.H. Sherzer; hypotypes, UMMP 36191 and GSC 60264, Formosa Reef Limestone, Locs. 23635 and 97215 respectively; hypotypes, UNSM 1685 and 1687, 2.3 to 3.6 m below top of Anderdon Limestone, Loc. G; hypotype, GSC 60265, Anderdon Limestone, near crusher pit, Loc. K; hypotypes, GSC 60266 and 60267, 1 to 1.3 m below top of Anderdon Limestone, south end of Loc. K; hypotypes, GSC 60268-60271, Anderdon Limestone, south end of Loc. K. Hypotypes, GSC 60272-60275, 17.7, 18.3, and 28.6 m respectively below top of Detroit River Group; Loc. 15114. Hypotypes, GSC 60276-60279, 6.1, 5.2 and 2.3 m above and 1.9 m below respectively top of lower Detroit River Group; Loc. 23566. Hypotypes, GSC 60282-60290, 8, 6.8, 5.8, 5.2, 4.8, 4.5, and 4.5 m above and 1.6 and 3.9 m below respectively top of lower Detroit River Group; Loc. 97210. Hypotypes, GSC 60291-60297, Detroit River Group, 4.2, 8.1, 10.6, 10.6, 11, 12.9 and 12.9 m respectively above quarry floor, Loc. 76001; hypotype, UNSM 9627, Detroit River Group, upper bench, Loc. 76001; hypotypes, GSC 60298-60300, lower Detroit River Group, Loc. 97211; hypotypes, GSC 60301-60304, near top of Detroit River Group, Loc. 23651.

Syringostroma pustulosum (Grabau)

Plate 2, figures 1, 2

Stromatopora (*Coenostroma*) *pustulosum* Grabau, 1910, p. 91-92, pl. 9, figs. 3, 4; non *Stromatopora pustulosa* Safford, 1869, p. 285.

Syringostroma aurora Galloway and Ehlers, 1960, p. 92-93, pl. 10, figs. 1a, 1b; non Parks, 1904, p. 182-183, pl. 2, fig. 4, pl. 3, figs. 1, 2.

Syringostroma aureolla Galloway and Ehlers, 1960, p. 93-95, pl. 10, figs. 2a, 2b; non Fritz and Wainnes, 1956, p. 103-104, pl. 3, figs. 1, 4.

Syringostroma densum Fagerstrom, 1962, p. 427-428 (partim), pl. 67, figs. 3, 6, non pl. 67, figs. 1, 2, 4, 5.

Revised Description. Coenosteum large; flat, lamellar, tabular or nearly hemispherical. Surface smooth to undulant; may bear low, poorly defined and irregularly spaced melon-like elevations, or papillae (the ends of megapillars) commonly surrounded by open pseudozooidal tubes. Astrorhizae well-developed, 5 to 7 mm in diameter and spaced 4 to 6 mm apart, and radiating from papillae;

astrorhizal canals narrow and delicately branching. Papillae 0.3 to 0.5 mm in diameter and spaced 0.4 to 0.7 mm centre-to-centre. Latilaminae poorly developed, 1 to 2 mm thick. Perithecium and mamelons absent.

Vertical section. Skeleton composed of a reticulate network of laminae and pillars. Laminae composed of 1 to 5 dense, dark microlaminae generally with varying amounts of minutely cellular clothing tissue. Microlaminae thin (approximately 0.025 mm), subhorizontal except as they approach megapillar margins where they are swept upwards, appearing to be draped over ends of megapillars and rather uniformly spaced 10 to 20 in 2 mm except near megapillars where spacing is closer; microlaminae not persistent through megapillars. Megapillars thick, straight, persistent through several laminae, with uniform sub-parallel sides, and composed of moderately coarse cellular tissue, with specks in water jet microstructure. Pillars indistinct, composed of diffuse cellular tissue, spindle-shaped to parallel sided, approximately 0.05 to 0.2 mm thick, spaced 3 to 5 in 1 mm and may be superposed, especially those adjacent to megapillars. Galleries of two types: (a) large, laterally elongate galleries best developed around margins of megapillars and commonly swept upward into moderately short, tabulate pseudozooidal tubes bordering the megapillars, and (b) smaller (approximately 0.1 mm in diameter), more numerous, round to oval galleries. Astrorhizal canals moderately abundant, generally round, and approximately 0.5 mm in diameter. Dissepiments absent; mamelon columns absent to poorly developed.

Tangential section. Approximately 75 to 90 per cent of area consists of relatively dense, coarsely cellular tissue confluent among poorly defined laminae and moderately well-defined megapillars. Clothing tissue abundant, thick; individual microlaminae and pillars generally not recognizable. Megapillars moderately large, subcircular, rather uniformly spaced, and typically enclosed by one cirlet of moderately well-defined holes 0.05 to 0.15 mm in diameter marking locations of upswept larger galleries and pseudozooidal tubes peripheral to megapillars. Galleries obscure to well-defined; round to oval, 0.1 to 0.2 mm in diameter. Astrorhizal tubes and canals moderately abundant, up to 0.5 mm wide, may be sharply deflected where they meet megapillars, and subradially divergent from poorly defined, irregularly spaced mamelon columns.

Remarks. *Syringostroma pustulosum* appears to be endemic to the Detroit River Group and even in these rocks is neither as abundant nor as widely distributed as *S. sherzeri* (?). In addition, specimens of *S. pustulosum* are generally not as well-preserved as those of *S. sherzeri* (?), e.g., the microlaminae are more diffuse, clothing tissue is more abundant, the galleries contain more specks that have probably migrated from the adjacent primary tissue and in tangential sections of some coenostea the holes developed by upswept galleries surrounding the megapillars appear diffuse and confluent forming a continuous open circle (moat). Biometrical data (Fig. 2) are based on specimens with distinct microlaminae.

The chief distinguishing features of *S. pustulosum* are the relatively uniformly spaced, undulatory microlaminae and megapillars of moderate size and spacing. The galleries are not as strongly upswept at the megapillar margins as in *S. sherzeri* (?) but, nonetheless, there is commonly one ring of holes surrounding each megapillar in tangential sections of *S. pustulosum*.

There has been confusion among previous authors concerning the detailed morphology and nomenclatural status of *Stromatopora* (*Coenostroma*) *pustulosum* Grabau (1910).

Grabau's name was clearly a homonym of *Stromatopora pustulosa* Safford (now *Labechia pustulosa*) from the Ordovician of Tennessee. Grabau based his species on two specimens, both from the type section of the Anderdon Limestone. One of these specimens (UMMP 14057) has a moderately large surface with numerous, well-developed astrorhizae and low, irregularly placed undulations which resemble mamelons; Galloway and Ehlers (1960) placed this specimen in *Syringostroma aurella* Fritz and Waines. Grabau's other specimen (UMMP 14075) has a smaller and much more poorly preserved surface that apparently lacks both astrorhizae and mamelon-like undulations; Galloway and Ehlers (1960) placed this specimen in *Syringostroma aurora* Parks.

On the basis of detailed study of both the external and internal features of Grabau's type material, other topotypes, and numerous coenostea from several other outcrop areas in southwestern Ontario, the present author has concluded that coenosteal shape and surface morphology are extremely variable and therefore are less useful taxonomic criteria than internal features for the identification of *Syringostroma pustulosum*. Poorly formed, low, irregularly spaced mamelon-like undulations are present in some specimens and others have mamillae; however, the majority of coenostea lack both mamelons and mamillae or else the surface is too poorly preserved to be certain of the presence or absence of these features. Astrorhizae in varying degrees of development appear to be present in every specimen except UMMP 14075, Galloway and Ehlers (1960) syntype of *Syringostroma aurora*. Because the present author prefers the large sample, population approach to taxonomy at the species level and because of the rather poor preservation of UMMP 14075, this specimen is here regarded as merely an uncommon variant of *Syringostroma pustulosum*.

In contrast to the relatively great variation in external morphology, there is a surprising uniformity in the size and arrangement of the microlaminae and megapillars of *S. pustulosum* (Figs. 2 to 5) which may be used to distinguish *S. pustulosum* from other similar species. Thus, on the basis of these simple measurements it is readily apparent that *S. pustulosum* (Grabau) 1910 (= *Syringostroma aurora* and *S. aurella* of Galloway and Ehlers, 1960 and the present report) constitutes a biometrically similar assemblage of specimens. Furthermore, *S. pustulosum* is in turn distinctly different from both *Syringostroma aurora* Parks (1904) and *S. aurella* Fritz and Waines (1956) by virtue of its less closely spaced laminae and megapillars, and larger megapillars.

In comparison to the other species of *Syringostroma* in the Detroit River Group, *S. pustulosum* most closely resembles *S. cylindricum* (Fig. 2). The chief differences are the absence of cylindrical to elliptical coenostea with unlaminated and unpillared axial regions in *S. pustulosum*. In addition, *S. cylindricum* lacks the mamelon-like surface undulations present in some coenostea of *S. pustulosum*.

Material and Occurrence. Syntypes, UMMP 14057 and 14075, Anderdon Limestone, Loc. K, collected by W.H. Sherzer or A.W. Grabau; hypotypes, UNSM 1676 and 1683, approximately 2.9 m below top of Anderdon Limestone, Loc. G; hypotypes, GSC 60305 and 60306, Lucas or Amherstburg Dolomite, Loc. I; hypotypes, GSC 60307 and 60308, approximately 1 to 2.3 m below top of Anderdon Limestone, north end of Loc. K; hypotypes, GSC 60309-60312, 60335-60337, Anderdon Limestone, near crusher pit in floor of Loc. K; hypotypes, GSC 60313-60317, lowest 1 m of Anderdon Limestone, Loc. 76000; hypotype, GSC 60318, 1 m below top of lower Detroit River Group, Loc. 23566. Hypotypes, GSC 60319-60325, 4.2, 3.9, 2.3, 2.3, 1.6, 1.6 and 1.3 m

respectively below top of lower Detroit River Group; Loc. 97210. Hypotypes, GSC 60326-60328; all three specimens 4.9 m above top of lower Detroit River Group; Loc. 97210. Hypotypes, GSC 60329-60331; the lower bench, 3.2 m above quarry floor, and upper bench respectively, Detroit River Group; Loc. 76001. Hypotype, GSC 60332, lower Detroit River Group, Loc. 97211; hypotypes, GSC 60333 and 60334, top 0.3 m of Detroit River Group, Loc. 23651.

Syringostroma cylindricum Fagerstrom

Plate 4, figure 1

Syringostroma cylindricum Fagerstrom, 1961a, p. 10-11, pl. 2, figs. 10-14.

Syringostroma sherzeri (Grabau). Fagerstrom, 1962, p. 428 (partim), pl. 65, figs. 9, 10, pl. 67, fig. 7, non pl. 67, fig. 8.

Revised Description. Coenosteum uniformly subcylindrical to irregularly elongate; up to 7 cm in maximum diameter. Ends of megapillars appear at surface as low, rounded mamillae 1 to 1.3 mm in diameter and spaced 1.2 to 1.6 mm apart centre-to-centre. Mamelons absent. Latilaminae and astrorhizae absent to obscure.

Vertical section. Tissue structure sharply divisible into two regions: (a) axial region composed of dense, coarsely cellular, amalgamate tissue (no laminae or pillars) with irregular to elongate galleries and short vermicular tubes resembling astrorhizae, and (b) peripheral region composed of minutely cellular tissue arranged in a more open reticulate network of encircling laminae and pillars. During astogeny adjacent parallel coenostea (each with separate axial amalgamate regions and encircling laminae) may later become enveloped by a succession of common laminae to conceal their original separate arrangement. Laminae composed of 1 to 4 dense, dark microlaminae generally with varying amounts of clothing tissue. Within the peripheral region there is a progressive increase in the closeness of microlaminar spacing from approximately 4 in 2 mm adjacent to the axial region to as many as 28 in 2 mm near the coenosteal surface. Microlaminae thin (approximately 0.035 mm), concentric around coenosteal axis except as they approach megapillar margins where they may be swept upward as if draped over ends of megapillars; persistence of microlaminae through megapillars variable. Megapillars thick, straight, peripherally divergent from coenosteal axis, persistent through several laminae, of variable diameter, and composed of moderately coarse cellular tissue, commonly in water jet microstructure. Pillars variably distinct, composed of diffuse cellular tissue, spindle-shaped to parallel-sided, 0.05 to 0.3 mm in diameter, spaced 3 to 5 in 1 mm, and commonly superposed through 2 or 3 laminae. Galleries of two types: (a) large, laterally elongate galleries best developed around margins of megapillars and commonly swept upward into short, tabulate pseudozooidal tubes bordering the megapillars, and (b) smaller (approximately 0.1 mm in diameter), more numerous, round to oval galleries. Astrorhizal canals uncommon, approximately 0.2 to 0.3 mm in diameter. Dissepiments and mamelon columns absent.

Tangential section. Approximately 70 to 90 per cent of area consists of cellular tissue confluent among poorly defined laminae and pillars, conspicuous megapillars, and abundant clothing tissue. Megapillars abundant, large, subcircular, irregularly spaced due partly to curvature of coenosteal surface, and typically encircled by 1 to 2 microlaminae and 1 to 2 circlets of variably defined galleries 0.1 to 0.15 mm in diameter; 4 to 8 galleries in innermost circlet formed by upswept larger galleries and

pseudozooidal tubes peripheral to megapillars. Smaller galleries variably distinct; irregular in size, shape, and distribution. Astrorhizal canals locally large and conspicuous. Cellular structure well-developed in megapillars.

Remarks. Specimens of this species in the Detroit River Group tend to be very poorly preserved; the chief exceptions are the materials from the Formosa Reef and type Anderdon Limestones. The taxonomic value of the biometrical data presented in Fig. 2 is uncertain and difficult to compare with other species of *Syringostroma* for three main reasons:

1. The peripheral divergence of the megapillars makes measurements of megapillar spacing highly variable and dependent upon the location of the tangential section with respect to the curved surface of the coenosteum. Therefore, because of this variation and their spurious taxonomic value, data on megapillar spacing have been omitted from Fig. 2d.
2. Microlaminae are much more crowded near the surface of the coenosteum than toward the axis.
3. Most measurements of megapillar diameter were made from vertical sections which are less reliable than measurements from tangential sections.

Because of the lack of complete coenostea of *S. cylindricum* the mode of growth with respect to the substrate is uncertain. However, the fact that individual microlaminae completely encircle the axial region makes it highly probable that the coenosteal axis was perpendicular to the substrate during life. The initial phase of astogeny resulted in formation of the poorly organized, amalgamate tissue of the axial region. Subsequently, microlaminae were added as concentric layers around the sides and the upper end of the coenosteum; interpretation of the differences in the nature and location of the living tissues responsible for secretion of the axial and marginal parts of the coenosteum must await collection of more nearly complete coenostea than are presently available.

In many respects the phylogenetic affinities of *S. cylindricum* are an enigma. So far as microlaminar spacing is concerned, *S. cylindricum* is very similar to both *S. densum* and *S. probicrenulatum* (Fig. 2A) but with respect to megapillar diameter *S. cylindricum* is most similar to *S. pustulosum*, *S. ambiguum* and *S. probicrenulatum* (Fig. 2C). However, the subcylindrical to subelliptical shape of the coenosteum and the amalgamate tissue in the axial region clearly distinguishes *S. cylindricum* from all other species of *Syringostroma* in the Detroit River Group and adjacent rocks.

Material and Occurrence. Holotype, UMMP 36210, Formosa Reef Limestone, Loc. 97214; paratype, UMMP 36211, Formosa Reef Limestone, Loc. 23635; hypotypes, UNSM 1684 and 1686, approximately 1 to 2.3 m below top of Anderdon Limestone, Loc. G; hypotypes, GSC 60338 and 60339, approximately 1 and 1.6 m respectively above base of Anderdon Limestone, Loc. 76000. Hypotypes, GSC 60340-60343; 31, 21.7, 21.4 and 21 m respectively below top of Detroit River Group, Loc. 15114. Hypotype, GSC 60344, top of lower Detroit River Group, Loc. 23566. Hypotypes, GSC 60345-60347; 1.6 m below and 4.2 and 4.9 m respectively above top of lower Detroit River Group; Loc. 97210. Hypotype, GSC 60348; Detroit River Group; upper bench, Loc. 76001. Hypotypes, GSC 60349-60361, lower Detroit River Group, Loc. 97211; hypotypes, GSC 60362-60377, Detroit River Group, Loc. 15111; hypotypes, GSC 60378 and 60379, Detroit River Group?, Loc. IV.

Syringostroma densum Nicholson

Plate 3, figures 4, 5

Syringostroma densa Nicholson, 1875, p. 251-252, pl. 24, fig. 2.

Syringostroma densum Nicholson, 1886, pl. 11, figs. 13, 14; Nicholson, 1891, p. 326-327, pl. 10, figs. 8, 9; Galloway and St. Jean, 1957, p. 188-190, pl. 16, figs. 3a, 3b; Fagerstrom, 1962, p. 427-428 (partim), pl. 67, fig. 4 (non) pl. 67, figs. 1-3, 5, 6; non Fritz and Waines, 1956, p. 110-111.

Syringostroma sanduskyense Galloway and St. Jean, 1957, p. 190-192, pl. 16, figs. 4a, 4b.

Description. Coenosteal shape ranges from lamellar crusts or sheets up to about 5 cm thick to hemispheroids up to about 10 cm in diameter. Surface irregularly undulant to knobby, lacking mamelons but covered with papillae 0.2 to 0.3 mm in diameter and spaced 0.3 to 0.4 mm apart centre-to-centre. Astrorhizae of variable prominence, up to about 12 mm in diameter, spaced 5 to 10 mm apart centre-to-centre, and with canals about 0.2 to 0.3 mm in diameter, the ends of which typically fail to interfinger with those of adjacent astrorhizal systems. Latilaminae commonly present as alternating light and dark bands 1 to 4 mm thick. Peritheca, if present, thin and composed of poorly organized, amalgamate tissue.

Vertical section. Skeleton composed of a reticulate network of laminae and pillars. Laminae 0.1 to 0.4 mm thick, composed of 1 to 3 dense, dark microlaminae, and with varying amounts of minutely cellular clothing tissue. Microlaminae thin (approximately 0.03 mm), subhorizontal and subparallel, rising gently at megapillar margins, not persistent through megapillars, commonly thickened on lower surface by clothing tissue, and relatively uniformly spaced 9 to 22 in 2 mm. Megapillars abundant, thick, straight, persistent through several laminae, with relatively uniform, parallel sides, and composed of moderately coarse cellular tissue, commonly in water jet microstructure. Pillars indistinct, composed of moderately dense cellular tissue, strongly flaring upward, not prominently superposed, and spaced 4 to 6 in 2 mm. Galleries prominent, laterally elongate, may span entire space between adjacent megapillars and not superposed to form pseudozooidal tubes. Astrorhizal canals round to oval, 0.15 to 0.25 mm in diameter. Dissepiments and mamelon columns absent.

Tangential section. Approximately 70 to 80 per cent of area consists of abundant, minutely cellular clothing tissue, poorly defined laminae, and pillars, and moderately prominent megapillars. Megapillars abundant, relatively small, subcircular, rather uniformly and closely spaced, composed of moderately coarse cellular tissue, and generally encircled by a single continuous gallery so that each megapillar appears to stand free of adjacent laminae and pillars; some megapillars enclosed by a cirlet of 5 to 7 small, poorly defined holes marking locations of upswept galleries peripheral to megapillars. Galleries irregular in size, shape, and distribution. Astrorhizal canals prominent, non-tabulate.

Remarks. Specimens of this species are typically among the most poorly preserved of those belonging to the Genus **Syringostroma** in the Detroit River Group and overlying rocks. Except for the material from the Sibley Quarry (Locality G), the microlaminae are almost completely destroyed, the cellular tissue is diffuse, and the laminae relatively widely spaced. However, post-mortem alteration

apparently has not affected the diameter and spacing of the megapillars. Thus, the chief criteria for identification of this species are: (1) the relatively small size and close spacing of the megapillars, (2) the subhorizontal and subparallel arrangement of the microlaminae, (3) the general lack of a cirlet of discrete galleries surrounding the megapillars in tangential sections, and (4) the absence of mamelons.

The megapillars in the topotype specimen illustrated by Galloway and St. Jean (1957, pl. 16, fig. 3a, 3b) appear to be somewhat more widely spaced than the Detroit River material but otherwise this specimen is biometrically similar. Fritz and Waines (1956, p. 110-111) presented biometrical data for a specimen they identified as **S. densum**; however, it is unlikely that this identification is correct due to the presence of mamelons and much wider spacing of the megapillars in their material than in either Nicholson's types or in the Detroit River specimens. Galloway and St. Jean (1957, p. 190-192) described a single coenosteum as **S. sanduskyense** that is biometrically very similar to the type material of **S. densum** and to the material from the Detroit River Group (see Fig. 2 and Pl. 3, fig. 6).

Material and Occurrence. Holotype, BM(NH) P5598 (includes 8 thin-sections numbered 311, 311a-g), either Columbus Limestone or Detroit River Group, Kelley's Island, Ohio, probably collected by H.A. Nicholson; hypotype, GSC 60381, either Amherstburg or Lucas Dolomite, Loc. I; hypotypes, UNSM 1675, 1677-1681, and GSC 60382, approximately 2.3 to 3.6 m below top of Anderdon Limestone, Loc. G; hypotypes, GSC 60383-60387, Anderdon Limestone, south end of Loc. K; hypotypes, GSC 60388-60390, Anderdon Limestone, near crusher pit, Loc. K; hypotypes, GSC 60391 and 60392, Anderdon Limestone, Loc. K; hypotypes, GSC 60393-60395, upper 1 m of Anderdon Limestone, Loc. K; hypotypes, GSC 60396-60398, lowest 1.6 m of Anderdon Limestone, Loc. 76000; hypotype, GSC 60399, 21.7 m below top of Detroit River Group, Loc. 15114. Hypotypes, GSC 60400-60402; 1 m below and 0.3 and 1.9 m respectively above the top of the lower Detroit River Group, Loc. 23566. Hypotype, GSC 60403, 1.6 m below top of lower Detroit River Group, Loc. 97210. Hypotypes, GSC 60404-60409; 3.2, 6.5, 6.5, 8.1 and 12.9 m above quarry floor and from upper bench; Detroit River Group; Loc. 76001. Hypotype, USNM 127282 and Ohio State University Museum 2211, Columbus (?) Limestone, near Sandusky, Ohio, collector unknown (the holotype of **Syringostroma sanduskyense** Galloway and St. Jean, 1957, p. 190-192).

Syringostroma nodulatum (Nicholson)

Plate 3, figures 1-3

Stromatopora nodulatum Nicholson, 1875, p. 249-251, pl. 24, figs. 3, 3a, 3b.

Syringostroma nodulatum (Nicholson). Nicholson, 1891, p. 325-326, pl. 10, figs. 5-7; Stearn, 1966a, p. 115.

Parallelopora nodulata (Nicholson). Galloway and St. Jean, 1957, p. 212-214, pl. 20, figs. 2a, 2b; Galloway, 1957, pl. 31, fig. 16; St. Jean, 1967, p. 429, pl. 4, fig. 8, pl. 5, fig. 1.

Emended Description. Coenosteum very large, lamellar to hemispherical; mamelons well-developed, about 3 mm high, 7 to 9 mm in diameter at base, and spaced 10 to 12 mm apart centre-to-centre with prominent astrorhizal canal systems radiating from summits. Latilaminae 1-2 mm thick and undulating between mamelons. Peritheca unknown.

Vertical section. Skeleton consists of a reticulate network of microlaminae, laminae, megapillars, and pillars; microstructure cellular. Microlaminae poorly developed, thin (approximately 0.025 mm), about 14 to 16 in 2 mm, undulating into prominent mamelon columns, and fused by abundant clothing tissue into thicker, prominent laminae spaced about 5 to 9 in 2 mm. Neither microlaminae nor laminae droop between megapillars nor can they be distinguished within the megapillars. Megapillars small, abundant, closely spaced, tending to replace pillars, and with larger than normal cellules (0.02-0.04 mm in diameter, Pl. 3, fig. 2) and dark specks aligned in vertical water jet microstructure (Pl. 3, fig. 3). Galleries round, oval, or laterally elongate (where undivided by megapillars or pillars), 0.15 to 0.25 mm in minimum diameter and up to 1 mm long. Astorhizal canals of about same size and shape as galleries. Pillars small, rare, poorly formed. Dissepiments rare to absent.

Tangential section. About 80 to 90 per cent of area consists of coarsely cellular tissue. Laminae and microlaminae enclose or partially enclose large, well-formed mamelon columns spaced about 8 to 14 mm apart centre-to-centre (mean spacing = 10.5 mm; N = 14). Megapillars very small and closely spaced (Figs. 2, 3 and 5), containing both large (up to 0.035 mm) and normal sized (approximately 0.005 mm) cellules in random arrangement, and lacking regularly arranged, small encircling galleries. Pillars small, rare, poorly formed, round to oval and joined to megapillars and other pillars in short vermicular chains by microlaminae and clothing tissue. Astorhizal canals mostly non-tabulate; short (confined to centres of mamelon columns), vermicular to Y-shaped and about 0.15 to 0.25 mm in diameter.

Remarks. Although coenostea of *S. nodulatum* are abundant and well-preserved in the rocks of the Upper Detroit River Group and the Columbus Limestone they appear to be confined to the areas of north-central Ohio and Ingersoll, Ontario (the other occurrences reported by Flügel and Flügel-Kahler, 1968, p. 284-285 cannot be confirmed).

The presence of large, prominent, and regularly arranged mamelons distinguishes this species from all other species of *Syringostroma* in the Detroit River Group and Columbus Limestone except for *S. probicrenulatum* (see Table 1). In addition, *S. nodulatum* has the smallest and most closely spaced megapillars (Fig. 5) of all North American species; in fact, one of the diagnostic features of *S. nodulatum* is the nearly complete replacement of the normal pillars by megapillars.

Galloway and St. Jean (1957, p. 212-214) assigned this species to the genus *Parallelopora*, apparently without examining Bargatzky's holotype of the type species, *P. ostiolata*. Examination and comparison of the holotypes of the type species of both *Syringostroma* and *Parallelopora* by the present author as well as many coenostea of *S. nodulatum* confirms that this species is indeed a species of *Syringostroma* as noted by Stearn (1966a, p. 115). Contrary to Stearn's assertion that the cellular microstructure of *S. nodulatum* is not as coarse as in *Parallelopora*, statistical comparison of mean cellule diameters in both vertical and tangential sections of the holotypes of *S. nodulatum* and *P. ostiolata* indicates that they are not significantly different at the 0.95 level (Table 3).

Thus, in the opinion of the present writer and based on his observations of the holotypes of the type species of both *Syringostroma* and *Parallelopora*, the chief difference between these genera is the presence of true megapillars in *Syringostroma* and their absence in *Parallelopora* as well as the remarkably prominent vertical alignment of the larger than average cellules in *Parallelopora*. Stearn (1966a,

TABLE 3

Statistics for cellule diameter based on holotype specimens of *Syringostroma nodulatum* and *Parallelopora ostiolata* and values of F and Student's-t calculated from these statistics

	N	OR	\bar{X}	s	F	t
Measured in vertical sections						
<i>S. nodulatum</i>	9	0.02-0.04	0.029	0.0068	1.87	1.53
<i>P. ostiolata</i>	8	0.02-0.04	0.035	0.0093		
Measured in tangential sections						
<i>S. nodulatum</i>	6	0.02-0.36	0.0317	0.0060	1.72	2.01
<i>P. ostiolata</i>	7	0.03-0.05	0.039	0.0069		

GSC

N = No. of measurements
 \bar{X} = Mean (in mm)

OR = Observed Range (in mm)
 s = Standard deviation (in mm)

p. 118-120, pl. 19, fig. 9) has noted and illustrated vertical structures in *Parallelopora* that are similar to megapillars. In vertical sections of the holotype of *P. ostiolata*, the close spacing and vertical alignment of cellules and dark specks (see Lecompte, 1952, pl. 51, figs. 3a, 3b) is particularly suggestive of megapillars but careful examination of tangential sections clearly indicates that true megapillars (as described above in the "Remarks" for the genus *Syringostroma*) are not present (see Stearn, 1966a, pl. 19, figs. 3, 8 and Lecompte, 1952, pl. 51, fig. 3c).

The taxonomic significance of the enlarged cellules and melanospheres in the holotype of *P. ostiolata* and to a lesser degree in the holotype of *S. nodulatum* is uncertain but it may be the result of diagenetic alteration as described by Stearn (1966a, p. 82-83). If the absence of megapillars and the strong vertical alignment of large cellules and dark specks are regarded as important diagnostic features of *Parallelopora*, then the present author knows of no specimens of this genus in eastern North America.

Material and Occurrence. Holotype BM(NH) P5604, Detroit River Group or upper Columbus Limestone, Kelley's Island, Ohio; hypotypes, GSC 60410 and 60411, 2.6 and 5.2 m respectively above base of Columbus Limestone, Loc. 15114; hypotypes, GSC 60412-60418, Columbus Limestone, Loc. 15114; hypotype, GSC 60419, probably Detroit River Group, Loc. V.

Syringostroma ambiguum Fagerstrom

Syringostroma ambiguum Fagerstrom, 1961a, p. 11, pl. 1, figs. 13-15.

Remarks. The original description of this species is adequate but is here supplemented by the biometrical data in Figs. 2, 3 and 5. The holotype is not well enough preserved to determine the number of discrete galleries formed by upswept galleries marginal to the megapillars.

This species has the closest spacing of microlaminae of all species of *Syringostroma* known to the author and is further characterized by extremely abundant and conspicuous astorhizal canals.

Material and Occurrence. Holotype, UMMP 36212, Formosa Reef Limestone, Loc. 23635.

Syringostroma probicrenulatum Fagerstrom

Plate 4, figures 2-3

Syringostroma probicrenulatum Fagerstrom, 1961a, p. 9-10, pl. 1, figs. 1-3.

Remarks. The original description of this species is adequate but is here supplemented by the biometrical data in Figs. 2, 3 and 5. The available specimens are all well-preserved.

Syringostroma probicrenulatum is apparently rare but is extremely important in the study of the evolution of *Syringostroma* because it shows the incipient development of megapillars, the most diagnostic morphological feature for identification of the genus. In *S. probicrenulatum* the megapillars are poorly formed, irregularly spaced, short, and commonly not perpendicular to the microlaminae in contrast to the long, straight, and uniformly spaced megapillars so typical of other species in the genus.

The biometrical data in Fig. 3 indicate a remarkably high level of variation among the coenostea assigned to this species due to the incipient development of the megapillars; therefore, both the size and spacing of the megapillars are of questionable value in comparing *S. probicrenulatum* with other species of *Syringostroma*. The identification of *S. probicrenulatum* is based largely on qualitative rather than quantitative features.

Material and Occurrence. Holotype, UMMP 36187, paratypes UMMP 36188 and 36189, collected by J.A. Fagerstrom and hypotypes UNSM 4723, 4751, 4762, and 4772, collected by P.J. Roper, Formosa Reef Limestone (all specimens from Loc. 23635 except UMMP 36187 which is from Loc. 97216); hypotype, GSC 60380, Formosa Reef Limestone, Loc. 97215.

Group II: Genera Having Compact, Transversely Porous/ Transversely Fibrous Microstructure

Anostylostroma-*Pseudoactinodictyon* "Genus Group"

Remarks. The Detroit River Group and adjacent rocks contain a very large number of highly variable coenostea, some of which are typical of species of the Genus *Anostylostroma*, others are typical of the Genus *Pseudoactinodictyon*, and still others are intermediate between these two genera. The following unorthodox taxonomic treatment of these very similar and presumably closely related forms was adopted to emphasize the difficulties encountered in attempting to subdivide what appears to be a taxonomic (genetic?) continuum.

The similarities and differences between *Anostylostroma* and *Pseudoactinodictyon* are commonly subtle matters of degree rather than kind. Thus, in both genera the tissue may be compact, flocculent, or transversely fibrous or porous (Pl. 5, fig. 3) and in well-preserved material consists of a single dark, dense layer (Pl. 5, fig. 8); pillars and dissepiments are present in varying numbers and sizes, and mamelons and astrorhizae are variably developed or absent.

The chief differences between these genera are indicated in Table 4. The abundance of dissepiments in species of *Anostylostroma* is highly variable and partly dependent on the state of organization of the laminae and pillars as well as the quality of preservation. Thus, in poorly preserved coenostea or those having abundant repair tissue and poorly developed mamelons, the dissepiments may become almost identical to those in *Pseudoactinodictyon*. Even within a single vertical section there may be areas with dissepiments typical of *Anostylostroma* that grade laterally to areas more typical of *Pseudoactinodictyon* (Pl. 5, fig. 1). This problem is made even more complex by the fact that during the diagenesis of coenostea of *Pseudoactinodictyon* there is a tendency for selective loss of laminae and pillars to precede the loss of dissepiments leaving areas of abundant clothing tissue in which only dissepiments can be recognized;

TABLE 4

Major morphologic differences between the genera *Anostylostroma* and *Pseudoactinodictyon* observed among coenostea from the Detroit River Group and described by Flugel (1958) and Stearn (1966a, b)

Anostylostroma

1. Dissepiments variably developed but generally common; may overlap; generally do not replace laminae.
2. Laminae prominent, continuous; microstructure porous, fibrous.
3. Pillars flare upward, spread laterally along underside of superjacent lamina (like *Pseudoactinodictyon*); locally Y-shaped to arborescent; generally not superposed nor replaced by dissepiments; "ring-pillars" rarely present (like *Stromatoporella*) in tangential section.

Pseudoactinodictyon

1. Dissepiments generally abundant; may replace laminae; generally overlapping, arranged in irregular vertical stacks; closely crowded.
2. Laminae variably prominent; locally absent to continuous; generally not porous but may be fibrous; may contain foramina.
3. Pillars generally rod-like; may be replaced by dissepiments; generally thickened and superposed in mamelon columns; divide at top and spread along underside of laminae (like *Anostylostroma*); "ring-pillars" rarely present (like *Stromatoporella*) in tangential section.

GSC

such coenostea are strongly reminiscent of the Ordovician-Silurian Genus *Pseudolabechia* Yabe and Sugiyama as interpreted by Galloway (1957, p. 429-430).

Conversely, diagenesis commonly appears to enhance recognition of the very typical porous and/or fibrous microstructure of the laminae and pillars in *Anostylostroma*. However, in cases of extreme alteration the pores and fibers may disappear in an ill-defined mass of clothing tissue that may completely fill the galleries (Fagerstrom, 1962, pl. 65, figs. 1-8).

Previous authors have tended to overemphasize the importance of Y-shaped pillars in vertical sections of *Anostylostroma*. It is true that pillars of this shape may be present (Pl. 5, fig. 3) but in the author's experience they are quite rare (Pl. 5, figs. 6, 8) and may even be absent in many sections. Superposition of pillars through more than 2 or 3 laminae is uncommon in both *Anostylostroma* and *Pseudoactinodictyon* except in coenostea having unusually closely spaced pillars and laminae or in the axial parts of well-developed mamelon columns (Pl. 5, fig. 8; Pl. 6, fig. 1).

Tangential sections fortuitously cut through upwardly branching (funnel or Y-shaped) pillars in *Anostylostroma* may appear to rarely contain ring-pillars (Pl. 5, fig. 5). Similarly, tangential sections cut through dissepiments in both *Anostylostroma* and *Pseudoactinodictyon* may also appear to have ring-pillars (see Pl. 6, fig. 2). However, true ring-pillars (characteristic of the genus *Stromatoporella*) formed by major deflections of the laminae to produce hollow cylinders between adjacent laminae are not present in either *Anostylostroma* or *Pseudoactinodictyon*.

The initial attempt to subdivide the *Anostylostroma*-*Pseudoactinodictyon* "Genus Group" consisted of subjectively establishing "pure" end-members, i.e. a group of coenostea clearly conforming to the concept of the Genus *Anostylostroma* as described by previous authors and using the criteria of Table 4, and another group of coenostea clearly conforming to the concept of *Pseudoactinodictyon*. It is important to note however, that establishment of the criteria listed in Table 4 was an on-going process that

underwent much modification throughout this initial phase of taxonomic subdivision. Furthermore, the number of coenostea that could not be assigned with confidence to either of these genera was initially quite large but with additional refinement of the criteria of Table 4 more and more coenostea were reassigned so that the final number of intermediate coenostea, informally described below as "*Anostylostroma* sp. - ?*Pseudoactinodictyon* sp.", is a small percentage of the total number in this "Genus Group".

Not only is there intergradation among the gross morphological features in the *Anostylostroma-Pseudoactinodictyon* "Genus Group" but also in the size and spacing of internal skeletal elements (see Table 8). Thus, for the two most abundant species of both *Anostylostroma* and *Pseudoactinodictyon* the vast majority of the counts of the number of laminae in 2 mm fall in the range of 4 to 8 (Figs. 8A, 13A); yet, this range may be exceeded by the values for laminar spacing in a single thin-section.

However, statistical comparison of large samples (using the data of Table 8) of each of these same four species (rather than comparing individual coenostea) indicates that the inter-sample variances are quite similar (F-tests) but that their mean values for laminar spacing are significantly different (t-tests), except for *A. laxum* and *A. columnare* which are easily distinguished on the basis of the presence/absence of mamelons (see below). Conversely, the spacing of the pillars in all of these same species is essentially the same (Table 8) and thus of minor taxonomic importance.

Genus *Anostylostroma* Parks

Anostylostroma Parks, 1936, p. 44-46; see also references to discussions of this genus cited by Flügel and Flügel-Kahler, 1968, p. 527.

Remarks. The Genus *Anostylostroma* is abundantly and diversely represented in the rocks of the Detroit River Group and Columbus Limestone (in addition to the three species described below see Galloway and St. Jean, 1957, p. 95-124) and includes species with mamelons and species lacking mamelons.

In coenostea with well-developed mamelons there is a marked tendency for both laminae and pillars to be more widely spaced in the axial portions of the mamelon columns (Pl. 5, fig. 6). Thus, to compare the spacing of laminae and pillars between coenostea with mamelons and those without, measurements were not made near the column axes. Similarly, pillars selected for measurement of spacing to the nearest neighbor were those of circular, rather than elliptical cross-section because of the belief that those with circular sections were cut more nearly perpendicular to the pillar axis and therefore the spacing measurements more nearly represented minimum values.

Because of the obvious upward increase in diameter resulting from the funnel-shape of some of the pillars and the tendency for both pillars and laminae to increase in thickness during diagenesis, variation in both pillar diameter and laminar thickness proved to be too great for use as taxonomic criteria.

Anostylostroma laxum (Nicholson)

Plate 5, figures 1-4

Clathrodictyon laxum Nicholson, 1887, p. 12, 13, pl. 3, figs. 4, 5; Parks, 1936, p. 13-16, pl. 1, figs. 1-8, pl. 2, fig. 4.

Anostylostroma laxum (Nicholson). Galloway and St. Jean, 1957, p. 116-118, pl. 5, figs. 2a, 2b; Stearn, 1966a, p. 90.

? *Stromatopora ponderosa* Nicholson, 1875, p. 246, 247, pl. 24, figs. 4, 4a, 4b.

Clathrodictyon ponderosum (Nicholson). Parks, 1936, p. 42-44, pl. 5, figs. 5, 6.

Anostylostroma ponderosum (Nicholson). Galloway and St. Jean, 1957, p. 111-113, pl. 4, figs. 2a, 2b; Fagerstrom, 1962, p. 425, 426, pl. 65, figs. 1-8.

? *Stromatopora substriatella* Nicholson, 1875, p. 248, 249, pl. 24, figs. 5, 5a.

Clathrodictyon substriatellum (Nicholson). Parks, 1936, p. 18-23, pl. 2, figs. 1-8.

Anostylostroma substriatellum (Nicholson). Galloway and St. Jean, 1957, p. 119, 120, pl. 5, figs. 4a, 4b.

Anostylostroma arvense (Parks). Fagerstrom, 1961a, p. 6, pl. 2, figs. 1-3.

Anostylostroma arvense densilaminatum Fagerstrom, 1961a, p. 6, 7, pl. 2, figs. 4-6.

Revised Description. Coenostea of various sizes and shapes from lamellar crusts to very large hemispherical masses. Surface smooth to papillate, irregularly undulating; mamelons absent to very poorly developed, i.e. irregularly and widely spaced, smoothly rounded to nipple-like elevations. Astorhizae absent to rare; poorly developed; a few "mamelons" have an axial canal. Latilaminae absent to moderately prominent; 2 to 3 mm thick.

Vertical section. Tissue compact, consisting of a thin (approximately 0.02 mm), dark, dense central (primary) layer bounded by varying thicknesses of less dense, lighter clothing tissue, and arranged in a clearly defined reticulate net of laminae, pillars and dissepiments. Laminae flat to highly contorted (Pl. 5, figs. 1, 3), transversely porous to fibrous (Pl. 5, fig. 3), and spaced 4 to 10 in 2 mm (Figures 8A, 8C and 9). Pillars commonly expand or branch upward to appear as Y-shaped to arborescent structures (Pl. 5, fig. 3), not notably superposed, and spaced 4 to 11 (most commonly 5 or 6) in 2 mm. Galleries subrectangular to suboval; not superposed to form pseudozooidal tubes. Dissepiments rare to common, smoothly arched, and of varying sizes. Astorhizal canals rare; round, 0.4 to 0.5 mm in diameter. Mamelon columns absent to poorly formed; not persistent (Pl. 5, fig. 1).

Tangential section. Laminae appear as wandering to smoothly concentric narrow to broad, moderately dark areas among the relatively large, open areas of the galleries. Pillars penetrate both the laminae and galleries, appear as small (0.04-0.2 mm in diameter) round to elliptical dots spaced 0.10 to 0.35 mm apart (Figures 8B, 8D and 9), and are either isolated or joined by dissepiments into short vermicular chains. Mamelon columns absent (Pl. 5, fig. 4), or poorly formed, irregularly spaced, and of various sizes and shapes (Pl. 5, fig. 2). Astorhizal canals are rare, short, and variably tabulate.

Remarks. The Nicholson collection in the British Museum (Natural History) contains three syntypes of *Clathrodictyon laxum* labelled (in Nicholson's handwriting and also mentioned in his notebook) as follows:

I. BM(NH) P6007 and thin-sections 314 and 314a plus one unnumbered thin-section; illustrated in Nicholson, 1887, pl. 3, figs. 4, 5; collected from the Corniferous Limestone (=Bois Blanc?), Port Colborne, Ontario, presumably by Nicholson.

This specimen is highly silicified and weathered but the surface appears to contain small, nipple-like mamelons (cf. Nicholson, 1887, p. 12); the specimen is too small to determine whether the mamelons are regularly arranged. The presence of astrorhizae is equivocal.

Internally, the microstructure, pillars, etc. are typical of *Anostylostroma* (Stearn, 1966a, p. 91-92). Laminar spacing (in 2 mm): $N = 6$, $\bar{X} = 6.17$, $s = 0.75$, median = 6. Pillar spacing (tangential section): $N = 10$, $\bar{X} = 0.21$ mm, $s = 0.042$ mm, median = 0.20 mm. Although the thin-sections are small, there is no evidence of mamelon columns.

II. BM(NH) P6019 and thin-sections 327, 327a and 327b never illustrated; collected from either the upper Detroit River Group or the Columbus Limestone, Kelley's Island, Ohio, by G.J. Hinde. The largest surface is just slightly over 6 square centimetres so the presence of regularly spaced mamelons is equivocal; there is no evidence of astrorhizae. Internally, the coenosteum is a typical *Anostylostroma* but the presence of numerous corallites of *Syringopora* has distorted the laminae so that the presence of mamelon columns cannot be determined; between the corallites the laminae are generally flat to slightly undulant rather than steeply inflected as in typical mamelons. Laminar spacing (in 2 mm): $N = 7$, $\bar{X} = 5.57$, $s = 0.53$, median = 6. Pillar spacing (tangential section): $N = 6$, $\bar{X} = 0.20$ mm, $s = 0.028$ mm, median = 0.20 mm.

F and t-test comparisons of laminar and pillar spacing for BM(NH) P6007 and P6019 indicate that the differences are not significant. However, there may be differences in the presence and nature of the mamelons and astrorhizae but the small size of the coenostea and their weathered surfaces precludes any definitive comparison of either of these features. Based on the author's examination of a very large number of coenostea from the Detroit River Group here assigned to *A. laxum*, mamelons (if present) are low and irregularly spaced and astrorhizae (if present) are generally poorly developed. Neither BM(NH) P6007 nor P6019 has the laminae as closely spaced as described by Nicholson (1887, p. 12).

III. BM(NH) P6018 and thin-sections 326 and 326a; never illustrated; collected from the "Corniferous (=Bois Blanc?) Limestone, Port Colborne, Ontario" presumably by Nicholson. A very poorly preserved coenosteum of very limited value in determining the characteristic features of *A. laxum*.

Although *Stromatopora ponderosa* Nicholson and *S. substriatella* Nicholson appear to be conspecific with *Anostylostroma laxum* and have priority, the type specimens for both these species are not included in the Nicholson collection in the British Museum (Natural History) nor have they been located at the Royal Ontario Museum, Field Museum or the Universities of Aberdeen, Edinburgh, Glasgow, or Birmingham and thus may be presumed lost. In none of Nicholson's writings did he ever compare the features of the above three closely related species which is indeed surprising in view of the fact that the type material for each was collected from essentially synchronous rocks in northern Ohio.

Nicholson's original illustration of the surface of *S. ponderosa* (1875, pl. 24, fig. 4) makes it appear irregularly undulant; in the present author's opinion these undulations are too irregularly arranged to be regarded as mamelons, hence the queried synonymy of this species and *Anostylostroma laxum*.

Examination and comparison of Parks's (1936) type material of his species *Clathrodictyon ponderosum*, *C. substriatellum*, and *C. laxum* with numerous coenostea of *Anostylostroma* from the Detroit River Group indicates that

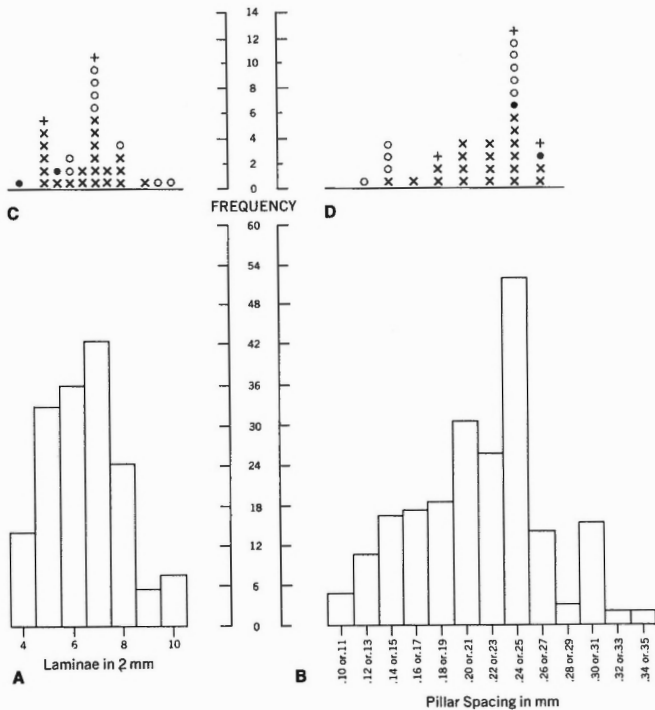
although there is variation in both external and internal morphology there is also an underlying unity of features which strongly indicates that these coenostea are conspecific. Those features include the absence or irregular development (size; spacing) of mamelons, mamelon columns, astrorhizae, and latilaminae; the laminae are spaced about 5 to 8 in 2 mm, and pillars generally spaced about 0.20 to 0.25 mm apart in tangential sections (Figs. 8 and 9).

Parks (1936) summarized the differences between *Clathrodictyon ponderosum*, *C. substriatellum* and *C. laxum* and concluded that each was a valid species. However, the differences cited by Parks fall well within the range of variation present in the abundant coenostea from the Detroit River Group. Thus, *C. laxum* was presumed by Parks to differ from *C. substriatellum* in having a flat coenosteum, more closely spaced laminae, and more widely spaced pillars. In the experience of the present author, coenosteal shape varies from lamellar to hemispherical with all gradations between and the data of Figure 9 clearly indicate that the spacing of laminae and pillars in these species is essentially the same. The presence of papillae (= tubercles of Nicholson, 1875) depends on the amount of weathering that the surface of the coenosteum has undergone so that the presumed smooth surface of *Stromatopora substriatellum* Nicholson (1875) is of doubtful taxonomic significance. The upward bifurcation of the pillars and the abundance of dissepiments are variable even within a single thin-section and therefore are also of doubtful significance (cf. Parks, 1936, p. 15, 20-23) in distinguishing between *substriatellum* and *laxum*. Finally, the near coincidence in the geographic and stratigraphic occurrences of *ponderosum*, *substriatellum*, and *laxum* further supports the conclusion of the present author that these three species are indeed synonymous.

The data of Figure 9 indicate that among coenostea from the lower Detroit River there is moderately good negative correlation between laminar and pillar spacing, i.e. coenostea with more closely spaced laminae tend to also have more closely spaced pillars whereas those with laminae farther apart have more widely spaced pillars. However, this negative correlation is much poorer (i.e. intercoenosteal variation is greater) among coenostea from the upper Detroit River. Furthermore, the upper Detroit River data are clustered in three regions in Figure 9: four coenostea near the left margin from the type Anderdon Limestone (Locs. G and K), two coenostea in the upper right are from Loc. 97211 and three coenostea near the right-centre are from Locs. G and 97211. Such clusters from essentially contemporaneous organisms at three localities suggest that the relations between laminar and pillar spacing may be under strong environmental (not genetic) influence.

The presence of symbiotic *Syringopora* (caunopore tubes) and other corals in the type material of *ponderosa*, *substriatella* and *laxum* is common among coenostea of many species of stromatoporoids. Although these corals and other "inclusions" may cause distortion in the arrangement and shapes of the laminae, pillars, dissepiments, etc. they have no direct bearing on the identification of the surrounding stromatoporeid.

The above revised description of *Anostylostroma laxum* is largely based on the extraordinarily well-preserved material from type area of the Formosa Reef Limestone (Loc. 23635; Fagerstrom, 1961b). Therefore, many of the features described cannot be recognized in poorly preserved material. The density and thickness of clothing tissue is particularly susceptible to diagenetic alteration so that the variation in the laminae illustrated by Fagerstrom (1962, pl. 65, figs. 1-8) occurs among specimens at several localities. The abundance of dissepiments is also highly



Median values for coenostea from lower Detroit River Group rocks (including the type Formosa Reef Limestone) x
 Coenostea from the middle Detroit River Group ●
 Coenostea from the upper Detroit River Group ○
 Coenostea of uncertain stratigraphic position within the Detroit River Group +

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FIGURE 8A. Frequency distribution of 172 values for closeness of laminae from 34 coenostea of *A. laxum* from the Detroit River Group.

FIGURE 8B. Frequency distribution of 222 values for pillar spacing (measured in tangential sections) from the same coenostea used in Fig. 8A.

FIGURE 8C. Frequency distribution of median values for the data of Fig. 8A.

FIGURE 8D. Frequency distribution of median values for the data of Fig. 8B.

Note: The same scale has been used on the abscissa in Figs. 8A and 8C and in Figs. 8B and 8D; the same scale on the ordinate is used for Figures 8A and 8B and for 8C and 8D.

variable and appears to be unrelated to the spacing of the confining laminae. However, in small areas of some thin-sections the disseminations are so abundant that they may replace pillars (as in *Pseudoactinodictyon*). The superposition of pillars is generally confined to the space between 2 or 3 laminae (Pl. 5, fig. 1). However, there is a rather clear relationship between the abundance of superposed pillars and their spacing; i.e. closely spaced pillars tend to be more commonly superposed than widely spaced pillars.

The absence of well-developed, regularly spaced mamelons in *A. laxum* clearly distinguishes this species from all others in the Genus *Anostylostroma* in the Detroit River Group.

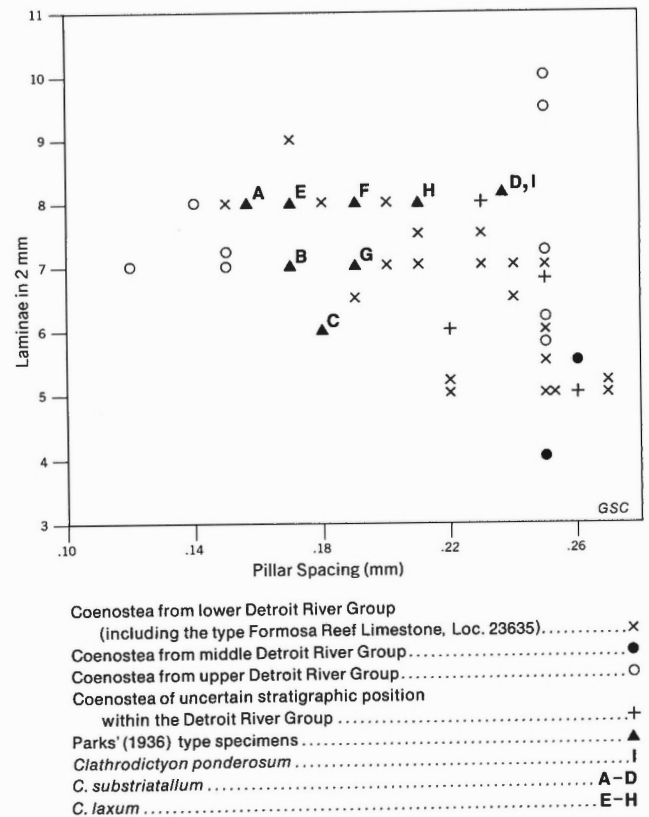


FIGURE 9. Relations between closeness of laminae and proximity of pillars (based on median values) in *A. laxum*.

Material and Occurrence. Syntypes, BM(NH) P6007 with thin-sections numbered 314 and 314a, P6018 with thin-sections 326 and 326a, Corniferous Limestone (= Bois Blanc?), Port Colborne, Ontario, collected by H.A. Nicholson and BM(NH) P6019 with thin-sections numbered 327, 327a and 327b, Corniferous Limestone (= Columbus or Detroit River), Kelley's Island, Ohio, collected by G.J. Hinde. Hypotypes, UMMP 36192-36194, 36196-36198, 36206, Formosa Reef Limestone, Loc. 23635; hypotypes, UNSM 1661-1664, 1667, 1668, 1688-1693, 2.3 to 3.6 m below top of Anderdon Limestone, Loc. G; hypotype, UNSM 4724, Formosa Reef Limestone, Loc. 23635, collected by P.J. Roper; hypotypes, UMMP 36079 and 36080, probably from Amherstburg Dolomite, Loc. H, collected by W.H. Sherzer; hypotypes, GSC 60306, 60420 and 60421, Amherstburg or Lucas Dolomite, Loc. I; hypotypes, GSC 60422-60425, Anderdon Limestone, near crusher pit Loc. K; hypotype, GSC 60426, lower Lucas Dolomite, Loc. 76000, collected by R.H. Blodgett. Hypotypes, GSC 60427-60437; 18.4, 25.2, 29.1, 30.1, 30.4, 31.1, 31.1, 31.1, 31.4 and 32.7 m respectively below top of Detroit River Group, Loc. 15114. Hypotypes, GSC 60438 and 60439; 1.9 and 2.9 m respectively below top of lower Detroit River Group; Loc. 23566. Hypotypes, GSC 60440-60444; 4.5, 4.5, 4.9, 4.9 and 5.2 m respectively below top of lower Detroit River Group; Loc. 97210. Hypotypes, GSC 60445 and 60446; 9.1 and 12.9 m respectively above quarry floor; Loc. 76001. Hypotypes, GSC 60447 and 60448, lower Detroit River Group, Loc. 97211; hypotypes, GSC 60449 and 60450, near top of Detroit River Group, Loc. 23651; hypotypes, GSC 60451-60454, upper unit of Columbus Limestone, Loc. 97217; hypotype, GSC 60455, lower unit of Columbus Limestone, Loc. 97218; hypotypes, GSC 60456 and 60457,

Columbus Limestone, Loc. 97218; hypotype, GSC 60458, lower unit of Columbus Limestone, Loc. 97219; hypotype, GSC 60459, Columbus Limestone, Loc. 97219; hypotypes, GSC 60460-60464, probably upper Detroit River, Loc. V; hypotype, GSC 60465, upper Columbus Limestone (Zone H), Loc. VI; hypotype, GSC 60466, 1.3 m below top of Detroit River Group, Loc. VII; hypotypes, GSC 60467-60469, upper Columbus Limestone (Zone H), Loc. VII; hypotypes, GSC 60470 and 60471, 0.46 m below top of Detroit River Group, Loc. X.

Anostylostroma columnare (Parks)

Plate 5, figure 7

Clathrodictyon laxum columnare Parks, 1936, p. 16-18, pl. 9, figs. 5, 6.

Clathrodictyon moosense proximale Parks, 1936, p. 35-36, pl. 19, figs. 7, 8.

Clathrodictyon arvense Parks, 1936, p. 23-24, pl. 3, figs. 1, 2.

Anostylostroma arvense (Parks). Galloway and St. Jean, 1957, p. 110-111, pl. 4, figs. 1a, 1b; Galloway and Ehlers, 1960, (partim) p. 82-84, pl. 8, figs. 1a, 1b.

Anostylostroma columnare (Parks). Galloway and St. Jean, 1957, p. 97-98, pl. 1, figs. 3a, 3b.

Remarks. This species has been adequately described by Parks (1936) and Galloway and St. Jean (1957) so there is no need for a formal description here. However, the biometrical data of Figures 10 and 11 are presented to provide additional information on intercoenosteal variation and for comparison with other closely related species. Coenostea having median values of 3.0-5.9 mm for mamelon spacing are here assigned to *A. columnare* (Fig. 10D).

A. columnare is not as abundant in the Detroit River Group as *A. laxum*. The two species are commonly found together in the same bed and are undoubtedly very closely related; the chief difference between them is the presence of well-developed mamelons, having greatly thickened pillars in *A. columnare* (Parks, 1936, Pl. 9, figs. 5, 6). The data of Figure 11 suggest that in *A. columnare* there is a tendency for coenostea with closely spaced laminae to also have closely spaced pillars; this same relation was noted above for coenostea of *A. laxum* (Figure 9). However, it is important to note that the size and spacing of the mamelons is unrelated to the spacing of either the laminae or the pillars.

Astrorhizae appear to be absent from Parks's holotype of *Clathrodictyon laxum columnare* and Galloway and St. Jean's hypotype of *Anostylostroma columnare* but the latter authors noted but did not illustrate, tabulate tubes in the axes of some of the mamelon columns in their material which apparently are similar to the axial tubes or canals in vertical sections from two coenostea (GSC 60474, 60475) from the Detroit River Group. Finally, the vertical continuity of the mamelon columns and the amount of pillar thickening is also highly variable; in some sections the columns persist through only a few laminae whereas in others they traverse several latilaminae.

Material and Occurrence. Holotype, ROM 1571 Cn, probably from the Columbus Limestone, Marblehead, Ohio, probably collected by W.A. Parks; median value for mamelon spacing = 4.0 mm (Fig. 10D). Hypotype, UMMP 36086, probably collected by W.H. Sherzer from the Amherstburg Dolomite, Loc. H; this specimen is a hypotype of *Anostylostroma*

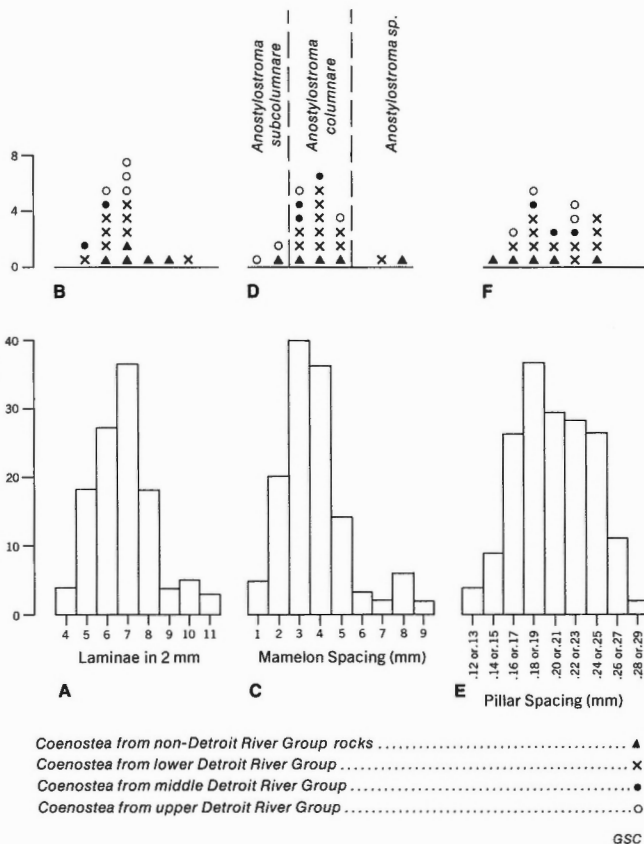


FIGURE 10A,C,E. Frequency distributions for 22 mamelon-bearing coenostea of *Anostylostroma*. Lamellar spacing from vertical sections; mamelon and pillar spacing from tangential sections.

FIGURE 10B,D,F. Frequency distributions of median values for same coenostea.

arvense as interpreted by Galloway and Ehlers, 1960; median value for mamelon spacing = 4.0 mm (Fig. 10D). Hypotype, UMMP 36195, Formosa Reef Limestone, Loc. 23635; this specimen is a paratype of *Anostylostroma arvense densilaminatum* Fagerstrom, 1961a. Hypotype, GSC 60472, Formosa Reef Limestone, Loc. 97215; hypotypes, GSC 60473 and 60474, Anderdon Limestone, Loc. K; hypotype, GSC 60475, 31.7 m below top of Detroit River Group, Loc. 15114; hypotype, GSC 60476, 2.6 m above base of Columbus Limestone, Loc. 15114; hypotypes, GSC 60477 and 60478, both 1.6 m below top of lower Detroit River Group, Loc. 23566. Hypotypes, GSC 60479-60482; 3.9 m below top of lower Detroit River Group; Loc. 97210. Hypotypes, GSC 60483-60490; 4.2, 4.9, 5.2, 5.5, 5.5, 2.6 and 2.6 m respectively below top of lower Detroit River Group; Loc. 97210; hypotypes, 60491-60493, lower Detroit River Group, Loc. 97211; hypotype, GSC 60494, Bois Blanc Limestone, Loc. II; hypotype, ROM 2621D (see Parks, 1936, p. 35-36); median value for mamelon spacing = 3.0 mm (Fig. 10D).

Anostylostroma subcolumnare Galloway and St. Jean

Plate 5, figures 8, 9

Anostylostroma subcolumnare Galloway and St. Jean, 1957, p. 101-103, pl. 2, figs. 2a, 2b.

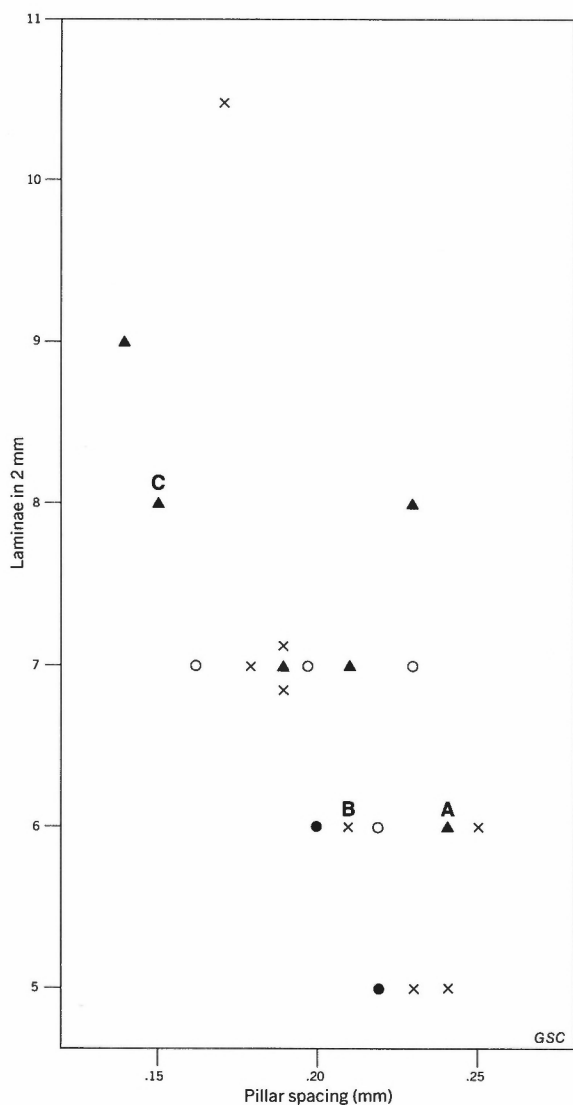


FIGURE 11. Relations between closeness of laminae and proximity of pillars (based on median values) for coenostea used in Figures 10B,F. Note moderate negative correlation; cf. Figure 9. Point A = holotype of *Clathrodiction laxum columnare*; B = holotype of *A. arvensis* Galloway and Ehlers; C = holotype of *C. moosense proximale*.

Description. Coenosteam tabular to hemispherical, 3 to 5 cm thick. Surface mamillate; mamillae 1 to 2 mm in diameter and marking upper ends of small mamelon columns. Latilaminae and astrorhizae absent. Peritheca consisting of a very thin layer of dense amalgamate tissue.

Vertical section: Tissue compact; consisting of a thin (approximately 0.025–0.05 mm), dark dense layer and arranged in a reticulate net of prominent, persistent laminae, thicker pillars, and less prominent dissepiments. Laminae undulate sharply into small, persistent, and clearly defined mamelon columns; transversely porous to fibrous, and spaced about 5 to 8 in 2 mm. Pillars between mamelon columns typically expand upwards, rarely branching (Y-shaped), commonly superposed through 3 to 5 laminae, and spaced about 5 to 6 in 2 mm. Galleries subrectangular to suboval (hemispherical under dissepiments) and not superposed to

form pseudozooidal tubes. Rare dissepiments smoothly arched and spanning short lateral distances. Mamelon columns prominent, nearly filled with dark, moderately dense tissue of greatly thickened pillars. Astrorhizal canals absent.

Tangential section. Mamelon columns prominent, small (1–2 mm in diameter), encircled by 1 to 3 concentric laminae, regularly spaced 1.0 to 2.9 mm (Fig. 10D) apart (centre-to-centre between nearest neighbors), and consisting of dark, moderately dense tissue of greatly thickened, nearly confluent pillars commonly in radial arrangement near periphery of columns. Pillars between mamelon columns small (0.05–0.15 mm in diameter), round to oval, spaced about 0.15 to 0.25 mm apart (centre-to-centre between nearest neighbors) and generally not joined in chains. Astrorhizal canals absent.

Remarks. Although the description of the vertical section of this species by Galloway and St. Jean (1957, p. 101–102) is correct in every respect, their description of the tangential section is so incomplete that new descriptions of both sections are presented above.

The chief differences between *A. subcolumnare* and *A. columnare* are the smaller and more closely spaced mamelon columns in the former species (Fig. 10D); differences in laminar and pillar spacing are insignificant. Among the specimens of *Anostylostroma* from the Detroit River Group containing regularly spaced mamelon columns, those of *A. subcolumnare* have the most densely spaced and thickened pillars. Because of the generally good quality of preservation of these specimens and the clearly defined borders of the pillars between the mamelon columns, the dense, dark pillar tissue in the columns of *A. subcolumnare* is here regarded as an original morphologic feature of this species and important in its identification. The degree of pillar thickening in *A. columnare* and *A. sp.* is more variable and may be in part the result of secondary addition to or rearrangement of the original pillar tissue.

Material and Occurrence. Hypotype, GSC 60495, Bois Blanc Limestone, Loc. II. Hypotypes, GSC 60496 and 60497, 0.46 and 1.1 m respectively below top of Detroit River Group, Loc. X.

Anostylostroma sp.

Plate 5, figures 5, 6

Description. Coenosteam lamellar (?), 4–5 cm thick. Surface unknown. Latilaminae absent.

Vertical section. Tissue compact; consisting of a thin (approximately 0.02 mm), dark, dense central ("primary") layer bounded by varying thicknesses of less dense, lighter clothing tissue, and arranged in a clearly defined reticulate net of prominent laminae and less prominent pillars and dissepiments. Laminae undulate smoothly into relatively large, widely spaced, and persistent mamelon columns becoming flat between columns; transversely porous and fibrous; spaced about 7 to 8 in 2 mm. Pillars commonly expand or branch upward (Y-shaped), not superposed, and spaced about 5 to 7 in 2 mm. Galleries subrectangular to suboval and not superposed to form pseudozooidal tubes. Dissepiments common, smoothly arched and spanning relatively short lateral distances. Astrorhizal canals absent. Mamelon columns contain moderately dense tissue from thickened pillars.

Tangential section: Mamelon columns large (5–6 mm in diameter), encircled by 4 to 7 concentric laminae, and spaced about 6 to 9 mm (Fig. 10D) apart (centre-to-centre between

nearest neighbors). Pillars appear as small (0.04-0.25 mm in diameter) round to elliptical dots penetrating both the galleries and laminae, spaced 0.15 to 0.25 mm apart, and typically are isolated but may be joined by dissepiments into short vermicular chains. Astrorhizae absent; some mamelon columns appear to have an axial tube.

Remarks. The above description is based on one incomplete but moderately well-preserved coenosteum from the lower Detroit River Group at Locality 15114 and one poorly preserved coenosteum from the Bois Blanc Limestone at Locality II. Judgment regarding the taxonomic significance of the more widely spaced mamelon columns in these coenostea (Fig. 10D) must await the collection of additional material. The Detroit River specimen occurs in close association with both *A. laxum* and *A. columnare* and the Bois Blanc specimen is sympatric with *A. columnare* and *A. subcolumnare*.

Galloway and St. Jean (1957, p. 108-109) described *A. compactum* from a single coenosteum from the Logansport Limestone in northern Indiana. The coenosteum described above as *A. sp.* appears to be remarkably similar to the Logansport specimen in all features except the degree of persistence of the mamelon columns. However, the important difference in the stratigraphic occurrence of these two coenostea suggests that additional collecting will be required to prove that they are conspecific or that both are not unusual variants of better known or more abundant species.

Material and Occurrence. Figured specimen, GSC 60498, 31.7 m below top of the Detroit River Group, Loc. 15114. Other specimen assigned: GSC 60499, Bois Blanc Limestone, Loc. II.

Genus *Pseudoactinodictyon* Flügel

Pseudoactinodictyon Flügel, 1958, p. 137; Stearn, 1966a, p. 99-101; Stearn, 1966b, p. 52-53; Birkhead, 1967, p. 82.

Type species: *P. juxi* Flügel, 1958, p. 137-138, pl. 19, figs. 1-4.

Remarks. Flügel's (1958) original description of *Pseudoactinodictyon* (translated into English in Stearn, 1962, p. 17) indicated that the tissue is cellular (= maculate). This interpretation of the microstructure was used in subsequent identifications of the genus by Stearn (1962) and Birkhead (1967). However, after examination of the type species Stearn (1966a; 1966b) described the tissue as compact; this later interpretation is in accord with the microstructure of the material referred to *Pseudoactinodictyon* in the present report, including the holotype of *Actinodictyon vagans* Parks.

After subjectively separating the coenostea of *Pseudoactinodictyon* from those of *Anostylostroma* on the basis of the criteria listed in Table 4, measurements of the number of laminae in 2 mm and the centre-to-centre, nearest neighbor spacing of pillars and mamelon columns were made. Because of the tendency for dissepiments to replace laminae in *Pseudoactinodictyon* (Pl. 6, fig. 1), values for the spacing of laminae are somewhat less objective than for *Anostylostroma*. Measurements of pillar spacing were made in tangential sections between isolated round pillars not joined by dissepiments and located between the axes of mamelon columns.

Coenostea of *Pseudoactinodictyon* are relatively abundant only near Beachville and Amherstburg, Ontario. Both qualitative and quantitative aspects of coenosteal morphology strongly suggest that three species are present in

these rocks: (1) *P. andersonense* (Galloway and Ehlers, 1960, p. 88-90, pl. 9, figs. 2a-c) represented by a single coenosteum (UMMP 14309) from the Anderson Limestone at Amherstburg, Ontario (Loc. K), (2) *P. stearni*, n. sp., also from the Anderson at Loc. K and near Trenton, Michigan (Loc. G) and (3) *P. vagans* (Parks) near Beachville, Salem, and McRae Point, Ontario.

Although these species can be distinguished by both qualitative and quantitative aspects of coenosteal morphology, the data of Figures 12-14 and Table 8 suggest that the laminae in *P. stearni* are more closely spaced than in *P. vagans*. In order to statistically evaluate the significance of this apparent difference an F-test ($F = 1.79$) and a t-test ($t = 6.69$ for 78 degrees of freedom) were made. The value of F indicates that the variances of the two samples are sufficiently similar to make a meaningful t-test and the value of t indicates that the means are indeed significantly different.

A similar test of the significance of the difference in mean values for pillar spacing in the samples of *P. stearni* and *P. vagans* from the Detroit River Group (Figs. 13C, D and 16C, D) was not undertaken because the difference (0.018 mm) was considerably less than the accuracy of the device used to measure pillar spacing originally.

Thus, in distinguishing between coenostea of the three species of *Pseudoactinodictyon* currently recognized in the Detroit River Group the presence/absence and spacing of mamelons, the spacing of laminae, and the sizes and shapes of pillars were found to be the most useful taxonomic criteria.

Pseudoactinodictyon vagans (Parks)

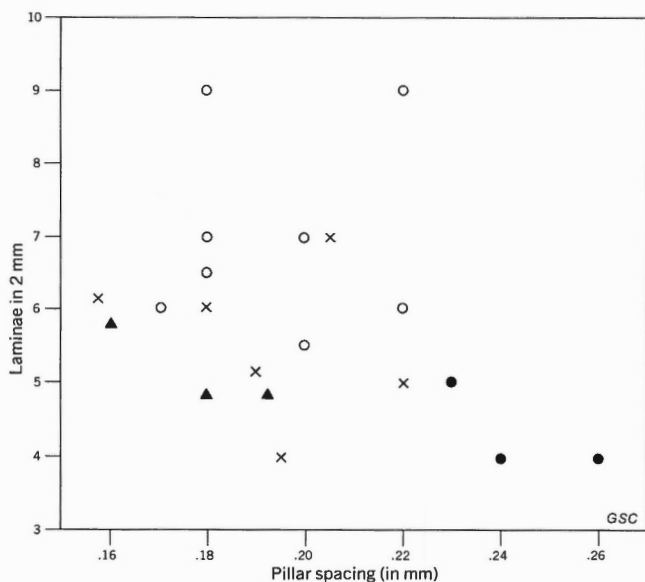
Plate 6, figures 1, 2

Actinodictyon vagans Parks, 1936, p. 113-116, pl. 18, figs. 1-7; non Galloway and St. Jean, 1957, p. 230-231, pl. 22, figs. 5a, 5b.

Pseudoactinodictyon vagans (Parks). Flügel, 1958, p. 139-142, pl. 2, figs. 2-4.

Emended Description. Coenosteum large, lamellar to hemispherical, and up to 5 cm thick. Surface undulant with poorly to moderately well-developed low mamelons about 3 mm in diameter and rather uniformly spaced about 3 to 4 mm apart centre-to-centre. Astrorhizae and latilaminae absent to poorly developed. Peritheca unknown.

Vertical section. Tissue consisting of a network of well-developed, prominent laminae, pillars, and numerous dissepiments. Laminae undulate between low, rather widely spaced, and variably developed mamelon columns; about 0.05 to 0.07 mm thick (excluding variable thicknesses of clothing tissue) and spaced about 4 to 6 in 2 mm (Fig. 13A, B); microstructure compact to transversely fibrous and porous. Pillars variably developed from short (not notably superposed), straight, rod-like structures about 0.05 mm in diameter in areas between mamelon columns to prominent, long (superposed through 3 to 5 laminae), upwardly flaring and divergent structures, as much as 0.12 mm in diameter near the axes of the mamelon columns. Galleries rectangular to hemispherical, bounded below by flat laminae and above by either laminae or rounded dissepiments, and not superposed to form pseudozooidal tubes but laterally elongate near mamelon columns. Dissepiments abundant, crowded between laminae, generally overlapping, arranged in irregular subvertical stacks and locally replacing laminae. Astrorhizal canals absent to very poorly developed.



Coenostea of *P. vagans* from lower Detroit River
 Group rocks at Beachville (Localities 23566 and 97210) x
 Coenostea of *P. vagans* from middle Detroit River
 Group rocks at Beachville (Localities 23566 and 97210) •
 Coenostea of *P. stearni* from the Anderdon Limestone
 (Localities G and K) o
 Parks', 1936, cotypes of *P. vagans* from the Upper
 Columbus Limestone, Kelley's Island, Ohio ▲

Note the relatively low level of correlation between these variates, the generally closer spacing of laminae in coenostea of *P. stearni* and the wider spacing of pillars in coenostea of *P. vagans* from the middle Detroit River Group

FIGURE 12. Relations between pillar and laminar spacing (based on median values) in *Pseudoactinodictyon* spp.

Tangential section. Tissue consists of irregularly wandering laminae between the prominent mamelon columns, numerous pillars joined by dissepiments into short, vermicular chains, very irregularly shaped galleries, and local areas of abundant, overlapping dissepiments. Pillars appear as round dots, commonly thickened by clothing tissue, 0.05–0.1 mm in diameter, and spaced about 0.16 to 0.25 mm apart, centre-to-centre (Figs. 13C, D). Mamelon columns composed of laminae and pillars thickened by clothing tissue, unthickened dissepiments, and very irregularly shaped galleries; about 2 to 4 mm in diameter, spaced 3 to 6 mm apart centre-to-centre (Fig. 14) and with occasional axial astrophthalic canals about 0.4 to 0.5 mm in diameter.

Remarks. In Parks's original description of this species he noted that the laminae were spaced about 3 to 6 in 2 mm. However, after examining the type material Flügel (1958, p. 114) described the laminar spacing as 6 to 10 in 2 mm. The values for laminar spacing in coenostea from the Detroit River Group (Figs. 13A, B) are in close agreement with the values given by Parks and determined from measurement of the type material by the present author (Fig. 15A).

Galloway and St. Jean (1957, p. 230–231) described two coenostea from the Jeffersonville Limestone of southern Indiana as *Actinodictyon vagans* Parks. However, their specimens apparently differ from the type material of this species in the size and spacing of the mamelons, the absence of astrophthalic canals, and the lack of thickened pillars in the mamelon columns.

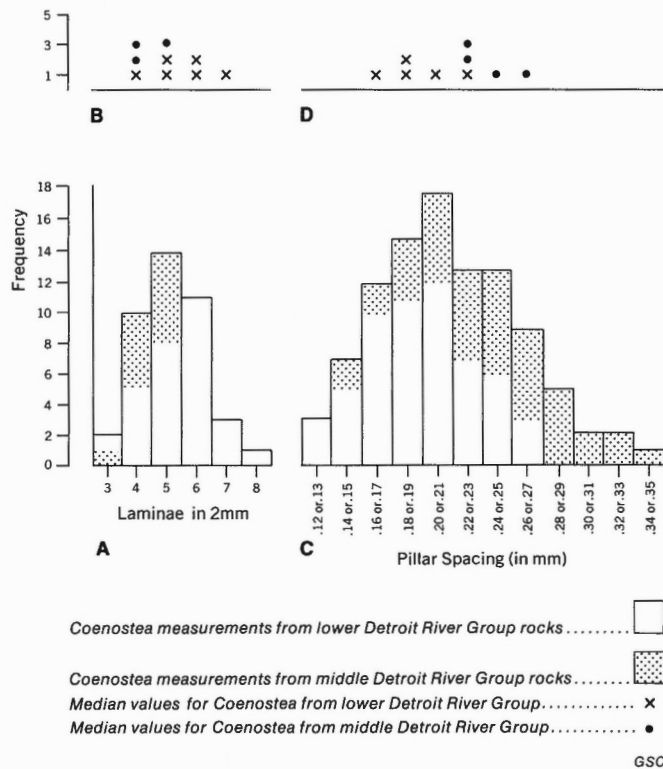


FIGURE 13A. Frequency distribution of 41 values for the closeness of laminae from 9 coenostea of *P. vagans* from the Detroit River Group (Localities 23566 and 97210).

FIGURE 13B. Frequency distribution for median values for the data of Fig. 13A. Note that the same scale on the abscissa is used in Figures 13A and 13B.

FIGURE 13C. Frequency distribution of 100 values for spacing of pillars (measured in tangential sections) from the same coenostea used in Figs. 13A, B.

FIGURE 13D. Frequency distribution for median values for the data of Figure 13C. Note that the same scale on the abscissa is used in Figures 13C, D.

P. vagans differs from *P. anderdonense* (Galloway and Ehlers, 1960) in having smaller, more closely spaced mamelons, and much more widely spaced laminae and from *P. stearni* in having thickened, upwardly divergent pillars in the mamelon columns, less closely spaced laminae, and more uniformly spaced mamelons.

Material and Occurrence. Lectotype (selected by Galloway and St. Jean, 1957, p. 231), ROM 1572 Cn, Columbus Limestone?, Kelley's Island, Ohio, collected by J. Townsend; paralectotypes, ROM 1573 Cn, 1574 Cn and 1575 Cn, Columbus Limestone?, Kelley's Island, Ohio, collected by J. Townsend; hypotype, GSC 60502, Formosa Reef Limestone, Loc. 97215. Hypotype, GSC 60503, approximately 17.2 m above top of lower Detroit River Group, Loc. 23566. Hypotypes, GSC 60504 and 60505, both specimens from 1.9 m below top of lower Detroit River Group, Loc. 23566. Hypotypes, GSC 60506–60510; 4.9, 5.2, 8.7, 9.1, and 13.6 m respectively above the top of the lower Detroit River Group; Loc. 97210. Hypotypes, GSC 60511–60514; 1, 1.9, 2.3 and 2.3 m respectively below top of lower Detroit River Group;

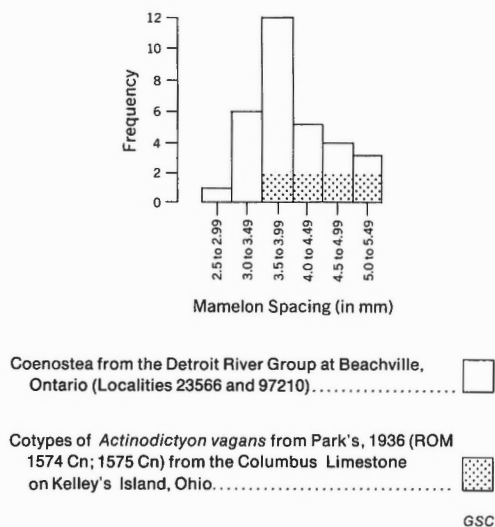


FIGURE 14. Frequency distribution of 31 values for spacing of mamelon columns (measured in tangential sections) from 8 coenostea of *P. vagans*. Because the Kelley's Island data are based on just two coenostea, the taxonomic significance of their apparent wider spacing of mamelon columns is uncertain but considered to fall within the expected range of variation of a single species.

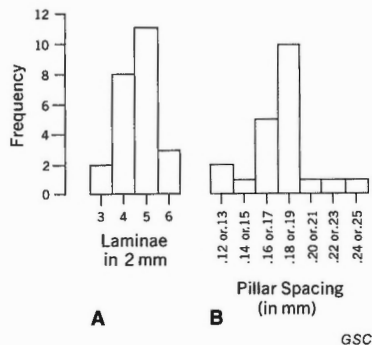


FIGURE 15A. Frequency distribution of 24 values for laminar spacing from Park's (1936) cotypes of *Actinodictyon vagans* (ROM 1572 Cn to 1575 Cn), Columbus Limestone, Kelley's Island, Ohio.

FIGURE 15B. Frequency distribution of 21 values for pillar spacing (measured in tangential sections) from Park's (1936) cotypes of *Actinodictyon vagans* (ROM 1572 Cn; 1574 Cn; 1575 Cn), Columbus Limestone, Kelley's Island, Ohio.

Loc. 97210. Hypotypes, GSC 60515 and 60516, Detroit River Group, Loc. 15111; hypotypes, GSC 60517 and 60518, probably from the upper Detroit River Group, Loc. IV; hypotype, GSC 60519, approximately 1.6 m below top of Detroit River Group, Loc. VIII.

***Pseudoactinodictyon stearni* n. sp.**

Plate 6, figures 3, 4

***Anostylostroma ponderosum* Fagerstrom, 1962, p. 425-426 (partim), pl. 65, figs. 4, 8, non pl. 65, figs. 1-3, 5-7.**

Description. Coenosteum large, lamellar, broadly and irregularly undulating. Mamelons poorly developed, irregularly spaced (about 6-12 mm apart), and relatively large

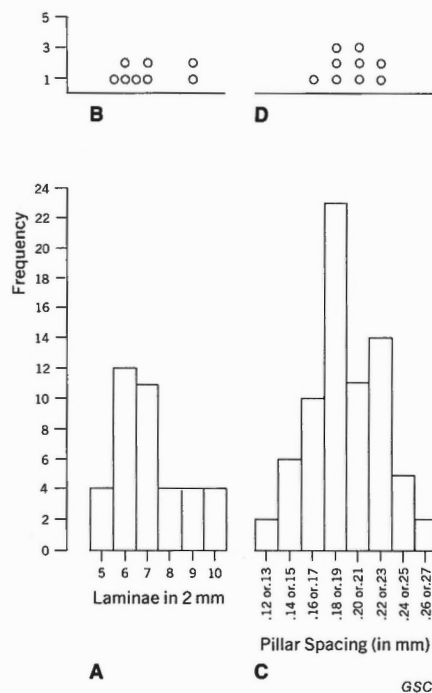


FIGURE 16A. Frequency distribution of 39 values for laminar spacing from 8 coenostea of *P. stearni* from the Anderdon Limestone at Localities G and K.

FIGURE 16B. Frequency distribution of median values for laminar spacing for the same coenostea used in Figure 16A. Note that the same scale on the abscissa is used in Figures 16A and 16B.

FIGURE 16C. Frequency distribution of 73 values for pillar spacing (measured in tangential section) from 9 coenostea of *P. stearni*.

FIGURE 16D. Frequency distribution of median values for pillar spacing for the same coenostea in Figure 16C. Note that the same scale on the abscissa is used in Figures 16C and 16D. The data in Figure 16 are based on specimens from the Anderdon Limestone, Locs. G and K.

(about 6-8 mm in diameter). Astrorrhizae generally present but not prominent. Latilaminae about 1 to 3 mm thick. Peritheca not observed.

Vertical section. Tissue consisting of a network of moderately well-developed, generally persistent laminae, numerous, less prominent dissepiments, and pillars of varying degrees of prominence from nearly absent to numerous and closely spaced. Laminae undulate between generally low, rather widely spaced, and variably developed mamelon columns; about 0.03 to 0.05 mm thick (excluding variable thicknesses of clothing tissue) and spaced about 5 to 10 in 2 mm (Figs. 16A and 16B); microstructure compact, transversely fibrous to porous, locally flocculent to melanospheric. Pillars compact, generally confined to a single interlamina space, straight, rod-like, most prominent near axes of mamelon columns, and about 0.05 to 0.07 mm in diameter (exclusive of clothing tissue). Galleries rectangular to hemispherical, bounded below by flat laminae and above by either laminae or rounded dissepiments; not superposed to form pseudozooidal tubes. Dissepiments moderately crowded between laminae, laterally overlapping but not arranged in vertical stacks, and may locally replace laminae. Astrorrhizal

canals generally absent or poorly developed but locally may be large with strongly upswept horizontal canals near mamelon columns (see Fagerstrom, 1962, Pl. 65, fig. 8).

Tangential section. Tissue consists of irregularly wandering laminae between moderately prominent mamelon columns, relatively small pillars, and abundant, overlapping dissepiments. Mamelon columns variable in diameter (about 5-14 mm) and spacing (about 6-14 mm centre-to-centre). Astrorhizae absent to poorly developed, typically consisting of a single canal near the axis of mamelon columns; lateral astrorhizal canals uncommon. Pillars variably abundant, round to elongate, 0.06-0.15 mm in minimum diameter, rarely joined by dissepiments into short vermicular chains, and spaced about 0.14 to 0.23 mm apart (Figs. 16C and 16D).

Remarks. Extensive collecting by the author from the Anderdon Limestone on several occasions at Localities G and K has failed to provide additional topotypic specimens of *P. andersonense* (Galloway and Ehlers, 1960, p. 88-90, pl. 9, figs. 2a-2c). However, these same rocks as well as the overlying lower Dundee Limestone and the upper Columbus Limestone in northern Ohio do contain a moderate number of coenostea of *P. stearni* which differs from *P. andersonense* by having larger mamelons, more widely spaced laminae, and astrorhizal canals near the axes of the mamelon columns. The differences between *P. stearni* and *P. vagans* were previously noted in the "Remarks" sections for the descriptions of the Genus *Pseudoactinodictyon* and the species *P. vagans*.

This species is named in honor of Professor Colin W. Stearn, McGill University, Montreal in appreciation for his help and encouragement in the generic identification of nearly all of the stromatoproids from the Detroit River Group in southwestern Ontario.

Material and Occurrence. Holotype, GSC 60520, lower Anderdon Limestone, near crusher pit, Loc. K. Paratypes, GSC 60500, 60501, 60521 and 60522, approximately 1.3 m below top of Anderdon Limestone, Loc. K; paratypes, GSC 60523 and 60524, lower Anderdon Limestone, near crusher pit, Loc. K; paratypes, GSC 60525 and 60526, Anderdon Limestone, south end, Loc. K; paratypes, GSC 60527 and 60528, lower Dundee Limestone, Loc. K. Paratypes, UNSM 1665 and 1666, 2.3 to 3.6 m below top of Anderdon Limestone, Loc. G (these specimens were formerly hypotypes of *Anostylostroma ponderosum* (see Fagerstrom, 1962). Paratypes, GSC 60529 and 60530, probably upper Detroit River Group, Loc. V.

"*Anostylostroma* sp. - *Pseudoactinodictyon* sp."

Plate 8, figures 1-3

Remarks. As noted above in the general discussion of the taxonomic problems in subdividing the *Anostylostroma-Pseudoactinodictyon* "Genus Group" there are some coenostea that are intermediate in their morphological features between more typical members of these two genera. Instead of presenting formal descriptions and comparisons of these intermediate coenostea, selected examples have been illustrated and the salient morphological features of each are carefully noted in the plate captions.

Material and Occurrence. GSC 61336, approximately 1.3 m below top of Anderdon Limestone, Loc. K; GSC 61337 and 61338, 0.65 m above top of the lower Detroit River Group, Loc. 23566; GSC 61339, 6.1 m above top of lower Detroit River Group, Loc. 97210; GSC 61340, upper Detroit River Group, Loc. 76001; UNSM 1664, a former hypotype of *Anostylostroma ponderosum* Fagerstrom, 1962, upper Anderdon Limestone, Loc. G.

Genus *Amphipora* Schulz

Amphipora Schulz, 1883, p. 89; see also references to discussions of this genus cited by Flügel and Flügel-Kahler, 1968, p. 525-526 and by Fischbuch, 1970a, p. 64-68.

Remarks. Although there has been some disagreement among previous authors regarding the taxonomic importance of various morphologic features of *Amphipora*, most recent workers agree that the chief criteria for identification of coenostea of this possibly widely distributed (Duncan in Cloud, 1959, p. 948) genus include: (1) cylindrical to dendroid coenosteal shapes, (2) compact to fibrous tissue having a dark axial line where well-preserved (like *Anostylostroma*), and (3) amalgamate arrangement of the major internal structural elements. Features of more variable development, and thus of lesser taxonomic importance, include the presence or absence of: (1) an axial canal, (2) cysts in the axial canal, (3) well-developed marginal vesicles, and (4) a peripheral membrane.

Examination of hundreds of coenostea from the Detroit River Group confirms the relative importance of these features; in addition, biometrical and other non-quantitative data presented below indicate that coenostea of *Amphipora* are exceedingly variable with regard to the size and shape of the coenostea as well as the internal structural elements. This variability and generally poor preservation have been the chief obstacles to establishment of discrete species of *Amphipora*; the genus and its species appear to have no biostratigraphic value for either local or regional correlation of the Detroit River Group (cf. Conkin and Conkin, 1973, p. 31-40).

Flügel and Flügel-Kahler (1968, p. 526-527) list 39 species and subspecies assigned by them and other workers to the genus *Amphipora* and 6 other species of uncertain generic placement. However, in the opinion of the present author, the validity of most of these minor taxa is doubtful until the range of variation of each has been more completely documented.

In his study of *Amphipora* from the Middle and Upper Devonian rocks of western Canada, Fischbuch (1970a) recognized three species based on the presence, absence and diameter of an axial canal (if present) and the relative size and arrangement of the marginal vesicles and other internal structures. Attempts by the present author to use these same criteria for establishment of discrete species of *Amphipora* in the Detroit River Group were only partially successful. For example the number, arrangement, and size of vesicles in specimens from the Detroit River Group is difficult to determine due to poor preservation but appears to vary progressively from virtual absence of vesicles to many, large, well-defined vesicles located anywhere in the coenostea from near the axis to just inside the thin marginal membrane. Furthermore, the presence or absence of vesicles appears to be unrelated to the presence or absence of an axial canal or to the diameter of either the coenostea or the axial canal. Thus, in this report a rather conservative approach toward subdivision of the Genus *Amphipora* has been taken with recognition of only three species: (1) *A. ramosa* (?) for coenostea with a single, well-defined axial canal that is significantly larger than any of the adjacent vesicles or canals, (2) *A. nattressi* for coenostea lacking an axial canal but with many small vesicles randomly located between the axis and margin of the coenostea, and (3) *A. sp.* for a very small sample of larger than average coenostea having very large, well-defined vesicles randomly located between the axis and the margin. One of the large axial vesicles in *A. sp.* may correspond to the axial canal of *A. ramosa* (?) above.

All of the biometrical data from cylindrical to conical coenostea presented in Figures 17-20 were measured on cross-sections from thin-sections. Typically, the shapes of these coenostea as well as the axial canal (if present) appear elliptical in thin-section because the section is not oriented precisely perpendicular to the coenosteal axis or because the coenosteam actually is elliptical in cross-section, either naturally or due to crushing. Crushed coenostea were eliminated from biometrical consideration. Minimum values of coenosteal diameter and the diameter of the axial canal (if present) were measured to minimize apparent variation due to the non-perpendicular orientation of the thin-section with respect to the coenosteal axis. From thin-sections it is impossible to distinguish naturally elliptical coenostea from those due to non-perpendicular orientation but the present author has assumed elliptical vs. cylindrical or conical coenosteal shape is of no taxonomic importance in the identification of species of *Amphipora* and *Stachyodes*.

***Amphipora ramosa* (?) (Phillips)**

Plate 6, figures 5, 6, 9

?*Caenopora ramosa* Phillips, 1841, p. 19, pl. 8, fig. 22; see also references to this species cited by Flugel and Flugel-Kahler, 1968, p. 342-348.

?*Idiostroma nattressi* Grabau, 1910, p. 94, pl. 9, figs. 5, 6, pl. 8, figs. 2, 3.

Amphipora ramosa (Phillips). Galloway and Ehlers, 1960, p. 98, 99, pl. 11, figs. 1a, 1b, 4b, 4c, 8; ?Fischbuch, 1970a, p. 69-70, pl. 15, figs. 1-5; ?Lecompte, 1952, p. 325-328, pl. 68, figs. 1-7.

Amphipora nattressi (Grabau) (partim). Galloway and Ehlers, 1960, p. 99-101, pl. 11, figs. 4b, 4c, 8 and possibly figs. 3, 4a, 5-7.

?*Amphipora pervesiculata* Lecompte, 1952, p. 331, pl. 70, figs. 3-5.

Remarks. Fischbuch's (1970a, p. 69, 70) description of *A. ramosa* adequately describes the material from the Detroit River Group with the following exceptions:

1. Coenosteal diameter of specimens from the Detroit River appears to be less and has a greater range (Figs. 17A and 19) than Fischbuch's material. The statistical significance of these differences cannot be tested due to the inadequacy of Fischbuch's published data.

2. Axial canal diameter of the Detroit River specimens also appears to be considerably less (Fig. 17B). Again, Fischbuch's data are inadequate to test the statistical significance of this difference. However, because of the very high level of variation in axial canal diameter (CV = 40.0) for the Detroit River material and its low level of correlation with coenosteal diameter (Fig. 18) and other features of the coenosteam, there is doubt that this difference has any taxonomic significance. The data in Figs. 17-19 clearly indicate that there is no regular geographic or stratigraphic significance to the variation in coenosteal and axial canal diameter, either.

3. Marginal vesicles in the Detroit River specimens range from about 0.10 to 0.30 mm in diameter; they are neither as abundant nor as large as those in specimens referred to *A. ramosa* by Fischbuch (1970a, pl. 15, figs. 1, 4, 5) or by Lecompte (1952, pl. 67, fig. 3, pl. 68, figs. 1-7).

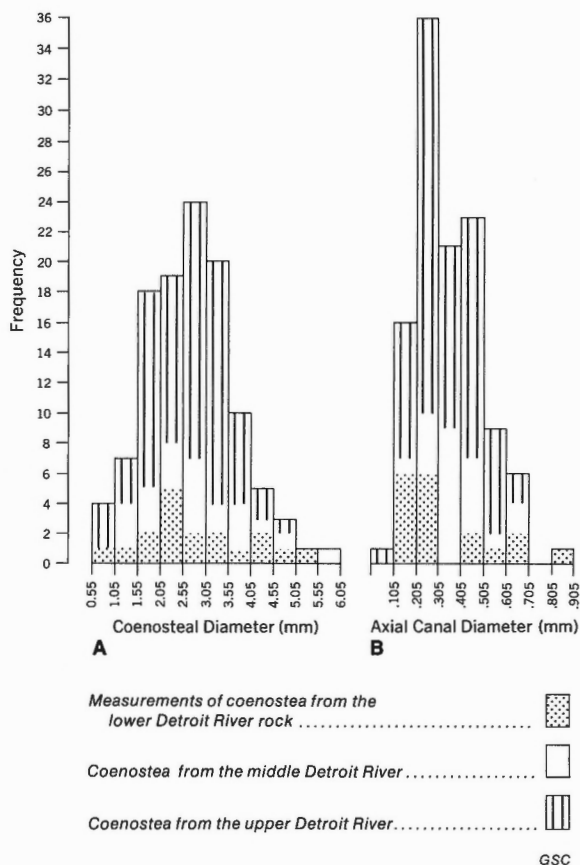


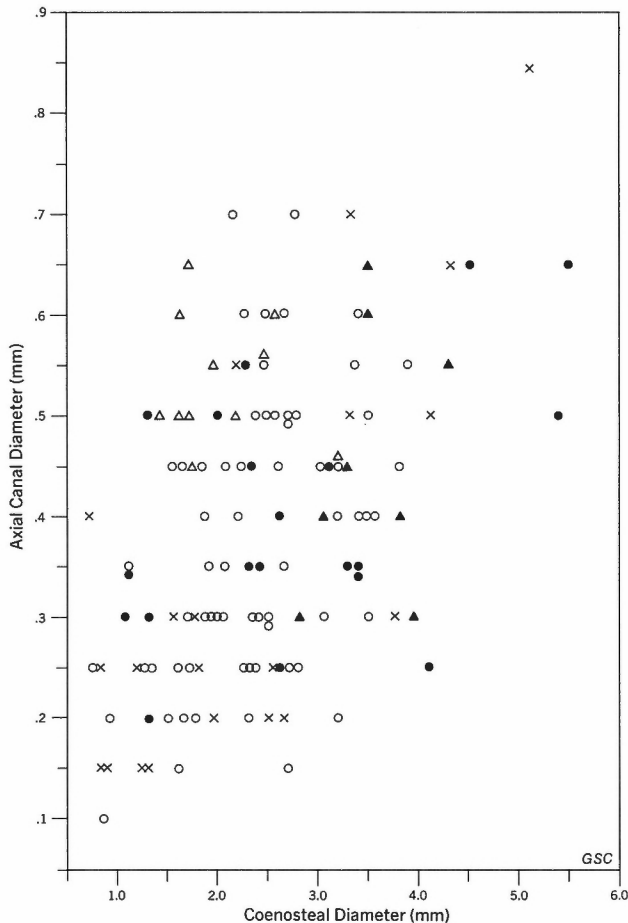
FIGURE 17A. Frequency distribution of 112 values for the minimum coenosteal diameter of *Amphipora ramosa* (?) from the Detroit River Group at Locs. 15114, 23566, 97210, 97211.

FIGURE 17B. Frequency distribution for values for minimum axial canal diameter in the same coenostea used in Figure 17A.

In comparison to material from the Detroit River Group, the Lecompte coenostea of *A. ramosa* have relatively smaller axial canals whereas his coenostea of *A. pervesiculata* have relatively larger axial canals (Fig. 18). In view of the low level of correlation between these variates and their great variability, the taxonomic significance of these differences is doubtful.

As noted by Stearn (1966a, p. 109), the holotype of *A. ramosa* has not been located. Until the holotype (or syntypes) has been restudied or a neotype designated and the variation in a large suite of topotypic material described, the taxonomic features of this apparently widely distributed species (Flügel and Flügel-Kahler, 1968, p. 342-348) will remain uncertain.

Material and Occurrence. Hypotypes, UMMP 14040, incomplete coenostea, Amherstburg Dolomite, Locality H and UMMP 14042A, Anderdon Limestone, Locality K, collected by A.W. Grabau or W.H. Sherzer; hypotype, UMMP 34916, Anderdon Limestone, Locality K, collected by G.M. Ehlers; hypotype, GSC 60571, lowest 1 metre of Anderdon Limestone, Loc. 76000; hypotype, GSC 60572, Formosa Reef Limestone, Loc. 97215. Hypotypes, GSC 60573-60575; 1.3, 15.6 and 15.6 m respectively below top of Detroit River Group, Loc. 15114. Hypotype, GSC 60576, near top of



Coenostea from lower Detroit River Group rocks x
 Coenostea from middle Detroit River Group rocks •
 Coenostea from upper Detroit River Group rocks o
 Coenostea of *A. ramosa* of Lecompte (1952, pl. 68, figs. 1-7) ▲
 Coenostea of *A. pervisiculata* Lecompte (1952, p. 331, pl. 70, figs. 3-5) ... △

FIGURE 18. Relations between minimum coenosteal and minimum axial canal diameters for the same coenostea used in Figures 17A, B. $r = 0.57$ for all Detroit River coenostea.

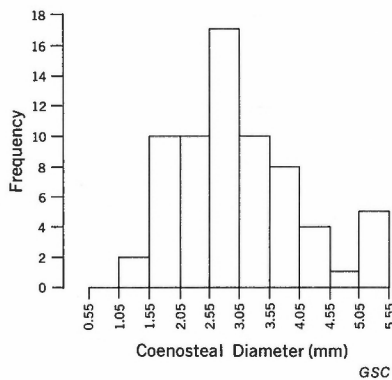


FIGURE 19. Frequency distribution of 67 values for minimum coenosteal diameter of *Amphipora ramosa* (?) from the upper Detroit River Group (Anderdon Limestone) at Locs. K and 76000. Comparison of Figures 17A and 19 clearly indicates that coenosteal diameter in *A. ramosa* (?) is essentially the same.

Detroit River Group, Loc. 23566. Hypotypes, GSC 60577-60581; 2.9, 2.9, 2.9, 13.3 and 17.2 m respectively, above top of lower Detroit River Group; Loc. 97210. Hypotypes, GSC 60582-60584, Detroit River Group, Loc. 15111; hypotype, GSC 60585, lower Detroit River Group, lower bench Loc. 76001; hypotype, GSC 60593, 30.7 m below top of Detroit River Group, Loc. 15114; hypotype, GSC 60594, 6.8 m above top of Lower Detroit River Group, Loc. 97210; hypotype, GSC 60595, near top of Detroit River Group, Loc. 23651.

The thin-sections and rock samples numbered as follows contain specimens of both *Amphipora ramosa* (?) and *Amphipora nattressi* in such close association that it is impossible to separately number them: hypotype, GSC 60596, Anderdon Limestone, Loc. K; hypotypes, GSC 60597-60599 and 61318, lowest 1 to 1.6 m of Anderdon Limestone, Loc. 76000; hypotypes, GSC 60600-60604, 61324 and 60625, lower Detroit River Group, Loc. 97211; hypotypes, GSC 60605-60608, and 61326-61328, Detroit River Group, Loc. 15111; hypotypes, GSC 60609-60611, 9.7 m below the top of the Detroit River Group, Loc. VIII. Hypotypes, GSC 60612-60620; 0.1, 1, 1.3, 4.2, 6.8, 11, 15.2, 26.6 and 31.7 m respectively below top of the Detroit River Group, Loc. 15114. Hypotypes, GSC 60621 and 60622, 1.3 and 1 m respectively, below top of the lower Detroit River Group, Loc. 23566. Hypotypes, GSC 60623-60627; 11.9, 4.0, 3.7, 3.4 and 1 m, respectively, above the top of the lower Detroit River Group, Loc. 97210. Hypotypes, GSC 60628-60630; 0.02, 1.6, and 3.2 m, respectively, below the top of the lower Detroit River Group, Loc. 97210. Hypotypes, GSC 60631 and 60632; 4.2 (lower Detroit River Group) and 15.5 m (middle Detroit River Group), respectively, above quarry floor, Loc. 76001. Hypotypes, GSC 61319-61321; 0.3, 4.2 and 6.8 m, respectively, below top of the Detroit River Group, Loc. 15114. Hypotype, GSC 61322, upper Detroit River Group, Loc. 15114. Hypotype, GSC 61323, 2.3 m above the top of the lower Detroit River Group, Loc. 97210.

***Amphipora nattressi* (Grabau)**

Plate 6, figures 7-9

***Idiostroma nattressi* Grabau, 1910, p. 94, pl. 9, fig. 7, non pl. 8, figs. 2-3.**

? ***Amphipora angusta* Lecompte, 1952, p. 324, pl. 67, fig. 2; Fischbuch, 1970a, p. 70-71, pl. 15, figs. 6-9.**

***Amphipora nattressi* (Grabau) (partim).** Galloway and Ehlers, 1960, p. 99-101, pl. 11, figs. 2a, 2b, ?pl. 11, figs. 3, 4a, 5-7, non pl. 11, figs. 4b, 4c, 8.

Emended Description. Coenostea cylindrical to subconical, possibly dendroid; with or without smaller branches, knobs, or other surficial irregularities. Coenosteal diameter varies from about 0.5 to 5.0 mm (see Fig. 20).

Cross section: Tissue compact transversely fibrous; consisting of a thin (approximately 0.02 mm), dark, dense central layer bounded by varying thicknesses of less dense, lighter clothing tissue. Arrangement of internal structures amalgamate. Axial canal absent. Size, shape, location, and arrangement of vesicles variable but generally more prominent toward periphery where they range from about 0.10 to 0.35 mm in diameter. Marginal (peripheral) membrane (or perithea) generally thinner than internal structures.

Longitudinal section: Laminae and pillars amalgamate. Axial canal absent. Size, location, and arrangement of vesicles variable but commonly elongate and upwardly divergent.

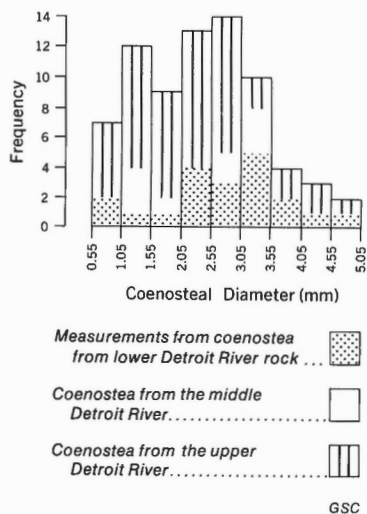


FIGURE 20. Frequency distribution of 74 values for minimum coenosteal diameter of *Amphipora nattressi* from the Detroit River Group at Locs. 15114, 23566, 97210, 97211. The fact that middle Detroit River coenostea are restricted to diameters of about 1.0 to 3.5 mm is of doubtful biostratigraphic significance.

Remarks. Coenostea of *Amphipora ramosa* (?) and *A. nattressi* are abundant and widely distributed in the Detroit River Group and are morphologically the same in all essential features except for the presence of a single, well-defined axial canal in the former species. In an attempt to evaluate the significance of the difference in coenosteal diameter in the samples used in Figs. 17A and 20 an F-test ($F = 1.18$) and a t -test ($t = 1.68$ for 184 degrees of freedom) were made. The value of F indicates that the variances of the two samples are sufficiently similar to make a meaningful t -test and the value of t indicates that the means (\bar{X}) for coenosteal diameter in the two samples are not statistically significantly different. Comparisons of the size, location, and arrangement of the internal vesicles as stressed by some previous authors (e.g., Lecompte, 1952, p. 324-328 and Fischbuch, 1970a, p. 67-71), indicated that among Detroit River Group coenostea these features are so variable in their development as to be also useless as taxonomic criteria for distinguishing these species.

Even the validity of the presence or absence of an axial canal as an important taxonomic criterion is questionable because in most rock samples containing several coenostea of *Amphipora*, examples of coenostea with an axial canal (*A. ramosa* (?)) are intimately associated with other coenostea lacking an axial canal (*A. nattressi*). Genetic and ecologic theory suggest that such intimate association of two species of the same genus is quite uncommon and that therefore the present basis for distinguishing between these species may not be biologically valid.

The thin-section of the holotype of *A. angusta* Lecompte (1952, p. 324, pl. 67, fig. 2) contains numerous, closely packed coenostea most of which have a notable concentration of very large peripheral vesicles from 0.02 to over 1.25 mm in greatest dimension. The diameter of eight coenostea ranges from 1.35 to 2.20 mm (mean = 1.79; standard deviation = 0.317; median = 1.77). These dimensions are very similar to those for the Beachville sample of *A. nattressi* (Fig. 20) which suggests that the species may be synonyms; however, the sizes of the peripheral vesicles in *A. angusta* greatly exceed the sizes of the vesicles in most coenostea of *A. nattressi*.

Material and Occurrence. Lectotype (designated by Galloway and Ehlers, 1960, p. 101), UMMP 14039, an incomplete coenosteam, Anderson Limestone, Locality K, collected by A.W. Grabau or W.H. Sherzer; hypotype, GSC 61329, 0.3 m below top of Detroit River Group, Loc. 15114. Hypotypes, GSC 60586 and 61330; 1 m above and 0.6 m below, respectively, the top of lower Detroit River Group, Loc. 23566; hypotype, GSC 60587, 13.3 m above top of lower Detroit River Group, Loc. 97210; hypotypes, GSC 60588-60591, lower Detroit River Group, Loc. 97211; hypotype, GSC 60592, Detroit River Group, Loc. 15111.

For a listing of other numbered hypotypes of *A. nattressi* in such close association with *A. ramosa* (?) that it is impossible to separately number them, see above under "Material and Occurrence" for *A. ramosa* (?).

Group III: Genera Having Tripartite/Ordinacellular Microstructure

Genus *Stromatoporella* Nicholson

Stromatoporella Nicholson, 1886, p. 92-95 (partim); Parks, 1936, p. 90-95; Lecompte, 1951, p. 152-160 (partim); Galloway, 1957, p. 436-437; Stearn, 1966a, p. 93-96; Kazmierczak, 1971, p. 86-87; Zupalova, 1971, p. 51; non Sleumer, 1968.

?*Pseudostromatoporella* Kazmierczak, 1971, p. 76-78.

Type species: *Stromatopora granulata* Nicholson, 1873, p. 94; see also St. Jean, 1977.

Remarks. Stearn (1966a) and St. Jean (1977) have discussed some of the previous disagreements among stromatoporoid taxonomists regarding the critical features of this genus; their conclusions are the basis for the identification of the species described below.

Part of the controversy over the diagnostic features of *Stromatoporella* is the nature, origin, and significance of the "voids", cellules, tubules, etc. in the microstructure of the laminae. Although similar to the cellular/microlaminar genera *Habrostroma* and *Syringostroma* described above, the cellules of *Stromatoporella* differ in the following ways:

1. Size; they are larger and with more clearly defined borders than the typical cellules of *Habrostroma* and *Syringostroma*.
2. Arrangement; they occupy the axial regions of the laminae giving rise to the tripartite and ordinacellular microstructures of Stearn (1966a), are less abundant and less regularly arranged in the pillars than in the laminae and are typically absent near the borders of the laminae, pillars and clothing tissue, if present (Pl. 7, fig. 1). In contrast, the cellules of *Habrostroma* and *Syringostroma* are not concentrated in or confined to the axes of the microlaminae (or laminae) and commonly are more abundant (and better preserved) near the pillar borders than in the microlaminae (Pl. 3, fig. 8).

This distinction between cellular/microlaminar tissue and tripartite/ordinacellular tissue became virtually the sole criterion used by Kazmierczak (1971) for establishment of his new genus *Pseudostromatoporella*. This genus appears to include species having ring-pillars, cellules, and microlaminae (Kazmierczak, 1971, p. 87), a combination unknown among the stromatoporoids from the North American craton as well as the other coenostea of *Stromatoporella* noted by Stearn (1966a, p. 93-96). Thus, all Detroit River and Columbus coenostea having true ring-pillars also have tripartite/ordinacellular laminae.

In his discussion of *Stromatoporella*, Lecompte (1951) regarded the microstructure as cellular and the genus as most closely related to *Stromatopora*, *Parallelopora*, and possibly *Syringostroma*. The present author examined two specimens identified by Lecompte as *Stromatoporella granulata* (MRHN 7449, 7454) and found the laminae to be tripartite (Pl. 7, Fig. 1) and ordinicellular, thus conforming to the microstructure of Nicholson's specimen BM(NH) 329 (see Stearn, 1966a, p. 15, figs. 6, 7 and St. Jean, 1977). However, the arrangement of the cellules in the Lecompte material is unlike that in *Stromatopora*, *Parallelopora*, or *Syringostroma* (as described above) and there is no evidence of microlaminae.

Minimum inside diameters of ring-pillars was measured in tangential sections having minimal amounts of thickening by clothing tissue (Figs. 21, 22). The thickness of the laminae, the diameter and spacing of the solid pillars, and the spacing of the ring pillars were not measured because preliminary study clearly indicated that the level of intra-coenosteal variation was so high for each of these variates that they are of doubtful taxonomic significance.

Some previous authors (e.g. Parks, 1936; Galloway and St. Jean, 1957) have used the relative abundance of solid vs. ring pillars as a taxonomic criterion at the species level. However, study of the distribution and relative abundance of these pillars among species of *Stromatoporella* in the Detroit River Group strongly suggests that ring pillars are only apparent in those areas of tangential sections cut about midway between adjacent laminae and that even in these places the proportions of solid and ring pillars is exceedingly variable and thus of very limited value for distinguishing between otherwise similar species.

In addition to the relatively more numerous and widely distributed coenostea of *Stromatoporella perannulata*, the rocks of the Detroit River Group contain a few coenostea of *S. sibleyense* (= *Anostylostroma sibleyense* Fagerstrom, 1962, p. 426-427) from the Anderdon Limestone south of Detroit (Locality G) and from the upper Detroit River Group near St. Mary's, Ontario (Locality 15110). Due to the unusual shapes of coenostea of this species, it is impossible to gather meaningful biometrical data for comparison with other species of *Stromatoporella*.

Still other species of *Stromatoporella* have been described by Nicholson (1873; 1892), Nicholson and Murie (1878), Parks (1936), and Galloway and St. Jean (1957) as well as herein from the Bois Blanc and Columbus Limestones in southwestern Ontario and northern Ohio. The validity of many of these species is uncertain until a restudy of the type material and larger topotypic samples has been completed. Until such time, the biostratigraphic importance of *Stromatoporella* in the vicinity of the Michigan Basin is severely limited.

***Stromatoporella perannulata* (?) Galloway and St. Jean**

Plate 7, figures 2-4

***Stromatoporella perannulata* Galloway and St. Jean, 1957, p. 142-144, pl. 9, figs. 3a, 3b.**

Description. Coenostea of variable size and shape from small, undulant lamellar crusts to larger, laterally expanded domes with low, poorly developed, irregularly arranged mamelons. Astorhizae absent. Latilaminae not prominent, 2 to 3 mm thick.

Vertical section. Tissue consisting of a reticulate net of prominent, broadly undulating laminae and short, non-superposed solid and ring pillars. Microstructure of laminae

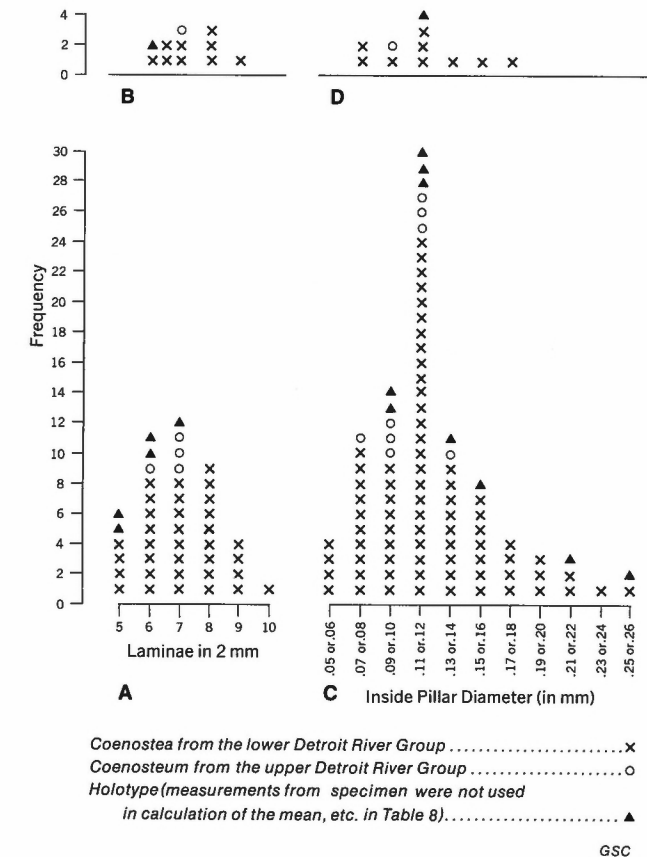


FIGURE 21A. Frequency distribution of 43 values for laminar spacing in 11 coenostea of *S. perannulata* (?).

FIGURE 21B. Frequency distribution of median values for laminar spacing for the same coenostea used in Figure 21A. Note that the same scale on the abscissa is used in Figures 21A and 21B.

FIGURE 21C. Frequency distribution of 90 values for minimum inside diameter of ring pillars (measured in tangential sections) from the same coenostea of *S. perannulata* (?).

FIGURE 21D. Frequency distribution of median values for inside diameter of ring pillars from the same coenostea used in Figure 21C. Note that the same scale on the abscissa is used in Figures 21C and 21D.

tripartite, ordinicellular, and transversely fibrous and porous. Laminae locally appear crenulate or wrinkled where they join ends of abundant, well-developed ring pillars; spaced 5 to 10 in 2 mm (see Fig. 21A), and are about 0.05 to 0.08 mm thick. Pillars include both solid and ring pillars in varying proportions; both types are spindle-shaped and spaced about 5 to 10 in 2 mm. Galleries large, laterally elongate where pillars are missing to square or sub-rectangular where pillars are closely spaced, and not superposed to form pseudozooidal tubes. Dissepiments rare to locally abundant where they resemble highly crenulate laminae. Astorhizal canals absent.

Tangential section. Laminae prominent, appear as wandering dark lines between mamelon columns and as concentric bands around mamelon columns. Mamelon

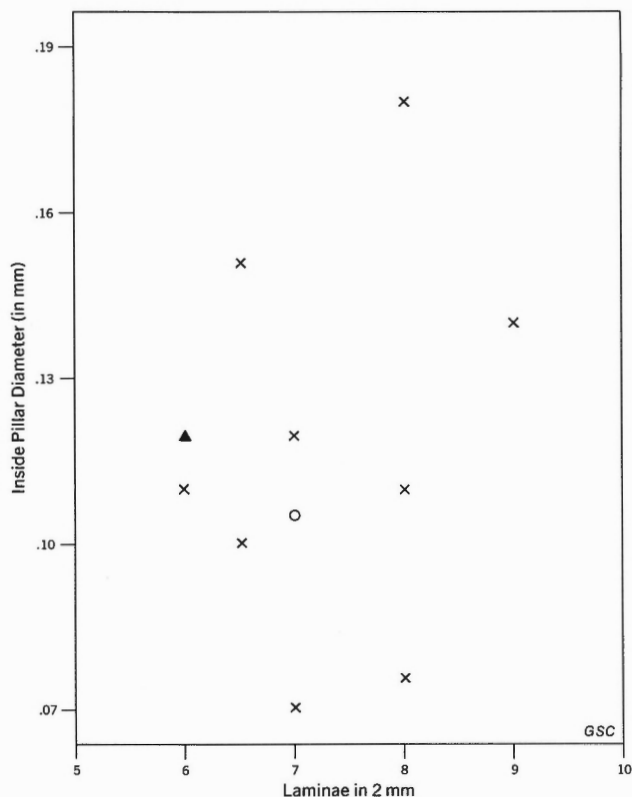


FIGURE 22. Relations between closeness of laminae and inside diameter of ring pillars (based on median values) from the same coenostea of *S. perannulata* (?) used in Figure 21A. Symbols same as for Figure 21.

columns large, poorly defined, irregularly spaced 4 to 11 mm apart centre-to-centre, averaging about 5 mm. Solid pillars large, round to oval, 0.05 to 0.17 mm in minimum diameter, typically more abundant than ring pillars. Ring pillars very large and prominent locally, consisting of a circular fibrous to porous wall and a central opening (lumen) ranging in minimum inside diameter from 0.05 to 0.26 mm (see Fig. 21C) depending on the thickness of the clothing tissue. Solid and ring pillars may be joined by dissepiments, or crenulate laminae in short vermicular chains. Astrorhizal canals absent.

Remarks. The presence or absence of mamelons is a moderately objective criterion that has been used in this and in other reports to distinguish between two closely related species of *Stromatoporella*: *S. perannulata* has mamelons and *S. eriensis* lacks mamelons.

Contrary to the original description of *S. perannulata*, the present author's examination of thin-sections from the holotype indicates that the presence of mamelons is uncertain; the same is true of some of the coenostea from the Detroit River Group questionably assigned below to this species. Thus, the taxonomic significance of the presumed difference between *S. perannulata* and *S. eriensis* is uncertain and should be tested further using large suites of topotypic material.

S. perannulata presumably differs from *S. cellulosa* (Nicholson and Murie) by having more closely spaced laminae and from *S. huronensis* (Parks) by having more closely spaced mamelons. Evaluation of the validity of these differences must also await future study of larger samples but the

relatively high level of variation in *S. perannulata* (Figs. 21A, B; Table 8) suggests that they are also doubtful features upon which to base different taxa.

The biometrical data of Figures 21, 22 and Table 8 suggest that there is only one species represented in the sample, that the inside diameter of the ring pillars is probably so highly variable as to be virtually useless as a taxonomic criterion, and that there is no correlation between the spacing of the laminae and the size of the ring pillars. Examination of several vertical sections indicates that the ring pillars are commonly spindle or funnel-shaped so that their apparent size in tangential sections is highly dependent upon the fortuitous location of sections between adjacent laminae.

Material and Occurrence. Holotype, USNM 127287, Jeffersonville Limestone near Louisville, Kentucky, collected by P. McGrain and F. Walker; hypotypes, UNSM 4729 and 4750, Formosa Reef Limestone, Loc. 23635, collected by P.J. Roper; hypotypes, GSC 60546-60554, Formosa Reef Limestone, Loc. 97215; hypotype, GSC 60555, 31.1 m below top of Detroit River Group, Loc. 15114. Hypotypes, GSC 60556 and 60557; 1 and 1.3 m, respectively, below top of lower Detroit River Group, Loc. 23566. Hypotypes, GSC 60558-60560; 1.3, 3.9 and 4.2 m, respectively, below top of lower Detroit River Group, Loc. 97210; hypotype, GSC 60562, Columbus Limestone (Zone H), Loc. VI.

***Stromatoporella eriense* (?) (Parks)**

Plate 7, figure 5

? *Strictostroma eriense* Parks, 1936, p. 81-83, pl. 5, figs. 1-4.

? *Stromatoporella eriensis* (Parks). Galloway and St. Jean, 1957, p. 145-147, pl. 10, figs. 2a, 2b.

Remarks. The chief difference between *S. perannulata* Galloway and St. Jean and *S. eriense* Parks as these two species are presently understood is the presence of poorly developed mamelons in the former and the absence of mamelons in the latter. In addition, the type material of *S. eriense* is domal to subhemispherical whereas Galloway and St. Jean (1957, p. 143) described their single specimen of *S. perannulata* as "massive" but failed to include the meaning of this term in their "Glossary" (p. 38-48).

The author collected four large, subhemispherical coenostea from the Columbus Limestone of northern Ohio that lack mamelons and are therefore tentatively assigned to *S. eriense*. Some of the coenostea have been replaced by chert; this replacement did not destroy the well-developed ring pillars but did destroy the tripartite microstructure of the laminae.

Material and Occurrence. Hypotype, GSC 60561, upper Detroit River Group, Loc. 23651; hypotype, GSC 60563, Columbus Limestone (Zone H), Loc. VII; hypotype, GSC 60564, upper Detroit River Group, Loc. VII; hypotype, GSC 60565, 6.5 m below top of Columbus Limestone, Loc. IX; hypotype, GSC 60566, probably from Columbus Limestone, Loc. IX.

***Stromatoporella sibleyense* (Fagerstrom)**

Anostylostroma sibleyense Fagerstrom, 1962, p. 426-427, pl. 66, figs. 1-7.

Emended Description. Microstructure of laminae tripartite, with light axial layer appearing fibrous in some coenostea. Ring pillars locally abundant and prominent.

Remarks. Except for the lack of mention of the microstructure of the laminae and recognition of the presence of ring pillars, the original description of this species is correct. The preservation of all available material is poor; laminae are typically recrystallized with accompanying destruction of the original tripartite microstructure and laminae, pillars, and ring pillars are covered by relatively thick layers of clothing tissue that has filled some ring pillars and reduced the diameter of the others so that the inside diameter is not a useful criterion for comparing this species with others of the same genus.

The chief features used to identify coenostea of this species are the irregular and "lumpy" external form of the coenostea, the presence of confluent laminae surrounding adjacent "lumps", and a relatively large axial region composed of poorly organized (amalgamate) tissue located inside two or more encircling laminae.

Material and Occurrence. Holotype, UNSM 1669 and paratypes UNSM 1670-1674, UMMP 43728, GSC 15960, Anderdon Limestone (Unit 4 of Ehlers, Stumm, and Kesling, 1951, p. 15), Loc. G; hypotype, GSC 60567, upper Detroit River Group, Loc. 15110.

Genus *Stictostroma* Parks

Stictostroma Parks, 1936, p. 77, 78; Galloway, 1957, p. 435, 436; Galloway and St. Jean, 1957, p. 124, 125; St. Jean, 1962.

Type species: *Stictostroma mamilliferum* Galloway and St. Jean (1957; see also discussion by Fagerstrom, 1977).

Stictostroma problematicum (?) - *Stictostroma anomalum* - *Stictostroma mamilliferum* "Species Group"

Plate 8, figures 6, 7

?*Clathrodictyon problematicum* Parks, 1904, p. 184, pl. 4, figs. 5, 6.

?*Stictostroma problematicum* (Parks). Parks, 1936, p. 88-90, pl. 5, figs. 7, 8, pl. 6, figs. 1-3; Fritz and Waines, 1956, p. 111-113, pl. 2, figs. 7-9.

Stictostroma anomalum Galloway and Ehlers, 1960, p. 86-88, pl. 9, figs. 1a, 1b. (Only the description and illustrations pertaining to UMMP 36085. UMMP 36077B and UMMP 36078 are probably species of *Anostylostroma*.)

?*Stromatopora mamillata* Nicholson, 1873, p. 94, 95, pl. 4, fig. 4; non Schmidt, 1858, p. 56.

Stictostroma mamillatum (Nicholson). Parks, 1936, p. 78-81, pl. 14, figs. 3-6.

Stictostroma mamilliferum Galloway and St. Jean, 1957, p. 125-127, pl. 6, figs. 4a, 4b (see also Fagerstrom, 1977).

Stictostroma mccannelli Fagerstrom, 1961a, p. 7, pl. 2, figs. 7-9.

Remarks. The rocks of the Bois Blanc Limestone and Detroit River Group contain numerous coenostea of *Stictostroma* having moderately to well-developed mamelons (e.g. *Stromatopora mamillata* Nicholson, 1873) irregularly arranged from 4 to 9 mm apart centre-to-centre, no astrorhizae or poorly developed astrorhizae with canals

confined to the axial regions of the mamelons, and laminae spaced from 6 to 14 in 2 mm. They constitute a reasonably homogeneous "group" and include type and other materials ascribed by previous authors to at least three and possibly five species of *Stictostroma* (see synonymy above).

The nature of the mamelons and astrorhizae in the holotype (ROM 2607 D) of *Stictostroma problematicum* is uncertain and much of the internal structure has been influenced by the presence of symbiotic corals. Nonetheless, it is apparent that this is a species of *Stictostroma* having about 6 to 8 laminae in 2 mm and may be conspecific with some coenostea from the lower and middle Detroit River Group. All coenostea of *Stictostroma* having mamelons, either poorly developed or no astrorhizae and median values of less than 8.5 for the number of laminae in 2 mm are here regarded as *S. problematicum* (?) (Figs. 23A, 23B and 24).

Galloway and Ehlers (1960) assigned four coenostea collected by Grabau from the Oakwood salt shaft (Appendix I, Locality H) "coral bed" (probably the Amherstburg Dolomite; see Fagerstrom, 1971, p. 88) to their new species, *S. anomalum*. After examination of these coenostea, the present author regards only one of them (UMMP 36085) as a species of *Stictostroma*; the other coenostea are so poorly preserved that identification of the genus is uncertain. Galloway and Ehlers (1960, p. 86) remarked that the laminae in UMMP 36085 are spaced "about 8 in 2 mm"; the median value for laminar spacing in this specimen is 9.5. Median values for coenostea here assigned to *S. anomalum* range from 8.5 to 10.5 in 2 mm (Figs. 23B and 24).

Coenostea of *S. mamilliferum* are common in the Bois Blanc Limestone? at Parks's (1936) presumed type locality (Fagerstrom, 1977) and have also been described by Galloway and St. Jean (1957, p. 125-127). Despite the fact that astrorhizae are presumed to be absent in this species, the larger sample collected by the present author from the same locality includes a few coenostea having astrorhizae confined to the axial regions of the mamelons as well as coenostea lacking astrorhizae. The spacing of the laminae in *S. mamilliferum* varies from 9 to 14 in 2 mm with median values greater than 10.5 (Fig. 23B).

The data of Figures 23A and 23B suggest that the distribution of values for laminar spacing may be polymodal and that this variate may be used for recognition of the three species noted above. The biologic significance of these divisions is uncertain but there is strong suggestion that the closeness of laminar spacing decreased progressively from the Bois Blanc? through the lower Detroit River, to the middle Detroit River. However, this may prove illusory because all the Bois Blanc? data are from one locality (Loc. 97212) and the data from the middle Detroit River are from one specimen. Conversely, the data from Figures 23C, 23D and 24 suggest that pillar spacing is of only limited value for taxonomic and biostratigraphic purposes.

Material and Occurrence.

A. The following coenostea are here assigned to *Stictostroma problematicum* (?) (Parks): hypotype, UMMP 36201, formerly a paratype of *S. mccannelli*, Formosa Reef Limestone, Loc. 23635; hypotype, UMMP 36203, formerly a paratype of *S. mccannelli*, Formosa Reef Limestone, Loc. 97213, collected by G.M. Ehlers; hypotype, UMMP 36204, formerly a paratype of *S. mccannelli*, Formosa Reef Limestone, Loc. 23635; hypotype, GSC 60532, Formosa Reef Limestone, Loc. 97215. Hypotypes, GSC 60533-60536; 3.9 m above and 3.9, 5.8 and 6.5 m below, respectively, the top of the lower Detroit River Group, Loc. 97210. Hypotype, GSC 60537, probably from the upper Detroit River Group, Loc. V.

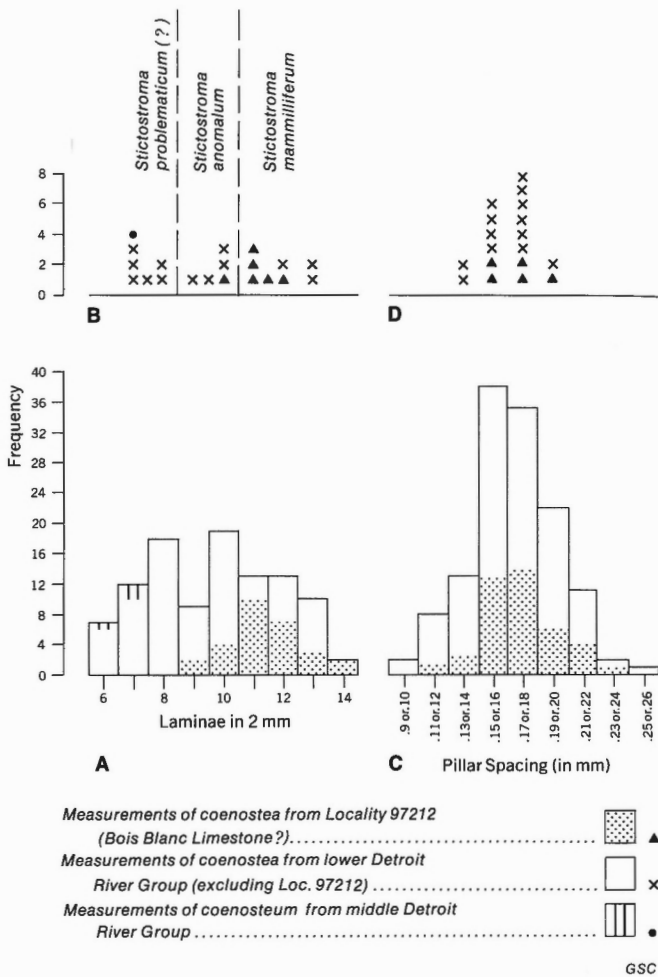


FIGURE 23A. Frequency distribution of 103 values for laminar spacing from 20 coenostea of the *S. problematicum* (?)–*S. anomalum*–*S. mamilliferum* "Species Group".

FIGURE 23B. Frequency distribution of median values for laminar spacing for same coenostea used in Figure 23A. Same scale on the abscissa used for Figures 23A, B.

FIGURE 23C. Frequency distribution of 132 values for pillar spacing from 18 coenostea of the *S. problematicum* (?)–*S. anomalum*–*S. mamilliferum* "Species Group".

FIGURE 23D. Frequency distribution of median values for pillar spacing for the same coenostea used in Figure 23C. Symbols same as Figure 23B. Same scale on abscissa used for Figures 23C, D.

B. The following coenostea are here assigned to *Stictostroma anomalum* Galloway and Ehlers: paratype, UMMP 36085, probably from the Amherstburg Dolomite, Loc. H, collected by A.W. Grabau; hypotype, UMMP 36205, formerly a paratype of *S. mccannelli*, Formosa Reef Limestone, Loc. 23635; hypotype, GSC 60538, 30.4 m below top of Detroit River Group, Loc. 15114; hypotype, GSC 60539, 6.1 m below top of lower Detroit River Group, Loc. 97210; hypotype, GSC 60540, upper Bois Blanc Limestone or lower Detroit River Group, Loc. 97212.

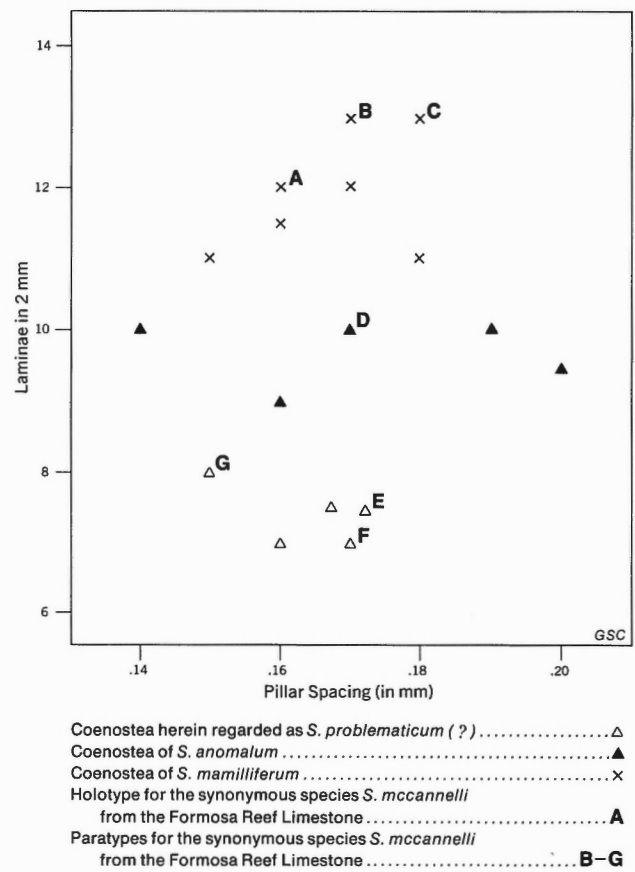


FIGURE 24. Relations between closeness of laminae and proximity of pillars (based on median values) for *S. problematicum* (?)–*S. anomalum*–*S. mamilliferum* "Species Group".

C. The following coenostea are here assigned to *Stictostroma mamilliferum* Galloway and St. Jean: syntypes, BM(NH) P5764 and P5766, probably from the Bois Blanc Limestone near Port Colborne, Ontario, collected by H.A. Nicholson, see Fagerstrom, 1977; hypotypes, USNM 127299 and GSC 60541–60544, either upper Bois Blanc Limestone or lower Detroit River Group, Loc. 97212; hypotypes, UMMP 36199, 36200 and 36202, Formosa Reef Limestone, Loc. 23635, these specimens were formerly the holotype and two paratypes of *Stictostroma mccannelli* Fagerstrom, 1961a.

Stictostroma longitubiferum Fagerstrom

Plate 8, figures 4, 5

Stictostroma longitubiferum Fagerstrom, 1961a, p. 7–8, pl. 1, figs. 8, 11.

Remarks. This species is characterized by the development of very conspicuous astrophorae (up to 0.4 mm in diameter) that are commonly but not always located near the centres of the mamelons; this feature is the only difference between *S. longitubiferum* and *S. problematicum* (?)–*S. anomalum* as described above (cf. Figures 23B and 25B). The original description of *S. longitubiferum* is correct in all essentials; however, the additional data on laminar spacing in Figure 25 are presented to provide information on the range and

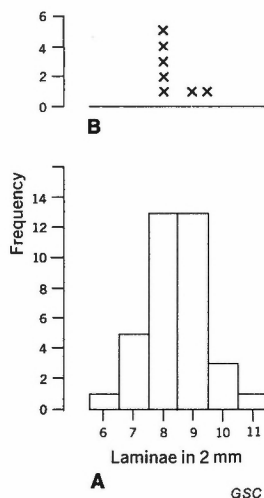
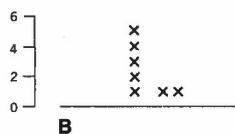


FIGURE 25A. Frequency distribution of 36 values for laminar spacing from 7 coenostea of *S. longitubiferum* from Locality 23635.

FIGURE 25B. Frequency distribution of median values for laminar spacing for the same coenostea used in Figure 25A. Note that the same scale on the abscissa is used in both figures.



variation in this variate. Comparable data on the centre-to-centre, nearest neighbor spacing of pillars was not gathered during the biometrical phase of the study of *S. longitubiferum* because previous experience with this variate during study of the *S. problematicum* (?)–*S. anomalum*–*S. mamilliferum* "Species Group" indicated that it was not an important taxonomic criterion for the identification of species of *Stictostroma* in the Detroit River Group (Table 8).

Collection of additional coenostea, not available during the initial study of the Formosa Reef fauna (Fagerstrom, 1961a) clearly indicates that the laminae are both tripartite and porous which are essential features of the genus *Stictostroma*.

Material and Occurrence. Holotype, UMMP 36207; paratypes, UMMP 36208, 36209; hypotype, UMMP 36201, formerly a paratype of *S. mccannelli* Fagerstrom, 1961a; hypotypes, UNSM 4715, 4718, 4720, 4749, 4760, and 4768, collected by Paul J. Roper; all specimens from the Formosa Reef Limestone at Loc. 23635. Hypotype, GSC 60545, 30.7 m below top of Detroit River Group, Loc. 23564.

Stictostroma sp.

Remarks. The rocks of the Lower Detroit River Group at Locality 97210 also contain coenostea of one or more species of *Stictostroma* that appear to differ from *S. problematicum* (?) and *S. anomalum*, as described above, only by lacking mamelons. Median values for laminar spacing vary from 8 to 10 in 2 mm and astrorhizae are either absent or poorly developed.

However, correct determination of the presence or absence of mamelons is indeed difficult in these coenostea because they occur in dense biostromal limestone from which large coenosteal surfaces are almost impossible to prepare for study. Furthermore, in coenostea having large, low,

widely spaced mamelons it may be impossible to distinguish these features in tangential sections from other irregular undulations of the laminae.

Thus, interpretation of the taxonomic significance of the nature (size; spacing) of the mamelons in some coenostea of *Stictostroma* and their absence in others must await the study of much larger samples than are presently available. Review of the current literature on species of *Stictostroma* from Devonian rocks of the North American craton suggests that the five coenostea noted here may be the only ones lacking mamelons with the possible exception of one coenosteam described by Birkhead and Fraunfelder (1973, p. 1072-1073) as *Stictostroma vacuolatum* from rocks of post-Detroit River and post-Columbus age in southeastern Missouri.

Material and Occurrence. GSC 61331-61335; 0.6, 2.6, 3.9, 4.5 and 4.5 m, respectively, below top of lower Detroit River Group, Loc. 97210.

Genus *Trupetostroma* Parks

Trupetostroma Parks, 1936, p. 52-55; Stearn, 1966a, p. 102-105.

Type species: *Trupetostroma warreni* Parks, 1936, p. 55-57, pl. 10, figs. 1, 2.

Trupetostroma (?) sp.

Pl. 7, figs. 6, 7

Description. Coenosteal shape uncertain, possibly subcylindrical to subconical; size varies from small to large irregular masses. Mamelons, astrorhizae, latilaminae and perithecium absent to poorly developed.

Vertical section: Tissue consisting of a reticulate network or grid of clearly defined, continuous laminae and strongly superposed, prominent pillars. Laminae ordinaricellular to tripartite, transversely porous to fibrous, about 0.07 to 0.09 mm. thick excluding clothing tissue of variable thickness, and spaced about 5 to 7 in 2 mm. (Fig. 26A). Mamelons absent to poorly developed, not forming continuous columns. Pillars superposed through 3 to 8 laminae, spool-shaped between laminae; composed of moderately dense, uniformly "speckled" to flocculent or transversely fibrous tissue, and spaced about 4 to 8 to 2 mm. Galleries square to subrectangular to subcircular, some are vertically elongate and others are laterally elongate, superposed but not forming continuous pseudozooidal tubes. Dissepiments relatively rare, consisting of dense, dark, compact tissue about 0.02 to 0.04 mm. thick, and generally lacking clothing tissue. Astrorhizal canals absent to poorly developed, round to subelliptical and about 0.2 to 0.3 mm. in diameter.

Tangential section: Laminae generally appear as wandering irregular bands of moderately dense tissue. Pillars appear as relatively more dense, round to elliptical dots 0.1 to 0.3 mm. in diameter, spaced about 0.13 to 0.25 mm. apart (Fig. 26C) and not generally joined in vermicular chains. Laminae and pillars occupy about 60% to 80% of the area of the section. Mamelon columns and astrorhizae absent to poorly developed.

Remarks. *Trupetostroma* (?) appears to be endemic to the lower Detroit River Group in the Beachville area and is presently known from only three coenostea, each of which is encrusting a solitary rugose coral in an association suggestive of some level of symbiosis (sensu lato). Initially, the form of

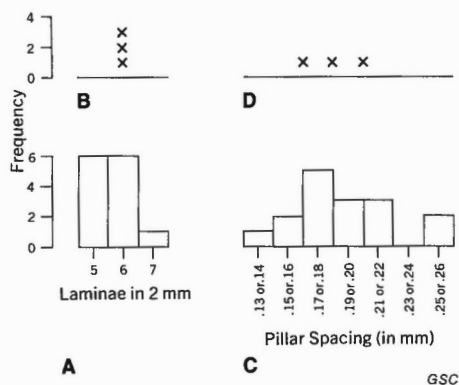


FIGURE 26A. Frequency distribution of 13 values for laminar spacing from 3 coenostea of *Trupetostroma* (?) sp., lower Detroit River Group, Locs. 15114 and 23566.

FIGURE 26B. Frequency distribution of median values for laminar spacing for the same coenostea used in Figure 26A. Same scale on the abscissa is used in Figures 26A and 26B.

FIGURE 26C. Frequency distribution of 16 values for pillar spacing for the same coenostea used in Figure 26A.

FIGURE 26D. Frequency distribution of median values for pillar spacing for the same coenostea used in Figure 26C. Same scale on the abscissa is used in Figures 26C and 26D.

the coenosteum was subconical with the laminae forming relatively smooth concentric layers around the coral but in the outer parts of the coenosteum the laminae tend to become highly contorted; the reason for contortion of these laminae is uncertain but apparently it is not the result of "foreign inclusions" in the stromatoporoid structure of either organic or inorganic origin. The degree of thickening of the laminae and pillars by addition of clothing tissue is highly variable and therefore has had considerable effect on the sizes and shapes of the adjacent galleries.

Although the biometrical data in Figure 26 are based on a very small sample, they clearly suggest that the spacing of the laminae is relatively less variable than the spacing of the pillars.

The microstructure of the coenostea here questionably referred to *Trupetostroma* differs from more typical species of the genus; although laminar foramina (not ordinicells) and pillar vacuoles (not cellulules) are present in the Detroit River materials these structures are rare and small. Previous authors have not reported *Trupetostroma* from the Detroit River Group or any of its correlative or adjacent rocks in the vicinity of the Michigan Basin (Fig. 1).

Material and Occurrence. Figured specimens: GSC 60568 and 60569, 29 and 32 m below top of the Detroit River Group, Loc. 15114, and GSC 60570, 1.3 m below top of lower Detroit River Group, Loc. 23566.

Group IV: Genus With Striated Microstructure

Stachyodes (?) sp.

Plate 6, figure 10

Remarks. The Detroit River stromatoporoid fauna also contains a few poorly preserved coenostea that are questionably referred to a species of *Stachyodes*. The chief difficulty

in identifying these specimens is the determination of the microstructure of the laminae and pillars. Stearn (1966a, p. 116-117) described the microstructure of *Stachyodes* as striated, due to the subparallel alignment of dark granules but Lecompte (1952, p. 298-302) regarded the tissue as compact or reticulate. Galloway and Ehlers (1960, p. 101-102) described the laminae and pillars as porous and lacking a dark median line; this microstructure is here regarded as diagenetic in origin and is present in many coenostea assigned above to the Genus *Amphipora*.

For the purposes of the present report the chief basis for assignment of coenostea to *Stachyodes* (?) sp. is the presence of one or two clearly defined rings of marginal laminae separated by pillars and galleries in distinction to coenostea of *Amphipora* in which the marginal tissue is amalgamate. Furthermore, in a few of the coenostea of *Stachyodes* (?) sp. there is some suggestion of striated microstructure.

Because of the small size of the sample of *Stachyodes* (?) sp. and the poor quality of preservation, no attempt has been made to formally describe this species, to name it, or to characterize the degree of morphological variation. However, it is important to note that the coenosteal diameter and axial canal diameter (if present) is essentially the same as for *Amphipora ramosa* (?) and *A. nattressi* and that some coenostea of *Stachyodes* (?) sp. lack a single axial canal; instead, they are composed of multiple axial canals that appear to diverge upward in longitudinal sections. Furthermore, coenostea of *Stachyodes* (?) sp., *Amphipora ramosa* (?) and *A. nattressi* may occur side-by-side in the same thin-section which suggests that the morphological differences between these taxa were not ecologically induced.

Material and Occurrence. GSC 61341, lowest 1 metre of Anderdon Limestone, Loc. 76000; GSC 61342 and 61343; 0.46 and 27.5 m, respectively, below top of the Detroit River Group, Loc. 15114; GSC 61345, lower Detroit River Group, 3.2 m above floor of quarry, Loc. 76001; GSC 61346, lower Detroit River Group, Loc. 15111.

BIOSTRATIGRAPHY AND CORRELATION

Introduction

This study attempted to determine which taxa or variants were most useful for the correlation of the Detroit River Group and adjacent rocks. It included careful determination (when possible) of the precise stratigraphic occurrence of nearly all specimens and the stratigraphic segregation of the morphometric data presented in most of the histograms and some of the scatter diagrams accompanying the formal systematic descriptions of the species. Unfortunately, no particular taxa or variants were discovered that are notable for their value in either local or regional correlation; i.e. the taxa either have stratigraphically extended range-zones or are very local in their distribution. Thus, all species, except two, known from the Bois Blanc and the Dundee/Delaware Limestones are also present in the Detroit River; however, the Bois Blanc and Dundee/Delaware faunas are totally different.

The nature, use and limitations of various similarity coefficients in ecology, biogeography and biostratigraphy have been discussed by Cheetham and Hazel (1969), Campbell and Valentine (1977), Fallaw (1977) and Flessa et al. (1978). In conformity with the usage of Campbell and Valentine (1977), the Jaccard and Simpson coefficients were calculated (Table 5) for several pairs of geographically,

TABLE 5

Similarity coefficients (Jaccard's below diagonal line; Simpson's above diagonal line) for selected stratigraphic and geographic occurrences of stromatoporoids described in the present report from the vicinity of the Michigan Basin

	Dundee/Delaware	Columbus	Type Anderdon	Upper Detroit R. (all locations)	Upper Detroit R. (Beachville)	Lower Detroit R. (all locations)	Lower Detroit R. (Beachville)	Type Formosa Reef	Formosa Reef (Loc. 97215)	Bois Blanc
Lower Dundee/Delaware		.33 (3)		.67 (3)						
Columbus (Ont.; N. Ohio)	.09 (11)		.33 (9)	.56 (9)		.56 (9)				
Type Anderdon		.17 (18)			.75 (4)		.78 (9)	.42 (12)		
Upper Detroit R. (Beachville)			.21 (14)				1.0 (4)			
Upper Detroit R. (all locations)	.13 (16)	.28 (18)				.73 (15)				
Lower Detroit R. (all locations)		.25 (20)		.55 (20)						.33 (6)
Lower Detroit R. (Beachville)			.39 (18)		.25 (16)			.64 (14)		
Type Formosa Reef			.24 (21)				.50 (20)		.67 (9)	
Formosa Reef (Loc. 97215)								.35 (17)		
Bois Blanc (all locations)						.11 (18)				

Note: Numbers in parentheses below Jaccard's coefficients are the values of $N_1 + N_2 - C$ where N_1 and N_2 are the number of species in the smaller and larger faunas respectively and C is the number of species in common. Numbers in parentheses below Simpson's coefficients are the values of N_1 .

stratigraphically or paleoecologically similar fossil assemblages (sensu Fagerstrom, 1964, p. 1198) from the Bois Blanc, Detroit River, Columbus and Dundee/Delaware which will be compared and discussed below. As noted by Campbell and Valentine (1977), these particular coefficients represent extreme levels of similarity; other coefficients will generally fall between Simpson's (produces high values) and Jaccard's (produces low values).

Local Biostratigraphy

Bois Blanc Limestone

In the vicinity of the Michigan Basin stromatoporoids from undoubted Bois Blanc Limestone rocks have been described only from the vicinity of Mackinaw City, Michigan (Locality II, Appendix I and Locality D of Galloway and Ehlers, 1960, p. 81) where five species are recognized: three species of *Anostylostroma* (identified herein) and two species of *Stachyodes* (Galloway and Ehlers, 1960, p. 102-104). From east of the basin margin near Port Colborne, Ontario, Nicholson described *Stictostroma mamilliferum*, *Stromatoporella tuberculata* and *Anostylostroma laxum* from material probably collected from the Bois Blanc for a total of eight species of which only *S. tuberculata* has been identified from more than one locality (Parks, 1936, p. 107).

The three species from east of Gorrie, Ontario (Locality 97212, Appendix I) have been excluded from the above compilation because of the uncertainty as to whether they are from the upper Bois Blanc or lower Detroit River. The fauna includes *S. mamilliferum* and *S. anomalum* both of which are known elsewhere from both the Bois Blanc and Detroit River as well as *Habrostroma proxilaminata* which ranges from the lower Detroit River to the upper Dundee.

Detroit River Group: Beachville- Ingersoll Area, Ontario

The three enormous and actively growing quarries along the Thames River between Beachville and Ingersoll, Ontario (Localities 15114, 23566 and 97210, Appendix I) collectively include continuous exposures of remarkably pure limestone of nearly the complete Detroit River Group (total thickness = 36.1 m). The chemical data presented by Hewitt (1960, p. 149-151) suggest that the Bois Blanc - Detroit River contact is gradational and located at approximately the position of the quarry floor at Locality 97210 and both lithologic and paleontologic data clearly indicate that the Detroit River - Columbus contact is exposed at Locality 15114 (Ehlers and Stumm, 1951; Hewitt, 1960, p. 155-157).

A line joining the three large Thames River quarries noted above, as well as Locality 97211, is generally parallel to the regional dip into the Michigan Basin and the Chatham Sag (Fig. 1). Therefore, the approximate elevations of the top of the lower Detroit River Group at Localities 15114, 23566 and 97210 were used to determine that the magnitude of the regional dip of this surface is approximately 9.1 m per km (or 45 feet per mile), a figure somewhat higher than those noted by Caley (1941, p. 60), Hewitt (1960, p. 148) and Liberty and Bolton (1971, p. 72, 73) for southwestern Ontario.

To estimate the stratigraphic position of the thin outcrop of coral and stromatoporoid-rich grey limestone at Locality 97211 it was assumed that this locality was on the approximate line of maximum dip trending northeastward from Localities 15114, 23566 and 97210 and that the magnitude of the dip was uniformly 9.1 m per km. If one begins with the elevation of the outcrop at Locality 97211 (≈ 295 m) to its estimated stratigraphic position at Locality 97210, a distance of approximately 3.7 km, the estimated elevation of this horizon would be approximately 261 m ($3.7 \times 9.1 = 33.7$; $295 - 34 = 261$). This projected elevation at Locality 97210 is slightly below the elevation of the main coral/stromatoporoid biostrome (264 to 262 m) but nonetheless is so close that it is here concluded that all of the fossils from Locality 97211 are from the lower Detroit River Group. This conclusion is further supported by the fact that the similarity coefficients for comparison of Locality 97211 with the lower Detroit River fauna at Localities 15114, 23566 and 97210 are very high (Jaccard's = .47; Simpson's = .89) relative to the values listed in Table 5. Furthermore, the presence of *Prosserella* sp., a genus endemic to the Detroit River, and the absence of chert, a characteristic of the Bois Blanc, at Locality 97211 clearly indicates that this outcrop is Detroit River rather than Bois Blanc.

The only exposures of stromatoporoid-bearing rocks of the middle Detroit River are in the large Thames River valley quarries (Localities 15114, 23566 and 97210). These rocks are tan to grey limestone (grainstone of Dunham, 1962) and although stromatoporoids are present they are considerably less common and diverse than in the lower Detroit River Group (Fig. 27). The contact between the middle and upper Detroit River is gradational from grainstones below to grey *Amphipora*-rich limestone (mudstone of Dunham, 1962) above. The middle Detroit River is approximately 12.9 m thick and at Locality 15114 the upper Detroit River is approximately 16.2 m; at Localities 23566 and 97210 the top of the Detroit River is not exposed.

In the Thames River valley three stromatoporoid-based assemblage-zones can be recognized having vertical ranges coincident with the lower, middle and upper Detroit River lithostratigraphic units described above. In succession from the base to top these biostratigraphic zones are the *Anostylostroma columnare*, *Syringostroma sherzeri*(?) and *Amphipora nattressi* Assemblage-zones. Only *A. columnare* is confined to its local assemblage-zone (i.e. the assemblage-zone and range-zone are approximately coincident); elsewhere this species is present in the Bois Blanc and upper Detroit River. The zonal indices were chosen because they are relatively common in their respective zones but none of the Thames valley Detroit River Group assemblage-zones has great local or regional chronostratigraphic significance.

Stromatoporoids are also both abundant and diverse at another large active quarry located about 7.4 km north of Ingersoll (Locality 76001, Appendix I). Hewitt (1960, p. 158-160) described the exposed stratigraphic section consisting of 32.4 m of the Detroit River Group as "rather uniform in character" and lacking any "easily distinguishable

marker horizons, except for the lighter colored, medium crystalline, fossiliferous 8-foot (= 2.6 m) section at the base". He also tentatively correlated these lowest fossiliferous beds with the coral/stromatoporoid biostrome described above at Localities 15114, 23566 and 97210. Although the present author agrees with Hewitt's remarks, the basal fossiliferous beds were very poorly exposed when he visited the quarry in 1964 and therefore the stratigraphic position of specimens from Locality 76001 was determined in relation to the bench about 12.3 to 12.9 m above the quarry floor. In addition, stromatoporoids at Locality 76001 are neither as abundant nor as well preserved as those from the Thames River valley (Localities 15114, 23566, 97210) nor are the Thames valley lithostratigraphic and biostratigraphic units readily recognizable.

Detroit River Group: Formosa Area, Ontario

Fagerstrom (1961a, b) described the general stratigraphic and faunal relations of the exceedingly fossiliferous grey limestone (boundstone of Dunham, 1962) reefs in the vicinity of Formosa, Ontario. The data of the present report are based on much larger samples than those available in 1961 and thus provide a much better understanding of the levels of variation in most of the stromatoporoid taxa in the reef community. The most intense collecting effort both prior to and since 1961 was directed toward the type area of the Formosa Reef Limestone (Localities 23635 and 97216) where large fresh exposures are readily available. A less intense collecting effort was devoted to Locality 97215; the main purpose of this effort was to try to increase the size of the hypodigm for *Syringostroma columnare* (this was unsuccessful) and determine the level of similarity in the faunas of two (or more?) separate but closely adjacent reefs (Table 5). Not only are the taxonomic compositions of the reefs very dissimilar (Table 5) but the chief frame-building species are also unlike (*Anostylostroma laxum* at Locality 23635 and *Stromatoporella perannulata* at Locality 97215). These data clearly indicate that the distributions of the stromatoporoids is highly varied among closely spaced and presumably almost contemporaneous reef communities.

Detroit River Group: Amherstburg, Ontario-Trenton, Michigan Area

Although Ehlers, Stumm and Kesling (1951) reported stromatoporoids in the Detroit River Group in the large quarries west of Sylvania, Ohio (Locality A of Fagerstrom, 1971) repeated attempts to verify this report have resulted in failure.

By contrast, stromatoporoids are both abundant and varied from the Anderdon Limestone in its type area near Amherstburg, Ontario and Trenton, Michigan. The Anderdon was originally described as including a reef (Sherzer and Grabau, 1909) but during the period of 1956-1975 when the present author collected extensively at Localities G, K and 76000 no true reef boundstones (Dunham, 1962) were exposed in either the Anderdon or the adjacent rocks and in fact neither the Lucas Dolomite (below) nor the Dundee Limestone (above) were found to contain identifiable stromatoporoids. The Anderdon stromatoporoids at Locality G were first described by Fagerstrom (1962) and these data are here supplemented by the much more extensive data collected since 1962.

Linsley (1968, p. 351-360) originally described the very distinct differences in the Anderdon gastropod faunas from the closely adjacent quarries in the Amherstburg, Trenton

was intensively collected by the author (Localities 15114, 97217, 97218, V, VII and IX), only one locality yielded three species, one yielded two species and the others one each and, of the nine Columbus species, only two (possibly three) are present at more than one locality.

Dundee/Delaware Limestone

In contrast to their importance in the Detroit River Group and the Columbus Limestone, stromatoporoids are rare in the overlying Dundee and Delaware Limestones in the vicinity of the Michigan Basin. In the course of the field work for the present report less effort was expended in sampling the Dundee and Delaware than on the Detroit River and Columbus; nonetheless, the fact that only three species (*Habrostroma proxilaminata*, *Syringostroma densum* and *Pseudoactinodictyon stearni*; Fig. 28) from three quarries (Localities III, 23651, K) are presently known from the Dundee/Delaware rather clearly indicates a marked reduction in both abundance and diversity of stromatoporoids following their Detroit River/Columbus acme. All three Dundee/Delaware species are "hold-overs" from the upper Detroit River but only *Syringostroma densum* appears to be common to the Delaware and Columbus.

Summary and Conclusions

The data regarding the local biostratigraphic range-zones of the species described in this report are summarized in Figs. 27 and 28. Similarity coefficients (Jaccard's and Simpson's) comparing stratigraphically coeval units as well as stratigraphically disjunct units among several localities near the margins of the Michigan Basin are presented in Tables 5 and 6. These coefficients are strongly influenced by numerous factors including: collecting intensity, quality of the exposures and preservation of the coenostea. The author had no control over the latter two factors except that every known outcrop of the Detroit River Group in Ontario, Michigan, Ohio and Indiana was visited and sampled during the field phase of this study as well as nearly every outcrop of the Bois Blanc, Columbus and Dundee/Delaware in the areas of their contact with the Detroit River. To achieve uniformity in collecting intensity, effort was made to sample every stromatoporoid-bearing stratigraphic unit in proportion to the apparent abundance of coenostea. Thus, the "raw" biostratigraphic and biogeographic data are roughly comparable among the various localities which in turn lends additional validity to the following conclusions:

1. Although the levels of similarity in Table 5 are surprisingly low, they indicate that the Detroit River Group stromatoporoids are much more similar to those of the Columbus Limestone than to either the Bois Blanc or Dundee/Delaware Limestones.
2. Nearly all species occur in more than one lithostratigraphic unit (Fig. 28). However, *Syringostroma nodulatum* is an excellent index to Zone H of the Columbus Limestone and possibly the upper Detroit River in Ontario and northern Ohio and *Stictostroma longitubiferum* is confined to the lower Detroit River. Several other species are restricted to the Detroit River Group (lower + middle + upper; e.g. *Syringostroma pustulosum*, Fig. 28) and therefore have some value for purposes of regional correlation (see below). Thus, simple presence/absence data based on stromatoporoid species are of limited value for recognition of any of the rock-stratigraphic units studied herein.
3. Greatest similarities (Table 5) occur among the various rock-stratigraphic units within the Detroit River Group, especially between the biostromes of the lower and upper

Detroit River. The levels of similarity among presumably coeval units are no better than among units that are stratigraphically disjunct and reef-to-reef similarities are no better than those for reef-to-biostrome. Thus, the relative importance of environmental versus chronostratigraphic factors in influencing the distribution of stromatoporoid species is uncertain.

4. The type Formosa Reef Limestone is probably the chronostratigraphic equivalent of the lower Detroit River in the Beachville area which indirectly supports its previous correlation by Fagerstrom (1961a, p. 45; 1971, p. 59). However, Fagerstrom's (1962, p. 430; 1971, p. 70-71) suggestion that the Anderdon and Columbus may be correlative is not supported by the data of Table 5.
5. The *Amphipora nattressi* Zone (Fig. 27) is of uncertain value for correlation of the upper Detroit River Group. In the type area of the Anderdon Limestone it contains 13 species and is sharply distinct from the underlying Lucas Dolomite, which contains no identifiable stromatoporoids. In the vicinity of Beachville, Ontario, the *A. nattressi* Zone contains only 4 species, all of which are also present in the type Anderdon. Thus, the value of Simpson's similarity coefficient (Table 5) indicates perfect similarity whereas Jaccard's coefficient indicates relatively little similarity. It is important to note that using Jaccard's method for determining faunal similarity, the value of the coefficient is higher between the lower and upper Detroit River at Beachville than between the upper Detroit River at Beachville and the type Anderdon (Table 5). These discrepancies simply illustrate the caution that must be exercised when interpreting Simpson's coefficients when one of the samples has very low diversity. Of the total known stromatoporoid fauna from the upper Detroit River (16 species) only *Pseudoactinodictyon anderdonense* and *Stictostroma sibleyense* are confined to these rocks (Fig. 28); the former is known from only one coenosteam so is of virtually no biostratigraphic value and the latter from only two localities and is thus of very limited biostratigraphic value.

Regional Biostratigraphy

Introduction

Comparison of the Michigan Basin stromatoporoids described herein with other faunas is difficult. Although stromatoporoids are present (locally abundant) in carbonate rocks adjacent to the Michigan Basin and have been described by several previous authors, there are minimal data for most species regarding intra- or inter-coenosteal variation or detailed biostratigraphic occurrence and identifications have been based on examination of one or two small thin-sections. The very preliminary comparisons to be described below suggest that stromatoporoids will prove far less useful than conodonts (Orr, 1971), cephalopods (House, 1978, p. 12), brachiopods (Fagerstrom, 1971) and corals (Oliver, 1976) for regional correlation of the Detroit River Group and associated rocks. However, as yet none of these fossil groups has conclusively established the precise age and stratigraphic relations of the Detroit River; the very high level of endemism of the fauna is the chief obstacle to detailed correlation of the Detroit River both intra-basinally and regionally.

Stromatoporoids are neither abundant nor diverse in the Bois Blanc or the Dundee/Delaware Limestones in the Michigan Basin or the adjacent areas of the craton so no effort will be made to interpret the stratigraphic relations of these rocks on the basis of stromatoporoids. Conversely, the

Detroit River Group and its presumed correlatives from the James Bay Lowland to Kentucky and west to Missouri represent the Appalachian Faunal Province stromatoporoid acme-zone and are thus worthy of attention.

Columbus Limestone (central Ohio)

Galloway and St. Jean (1957, p. 79-81) listed the stromatoporoid species available to them from the Columbus Limestone at six localities in central Ohio. Of the seven species (*Anostylostroma substriatellum* = *A. laxum*) they recognized, three were new and sample sizes for all seven were small; two of the new species were each based on a single coenosteum.

As the present author has not examined these materials, detailed discussion of their similarity to Michigan Basin stromatoporoids would have to be based on published illustrations (some of which have been retouched and "stylized") and are thus of uncertain value. However, four of the seven listed species are present in the Detroit River Group.

Jeffersonville Limestone (southeastern Indiana and north-central Kentucky)

Many authors, including Perkins (1963) and Kissling and Lineback (1967) have noted the great abundance of stromatoporoids in the reefoid and biostromal limestones in the lower and middle Jeffersonville in its type region and Galloway and St. Jean (1957, p. 77-79) identified a total of 28 species (*Anostylostroma arvense* and *A. ponderosum* = *A. laxum*) from the Jeffersonville (undivided) at 14 localities. On Galloway and St. Jean's scale of rare, common and abundant, 19 species are rare at all localities where they were listed. Of their 28 species, 20 were new and of these, 12 were based on one coenosteum each and 5 were based on two coenosteum each. Again, the present author has not examined any of these materials; however, of the eight previously described species listed by Galloway and St. Jean, five are also present in the Detroit River Group and generally support the conclusion of Fagerstrom (1971) that the Detroit River and Jeffersonville are approximately correlative.

Amphipora Zone

Perkins (1963) informally named the rocks of the middle Jeffersonville Limestone in southeastern Indiana, the *Amphipora* zone "on the basis of the abundance of ramose stromatoporoid coenosteum". Although the present author has not examined Perkins's materials, his illustrations (Pl. 3, figs. 3, 4) suggest that this generic identification was probably correct and that both *A. ramosa* (?) and *A. nattressi* may be present. Furthermore, Perkins's Fig. 5 (p. 1344) indicates that ramose coenosteum are confined to his *Amphipora* zone. However, Galloway and St. Jean (1957, p. 77-79) list *Amphipora* as present at only one of their 14 collecting localities in the type region of the Jeffersonville.

Conkin and Conkin (1973) further discussed the distribution of *Amphipora* in the type Jeffersonville and largely on the basis of the coincidence of the *Amphipora* Range Zone and Acme Zone in these rocks, correlated their *Amphipora* Zone (by "inference" in some cases) to the lower Onondaga Limestone of New York, the type lower Bois Blanc Limestone, the Lucas Limestone at Beachville, Ontario and the Bellepoint Member of the Columbus Limestone in central Ohio, without serious consideration of the biostratigraphic significance of the other faunal elements of the zone.

In the Detroit River Group near Beachville, Ontario both *Amphipora ramosa* (?) and *A. nattressi* are abundant from near the base to its upper contact with the Columbus Limestone (Fig. 27). Consideration of the occurrence of

Detroit River and Jeffersonville brachiopods (Fagerstrom, 1971) strongly indicates that the Detroit River is correlative with much more of the Jeffersonville than just the *Amphipora* Zone and illustrate the pitfalls of regional correlations based on local range-zones and acme-zones.

Fagerstrom (1971, p. 6-8) reviewed the problems in using the local biostratigraphic zones in the type area of the Detroit River Group as established by Lane et al. (1909). The upper Detroit River Anderdon Limestone in this area is approximately coincident with their *Amphipora nattressi* Subzone and present data suggest that the Anderdon is the local range-zone and acme-zone of the Genus *Amphipora*. However, it is important to add that there is no evidence that this local range and acme is correlative with the entire Detroit River at Beachville, Ontario where *Amphipora* occurs in large numbers from virtually the base to the top. Thus, for local correlation within the Detroit River as well as regional correlation between the Detroit River and the Jeffersonville, the occurrence of *Amphipora* spp. is of very limited value (cf. Galloway and St. Jean, 1957, p. 235; Duncan in Cloud, 1959, p. 948). *Amphipora* is absent from the Grand Tower Limestone of Illinois and Missouri, a presumed near-correlative of the Detroit River, Columbus and Jeffersonville (see below).

Grand Tower Limestone (southern Illinois and southeastern Missouri)

Although stromatoporoids are neither abundant nor diverse in the Grand Tower Limestone, Birkhead (1967) and Birkhead and Fraunfelter (1973) have described four species. Two of these species (based on three coenosteum) are endemic to southeastern Missouri but the other two (*Anostylostroma laxum*; *Syringostroma sherzeri*) are abundant and widely distributed in the Detroit River Group and *A. laxum* is also present, but rare, in the Columbus and Jeffersonville Limestones.

It is also interesting to note that of the 33 stromatoporoid species described from the Grand Tower and its presumed equivalent (lower Callaway Formation) in central Missouri (Birkhead, 1967; Birkhead and Fraunfelter, 1973) not one species is common to both areas and the vast majority of the species are apparently confined to a single collecting site.

Kwataboahagan Formation (Hudson Bay Lowlands)

Although stratigraphic and paleontologic studies in the Hudson Bay Lowland are still largely at the reconnaissance level, there is clear indication that rocks correlative with the Bois Blanc, Detroit River, Columbus and Dundee/Delaware are present (Martison, 1953, p. 29, 34, 37, Fig. 2; Wilson, 1953, p. 76, 78, 117-124). Furthermore, coral and stromatoporoid-rich reefs and biostromes are at least as important in the Lowlands Devonian rocks as in the vicinity of the Michigan Basin.

The earliest published report of stromatoporoids from the Hudson Bay area was by Parks (1904); he described seven species (4 new) from rocks (unnamed) exposed in the lower reaches of the Kwataboahagan River that he correlated with the "Upper Helderberg" (= Bois Blanc + Onondaga Limestones) of New York. Wilson (1953, p. 72, 73) identified two other species (none new) from reefs exposed by the Abitibi River at Coral Rapids and by the Mattagami River at Grand Rapids and Fritz and Waines (1956) described an additional 14 species (12 new) from Coral Rapids. Both Wilson and Fritz and Waines referred their fossils to the upper part (overlying the gypsum) of the Abitibi River Formation (Fig. 29) which Wilson correlated with the Detroit River Group in the area of the Michigan Basin. More recently Sanford, Norris and

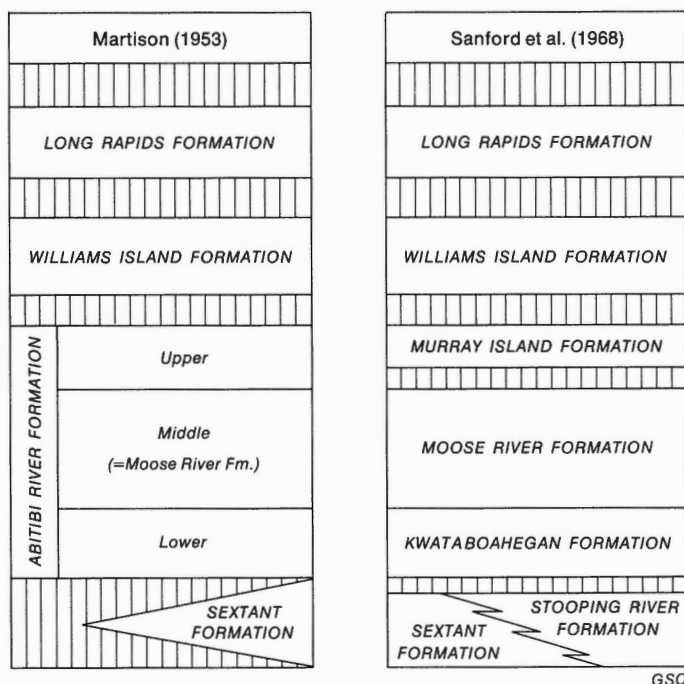


FIGURE 29. Comparison of lithostratigraphic terminology for Devonian rocks in the Hudson Bay Lowlands used by Martison (1953) and Sanford et al. (1968). The Moose River Formation (or Middle Abitibi River) consists of interbedded limestone, dolomite and gypsum. The Upper Abitibi River consists of reefs and biostromes from which the fossils described by Fritz and Waines (1956) were collected. The Kwatabohegan Formation is regarded by Sanford et al. as synonymous with the Upper Abitibi River and is the probable source of the fossils described by Parks (1904). Thus, Martison (1953) and Sanford et al. (1968) disagree regarding the stratigraphic position of the stromatoporoid-bearing rocks with respect to the gypsiferous Moose River Formation.

Bostock (1968) studied the rock succession near Coral Rapids and concluded that the fossiliferous reefs underlie the gypsiferous limestone, abandoned the Abitibi River Formation as a lithostratigraphic unit and proposed the new names Kwatabohegan (type section located in the vicinity of Parks's 1904 fossil collection) and Moose River Formations (Fig. 29). The Kwatabohegan also includes the Coral Rapids and Grand Rapids reefs and the Moose River includes the conformably overlying unfossiliferous limestone and gypsum; Sanford, Norris and Bostock (1968) correlated the Kwatabohegan with the Amherstburg and the Moose River with the Lucas Formation of the Detroit River Group.

Of the seven species described by Parks (1904), six were based on one coenosteum each; Parks did not indicate the number of specimens upon which he based the new species *Syringostroma aurora*. The present author has studied the type material for *Clathrodictyon laxum* (= *Anostylostroma laxum* of the present report), *Actinostroma moosensis* (= *Clathrodictyon moosense proximale* Parks, 1936; = *Anostylostroma columnare* of this report) and *Clathrodictyon problematicum* (may be synonymous with *Stictostroma problematicum* (?) of this report). The morphology and taxonomic status of each of these species was also discussed by Parks (1936). The types of Parks's (1904) other Hudson Bay Lowland species and the specimens

identified by Wilson (1953) were not examined in conjunction with the present study so their value in correlation is uncertain. However, on the basis of the data presented by Fritz and Waines (1956, Table 8) on *Syringostroma aurora* Parks (1904, p. 182-183) it appears highly probable that it is a synonym of *Syringostroma nodulatum* Nicholson (1875; and the present report). In addition, there is no evidence that either Parks or Wilson examined the type specimens of the previously described species to which they ascribed their materials, and the original descriptions of each of these species are very incomplete.

In their summarization of the stromatoporoid fauna at Coral Rapids, Fritz and Waines (1956, p. 115) noted that "the genus *Syringostroma* is the most abundantly represented" and of their 12 new species, 5 belong to this genus. *Syringostroma* is also the most abundant and diverse taxon in the Detroit River Group and as will be shown below, there is a very strong species-level resemblance between the Coral Rapids and Detroit River faunas.

The author has examined the type specimens of the following Fritz and Waines (1956) species, compared them with material described herein from the Detroit River Group and reached the following conclusions:

1. *Syringostroma recticolumnae* is a synonym of *S. sherzeri* (?). See Fig. 3.
2. *Syringostroma crebricolumnae* is probably a synonym of *S. densum*. The spacing of the microlaminae in the holotype of *S. crebricolumnae* is uncertain due to poor preservation.
3. *Syringostroma distincticolumnae* is probably a synonym of *S. pustulosum*. The diameter (median = 0.435 mm; \bar{X} = 0.45 mm; N = 10) and spacing (median = 0.70 mm; \bar{X} = 0.73 mm; N = 6) of the megapillars in the holotype are slightly greater than is typical for *S. pustulosum*. See Fig. 3.
4. *Actinostroma parksi* is probably a synonym of *Syringostroma nodulatum*. The mamelons of *S. nodulatum* appear to be higher and more uniformly spaced than those of the holotype of *A. parksi*.
5. *Syringostroma aurella* appears to be absent from the Michigan Basin (cf. Galloway and Ehlers, 1960, p. 93-95) and the significance of the morphologic differences between holotypes of *S. aurella* and *S. aurora* cited by Fritz and Waines is uncertain due to small sample size for each species. *S. aurella* is most similar to *S. nodulatum* but has more closely spaced mamelons and larger megapillars (median = 0.26 mm; \bar{X} = 0.27 mm; N = 9) than is typical for *S. nodulatum*. See Fig. 3.
6. *Stromatopora gallowayi* appears to be absent from the Michigan Basin; the size (median and \bar{X} = 0.22 mm; N = 9) and spacing (median = 0.27 mm; \bar{X} = 0.29 mm; N = 9) of the megapillars are most similar to *Syringostroma nodulatum* (Fig. 3) but *S. gallowayi* lacks mamelons.
7. *Stromatopora saintjeani* has microlaminae spaced similarly to those of *Habrostroma densilaminata* (median = 10 in 2 mm; \bar{X} = 10.4 in 2 mm; N = 5) and mamelons spaced similarly to *H. proxilaminata* (median = 9.5 mm; \bar{X} = 9.7 mm; N = 3). See Figs. 6 and 7.
8. *Stictostroma problematicum* is a synonym of *Anostylostroma laxum*. The microstructure of the laminae is fibrous to porous (not tripartite, ordinaricellular as in *Stictostroma*), mamelons are absent and the laminae are spaced about 6 to 7 in 2 mm. The presence of "caunopore tubes" (= symbiotic auloporoid corals) has no importance for identification of this species.

9. *Stictostromella bifidapila* is a species of *Stictostroma* that is characterized by upwardly dividing (bifid) pillars that resemble ring-pillars in tangential section. This species is absent in the vicinity of the Michigan Basin. The vertical section of the holotype also contains cross-sections of coenostea of both *Amphipora ramosa* (?) and *A. nattressi* not mentioned by Fritz and Waines (1956).
10. *Clathrodictyon regulare* is a species of *Anostylostroma* having more closely spaced laminae (median = 11 in 2 mm; \bar{X} = 11.6 in 2 mm; N = 7) than any species of *Anostylostroma* in either the Bois Blanc, Detroit River, Columbus or Dundee/Delaware in the Michigan Basin; the nature of the mamelons (if present) is unknown to this author.
11. *Stictostromella crebrapila* is a species of either *Stictostroma* or *Anostylostroma*. The vertical section of the holotype is oblique and the laminae and pillars are distorted by repair tissue so the section cannot be directly compared to material from the Michigan Basin.
12. The holotype of *Stylodictyon robustum* is very poorly preserved; Flügel and Flügel-Kahler (1968, p. 366) suggested that it might be a species of *Pseudoactinodictyon* but the presence of small areas of tripartite, ordincellular microstructure of the laminae more likely make it a species of *Stictostroma*.

If it is assumed that *Syringostroma nodulatum* Nicholson, *S. aurora* Parks and *Actinostroma parksi* Fritz and Waines are indeed synonymous, as suggested above, then it might logically follow that the Kwatabohegan Formation is correlative in the Michigan Basin only with the upper Columbus Limestone (Zone H) because *S. nodulatum* is confined to the Columbus there. However, such a correlation, based on the presumed synchronicity of the basal range-zone boundary of one species, runs counter to evidence from the other species common to the Kwatabohegan Formation and the Michigan Basin. Thus, the common occurrence of *Syringostroma sherzeri* (?), *S. pustulosum*, *Stictostroma problematicum* (?), *Amphipora ramosa* (?) and *A. nattressi* in the Kwatabohegan and the Detroit River Group more strongly suggests that these rocks are correlative and that the appearance of *Syringostroma nodulatum* in the Hudson Bay area merely preceded its appearance in the Michigan Basin. The other species common to Hudson Bay and the Michigan Basin (*Syringostroma densum*, *Anostylostroma laxum* and *A. columnare*) are relatively long-ranging in the latter area and therefore of less value for correlation.

The values of Jaccard's and Simpson's similarity coefficients (Table 7) lend further support to the above conclusion that the Kwatabohegan and Detroit River are coeval but the present faunal data are simply inadequate to either support or refute the suggestion of Sanford, Norris and Bostock (1968, p. 31 and Fig. 2) that the Kwatabohegan correlates only with the lower Detroit River Amherstburg Dolomite.

The values of the similarity coefficients in Table 7 are not directly comparable to those of Table 5 because of the enormous differences in the intensity of collecting and laboratory efforts directed toward their study. Thus, in view of these limitations as well as the general uncertainty of stromatoporoid-based local and regional correlations (noted above) the chronostratigraphic relations of the Hudson Bay Lowlands rocks suggested here can only be regarded as tentative.

TABLE 7

Jaccard's (left column) and Simpson's (right column) similarity coefficients for comparison of the stromatoporoid fauna of the Kwatabohegan Formation in the Hudson Bay Lowlands with selected lithostratigraphic units in the vicinity of the Michigan Basin.

	JACCARD'S	SIMPSON'S
Dundee / Delaware (Michigan; Ontario)	.062 (16)	.33 (3)
Columbus (Northern Ohio; Ontario)	.21 (19)	.445 (9)
Detroit River (all localities)	.26 (31)	.57 (14)
Bois Blanc (Michigan; Ontario)	.10 (20)	.29 (7)

Note: The following species identified by previous authors from the Hudson Bay Lowlands were omitted from the calculations because their taxonomic status is uncertain: *Syringostroma ristigouchense*, *Stromatopora tubulifera*, *Stictostromella crebrapila* and *Stylodictyon robustum*. Numbers in parentheses following Jaccard's coefficients are the values of $N_1 + N_2 - C$ where N_1 and N_2 are number of species in the smaller and larger faunas respectively and C is the number of species in common. Numbers in parentheses following Simpson's coefficients are the values of N_1 .

GSC

Onondaga Limestone (New York)

The correlation of the Detroit River Group and the Onondaga Limestone has been rather firmly established on the basis of both brachiopods (Fagerstrom, 1971) and corals (Oliver, 1976). Although Oliver (1954) reported the presence of stromatoporoids in reef facies of the lower Onondaga in western New York, there has been no systematic work done on these materials for comparison with the stromatoporoids described herein.

REFERENCES

- Abbott, B.M.
1973: Terminology of stromatoporoid shapes; *Journal of Paleontology*, v. 47, p. 805-806.
- Best, E.W.
1953: Pre-Hamilton Devonian stratigraphy, southwestern Ontario, Canada; *Geological Society of America, Bulletin*, v. 64, p. 1395.
- Birkhead, P.K.
1967: Stromatoporoidea of Missouri; *Bulletins of American Paleontology*, v. 52, p. 23-110.
- Birkhead, P.K. and Fraunfelter, G.H.
1973: Some Middle Devonian stromatoporoids from southern Illinois and southeastern Missouri; *Journal of Paleontology*, v. 47, p. 1069-1076. (See also *Journal of Paleontology*, v. 48, p. 414).
- Caley, J.F.
1941: Palaeozoic geology of the Brantford area, Ontario; *Geological Survey of Canada, Memoir* 226, 176 p.
1943: Palaeozoic geology of the London area, Ontario; *Geological Survey of Canada, Memoir* 237, 171 p.
- Campbell, C.A. and Valentine, J.W.
1977: Comparability of modern and ancient marine faunal provinces; *Paleobiology*, v. 3, p. 49-57.

- Carman, J.F.
1936: Sylvania Sandstone of northwestern Ohio; Geological Society of America, Bulletin, v. 47, p. 253-266.
- Cazier, M.A. and Bacon, A.
1949: Introduction to quantitative systematics; American Museum of Natural History, Bulletin, v. 93, p. 343-388.
- Cheetham, A.H.
1966: Cheilostomatous Polyzoa from the Upper Bracklesham Beds (Eocene) of Sussex; British Museum (Natural History), Bulletin, Geology, v. 13, p. 1-115.
1968: Morphology and systematics of the bryozoan Genus *Metrarabdotos*; Smithsonian Miscellaneous Collection, v. 153, p. i-121.
- Cheetham, A.H. and Hazel, J.E.
1969: Binary (presence-absence) similarity coefficients; Journal of Paleontology, v. 43, p. 1130-1136.
- Cloud, P.E.
1959: Paleoecology - retrospect and prospect; Journal of Paleontology, v. 33, p. 926-962.
- Cockbain, A.E.
1979: Intracoenosteal variation in a specimen of *Actinostroma*; Geological Survey of Western Australia, Annual Report for 1978, p. 87-89.
- Conkin, J.E. and Conkin, B.M.
1973: The *Amphipora ramosa* zone and its significance in Middle Devonian stratigraphy of east-central North America; Earth Research, v. 1, p. 31-40.
- Doheny, E.J., Droste, J.B., and Shaver, R.H.
1975: Stratigraphy of the Detroit River Formation (Middle Devonian) of northern Indiana; Indiana Geological Survey, Bulletin 53, 86 p.
- Dow, J.W.
1962: Lower and Middle Devonian limestones in north-eastern Ohio and adjacent areas; Ohio Geological Survey, Reports of Investigations 42, 67 p.
- Dunham, R.J.
1962: Classification of carbonate rocks according to depositional texture; in Ham, W.E. (ed.), Classification of carbonate rocks; American Association of Petroleum Geologists, Memoir 1, 279 p.
- Ehlers, G.M. and Stumm, E.C.
1951: Middle Devonian Columbus Limestone near Ingersoll, Ontario, Canada; American Association of Petroleum Geologists, Bulletin, v. 35, p. 1879-1888.
- Ehlers, G.M., Stumm, E.C., and Kesling, R.V.
1951: Devonian rocks of southeastern Michigan and northwestern Ohio; Geological Society of America Field Trip Guidebook (Detroit), 40 p.
- Fagerstrom, J.A.
1961a: The fauna of the Middle Devonian Formosa Reef Limestone of southwestern Ontario; Journal of Paleontology, v. 35, p. 1-48.
1961b: Age and stratigraphic relations of the Formosa Reef Limestone (Middle Devonian) of southwestern Ontario, Canada; Geological Society of America, Bulletin, v. 72, p. 341-350.
1962: Middle Devonian stromatoporoids from south-eastern Michigan; Journal of Paleontology, v. 36, p. 424-430.
1964: Fossil communities in paleoecology: their recognition and significance; Geological Society of America, Bulletin, v. 75, p. 1197-1216.
1967: Stratigraphic and paleogeographic significance of the Holland Quarry Shale (Lower Devonian), northwestern Ohio; Geological Society of America, Bulletin, v. 78, p. 1185-1190.
1971: Brachiopods of the Detroit River Group (Devonian) from southwestern Ontario and adjacent areas of Michigan and Ohio; Geological Survey of Canada, Bulletin 204, 112 p.
1977: The stromatoporoid Genus *Stictostroma* Parks, 1936: its type species, type specimens and type locality; Journal of Paleontology, v. 51, p. 416-419.
- Fagerstrom, J.A. and Saxena, K.M.L.
1973: Intracoenosteal variation in a Devonian stromatoporoid; Lethaia, v. 6, p. 155-162.
- Fallow, W.C.
1977: Trends in trans-North Atlantic commonality among Phanerozoic invertebrates, and plate tectonic events; Geological Society of America, Bulletin, v. 88, p. 62-66.
- Fischbuch, N.R.
1970a: *Amphipora* and *Euryamphipora* (Stromatoporoidea) from the Devonian of western Canada; Palaeontology, v. 13, p. 64-75, pls. 14-17.
1970b: Devonian reef-building stromatoporoids from western Canada; Journal of Paleontology, v. 44, p. 1071-1084.
- Flessa, K.W. and Miyazaki, J.M.
1978: Trends in trans-North Atlantic commonality among Phanerozoic invertebrates, and plate tectonic events: discussion and reply; Geological Society of America, Bulletin, v. 89, p. 476-480.
- Flügel, E.
1958: *Pseudoactinodictyon* n. gen. und *Actinodictyon* Parks (Stromatoporoidea); Senckenbergiana Lethaea, v. 39, p. 135-151.
- Flügel, E. and Flügel-Kahler, E.
1968: Stromatoporoidea (Hydrozoa palaeozoica); Fossilium Catalogus 1: Animalia, pars 115, 116, 681 p., W. Junk, Gravenhage.
1975: Stromatoporen aus dem Unteren Kohlenkalk (Tn 1b, Strunium) von Aachen; Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, v. 149, p. 1-38.
- Fritz, M.A. and Waines, R.H.
1956: Stromatoporoids from the upper Abitibi River Limestone; Geological Association of Canada, Proceedings, v. 8, p. 87-126.

- Galloway, J.J.
1957: Structure and classification of the Stromatoporoidea; *Bulletins of American Paleontology*, v. 37, no. 164, p. 341-480.
- 1960: Devonian stromatoporoids from the Lower Mackenzie valley of Canada; *Journal of Paleontology*, v. 34, p. 620-636.
- Galloway, J.J. and Ehlers, G.M.
1960: Some Middle Devonian stromatoporoids from Michigan and southwestern Ontario; *University of Michigan Museum of Paleontology, Contributions*, v. 15, p. 39-120.
- Galloway, J.J. and St. Jean, J., Jr.
1957: Middle Devonian Stromatoporoidea of Indiana, Kentucky and Ohio; *Bulletins of American Paleontology*, v. 37, p. 29-308.
- Gardner, W.C.
1974: Middle Devonian stratigraphy and depositional environments in the Michigan Basin; *Michigan Basin Geological Society, Special Paper 1*, 138 p.
- Gingerich, P.D.
1974: Size variability of the teeth in living mammals and the diagnosis of closely related sympatric fossil species; *Journal of Paleontology*, v. 48, p. 895-903.
- Girty, G.H.
1897: A revision of the sponges and coelenterates of the Lower Helderberg Group of New York; *New York State Geologist, Annual Reports*, v. 14, p. 259-322.
- Goldfuss, G.A.
1826: *Petrefacta Germaniae*; v. 1, 76 p., 25 pls., Arnz & Co., Dusseldorf.
- Goudge, M.F.
1938: Limestones of Canada, part IV, Ontario; *Canada Department of Mines and Resources, Mines and Geology Branch*, no. 781, 362 p.
- Gould, S.J.
1974: The origin and function of "bizarre" structures: antler size and skull size in the "Irish Elk" *Megaloceras giganteus*; *Evolution*, v. 28, p. 191-220.
- Grabau, A.W. and Sherzer, W.H.
1910: The Monroe Formation of southern Michigan and adjoining regions; *Michigan Geological and Biological Survey, Publication 2, Geological Series 1*, 248 p., 32 pls.
- Hartman, W.D. and Goreau, T.E.
1970: Jamaican coralline sponges: their morphology, ecology and fossil representatives; *Zoological Society of London, Symposium 25*, p. 205-243.
- Hewitt, D.F.
1960: The limestone industries of Ontario; *Ontario Department of Mines, Industrial Mineral Circular 5*, 177 p.
- Hogg, N., Satterly, J., and Wilson, A.E.
1953: Drilling in the James Bay Lowland, pt. 1. Drilling by the Ontario Department of Mines; *Ontario Department of Mines, 61st Annual Report*, p. 115-140.
- House, M.R.
1978: Devonian ammonoids from the Appalachians and their bearing on international zonation and correlation; *Palaeontological Association, Special Papers in Palaeontology*, no. 21, 70 p.
- Janssens, A.
1968: Stratigraphy of Silurian and pre-Olenangy Devonian rocks of the South Birmingham pool area, Erie and Lorain Counties, Ohio; *Ohio Geological Survey, Reports of Investigations 70*, 20 p.
- 1970: Middle Devonian formations in the subsurface of northwestern Ohio; *Ohio Geological Survey, Reports of Investigations 78*, 22 p.
- Kaźmierczak, J.
1971: Morphogenesis and systematics of the Devonian Stromatoporoidea from the Holy Cross Mountains, Poland; *Palaeontologia Polonica 26*, 150 p., 41 pls.
- 1976: Cyanophycean nature of stromatoporoids; *Nature*, v. 264, p. 49-51.
- Kissling, D.L. and Lineback, J.A.
1967: Paleocological analysis of corals and stromatoporoids in a Devonian biostrome, Falls of the Ohio, Kentucky-Indiana; *Geological Society of America, Bulletin*, v. 78, p. 157-174.
- Landes, K.K.
1951: Detroit River Group in the Michigan Basin; *United States Geological Survey, Circular 133*, 23 p.
- Lane, A.C., Prosser, C.R., Sherzer, W.H., and Grabau, A.W.
1909: Nomenclature and subdivision of the upper Siluric strata of Michigan, Ohio, and western New York; *Geological Society of America, Bulletin*, v. 19, p. 553-556.
- Lecompte, M.
1951: Les stromatoporoides du Dévonien moyen et supérieur du Bassin de Dinant, Première partie; *Institut Royal des Sciences Naturelles de Belgique, Memoire 116*, 215 p., 35 pls.
- 1952: Les stromatoporoides du Dévonien moyen et supérieur du Bassin de Dinant, Deuxième partie; *Institut Royal des Sciences Naturelles de Belgique, Memoire 117*, p. 216-359, pls. 36-70.
- 1956: Stromatoporoidea, p. F107-F144. In R.C. Moore (ed.), *Treatise on Invertebrate Paleontology, Part F, Coelenterata*; *Geological Society of America and University of Kansas Press*.
- Liberty, B.A.
1966: Geology of Bruce Peninsula, Ontario; *Geological Survey of Canada, Paper 65-41*.
- Liberty, B.A. and Bolton, T.E.
1971: Paleozoic geology of the Bruce Peninsula area, Ontario; *Geological Survey of Canada, Memoir 360*, 163 p.
- Linsley, R.M.
1968: Gastropods of the Middle Devonian Anderdon Limestone; *Bulletins of American Paleontology*, v. 54, p. 333-465.

- Martison, N.W.
1953: Petroleum possibilities of the James Bay Lowland area; Ontario Department of Mines, 61st Annual Report, p. 1-58.
- Mayr, E.
1970: Populations, species, and evolution; Harvard University Press, Cambridge, Massachusetts, 453 p.
- Nestor, H.
1966: Wenlockian and Ludlovian Stromatoporoidea of Estonia; Eeste NSV teaduste akadeemia Geoloogia Instituut, Akadeemia nauk. Estonskoi SSR, Instituta geologii.
- Nicholson, H.A.
1873: On some new species of **Stromatopora**; Annals and Magazine of Natural History, 4th series, v. 12, p. 89-95, pl. 4.
1875: Descriptions of Amorphozoa of the Silurian and Devonian Systems; Geological Survey of Ohio, Report, v. 2, pt. 2, p. 245-255.
1886, 1889, 1891, 1892: A monograph of the British stromatoporoids. Palaeontographical Society of London, Monograph 39, 1886; 42, 1889; 44, 1891; 46, 1892, 234 p.
1887: On some new or imperfectly known species of stromatoporoids; Annals and Magazine of Natural History, ser. 5, v. 19, p. 1-17.
1891: On some new or imperfectly known species of stromatoporoids; Annals and Magazine of Natural History, ser. 6, v. 7, p. 309-328.
- Nicholson, H.A. and Murie, J.
1878: On the minute structure of **Stromatopora** and its allies; Journal of the Linnean Society, Zoology, v. 14, p. 187-246.
- Oliver, W.A., Jr.
1954: Stratigraphy of the Onondaga Limestone in central New York; Geological Society of America, Bulletin, v. 65, p. 621-652.
1976: Noncystimorph colonial rugose corals of the Onesquethaw and Lower Cazenovia stages (Lower and Middle Devonian) in New York and adjacent areas; United States Geological Survey, Professional Paper 869, 156 p.
- Orr, R.W.
1971: Conodonts from Middle Devonian strata of the Michigan Basin; Indiana Geological Survey, Bulletin 45, 110 p.
- Parks, W.A.
1904: Devonian fauna of Kwataboahagan River; Ontario Bureau of Mines, 13th Report, pt. 1, p. 180-191.
1908: Niagara stromatoporoids; University of Toronto Studies, Geological Series, v. 5, 68 p.
1909: Silurian stromatoporoids of America; University of Toronto Studies, Geological Series, v. 6, p. 1-52.
1936: Devonian stromatoporoids of North America, Part I; Toronto University Studies, Geological Series, no. 39, 125 p.
- Perkins, R.D.
1963: Petrology of the Jeffersonville Limestone (Middle Devonian) of southeastern Indiana; Geological Society of America, Bulletin, v. 74, p. 1335-1354.
- Phillips, J.
1841: Figures and descriptions of the Palaeozoic fossils of Cornwall, Devon, and West-Somerset; Longman, Brown, Green and Longmans, London, 231 p.
- Riding, R.
1974: Stromatoporoid diagenesis: outline of alteration effects; Geological Magazine, v. 111, p. 143-148.
- Rosen, F.B.
1867: Über die Natur der Stromatoporen und über die Erhaltung der Hornfasern der Spongien in fossilem Zustande; Verhandlungen der Russisch Kaiserlichen Mineralogischen Gesellschaft zu Saint Petersburg, ser. 2, v. 4, p. 1-98.
- Safford, J.M.
1869: Geology of Tennessee; S.C. Mercer, Printer to the State, Nashville, Tennessee, 285 p.
- St. Jean, J.
1962: Micromorphology of the stromatoporoid genus **Stictostroma** Parks; Journal of Paleontology, v. 36, p. 185-200.
1967: Maculate tissue in Stromatoporoidea; Micropaleontology, v. 13, p. 419-444.
1977: **Stromatoporella** Nicholson, 1886 (Fossil Order Stromatoporoidea): problem of the type-specimen of the type-species, **Stromatoporella granulata** (Nicholson), 1873; Bulletin of Zoological Nomenclature, v. 33, p. 233-240.
- Sanford, B.V.
1967: Devonian of Ontario and Michigan; International Symposium on the Devonian System, v. 1, p. 973-999, Alberta Geological Society, Calgary.
- Sanford, B.V. and Brady, W.B.
1955: Paleozoic geology of the Windsor-Sarnia area, Ontario; Geological Survey of Canada, Memoir 278 (supplement to Memoir 240).
- Sanford, B.V., Norris, A.W., and Bostock, H.H.
1968: Geology of the Hudson Bay Lowlands (Operation Winisk); Geological Survey of Canada, Paper 67-60, 45 p.
- Schmidt, F.
1858: Untersuchungen über die silurische Formation von Estland: Nord-Livland und Oesel; Archiv für Naturkunde Liv-, Est-, und Kurlands, ser. 1, v. 2, p. 1-248.
- Schulz, E.
1883: Die Eifelkalkmulde von Hillesheim, Nebst einem palaeontologischem Anhang; Jahrbuch der Preussischen geologischen Landesanstalt für 1882, 94 p.
- Shaver, R.H.
1974: The Muscatatuck Group (New Middle Devonian Name) in Indiana; Indiana Geological Survey, Occasional Paper 3, 7 p.

- Shearow, G.G.
1957: Geologic cross section of the Paleozoic rocks from northwestern to southeastern Ohio; Ohio Geological Survey, Reports of Investigation 33, 42 p.
- Shelden, F.D., et al.
1959: Geology of Mackinac Island and Lower and Middle Devonian south of the Straits of Mackinac; Michigan Basin Geological Society, Annual Geological Excursion, 63 p.
- Sherzer, W.H. and Grabau, A.W.
1909: New upper Siluric fauna from southern Michigan; Geological Society of America, Bulletin, v. 19, p. 540-553.
- Shiells, K.A.G.
1966: A new productid brachiopod from the Upper Viséan of Scotland; Palaeontology, v. 9, p. 426-447.
- Simpson, G.G.
1940: Types in modern taxonomy; American Journal of Science, v. 238, p. 413-431.
- Simpson, G.G., Roe, A., and Lewontin, R.C.
1960: Quantitative zoology (revised edition); Harcourt, Brace and Co., New York, 440 p.
- Sleumer, B.H.G.
1968: Gross structure and microstructure of **Stromatoporella granulata** (Nicholson, 1873) and their consequences on the definition of some Devonian stromatoporoid genera; Leidse Geologische Mededelingen, v. 43, p. 9-40.
1969: Devonian stromatoporoids of the Cantabrian Mountains (Spain); Leidse Geologische Mededelingen, v. 44, p. 1-136.
- Spencer, J.W.
1884: Niagara fossils: II. Stromatoporoidea of the Upper Silurian System; Museum of the University of the State of Missouri, Bulletin, v. 1, p. 43-52.
- Stauffer, C.R.
1909: The Middle Devonian of Ohio; Ohio Geological Survey, Bulletin 10, 204 p.
1915: The Devonian of southwestern Ontario; Geological Survey of Canada, Memoir 36, 341 p.
- Stearn, C.W.
1962: Stromatoporoid fauna of the Waterways Formation (Devonian) of northeastern Alberta; Geological Survey of Canada, Bulletin 92, p. 1-23.
- Stearn, C.W.
1966a: The microstructure of stromatoporoids; Palaeontology, v. 9, p. 74-124.
1966b: Upper Devonian stromatoporoids from southern Northwest Territories and northern Alberta; Geological Survey of Canada, Bulletin 133, p. 35-68.
1972: The relationship of the stromatoporoids to the sclerosponges; Lethaia, v. 5, p. 369-388.
1975: The stromatoporoid animal; Lethaia, v. 8, p. 89-100.
1977: Studies of stromatoporoids by scanning electron microscopy; Second International Symposium on Corals and Fossil Coral Reefs, Bureau des Recherches Géologiques et Minières, Paris, no. 89, 542 p.
- Wendt, J.
1975: Aragonitische Stromatoporen aus der alpinen Obertrias; Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, v. 150, p. 111-125.
- Wilson, A.E.
1953: A report on fossil collections from the James Bay Lowland; Ontario Department of Mines, 61st Annual Report, p. 59-81.
- Winchell, A.
1866: The Grand Traverse region.; Michigan Geological Survey, Dr. Chase's Steam Printing House, Ann Arbor, Michigan, Michigan Geological Survey, p. 83-97.
- Yang, J. and Dong, Y.
1979: Devonian stromatoporoids from central and eastern parts of Guangxi, China; Paleontologia Sinica, whole no. 157 (new ser. B, no. 14), 89 p.
- Yavorsky, V.I.
1931: Nekotorye devonskie Stromatoporoidea iz okrain Kuznetskogo Basseina, Urala i drugikh mest; Izvestiya Vsesoyuznogo geologii i razvedka, obed., v. 50, p. 1387-1415.
1955: Stromatoporoidea Sovetskogo Soyuza; Trudy, Vsesoyuznogo rachno issledovatel'skogo geologicheskogo instituta (Vsegie), Ministerstva Geologii i ohrani nedr, new ser., v. 8, 173 p.
- Zukalova, V.
1971: Stromatoporoidea from the Middle and Upper Devonian of the Moravian karst; Rozpravy Ustredniho ustavu geologického, v. 37, 143 p.

APPENDIX I

LOCALITY INDEX

Introduction

The following list of locality descriptions includes only those exposures from which the stromatoporoids described in this report were collected. They are arranged by major outcrop areas from southeastern Michigan northeastward into the peninsula of southwestern Ontario and northern Michigan and then to Pelee Island, Ontario, Kelleys Island and Marblehead, Ohio and northeastern Indiana; the Detroit River and adjacent rocks apparently contain no stromatoporoids in northern Michigan or northwestern and central Ohio. The scheme of locality designations is as follows:

- a. Capital letters for localities in the type region of the Detroit River Group (see Fagerstrom, 1971, p. 86-90).
- b. Arabic numbers for localities in Ontario; assigned by the Geological Survey of Canada and on file in Ottawa (see Fig. 30). Precise locations of many of these quarries and outcrops are indicated on the maps accompanying Caley (1941, 1943), Liberty (1966) and Liberty and Bolton (1971).
- c. Roman numerals for localities in the United States but not in the type region of the Detroit River Group (Fig. 31). (Roman numeral I has been omitted to avoid confusion with capital letter I.)

Localities

G. Solvay Process Co. quarry (= Sibley Quarry of Grabau and Sherzer, 1910), W½, sec. 7, T.4S., R.11E., Wayne Co., Michigan (Fig. 31). See Ehlers, Stumm and Kesling, 1951, p. 14-17; Fagerstrom, 1971, p. 86, 88.

H. Oakwood salt shaft, International Salt Co., Fort and Sanders Streets, Detroit Michigan (Fig. 31). See Fagerstrom, 1971, p. 86, 88.

I. Livingstone Channel in the bed of the Detroit River about 2 km west of Amherstburg, Ontario between Bois Blanc Island and the southern end of Grosse Isle. See Fagerstrom, 1971, p. 88, 89.

J. Amherstburg Channel in the Detroit River, directly north of Bois Blanc Island and northwest of Amherstburg, Ontario (Fig. 31). See Fagerstrom, 1971, p. 86, 89-90.

K. Brunner, Mond Canada, Ltd. quarry located about 2.8 km northeast of Amherstburg, Anderdon Tp., Essex Co., Ontario (Fig. 31). This is the same locality as the "Anderdon quarry" of Sherzer and Grabau (1909, p. 542) and of Grabau and Sherzer (1910). (See Hewitt, 1960, p. 164-167; Fagerstrom, 1971, p. 86, 90).

76000 Large active quarry of Amherst Quarries Ltd. on Pike Road, approximately 2.4 km southeast of Amherstburg; Lot 22, Con. III, Malden Tp., Essex Co., Ontario (Fig. 31). The stratigraphic section on the south wall of the quarry consists of approximately 11.3 m of brown Lucas Dolomite overlain by 1.3 m of grey Anderdon Limestone (see Goudge, 1938, p. 219; Hewitt, 1960, p. 168); the contact is non-gradational.

15114 Large active quarry of the Chemical Lime, Ltd., approximately 2.4 km northeast of Ingersoll, North Oxford Tp., Oxford Co., Ontario (Fig. 30). (See Ehlers and Stumm, 1951, p. 1881; Hewitt, 1960, p. 155-157).

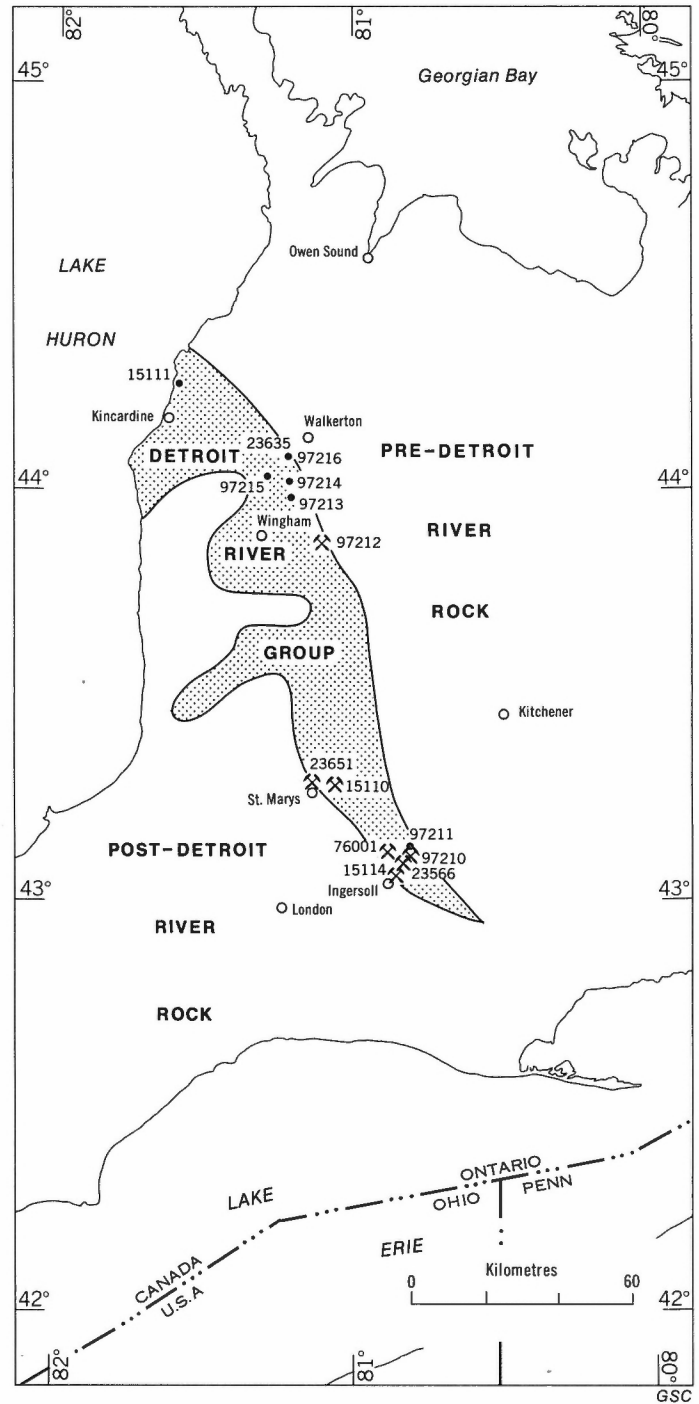


FIGURE 30. Index map showing localities in southwestern Ontario from which specimens described in this report were collected during the summers of 1957, 1958, 1963, 1964, 1966, 1968, 1973 and 1977. (Modified from Hewitt, 1960, Map No. 1960c.)

23566 Northwest corner of large active quarry of the North American Cyanamid, Ltd. approximately 3.2 km southwest of Beachville, North Oxford Tp., Oxford Co., Ontario (Fig. 30). (See Caley, 1941, p. 52; Hewitt, 1960, p. 152-154.) In 1977 this quarry operated by Beachvillime Ltd. (subsidiary of DOFASCO).

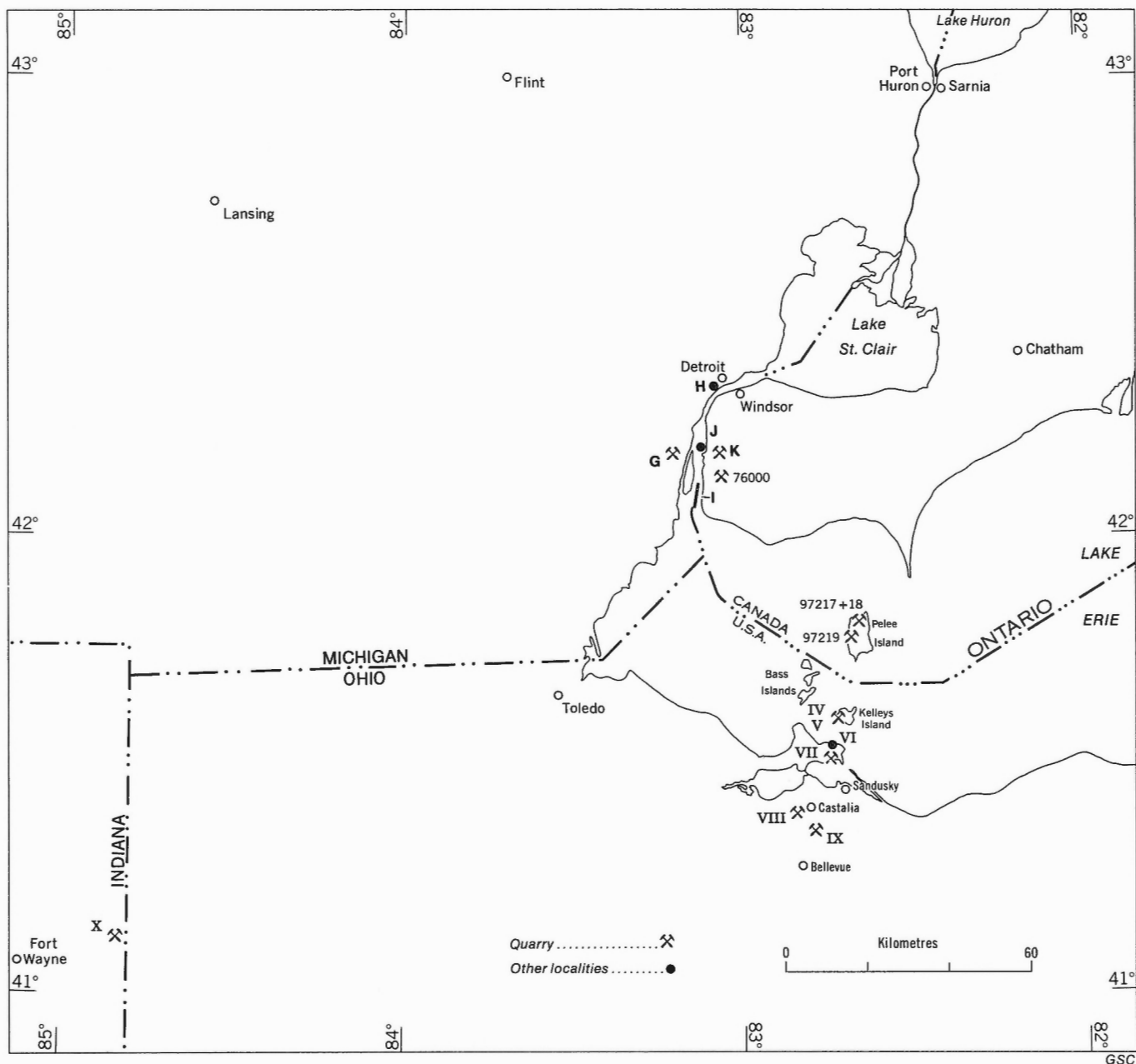


FIGURE 31. Index map showing localities in Lake Erie, north-central Ohio, southeastern Michigan and eastern Indiana, from which specimens described in this report were collected during the summers of 1963, 1964, 1966, 1968, 1973, 1974 and 1975.

- 97210 Large active quarry of the Gypsum, Lime, and Alabastine Ltd. (Dominion Tar and Chemical Co., Ltd.), approximately 2.4 km southwest of Beachville; Lots 17, 18, Con. II, North Oxford Tp., Oxford Co., Ontario (Fig. 30). (See Goudge, 1938, p. 260-263; Hewitt, 1960, p. 149-151; Oliver, 1976, p. 144-145, locality C27).
- 97211 Small abandoned quarry adjacent to abandoned lime plant of the Toronto Cement Corp., approximately 1.1 km northeast of Beachville; Lot 23, Con. I, North Oxford Tp., Oxford Co., Ontario (Fig. 30). When visited by the author in 1957 and 1964 the exposed section consisted of about 0.6-1 m of coral and stromatopoid-rich limestone near the base of

the Detroit River Group. The adjacent quarry floor included piles of quarried rock also containing abundant corals and stromatopoids and one specimen of *Prosserella* sp., a brachiopod characteristic of the Detroit River Group. (See Goudge, 1938, p. 260.)

- 76001 Large active quarry of Canada Cement Co., Ltd., approximately 5.6 km south of the village of Embro; Lots 2 and 3, Con. III, West Zorra Tp., Oxford Co., Ontario (Fig. 30). (See Hewitt, 1960, p. 158-160).
- 23651 Small abandoned quarry of the Standard White Lime Co., in St. Marys; Lot 16, Con. XVIII, Blanshard Tp., Perth Co., Ontario (Fig. 30). This locality is

- synonymous with Locality III of Caley (1943, p. 38). The stratigraphic section was briefly described by Goudge (1938, p. 274).
- 15110 Small, abandoned quarry (contains water) formerly operated by the Standard White Lime Co., approximately 4 km northeast of St. Marys; Lot 6, Con. XIV, Downie Tp., Perth Co., Ontario (Fig. 30). About 1.6 m of the (upper?) Detroit River Group are exposed.
- 97212 Small abandoned quarry on the north bank of the Maitland River, Lot 12, Con. VIII, Howick Tp., Huron Co., Ontario (Fig. 30), about 2.6 km east of Gorrie (Fagerstrom, 1977). About 2.6 m of grey, cherty limestone containing an abundant and diverse coral and stromatoporoid fauna are exposed. Best (1953), Liberty (1966), and Liberty and Bolton (1971) regarded the rocks as Bois Blanc but Oliver (1976, p. 145, Loc. C36) regarded them as lower Detroit River. Three stromatoporoid species are known from this locality (*Habrostroma proxilaminata*, *Stictostroma mamilliferum*, *Stictostroma anomalum*); all three are known elsewhere in the Detroit River but only *S. mamilliferum* is known elsewhere from the Bois Blanc. Thus, the presence of chert suggests that the rocks are Bois Blanc whereas the corals and stromatoporoids suggest that they may be Detroit River.
- 97213 Knoll of grey, weathered reef limestone approximately 0.4 km north of the Teeswater River and 4.8 km southeast of the village of Teeswater; Lots 4 and 5, Con. IV, Culross Tp., Bruce Co., Ontario (Fig. 30). Formosa Reef Limestone (Fagerstrom, 1961b).
- 97214 A high, vertical exposure of grey, weathered reef limestone along the road and several small wooded knolls north of the road just east of the bridge crossing Formosa Creek, approximately 2.9 km southwest of the village of Formosa; Lots 3 and 4, Con. XI, Culross Tp., Bruce Co., Ontario (Fig. 30). Formosa Reef Limestone (Fagerstrom, 1961b).
- 97215 Small exposure of grey, weathered reef limestone along Ontario Highway 4, approximately 0.8 km south of the village of Salem; Lots 15 and 16, Con. XI and XII, Culross Tp., Bruce Co., Ontario (Fig. 30). Formosa Reef Limestone (Fagerstrom, 1961b).
- 97216 Large, abandoned quarry of the Ontario Hydro-Electric Co., Ltd., on the south side of Greenock Creek, approximately 3.8 km north of the village of Formosa; Lots A and B, Con. III S, Brant Tp., Bruce Co., Ontario (Fig. 30). (See Goudge, 1938, p. 210-211; Fagerstrom, 1961b; Locality 12 of Fagerstrom, 1961a, p. 4). Formosa Reef Limestone.
- 23635 Highway road cut, 4 km north of the village of Formosa; Lot A, Con. III S, Brant Tp., and Lot 72, Con. I S, Greenock Tp., Bruce Co., Ontario (Fig. 30). (See Locality 6 of Fagerstrom, 1961a, p. 4). Formosa Reef Limestone.
- 15111 A series of low ledges exposed on the shore of Lake Huron at McRae Point, approximately 5.1 km west of the village of Tiverton; Con. A, Kincardine Tp., Bruce Co., Ontario (Fig. 30). Detroit River Group.
- II. A series of low ledges exposed on the farm of Pierce and Son Dairy south of Central Avenue approximately 2.7 km west of Mackinaw City (Fig. 1); NW¼, NW¼, sec. 14, T. 39N, R. 9W, Emmet Co., Michigan (Oliver, 1976, p. 145, loc. 7662-SD). Slabs of fossiliferous limestone have also been piled into a fence along Central Ave. Bois Blanc Limestone.
- III. Large active quarry of the Michigan Limestone and Chemical Co. at Rogers City, Presque Isle Co., Michigan (Fig. 1). The stratigraphic section is described in Shelden et al., 1959, p. 9-11.
- 97217 Small abandoned quarry (contains water) south and east of the paved road, approximately 1.2 km northeast of Scudder, Pelee Island, Ontario (Fig. 31). The exposed stratigraphic sections at Localities 97217, 97218 and 97219 (Fig. 31) consist of two units of the upper Columbus Limestone (Zone H of Stauffer, 1909): a lower massively bedded (beds 0.3 to 1 m thick), coarsely crystalline, greyish brown limestone and an upper more thinly bedded (beds 5 to 13 cm thick) of similar limestone. The rocks of both units contain an abundant fauna dominated by corals and brachiopods. In 1966 about 3 m of the lower unit and 1.6 m of the upper unit were exposed.
- 97218 Small abandoned quarry (contains water) north of the paved road, approximately 1.2 km northeast of Scudder, Pelee Island, Ontario (Fig. 31).
- 97219 Small abandoned quarry (contains water) approximately 1 km northeast of the west dock, Pelee Island, Ontario (Fig. 31). This is the Wm. McCormick quarry of Stauffer (1915, p. 209-211).
- IV. Large abandoned quarry (dry) just north of the Glacial Grooves State Memorial near the north shore of Kelleys Island, Ohio (Fig. 31). This is probably the North Side quarry of Stauffer (1909, p. 139-140); the present author is in general agreement with the stratigraphic section described therein but would place the gradational contact between the Detroit River Group (below) and Columbus Limestone (above) at the top of Stauffer's Unit 8 which is a very distinctive massive bed of typical Detroit River lithology.
- V. Large abandoned quarry (dry) formerly operated by the Kelstone Co. approximately 0.3 km west of the west end of Bockerman Road, Kelleys Island, Ohio (Fig. 31). This may be the South Side quarry of Stauffer (1909, p. 136-139); the present author is in general agreement with the stratigraphic section described therein but would place the gradational contact between the Detroit River Group (below) and the Columbus Limestone (above) at the top of Unit 8 from which he has collected specimens of *Prosserella* sp., a brachiopod characteristic of the Detroit River (Fagerstrom, 1971).
- VI. East wall of the Russian Cemetery (a "peninsula" in the large Marblehead quarry) approximately 0.8 km south of Marblehead, Ottawa Co., Ohio (Fig. 31). Columbus Limestone; Zone H (Stauffer, 1909).
- VII. South wall of the large active Marblehead quarry approximately 0.4 km north of the resort village of Mineyahta on-the-Bay, Ottawa Co., Ohio (Fig. 31). The Detroit River Group (below) - Columbus

Limestone (above) contact is placed at the base of a distinctive coral and brachiopod biostrome consisting of a 2.6 to 3.2 m thick bed of coarsely crystalline grey limestone. Specimens of the characteristic Detroit River brachiopod *Prosserella* sp. (Fagerstrom, 1971) occur 1.3 m below this contact.

- VIII. South wall of large abandoned quarry (dry) formerly operated by the Wagner Stone Co. on south side of Ohio Route 101 approximately 2.7 km southwest of Castalia, Erie Co., Ohio (Fig. 31). The exposed stratigraphic section is about 25.9 m thick and includes the typical *Prosserella*-bearing brown dolomite of the Detroit River Group (below) and the thinner bedded, grey abundantly fossiliferous Columbus Limestone (Zone H, Stauffer, 1909) in the upper 1.6 m. The Detroit River - Columbus contact is gradational and occurs in an 8 m thick interval of tan to brown dolomite (cherty toward the top) directly below the fossiliferous Columbus.
- IX. East wall of large active quarry approximately 0.8 km south of the junction of Portland Road, the Ohio Turnpike and the Pennsylvania Railroad at Parkertown and approximately 7.2 km south of Castalia, Erie Co., Ohio (Fig. 31). The exposed stratigraphic section is about 32.4 m thick and includes about 12.9 m of the typical *Prosserella*-

bearing brown dolomite of the Detroit River Group (below), about 14.6 m of massively bedded, grey crystalline Columbus Limestone (including abundant specimens of *Brevispirifer gregarius* about 1.3 to 1.6 m above the base and *Paraspirifer acuminatus* about 11.3 to 14.6 m above the base), and about 4.9 to 6.5 m of thinner bedded Delaware Limestone with abundant *Leptaena "rhomboidalis"* at the top. The Columbus contains a very persistent 5 to 8 cm thick shale parting about 6.5 m below the top; its lower and upper contacts are faunally distinct but lithologically gradational.

- X. East wall of large Midwest Aggregates Co. quarry located on the north side of Indiana State Route 14, approximately 3.2 km west of Edgerton, Allen County, Indiana (Fig. 31). The exposed stratigraphic section includes about 10.7 m of interbedded tan to grey limestone and dolomite of the Detroit River Group (below) and about 8 m of thinner bedded grey limestone of the Traverse Group (above). The contact is placed just above a 1 to 1.3 m thick coral-rich limestone unit also containing *Acrospirifer* (?) *macrothyris*, a species previously known in the Detroit River only from near the top of the Anderson Limestone at its type locality (Fagerstrom, 1971, p. 42-44, 62-63). *A. (?) macrothyris* is unknown from post-Detroit River or post-Columbus rocks.

APPENDIX II

STROMATOPOROID MORPHOMETRICS

Introduction

Although the generally high level of intracoenosteal variation that is so pervasive among stromatoporoids is readily apparent even in casual examination of one thin-section, the general history of stromatoporoid systematics at the species level has been marked by descriptions based on very small samples; a great many species were founded on just one specimen (Galloway, 1960; Sleumer, 1969, p. 26) despite the fact that stromatoporoids are commonly abundant in the toptype sections from which the holotype was collected. Large samples from some of these sections rather clearly indicate that many presumed "species" are merely individual variants that fall within a reasonable range of variation about the "average" or typical morphology.

During the field collecting phase of the present study particular effort was made to collect large samples from each stromatoporoid-bearing locality and stratigraphic unit; many stratigraphic sections were collected literally centimetre-by-centimetre. In the laboratory, at least two and in many cases three or four large thin-sections were prepared for microscopic examination of most coenostea.

The typical curved stromatoporoid coenosteum makes the preparation of vertical sections that are truly perpendicular to the plane of the laminae and tangential sections that are perpendicular to the axes of the pillars difficult; indeed, significant areas of most thin-sections are variably oblique and should be avoided when gathering morphometric data. Oblique sections provide spurious or even erroneous data; for example, in obliquely "vertical" sections laminar spacing is increased and in oblique "tangential" sections the pillars appear elliptical so that measures of minimum diameter must be made in areas neither in the axes of mamelon columns where pillar thickening is highly probable

nor adjacent to mamelon columns where the pillars are usually "tipped" at varied angles to the general plane of the laminae. In small hemispherical and cylindrical coenostea the pillars and other macrostructures perpendicular to the laminae are commonly radially arranged and so measurements of their spacing are of limited taxonomic value (i.e. megapillar spacing for *Syringostroma cylindricum*). In sections perpendicular to the axes of astrorhizal canals, the canals appear circular whereas in oblique sections they appear elliptical or even tubular; thus, measurements of canal diameter should be made on circular-appearing canals or the minimal diameter of elliptical canals.

The presence of latilaminae, where laminae become clustered or "bunched" at latilaminar boundaries (Fagerstrom, 1961a, p. 6), requires more than the "normal" number of measurements of laminar spacing, especially if the thickness of adjacent latilaminae is highly varied. Similarly, laminar spacing generally decreases toward the margins of mamelon columns and megapillars so spacing measurements should be made approximately mid-way between adjacent mamelons and/or megapillars. In species where both laminae and microlaminae are present, their spacings are different so that mixed data on laminar and microlaminar spacing (e.g. *Syringostroma densum*, Figs. 2a, b) are not easily compared. Although the spacing of pillars, megapillars, mamelon columns and other vertically oriented macrostructures can be measured either in vertical or tangential sections, centre-to-centre measurements between nearest neighbors in tangential sections are the most accurate.

Other very obvious sources of intracoenosteal variation include the presence of symbiotic (*sensu lato*) corals within the stromatoporoid coenosteum (e.g. the holotype of *Stictostroma problematicum*, an aptly named species), the

surfaces of attachment of the coenosteum to the sedimentary substrate, areas of "inclusions" of the sedimentary matrix or other "disruptions" in the arrangement of the macrostructures (repair tissue of Galloway and St. Jean, 1957). Such coenosteal areas are not suitable for morphometric study.

The chapters on "Species of the Genus *Syringostroma*" and "Systematic Paleontology" of this report include comments on the morphologic features that were chosen for biometric analysis and the descriptions of most species are accompanied by considerable morphometric data where sample size is sufficiently large (see also Table 8). However, the quality of many of these data differ from species to species as a result of differences in the degree of diagenesis that the coenosteal areas in the sample have undergone (see also discussion of diagenesis in the "Introduction" to the chapter on "Systematic Paleontology" and "Remarks" for the Group I genera in the same chapter). Diagenesis has generally been more effective in altering the size (or thickness) of macrostructures than in altering their arrangement (or spacing) so that in comparing closely related species more importance generally has been given to differences in arrangement and spacing than to size and thickness. In coenosteal areas and samples of species that have undergone notable diagenesis, the "Systematic Descriptions" commonly include remarks on the presumed effects and the degree of alteration involved.

Not all morphometric data are of equal taxonomic significance. For example, the size (diameter) of pillars (as seen in tangential sections) depends upon the amount of diagenetic "thickening" they have undergone, their shape (cylindrical, spindle, upwardly flaring, etc. as seen in vertical section), the location of the plane of the tangential section between adjacent laminae etc. and therefore is highly variable and of minor significance as a taxonomic criterion. By contrast, values for megapillar diameter are relatively more "stable" in the same coenosteum as well as among coenosteal areas of the same species of *Syringostroma* (Fig. 2C, 3-5; Table 1) and have been shown to be of considerable taxonomic significance (see chapter on "Species of the Genus *Syringostroma*"). In fact, among the species of some genera (e.g. *Syringostroma*) it is possible to establish a hierarchy of taxonomic criteria based on differing degrees of morphometric variation (Cheetham, 1966, p. 20-21). Thus, features of high variability have relatively lower taxonomic value than features of low variability. Furthermore, the levels of variation in the same features among different species may also vary (compare the increasing levels of intraspecific variation in megapillar spacing from *Syringostroma nodulatum* to *S. sherzeri* (?) in Figs. 2, 3).

In summary, the relatively great variation (both intracoenosteal and intraspecific) in stromatoporoids makes it essential for identifications at the species level to be based on large samples (from the same locality and restricted stratigraphic unit, if possible), that large (or numerous) thin-sections be prepared from each coenosteum, that numerous measurements of several variates be made in "typical" (non-deformed) areas of each thin-section, and that the variates chosen for measurement have undergone minimal diagenesis. Even when these conditions are met, stromatoporoid systematists must recognize that variation will inevitably be high and that morphometric techniques can only supplement and not replace species-level taxonomic decisions also based on non-morphometric criteria.

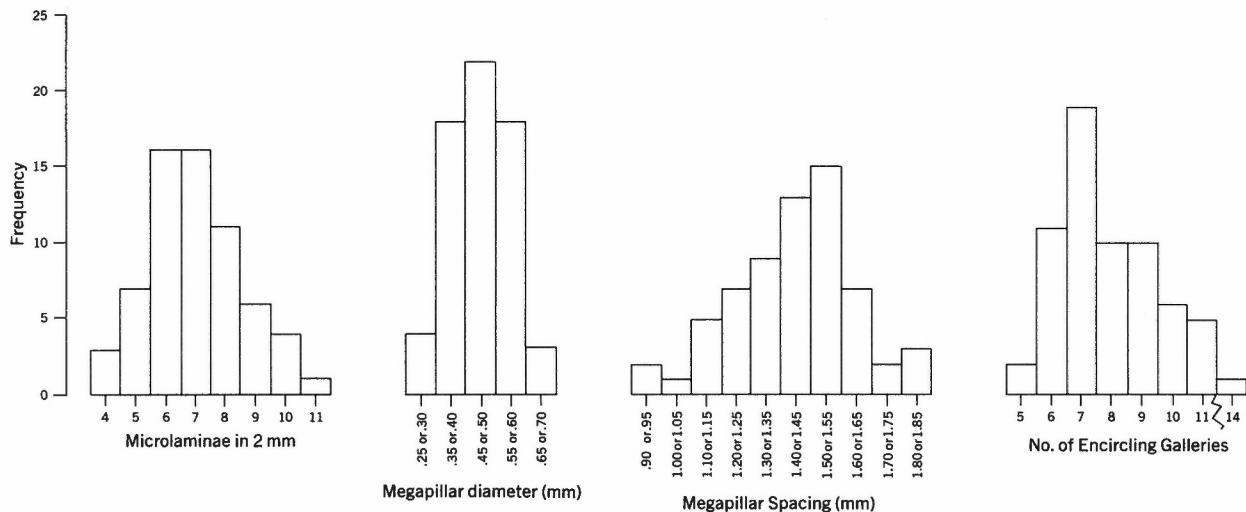
Intracoenosteal Variation

Detailed analyses of coenosteal ontogeny (or astogeny?) have not been undertaken for most stromatoporoid species but the preliminary studies by Fagerstrom and Saxena (1973)

and Cockbain (1979) suggest that although intracoenosteal variation is very high there is no evidence for any progressive morphologic change during the life of the individual coenosteum. Thus, variation is so great that morphometric data from one part of the coenosteum (one thin-section) may not be representative of the entire coenosteum and therefore presumed taxonomic differences based on small sample sizes are of uncertain validity. From these same preliminary data, as well as personal experience in making measurements on highly varied stromatoporoid macrostructures, it may be inferred that relatively simple univariate and bivariate statistical methods will adequately characterize both central tendency and variation. Of necessity, the gathering of the basic morphometric data involves judgments that are unlikely to be precisely repeated on successive occasions for the same thin-section by the same or different workers. For example, throughout the present study measurements of the number of laminae, microlaminae or pillars in 2 mm were made to include the maximum number for each such measurement, i.e. the vertical thin-section was moved on the microscope stage so that a lamina or pillar coincided with the mark on the eyepiece micrometer that was the "beginning" of a 2 mm "traverse" of counts across the thin-section. Such measurements by other workers could be similarly "adjusted" to include minimum numbers of laminae or pillars in 2 mm thus rendering it impossible to compare such data in any taxonomically meaningful way with those presented herein. Subjecting such inconsistent data to highly complex statistical analyses could lead to conclusions not supported by reasoned non-morphometric study of the same coenosteal areas. Conversely, univariate and bivariate statistics have been very useful in revealing taxonomically significant differences among coenosteal areas (samples) for many species and subspecies (see for example the species of *Syringostroma* and *Habrostroma* described above).

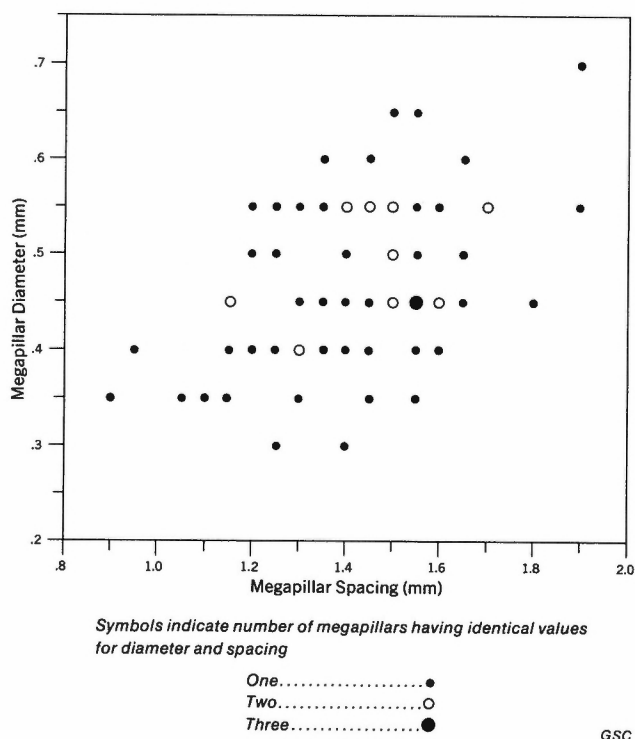
Because of variation in the shapes of the megapillars in tangential sections of *Syringostroma sherzeri* (?) (i.e. irregular, circular or elliptical), the megapillar data of Fagerstrom and Saxena (1973) were measured to the nearest 0.05 mm and statistically treated as discontinuous variables. However, in fact, both megapillar diameter and megapillar spacing are continuous variables so in order to treat these data statistically as continuous in the present study, the megapillar diameter and spacing measurements for all species of *Syringostroma* are minimum values estimated to the nearest 0.01 mm. For the other (non-*Syringostroma*) species these same guidelines were followed: (1) measurement of minimum diameters of pillars, mamelon columns, astrorhizal canals, etc. estimated to nearest 0.01 mm and (2) measurement of centre-to-centre, nearest neighbor spacing estimated to nearest 0.01 mm. Counts, such as laminae, pillars, etc. in 2 mm, must remain as discontinuous variables. However, Cockbain (1979 and personal communication) has measured the distance in which a predetermined (e.g. 10 or 15) number of laminae or pillars occur. Such measurements provide data that can be statistically treated as continuous, but have the disadvantage of not being readily comparable to data on laminae and pillar spacing for most previously described species which are based on counts.

Fagerstrom and Saxena (1973) noted that it was unsafe to assume that intracoenosteal data on the size and arrangement of morphological features in one thin-section were normally distributed but they did not investigate the validity of this assumption for an entire coenosteum. Histograms of their data (Fig. 32) and χ^2 tests indicate that these data are very probably normally distributed, except for the number of galleries surrounding each megapillar. Thus, when several samples are available (in the case of *S. sherzeri* (?) each thin-section was considered to be one sample) the data may be considered to have been drawn from a normally distributed population (the entire coenosteum).



GSC

FIGURE 32. Histograms showing intracoenosteal variation for four variates of *Syringostroma sherzeri* (?) measured in eight vertical and eight tangential randomly located thin-sections from UNSM 9627. Data for all variates, except number of galleries encircling each megapillar, are here regarded as normally distributed (e.g. χ^2 for megapillar spacing = 2.51; d.f. = 4).



GSC

FIGURE 33. Relations between megapillar size and spacing in coenosteam (UNSM 9627) of *S. sherzeri* (?) from lower Detroit River rocks, Loc. 76001 (see Fagerstrom and Saxena, 1973); $r = 0.43$. UNSM 9627 = point K, Figure 3.

In summary, by controlled data collection techniques and large sample sizes the conventional statistical techniques (F-tests, t-tests, etc.) based on continuous variation in normally distributed populations may be used for comparison of variates from several thin-sections from the same

coenosteam. Furthermore, data from large samples of normally distributed discontinuous variates (e.g. number of laminae in 2 mm) may also be compared using conventional statistics rather than the non-parametric methods used by Fagerstrom and Saxena (1973) and Cockbain (1979).

Although the emphasis by both Fagerstrom and Saxena (1973) and Cockbain (1979) was on comparison of univariate data, the bivariate data of Figs. 3, 4 and 33 strongly confirm their conclusions regarding very high levels of intracoenosteal variation. Yet, despite the very poor correlation between megapillar diameter and spacing it is significant to note that not one of the joint values (points) in Fig. 33 lies outside the "field" of points for *S. sherzeri* (?) in Fig. 3; thus, the discreteness of the "cluster" of points based on joint mean values for several coenostea of *S. sherzeri* (?) generally agrees with the level of variation for one coenosteam and suggests that the identification of this species can be done with relatively few measurements of megapillar diameter and spacing. In other words, despite the high levels of intracoenosteal variation (univariate and bivariate), the variation is not so great as to negate the importance of megapillar diameter and spacing for distinguishing *S. sherzeri* (?) from its congeners. In contrast, the data of Figs. 32 and 4 indicate that identifications based on measurements of just megapillar diameter and number of encircling galleries are quite likely to be incorrect and again confirm that there is indeed a hierarchy of taxonomic criteria for the identification of *Syringostroma* spp. (see chapter on "Species of the Genus *Syringostroma*").

Intraspecific Variation

During the phase of the present study that involved the assignment of individual coenostea to particular genera and species a rather strict routine was followed:

1. Generic assignment of coenostea was based entirely on non-morphometric features, chiefly the nature and arrangement of the macrostructures and microstructures. (See "Introduction" to chapter on "Systematic Paleontology".)

2. The presence or absence of a system of regularly arranged mamelons (mamelon columns in thin-sections) was assumed to have taxonomic significance at the species level so the coenostea assigned to each genus were then subdivided into those having mamelons and those lacking mamelons.
3. The presence or absence of a well-defined system of astrorhizal canals was also assumed to have taxonomic significance at the species level so the coenostea assigned to the two tentative "groups" in Step 2 above were next subdivided again into those having a system of astrorhizae and those lacking such a system. At this stage each genus could potentially have yielded four tentative "groups": (a) coenostea lacking both mamelons and astrorhizae, (b) coenostea with mamelons but lacking astrorhizae, (c) coenostea lacking mamelons but with astrorhizae, and (d) coenostea with both mamelons and astrorhizae; in fact, none of the genera in this study was divisible into so many "groups".
4. At this stage a "tentative working hypothesis" was made, namely that at any one locality and reasonably restricted stratigraphic interval only one of the above "groups" was likely to be present in large numbers so the coenostea in each of the above "groups" were then subdivided again by locality and stratigraphic interval. The "group" at this stage containing the most coenostea (largest sample) became the initial "working morphometric standard" with which all other coenostea from other localities and stratigraphic intervals was compared. In Steps 1-4 all subdivision of each genus was based on non-morphometric criteria.
5. The "raw" morphometric data for coenostea in the "working morphometric standard" were accumulated in histograms for each variate measured and the median for each variate was determined for each coenostea and plotted above the histogram (e.g. Fig. 16). The size of the "standard" increased as measurements from more and more coenostea were made and each coenostea judged as to whether or not it reasonably "conformed" to the "standard"; evidence for non-conformity included the development of bimodality or polymodality in the histogram and the presence of "breaks" in the succession of values of the medians to form separate "groups" of median values (e.g. Fig. 6). The histograms and medians for each variate were continuously cross-checked to determine whether apparent "non-conformities" (differences) in one variate were accompanied by differences in other variates; however, a difference in just one variate was judged to be all that was required to regard the difference as taxonomically significant.
6. If the histograms of two closely related (congeneric) "working morphometric standards" were normally distributed, the mean (\bar{X}) and variance (s^2) of each was calculated, F-tests were made to compare the variances and if the variances were not significantly different, the sample means were compared by use of Student's t -test. Values of t greater than those at the 0.05 level of significance were regarded as taxonomically significant. Note that in Step 5 above, when data from thin-sections of individual coenostea were compared to the growing "working morphometric standard" their median values were used (following Fagerstrom and Saxena, 1973) but at Step 6 the statistical comparison of the "standards" of two or more morphologically similar assemblages of coenostea was based on means and variances (see also discussion of "Intracoenosteal Variation" above). In all cases, the coenostea used for statistical comparisons of assemblages were from the Detroit River Group. (The

"data-sets" for most of the species of *Syringostroma* included several variates, were very large and were normally distributed for nearly all variates; their comparison using simple, conventional statistics was very rewarding for distinguishing among the several species, see Figs. 2-5.)

7. The final step was to search the stromatoporoid literature for previously described taxa that appeared to "conform" to the "groups" thus established using the routine described in Steps 1-6 and, if possible, examine the type material for these taxa.

Failure to follow this routine could easily lead to the recognition of taxa based on non-morphometric or at best quasi-morphometric criteria with the statistical data merely used to confirm or support a priori taxonomic decisions that were little more than hypotheses (or "hunches" or "guesses"). Such a use of statistics can also become a form of circular reasoning, i.e. a "model" is set-up, usually based on the holotype or its published description and 1 or 2 paratypes, then other specimens are individually compared to the "model" and those judged to conform to the "model" then become the basis for a statistical characterization of the "sample" (commonly based on heterogeneous materials; see Cazier and Bacon, 1949, p. 352-354). In this case the final statistics merely support a number of prior taxonomic decisions and play no part in the making of those decisions. By contrast, in the routine in Steps 1-6 above the statistics become part of the decision-making process and at the end of the routine one or more type specimens are compared to the sample. Thus, in the present study, measurements from the type materials were compared with the much larger "data-sets" which were developed from the "working morphometric standard"; the types served primarily in their proper role as "name-givers" to "standards". This routine also leads to the proper use of the hypodigm concept of Simpson (1944).

In summary, the characterization and identification of the species described in this report involved the gathering and simple statistical analysis of a great mass of morphometric data (Figs. 2-26 and Table 8). Many decisions on the taxonomic significance of morphologic differences between individual coenostea and between assemblages of coenostea were supported by and partly based on statistical comparisons which in some cases resulted in the placement of two or more very poorly understood species in synonymy (e.g., see *Anostylostroma laxum*) or the recognition of new species (e.g., *Habrostroma formosensis*). The fact that many of the morphometric differences are present among coenostea of two or more sympatric species strongly suggests that these differences had some genetic basis and were not merely different morphologic responses to differences in one or more environmental parameters. Thus, most of the morphologic species described in this report appear to have been true biological species (sensu Mayr, 1970, p. 12-13, 21).

Coefficients of Variation

Univariate statistics are not very useful in characterizing samples of many species of marine invertebrate fossils because such organisms commonly increase in size (of the entire organism as well as the individual "parts" of the organism) and change shape during nearly their entire life-span (e.g. Fagerstrom, 1964, p. 1202, 1212; Shiells, 1966, p. 443). In contrast, univariate statistics have proven very useful in characterizing samples of organisms having distinguishable growth stages (e.g. arthropods; mammals) or colonial organisms in which the individual "parts" of the colony are all morphologically similar, i.e. there is no astogenetic change among the "parts" during the life-span of the colony.

TABLE 8

Univariate statistics for samples of stromatoporoid species from the Detroit River Group and Columbus Limestone in the vicinity of the Michigan Basin. n = number of coenostea in each sample; N = total number of measurements (or counts) from all coenostea in each sample; \bar{X} = mean; M = median; CV = interspecimen/intraspecific coefficient of variation. Note: similar data for species of *Syringostroma* are presented in Figure 2.

Species; variate	n	N	\bar{X}	M	CV
Habrostroma densilaminata					
microlaminae in 2 mm	7	56	12.3	12	23.5
mamelon spacing (mm)	5	8	4.6	4.5	16.2
H. proxilaminata					
microlaminae in 2 mm	14	112	18.3	18	17.2
mamelon spacing (mm)	13	44	7.4	7.5	18.4
H. formosensis					
microlaminae in 2 mm	5	40	24.3	25	16.9
mamelon spacing (mm)	4	24	7.4	8	19.0
H. beachvillensis					
laminae in 2 mm	2	14	5.5	7	19.8
mamelon spacing (mm)	9	30	4.4	4	14.3
H. larocquei					
laminae in 2 mm	3	18	9.9	9.5	22.2
diam; astror. canals (mm)	3	23	.21	.21	24.5
pillar diameter (mm)	4	37	.11	.11	26.6
Anostylostroma laxum					
laminae in 2 mm	34	172	6.5	6	23.2
pillar spacing (mm)	34	222	.21	.22	25.5
A. columnare					
laminae in 2 mm	14	68	6.3	6	18.4
pillar spacing (mm)	17	107	0.21	0.19	16.3
mamelon spacing (mm)	17	86	3.8	4	21.7
A. subcolumnare					
laminae in 2 mm	3	24	7.1	7	23.2
pillar spacing (mm)	3	24	0.19	0.18	20.1
mamelon spacing (mm)	3	21	2.4	2.25	22.9
A. sp.					
laminae in 2 mm	2	11	7.2	7	5.64
pillar spacing (mm)	2	16	0.20	0.19	13.7
mamelon spacing (mm)	2	8	7.6	8.25	18.2
Pseudoactinodictyon vagans					
laminae in 2 mm	9	41	5.1	5	21.5
pillar spacing (mm)	9	100	.21	.21	22.4
mamelon spacing (mm)	8	31	3.9	3.8	17.0
P. stearni					
laminae in 2 mm	8	39	7.1	7	20.8
pillar spacing (mm)	9	73	.20	.19	16.5
mamelon spacing (mm)	4	11	8.9	7.5	30.7
Amphipora ramosa (?)					
coenosteal diameter (mm)	112	112	2.71	2.62	36.7
axial canal diameter (mm)	112	112	.37	.36	40.0
A. nattressi					
coenosteal diameter (mm)	74	74	2.45	2.3	44.1
Stictostroma problematicum (?)					
laminae in 2 mm	7	39	7.3	8	12.8
pillar spacing (mm)	6	44	.16	.16	20.1
S. anomalum					
laminae in 2 mm	5	31	9.2	10	9.18
pillar spacing (mm)	5	35	.17	.17	19.2
S. mamilliferum					
laminae in 2 mm	8	40	11.9	12	8.66
pillar spacing (mm)	7	52	.17	.17	15.3
S. longitubiferum					
laminae in 2 mm	7	36	8.4	8.5	12.1
S. sp.					
laminae in 2 mm	5	27	9.2	9	11.8
Stromatoporella perannulata (?)					
laminae in 2 mm	11	43	7.1	7	17.8
inside pillar diameter (mm)	11	90	.12	.12	33.5
Trupetostroma (?) sp.					
laminae in 2 mm	3	13	5.6	6	11.6
pillar spacing (mm)	3	16	.19	.185	17.7

Although the biologic affinities and the colonial vs. non-colonial status of the Stromatoporoidea are uncertain, the fact that the size, shape and arrangement of their internal macrostructures do not undergo major progressive change within the coenosteum (Fagerstrom and Saxena, 1973) indicates that the univariate data of Fig. 2 and Table 8 (especially the values of the coefficients of variation; not recorded in Fig. 2 but readily calculated from the data presented there) may be compared with similar data from other species of stromatoporoids as well as other higher taxa in order to determine their relative levels of variation.

The values of the coefficients of variation (CV) for intracoenosteal and interspecimen/intraspecific variation in *Syringostroma sherzeri* (?) (Table 9) indicate that the levels of both types of variation are very high but of similar magnitudes and that interspecimen/intraspecific variation is not consistently greater than intracoenosteal variation as might be logically assumed. Furthermore, comparison of the data of Tables 8 and 9 indicates that variation in *Syringostroma sherzeri* (?) is of the same general magnitude as in the other stromatoporoid species present in the Detroit River Group and Columbus Limestone.

Simpson, Roe and Lewontin (1960, p. 91-93) noted that the great majority of coefficients of variation derived from linear dimensions of relatively homogeneous samples of mammals lie between 4 and 10 and that 5 and 6 are good average values; they also presented data in support of these generalizations (see also Gingerich, 1974). However, these data also suggest that among deer, features of the skull and teeth are far less variable (lower values for the coefficient of variation) than features of the antlers, a fact also confirmed by Gould (1974, p. 202-204) who calculated values as high as 33.92 for the coefficient of variation for features of the antlers of the recently extinct "Irish Elk".

TABLE 9

Comparison of values for coefficients of variation (CV) for intracoenosteal (based on UNSM 9627; see Fagerstrom and Saxena, 1973, Table 1) and interspecimen/intraspecific (based on data of Fig. 2 herein) variation in four variates of *Syringostroma sherzeri* (?) from the Detroit River Group, southwestern Ontario.

	microlaminae in 2 mm	megapillar diameter	megapillar spacing	no. of encircling galleries
intracoenosteal (CV)	22.62	19.71	14.10	22.21
interspecimen/intraspecific (CV)	35.51	17.17	17.37	13.01

Nearly all of the values of CV for the stromatoporoid coenostea in Tables 8 and 9 and Fig. 2 exceed those for mammal skulls and teeth and most of them also exceed the values for deer antlers but are quite comparable to those for features of bryozoan zoecia (Cheetham, 1966, p. 18; Cheetham, 1968, p. 29). Very high levels of variation among clonally reproduced zoecia (and also stromatoporoid coenostea?) strongly suggest that in some colonial species morphology is more strongly influenced by non-genetic (environment; location of zoecia on zoarium, etc.) than by genetic factors.

The high levels of coenosteal variation in stromatoporoids make it imperative that species differences based on morphometric comparisons be supported by as much data as can be reasonably gathered. The need for large samples, the preparation of numerous large thin-sections and the tedious measurement of the size, spacing, etc. of macrostructures for correct species level taxonomy will in turn severely limit the value of stromatoporoids for biostratigraphic (see chapter entitled "Biostratigraphy and Correlation"), paleoecologic and biogeographic interpretation.

PLATES 1-8

Illustrations of Stromatoporoid Taxa

PLATE 1

- Figures 1, 2. **Habrostroma densilaminata** (Fagerstrom); figure 1, paratype, UMMP 36184, Loc. 23635, vertical section, X15, showing well-preserved cellular/microlaminar microstructure, spar-filled galleries and moderate thicknesses of clothing tissue on the microlaminae; figure 2, paratype, UMMP 36184, tangential section, X15, showing well-preserved cellules and specks, flocs and melanospheres and spar-filled galleries and astrorhizal canals with sharp boundaries.
- Figure 3. **Stromatopora(?) vesiculosum** (Lecompte); holotype of **Syringostroma vesiculosum**, MRHN 5484b, tangential section, X15, showing large, spar-filled galleries and cellules and vacuoles in the dark tissue; in this section, but not necessarily in this figure, cellule and vacuole diameters range from 0.030 to 0.045 mm, cf. Pl. 1, figs. 2, 5, 8 which contain only cellules. Photograph provided through courtesy of P. Sartenaer.
- Figures 4-6. **Habrostroma formosensis** n. sp.; figure 4, paratype, UMMP 36183, Loc. 23635, vertical section, X10, showing well-preserved microlaminae with minimal amounts of clothing tissue; figures 5, 6, holotype, GSC 60241, Loc. 23635, tangential and vertical sections respectively, X10, showing abundant clothing tissue, specks, flocs and melanospheres and large, spar-filled astrorhizal canals.
- Figures 7, 8. **Habrostroma proxilaminata** (Fagerstrom); figure 7, paratype, UMMP 36179, Loc. 23635, vertical section, X10; figure 8, holotype, UMMP 36177, Loc. 23635, tangential section, X10.

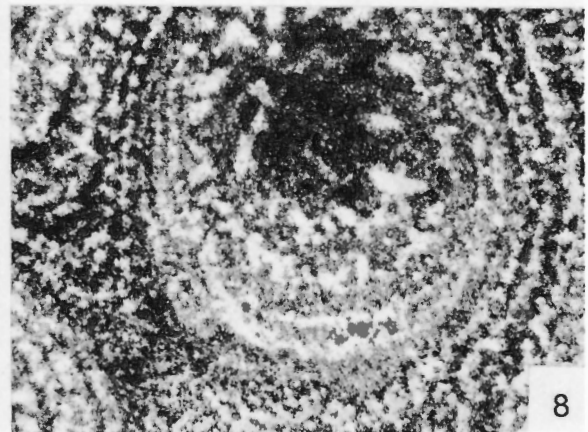
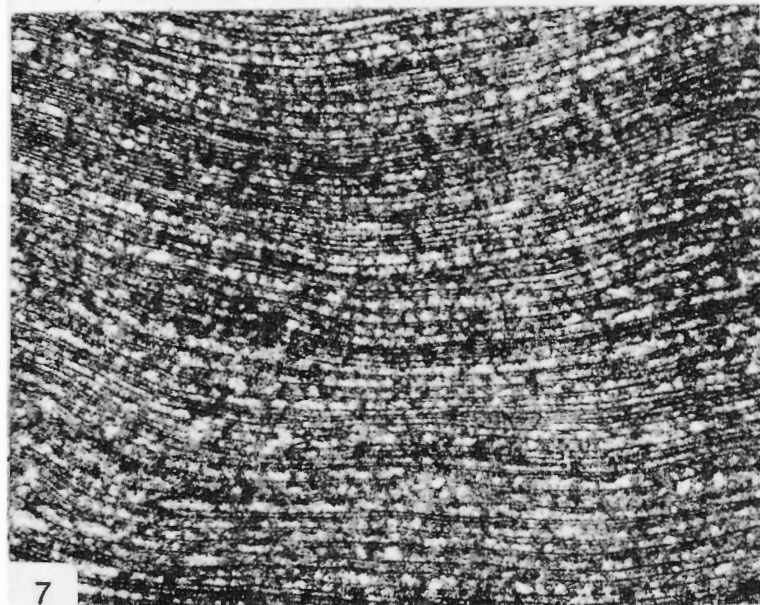
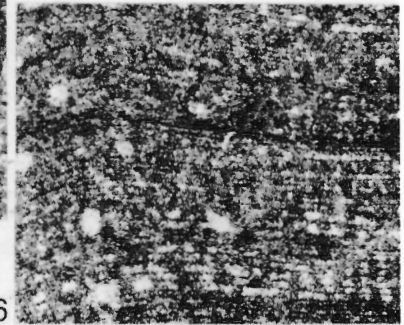
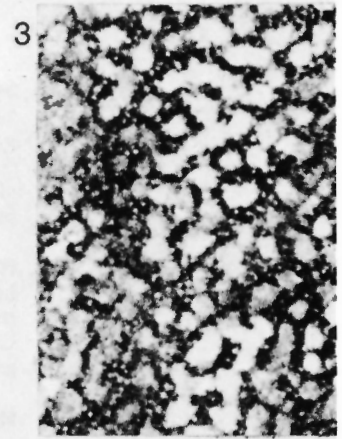
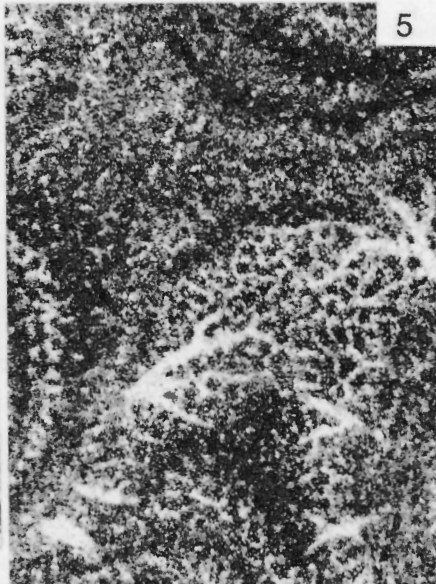
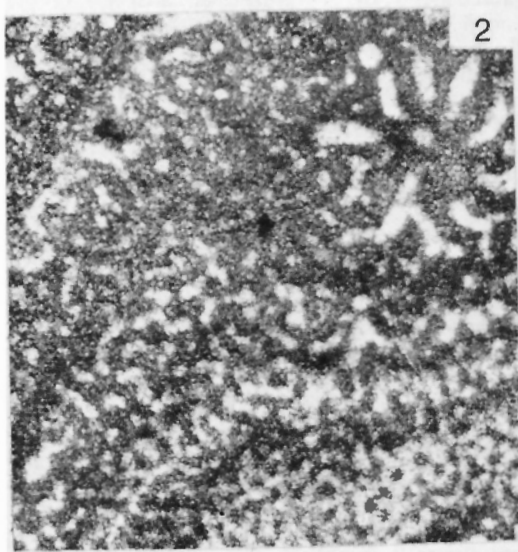
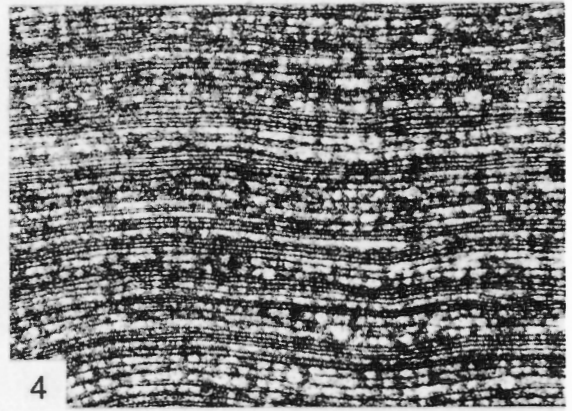
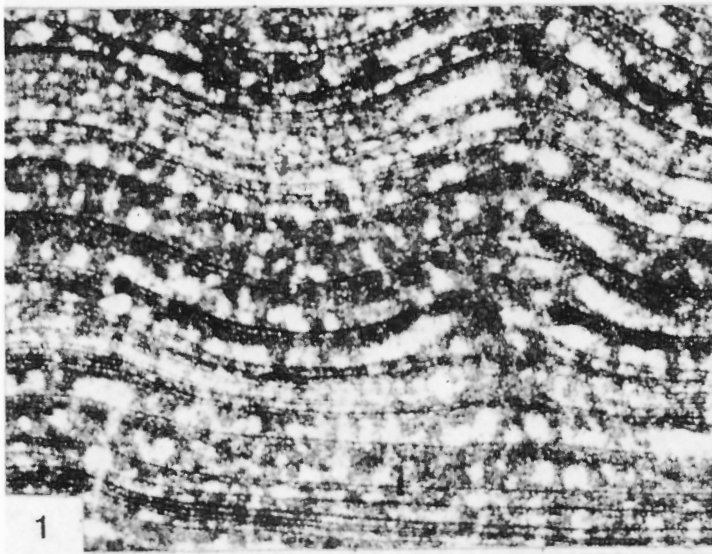


PLATE 2

- Figures 1, 2. **Syringostroma pustulosum** (Grabau); figure 1, hypotype, GSC 60318, Loc. 23566, tangential section, X10, showing dark megapillars, some surrounded by a single gallery or "moat" (lower left) and others surrounded by a cirlet of 2 to 5 galleries; figure 2, hypotype, GSC 60320, Loc. 97210, vertical section, X10, showing megapillars with specks, floccs and cellulose in water-jet arrangement and nearly complete conversion of microlaminae to laminae.
- Figures 3, 4. **Habrostroma larocquei** (Galloway and St. Jean); figure 3, hypotype, GSC 60262, Loc. 76001, vertical section, X10, with only remnants of pre-diagenetic microlaminae and moderate development of superposed pillars; figure 4, hypotype, GSC 60262, Loc. 76001, tangential section, X10, showing pillars with well-preserved cellular microstructure.
- Figures 5, 6. **Habrostroma beachvillensis** n. sp.; figure 5, paratype, GSC 60251, Loc. 15114, vertical section, X10, showing fusion of microlaminae to form laminae and local areas of microreticulate microstructure; figure 6, holotype, GSC 60243, Loc. 97210, tangential section, X10, with specks, floccs and melanospheres.
- Figures 7-9. **Syringostroma sherzeri** (?) (Grabau); figure 7, hypotype, GSC 60281, Loc. 97210, vertical section, X10, showing fusion of microlaminae to laminae neither of which maintain their identity in the axial parts of the megapillars, deeply drooped microlaminae and laminae between megapillars and elongate upswept galleries near megapillar margins; figure 8, hypotype, GSC 60287, Loc. 97210, tangential section, X10, with prominent dark megapillars encircled by numerous small galleries and remnants of former microlaminae; figure 9, hypotype, GSC 60297, Loc. 76001, tangential section, X10, with diffuse megapillars and poorly developed encircling galleries, abundant clothing tissue and large astrorhizal canals.

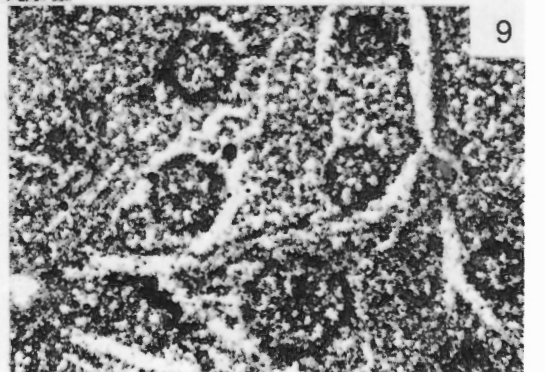
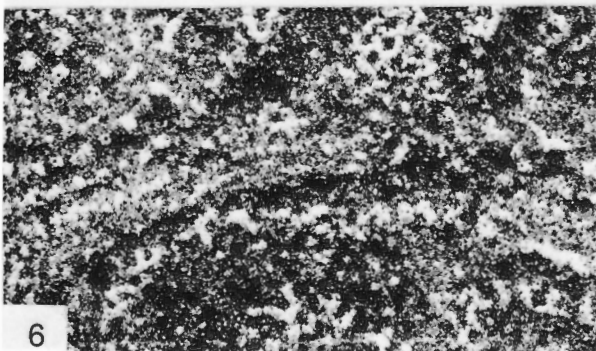
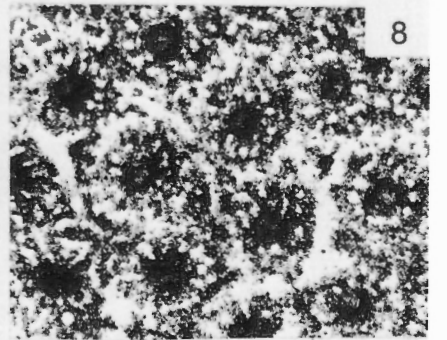
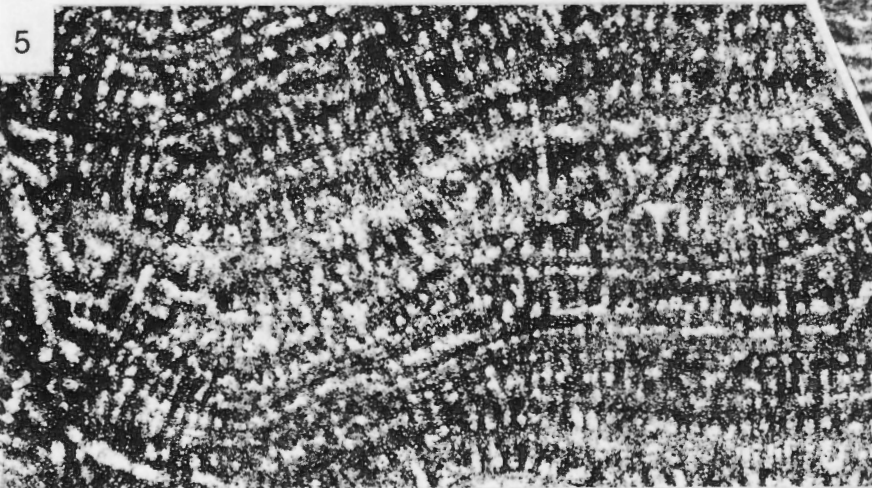
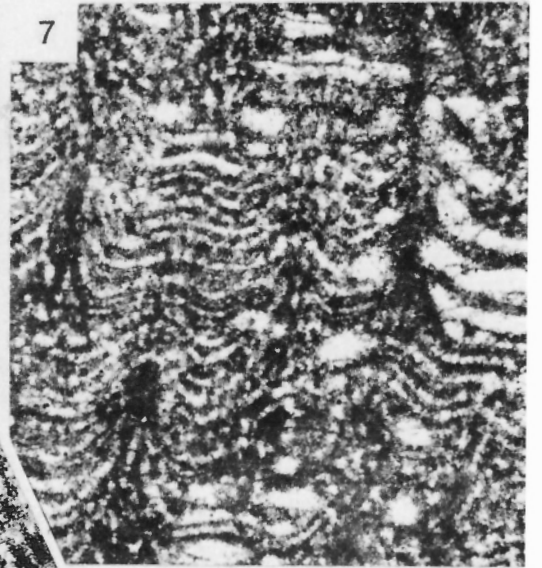
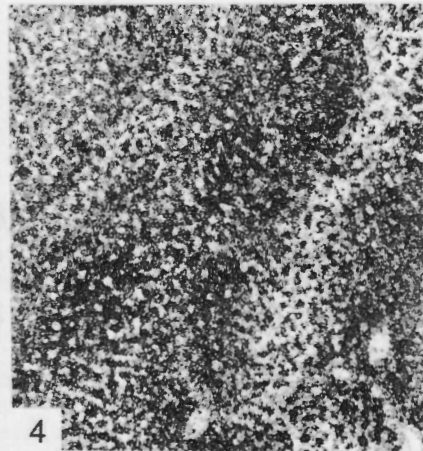
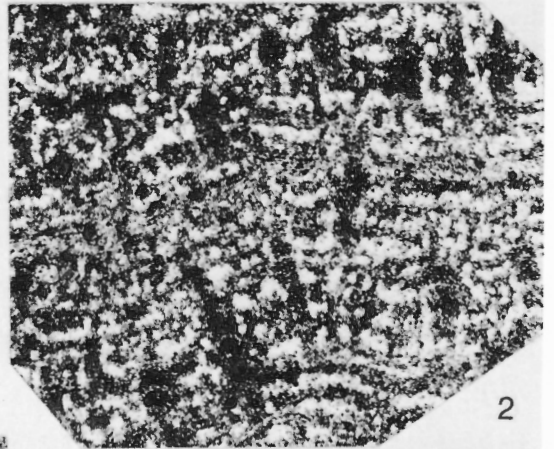
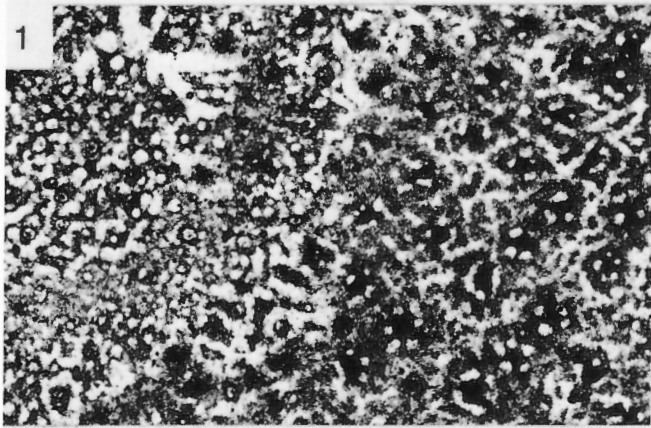


PLATE 3

- Figures 1-3. **Syringostroma nodulatum** (Nicholson); figure 1, holotype, BM(NH) P5604, vertical section, X10, with uniformly speckled cellular tissue (cellules in megapillars larger than cellules in laminae); figure 2, holotype, BM(NH) P5604, tangential section, X20, showing prominent small megapillars with well-developed cellules and encircled by one gallery (or "moat"); megapillars have replaced nearly all normal-sized pillars; figure 3, holotype, BM(NH) P5604; vertical section, X20, with moderate development of vertically aligned specks and floccs in megapillars and laminae.
- Figures 4, 5. **Syringostroma densum** Nicholson; figure 4, hypotype, GSC 60393, Loc. K, vertical section, X10, showing poorly developed small megapillars, thin unwrinkled microlaminae and laminae interrupted by megapillars; figure 5, hypotype, GSC 60399, Loc. 15114, tangential section, X10, with prominent dark megapillars surrounded by 1 to 5 galleries.
- Figure 6. **Syringostroma sanduskyense** Galloway and St. Jean (= **S. densum** herein); holotype, USNM 127282, vertical section, X30, showing poorly preserved microlaminae and very diffuse laminae and megapillars (cf. Galloway and St. Jean, 1957, pl. 16, fig. 4a).
- Figures 7, 8. **Syringostroma ristigouchense** (Spencer); hypotype, ROM 31493, probably collected by W.A. Parks from the Dalhousie Formation (Lower Devonian; Helderbergian) at Cap Bon Ami near Dalhousie, New Brunswick and possibly illustrated in Parks, 1909, pl. 16, figs. 3-5; figure 7, tangential section, X10, showing prominent small megapillars with well-preserved cellules surrounded by a single "moat-like" gallery; figure 8, vertical section, X10, showing cellules, specks and floccs in water-jet microstructure in the megapillars.

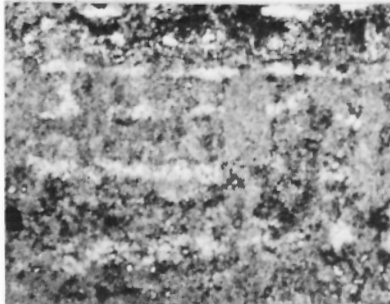
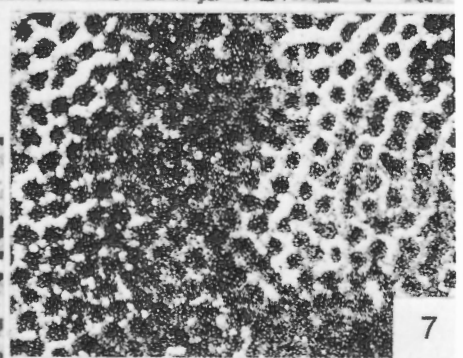
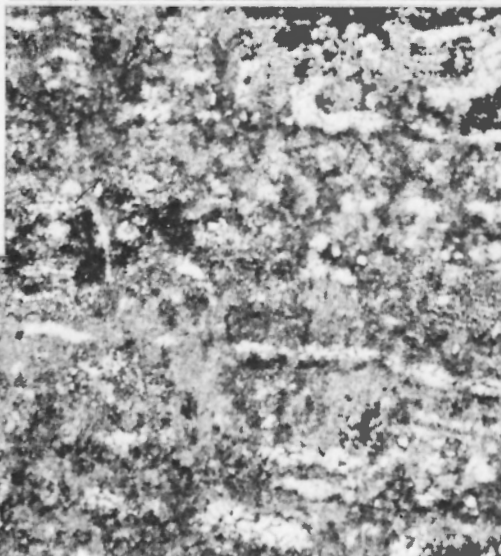
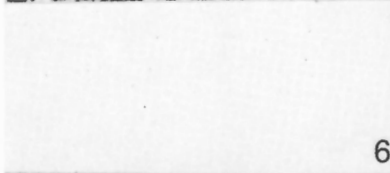
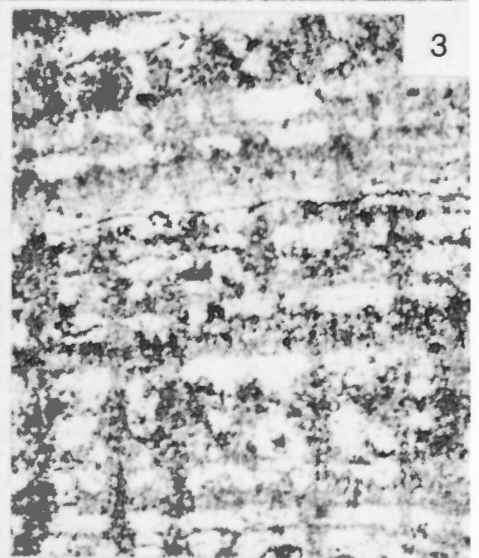
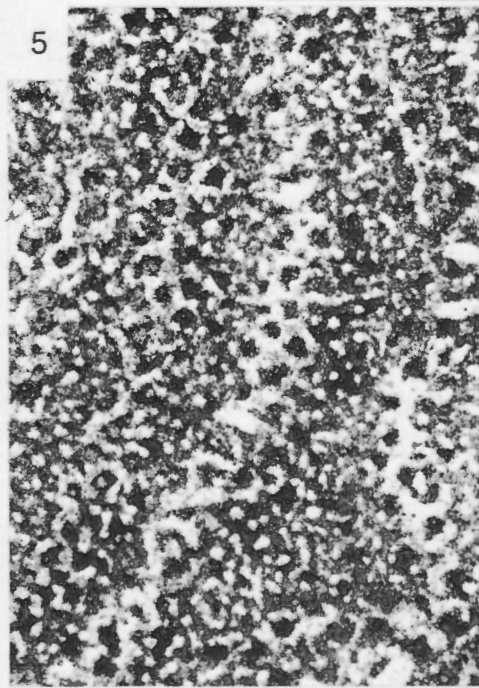
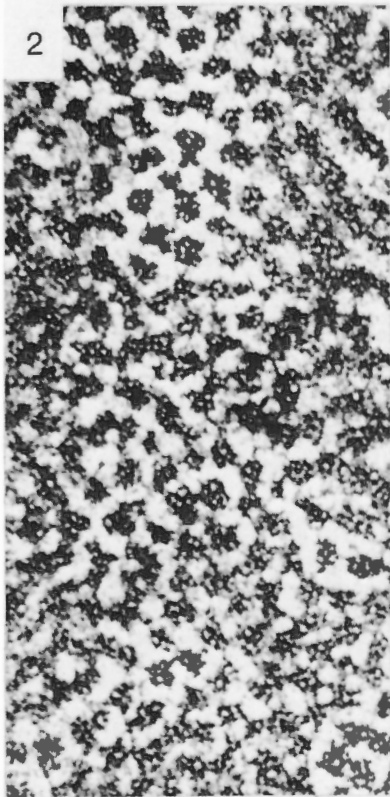
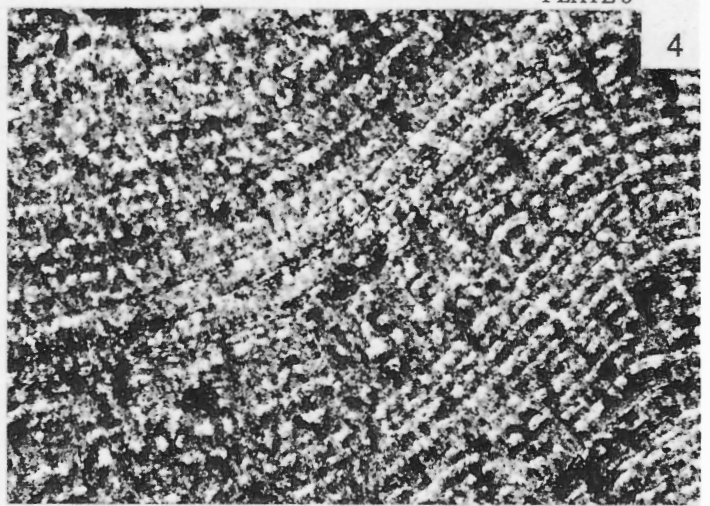
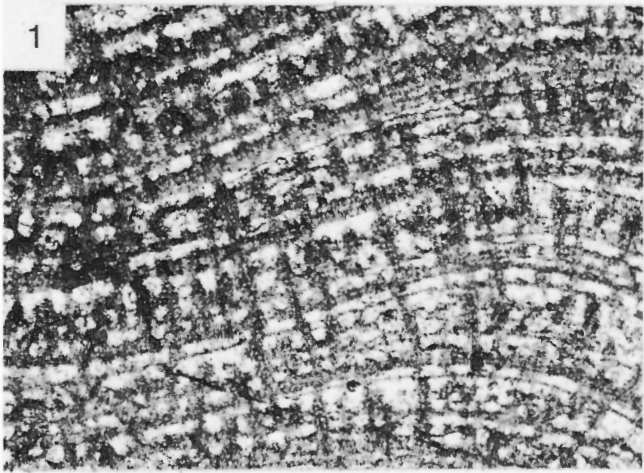


PLATE 4

- Figure 1. **Syringostroma cylindricum** Fagerstrom; paratype, UMMP 36211, Loc. 23635, section transverse to coenosteal axis, X10, showing amalgamate axial region and peripheral reticulate region consisting of concentric microlaminae, laterally elongate galleries and poorly developed megapillars.
- Figures 2, 3. **Syringostroma probicrenulatum** Fagerstrom; figure 2, holotype, UMMP 36187, Loc. 23635, vertical section, X10, showing diffuse vertically non-persistent megapillars, wrinkled microlaminae many of which are in various stages of alteration (fusion) to laminae and large dark melanospheres; figure 3, holotype, UMMP 36187, Loc. 23635, tangential section, X10, showing numerous unevenly arranged megapillars surrounded by 1 to 4 galleries and well-developed astrorhizal canals.
- Figures 4, 5. **Stromatopora cooperi** Lecompte; figure 4, paratype, MRHN 6437b, vertical section, X15, showing local areas of vertically aligned pillars, specks and cellules, local amalgamate areas and occasional discontinuous laminae; figure 5, paratype, MRHN 6437c, tangential section, X15, with abundant amalgamate tissue, local large pillars (not megapillars) and astrorhizal canals. Photographs provided through courtesy of P. Sartenaer.

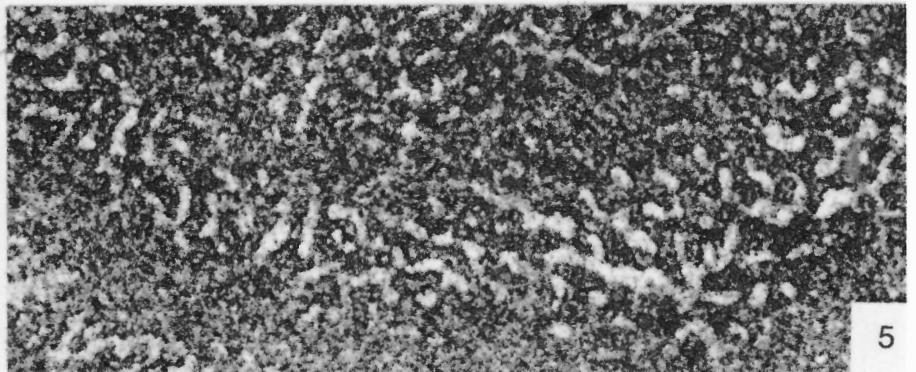
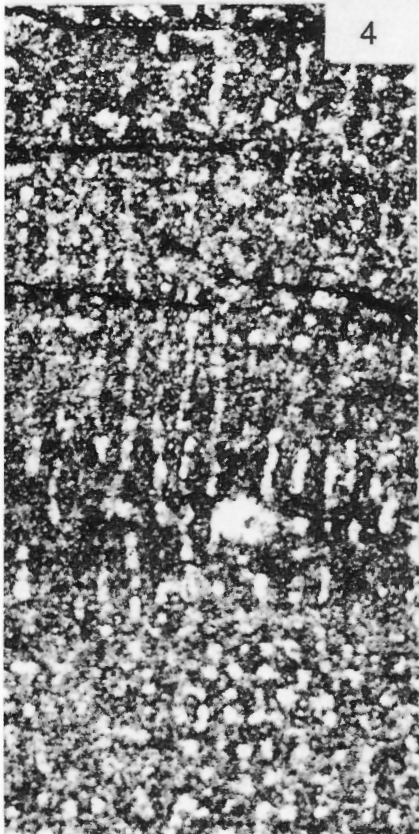
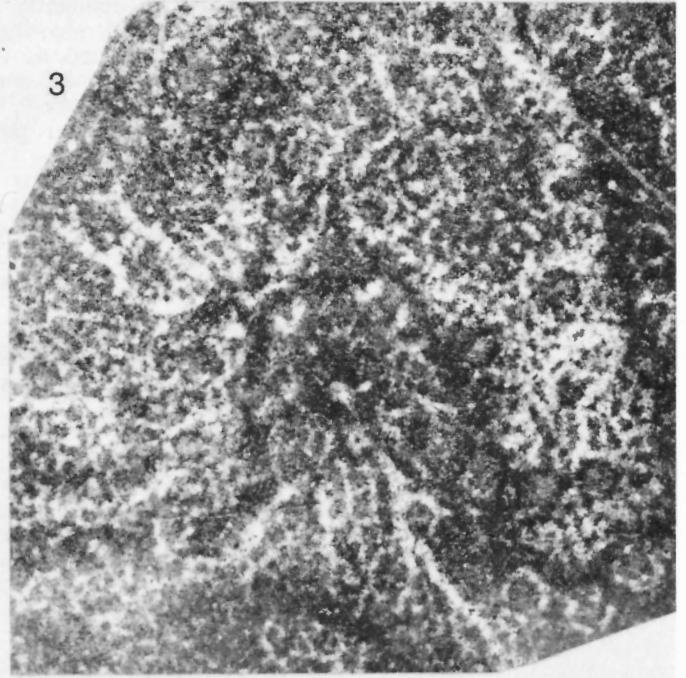
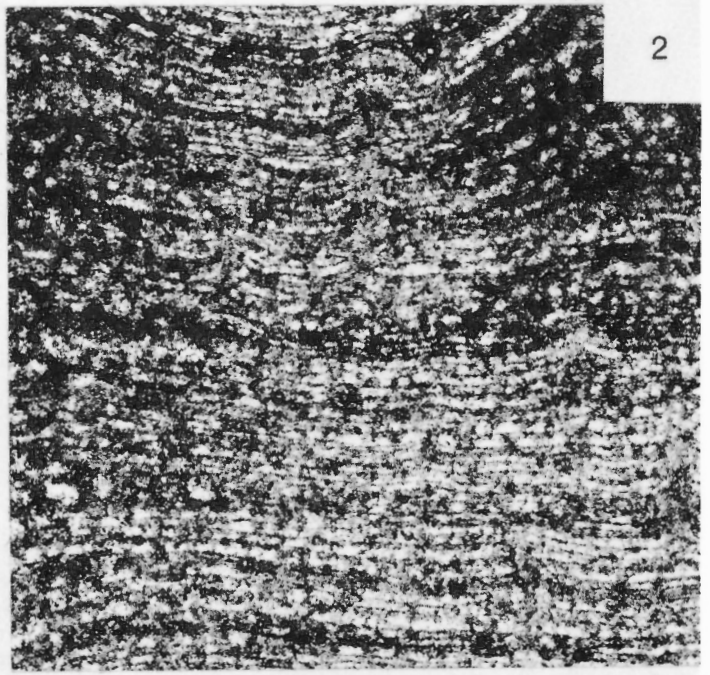
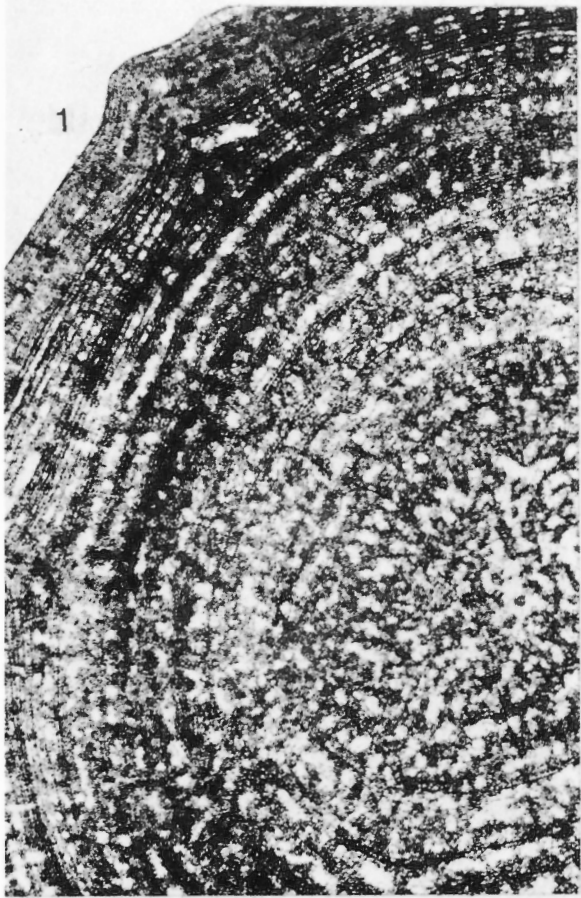


PLATE 5

- Figures 1-4. **Anostylostroma laxum** (Nicholson); figure 1, hypotype, GSC 60438, Loc. 23566, vertical section of moderately contorted coenosteum, X5, showing uneven development and spacing of undulations ("mamelon columns") and variable development of dissepiments; figure 2, hypotype, UMMP 36193, Loc. 23635, tangential section, X5, showing poorly developed mamelon columns; figure 3, hypotype, GSC 60470, Loc. X, vertical section, X10, showing flat transversely fibrous to porous laminae and numerous non-superposed, Y-shaped pillars; figure 4, hypotype, GSC 60470, Loc. X, tangential section, X10, showing well-defined round to elliptical pillars, some joined by dissepiments into short vermicular chains.
- Figures 5, 6. **Anostylostroma** sp.; figure 5, figured specimen, GSC 60498, Loc. 15114, tangential section, X10, showing well-developed mamelons and numerous hollow pillars resembling ring-pillars; figure 6, figured specimen, GSC 60498, Loc. 15114, vertical section, X10, showing mamelon column with thickened pillars, variably superposed.
- Figure 7. **Anostylostroma columnare** (Parks); hypotype, GSC 60483, Loc. 97210, tangential section, X10, showing well-developed mamelon columns and moderate thickening of pillars in column axes.
- Figures 8, 9. **Anostylostroma subcolumnare** Galloway and St. Jean; figure 8, hypotype, GSC 60497, Loc. X, vertical section, X10, with prominent mamelon columns containing closely spaced, thickened pillars; figure 9, hypotype, GSC 60497, Loc. X, tangential section, X10, showing prominent, closely spaced mamelon columns and thickened pillars in column axes.

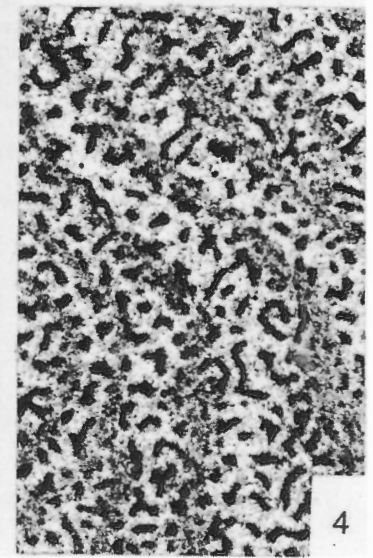
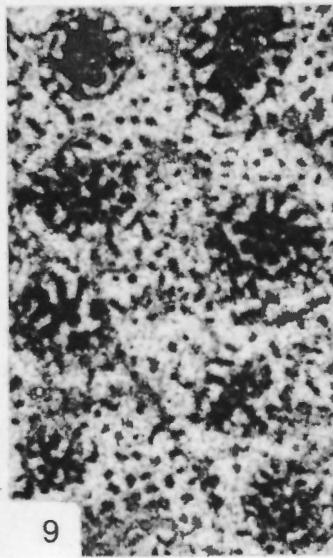
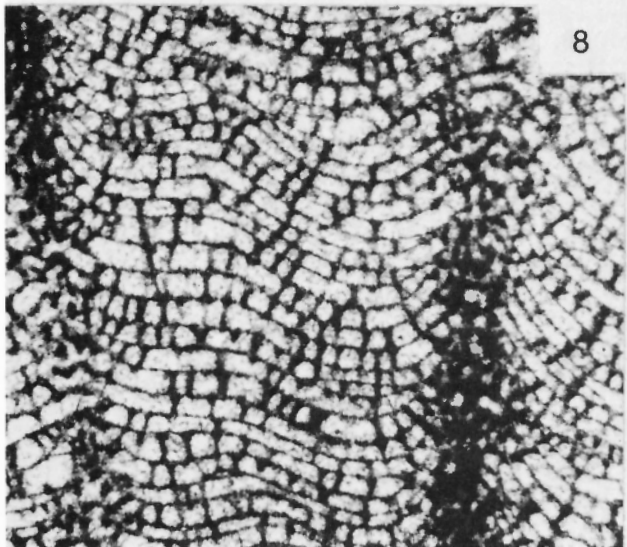
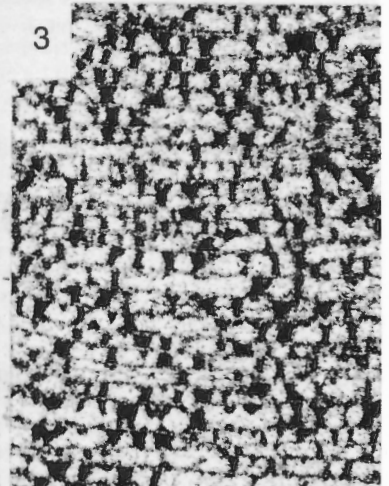
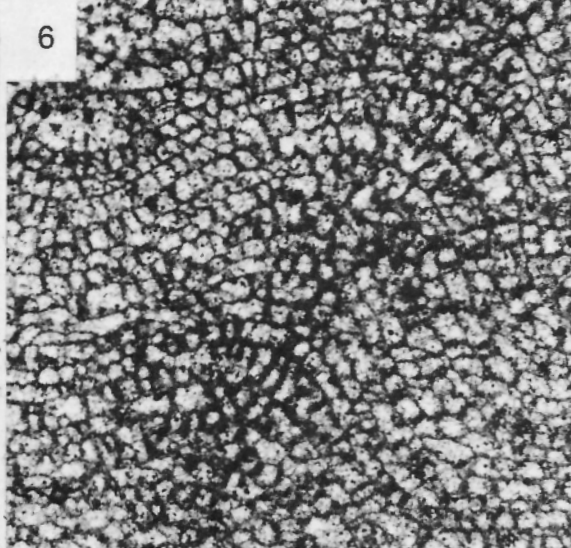
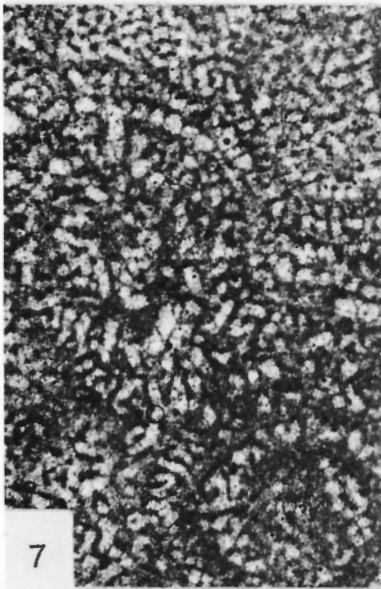
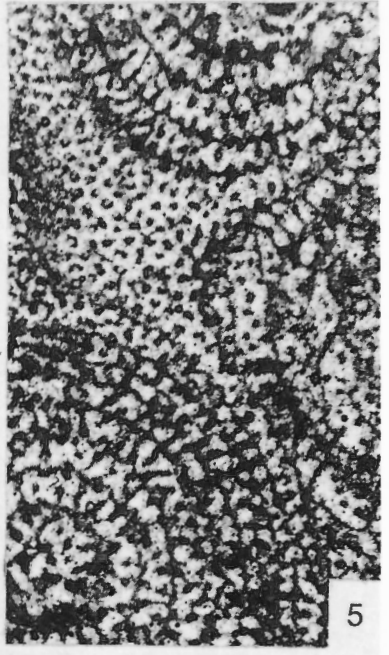
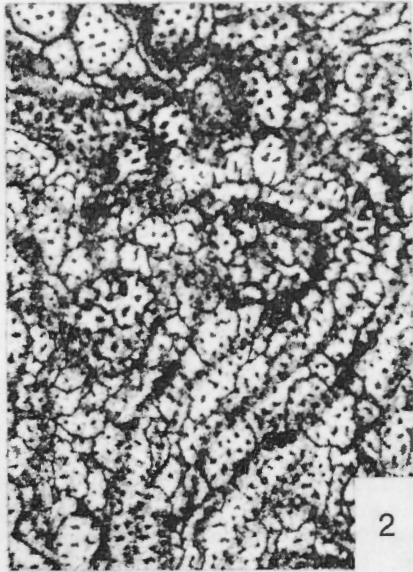


PLATE 6

- Figures 1, 2. **Pseudoactinodictyon vagans** (Parks); figure 1, hypotype, GSC 60512, Loc. 97210, vertical section, X10, showing almost complete replacement of laminae by dissepiments and thickened superposed pillars in mamelon columns; figure 2, hypotype, GSC 60512, Loc. 97210, tangential section, X10, with abundant dissepiments, some of which resemble ring-pillars, and thickened pillars in mamelon columns.
- Figures 3, 4. **Pseudoactinodictyon stearni** n. sp.; figure 3, holotype, GSC 60520, Loc. K, vertical section, X5, showing abundant dissepiments (locally replacing laminae), transversely fibrous to porous laminae and thickened pillars in mamelon columns; figure 4, paratype, UNSM 1665, Loc. G, tangential section, X10, with abundant pillars locally joined by abundant dissepiments into short vermicular chains.
- Figures 5, 6. **Amphipora ramosa** (?) (Phillips); figure 5, hypotype, GSC 61318, Loc. 76000, transverse sections of four coenostea (toward upper right) and longitudinal sections of two coenostea (toward lower left), X6, each coenosteum has a prominent axial canal, marginally divergent "laminae" and galleries or canals forming peripheral vesicles in transverse sections and compact to fibrous "laminae"; figure 6, hypotype, GSC 60598, Loc. 76000, transverse section, X10, of coenosteum with large axial canal, peripheral amalgamate macrostructure composed of non-laminar tissue, and canals, galleries and vesicles.
- Figures 7, 8. **Amphipora nattressi** (Grabau); figure 7, hypotype, GSC 60591, Loc. 97211, transverse section, X10, with amalgamate macrostructure and one or two poorly defined partially encircling laminae; figure 8, hypotype, GSC 60587, Loc. 97210, transverse section, X10, with amalgamate macrostructure throughout and compact to fibrous microstructure.
- Figure 9. **Amphipora ramosa** (?) (Phillips) (coenosteum toward upper left), **Amphipora nattressi** (Grabau) (coenosteum toward upper right) and **Amphipora** sp. (coenosteum in lower middle); hypotype, GSC 60591, Loc. 97211, transverse sections, X10, the presence of an axial canal in the coenosteum in the lower middle is uncertain.
- Figure 10. **Stachyodes** (?) sp.; figured specimen, GSC 61342, Loc. 15114, transverse section, X10, showing 2 or 3 encircling laminae; the presence of an axial canal is uncertain.

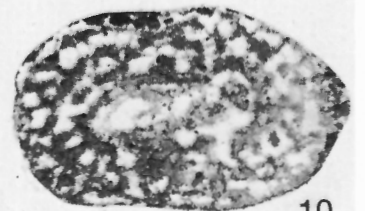
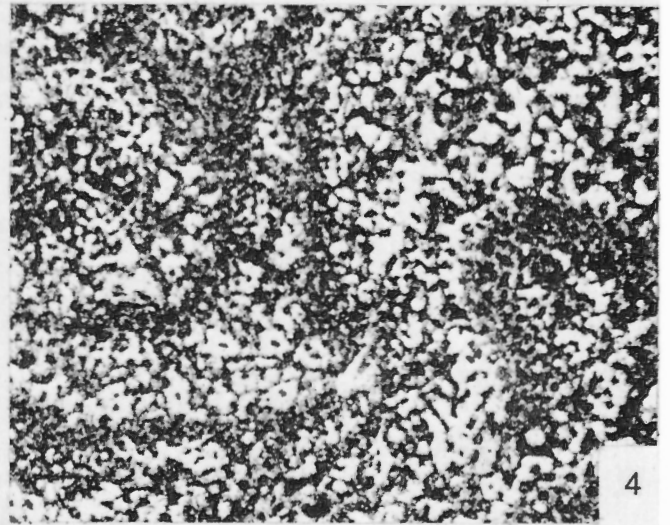
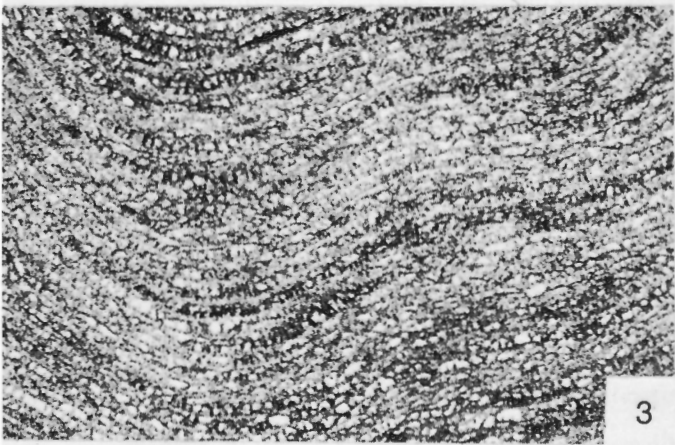
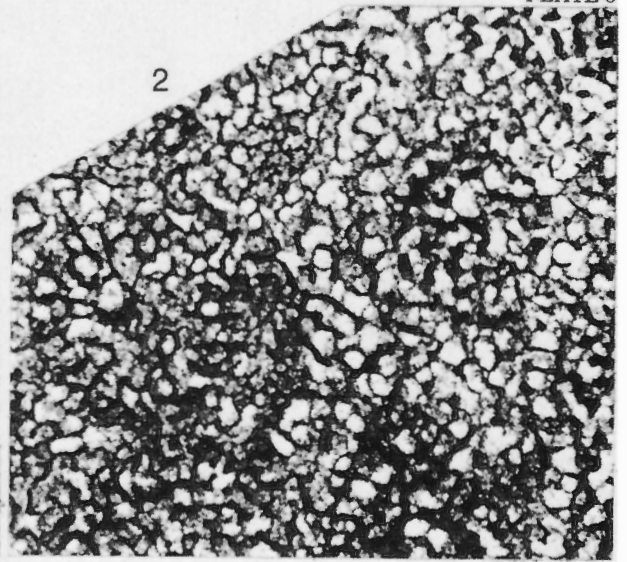
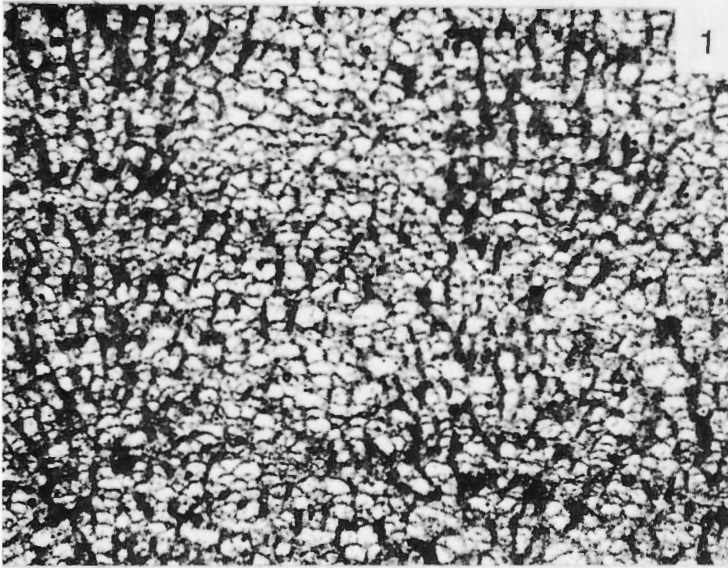


PLATE 7

- Figure 1. **Stromatoporella granulata** (Nicholson); hypotype, MRHN 7449a, vertical section, X30, showing well-preserved tripartite/ordinicellular microstructure and wrinkled laminae due to presence of ring-pillars. Photograph provided through courtesy of P. Sartenaer.
- Figures 2-4. **Stromatoporella perannulata** (?) Galloway and St. Jean; figure 2, hypotype, GSC 60551, Loc. 97215, vertical section, X25, showing moderately well-preserved tripartite/ordinicellular microstructure and absence of dissepiments; figure 3, hypotype, GSC 60546, Loc. 97215, vertical section, X25, with poorly preserved tripartite/ordinicellular microstructure and abundant dissepiments, flocs and melanospheres; figure 4, hypotype, UNSM 4750, Loc. 23635, tangential section, X10, with abundant ring-pillars (many with fibrous to porous walls).
- Figure 5. **Stromatoporella eriense** (?) (Parks); hypotype, GSC 60563, Loc. VII, vertical section, X5, showing abundant ring-pillars and no mamelons.
- Figures 6, 7. **Trupetostroma** (?) sp.; figure 6, figured specimen, GSC 60568, Loc. 15114, vertical section, X10, showing tripartite (not ordinicellular) laminae and vertically aligned (superposed), transversely fibrous pillars; coenosteum attached to epitheca of rugose coral; figure 7, figured specimen, GSC 60570, Loc. 23566, tangential section, X10, transverse to subcylindrical (?) or subconical (?) coenosteum with amalgamate axial region and concentric tripartite laminae in peripheral region.

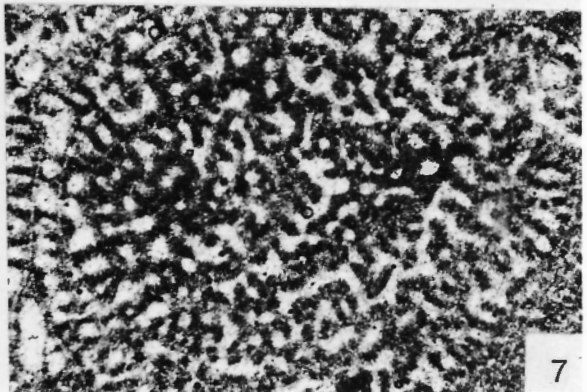
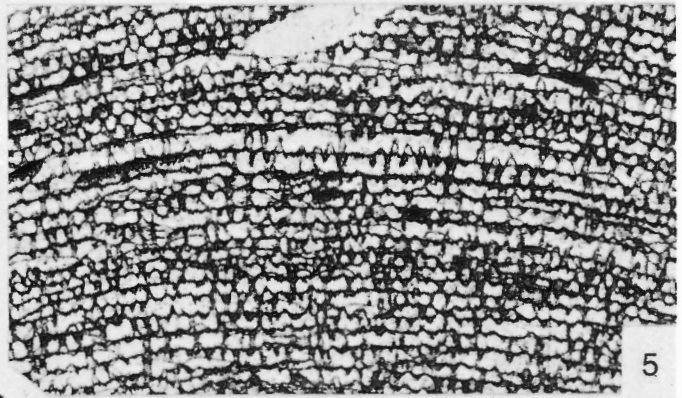
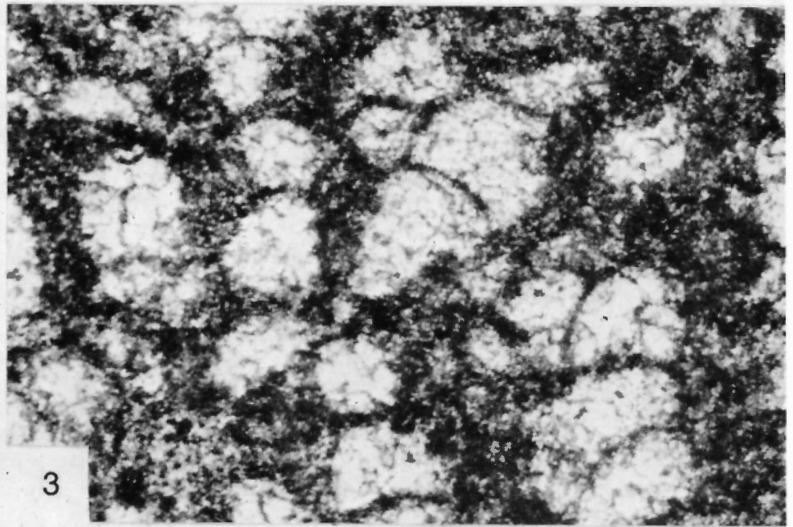
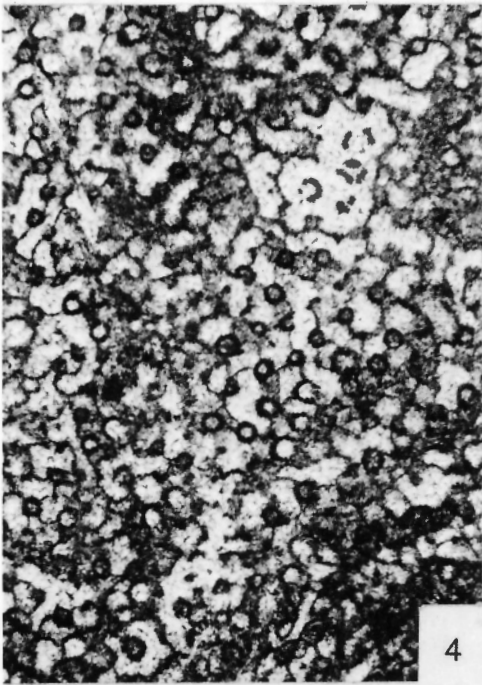
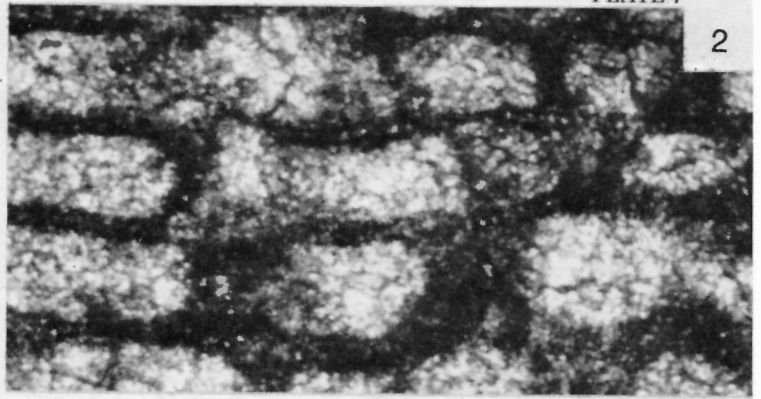
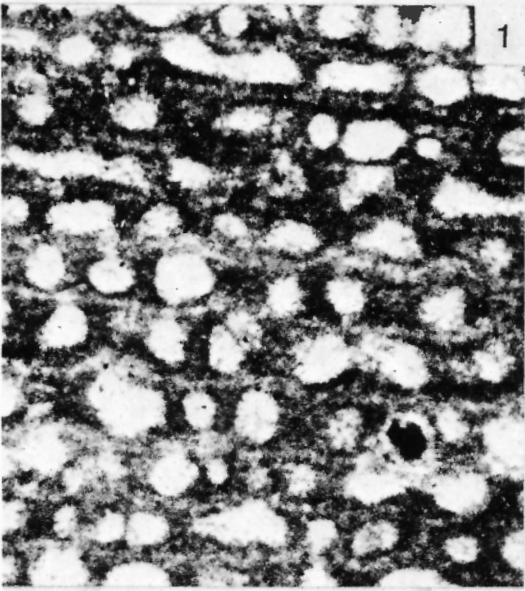
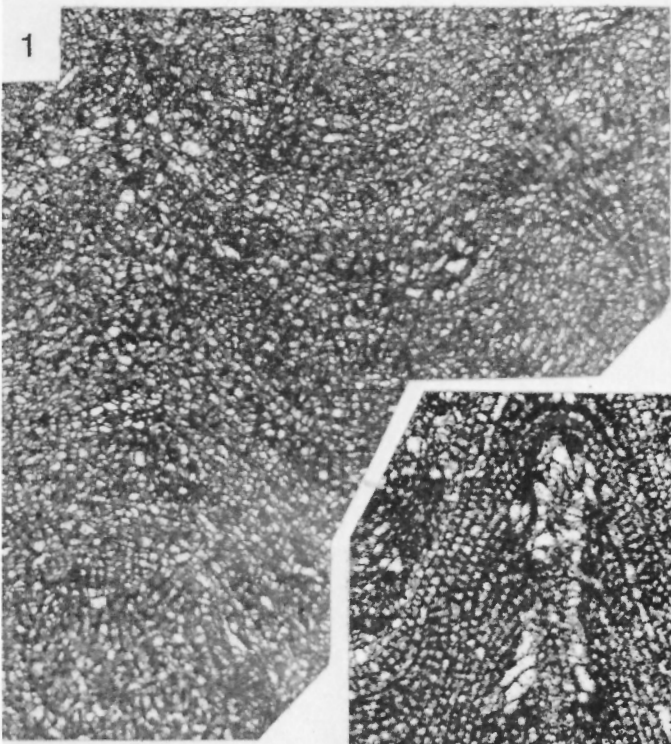
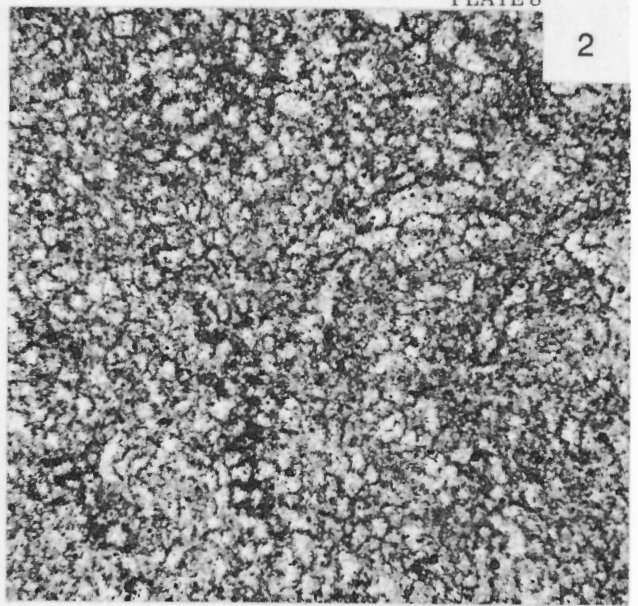


PLATE 8

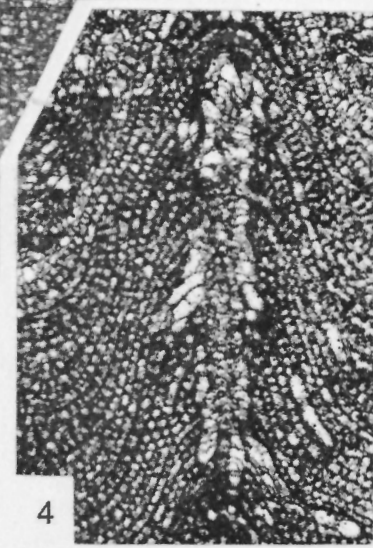
- Figures 1-3. "*? Anostylostroma* sp. - *? Pseudoactinodictyon* sp."; figure 1, figured specimen, GSC 61337, Loc. 23566, vertical section of a moderately contorted coenosteum, X5, with unevenly arranged mamelons having thickened pillars, abundant dissepiments and local areas of continuous laminae; figure 2, figured specimen, GSC 61340, Loc. 76001, vertical section of highly contorted coenosteum which locally appears cellular and in which dissepiments appear to have completely replaced laminae and pillars, X10; figure 3, figured specimen, GSC 61338, Loc. 23566, tangential section, X10, showing abundant dissepiments (lower left), thickened rod-like to ring-like pillars (central) and poorly formed laminae and fibrous pillars (upper right).
- Figures 4, 5. *Stictostroma longitubiferum* Fagerstrom; figure 4, hypotype, GSC 60545, Loc. 15114, vertical section, X5, showing abundant large astrorhizal canals in the vicinity of a conspicuous mamelon; figure 5, hypotype, UNSM 4749, Loc. 23635, tangential section, X10, with numerous large astrorhizal canals radiating from mamelon columns.
- Figures 6, 7. *Stictostroma mamilliferum* Galloway and St. Jean; figure 6, hypotype, GSC 60541, Loc. 97212, vertical section, X30, with excellent preservation of tripartite/ordinicellular microstructure in the laminae and dense, dark non-superposed pillars; figure 7, hypotype, GSC 60543, Loc. 97212, tangential section, X10, showing well-defined pillars and laminae and one mamelon.



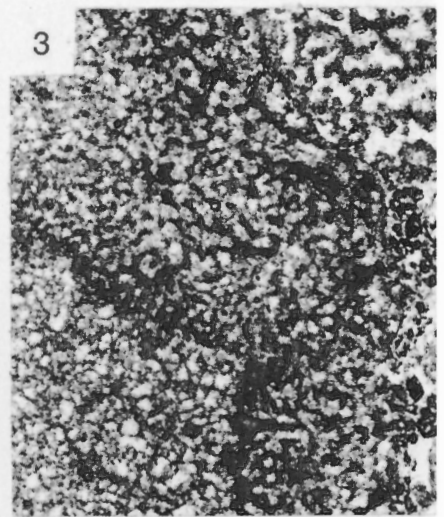
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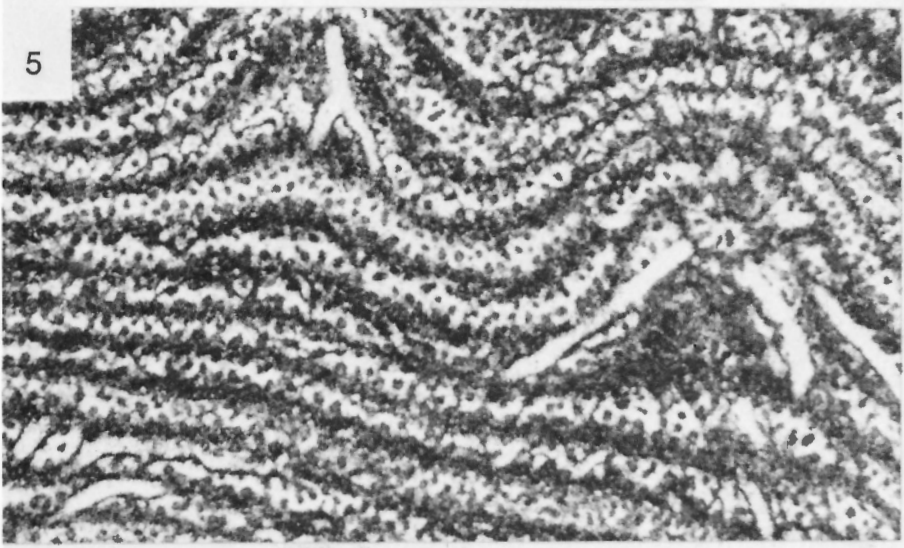
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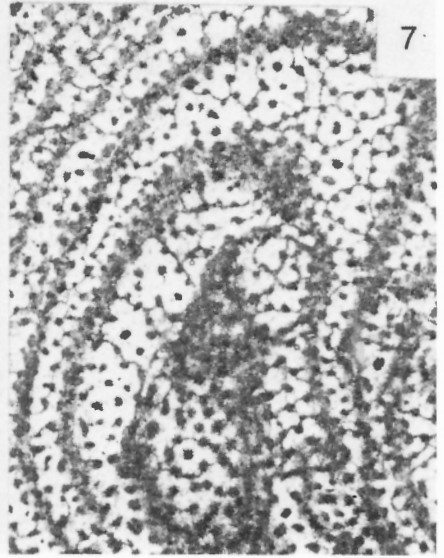
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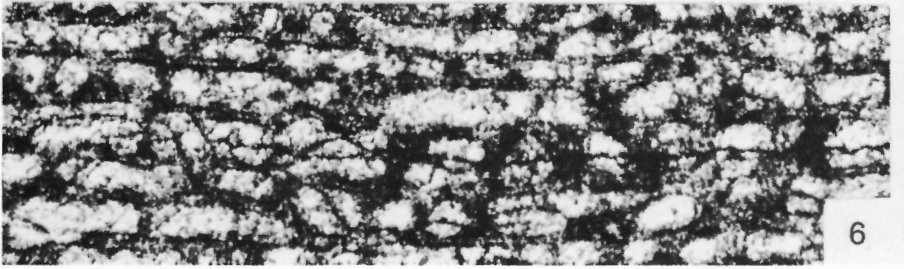
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