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CRYPTOSTOMATOUS BRYOZOA FROM THE MIDDLE DEVONIAN TRAVERSE GROUP OF MICHIGAN

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CONTENTS

INTRODUCTION

Purposes of the investigation

THE purposes of this study are to describe the species of cryptostomatous Bryozoa of the Middle Devonian Traverse group of rocks of Michigan, to point out their taxonomic relationships, and to discuss new features concerning their morphology. The investigation was made to determine also whether this par-

ticular order of Bryozoa would contribute to the correlation of the Traverse strata.

The results of this study form the basis of a dissertation submitted in partial fulfillment of the requirements for the degree of doctor of philosophy at the University of Michigan.

Previous work on cryptostomatous Bryozoa from the Traverse group

Alexander Winchell (1866, p. 92) was the first to describe cryptostomatous Bryozoa from the Traverse strata. He defined *Fenestrellina eximia, F. filitexta,* and *Sulcoretepora sulcata,* but did not publish illustrations of them.

E. O. Ulrich (1890, pp. 507–508, 526) described and figured three new species, *Scalaripora approximata, S. separata,* and *Euspilopora serrata,* all from the upper Traverse.

E. R. Pohl (1930, pp. 30–32) reported the occurrence in the Traverse of *Reteporina striata* (Hall) and a species of *Sulcoretepora,* which he thought closely resembled *S. gilberti* (Meek), and stated that these two species were common to the Traverse group of Ohio and the Bell shale of Michigan. *Scalaripora separata* Ulrich, *S. approximata* Ulrich, and *Sulcoretepora* near *incisurata* (Hall) also were listed by Pohl as being common to the Traverse of Michigan and the Devonian strata at the mouth of the Ausable River, Ontario.

C. F. Deiss (1932, pp. 238–268) described forty-two species and five varieties belonging to seven genera, and listed six species which had previously been described from the Devonian of New York or Iowa.

Acknowledgments

The author wishes to express his appreciation to the men who have aided him during the course of this study. To Professors E. C. Case and G. M. Ehlers, of the University of Michigan, and to Professor C. F. Deiss, of the University of Montana, for their help, directions, suggestions, and encouragement, he is deeply indebted. Dr. R. S. Bassler has given much help and

encouragement. A fine collection of Traverse Bryozoa was loaned for study by Mr. G. O. Raasch, of the Milwaukee Museum. Professor A. S. Warthin, of Vassar College, loaned additional material and offered valued information. Material from the Cedar Valley strata of Iowa was loaned by Professor A. K. Miller, of the University of Iowa. Hall's types of Bryozoa, preserved in the New York State Museum at Albany, were made available for study through the kindness of Dr. Rudolf Ruedemann, New York State paleontologist.

The completion of the work was made possible by a University of Michigan fellowship in the department of geology for the year 1934–35.

GENERAL DESCRIPTION OF TRAVERSE GROUP

Geographic distribution

Strata of the Traverse group underlie a large part of the Michigan Basin. The only exposures in Michigan, however, are in the northern part of the Southern Peninsula. They lie at or near the surface in an arcuate belt extending from Charlevoix, on the western side, to Alpena, on the eastern side. The counties in which outcrops occur are, from west to east, Charlevoix, Emmet, Cheboygan, Presque Isle, and Alpena.

Within the Traverse belt there are three areas in which the rocks are well exposed: (1) a western area in the vicinity of Little Traverse Bay; (2) a central area in Cheboygan and western Presque Isle counties, from Afton to the vicinity of Black Lake; and (3) an eastern area in Alpena County. Since the rocks are poorly exhibited in the intervening regions and no beds are known to be exposed in all three, our knowledge of the stratigraphy of the Traverse group must be gained through a comparison of the sections of these three areas.

Little Traverse Bay area

The rocks of the Little Traverse Bay region were studied by Drs. E. R. Pohl and G. O. Raasch in 1928. These strata were divided by Pohl (1930, p. 5) into three units, the Petoskey forma-

tion [1] at the top, the Charlevoix stage in the middle, and the Gravel Point stage at the base (see Fig. 1). The first two were named from the towns of Petoskey and Charlevoix. The third received its name from a point on the south side of Little Traverse Bay, two miles west of Charlevoix. This spot was termed "Gravel Point" in the field notes of the 1926 Michigan Geological Survey party. On the maps of Winchell (1866, p. 82) and Grabau (1902, p. 208) it is designated as "Pine River Point." On the United States Lake Survey charts the same locality is called "South Point." Although the proper name is not "Gravel Point," it seems better to retain this name rather than to introduce another into the literature.

Pohl's section describes approximately 230 feet of rock, composing the highest third of the Traverse. A well drilled at Bay View (Grabau, 1902, p. 197) indicates that at least 400 feet of unexposed beds underlies the lowest strata observed by Pohl.

Afton–Black Lake area

The highest Traverse strata of the Afton–Black Lake area are exposed along a north–south road which joins a main east–west highway one-half mile west of Afton, Cheboygan County. The exact location of the exposures is between points one and one-half and two and three-quarter miles south of the junction of the two roads.

The outcrops mentioned above were examined by the Michigan Geological Survey party of 1926 and by G. M. Ehlers and the writer of this paper in 1934. Although a number of the ledges of rock had become covered by soil since 1926, enough outcrops were seen to enable one to check the observations of the 1926 party and to determine the presence of 80 to 90 feet of limestone and shale in the section, the highest bed of which probably is not more than 10 feet below the base of the Antrim black shale (see Fig. 1).

It is possible that the lower fourth or more of the section exposed along the road is equivalent to the 37 to 38 feet of lime-

[1] The name "Petoskey" was first proposed by Grabau (1902, p. 201) for a limestone which is now a part of the Petoskey formation.

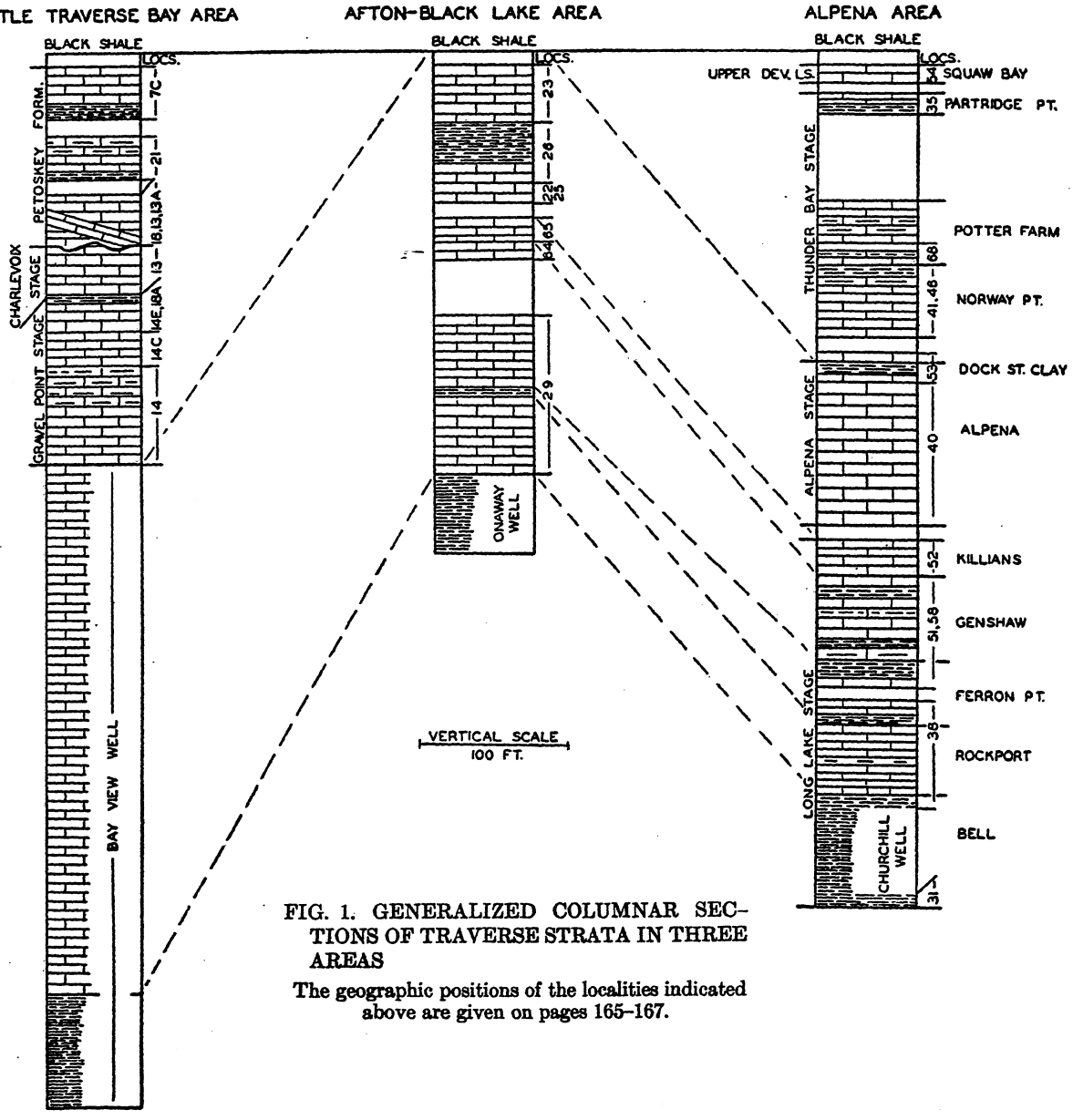

FIG. 1. GENERALIZED COLUMNAR SECTIONS OF TRAVERSE STRATA IN THREE AREAS

The geographic positions of the localities indicated above are given on pages 165–167.

stone which is excellently exhibited in the quarry of the Campbell Stone Company about three quarters of a mile north of Afton. Further study, however, may show that the lowest beds of the road section are above the highest beds of the quarry.

At no great distance below the lowest stratum of the Campbell Stone Company quarry is a black limestone, which outcrops at locality 65 [2] about one and one-quarter miles north of this quarry (see Fig. 1). This limestone is thought to be the westward continuation of the Killians limestone of the Alpena region because its paleontologic and lithologic characteristics are like those of typical examples of this limestone. This belief is supported by the identification of fossils from underlying limestones exposed at locality 64, a point on an east–west highway about one third of a mile east of locality 65; the paleontologic identifications indicate that the limestones belong to the Genshaw formation, which immediately underlies the Killians limestone of Alpena County.

Strata lower in the Traverse section of the Afton–Black Lake area are shown in the abandoned quarry at Black Lake, locality 29, and in the slope above this quarry (see Fig. 1). The limestones exposed on the slope above the quarry contain *Gypidula romingeri* Hall and Clarke and a large species of *Atrypa* characteristic of the Genshaw formation. Below the Genshaw limestones are about three feet of shale, with a few thin layers of limestone. The shale and the thin layers of limestone contain a large number of fossils characteristic of the Ferron Point formation, which has a greater thickness in the Alpena area than in the Black Lake quarry. The Rockport limestone, which is typically exposed in the quarry of the Kelly Island Lime and Transport Company at Rockport, Alpena County, composes the face of the Black Lake quarry. Although the Bell shale, the lowest formation in the Traverse group, is unexposed in the Afton–Black Lake area, a well record near the Black Lake quarry shows that it must be only a very few feet below the base of this quarry.

[2] The geographic positions of this and all localities mentioned subsequently are given on pages 165–167.

Alpena area

The first detailed classification of the Traverse group of the Alpena area was made by A. W. Grabau in 1902 (pp. 173–174). This classification was accepted by W. A. Ver Wiebe in 1927 (pp. 181–190), except for the assignment of certain strata to stratigraphic divisions different from those proposed by Grabau.

Recently, as the result of considerable field study, A. S. Warthin and G. A. Cooper (1935b, pp. 524–526) have been able to reclassify the Traverse group of the Alpena area and to divide it into smaller stratigraphic units.

The sequence of formations, from top to bottom, in the Alpena area is tabulated below (see also Fig. 1):

Thunder Bay stage, Grabau (1902, p. 192)
- Partridge Point formation, Warthin and Cooper (1935b, p. 525)
- Potter Farm formation, Warthin and Cooper (1935b, p. 525)
- Norway Point formation, Warthin and Cooper (1935b, p. 525)

Alpena limestone stage, Grabau (1902, p. 175)
- Dock Street clay, Grabau (1902, p. 192); a local clay facies of the upper part of the Alpena limestone

Long Lake stage, Grabau (1902, p. 184)
- Killians limestone, Warthin and Cooper (1935b, p. 526)
- Genshaw formation, Warthin and Cooper (1935b, p. 526)
- Ferron Point formation, Warthin and Cooper (1935b, p. 526)
- Rockport limestone, R. A. Smith (1916, p. 175)
- Bell shale, Grabau (1902, p. 191)

DESCRIPTION OF BRYOZOA

The species described or listed in this paper do not constitute the entire fauna of cryptostomatous Bryozoa of the Traverse rocks. A number of specimens believed to be new species have not been described because they are too poorly preserved to enable one adequately to determine their morphology. Further collecting from the Traverse undoubtedly will yield many additional species.

FAMILY FENESTRELLINIDAE BASSLER

1849. *Fenestellidae* King, Ann. and Mag. Nat. Hist., 2d ser., Vol. III, p. 388.
1900. *Fenestellidae* Nickles and Bassler, U. S. Geol. Surv., Bull. No. 173, p. 37.
1935. *Fenestrellinidae* Bassler, Fossilium Catalogus, Pars 67, p. 19.

Definition from Nickles and Bassler. — "Zoarium a reticulated expansion, celluliferous on one side only, composed of rigid branches, united by regular nonporiferous bars (dissepiments), or branches may be sinuous and anastomose at regular intervals, or may remain free; zooecia oblong, quadrate, or hexagonal in outline, embedded in a calcareous crust which is minutely porous, especially on the noncelluliferous side; orifice anterior, semi-elliptical, truncated behind; apertures rounded, with peristome and closed at times by a centrally perforated closure; a superior hemiseptum generally present, an inferior one less frequently."

Genus FENESTRELLINA D'Orbigny

1839. *Fenestella* Lonsdale, Murchison's Silurian System, p. 677.
1849. *Fenestrellina* D'Orbigny, Rev. et mag. zool. (2), Vol. I, p. 501.
1900. *Fenestella* Nickles and Bassler, U. S. Geol. Surv., Bull. No. 173, p. 37.
1935. *Fenestrellina* Bassler, Fossilium Catalogus, Pars 67, p. 19.

Definition from Nickles and Bassler. — "Zoarium flabellate or funnel shaped, celluliferous on the inner side; branches generally straight, sometimes flexuous, connected at regular intervals by dissepiments; apertures in two rows, separated by a plain or tuberculated median keel."

Genotype. — *Fenestella crassa* McCoy. Range, Ordovician to Carboniferous.

Fenestrellina regularis, sp. nov.

(Pl. I, Figs. 3–4)

Description. — Zoarium known only from flattened fragments.

Obverse. — Branches angular, subparallel; average width 0.32 mm.; ten in space of 5 mm. Dissepiments narrow, rounded, depressed below plane of branches; nine or ten in space of 5 mm. Fenestrules oval, narrower than on reverse side. Apertures small and circular; average diameter 0.10 mm.; opening directly outward; twenty to twenty-one in space of 5 mm., averaging three to a fenestrule; separated by distances approximately equal to diameters of apertures. Peristomes strongly developed, slightly indenting margins of fenestrules. Carina prominent, rounded;

bearing a row of low nodes, spaced approximately 0.4 mm. apart; carina divided at point of bifurcation, new ranges of apertures appearing inside bifurcation.

Reverse. — Branches rounded, smooth, narrower than those on obverse face; at irregular intervals cylindrical rootlets or stolons are given off from branches. Dissepiments rounded, not depressed below plane of branches. Fenestrules oval; length 0.30 to 0.40 mm.; width approximately 0.3 mm.

Remarks. — This species differs from *Fenestrellina eximia* var. *problematica* (Deiss) in having stronger branches and narrower dissepiments. The type of bifurcation of the branches distinguishes it from *Fenestrellina rockportensis*, sp. nov., and *F. alpenensis*, sp. nov.

Types.[3] — Holotype No. 17069; paratype No. 17070.

Occurrence. — Alpena limestone stage: Dock Street clay; locality 53.

Fenestrellina rockportensis, sp. nov.

(Pl. I, Figs. 1-2)

Description. — Zoarium known only from flexuose fragments.

Obverse. — Branches thick, angular, and subparallel; average width 0.4 mm.; widest immediately before bifurcation; seven to nine in space of 5 mm. Fenestrules irregularly oval, those in mature part of zoarium inflected by apertures; length 0.5 to 0.6 mm.; width 0.15 to 0.3 mm.; slightly smaller than on reverse face. Apertures large and circular; average diameter 0.13 mm.; opening directly outward; twenty to twenty-two in space of 5 mm.; separated by distances approximately equal to diameters of apertures; three and, occasionally, four rows of apertures present on branch for interval of two or three mm. before bifurcation. Peristomes prominent, most of them indenting margins of fenestrules. Carina not prominent, bearing a row of low nodes; strongest between points of bifurcation and at these points divided into irregularly spaced low nodes.

Reverse. — Branches rounded, smooth, without nodes. Dis-

[3] The types of all species described in this paper are preserved in the Museum of Paleontology of the University of Michigan.

sepiments rounded, not depressed below plane of branches. Fenestrules oval to rounded-quadrate, occasionally emarginated; length 0.6 to 0.7 mm.; width 0.2 to 0.4 mm.

Remarks. — *Fenestrellina rockportensis* is a very characteristic fossil of a twenty-inch bed of limestone nine feet above the base of the Ferron Point formation in the Rockport quarry. Most of the entire under surface of this bed is covered by broken zoaria of this species. This species may be distinguished from its nearest relative, *Fenestrellina megalopora* (Deiss), by the absence of nodes on the reverse side at the junction of the branches and the dissepiments, the closer spacing of the apertures, and the presence of narrower fenestrules.

The exact generic position of *F. rockportensis* and the species next described, *F. alpenensis*, sp. nov., is not known. The fact that these species have more than two ranges of apertures on the branches before bifurcation would exclude them from being typical species of *Fenestrellina*, but would include them in the genus *Polypora*. The genus *Polyporella*, established by Simpson (1894, p. 894) but discarded by Nickles and Bassler as a synonym of *Polypora*, is undoubtedly the one to which these species belong. Since *Polyporella* possesses characters of both *Fenestrellina* and *Polypora*, a revision of these genera would be necessary to make *Polyporella* a valid genus. The validity of the genus *Polyporella* can be determined only by a study of type and other material unavailable to the writer at this time.

Types. — Holotype No. 17067; paratype No. 17068.

Occurrence. — Long Lake stage: Ferron Point formation; locality 38.

Fenestrellina alpenensis, sp. nov.

(Pl. I, Figs. 5–6)

Description. — Zoarium known only from flattened fragments.

Obverse. — Branches thin, angular, and subparallel; average width 0.3 mm.; widest immediately before bifurcation; eight or nine in space of 5 mm. Dissepiments slender, rounded, depressed below plane of branches; seven in space of 5 mm. Fe-

nestrules oval, not inflected by apertures; length 0.4 to 0.6 mm.; width 0.2 to 0.3 mm. Apertures circular; average diameter 0.09 mm.; opening laterally; twenty-one to twenty-three in space of 5 mm.; separated by distances less than diameter of apertures; three rows of apertures present on branch at points of bifurcation. Peristomes absent. Carina high and thin, extended into nodes opposite dissepiments.

Reverse. — Branches rounded, smooth, widest at junction of dissepiments. Dissepiments rounded, not depressed below plane of branches. Fenestrules oval to circular, same size as those on obverse face.

Remarks. — *Fenestrellina alpenensis* differs from *Fenestrellina rockportensis*, sp. nov., in having thinner branches, more regularly shaped and wider fenestrules, and no peristomes.

Types. — Holotype No. 17071; paratype No. 17072.

Occurrence. — Alpena limestone stage: Dock Street clay; locality 53.

Fenestrellina striata (Hall)

1884. *Fenestella striata* Hall, Thirty-sixth Ann. Rep. New York State Museum, p. 72.

The Traverse specimens of this species have been compared with the type specimens at the New York State Museum and are believed to be Hall's species.

Type. — Plesiotype No. 17181.

Occurrence. — Hamilton group of New York. Alpena limestone stage: Dock Street clay; locality 53.

Genus LOCULIPORA Hall

1885. *Loculipora* Hall, Report of State Geol. New York for Year 1884, p. 37.
1900. *Loculipora* Nickles and Bassler, U. S. Geol. Surv., Bull. No. 173, p. 38.

Definition from Nickles and Bassler. — "Zoarium funnel-shaped, branches connected by short, typically reduced to a minimum, nonporiferous dissepiments; apertures in two rows; branches and dissepiments carinated, the carinae coalescing; summits of carinae much expanded, angular, and slightly carinated, their width usually equalling that of the branches and dissepi-

ments below and hence causing difficulty in distinguishing the obverse and reverse sides."

Genotype. — *Fenestella perforata* Hall. Range, Silurian, Devonian.

Loculipora loculata, sp. nov.

(Pl. II, Figs. 1–3)

Description. — Zoarium known only from flattened fragments.

Obverse. — Branches broad, sinuous to zigzag and flattened; average width 0.35 mm.; eight in space of 5 mm. Dissepiments equal in width to branches and strongly carinated. Fenestrules oval to circular; average length 0.35 mm.; six in space of 5 mm.; arranged in intersecting linear series. Apertures opening directly outward; separated by distances approximately equal to diameters of apertures; disposed in rows surrounding fenestrules; ten or eleven occurring around a fenestrule. Carina strong, thin, with rounded, expanded summit; present on both branches and dissepiments. Openings of superstructure oval to circular; twice diameter of fenestrules; most of them more irregularly arranged than fenestrules.

Reverse. — Branches and dissepiments indistinguishable and of same size; summits broadly angular. Fenestrules surrounded by sloping hexagonal areas; same size as those on obverse face. Nodes absent on branches and dissepiments.

Remarks. — This species is distinguished from *Loculipora tropozonema* (Deiss) in that the openings of the superstructure are much larger than the fenestrules and that the reverse side does not bear nodes. *L. loculata* is distinguished from *L. perforata* (Hall) by the absence of angular carinae and from *L. circumstata* Hall and Simpson in having the fenestrules much smaller than the openings of the superstructure.

Types. — Holotype No. 17074; paratypes Nos. 17073, 17075.

Occurrence. — Alpena limestone stage: Dock Street clay; locality 53. Thunder Bay stage: Potter Farm formation; locality 68. Petoskey formation: bed 2, zone 2, of E. R. Pohl; locality 13.

Genus LYROPORA Hall

1857. *Lyropora* Hall, Proc. Am. Assn. Adv. Sci., Tenth Meeting, Part II, Natural History, p. 179. Genus named but not defined.
1882. *Lyropora* Ulrich, Journ. Cincinnati Soc. Nat. Hist., Vol. V, p. 150. First definition.
1890. *Lyropora* Ulrich, Geol. Surv. Ill., Vol. VIII, p. 396.

Definition from Ulrich, 1890. — "Zoaria flabellate, the fenestrated portion spread between two strong, noncelluliferous, diverging supports. Zooecia in from two to five rows. Median keel obsolete."

Type. — *Lyropora quincuncialis* Hall. Range, Devonian to Mississippian.

Lyropora devonica, sp. nov.

(Pl. II, Figs. 4–8)

Description. — Zoarium flabellate, arising from a spreading base; the fenestrated portion spread between two strong, noncelluliferous, lateral supports; greatest known height 7 cm.; greatest width, approximately 4 cm.

Obverse. — Branches slender, subangular; average width 0.35 mm.; eight in space of 5 mm. Dissepiments strong, rounded to flattened, depressed below plane of branches; six or seven in space of 5 mm. Fenestrules oval; average length 0.45 mm.; average width 0.27 mm.; narrower than on reverse face. Apertures large, circular; diameter 0.13 mm.; opening laterally; twenty-two to twenty-five in space of 5 mm.; separated by distances less than diameters of apertures; three or four ranges of apertures on branches at points of bifurcation, two on branches between these points. Peristomes absent. Carina not well developed, extended into high, elongate nodes at irregular intervals.

Reverse. — Branches rounded; same size as those on obverse side. Dissepiments rounded, somewhat narrower than branches of average width, not depressed below plane of branches. Fenestrules oval; average length 0.5 mm.; average width 0.3 mm.

Remarks. — This species can be distinguished from other fenestrellinids of the Traverse strata by its strong lateral supports. Many fenestrellinids have a thickened margin on the

fronds, but do not have the solid calcareous supports characteristic of this species. *L. devonica* is the first Devonian representative of the genus *Lyropora* to be described.

Types. — Holotype No. 17078; paratypes Nos. 17076, 17077, 17079, 17080.

Occurrence. — Petoskey formation: bed 2, zone 2, of E. R. Pohl; locality 13.

Genus ANASTOMOPORA Simpson

1895. *Anastomopora* Simpson, Fourteenth Ann. Rep. State Geol. New York, p. 517.

Original definition. — "This genus has a general resemblance to *Lyropora*, but the branches are sinuous and anastomosing; cell apertures disposed in three or more ranges, without separating carina."

Genotype. — *Fenestella cinctuta* Hall. Range, Devonian.

Anastomopora ovata, sp. nov.

(Pl. III, Figs. 3–4)

Description. — Zoarium known only from flattened fragments.

Obverse. — Branches rounded, broad; 0.4 to 0.9 mm. in width; sinuous and subparallel, anastomosing at intervals of 1.3 to 1.7 mm.; connected by very short, broad dissepiments. Dissepiments slightly depressed below plane of branches; width 0.6 to 1.0 mm.; four in space of 5 mm. Fenestrules oval; average length 0.6 mm.; average width 0.3 mm.; those on one side of branch alternate in position with those on other side. Apertures in three to seven ranges; twenty-five in space of 5 mm.; separated by distances approximately equal to diameters of apertures; arranged in irregular longitudinal and transverse series. Peristomes strong.

Reverse. — Branches sinuous to zigzag, smooth, strong, not distinguishable from dissepiments. Fenestrules oval, arranged in longitudinal and oblique series.

Remarks. — This species is distinguished from *Anastomopora petoskeyensis*, sp. nov., in having smaller fenestrules, higher dissepiments, and less tapering branches.

Type. — Holotype No. 17113.

Occurrence. — Alpena limestone stage: Dock Street clay; locality 53.

Anastomopora petoskeyensis, sp. nov.

(Pl. III, Figs. 1-2)

Description. — Zoarium known only from flattened fragments.

Obverse. — Branches rounded, broad; 0.4 to 1.0 mm. in width, rapidly increasing in width after bifurcation; sinuous and subparallel, anastomosing at intervals of approximately 1.5 mm.; connected by very short, broad dissepiments. Dissepiments much depressed below plane of branches; width approximately 0.6 mm.; three or four in space of 5 mm. Fenestrules oval; average length 0.9 mm.; average width 0.45 mm.; those on one side of branch alternate in position with those on other side. Apertures in three to six ranges; twenty-two in space of 5 mm.; separated by distances greater than diameters of apertures; arranged in longitudinal and irregular transverse series. Peristomes strong.

Reverse. — Branches zigzag, smooth, strong, not distinguishable from dissepiments; slightly angular. Fenestrules situated in center of sloping hexagonal areas and arranged in more or less regular longitudinal and oblique series.

Remarks. — This species is distinguished from *Anastomopora ovata,* sp. nov., by its tapering branches, larger fenestrules, and depressed dissepiments. It is distinguished from species of *Polypora* found in the Traverse by its sinuous branches.

Type. — Holotype No. 17082.

Occurrence. — Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 9.

Family ACANTHOCLADIIDAE Zittel

1880. *Acanthocladiidae* Zittel, Handbuch der Palaeontologie, I. Band, p. 603.
1900. *Acanthocladiidae* Nickles and Bassler, U. S. Geol. Surv., Bull. No. 173, p. 41.

Definition from Nickles and Bassler. — "Zoarium a pinnate or fenestrate expansion, celluliferous on one face only, consisting of strong central stems which give off numerous smaller, lateral

branches from their margins; the lateral branches are free or unite with those of the next stem; nonporiferous dissepiments rarely present; zooecial characters mostly as in the Fenestellidae."

Genus PENNIRETEPORA D'Orbigny

1849. *Penniretepora* D'Orbigny, Rev. et mag. zool. (2), Vol. I, p. 501.
1900. *Pinnatopora* Nickles and Bassler, U. S. Geol. Surv., Bull. No. 173, p. 41.
1935. *Penniretepora* Bassler, Fossilium Catalogus, Pars 67, p. 165.

Definition from Nickles and Bassler. — "Zoarium a small delicate stipe, with short, free lateral branches given off frequently and at regular intervals; apertures in two rows, separated by a moderate median keel."

Genotype. — *Retepora pluma* Phillips. Range, Devonian to Permian.

Penniretepora irregularis, sp. nov.

(Pl. IV, Figs. 1–3)

Description. — Zoarium a pinnate expansion, consisting of primary and secondary branches; secondary branches approximately at right angles to primary ones.

Branches subcylindrical, straight, or curved; diameter 0.2 to 0.5 mm.; distance between secondary branches 1.5 to at least 6.5 mm.; secondary branches narrower than primary ones; specimens too incomplete to enable one to determine existence of tertiary branches.

Apertures open directly and obliquely outward; oval in outline; average length 0.18 mm.; average width 0.10 mm.; separated longitudinally by a distance equal to two to four times their length and transversely by a distance slightly greater than their width; situated in longitudinal ranges, two to four occurring on a branch. Peristomes of centrally arranged apertures low and inconspicuous; those of laterally placed ones located at ends of short tubes.

Ridges between ranges parallel or slightly oblique to axis of branch.

Remarks. — The specimens of this species having only two

ranges of apertures agree in all particulars with the definition of *Penniretepora*. Some specimens, however, have two to four ranges, in this respect showing affinities with *Acanthocladia*. With the exception of the greater number of ranges these specimens agree entirely with *Penniretepora*. Owing to the fact that all specimens available for study are fragmentary and poorly preserved, the complete structural characters of the species cannot be determined. However, the species is distinct from other cryptostomatous Bryozoa of the Traverse and is easily recognized.

Types. — Holotype No. 17084; paratypes Nos. 17083, 17085.

Occurrence. — Gravel Point stage: zone 4 of E. R. Pohl; locality 8.

Family ARTHROSTYLIDAE Ulrich

1890. *Arthrostylidae* Ulrich, Geol. Surv. Ill., Vol. VIII, p. 400.

Original definition. — "Zoaria articulated, ramose, consisting of numerous sub-cylindrical segments, or, if dichotomously divided, of continuous branches, which articulate with a slightly expanded attached base. Zooecia sub-tubular, more or less oblique, radially arranged around a central axis, opening on all sides of the segments; more rarely, one side is non-celluliferous and striated longitudinally."

Genus HELOPORA Hall

1852. *Helopora* Hall, Pal. New York, Vol. II, p. 44.
1895. *Helopora* Ulrich, Geol. of Minnesota, Vol. III, Part I, pp. 189–190.

Original definition. — "Simple or branching cylindrical stems, often swelling at the upper extremity, poriferous on all sides; pores oval or subangular, arranged between longitudinal elevated lines."

Definition from Ulrich. — "Zoaria consisting of numerous, subequal, small, cylindrical segments, articulating terminally, poriferous on all sides. Zooecial tubes somewhat oblique, geniculated or proceeding to the surface in a straight line. Apertures slightly oblique or appearing direct, suboval, arranged in diagonally intersecting series (section *a*) or between more or less well defined

longitudinal ridges (section *b*). In section *a* the apertures are usually without a peristome, but an acanthopore occurs immediately beneath each. In section *b* the acanthopores are wanting, but a peristome, generally incomplete and prominently elevated posteriorly, is provided. Axial tube very slender."

Type. — *Helopora fragilis* Hall. Range, Silurian and Devonian.

Helopora inexspectata, sp. nov.

(Pl. IV, Figs. 4–9)

Description. — Zoarium ramose, consisting of articulated segments.

Segments subcylindrical; some simple, others bifurcated, all expanded at both proximal and distal ends; proximal end bluntly conical, articulating in a concave socket of distal end of preceding segment, both cone and socket concentrically striated; distal ends of some segments have two sockets; celluliferous except on articulating surfaces; average length of segments 6 mm.; average diameter at central parts of segments 1.2 mm.

Apertures open obliquely outward; elliptical to subpolygonal in outline; average length 0.13 mm.; average width 0.09 mm.; separated by distances less than widths of apertures; arranged in decussating linear series; proximal lip of each aperture extended as a short spine, the surface of an acanthopore; approximately fifteen to twenty apertures present in the circumference of a segment.

Longitudinal sections show tubular zooecia directed obliquely upward to the surface and acanthopores appearing as dark lines in mature parts of zooecial walls. Transverse sections show a radial arrangement of zooecia about a central axis.

Remarks. — This species unquestionably belongs to section *a* of the genus *Helopora,* which includes *H. fragilis* Hall from the Cataract and Clinton strata, *H. belula* Billings, *H. armata* Billings, and *H. nodosa* Billings from the Anticostian series, and *H. lindstroemi* Ulrich, from the Silurian of the island of Gotland. This is the first known occurrence of the genus *Helopora* in strata of Devonian age.

Types. — Holotype No. 17086; paratypes Nos. 17087, 17088, 17089.

Occurrence. — Long Lake stage: Ferron Point formation at localities 29 and 38; Ferron Point formation and lowest strata of Genshaw formation at localities 49 and 51. Silica shale; shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio.

Family RHABDOMESONTIDAE Vine

1884. *Rhabdomesontidae* Vine, Rep. Fifty-third Meeting of British Assn. Adv. Sci., 1883, p. 205.
1900. *Rhabdomesontidae* Nickles and Bassler, U. S. Geol. Surv., Bull. No. 173, p. 43.

Definition from Nickles and Bassler. — "Zoarium ramose or simple, not articulated, sometimes with an axial tube, but generally solid, in which case the axial region is occupied by thin-walled primitive tubes, with or without diaphragms; hemisepta usually present, but never conspicuous; apertures circular or oval, usually in linear series between longitudinal elevated ridges, or in diagonally intersecting series; vestibule a rhombic or hexagonal sloping area; mesopores generally absent."

Genus ACANTHOCLEMA Hall

1886. *Acanthoclema* Hall, Fifth Ann. Rep. State Geol. New York for Year 1885, Albany. Explanation of Plate XXV.
1887. *Acanthoclema* Hall and Simpson, Pal. New York, Vol. VI, p. xv.

Original definition. — "Zoarium ramose, solid. Cells arising from a filiform axis; apertures arranged in longitudinal rows separated by ridges. Usually with one or two nodes longitudinally between the cells, which are represented in the interior by short tubuli."

Genotype. — *Trematopora alternata* Hall. Range, Devonian to Mississippian.

Acanthoclema lineatum, sp. nov.

(Pl. IV, Figs. 10–11, 16, 18)

Description. — Zoarium composed of cylindrical bifurcating branches.

Branches thin, almost straight; distance between bifurcations unknown, in some specimens greater than 7.0 mm.; angle between branches from 45 to 90 degrees; average thickness 0.6 mm.

Apertures opening directly outward, elliptical in outline; average length 0.15 mm.; average width 0.09 mm.; ten to twelve in a distance of 3 mm. along length of branch; separated longitudinally by distance approximately equal to length of aperture and transversely by distance approximately equal to width of aperture; situated in longitudinal ranges, ten to fourteen ranges being present on most branches; apertures in adjacent ranges alternate in position. Peristomes low, inconspicuous.

Ridges between ranges straight and prominent, some ridges minutely granulose, often smooth.

Sections show crest of ridge bearing a single row of minute tubules. Zooecia sinuous, parallel to median axis for one third of their length and then directed outward to the surface. Inferior and superior hemisepta not observed.

Remarks. — This species is distinguished from *Acanthoclema sulcatum* Hall and Simpson in having a greater number of ranges on a branch, and from *Acanthoclema ohioense*, sp. nov., in possessing thicker branches and a greater number of ranges on a branch.

Types. — Holotype No. 17091; paratypes Nos. 17092, 17093, 17094.

Occurrence. — Alpena limestone stage: Dock Street clay; locality 53.

Acanthoclema ohioense, sp. nov.

(Pl. IV, Figs. 12, 15, 17)

Description. — Zoarium composed of cylindrical, bifurcating branches.

Branches thin, almost straight; distance between bifurcations unknown, in some specimens greater than 7.5 mm.; angle between branches approximately 50 degrees; some branches curve after bifurcation and become approximately parallel; average thickness 0.5 mm.

Apertures opening directly outward, elliptical in outline; av-

erage length 0.18 mm.; average width 0.09 mm.; ten to twelve occur in a distance of 3 mm. along length of branch; separated longitudinally by distance approximately equal to length of aperture and transversely by distance approximately equal to width of aperture; situated in longitudinal ranges, eight ranges being present on most branches; apertures in adjacent ranges alternate in position. Peristomes low and inconspicuous.

Ridges between ranges straight and prominent, bearing a single row of minute rounded nodes.

Longitudinal sections show sinuous zooecia, parallel to the median axis for one third of their length and then directed outward to the surface. Inferior hemiseptum on basal wall of zooecium, approximately one half of the distance between axis and aperture; superior hemiseptum, when present, near mouth of vestibule. Zooecial walls thin in axial region and thickened near surface.

Remarks. — This species is distinguished from *Acanthoclema lineatum*, sp. nov., by its narrower branches and smaller number of ranges of apertures. It differs from *Acanthoclema sulcatum* Hall and Simpson in having a greater number of ranges of apertures.

Types. — Holotype No. 17095; paratypes Nos. 17096, 17097.

Occurrence. — Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio.

Genus STREBLOTRYPA Ulrich

1890. *Streblotrypa* Ulrich, Geol. Surv. Ill., Vol. VIII, p. 403.

Original definition. — "Zoaria ramose, solid. Zooecia radiating from an imaginary axis, their primitive portion long, tubular; or from a linear axis when they are somewhat shorter. Inferior hemisepta best developed, situated rather far down. Apertures regularly elliptical, or somewhat truncated at the posterior margin, surrounded by a slight peristome and, within this, sometimes a narrow sloping area; arranged usually in rather regular longitudinal series. Just back of the aperture, occupying the depressed front of the cell, there are from one to twelve or more

small pits, which, when numerous, are arranged in two or three rows. Very small acanthopores occasionally present."

Genotype. — *Streblotrypa nicklesi* Ulrich. Range, Devonian, Carboniferous.

Streblotrypa anomala, sp. nov.

(Pl. IV, Figs. 13–14; Pl. V, Figs. 1–3)

Description. — Zoarium composed of cylindrical bifurcating branches.

Branches curved or straight; average distance between bifurcations unknown, in some specimens greater than 7.5 mm.; angle between branches 40 to 90 degrees; thickness 0.6 to 1.0 mm.

Apertures opening directly outward, elliptical in outline; average length 0.22 mm., average width 0.12 mm.; eight or nine in space of 3 mm. along length of branch; separated longitudinally by distance from one half to approximately entire length of aperture and transversely by distance less than width of aperture; situated in longitudinal ranges and separated by sinuous ridges; apertures in adjacent ranges alternate in position, oblique series of apertures being present. Peristomes low; some cannot be distinguished from sinuous ridges between apertures. Ten to twenty ranges occur on a branch.

Small acanthopores present on most peristomes at ends of apertures. Small, longitudinally arranged angular mesopores exist between ends of adjacent apertures. Two mesopores exist between most apertures, one to five being present between a few.

Zooecial walls thin in axial region but much thickened at periphery; hemisepta and details of wall structure not observed, owing to poor preservation of specimens.

Remarks. — This species has many resemblances to *Streblotrypa hamiltonensis* (Nicholson). It can be distinguished from *S. hamiltonensis*, however, by the longitudinal arrangement of the mesopores. Specimens of average size from the Silica shale are slightly smaller in diameter than most of the Traverse specimens, but it has not seemed advisable to divide the species on the basis of this slight difference.

Types. — Holotype No. 17100; paratypes Nos. 17098, 17099, 17101, 17102.

Occurrence. — Long Lake stage: Ferron Point formation; localities 29 and 38. Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio.

Family PTILODICTYONIDAE Zittel

1880. *Ptilodictyonidae* Zittel, Handbuch der Palaeontologie, I. Band, p. 603.
1900. *Ptilodictyonidae* Nickles and Bassler, U. S. Geol. Surv., Bull. No. 173, p. 45.

Definition from Nickles and Bassler. — "Zoarium bifoliate, composed of two layers of zooecia, grown together back to back, usually jointed, at least at the base, and forming leaf-like expansions or compressed branching or inosculating stems; mesotheca without median tubuli; zooecia usually have hemisepta and semi-elliptical orifices; apertures usually ovate, surrounded either by a sloping area or a ringlike peristome; vestibules separated by thick walls."

Genus STICTOPORINA Hall and Simpson

1887. *Stictoporina* Hall and Simpson, Pal. New York, Vol. VI, p. xx.

Original definition. — "Zoarium obtusely pointed at the base, enlarging above and becoming flattened; bifurcations few. Cells tubular, arising from a mesotheca. Apertures oval. Inter-apertural space elevated, angular, enclosing the apertures in rhomboidal or polygonal areas."

Genotype. — *Trematopora claviformis* Hall. Range, Devonian.

Stictoporina granulifera Stewart

(Pl. V, Figs. 4–8, 10)

1927. *Stictoporina granulifera* Stewart, Geol. Surv. Ohio, Fourth Series, Bull. No. 32, p. 32, Pl. II, Figs. 17–19.

Original description. — "Zoarium a flabellate expansion, bifoliate, proceeding from a conically truncated base, increasing in width from 1 mm. at the base to 15 mm. at the greatest width,

which is about two-thirds the distance from the base, and from here the margins converge to the distally rounded frond. Entire length of an almost complete frond is 26 mm.; greatest thickness is 2 mm.; thickest at the basal portion, thinning toward the margins; lenticular in cross section. Cells tubular, without diaphragms, generally oblique towards the distal margin of the frond. Zooecial apertures oval, depressed, from .20 to .35 mm. in diameter, separated by about one-half the diameter of an aperture, outlined by polygonal, granulose ridges. In the cylindrical basal portion of the frond the cells are fairly uniform in size and are arranged in definite rows separated by granulose ridges, but about 5 mm. above the base they become irregular in shape and arrangement, and are appreciably smaller as the margin is approached. Low, flattened monticules, the centers of which are from 2 to 4 mm. distant, mark the surface. The apertures on these are larger than the others although here and there smaller ones are scattered among them."

Revised description. — Zoarium of articulated falciform or flabellate fronds. Frond cylindrical at proximal end; expanded and flattened at distal end. Length of largest specimen 7.5 cm.; width of largest specimen 3.7 cm. On most specimens one edge of frond almost straight, with opposite edge strongly curved; some specimens with both edges curved. Most fronds unbranched, distal margin rounded or lobed.

Apertures on central area in distal part of frond open directly outward; those near edges open obliquely; rhomboidal to polygonal to subcircular in outline, arranged in intersecting, curved linear series; average diameter 0.20 mm.; eleven to fifteen in space of 3 mm. along any series. Apertures in proximal region elliptical in outline; average length 0.18 mm.; average width 0.09 mm.; separated longitudinally by distance approximately equal to length of aperture and separated transversely by distances greater or less than width of aperture. Apertures increase in size and change in shape from proximal to distal parts of frond. Ridges between apertures sharp, occupied by one or more rows of nodes.

Surface of most fronds marked by monticules, the apertures of which are separated by clusters of granules. Average diameter

of apertures on monticules 0.35 mm. Immature specimens without granules or monticules.

In tangential sections granules are shown as circular dots, with a light central area; vestibules elliptical, separated by thick walls and arranged in regular, intersecting linear series; length 0.17 mm.; width 0.10 mm.

Remarks. — An examination of a large number of specimens from the Silica shale and Traverse strata shows that the species is extremely variable in external form. Division of the specimens into different species on the basis of differences in shape is not possible. Zooecial characters also are variable, the presence of monticules and nodes between apertures not being a constant character. The pointed cylindrical proximal portion which flattens to form the broad expansion is a character common to all specimens.

Types. — Plesiotypes Nos. 17103, 17104, 17105, 17106.

Occurrence. — Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. Long Lake stage: Bell shale at localities 31 and 38; Ferron Point formation at localities 29, 49, and 51; possibly lowest strata of Genshaw formation at localities 49 and 51. Alpena limestone stage: near base of section at locality 40; Dock Street clay at locality 53.

Family STICTOPORELLIDAE Nickles and Bassler

1900. *Stictoporellidae* Nickles and Bassler, U. S. Geol. Surv., Bull. No. 173, p. 46.

Original definition. — "This family differs from the Ptilodictyonidae mainly in that the zoarium is not articulated, but grows upward from, and is continuous with, a spreading base."

Genus INTRAPORA Hall

1883. *Intrapora* Hall, Trans. Albany Inst., Vol. X, p. 157.

Original definition. — "Bryozoum growing as in *Stictopora;* stipe and branches broad, bifurcating at somewhat regular intervals. Both sides celluliferous, the intercellular spaces regularly punctured or pitted as if by numerous minute cell-apertures, entire intercellular space vesiculose."

Genotype. — *Intrapora puteolata* Hall. Range, Devonian, Mississippian.

Intrapora acanthopora, sp. nov.

(Pl. V, Fig. 9; Pl. VII, Fig. 1)

Description. — Zoarium composed of dichotomizing branches. Branches flat or slightly twisted; width 2.4 to 4 mm.; thickness 0.5 to 0.7 mm.; length between bifurcations unknown.

Apertures opening directly outward; oval in outline; average length 0.28 mm.; average width 0.14 mm.; seven in space of 3 mm.; arranged in poorly defined intersecting linear series; in contact with one another or separated by elongate, angular mesopores. Peristomes low, thin; bearing one or more small nodes, the termination of acanthopores.

Margin nonporiferous; narrow, edge sharp in cross section; occupied by elongate, angular mesopores arranged parallel to edge of branch, giving margin a striated appearance.

Mesopores abundant, angular, small; elongate in direction parallel to long axis of branch; crossed by closely spaced laminae, causing mesopores to be poorly defined in thin sections.

Remarks. — This species differs from all other species of *Intrapora* found in the Traverse in having thin branches and elongate mesopores.

Types. — Holotype No. 17107; paratype No. 17119.

Occurrence. — Long Lake stage: Bell shale; locality 31.

Intrapora irregularis Stewart

(Pl. VI, Figs. 1–2; Pl. VII, Fig. 2)

1927. *Intrapora irregularis* Stewart, Geol. Surv. Ohio, Fourth Series, Bull. 32, p. 33, Pl. III, Figs. 2–4.

Original description. — "Zoarium a compressed lamellate expansion, bifoliate, about 1 mm. in thickness. Size of frond unknown but fragments up to 18 mm. in width have been observed. Zooecial apertures generally oval, but sometimes nearly circular or somewhat irregular; disposed comparatively close at variable distances; sometimes in contact. Length of oval cells .25 mm., width about two-thirds as great. Peristomes fairly strong, slightly

elevated. Inter-zooecial space occupied by minute, angular mesopores, varying in size and irregularly arranged; sometimes a single series between apertures, sometimes more, and then again a number are clustered together to form maculae. A vertical section shows the thin-walled tubular zooecia and the tabulate mesopores parallel with the mesotheca for a short distance and then curving abruptly outward."

Revised description. — Zoarium consisting of irregular expansions; thickness 1 to 2 mm.; maximum width unknown, some specimens attaining a width of more than 35 mm.

Apertures opening directly outward; circular to subcircular in outline; average length 0.18 mm.; average width 0.13 mm.; those near clusters of mesopores larger than others; thirteen to fifteen in space of 4 mm.; arranged in irregular linear series; some in contact with one another, others separated by one or more angular mesopores. Peristomes low, sharp.

Margin nonporiferous, narrow, edge angular in cross section; occupied by mesopores; most mesopores near edge of expansion elongated at right angles to margin.

Mesopores abundant, angular, small, at some places grouped in irregularly spaced and shaped clusters; diameter approximately 0.08 mm.; crossed by tabulae or by closely spaced thin laminae; restricted to vestibular areas of interapertural spaces.

Acanthopores in walls between apertures, few and prominent.

Remarks. — This species is distinguished from other species of *Intrapora* found in the Traverse by an abundance of mesopores, grouped in clusters.

Types. — Plesiotypes Nos. 17108, 17120.

Occurrence. — Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. Long Lake stage: Bell shale; locality 31.

Intrapora petoskeyensis, sp. nov.

(Pl. VI, Figs. 3–5; Pl. VII, Fig. 7)

Description. — Zoarium composed of irregular branches. Branches flat; width 4 to 15 mm.; average thickness 1.0 mm.; length between bifurcations unknown.

Apertures opening directly outward; circular to elliptical in outline; average diameter 0.15 mm.; twelve to fifteen in space of 4 mm.; arranged in poorly defined intersecting linear series; in contact with one another or separated by angular mesopores. Peristomes low.

Margin nonporiferous, moderate in width, edge angular in cross section; occupied by angular mesopores arranged obliquely to or at right angles to edge of branch, often giving margin a striated appearance.

Mesopores abundant, angular, small; width approximately 0.88 mm.; most of them elongated in direction parallel to long axis of branch; crossed at distant intervals by relatively thick tabulae or by closely spaced thin laminae; restricted to vestibular areas of interapertural spaces.

Acanthopores not observed.

Remarks. — This species is distinguished from *Intrapora puteolata* Hall by its larger apertures, wider and thicker branches, and apparent lack of acanthopores. It is distinguished from *Intrapora traversensis*, sp. nov., by the absence of monticules, the presence of stronger peristomes, and the more numerous mesopores.

Types. — Holotype No. 17109; paratype No. 17121.

Occurrence. — Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; localities 14e and 17.

Intrapora puteolata Hall

(Pl. VI, Figs. 6–9; Pl. VII, Figs. 3–4)

1883. *Intrapora puteolata* Hall, Trans. Albany Inst., Vol. X, p. 158.

Original description. — "Bifurcations occurring at intervals of from six to eight mm.; branches variable in width, on most of the specimens observed from two to four mm., but on some 20 mm.; forming lamellose expansions; greatest thickness one mm., width of non-celluliferous margin .5 mm., base of frond thin, spreading; attached to foreign substances, cells for about one-half their length parallel to the mesial plate, then abruptly turning and opening directly outward; apertures oval, length

.23 mm., occasionally circular, sometimes irregularly disposed, at other times quite regularly arranged in oblique transverse rows at an angle of 45° to the margin of the branch, closely arranged, margins strong and equally elevated; intercellular space occupied by minute angular pits, variable in shape and size, usually a single series between two adjacent apertures, sometimes two and very rarely three; these pits cover the non-celluliferous margin of the branch."

Remarks. — The Traverse specimens of this species have been carefully compared with the syntypes. In his description Hall does not mention the presence of acanthopores. In the Traverse specimens acanthopores are present; most of them are found in groups, a few being scattered throughout the zoarium. Topotypes, examined by the writer, also show acanthopores having the same distribution.

Types. — Plesiotypes Nos. 17110, 17111, 17112, 17114, 17115, 17122.

Occurrence. — Devonian: Jeffersonville limestone; Falls of the Ohio, near Louisville, Kentucky. Hamilton group: Ontario. Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 14e. Alpena limestone stage: Dock Street clay; locality 53.

Intrapora traversensis, sp. nov.

(Pl. VI, Figs. 10–12; Pl. VII, Fig. 5)

Description. — Zoarium composed of irregular expansions; thickness of expansion 1.5 mm.; maximum width unknown, some specimens attaining width greater than 15 mm. Surface of expansions with low, rounded monticules; distance between monticules, 3 to 4 mm.

Apertures opening directly outward; circular in outline; average diameter 0.18 mm., largest ones on monticules; fifteen in space of 4 mm.; arranged in intersecting linear series; most of them in contact with at least one adjoining aperture. Peristomes low and sharp.

Margins nonporiferous, narrow, edge rounded in cross section;

occupied by nonelongated mesopores, giving margin pitted appearance.

Mesopores abundant, angular, small; diameter approximately 0.05 mm.; crossed at distant intervals by tabulae or by closely spaced thin laminae; restricted to vestibular areas of interapertural spaces.

Acanthopores in walls between apertures, abundant; some slightly inflecting walls.

Remarks. — *Intrapora traversensis* is distinguished from other species of *Intrapora* described in this paper by the abundant acanthopores in the walls between the apertures. It is distinguished from the broad areas of *Intrapora puteolata* Hall by the greater thickness of the zoaria and by the prominent monticules.

Types. — Holotype No. 17116; paratypes Nos. 17117, 17118.

Occurrence. — Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 14e.

Family RHINIDICTYONIDAE Ulrich

1895. *Rhinidictyonidae* Ulrich, Geol. of Minnesota, Vol. III, Part I, p. 124.
1900. *Rhinidictyonidae* Nickles and Bassler, U. S. Geol. Surv., Bull. No. 173, p. 48.

Definition from Nickles and Bassler. — "Zoarium bifoliate, continuous or jointed, consisting of compressed branches or leaf-like expansions; occasionally trifoliate; zooecia subquadrate, arranged longitudinally, inferior hemiseptum wanting; orifices and apertures elliptical or subcircular, sometimes a little truncated posteriorly; median tubuli between the median laminae and between the longitudinal rows of zooecia; mesopores wanting, but vesicular tissue often developed."

Genus EUSPILOPORA Ulrich

1890. *Euspilopora* Ulrich, Geol. Surv. Ill., Vol. VIII, p. 389.

Original definition. — "Zoaria consisting of small, flattened, irregularly divided branches. Zooecial apertures subcircular or elliptical, arranged in four or more rows over the central portion

of the branches between slightly elevated longitudinal ridges, bearing numerous, small nodes. At brief intervals, occurring alternately on each side of the branch, there are several short rows of apertures directed obliquely upward and outward from the central rows, extending nearly to the sharp margins. Between these lateral rows the margin of the frond is more or less indented, but a wide depressed non-poriferous space remains. This is covered with exceedingly fine granulose striae. Thin sections show that between the ends of the zooecia there is a vertical series of shallow lenticular vesicles, separated from each other by a thick layer of tissue. All the remaining interspaces are traversed vertically by exceedingly numerous minute tubuli."

Genotype. — *Euspilopora serrata* Ulrich. Range, Devonian.

Euspilopora diversa, sp. nov.

(Pl. VIII, Figs. 4, 6–8; Pl. IX, Fig. 1)

Description. — Zoarium ramose, arising from a spreading base. Branches, with few exceptions, straight and flat; width 1 to 2 mm.; average thickness 0.5 mm.; edges serrate, wavy, or smooth; distance between points of divergence of new branches on same edge of branch 2.3 to 10 mm.

Apertures opening directly outward; elliptical in outline; average length 0.13 mm.; average width 0.10 mm.; twenty in space of 5 mm.; separated longitudinally by distances less than lengths of apertures and transversely by distances approximately equal to widths of apertures; arranged in regular longitudinal series; those of adjacent series alternating in position and forming oblique series. On some branches several short rows of apertures extend obliquely upward and outward, giving edges of branches a wavy or serrated appearance.

Margin nonporiferous; narrow except between serrations and at angles between bifurcations.

Interspaces crowded with minute tubules; large granules also present in interspaces at one edge of vestibules; primitive part of zooecia subquadrate in outline, with one or two oval vesicles between ends of zooecia.

Remarks. — *Euspilopora diversa* is distinguished from *E. serrata* Ulrich by its wider branches and the absence of longitudinal ridges between apertures. It is distinguished from *E. palmipes* (Hall) in having fewer and narrower branches.

Types. — Holotype No. 17127; paratypes Nos. 17126, 17128, 17129.

Occurrence. — Gravel Point stage: zone 2 ("Large Atrypa zone") of E. R. Pohl; locality 15b.

Euspilopora kellumi, sp. nov.

(Pl. VIII, Fig. 5; Pl. IX, Figs. 2–5)

Description. — Zoarium an expanding unbranched, bifoliate frond, arising from a spreading base. Length of an almost complete frond 22 mm.; maximum width at a distance 18 mm. from base, 17 mm.; minimum width immediately above base, 2.5 mm.; thickness 0.4 to 0.9 mm.; thickest immediately above base.

Apertures opening directly outward; circular to subcircular in outline; largest ones near margins of maculae; average diameter 0.13 mm.; ten to thirteen in space of 3 mm.; most apertures separated by distances equal to diameters of apertures; arranged in regular longitudinal and oblique rows; five to ten longitudinal rows occur between adjacent maculae. Spaces between apertures flat, or slightly depressed; low nodes situated near edge of most apertures, the external expression of granules occurring in zooecial interspaces. Peristomes inconspicuous and thin.

Nonporiferous margin narrow, directed inward and downward at intervals of 1.5 to 2.5 mm., producing shallow grooves. Grooves enclosed by apertures with growth of expansion, thus being converted into maculae.

Maculae narrow in outline; length 1.5 to 4 mm.; width 0.5 to 1.5 mm.; separated longitudinally by distances approximately equal to their length and separated transversely by distances of 1.2 to 2.0 mm.; arranged in an irregular pinnate pattern, the central ones nearly parallel to long axis of frond, the lateral ones curving upward and outward from center, those on one side of

frond correspond in position to those of other side, so that frond is thinnest at maculae and thickest at celluliferous areas.

Intervestibular areas occupied by numerous minute tabulae and large concentric granules, situated near one edge of vestibules and composed of concentrically arranged particles. Maculae contain irregularly shaped vesicles.

Remarks. — *Euspilopora kellumi* is distinguished from *E. serrata* Ulrich and *E. palmipes* (Hall) by thicker branches, palmate instead of ramose zoaria, and by the absence of longitudinal ridges between the apertures.

Types. — Holotype No. 17130; paratypes Nos. 17131, 17132.

Occurrence. — Petoskey formation: localities 12 and 15; bed 2, zone 2, of E. R. Pohl; locality 13. Thunder Bay stage: Potter Farm formation, lower part; locality 68.

Euspilopora palmipes (Hall)

1883. *Stictopora palmipes* Hall, Trans. Albany Inst., Vol. X, p. 189.

The Traverse specimens of this species have been compared with the holotype at the New York State Museum and are believed to be Hall's species.

Type. — Plesiotypes Nos. 17136 and 17146.

Occurrence. — Hamilton group: New York. Thunder Bay stage: Partridge Point formation; locality 35. Petoskey formation: bed 2, zone 2; locality 13.

Euspilopora serrata Ulrich

1890. *Euspilopora serrata* Ulrich, Geol. Surv. Ill., Vol. VIII, p. 526, Pl. XLIII, Figs. 4–4h.

Original description. — "Zoarium a narrow stipe, branching dichotomously as a rule, with serrate margins, width about two mm., thickness 0.8 mm., attached to foreign bodies by a slightly expanded base. Cell apertures arranged in four or five longitudinal series, occupying the center of the branch, sending off alternate lateral series, composed of three or four irregular rows extending to the margins. Between these lateral series are concave

granulo-striate non-celluliferous spaces. The elevated ridges between the longitudinal series bear a considerable number of blunt spines. Cell apertures about seven in two mm. measuring down the rows; oval, about 0.10 mm. in longer diameter; width of end spaces about one and a half times the diameter of the apertures. Zooecial tubes prostrate for a short distance, then abruptly bent outward. Between the zooecia are vesicles or mesopores, which do not show at the surface and are provided with very thick diaphragms. The interspaces between the zooecia and the non-celluliferous portions are occupied by exceedingly numerous minute tubuli."

Remarks. — Ulrich lists this species from both the Thunder Bay stage and the "Hamilton" (Cedar Valley?), near Buffalo, Iowa. The specimens in the University of Michigan collections do not add information to Ulrich's description of the species.

Type. — Plesiotype No. 17185.

Occurrence. — Hamilton group: near Buffalo, Iowa. Thunder Bay stage: Partridge Point formation; locality 35.

Family SULCORETEPORIDAE Bassler

1890. *Cystodictyonidae* Ulrich, Geol. Surv. Ill., Vol. VIII, p. 385.
1935. *Sulcoreteporidae* Bassler, Fossilium Catalogus, Pars 67, p. 21.

Definition from Ulrich. — "Zoaria consisting of two or three layers of cells grown together back to back, forming thin foliate expansions or triangular branches. Primitive cells semicordate or obovate-acuminate in outline, arranged in longitudinal series between vertical double plates. Primitive aperture subcircular, being somewhat truncated on the posterior side. As growth proceeds the aperture is drawn out shaft-like, forming a tubular vestibule, and the longitudinal plates become obsolete. Superficial aperture with peristome and more or less developed lunarium. Interspaces between zooecia and vestibules occupied by vesicular tissue, the vesicles more or less completely filled with a minutely perforated calcareous deposit near the surface. Margin of zoarium sharp or rounded, and like the basal portion, non-celluliferous."

Genus CERAMELLA Hall and Simpson

1887. *Ceramella* Hall and Simpson, Pal. New York, Vol. VI, p. xix.

Original definition. — "Zoarium a thin foliaceous expansion, growing from a spreading base, celluliferous on each face. Cells tubular, oblique. Peristomes elevated. Surface marked by numerous sterile maculae which are usually depressed below the general surface of the frond."

Genotype. — *Ceramella scidacea* Hall. Range, Devonian.

Ceramella casei, sp. nov.

(Pl. VII, Figs. 6, 8; Pl. VIII, Figs. 1–3)

Description. — Zoarium a large, thin, bifoliate expansion, growing from a spreading base; maximum size unknown, a fragmented specimen attaining a length of 15 mm. and a width of 9 mm.; narrowest immediately above base; average thickness 0.6 mm.

Apertures opening directly outward; circular to subcircular in outline; average diameter 0.12 mm.; those near margins of maculae larger than others; twelve to fifteen in space of 3 mm.; most of them separated by distances greater than diameters of apertures; arranged in irregular, obliquely intersecting rows; three to ten apertures between adjacent maculae. Spaces between apertures flat, slightly depressed; on well-preserved specimens low nodes are present, the external expression of large granules occurring in zooecial interspaces. Peristomes inconspicuous except on apertures about maculae.

Margin nonporiferous, narrow, edge bluntly angular in cross section; at irregular intervals nonporiferous margin directed inward as a shallow groove. Grooves enclosed by apertures with growth of expansion, thus being converted into maculae.

Maculae narrow to broadly oval in outline; length 0.8 to 1.0 mm.; width 0.4 to 0.6 mm.; separated longitudinally by distances approximately equal to their length; separated transversely by distances approximately twice their width; arranged in irregular longitudinal rows, those near margins oblique to axis of frond.

Sections immediately beneath surface of frond show elliptical

vestibules located at one end of regularly shaped polygonal areas. Interspaces occupied by numerous minute tubules and by a few large granules situated near edge of vestibules and composed of concentrically arranged particles. Maculae composed of irregular polygonal vesicles. One or two angular vesicles are present between ends of adjacent zooecia in close proximity to the median lamina.

Remarks. — This species differs from *Ceramella scidacea* Hall in having much smaller apertures and maculae. The character and arrangement of apertures and maculae distinguish it from all other species of Cryptostomata found in the Traverse.

Types. — Holotype No. 17123; paratypes Nos. 17124, 17125.

Occurrence. — Long Lake stage: Ferron Point formation; locality 51. Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 9.

Genus SULCORETEPORA D'Orbigny

1849. *Sulcoretepora* D'Orbigny, Rev. et mag. zool. (2), Vol. I, p. 501.
1882. *Cystodictya* Ulrich, Journ. Cincinnati Soc. Nat. Hist., Vol. V, p. 152.
1890. *Cystodictya* Ulrich, Geol. Surv. Ill., Vol. VIII, p. 385.

Definition from Ulrich, 1890. — "Zoaria ramose, bifoliate, the branches acutely elliptical in cross section, with sub-parallel, sharp, non-poriferous, striated, granulose, or smooth margins. Zooecia apertures generally arranged in longitudinal series between ridges, sometimes in more pronounced oblique rows. Apertures sub-elliptical, partially closed in the fully matured condition with a more or less developed lunarium, that is always situated upon the side nearest to the margin of a branch. Interspaces finely striated, granulose, or smooth, and never with pits or cells, excepting when worn."

Genotype. — *Cystodictya ocellata* Ulrich. Range, Devonian to Coal Measures.

Sulcoretepora alternata, sp. nov.

(Pl. IX, Figs. 6–8; Pl. XI, Fig. 9; Pl. XII, Fig. 3; Pl. XIII, Fig. 2)

Description. — Zoarium with alternately arranged branches; distance between divergences of new branches 2 to 8 mm.

Branches curved and flat; width 2 to 5 mm.; average thickness 0.8 mm.

Apertures opening directly outward; subcircular to elliptical in outline; average length 0.22 mm.; average width 0.15 mm.; nine or ten in space of 4 mm.; most of them separated longitudinally by distances less than lengths of apertures, being closest at points of origin of new ranges and separated transversely by distances less than widths of apertures. Peristomes sharp and thin. Lunaria strong, present in most specimens. New ranges arise by alternate offsetting of apertures. Most new ranges continue into secondary branches. Six to thirteen ranges on a branch.

Ridges between ranges straight, prominent, and rounded; some striated; new ridges originate between new ranges; separated by an average distance of 0.3 mm.

Margin nonporiferous; width moderate; edge rounded in cross section; occasionally striated.

Remarks. — This species is distinguished from *Sulcoretepora deissi*, sp. nov., by its more closely spaced and smaller branches, narrower and more prominent longitudinal ridges, and sharper peristomes.

Types. — Holotype No. 17133; paratypes Nos. 17134, 17147, 17157, 17158.

Occurrence. — Long Lake stage: Ferron Point formation at locality 29; Ferron Point and possibly lowest strata of Genshaw formation at localities 49 and 51; Bell shale at locality 31.

Sulcoretepora bifidiplicata, sp. nov.

(Pl. X, Figs. 1–2)

Description. — Zoarium with dichotomizing branches; distance between bifurcations 10 to 15 mm. Branches curved and flat; width 3 to 4 mm.; average thickness 1 mm. At unequal distances margins of branches extended into rounded spurlike projections, in which several ranges of apertures terminate.

Apertures opening directly outward; elliptical in outline; those near margin slightly larger and more circular than those in central part of branch; average length 0.22 mm.; average width

0.12 mm.; eight in space of 3 mm.; separated longitudinally by distances approximately equal to widths of apertures. Peristomes inconspicuous. Lunaria weak; present in most apertures as an irregular swelling. Most ranges originate in spaces between bifurcations of ridges. Eight to twelve ranges on a branch.

Ridges between ranges high and rounded, some striated; width of ridges nearly equals width of apertures; new ridges originate by branching, or arise between new ranges of apertures; average distance between ridges 0.28 mm.

Margin nonporiferous; edge rounded; broad between bifurcations of branches.

Remarks. — The large size and bifurcation of the ridges, the uniformly dichotomizing branches, and the low peristomes distinguish *Sulcoretepora bifidiplicata* from all other species of *Sulcoretepora* found in the Traverse.

Some of the apertures of the holotype are covered by an extension of the outer skeletal laminae. This would indicate that this type is a portion of the older part of a zoarium.

Type. — Holotype No. 17135.

Occurrence. — Long Lake stage: Ferron Point formation; locality 29.

Sulcoretepora hamiltonensis (Ulrich)

1890. *Cystodictya hamiltonensis* Ulrich, Geol. Surv. Ill., Vol. VIII, p. 493, Pl. XLII, Fig. 4; Pl. XLIII, Fig. 1.

A number of poorly preserved specimens, which may be referred to this species, are present in the Traverse.

Type. — Plesiotype No. 17184.

Occurrence. — Hamilton group: Buffalo, Iowa, 18-Mile Creek, New York, and Milwaukee, Wisconsin. Gravel Point stage: locality 15b. Thunder Bay stage: Partridge Point formation; locality 35.

Sulcoretepora incisurata (Hall)

1883. *Stictopora incisurata* Hall, Trans. Albany Inst., Vol. X, p. 180.
1890. *Cystodictya incisurata* Ulrich, Geol. Surv. Ill., Vol. VIII, p. 492.

The Traverse specimens of this species have been compared with the syntypes preserved in the New York State Museum.

It is believed that Hall's types belong to a number of distinct species. The Traverse specimens are most closely related to the syntype in the New York State Museum which bears the number 6878/4.

Type. — Plesiotype No. 17183.

Occurrence. — Hamilton group: New York. Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 9.

Sulcoretepora obliqua, sp. nov.

(Pl. X, Figs. 3, 6–12; Pl. XI, Fig. 10; Pl. XII, Fig. 6; Pl. XIII, Fig. 1)

Description. — Zoarium composed of bifurcating and trifurcating branches; distance between branches unknown. Branches straight or slightly curved; flat or twisted; width 2 to 5 mm.; average thickness 1 mm.

Apertures opening directly outward; elliptical in outline; those near margin slightly larger than those in central part of branch; length 0.14 to 0.19 mm.; average width 0.14 mm.; eight in space of 3 mm.; separated longitudinally by distances greater than lengths of apertures and transversely by distances less than widths of apertures. Peristomes prominent and broad. Lunaria not observed. New ranges originate by alternate offsetting of apertures. Eight to fourteen ranges present on a branch.

Ridges between ranges straight and prominent; new ridges arise between new ranges; separated transversely by average distance of 0.33 mm.; terminating at inner edge of nonporiferous margins.

Margin nonporiferous; width moderate; outer edge straight, ornamented with distant, minute lobes.

Remarks. — The description and the figures of *Sulcoretepora incisurata* (Hall) as given by Hall and Simpson indicate such a great variation in the species that it is difficult to distinguish this species from *S. obliqua*. *S. obliqua* always has stronger longitudinal ridges, which do not terminate at the margin, and thicker branches than the type specimens of *S. incisurata*. *S. obliqua* has much stronger ridges and higher peristomes than *S. hamiltonensis*

(Ulrich). It differs from *S. sulcata* (Winchell) in having narrower branches and in lacking lunaria.

Types. — Holotype No. 17142; paratypes Nos. 17138, 17139, 17140, 17141, 17148, 17155, 17156.

Occurrence. — Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl at localities 9, 14e, 17, and 18a; zone 2 ("Large Atrypa zone"), of E. R. Pohl at locality 15b. Petoskey formation: locality 21 and possibly locality 10. Long Lake stage: top of Ferron Point formation; locality 49. Alpena limestone stage: locality 40 and Dock Street clay at locality 53.

Sulcoretepora lyrifica, sp. nov.

(Pl. X, Figs. 4–5)

Description. — Zoarium composed of dichotomizing branches; distance between bifurcations 5 to 15 mm. Branches flat; curving after bifurcation, then straightening and becoming approximately parallel; width 2 to 3 mm.; average thickness 0.85 mm.

Apertures opening directly outward; circular to elliptical in outline; those near margin larger and more circular than those in central part of branch; length 0.14 to 0.25 mm.; width 0.14 to 0.19 mm.; seven in space of 3 mm.; separated longitudinally by distances greater than lengths of apertures and transversely by distances less than widths of apertures. Peristomes narrow and prominent. Lunaria projected upward from peristomes. New ranges arise by an alternate offsetting of apertures. Seven to eleven ranges on a branch.

Ridges between ranges straight to sinuous, prominent, and sharply rounded, occupying the entire space between ranges; new ridges arise between new ranges of apertures, are sinuous when first formed, and terminate between first and second marginal ranges; distance between ridges 0.20 to 0.28 mm.

Margin nonporiferous, rounded, and narrow; edges of branch smooth or wavy.

Remarks. — This species is distinguished from *S. obliqua*, sp. nov., by the forked method of branching, by the termination of ridges before they reach the nonporiferous margin, and by the absence of oblique ranges of apertures.

Type. — Holotype No. 17137.

Occurrence. — Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 17.

Sulcoretepora ramifera, sp. nov.

(Pl. XI, Figs. 1–3)

Description. — Zoarium consisting of diverging branches of two sizes; primary ones large and dichotomizing at intervals of 13 to 15 mm.; average width 2.8 mm.; secondary ones smaller, more numerous than primary ones, diverging from primary branches at intervals of approximately 2 mm., average width 1.4 mm. Length of branches unknown. Average thickness 0.7 mm.

Apertures opening directly outward; elliptical in outline; average length 0.22 mm.; width 0.14 to 0.22 mm.; ten in space of 4 mm.; separated longitudinally and transversely by distances approximately equal to lengths of apertures; marginal ones larger than others and more rounded at proximal parts of branches. Peristomes generally inconspicuous; stronger ones raised on proximal and distal ends of apertures. Seven to thirteen ranges of apertures on primary branches. Number of ranges on secondary branches unknown, three or four ranges present at their points of origin.

Ridges almost obsolete near divergence of new branches, more prominent between points of divergence.

Margin nonporiferous, rounded; widest between secondary branches.

Remarks. — The presence of large primary and small secondary branches distinguishes *Sulcoretepora ramifera* from all other species of *Sulcoretepora* found in the Traverse. A number of irregularly distributed, enlarged zooecia occur on one of the specimens; these zooecia have an average diameter of 0.28 mm. and are situated at the top of low, broad cones, which apparently cover normal apertures. These resemble the enlarged zooecia which are found in *Sulcoretepora deissi,* sp. nov.

Types. — Holotype No. 17143; paratype No. 17186.

Occurrence. — Long Lake stage; Ferron Point formation and possibly Genshaw formation; locality 49.

Sulcoretepora deissi, sp. nov.

(Pl. XI, Figs. 7–8; Pl. XII, Figs. 1–2, 4–5, 7–9)

Description. — Zoarium with alternately arranged branches; distance between divergence of new branches 7 to 12 mm. Branches curved and flat; width 3 to 8 mm.; average thickness 1 mm.

Apertures opening directly outward; subcircular to elliptical in outline; those near margin slightly larger and more circular in outline than those in central part of branch; average length 0.28 mm.; average width 0.2 mm.; seven or eight in space of 4 mm.; most apertures separated longitudinally by distances less than lengths of apertures, being closest together at points of origin of new ranges; apertures separated transversely by distances less than widths of apertures. Peristomes sharp and thin. Lunaria present, strong. New ranges originate by an alternate offsetting of apertures. Most new ranges continue into branches. Seven to twenty ranges present on a branch.

Ridges between ranges straight; strongest on young branches, much reduced on old branches, some of which have irregular striations between apertures. New ridges arise between new ranges. Average distance between ridges 0.3 mm.

Margin nonporiferous; width moderate, widest between bifurcations of branches; edges rounded.

Remarks. — A description of the enlarged cells occurring on some specimens of this species is given on page 157.

Sulcoretepora deissi is distinguished from all other species of *Sulcoretepora* described in this paper by its relatively weak ridges and the large size and great thickness of its branches.

Types. — Holotype No. 17151; paratypes Nos. 17149, 17150, 17152, 17153, 17154.

Occurrence. — Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio.

Sulcoretepora sulcata (Winchell)

(Pl. XI, Figs. 4–6)

1866. *Stictopora sulcata* Winchell, The Grand Traverse Region, A Report on the Geological and Industrial Resources of the Counties of Antrim, Grand Traverse, Benzie and Leelanaw in the Lower Peninsula of Michigan, p. 92. Dr. Chase's Steam Printing House, Ann Arbor, Michigan.

Original description. — "Small, compressed, solid, ancipital, dichotomous stems, celluliferous on both sides; cells oval, with salient lips, arranged in 6–9 longitudinal series separated by prominent rigid striae (in one variety little developed). Greater diameter of stem 2.29 mm. (.09 in.); less diameter .89 mm. (.035 in.); distance between cells .2 mm. (.009 in.); greater diameter of cells .15 mm. (.006 in.); less diameter .1 mm. (.004 in.). Seven cells in 2.5 mm. (1 in.)."

Revised description. — Zoarium consisting of narrow, dichotomizing branches, distance between points of bifurcation 2 to 18 mm. Branches straight or slightly curved, flat; width 1.8 to 2.0 mm.; average thickness 0.80 mm.

Apertures opening directly outward; elliptical in outline; those near margin larger and more nearly circular than those in central part of branch; average length 0.20 mm.; average width 0.14 mm.; seven in space of 3 mm.; separated longitudinally by distances greater than lengths of apertures and transversely by distances less than widths of apertures. Peristomes sharp, most of them elevated on side toward margin. Lunaria relatively numerous and irregularly distributed. New ranges originate by an alternate offsetting of apertures. Five to seven ranges present on a branch.

Ridges between ranges of apertures low, narrow, inconspicuous; new ridges arise between new ranges and terminate at inner edge of nonporiferous margin; average distance between ridges 0.28 mm.

Margin nonporiferous, narrow; edge sharply angular; some apertures very close to edge of branch.

Remarks. — The specimens on which the revised description is based are from the type locality and have been carefully com-

pared with metatypes in the paleontological collection at the University of Michigan.

Sulcoretepora sulcata is distinguished from *S. obliqua*, sp. nov., by the presence of lunaria on the marginal apertures and by the absence of oblique ridges.

Types. — Plesiotypes Nos. 17144, 17145.

Occurrence. — Gravel Point stage: zone 3 ("Emmetensis zone") of E. R. Pohl; locality 8.

Genus SEMIOPORA Hall

1883. *Semiopora* Hall, Trans. Albany Inst., Vol. X, p. 193.
1900. *Semiopora* Nickles and Bassler, U. S. Geol. Surv., Bull. 173, p. 51.

Definition from Nickles and Bassler. — "Zoarium a flattened, bifurcating frond, proceeding from a spreading base; branches narrow, with parallel margins and a narrow noncelluliferous marginal space; interzooecial spaces occupied by vesicular tissue; apertures oval or subcircular, regularly disposed in parallel longitudinal rows; apertures largest in marginal rows; between the apertures in a longitudinal direction are the openings of two small mesopores side by side."

Genotype. — *Semiopora bistigmata* Hall. Range, Devonian.

Semiopora? ehlersi, sp. nov.

(Pl. XIII, Figs. 3–9)

Description. — Zoarium ramose, arising from a spreading base; distance between divergences of new branches 1.5 to 3.5 mm. Branches nearly straight, flat; width 0.8 to 2 mm.; average thickness 0.5 mm.

Apertures elliptical in outline; a few in center of branch opening obliquely outward, marginal ones always opening directly outward; average length 0.13 mm.; average width 0.09 mm.; eight in space of 3 mm.; most of them separated longitudinally by distances greater than lengths of apertures and transversely by distances less than widths of apertures. Peristomes low, broad. Lunaria absent. Six to ten ranges present on a branch.

Ridges between ranges inconspicuous; average distance between ridges 0.14 mm.

Margin nonporiferous, narrow.

Vertical sections through zooecia show a relatively short primitive part parallel to median lamina and a shaftlike vestibular part approximately at right angles to median lamina. Zooecial interspaces small, solid and very finely granulose; thin near median lamina, expanding abruptly to fill the entire space between vestibules.

Prominent walls between ranges of apertures shown in tangential sections cut immediately below surface of branch. Marginal zooecia obovate-acuminate in outline and centrally situated zooecia rectangular in outline in tangential sections cut near median lamina.

Remarks. — This species is readily distinguished from all others in the Traverse by its very small size. It is distinguished from *Sulcoretepora limata* (Hall and Simpson) by smaller spaces between apertures and shorter distances between points of bifurcation of the branches. The species does not have the mesopores found in *Semiopora bistigmata,* and for that reason may be considered a member of a new genus.

Types. — Holotype No. 17162; paratypes Nos. 17159, 17160, 17161, 17163.

Occurrence. — Long Lake stage: Ferron Point formation; locality 29. Very rare in Silica shale; shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio.

Genus TAENIOPORA Nicholson

1874. *Taeniopora* Nicholson, Geol. Mag., New Ser., Decade II, Vol. I, p. 121.

Original definition. — "Polyzoary calcareous, composed of a flattened linear expansion, which branches dichotomously, and is celluliferous on both sides. Each side of polyzoary is furnished with a strong median ridge or keel, which has a longitudinal direction, and separates the frond into two lateral halves. The cells have very prominent apertures, and are arranged in from three to five longitudinal rows on each side of the central keel;

the cells of contiguous rows alternating, so that a series of short oblique rows of cells are produced, which diverge from the keel like the barbs of a feather. The margins of the polyzoary are usually plain and non-celluliferous, and the cells are not separated by longitudinal striae or elevated ridges. No fenestrules are present, and the entire frond forms a continuous expansion, within which the cells are immersed."

Genotype. — *Taeniopora exigua* Nicholson. Range, Devonian.

Taeniopora exigua Nicholson

(Pl. XIII, Figs. 10–11)

1874. *Taeniopora exigua* Nicholson, Geol. Mag., New Ser., Decade II, Vol. I, p. 122, Pl. VI, Fig. 13.

1890. *Taeniopora exigua* Hall and Simpson, Pal. New York, Vol. VI, p. 263, Pl. LXII, Figs. 15–26.

Description from Hall and Simpson. — "Zoarium ramose, flattened, proceeding from a spreading base, or from rootlets attached to foreign bodies; branches triangular or flattened. The branches of the lower portion of the frond are usually triangular, although this condition may occur on all portions of the frond, sides concave, equal or nearly so, width 3 mm. or a little more; from each angle proceed depressed quadrangular branches, which both bifurcate and ramify laterally, continuing growth in the same manner as the parent branches; the flattened branches are from a little less than 3 mm. to 4 mm. wide, with parallel margins, not expanding before bifurcation; non-celluliferous marginal space flat, smooth, width from .33 to .50 mm.; transverse section rhomboidal, sometimes abruptly contracted near the margin, angular at the middle, with a prominent sharp elevation; greatest thickness, without the elevation, from .50 to .75 mm.; bifurcations on the specimens observed occur at intervals of from 15 to 30 mm.; lateral branches very frequent, branching and bifurcation sometimes occur together giving to the branch a trifurcating appearance; the branches usually diverge at an angle of about forty-five degrees. Cells tubular, cylindrical, gradually enlarging to the apertures; in the triangular branches they proceed from laminae which radiate from the center to each angle of the branch;

in the flattened branches they proceed from the mesotheca, and are recumbent for about one-half their length, then abruptly turning and generally opening directly outward; at the center of the branch their direction is parallel to the axis of the frond, each succeeding row of cells becoming more and more rectangular to the axis. Intercellular tissue vesiculose; near the base the vesicles are large, smaller and more compactly disposed near the surface. Cell apertures disposed in longitudinal parallel rows, and very frequently in oblique ascending rows, from the middle of the branch; usually six or eight longitudinal rows on each face of the branch; the apertures of the central rows are minute, circular, with a diameter of about .12 mm., sixteen in the space of 5 mm.; other times oval, length .30 mm., width two-thirds the length, ten in the space of 5 mm.; sometimes the apertures, with the exception of those of the marginal rows, are of the same size; at other times those of the central range are the smallest, those of each succeeding range being a little larger; on some fronds the apertures are distinctly papilliform. There is often a prominent, angular carina along the middle of the flattened branch, which has a height of from .50 to .75 mm., and a width at the base of .25 mm., generally straight, but sometimes a little sinuous; the sides of the triangular branches are concave and have no ridges or carina. Usually there are not more than eight ranges of apertures, and forms occur having only four ranges, while others have ten, but as all intermediate gradations occur, no specific distinction can be based on this character; there is also considerable variation in the strength of the carina."

Remarks. — The Traverse specimens agree in all respects with the specimens described by Hall and Simpson. This is the only species of *Taeniopora* yet found in the Traverse.

Types. — Plesiotypes Nos. 17164, 17165.

Occurrence. — Hamilton group: New York and Ontario. Alpena limestone stage: Dock Street clay; locality 53. Thunder Bay stage: Norway Point formation; localities 46 and 47. Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; localities 9, 14e, 17, 18a. Petoskey formation: bed 2, zone 2; locality 13.

Genus PRISMOPORA Hall

1884. *Prismopora* Hall, Rep. State Geol. New York for Year 1883, p. 50.

Original definition. — "Bryozoum consisting of triangular branches, frequently forming irregular groups from a principal axis; sides equal or unequal, subangularly concave, celluliferous on each face; cells arising from internal septa, which radiate from the center to each angle; angular margins non-celluliferous."

Genotype. — *Prismopora triquetra* Hall. Range, Devonian to Carboniferous.

Prismopora alpenensis, sp. nov.

(Pl. XIII, Figs. 12–13)

Description. — Zoarium consisting of triangular branches; distance between branches unknown. Branches bluntly pointed at distal ends. Faces concave; two faces being nearly equal in width, the third wider or narrower than the others; greatest known width 6 mm.; smallest width 2 mm.

Apertures open direct or oblique to faces; subcircular in outline; average diameter 0.10 mm.; largest near margins; situated on prominent oblique ridges; two to four ranges of closely spaced apertures on each ridge; distance between ridges 0.6 to 1.0 mm.; apertures also present in center of faces near distal ends of branches, where they are separated by distances approximately equal to diameters of apertures. Central area in proximal part of branches, elevated, vesicular, nonporiferous, and without ridges. Peristomes low and inconspicuous.

Nonporiferous margin narrow, edges acutely angular.

Numerous closely spaced vesicles present in spaces between apertures. A median lamina radiates from the center of the branch to each of the three edges.

Remarks. — This species is distinguished from all other species of *Prismopora* by the arrangement of apertures on ridges. With the exception of this character, the species conforms in structure to other species of the genus.

Types. — Holotype No. 17167; paratype No. 17166.

Occurrence. — Alpena limestone stage: Dock Street clay; locality 53.

Genus SCALARIPORA Hall

1883. *Scalaripora* Hall, Trans. Albany Inst., Vol. X, p. 159.

Original definition. — "Bryozoum consisting of irregular groups of triangular branches, more or less concave, traversed transversely by sharp, elevated laminae, situated at regular distances apart; branches celluliferous on each face; cells arising from internal plates, radiating from the center to each angle of branch; margins and summit of laminae non-celluliferous."

Genotype. — *Scalaripora scalariformis* Hall. Range, Devonian.

Scalaripora separata Ulrich

(Pl. XIII, Figs. 14–17)

1890. *Scalaripora separata* Ulrich, Geol. Surv. Ill., Vol. VIII, p. 507.
1890. *Scalaripora approximata* Ulrich, *ibid.*, p. 508.

Original description of Scalaripora separata. — "Zoarium consisting of triangular stems, each face having a width of about three mm. Margins sharp, nearly straight and parallel. Transverse ridges nearly as far apart as the width of the faces, eleven or twelve in three cm. Portions of face between margins and ridges depressed, celluliferous. Apertures about 0.18 mm. in diameter and less than their own diameter apart; with a faintly elevated peristome; arranged in more or less regular diagonal rows, nine or ten in three mm. Internal structure not observed."

Original description of Scalaripora approximata. — "This species differs from the preceding in being somewhat less robust, the margins slightly serrated and the cell apertures somewhat more approximated. A more striking peculiarity is that the transverse ridges are very close set, there being about twenty in two cm."

Remarks. — The distance between the ridges of most specimens of *Scalaripora separata* from Partridge Point, the type locality of the species, is approximately intermediate between those given by Ulrich for *S. separata* Ulrich and *S. approximata* Ulrich. An examination of a considerable number of specimens shows that the distance between ridges is quite variable, both

in the same and in different specimens. Since *S. separata* and *S. approximata* have been distinguished by a difference in the distance between ridges, which is a variable character, it seems most likely that these two species are the same.

Types. — Plesiotypes Nos. 17168, 17169, 17170, 17171.

Occurrence. — Thunder Bay stage: Partridge Point formation; locality 35.

Scalaripora variosa, sp. nov.

(Pl. XIV, Figs. 1–6)

Description. — Zoarium consisting of triangular branches; very irregular in shape at points of branching; distance between branches of some specimens at least 4 cm. Branches free or incrusting, most of them straight. Faces of branches concave, subequal in width at a given point; width 3 to 8 mm.; crossed by straight or curved ridges; distance between ridges 3 to 8 mm., average distance approximately 5 mm.

Apertures opening direct or oblique to faces; circular in outline; average diameter 0.18 mm.; arranged in irregular, intersecting series. Peristomes low, some slightly elevated on one side.

Margin nonporiferous; extended into celluliferous faces as shallow grooves, most of which are situated midway between ridges; two or three grooves present between some ridges.

Transverse sections show a median lamina radiating from the center of the branch to each of the three edges and long zooecial tubes, separated in the central part by large vesicles and near the surface by small, closely spaced ones. In tangential sections zooecial walls appear very prominent, adjacent ones being connected by thin bars, the walls of vesicles.

Remarks. — It was first believed that the large irregularly shaped specimens of this species belonged to *Glyptopora* or *Phractopora.* Later, single specimens were found having both the irregular and the triangular form of growth. The fact that the size and the arrangement of the apertures and the marginal grooves are similar in all parts of these specimens shows that the irregular and the triangular branches are different growth forms of the same species.

The species is easily distinguished from *S. separata* Ulrich, the only other species of this genus found in the Traverse, by the greater width of its branches, more distantly spaced transverse ridges, and by the presence of marginal grooves.

Types. — Holotype No. 17173; paratypes Nos. 17172, 17174, 17175, 17176, 17177.

Occurrence. — Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl at localities 9, 14e, and 18a; bed 1, zone 6 ("lower blue shale"), of E. R. Pohl at locality 14. Thunder Bay stage: Norway Point formation; localities 46 and 47. Alpena limestone stage: Dock Street clay; locality 53.

Genus PHRACTOPORA Hall

1883. *Phractopora* Hall, Trans. Albany Inst., Vol. X, p. 154.

Original definition. — "The manner of growth is essentially the same as that of *Lichenalia*, the surface is raised at irregular intervals into elevated crests, which are celluliferous on both sides; cells arising from a mesial epitheca, the crests unite leaving irregular cavities between them."

Genotype. — *Phractopora cristata* Hall. Range, Devonian to Mississippian.

Phractopora winchelli, sp. nov.

(Pl. XIV, Figs. 7–10)

Description. — Zoarium a thin bifoliate or trifoliate expansion, traversed by salient ridges; thickness 0.5 to 1.2 mm. Ridges irregular and curved, those on one surface not corresponding in position with those of other surface; height of ridges about 0.5 to 4.0 mm.; crests nonporiferous.

Apertures circular to elliptical in outline; opening directly or obliquely to surface; average diameter 0.22 mm.; approximately twenty-five in space of 5 mm.; separated by distances about equal to diameters of apertures; arranged in intersecting linear series. Spaces between apertures flat and smooth. Peristomes low, some elevated on one edge.

Margin nonporiferous, narrow; edge angular or bluntly

rounded; at irregular intervals directed inward as grooves. Marginal grooves enclosed by apertures as the frond increases in size, forming maculae. Length of maculae 0.6 to 1.5 mm., separated from one another by distances of approximately 3 mm. and arranged in irregular longitudinal series.

Sections immediately beneath surface of expansion show elliptical vestibules, most of which are acuminate at one end, and maculae composed of irregular vesicles. Longitudinal sections show numerous cystlike vesicles between zooecia; the zooecia are parallel to median lamina for approximately one half of their lengths and then curve outward forming tubular, nondissepimented vestibules.

Remarks. — This is the only species of *Phractopora* yet found in the Traverse. The broad expansions of the zoaria distinguish it from the branched parts of *Scalaripora variosa*, sp. nov. It is distinguished from *Phractopora cristata* Hall in having elongate instead of circular maculae.

Types. — Holotype No. 17182; paratypes Nos. 17178, 17179, 17180.

Occurrence. — Petoskey formation: bed 2, zone 2, of E. R. Pohl; locality 13.

NOTES ON THE MORPHOLOGY AND RELATIONSHIPS OF CERTAIN CRYPTOSTOMATOUS BRYOZOA

This study of the Traverse cryptostomatous Bryozoa has given additional information regarding the anatomy of these fossils and has raised a number of questions concerning their relationships.

The distinguishing character of the order Cryptostomata is a short zooecium, the orifice of which is at the bottom of a tubular shaft; the shaft, or vestibule, is surrounded by a solid or vesicular calcareous deposit. Some members of the order Cheilostomata also have this character; indeed, the Cryptostomata are so similar to this group that they have been regarded as possible Paleozoic Cheilostomata (Bassler, 1922, p. 363). However, the ovicells and the avicularia of the Cheilostomata have never been positively identified in the Cryptostomata. These structures and the dif-

ferentiation of the zooecia into monticules and maculae in the Cryptostomata provide an easy means of differentiating these two orders.

The affinities of the Cryptostomata with the Trepostomata and the Cyclostomata can be demonstrated by ramose forms which have thin-walled zooecial tubes with or without diaphragms and by the common occurrence of acanthopores and mesopores in some Cryptostomata.

The presence of the hemiseptum, a plate which is found near the base of the vestibule partly closing off the orifice, is probably the most distinctive structure in the Cryptostomata. However, this structure is not always present; it does not occur in a number of Devonian species.

The form and the surface structures of the zoaria are the most useful characters for identifying divisions within the Cryptostomata. Since these characters are surficial, identification of most species may be made without the use of thin sections. Some of the bifoliate, and most of the solid ramose forms must be identified by an examination of internal structures.

Three general types of zoarial form are found in the Cryptostomata. The first has unilaminate zoaria, the zooecia opening on one side only. The Fenestrellinidae, the Phylloporinidae, and the Acanthocladiidae are of this type. The second has ramose, cylindrical zoaria, the zooecia opening on all sides. This type is present in the Arthrostylidae and the Rhabdomesontidae. The third has bifoliate zoaria, the zooecia opening on two sides and growing back to back from a median lamina. Ptilodictyonidae, Stictoporellidae, Rhinidictyonidae, Sulcoreteporidae, and Actinotrypidae have this type, which is considered to be the most characteristic of the Cryptostomata.

There is little evidence to indicate that these three divisions based on zoarial forms should be considered taxonomic units or that members within such divisions are related phylogenetically; it seems more probable that similar zoaria were evolved by a number of stocks.

The shape of the zoarium is very constant for individuals of a species. This is due to the fact that there is a definite method

of budding of zooecia during the development of the zoarium of each species.

The method of budding to form new branches in the mature zoaria may prove to be of use in classifying some Cryptostomata. In *Fenestrellina rockportensis*, sp. nov. (Pl. I, Figs. 1–2), new branches arise in the mature portion of the zoaria by the development of new ranges of zooecia until four ranges have developed in the parent branch some distance before bifurcation takes place. At points of bifurcation one half of the ranges continue into each of the newly formed branches. This type of branching is common to a number of Devonian and Mississippian *Fenestrellinae*. Development of new branches takes place in a different manner in *Fenestrellina regularis*, sp. nov. (see Pl. I, Figs. 3–4). In this species the branch bifurcates; the outer ranges of zooecia continue as the outer range in the newly formed branch. Inside the bifurcation two new ranges develop, each forming the inner range of a new branch. This type is common to several species of *Fenestrellina*. The two types of branching just described have never been observed in the same species. The type of branching controlled by budding in the mature zoaria may prove to be a means of distinguishing certain forms of fenestrellinids which are difficult to separate from either *Fenestrellina* or *Polypora* (see "Remarks," p. 111). In such species as *F. rockportensis* the part of the branch between bifurcations has two ranges of apertures, separated by a median carina, and at places of bifurcation has three or four ranges of apertures. The present classification will not include species having such an arrangement in either typical *Fenestrellina* or *Polypora*. Such forms were designated *Polyporella* by Simpson (1894, p. 700), who selected *F. fistulata* Hall as the genotype. This genus, however, was considered a synonym of *Polypora* by Nickles and Bassler (1900, p. 39). Simpson's genus may have to be retained if further work proves that the budding in the mature zoarium is a diagnostic character.

The apertures of certain species of *Sulcoretepora* are surrounded by a ringlike peristome, which is often raised on one side into a crescent-shaped lunarium. The presence or the absence of lunaria on small fragments is not a specific character, because on

the larger and more complete zoaria lunaria are restricted to the older and broader parts of the colony. The lunaria in *Sulcoretepora* are always situated on the edge of the peristome nearest the margin of the branch, the concave surfaces being directed inward and upward.

The function of lunaria is not definitely known. It is improbable that they were protective to the extruded zooid, because they do not project far enough above the peristome to perform this function. Since many normal zooecia do not have these structures, it seems unlikely that they were points of attachment of muscles concerned with the extrusion of the zooid. Lunaria probably did not serve as hinges for opercula because they do not show definite articular surfaces.

It is quite possible that the lunaria may have increased the efficiency of the zooids in procuring food and oxygen by directing the mouths and the tentacles of the zooids upward and inward. The movements of the tentacles in directing water toward the mouths of many zooids pointing in the same direction would probably set up currents moving outward and downward from the center of the branch. The central zooids would then be bathed by a more or less continuous current of water carrying food and oxygen.

The apertures in the central area of the branch are always slightly smaller than the marginal ones, but the disparity in size cannot be certainly attributed to any unequal distribution of food.

Lang (1919, p. 107) has found that in the development of chilostomatous Bryozoa there has been a definite tendency in the phylogeny toward excessive calcification of the skeleton. He states that "It seems as if we could perceive in the Cheilostome polyzoa a definite reason for their extinction, namely the exaggeration of the calcareous skeleton brought about by an uncontrolled tendency."

Excessive calcification of the skeleton is also shown in the older, lunaria-bearing, parts of *Sulcoretepora*. In a few specimens of some species the secondary deposit covers the apertures of many zooecia (see Pl. X, Figs. 3, 6; Pl. XII, Figs. 2, 9).

The lunaria may also be considered a manifestation of a tendency to the deposition of excessive calcium carbonate during the later stages of the colony, although it seems more likely that lunaria were developed for a definite function, possibly that suggested in a previous paragraph.

Specimens of the older parts of *Sulcoretepora deissi*, sp. nov., *S. ramifera*, sp. nov., and *S. alternata*, sp. nov., often show enlarged zooecia which project above the surface. Thin sections through these reveal that the outer layers of the ectocyst curve upward around them (see Pl. XII, Fig. 7) and that the vertical laminae lining the vestibules in normal zooecia are absent, apparently having been absorbed. All stages from normal zooecia to ones two or three times normal size can be seen on the same specimen. A few of the large cells are entirely covered by calcium carbonate, appearing as low, rounded projections on the surface of the zoarium. The origin and the function of the large zooecia are unknown. It is possible that they were specialized reproductive units, or that they were paleobiological abnormalities due to parasitism.

Small cylindrical structures are present in the walls of several species of *Intrapora*. In transverse sections (see Pl. VI, Fig. 10) these structures exhibit a center which is lighter or darker than the periphery and they are large enough to be seen under low magnification. Longitudinal sections through the structures show that each consists of a minute central canal bounded by a succession of overlapping conical layers of sclerenchyma. These are, with little doubt, acanthopores. The central canal and the overlapping conical layers are identical in structure with the acanthopores found in the Trepostomata. Sections of topotypes of *Intrapora puteolata* Hall, the type species of the genus, have acanthopores identical with those of Traverse species. So far as the author knows, this is the first recognition of acanthopores in the genus *Intrapora*.

Ulrich (1895, p. 103) pointed out the structural identity of the nonporiferous margin and the maculae of certain Cryptostomata, but did not draw conclusions regarding the relationships of these areas. Specimens of *Euspilopora kellumi*, sp. nov., and

Ceramella casei, sp. nov., show all transitions from the narrow nonporiferous margin to the groovelike maculae characteristically developed on the expansions of certain bifoliate zoaria. In these species the nonporiferous margin is projected as an indentation, at rather definite intervals, toward the center of the expansion. As the size of the frond increases, the apertures that are formed at the margin of the expansion enclose the indentation and produce a macula. The maculae of *Ceramella* and of palmate species of *Euspilopora*, *Phractopora*, and *Dichotrypa* are believed to have originated in this way.

Three species, *Euspilopora serrata* Ulrich, *E. palmipes* (Hall), and *E. kellumi*, sp. nov., show three stages in the development of a palmate zoarium. In *E. serrata* the branches are separated by small nonporiferous areas. In *E. palmipes* the branches are joined together by much larger nonporiferous areas. In *E. kellumi* the celluliferous parts of the branches have coalesced, except about maculae, which were formerly nonporiferous marginal areas. It is possible that *Ceramella*, *Dichotrypa*, *Phractopora*, and all other genera possessing palmate zoaria with maculae have also evolved from forms having ramose zoaria.

Ulrich (1890, p. 298) suggested that the large apertures around maculae possibly belong to brood zooecia. In passing from the margins of the maculae to adjacent parts of the frond the zooecia show a gradual decrease in size. One would expect an abrupt difference in size if the larger ones were reproductive in function. It is possible that the marginal zooecia received more food than the central ones and, consequently, became larger. Since the zooecia around maculae probably were derived in the course of their phylogeny from zooecia situated along the margins of the branches, their large size may be attributed to inheritance.

The structural changes which took place during the development of the branches of *Sulcoretepora deissi*, sp. nov., from the Silica shale of Lucas Co., Ohio, are well shown in hundreds of specimens of this species.

Young branches of *Sulcoretepora deissi* are relatively narrow, with definite longitudinal ridges and prominent peristomes, usually without lunaria; the margins of the branches are angular in

cross section. Older branches are wider; the margins are more rounded than those of young ones, the ridges lower and broader, and the peristomes less sharp, lunaria being strongly developed on the marginal ranges of the zooecia. Very old branches are wide and are two to three times as thick as the young branches. Most of the very old branches have lost the longitudinal ridges, which are replaced by irregular striae. Many peristomes are much inflated and project above the surfaces of the branches. Lunaria are strongly developed. Many of the normal peristomes and some of the enlarged ones are covered by secondary sclerenchyma.

Specimens of *Sulcoretepora obliqua*, sp. nov., collected from bed 3, zone 6 ("upper blue shale"), of the Gravel Point stage of the Traverse, show structural changes in the development of the branches similar to those observed in *S. deissi*.

The structures of *Fenestrellina* reveal relatively little difference between the younger and the older parts of the zoarium. The mature part has thicker branches and dissepiments and, therefore, smaller fenestrules than the young part; on the reverse side the surface is irregular, owing to the presence of adventitious calcium carbonate; on the obverse side the apertures have a tendency to open upward. In the young part the reverse side is often smooth, or longitudinally striated, and the apertures of the obverse side have a tendency to open laterally.

STRATIGRAPHIC SIGNIFICANCE OF TRAVERSE CRYPTOSTOMATOUS BRYOZOA

Cryptostomatous Bryozoa compose a minor element in the large and varied Traverse faunas, most of the individuals of which are undescribed.

Since it is believed that associations of species will have to be used to determine the sequence and correlation of the Traverse beds, the information obtained from the study of one group of organisms, such as the Cryptostomata, is but a part of the mass of evidence which, it is hoped, will be accumulated. The study of each group will be of value as it produces evidence in harmony or in discordance with that of other groups.

Thirty-nine species of cryptostomatous Bryozoa, as indicated

STOMATOUS BRYOZOA

Gravel Point stage: Zone 3 ("Emmetensis zone"); loc. 8	Gravel Point stage: Zone 2 ("large Atrypa zone"); loc. 15b	Gravel Point stage: Zone 4; loc. 8	Gravel Point stage: Bed 1, zone 6 ("lower blue shale"); loc. 14	Gravel Point stage: Bed 3, zone 6 ("upper blue shale"); loc. 9	Gravel Point stage: Bed 3, zone 6 ("upper blue shale"); loc. 14c	Gravel Point stage: Bed 3, zone 6 ("upper blue shale"); loc. 17	Gravel Point stage: Bed 3, zone 6 ("upper blue shale"); loc. 18a	Petoskey formation: Bed 2, zone 2; loc. 13	Petoskey formation: Lower part; loc. 10	Petoskey formation: Lower part; loc. 12	Petoskey formation: Lower part; loc. 15	Petoskey formation: Middle part; loc. 21	Silica shale; near Silica, Lucas County, Ohio	Hamilton group; New York	Hamilton group; Ontario	Hamilton group; Milwaukee, Wis.	Hamilton group; near Buffalo, Iowa	Jeffersonville limestone; Falls of the Ohio, near Louisville, Kentucky
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SPECIES	LONG LAKE STAGE								ALPENA LS. STAGE		THUNDER BAY STAGE		
	Bell shale, lower part; loc. 31	Bell shale, upper part; loc. 38	Ferron Point formation, lower part; loc. 38	Ferron Point formation, upper part; loc. 49	Ferron Point formation, upper part; loc. 51	Ferron Point formation, loc. 20	Genshaw formation, basal part; loc. 40	Genshaw formation, basal part; loc. 51	Alpena limestone, near base; loc. 40	Alpena limestone; Dock Street clay; loc. 53	Norway Point formation; locs. 46 and 47	Potter Farm formation, lower part; loc. 68	Partridge Point formation; loc. 35
Fenestrellina alpenensis, sp. nov.										+			
regularis, sp. nov.										+			
rockportensis, sp. nov.			+										
striata (Hall)										+			
Loculipora loculata, sp. nov.										+		+	
Lyropora devonica, sp. nov.													
Anastomopora ovata, sp. nov.										+			
petoskeyensis, sp. nov.													
Pennieretepora irregularis, sp. nov.													
Helopora inexspectata, sp. nov.			+	+	+	+	+	+					
Acanthoclema lineatum, sp. nov.										+			
ohioense, sp. nov.													
Streblotrypa anomala, sp. nov.			+			+							
Stictoporina granulifera Stewart	+	+		+	+	+	?+	?+	+	+			
Intrapora acanthopora, sp. nov.	+												
irregularis Stewart	+												
petoskeyensis, sp. nov.													
puteolata Hall										+			
traversensis, sp. nov.													
Euspilopora diversa, sp. nov.													
kellumi, sp. nov.												+	
palmipes (Hall)													+
serrata Ulrich													+
Ceramella casei, sp. nov.					+								
Sulcoretepora alternata, sp. nov.	+			+	+	+	?+	?+					
bifidiplicata, sp. nov.						+							
deissi, sp. nov.													
hamiltonensis (Ulrich)													+
incisurata (Hall)													
lyrifica, sp. nov.													
obliqua, sp. nov.				+					+	+			
ramifera, sp. nov.				+			?+						
sulcata (Winchell)													
Semiopora? ehlersi, sp. nov.						+							
Taeniopora exigua Nicholson										+	+		
Prismopora alpenensis, sp. nov.										+			
Scalaripora separata Ulrich													+
variosa, sp. nov.										+	+		
Phractopora winchelli, sp. nov.													

in the table on pages 160–161, have been recognized in this study. Nineteen of these cannot be used in inter-Traverse correlation because they have been found at single localities. Six species, *Euspilopora palmipes* (Hall), *Fenestrellina striata* (Hall), *Intrapora puteolata* Hall, *Sulcoretepora hamiltonensis* (Ulrich), *S. incisurata* (Hall), and *Taeniopora exigua* Nicholson are present in the Hamilton group of New York and Ontario.

The cryptostomatous Bryozoa of the Traverse are more closely related to those of the New York Hamilton than to those of any other Middle Devonian rocks. A correlation of the Traverse with the Hamilton of New York is thus indicated. This is supported by recent work of A. S. Warthin and G. A. Cooper (1935a, p. 362) but is at variance with Pohl's view that the Traverse represents deposition between Onondaga and Hamilton times.

A few species of Traverse Cryptostomata have considerable stratigraphic range. *Stictoporina granulifera* Stewart is present in several beds between the base of the Bell shale and the Dock Street clay near the top of the Alpena limestone stage in the Alpena area. *Ceramella casei*, sp. nov., is found in the Ferron Point formation in the Alpena area and in the "upper blue shale" at the top of the Gravel Point stage of the Little Traverse Bay area. *Sulcoretepora obliqua*, sp. nov., is present in the upper part of the Ferron Point formation and in the Dock Street clay of the Alpena limestone stage in the Alpena area. This species also is found in several beds between the "upper blue shale" of the Gravel Point stage and the middle part of the Petoskey formation in the Little Traverse Bay area. Some of the fenestrellinids listed by Deiss (1932, p. 268) have ranges extending from the base to the top of the Traverse.

One of the most characteristic assemblages of Cryptostomata is found in the Ferron Point and possibly lowest Genshaw strata at Black Lake (locality 29), El Cajon Beach (locality 49), and the abandoned clay pit near Alpena (locality 51). The species of this assemblage are *Helopora inexspectata*, sp. nov., *Semiopora? ehlersi*, sp. nov., *Stictoporina granulifera* Stewart, *Streblotrypa anomala*, sp. nov., and *Sulcoretepora alternata*, sp. nov. Most of the species of this assemblage are limited to or are common in

the Ferron Point formation. *Helopora inexspectata,* sp. nov., however, has also been found in the lowest beds of the Genshaw formation, and *Stictoporina granulifera* Stewart and *Sulcoretepora alternata,* sp. nov., are doubtfully present in these beds. With the exception of *Sulcoretepora alternata,* sp. nov., all these species also occur in the Silica shale of northwestern Ohio, and indicate that the Silica shale may be equivalent in age to the Ferron Point formation. An investigation of the Silica shale fauna, by Miss Virginia Kline, has revealed a few mega fossils that occur in appr oximately the same beds in the Traverse. Because the distinctive elements of the fauna of one area are lacking in that of the other it is possible that the rocks in the two areas are not exactly equivalent.

The bryozoan faunules in the shales and shaley limestones at localities 29, 49, and 51 are undoubtedly the same. This correlation is supported by physical evidence and by associated fossils. Warthin (1934, p. 223) indicates that the rocks exposed at locality 29 were equivalent to the Long Lake limestone of the Alpena area.

Nine species, *Ceramella casei,* sp. nov., *Euspilopora kellumi,* sp. nov., *Euspilopora palmipes* (Hall), *Intrapora puteolata* Nicholson, *Loculipora loculata,* sp. nov., *Scalaripora variosa,* sp. nov., *Sulcoretepora hamiltonensis* (Ulrich), *Sulcoretepora obliqua,* sp. nov., and *Taeniopora exigua* Nicholson, occur in both the Little Traverse Bay and Alpena areas. In the eastern area all these species, with the exception of *Ceramella casei,* sp. nov., and *Sulcoretepora obliqua,* sp. nov., are found only in Dock Street shale facies of the uppermost Alpena limestone stage or in higher strata. Not one of these species is known from the Afton–Black Lake area. Their distribution would indicate that, if the Gravel Point, Charlevoix, or Petoskey strata are represented in the Alpena area, these strata must correspond in position to the higher part of the Traverse in the Alpena area.

Other fossils seem to support the stratigraphic relationship mentioned above. *Cylindrophyllum panicum* Winchell, *Schuchertella* cf. *anomola* (Winchell), *Atrypa dignata* Fenton and Fenton, *Chonetes emmetensis* Winchell, and *Leptalosia radicans* (Winchell)

are found in rocks of the Little Traverse Bay area and in the Alpena limestone or higher strata of the Alpena area.

A comparison of the stratigraphic sections (see Fig. 1) of the three areas shows that the section of the Afton–Black Lake area is much thinner than those of either the Alpena or the Little Traverse Bay area. It is possible that strata equivalent to the highest beds of the Alpena and Little Traverse Bay areas are absent in the Afton–Black Lake area. The apparent absence of species in the Afton area which are characteristic of the highest beds of the other areas supports this possibility. The absence of the highest Traverse strata in the Afton area may be accounted for by lack of deposition or by erosion prior to the deposition of the upper Devonian black shales. If the record of the Bay View well (Grabau, 1902, p. 197) is accurate, the entire section of the Afton–Black Lake area may be represented in the Little Traverse Bay area by the four hundred or more feet of beds which underlie the lowest known outcrops.

The upper Long Lake limestones in the Alpena area are at least three hundred feet below the black shale. In the Afton region the highest strata of the Long Lake are approximately one hundred and fifteen feet below the black shale. This would indicate that the upper Traverse of the Alpena region thins to the westward or is absent in the Afton region. A number of species occurring in the higher beds of the Afton area appear to be similar to species found in the Alpena limestone, thus indicating that these beds are equivalent in age to the Alpena limestone and that the Thunder Bay strata are absent in the Afton area.

The suggested relations of the strata in the three Traverse areas as just presented explain (1) why most species found in strata of the Little Traverse Bay area have not been found in the Afton–Black Lake area; (2) why a number of species common to the Little Traverse Bay and Alpena areas are restricted to the upper part of the Traverse in the Alpena area; (3) why there are few recognizable Long Lake species in the strata exposed in the Little Traverse Bay area; and (4) why the lower Traverse strata of the Alpena and Afton–Black Lake areas are similar, both faunistically and lithologically.

GEOGRAPHIC LOCATION OF TRAVERSE EXPOSURES NOTED IN THIS PAPER

The locality numbers noted below have been used either by the Michigan Geological Survey expedition of 1926, or by E. R. Pohl, or by the Museum of Paleontology of the University of Michigan in the course of their field work.

LOCALITY

7c Low bluff on shore of Grand Traverse Bay, between points one and two miles northwest of Norwood, in Secs. 22 and 28, T. 33 N., R. 9 W., Charlevoix County.

8 "Gravel Point," Lake Michigan shore, one and one-half miles west of Charlevoix, Secs. 28 and 29, T. 34 N., R. 8 W.

8a Shore of Lake Michigan from locality 8 to point about one mile south.

9 Abandoned quarry No. 1 of Charlevoix Rock Products Co., SE. ¼ SE. ¼ Sec. 28, T. 34 N., R. 8 W., about three quarters of a mile west of Charlevoix city line.

10 Charlevoix city quarry, now used as a dump ground, immediately south of the center of the east-west road, on the north line of Sec. 33, T. 34 N., R. 8 W., about one-half mile southwest of locality 9.

12 Abandoned quarry No. 2 of Charlevoix Rock Products Co., SW. ¼ Sec. 28, T. 34 N., R. 8 W., about one-quarter mile southwest of locality 9.

13 Abandoned Northern Lime Co. quarry ("Main Curtiss and two smaller quarries" of E. R. Pohl), at Bay Shore, Emmet County, and shore bluffs to west.

13a Small abandoned quarry in southwest corner of Sec. 5, T. 34 N., R. 6 W., and small bluffs and ledges near water's edge, forming a nearly continuous exposure, a mile in length, to the east of locality 13.

14 Petoskey Portland Cement Co. quarry, one and one-quarter miles west of the Petoskey city line, SW. ¼ Sec. 2 and SE. ¼ Sec. 3, T. 34 N., R. 6 W., Emmet County.

14c Abandoned quarry one mile west of west end of Petoskey Portland Cement Co. quarry (locality 14) and about one-eighth mile south of Little Traverse Bay, NW. ¼ NE. ¼ Sec. 9, T. 34 N., R. 6 W.

14e Abandoned "Bell" quarry, extreme NE. ¼ Sec. 8, T. 34 N., R. 6 W., and ledges on shore to west, Emmet County.

15 Abandoned Superior quarry of Northern Lime Co., about one and one-half miles west of Northern Lime Co. quarry at Bay Shore (locality 13).

15b Shore of Little Traverse Bay from Nine Mile Point to two and one-half miles west.

17 Antrim Lime Co. quarry, western part of Petoskey, SE. ¼ Sec. 1, T. 34 N., R. 6 W., Emmet County.

LOCALITY

18 Northern Lime Co. quarry, bordering Little Traverse Bay, near east end of Petoskey, Sec. 32, T. 35 N., R. 5 W., Emmet County.

18a Bluffs on shore of Little Traverse Bay at Pennsylvania R. R. station, Bay View, NW. ¼ Sec. 33, T. 35 N., R. 5 W., Emmet County.

21 Small quarry, approximately one mile east of Bay View, adjacent to Mud Lake, NE. ¼ NW. ¼ Sec. 34, T. 35 N., R. 5 W., Emmet County.

22 Rock cuts along north–south road, one-half mile west of Afton, between points one and one-half and two miles south of Afton, Cheboygan County.

23 Rock cuts along north–south road of locality 22, between points two and one-half to two and three-quarter miles south of Afton, Cheboygan County.

25 Campbell Stone Co. quarry, three quarters of a mile north of Afton, Sec. 36, T. 35 N., R. 2 W., Cheboygan County.

26 Rock cuts along north–south road between localities 22 and 23.

29 Abandoned quarry on shore of Black Lake, one-half mile west of Onaway State Park, Sec. 7, T. 35 N., R. 2 E., Presque Isle County.

31 Quarry of Michigan Limestone and Chemical Co. near Rogers City, Presque Isle County.

35 Partridge Point, on Thunder Bay, Lake Huron, about four miles south of Alpena.

38 Abandoned quarry of Kelly Island Lime and Transport Co., Rockport, Sec. 6, T. 32 N., R. 9 E., Alpena County.

40 Quarry of Michigan Alkali Co. at Alpena.

41 Spillway below powerhouse at Four Mile Dam, Sec. 7, T. 31 N., R. 8 E., Alpena County.

46 Shale bank on south side of Thunder Bay River, approximately one mile east of Four Mile Dam (locality 41).

47 Shale bank on south side of Thunder Bay River, at Seven Mile Dam, Sec. 1, T. 32 N., R. 7 E., Alpena County.

49 Abandoned quarry of El Cajon Portland Cement Co. at El Cajon Beach, Sec. 10, T. 31 N., R. 9 E., Alpena County.

51 Abandoned shale pit of Alpena Portland Cement Co., SE. ¼ Sec. 18, T. 32 N., R. 9 E., Alpena County.

52 Cut on French Road, about one-quarter mile south of Long Lake, east line of Sec. 8, T. 32 N., R. 8 E., Alpena County.

53 Quarry of Thunder Bay Quarries Co. at Alpena.

54 South side of Partridge Point along shore of Squaw Bay, Sec. 10, T. 30 N., R. 8 E., Alpena County.

LOCALITY

58 Ditch beside Long Lake road, about one-half mile southeast of Summerville, at southeast end of Long Lake, NE. ¼ Sec. 22, T. 32 N., R. 8 E., Alpena County.

64 Rock cut on east–west highway two miles north and three quarters of a mile east of Afton, about one quarter of a mile east of NW. cor. Sec. 30, T. 35 N., R. 1 W., Cheboygan County.

65 Rock cut on north–south road about two miles north and one-half mile east of Afton, approximately one hundred feet south of NW. cor. Sec. 30, T. 35 N., R. 1 W., Cheboygan County.

68 Small abandoned shale pit in the Alpena Cemetery in SW. ¼ Sec. 21, T. 31 N., R. 8 W., about one mile west of center of Alpena, Michigan.

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EXPLANATION OF PLATE I

PAGE

Fenestrellina rockportensis, sp. nov. 110

1. Obverse face of holotype, fragment from the mature part of a zoarium, showing form of branches and indented fenestrules (No. 17067). Long Lake stage: Ferron Point formation; locality 38. × 10

2. Reverse face of paratype, fragment from the immature part of a zoarium, showing thin branches and large, regular fenestrules (No. 17068). Long Lake stage: Ferron Point formation; locality 38. × 10

Fenestrellina regularis, sp. nov. 109

3. Obverse face of holotype, showing form of branches (No. 17069). Alpena limestone stage: Dock Street clay; locality 53. × 10

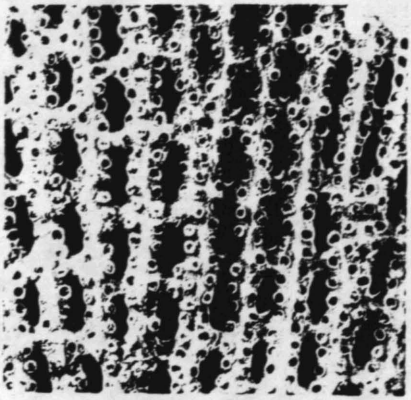
4. Reverse face of paratype, showing smooth branches and large elliptical fenestrules (No. 17070). Alpena limestone stage: Dock Street clay; locality 53. × 10

Fenestrellina alpenensis, sp. nov. 111

5. Obverse face of holotype, showing form of branches and large elliptical fenestrules (No. 17071). Alpena limestone stage: Dock Street clay; locality 53. × 10

6. Reverse face of paratype, showing smooth branches and oval to circular fenestrules (No. 17072). Alpena limestone stage: Dock Street clay; locality 53. × 10

PLATE I



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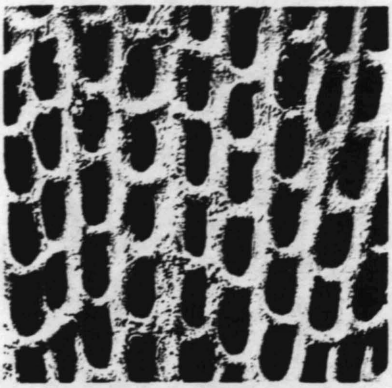

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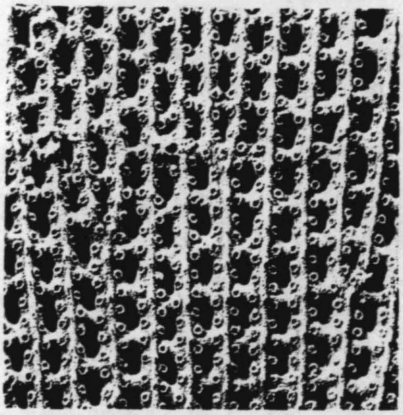

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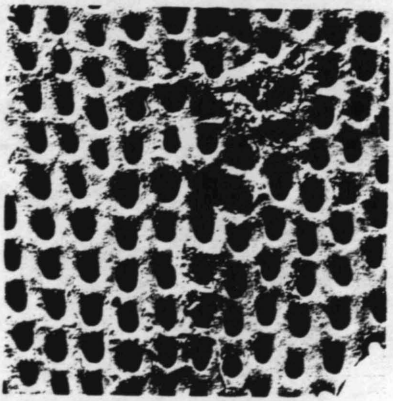

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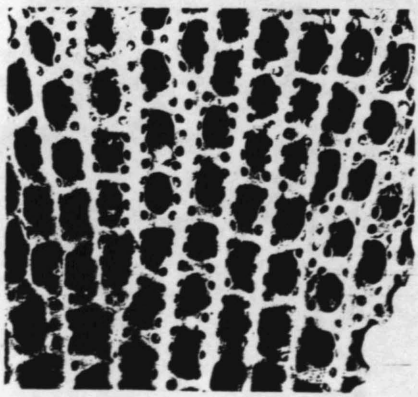

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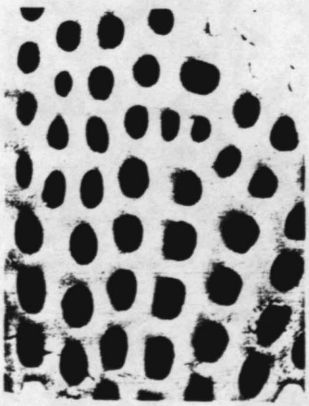

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EXPLANATION OF PLATE II

PAGE

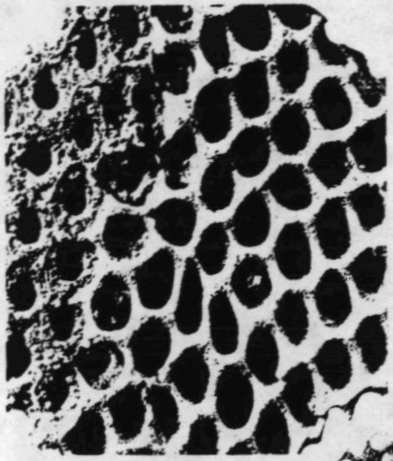
Loculipora loculata, sp. nov. 113

1. Obverse face of holotype, showing the superstructure on the right side of the figure and the branches, with the superstructure removed, on the left side. Note difference in size between superstructure and fenestrules (No. 17074). Petoskey formation: bed 2, zone 2, of E. R. Pohl; locality 13. × 10
2. Reverse face of paratype, showing angulated branches and arrangement of fenestrules (No. 17075). Petoskey formation: bed 2, zone 2, of E. R. Pohl; locality 13. × 10
3. Camera lucida drawing of a thin section, showing arrangement of apertures around fenestrules and position of carinae. Paratype (No. 17073). Petoskey formation: bed 2, zone 2, of E. R. Pohl; locality 13. × 10

Lyropora devonica, sp. nov. 114

4. Part of an immature zoarium, showing prominent lateral supports. Paratype (No. 17077). Petoskey formation: bed 2, zone 2, of E. R. Pohl; locality 13. × 1
5. An almost complete immature zoarium, showing base and lateral supports. Paratype (No. 17076). Petoskey formation: bed 2, zone 2, of E. R. Pohl; locality 13. × 1
6. Part of a mature zoarium. Holotype (No. 17078). Petoskey formation: bed 2, zone 2, of E. R. Pohl; locality 13. × 1
7. Reverse face of a paratype, showing rounded fenestrules and strong dissepiments (No. 17079). Petoskey formation: bed 2, zone 2, of E. R. Pohl; locality 13. × 10
8. Obverse face of another paratype, showing character of apertures and fenestrules and depressed dissepiments (No. 17080). Petoskey formation: bed 2, zone 2, of E. R. Pohl; locality 13. × 10

PLATE II



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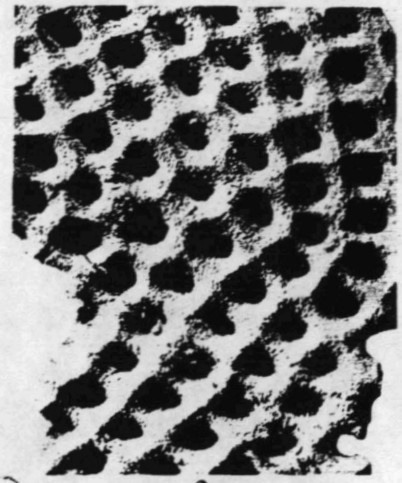

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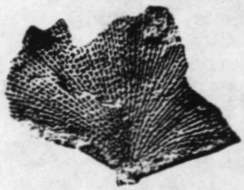

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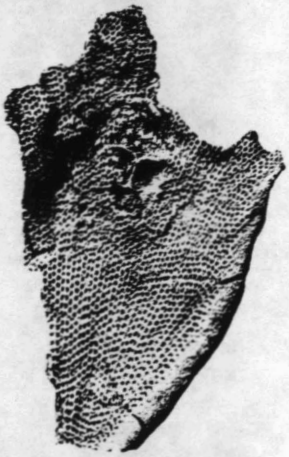

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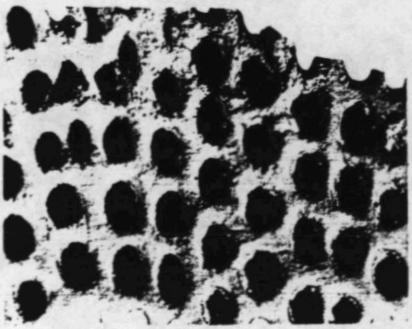

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EXPLANATION OF PLATE III

PAGE

Anastomopora petoskeyensis, sp. nov. 116

1. Obverse face of holotype, showing form of branches and dissepiments and distribution of apertures (No. 17082). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 9. × 10

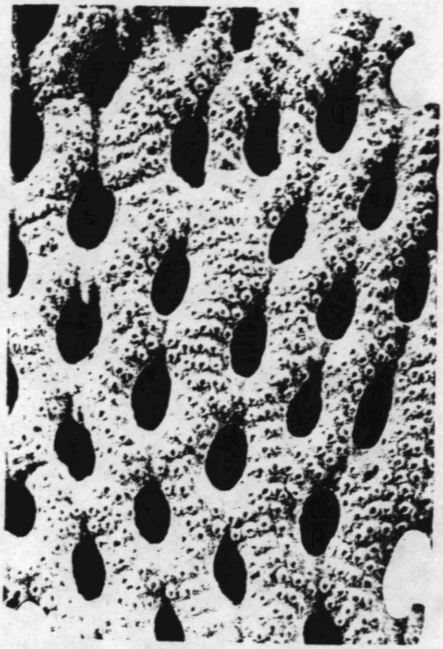
2. Reverse face of holotype, showing angulated anastomosing branches and shape of fenestrules. × 10

Anastomopora ovata, sp. nov. 115

3. Obverse face of holotype, showing anastomosing branches and character of fenestrules and apertures (No. 17113). Alpena limestone stage: Dock Street clay; locality 53. × 10

4. Reverse face of holotype, showing anastomosing branches and arrangement of fenestrules. × 10

PLATE III



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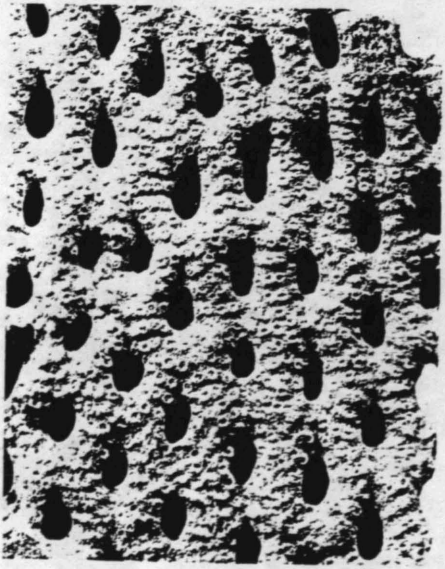

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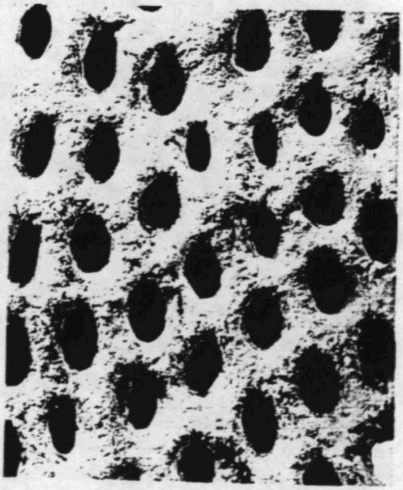

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EXPLANATION OF PLATE IV

PAGE

Penniretepora irregularis, sp. nov. 117

1. Celluliferous face of a paratype, showing three ranges of apertures separated by low longitudinal ridges (No. 17083). Gravel Point stage: zone 4 of E. R. Pohl; locality 8. × 10

2. Holotype, showing character of branching, noncelluliferous face (above) and celluliferous face (below) (No. 17084). Gravel Point stage: zone 4 of E. R. Pohl; locality 8. × 10

3. Celluliferous face of a paratype, showing two ranges of apertures (No. 17085). Gravel Point stage: zone 4 of E. R. Pohl; locality 8. × 10

Helopora inexspectata, sp. nov. 119

4. Holotype, showing pointed distal extremity of segment, character, and arrangement of apertures (No. 17086). Long Lake stage: Ferron Point formation; locality 38. × 10

5. A segment, showing double socket at distal end. Paratype (No. 17087). Long Lake stage: Ferron Point formation; locality 29. × 10

6. Proximal end of same segment. × 10

7. Double socket of same segment, showing concentric lines. × 10

8. Tangential section of another paratype, showing shape and arrangement of apertures. The dark dots between ends of apertures are acanthopores (No. 17089). Long Lake stage: lowest beds of Genshaw formation; locality 51. × 15

9. Longitudinal section of a paratype, showing tubular zooecia (No. 17088). Long Lake stage: lowest beds of Genshaw formation; locality 51. × 15

Acanthoclema lineatum, sp. nov. 120

10. Paratype, showing strong longitudinal ridges (No. 17094). Alpena limestone stage: Dock Street clay; locality 53. × 10

11. Holotype, showing arrangement of apertures. The longitudinal ridges have been worn away (No. 17091). Alpena limestone stage: Dock Street clay; locality 53. × 10

16. Camera lucida drawing of transverse section, showing shape and arrangement of zooecia. Paratype (No. 17092). Alpena limestone stage: Dock Street clay; locality 53. × 15

18. Camera lucida drawing of tangential section, showing shape of apertures and minute tubules in ridges between apertures. Paratype (No. 17093). Alpena limestone stage: Dock Street clay; locality 53. × 15

Acanthoclema ohioense, sp. nov. 121

12. Paratype, showing small, obscure nodes on the longitudinal ridges (No. 17097). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. × 10

15. Camera lucida drawing of longitudinal section, showing shape of zooecia and inferior and superior hemisepta (No. 17096). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. × 10

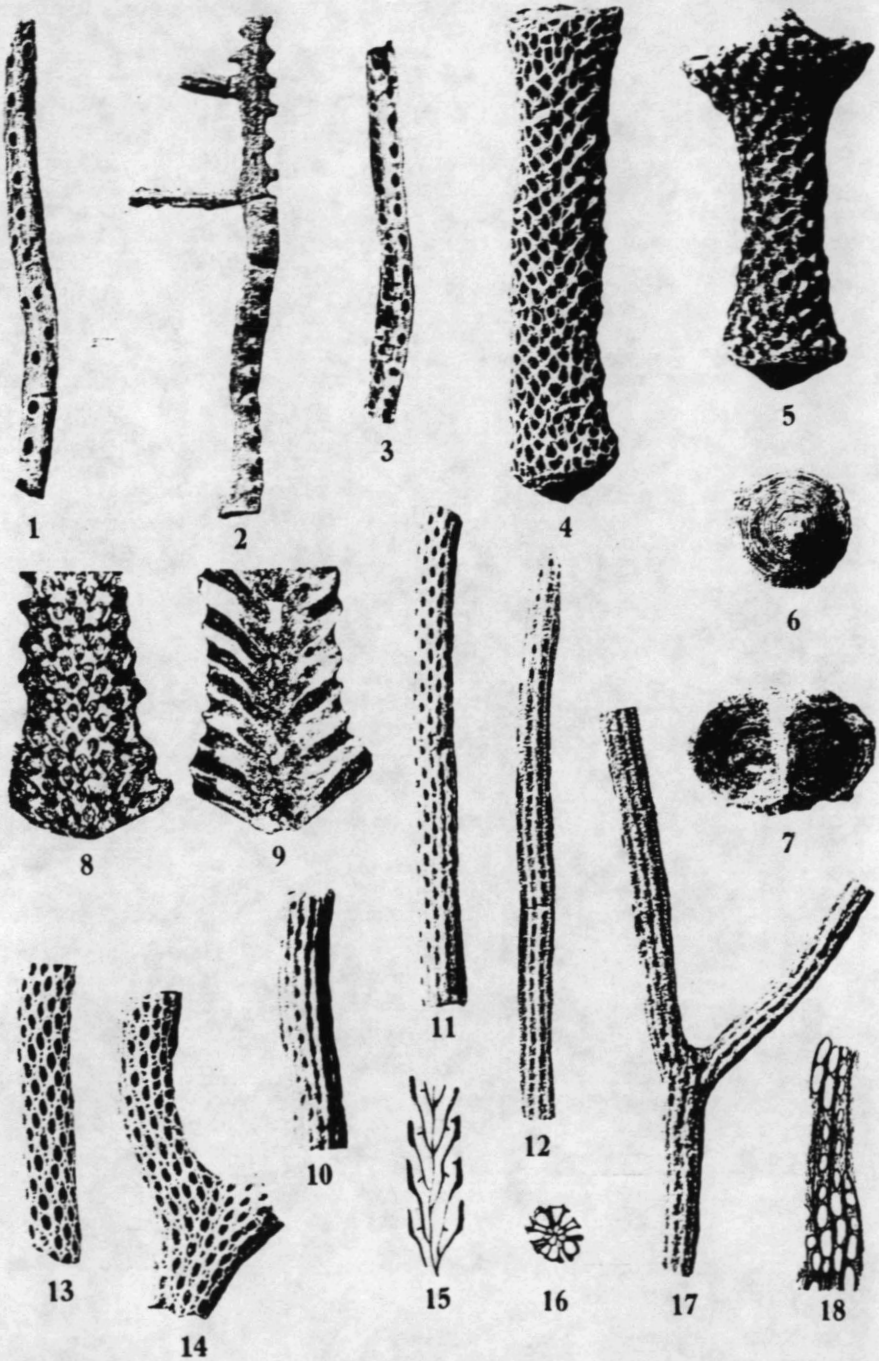
17. Holotype, showing branching and arrangement of apertures (No. 17095). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County. Ohio. × 10

Streblotrypa anomala, sp. nov. 123

13. Paratype, showing shape and arrangement of apertures, and longitudinal mesopores (No. 17098). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. × 10

14. Another paratype, showing method of branching (No. 17099). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. × 10

PLATE IV



EXPLANATION OF PLATE V

PAGE

Streblotrypa anomala, sp. nov. 123

1. Camera lucida drawing of transverse section, showing shape and arrangement of zooecia. Paratype (No. 17102). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. × 15

2. Holotype, showing arrangement of apertures and mesopores (No. 17100). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. × 10

3. Camera lucida drawing of longitudinal section, showing shape of zooecia and interzooecial spaces. The details of wall structure have been destroyed by replacement. Paratype (No. 17101). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. × 15

Stictoporina granulifera Stewart 124

4. An almost complete zoarium, showing shape of frond and pointed base. Plesiotype (No. 17104). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. × 1

5. Tangential section, showing shape and arrangement of apertures and form of granules in interzooecial spaces. Plesiotype (No. 17103). Long Lake stage: Bell shale; locality 31. × 30

6. A more expanded frond than that shown in Figure 4. Plesiotype (No. 17105). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. × 1

7. Part of surface of specimen illustrated in Figure 4, showing shape and arrangement of apertures. × 5

8. Camera lucida drawing of longitudinal section, showing shape of zooecia. The section is taken near the margin of the frond. Plesiotype (No. 17106). Long Lake stage: Bell shale; locality 31. × 15

10. Part of surface of frond illustrated in Figure 6, showing monticules and arrangement of apertures and granules on interzooecial walls. × 10

Intrapora acanthopora, sp. nov. 127

9. Holotype, showing method of branching (No. 17107). Long Lake stage: Bell shale; locality 31. × 5

PLATE V

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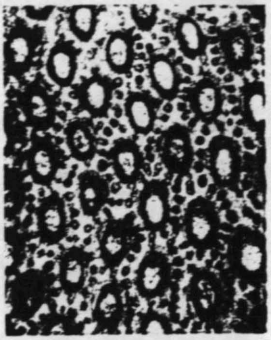

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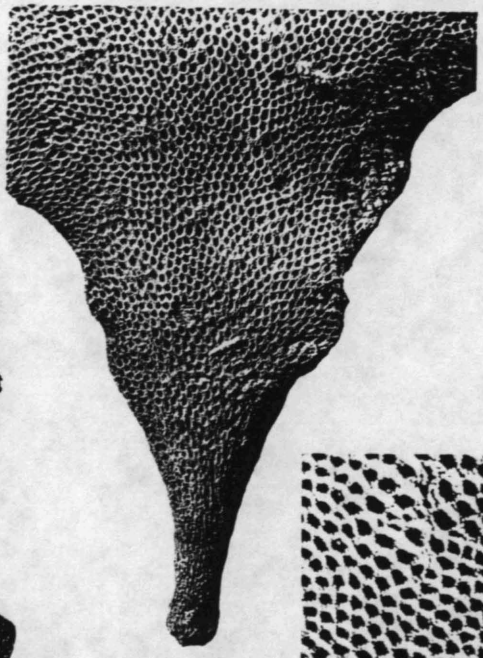

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EXPLANATION OF PLATE VI

PAGE

Intrapora irregularis Stewart..... 127

1. Plesiotype, showing shape and arrangement of apertures and distribution of mesopores (No. 17108). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. × 10
2. Same specimen, showing size of broken expansion. × 1

Intrapora petoskeyensis, sp. nov..... 128

3. Holotype, showing shape and arrangement of apertures and mesopores and character of nonporiferous margin (No. 17109). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 14e. × 10
4. Same specimen, showing size of branches. × 1
5. Same specimen, showing arrangement of apertures and mesopores. × 5

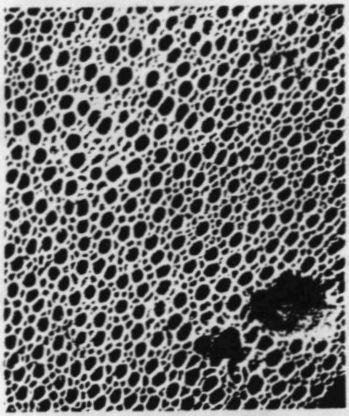
Intrapora puteolata Hall..... 129

6. Plesiotype, showing arrangement of apertures and mesopores and character of nonporiferous margin (No. 17110). Alpena limestone stage: Dock Street clay; locality 53. × 10
7. Same specimen. × 1
8. Part of an explanate zoarium. Plesiotype (No. 17111). Alpena limestone stage: Dock Street clay; locality 53. × 1
9. Part of a branched zoarium. Plesiotype (No. 17112). Alpena limestone stage: Dock Street clay; locality 53. × 1

Intrapora traversensis, sp. nov..... 130

10. Tangential section, showing shape of apertures, mesopores and acanthopores. Paratype (No. 17118). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 14e. × 30
11. Part of a zoarium, showing shape and arrangement of monticules. Holotype (No. 17116). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 14e. × 1
12. Part of surface of holotype, showing shape and arrangement of apertures and mesopores. × 10

PLATE VI



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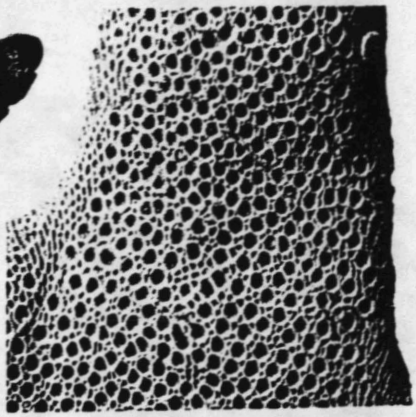

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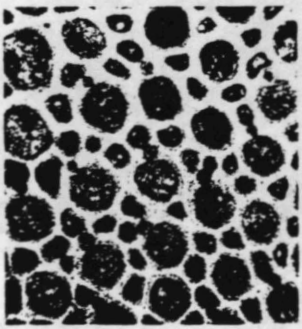

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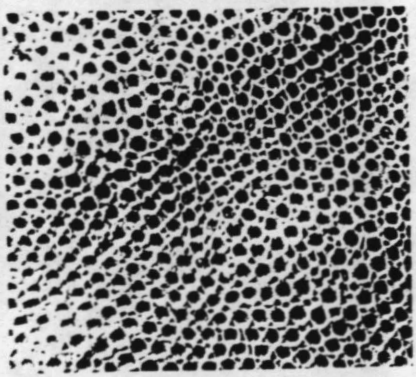

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EXPLANATION OF PLATE VII

PAGE

Intrapora acanthopora, sp. nov. 127

1. Tangential section, showing shape of apertures, and small acanthopores. The mesopores appear solid, being filled with horizontal laminae. Paratype (No. 17119). Long Lake stage: Bell shale; locality 31. × 30

Intrapora irregularis Stewart..... 127

2. Tangential section showing shape and arrangement of apertures and mesopores, and few, distantly spaced acanthopores. Plesiotype (No. 17120). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. × 30

Intrapora puteolata Hall..... 129

3. Tangential section showing shape and arrangement of apertures, mesopores, and acanthopores. Plesiotype (No. 17122). Alpena limestone stage: Dock Street clay; locality 53. × 30

4. Camera lucida drawing of longitudinal section, showing shape of zooecia, position of mesopores, and shape of interzooecial spaces. Plesiotype (No. 17114). Alpena limestone stage: Dock Street clay; locality 53. × 15

Intrapora traversensis, sp. nov..... 130

5. Camera lucida drawing of longitudinal section, showing shape of zooecia, and mesopores with distantly spaced tabulae. Paratype (No. 17117). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 14e. × 15

Intrapora petoskeyensis, sp. nov. 128

7. Tangential section, showing shape and arrangement of apertures and mesopores. Note absence of acanthopores. Paratype (No. 17121). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 14e. × 30

Ceramella casei, sp. nov. 136

6. Camera lucida drawing of longitudinal section, showing shape of zooecia and position of vesicles. Paratype (No. 17125). Long Lake stage: Ferron Point formation; locality 51. × 15

8. Tangential section, showing arrangement of apertures, minute tubules in wall spaces, and enlarged granules near the sides of apertures. Vesicles of a macula shown in upper central part of figure. Paratype (No. 17124). Long Lake stage: Ferron Point formation; locality 51. × 30

PLATE VII

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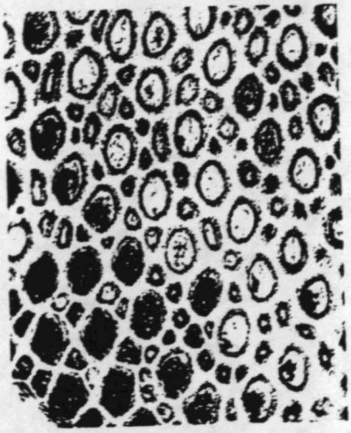

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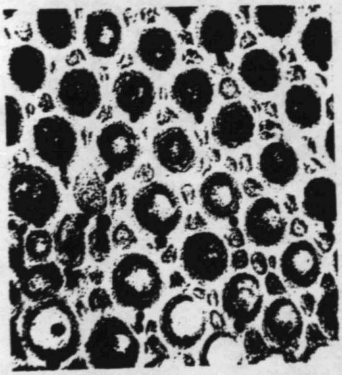

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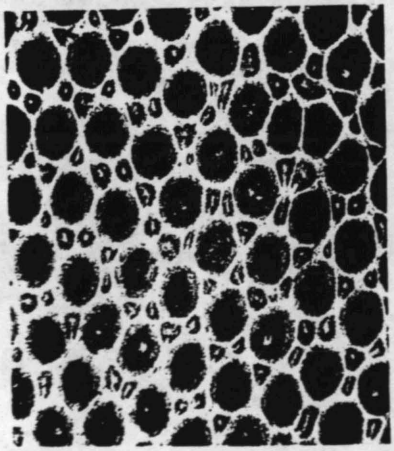

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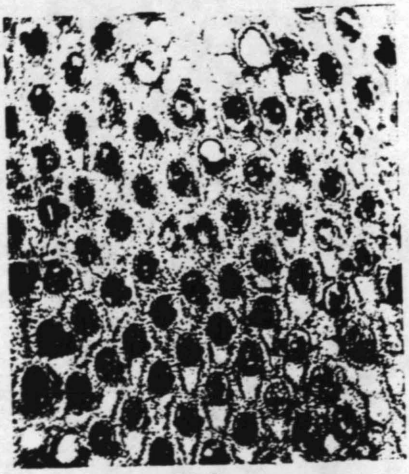

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EXPLANATION OF PLATE VIII

PAGE

Ceramella casei, sp. nov. 136

1. Holotype, showing arrangement of maculae (No. 17123). Long Lake stage: Ferron Point formation; locality 51. × 5
2. Holotype. × 1
3. Surface of holotype, showing character of apertures and maculae. × 10

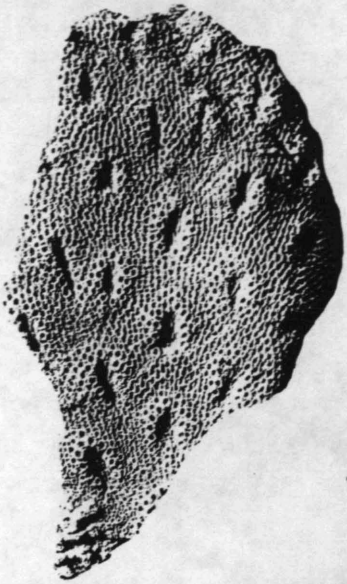
Euspilopora kellumi, sp. nov. 133

5. Tangential section, showing arrangement of apertures and interzooecial walls with large granules. Paratype (No. 17132). Petoskey formation: locality 15. × 30

Euspilopora diversa, sp. nov. 132

4. Part of branch, showing character of apertures and smooth, nonserrate margin. Paratype (No. 17129). Gravel Point stage: zone 2 ("Large Atrypa zone"), of E. R. Pohl; locality 15b. × 10
6. An almost complete zoarium, showing method of branching. Paratype (No. 17126). Gravel Point stage: zone 2 ("Large Atrypa zone"), of E. R. Pohl; locality 15b. × 1
7. Part of a zoarium. Holotype (No. 17127). Gravel Point stage: zone 2 ("Large Atrypa zone"), of E. R. Pohl; locality 15b. × 1
8. Distal part of holotype, showing serrate margin, form of apertures, and short lateral branches. × 10

PLATE VIII



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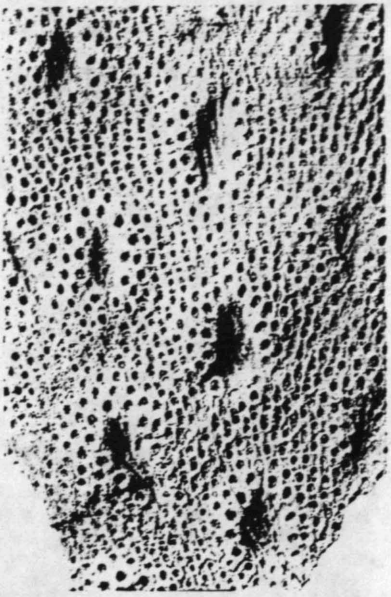

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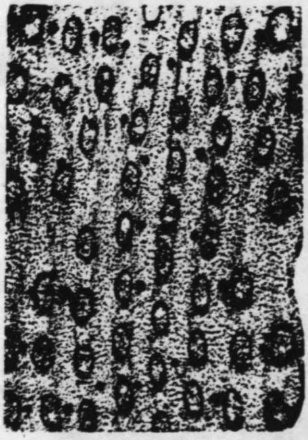

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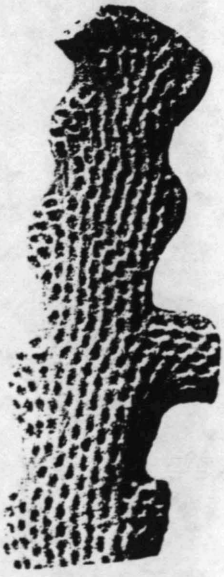

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EXPLANATION OF PLATE IX

PAGE

Euspilopora diversa, sp. nov. 132

1. Tangential section, showing shape and arrangement of apertures, minute tubules in walls, and large granules near margins of apertures (seen in upper left). Interzooecial cells shown in lower right. Paratype (No. 17128). Gravel Point stage: zone 2 ("Large Atrypa zone"), of E. R. Pohl; locality 15b. × 30

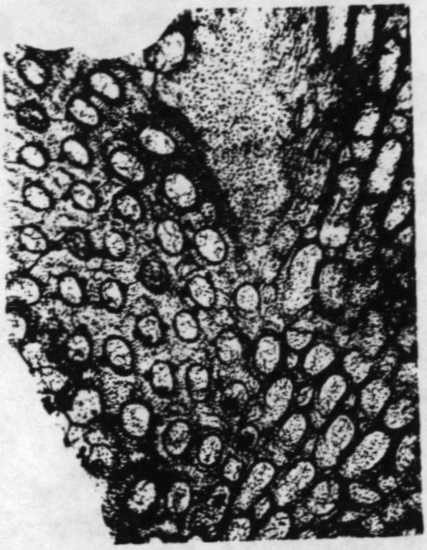
Euspilopora kellumi, sp. nov. 133

2. Holotype (No. 17130). Petoskey formation: locality 12. × 1
3. Holotype, showing arrangement of maculae and apertures. × 5
4. An almost complete zoarium, showing shape of expansion. Paratype (No. 17131). Petoskey formation: bed 2, zone 2, of E. R. Pohl; locality 13. × 1
5. Part of surface of holotype, showing maculae and character of apertures. × 10

Sulcoretepora alternata, sp. nov. 137

6. Part of zoarium, showing method of branching. Paratype (No. 17134). Long Lake stage: Ferron Point formation; locality 29. × 1
7. Holotype, showing size and arrangement of branches (No. 17133). Long Lake stage: Ferron Point formation; locality 29. × 1
8. Surface of holotype, enlarged to show low longitudinal ridges and arrangement of apertures. × 10

PLATE IX



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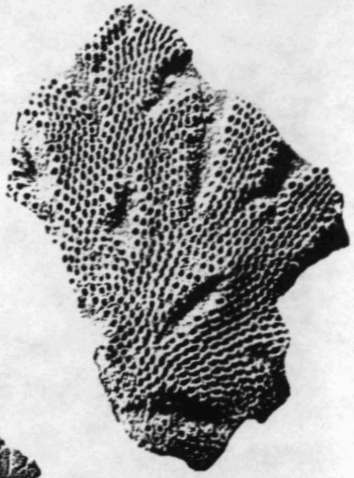

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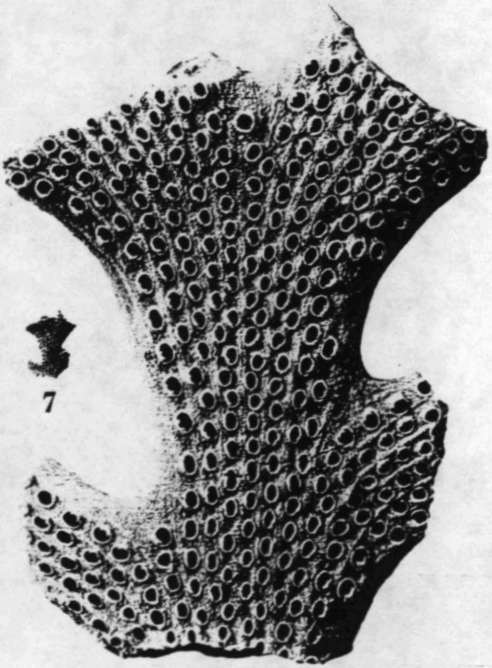

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EXPLANATION OF PLATE X

PAGE

Sulcoretepora bifidiplicata, sp. nov. 138

1. Holotype, showing method of branching (No. 17135). Long Lake stage: Ferron Point formation; locality 29. × 1
2. Holotype, showing character of ridges and apertures. × 5

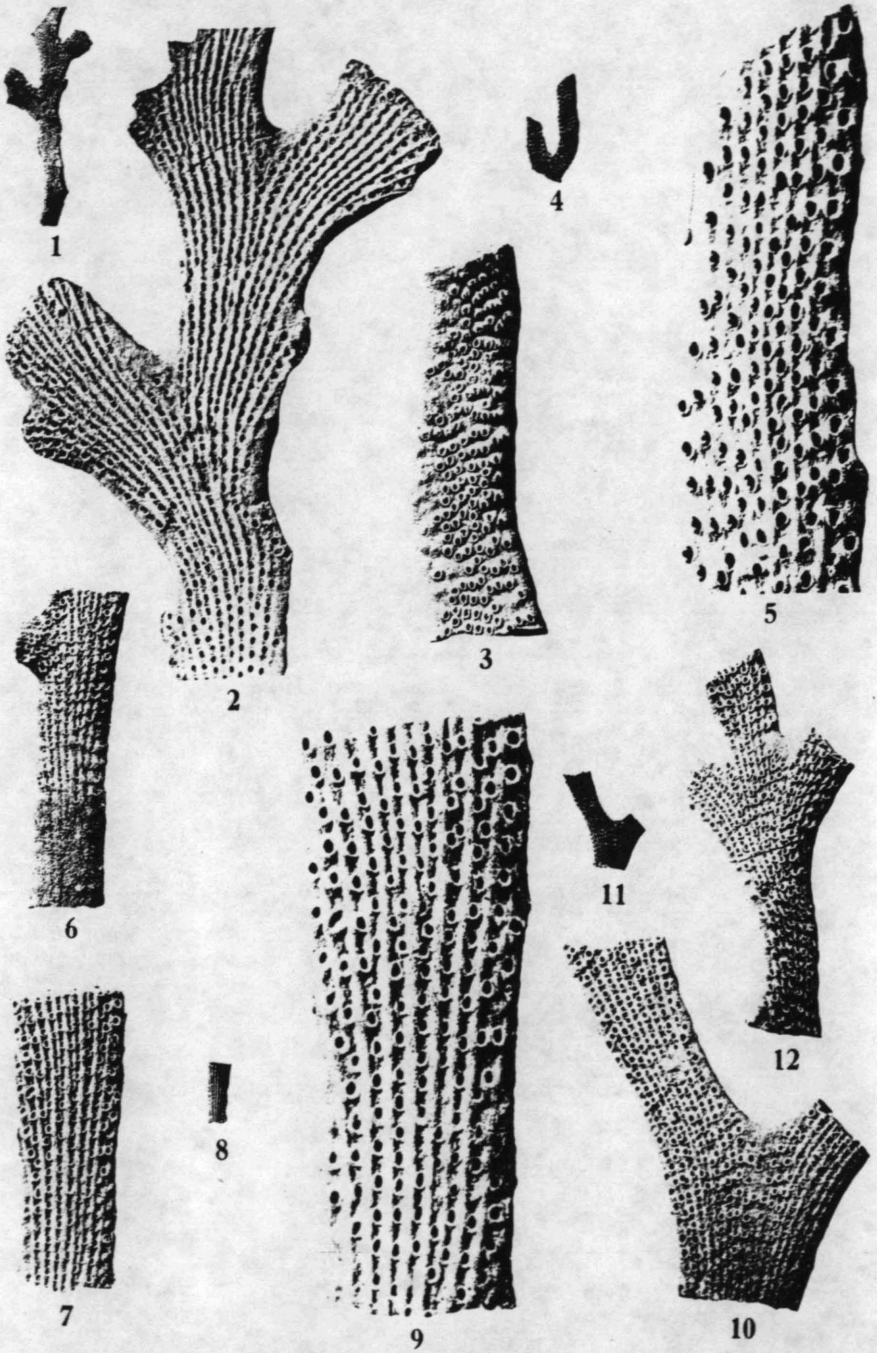
Sulcoretepora lyrifica, sp. nov. 141

4. Holotype, showing type of branching (No. 17137). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 17. × 10
5. Part of a branch of holotype, showing strong lunaria, prominent longitudinal ridges, and uneven margin. × 10

Sulcoretepora obliqua, sp. nov. 140

3. Branch, from old part of zoarium, showing rounded margins with some of the marginal apertures covered with adventitious calcium carbonate. Paratype (No. 17140). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 9. × 5
6. Branch, showing apertures covered with adventitious calcium carbonate. Paratype (No. 17139). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 9. × 5
7. Holotype, showing arrangement of apertures and ridges (No. 17142). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 9. × 5
8. Holotype. × 1
9. Holotype, showing details of surface. Note absence of lunaria. × 10
10. Paratype, showing branching (No. 17141). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 9. × 5
11. Same paratype. × 1
12. Paratype, showing trifurcating branches (No. 17138). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 9. × 5

PLATE X



EXPLANATION OF PLATE XI

PAGE

Sulcoretepora ramifera, sp. nov. 142

1. Part of a zoarium, showing primary and secondary branches and arrangement of apertures. Holotype (No. 17143). Long Lake stage: Ferron Point formation; locality 49. × 5

2. Holotype. × 1

3. Camera lucida drawing of part of the holotype, showing character of margin and apertures with lunaria. × 15

Sulcoretepora sulcata (Winchell) 144

4. Camera lucida drawing of part of a branch, showing arrangement of apertures and longitudinal ridges. Plesiotype (No. 17144). Gravel Point stage: zone 3 ("Emmetensis zone"), of E. R. Pohl; locality 8. × 15

5. Part of a zoarium, showing closely spaced branches. Plesiotype (No. 17145). Gravel Point stage: zone 3 ("Emmetensis zone"), of E. R. Pohl; locality 8. × 1

6. Specimen illustrated in Figure 4, showing distantly spaced branches. × 1

Sulcoretepora deissi, sp. nov. 143

7. Part of holotype, showing arrangement of apertures with lunaria and nonporiferous margin (No. 17151). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. × 10

8. Paratype, showing thin branches. Specimen from young part of branch (No. 17150). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. × 5

Sulcoretepora alternata, sp. nov. 137

9. Tangential section, showing vesicles between ends of zooecia and shape of zooecia. Paratype (No. 17147). Long Lake stage: Ferron Point formation; locality 29. × 15

Sulcoretepora obliqua, sp. nov. 140

10. Tangential section, showing shape of zooecia. Paratype (No. 17148). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 9. × 15

PLATE XI

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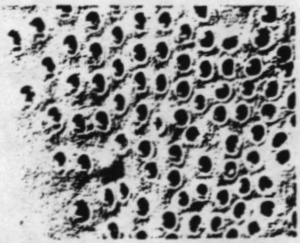

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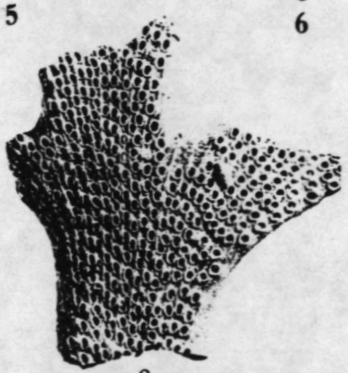

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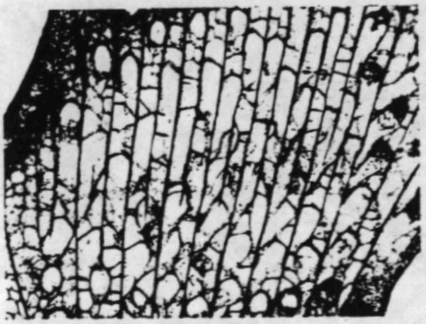

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EXPLANATION OF PLATE XII

PAGE

Sulcoretepora deissi, sp. nov. 143

1. Holotype, showing size of branch of specimen from mature part of zoarium (No. 17151). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. × 1

2. Surface of holotype, showing arrangement of apertures and several low nodes, formed by the closing over of large cells. × 5

4. Paratype, showing arrangement of branches. Specimen from mature part of zoarium (No. 17149). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. × 5

5. Same paratype, showing size of branch. × 1

7. Longitudinal section of a partly pyritized specimen, showing shape of zooecia, vesicles, and an enlarged cell. Several zooecia show weak superior hemisepta. Paratype (No. 17154). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. × 15

8. Tangential section, showing shape of zooecia, and vesicles within nonporiferous margin. Paratype (No. 17153). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. × 15

9. Paratype, showing several large cells, irregular striae between apertures, and excessive formation of calcium carbonate. Specimen from extremely old part of zoarium (No. 17152). Silica shale: shale pit of Sandusky Cement Co. at Silica, Lucas County, Ohio. × 5

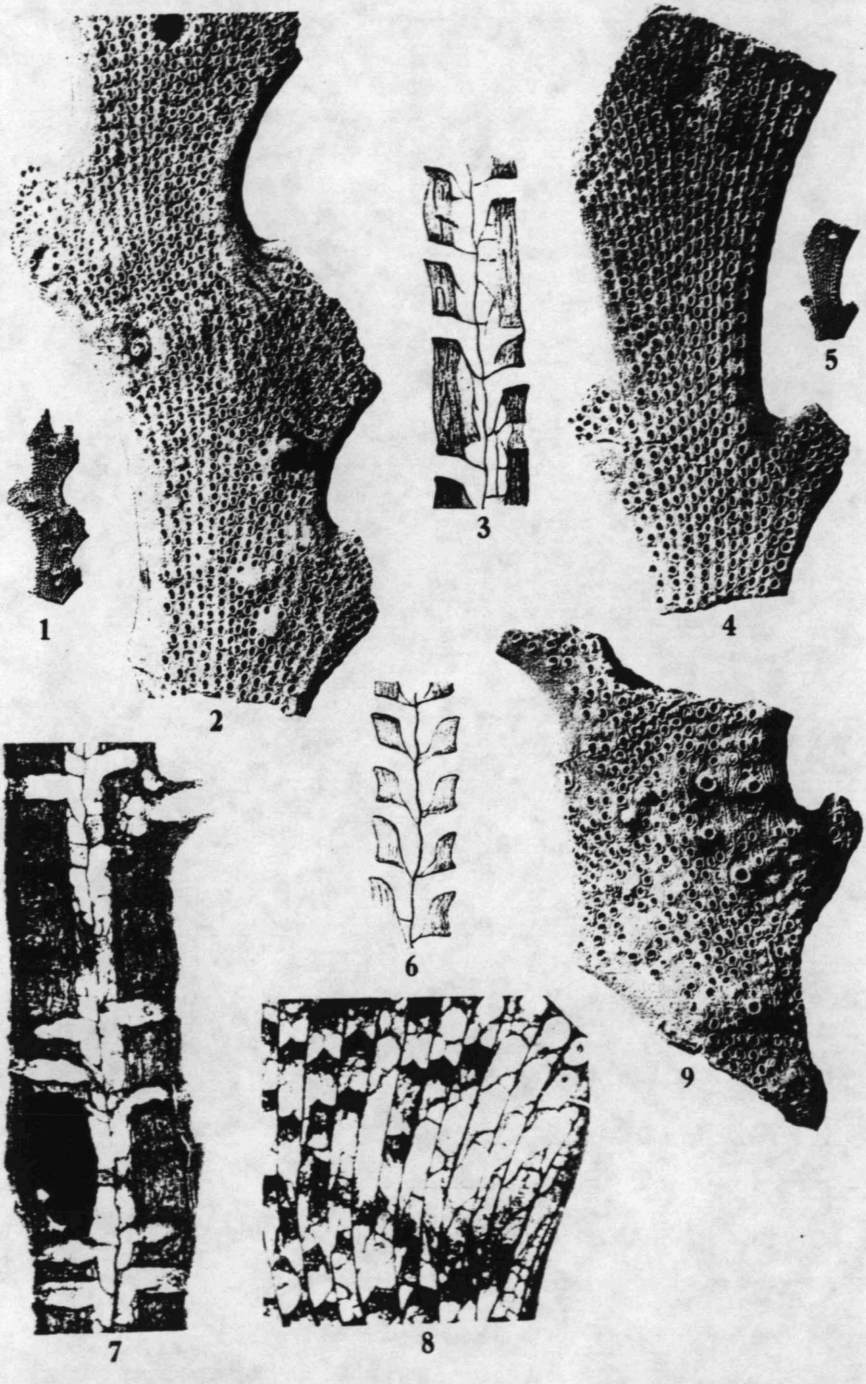
Sulcoretepora alternata, sp. nov. 137

3. Camera lucida drawing of part of a longitudinal section, showing shape of zooecia and vesicles. Paratype (No. 17157). Long Lake stage: Ferron Point formation; locality 29. × 15

Sulcoretepora obliqua, sp. nov. 140

6. Camera lucida drawing of part of a longitudinal section, showing shape of zooecia. Paratype (No. 17155). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 9. × 15

PLATE XII



EXPLANATION OF PLATE XIII

PAGE

Sulcoretepora obliqua, sp. nov. 140

1. Transverse section of branch, showing shape of zooecia and arrangement of vesicles. Paratype (No. 17156). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 9. × 15

Sulcoretepora alternata, sp. nov. 137

2. Transverse section of branch, showing shape of zooecia and vesicles. Paratype (No. 17158). Long Lake stage: Ferron Point formation; locality 29. × 15

Semiopora? ehlersi, sp. nov. 145

3. Holotype, showing bifurcation of branch and arrangement of apertures (No. 17162). Long Lake stage: Ferron Point formation; locality 29. × 10

4. Holotype. × 1

5. Camera lucida drawing of paratype, showing shape and arrangement of apertures and longitudinal ridges (No. 17163). Long Lake stage: Ferron Point formation; locality 29. × 15

6. Tangential section, near median lamina, showing shape of zooecia. Paratype (No. 17161). Long Lake stage: Ferron Point formation; locality 29. × 15

7. Part of a longitudinal section, showing shape of zooecia. Paratype (No. 17159). Long Lake stage: Ferron Point formation; locality 29. × 15

8. Camera lucida drawing of section shown in Figure 7; drawing made to show shape of zooecia more distinctly

9. Tangential section, close to surface, showing shape of apertures. Paratype (No. 17160). Long Lake stage: Ferron Point formation; locality 29. × 15

Taeniopora exigua Nicholson 147

10. Plesiotype, showing strong carinae on both main and lateral branches, and elevated apertures (No. 17165). Alpena limestone stage: Dock Street clay; locality 53. × 5

11. Opposite face of same specimen, showing strong carina on lateral branch. × 5

Prismopora alpenensis, sp. nov. 149

12. One face of holotype, showing arrangement of apertures on oblique ridges and raised nonporiferous central area (No. 17167). Alpena limestone stage: Dock Street clay; locality 53. × 5

13. One face of triangular branch, showing oblique ridges with apertures. Paratype (No. 17166). Alpena limestone stage: Dock Street clay; locality 53. × 5

Scalaripora separata Ulrich 150

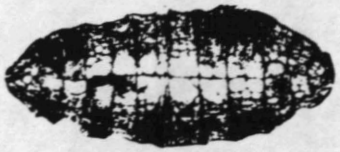
14. One face of branch, showing variation in distance between transverse ridges. Plesiotype (No. 17171). Thunder Bay stage: Partridge Point formation; locality 35. × 1

15. One face of branch showing transverse ridges and arrangement of apertures. Plesiotype (No. 17168). Thunder Bay stage: Partridge Point formation; locality 35. × 5

16. One face of branch, showing closely spaced transverse ridges. Plesiotype (No. 17169). Thunder Bay stage: Partridge Point formation; locality 35. × 1

17. One face of branch, showing average spaced transverse ridges. Plesiotype (No. 17170). Thunder Bay stage: Partridge Point formation; locality 35. × 1

PLATE XIII



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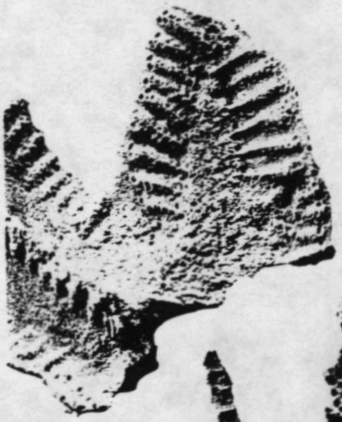

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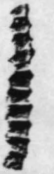

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EXPLANATION OF PLATE XIV

PAGE

Scalaripora variosa, sp. nov. 151

1. One face of a triangular branch, showing distantly spaced transverse ridges and nonporiferous margin. Paratype (No. 17172). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 9. × 5

2. One face of a triangular branch, showing average spaced transverse ridges and nonporiferous margin. Holotype (No. 17173). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 9. × 5

3. Transverse section, showing triangular outline of branch and character of zooecia and vesicles. Paratype (No. 17174). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 9. × 15

4. Part of zoarium, showing irregular shape near point of bifurcation. Paratype (No. 17176). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 9. × 5

5. End view of branch which had grown around a foreign object. Paratype (No. 17177). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 9. × 5

6. Tangential section, showing shape of zooecial tubes and vesicles. Paratype (No. 17175). Gravel Point stage: bed 3, zone 6 ("upper blue shale"), of E. R. Pohl; locality 9. × 15

Phractopora winchelli, sp. nov. 152

7. Camera lucida drawing of longitudinal section, showing shape of zooecia and vesicles. Paratype (No. 17178). Petoskey formation: bed 2, zone 2, of E. R. Pohl; locality 13. × 15

8. Part of expansion, showing irregular ridges. Paratype (No. 17179). Petoskey formation: bed 2, zone 2, of E. R. Pohl; locality 13. × 1

9. Tangential section, cut near surface, showing shape of apertures and irregularly shaped vesicles of the maculae. Paratype (No. 17180). Petoskey formation: bed 2, zone 2, of E. R. Pohl; locality 13. × 15

10. Surface of part of a zoarium, showing shape and arrangement of apertures and maculae. Holotype (No. 17182). Petoskey formation: bed 2, zone 2, of E. R. Pohl; locality 13. × 5

PLATE XIV

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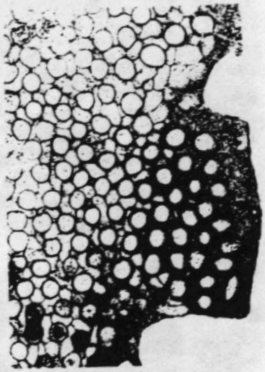

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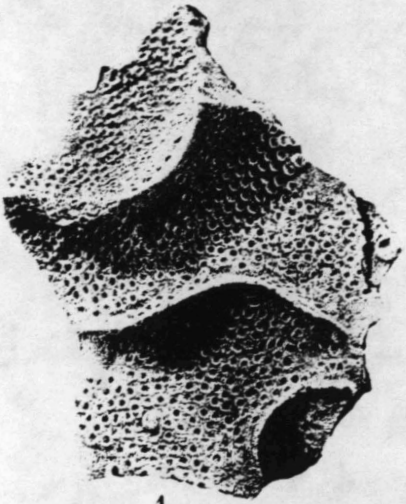

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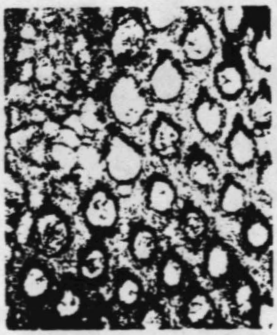

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