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Some Ordovician Corals From New Mexico, Arizona, and Texas

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Preface

The Montoya group of southern New Mexico contains three units of deposition of different ages (Flower, 1957): (1) Remnants of Winnipeg-Harding equivalents; (2) a series of strata of Red River age, the Second Value formation, commonly divisible into the Cable Canyon sandstone and the Upham dolomite; and (3) two formations of Richmond age, the dark, cherty Aleman dolomite andthe lighter, largely chert-free Cutter dolomite.

Faunas are all but nonexistent in the first of these units. The Red River and Richmond formations contain abundant faunas, but where dolomitization is advanced, original lithic differences between the formations are reduced and sometimes obliterated, and the contact between them may be so obscured that its position can be determined only with great difficulty.

Collections made prior to the recognition of the distinction between Red River and Richmond faunas in the limestones and dolomites are all but useless; except where the lithology of the associated matrix serves as a criterion, it is impossible to determine from which division the specimens were derived. New collections are being assembled which will ultimately serve as a basis of the restudy of these faunas. This work was in its very early stages when a discovery was made which precipitated thepresentpaper. In New Mexico, the early Paleozoic consists of the Bliss sandstone, of Cambrian and early Canadian age, the El Paso limestone, which contains a series of beds extending from very early to latest Canadian time, and the Montoya dolomite, containing the three groups of deposits noted above. Erosion has truncated both the El Paso and the Montoya groups; the patterns vary somewhat, but in general, the El Paso shows beveling to progressively greater depths as it is traced north and west from the Franklin Mountains in western Texas . In Arizona, the calcareous beds beneath the Devonian have been called the Longfellow limestone. They crop out only in two regions, near Dos Cabezas and in the Clifton-Morenci district. It has been evident that they represent the thinning erosion remnants of the El Paso limestone, and that in the Clifton-Morenci region the only fauna known is that of the first endoceroid zone (Flower, 1955), whereas at Dos Cabezas this fauna occurs with that of the first piloceroid zone above it.

The writer had submitted to him two faunas collected by Curt Teichert from the Clifton-Morenci region of Arizona in the summer of 1953. Both came from **a** horizon 5 feet beneath the base of the Devonian and were less than a quarter of a mile apart. One consisted of elements of the first endoceroid zone of the El Paso limestone, the description and illustration of which are now in progress. The other, however, consisted of some massive corals, which the writer recognized at once as representing the Montoya group, and, almost certainly, the type of coral association which had been observed, and then only partially collected, from the Upham dolomite of the lower part of the Montoya group.

This collection, together with such few corals as had at that time been collected from the Montoya group of New Mexico, were submitted to Dr. Dorothy Hill for study. The results are incorporated in the present paper. Although much collecting and study still remain to be done before a clear concept of the coral faunas of the Second Value, Aleman, and Cutter formations of the Montoya can be evaluated properly, the present paper gives the first indication that a remnant of the Montoya group is preserved in the Clifton-Morenci region of Arizona, where it had not been differentiated previously from the Longfellow limestone.

The materials on which this study is based, with the exception of a few specimens from other regions and institutions incorporated for comparison, are deposited in the collection of the New Mexico Bureau of Mines and Mineral Resources and are indicated by the abbreviation NMBM.

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Abstract

Poorly preserved corals of the genera Palaeophyllum, Streptelasma?, Nyctopora, Calapoecia, Paleofavosites, and Reuschia are described from Ordovician formations in New Mexico, Arizona, and Texas. Figures of thinsections of the holotype of Columnaria thomi Hall are given.

Introduction

ACKNOWLEDGMENTS

Four small collections of corals from the western United States were transmitted to the author for study, in 1953, throughthe courtesy and interest of Drs. R. H. Flower and C. Teichert. Unfortunately, the preservation leaves much to be desired, making safe determinations difficult. The writer, however, appreciates the opportunity to become acquainted at first hand with this Ordovician material. Through the kindness of Dr. G. A. Cooper and Dr. W. A. Oliver, of the United States National Museum, it is possible to give photographs of thinsections of the holotype of Columnaria thomi Hall.

FOSSIL LOCALITIES

Longfellow Limestone

A collection from the uppermost 5 feet of the "Longfellow limestone" (actually Upham dolomite of the Montoya group, and quite distinct from the true Longfellow limestone, as noted in the preface) on the west bank of the San Francisco River, three-fourths of a mile north of Clifton, east-central Arizona, consists of Palaeophyllum thomi? (Hall), Palaeophyllum sp. , Nyctopora sp. , Calapoecia sp. , and Reuschia sp. , and is clearly either Middle or Upper Ordovician.

Its characters, in comparison with the various Black River, Trenton, and Cincinnatian faunas of North America, are negative; it differs from them all by lacking genera characteristic for each stage. Thus it lacks Lichenaria, characteristic of the Chazyan, Black River, , and Trenton; Favistella and Streptelasma, of the Trenton and Cincinnatian; Bighornia, of the Upper Ordovician; and all heliolitids and favositids.

The association of Palaeophyllum, Nyctopora, and Calapoecia is one that can occur from Black River to Richmond, andmay indeed be a facies fauna. Reuschia, however, is known elsewhere at pre s ent only from 5a of Stord, Norway (D. anceps zone); this could indicate an Upper Ordovician age for the faunule, though the rarity of the genus makes it a poor guide to horizon.

Upham Dolomite (lower Montoya)

Mud Springs Mountains, near Truth or Consequences, New Mexico, 10 feet above basal sandstone of the Montoya, in the portion suspected by R. H. Flower of being in the Trenton stage. Palaeophyllum? sp. and Streptelasma? sp. are the only corals present in the collection (NMBM 567), both so badly (almost completely) replaced internally by dolomite that even generic identification is doubtful. The range doubtfully indicated is Trenton to Cincinnatian.

Aleman Dolomite (upper Montoya)

Spur east side of McKelligon Canyon, El Paso, Texas. The only species (NMBM 561) the writer has from here is Palaeophyllum thomi (Hall). This has the colony form of a group of species of the genus typified by P. williamsi Chadwick - phaceloid but not very regularly so, and with rare cerioid areas after increase - the group being Richmondian and early Silurian. A Richmondian age agrees reasonably well with the associated Rhynchotrema capax mentioned on the label.

Cutter Formation (uppermost Montoya)

Above the zone of Ordovician fossils, Mud Springs Mountains, near Truth or Cons equenc es , New Mexico. Paleofavos ites okulitchi ? Stearn is the only form present at the horizon and locality. Paleofavos ites occurs in several Richmondian limestones of North America, as well as in the Lower and Middle Silurian. The position of the New Mexico upper Cutter is thus Upper Ordovician or Lower or Middle Silurian. Of the species described, the New Mexico specimens are more similar to the Richmond than to the Silurian forms , and are closest to P. okulitchi Stearn from the Richmondian Stony Mountain formation. A correlation of the upper Cutter with the Richmondian is thus reasonable from the corals, but not to be strongly urged.

Systematic Descriptions

The classification adopted is that of Hill (1956) for the Rugosa, and of Hill and Stumm (1956) for the Tabulata.

Order RUGOSA

Suborder COLUMNARIINA

Family STAURIIDAE Edwards and Haime

Genus PALAEOPHYLLUM Billings, 1858

Type species. *Palaeophyllum rugosum* Billings, 1858; [Black River or lowermost Trenton, Lake St. John, Little Discharge, Canada.] P1. 1, fig. 6a- b.

Diagnosis. Phacelo-cerioid coralla, with peripheral, non-parricidal increase; corallites with narrow peripheral stereozone and without dissepiments; major septa long, thin toward axis , without paliform lobes; minor septa short; tabulae thin, distant, commonly complete and with marked axial depression, peripheral edges of some downturned.

This diagnosis was prepared after study of the type specimen (1379) of the type species in the collection of the Geological Survey of Canada, and of thinsections cut from it. This study (to be published in Canada), by finding that the tabulae are commonly depressed axially and that paliform lobes are either absent or perhaps very uncommon, indicates that the genus is more closely related to *Favistella* than to *Streptelasma,* and may be placed in the family Stauriidae.

P. rugosum (pl. 1, fig. 6) has corallites averaging 5 or 6 mm in diameter, with 20 major septa and 20 minor septa.

Palaeophyllurn thomi (Hall)

Pl. 1, fig. 1,2

Columnaria thomi Hall, in Emory, 1857, pl. 20, fig. la-d.
Cyathophylloides thomii Walcott, 1903, pl. 29.
Columnaria (Palaeophyllum) thomi (Hall) Bassler, 1915, p. 261.
Palaeophyllum thomi (Hall) Bassler, 1950, p. 275, pl. 18, fig. 1214; pl. 19, fig. 12.

Holotype (figured Walcott, 1903, and Bassler, 1950, as above), U. S. National Museum, No. 9851. Walcott states that "there is no original description nor is the locality of the specimen where found given"; also, that "the U. S. Geological Survey has collected this species in abundance about El Paso, Texas, associated with *Halysites* , *Hebertella insculpta, Rhyncotrema capax,* etc. , indicating the Richmond formation." By the courtesy of Dr. G. A. Cooper and Dr. W. Oliver, of the U. S. National Museum, four thinsections of the holotype were loaned to the writer for study and are figured herein (pl. 1, fig. 4a-e).

Description. The corallum is phaceloid; there is no evidence from the photographed surfaces or the thinsections that c e r ioid patches occur, nor is the type of increase seen. The corallites are only roughly parallel, their individual direction of growth varying somewhat. The smallest diameter in the writer's thinsections is 2 mm, and the largest 4.5 mm; the average adult diameter is possibly 3.5 to 4 mm.

A corallite of average diameter has 20 long major septa, which leaves an axial space about 1 mm in diameter, into which, in at least 2 of the 7 corallites studied, one longer major septum extends, with its axial edge slightly thicker and turnedaside after a constriction, as if representing an axial lobe; the axial edges of neighboring pairs or threes of the other major septa tend to touch. The peripheral edges of the major septa are dilated and with the dilated and very short minor septa form a narrow peripheral stereozone about a third of a mm wide, the minor septa being little longer than this; inside the peripheral stereozone the major septa thin, suddenly at first, then gradually. Twenty-two major septa are seen in a corallite of 4.5-mm diameter, and 20 in one of 2.5-mm diameter.

The tabulae are tall domes with an axial depression about 1 mm wide; many are incomplete, when the tabellae are large. No dissepiments occur. In Walcott's original drawing, the vertical section of the corallite apparently was drawn inverted.

Remarks. The holotype of this species differs from that of *Palaeophyllum rugosum,* the type species of *Palaeophyllum,* in having the tabulae notably domed, with a narrow axial depression, rather than simple, with a wide axial depression; it may also be phaceloid rather than phacelo-cerioid. Its tabulae somewhat resemble those of *Streptelasma.* This brings into prominence again the question of the generic boundaries between *Favistella, Palaeophyllum,* and *Streptelasma.* Having now studied the type specimens of both *P. rugosum* and *C. thomi,* the writer feels that this question can only be solved bya North American worker to whom large collections of Ordovician corals are available. Study of type specimens alone gives no idea of the variation possible within a species, and this leads to unfortunately fixed morphological views. For the present, the writer places *C. thomi* in *Palaeophyllum.*

Fragments (NMBM 561) from the Montoya dolomite, from the spur on the east side of McKelligon Canyon, El Paso, Texas , are almost certainly conspecific with the type specimen of *Columnaria* thomi Hall described above. The fragments are very short and of slender cylindrical branches partly replaced by beekite. The fragments do not show any new corallites rising from old ones, nor any calices , so that from the exterior it is not evident in which direction the coral was growing. One fragment shows a short outgrowth from one corallite, a type of connecting process. Another fragment shows three corallites in contact and prismatic at the point of contact, but such cerioid developments would seem to be rare in the dominantly phaceloid corallum.

The largest corallites are between 3 and 4 mm in diameter, but many smaller than this are found. There is a moderately thick wall, with 18 to 24 rather unequal major septa extending to or almost to the axis, leaving a narrow, rather irregular axial space. Minor septa are extremely short, only barely perceptible inside the wall even in the large corallites. In the only median vertical section showing tabulae, which has been obtained by the writer, one cannot be certain whether these are arranged with a median depression as in P. rugosum, or rise toward the axis andhave a median depression as in the holotype of P. thomi and in streptelasmids, but the latter interpretation is more likely.

There are suggestions of axial lobes to the major septa in some corallites.

Palaeophyllum thomi ? (Hall)

P1. 1, fig. 3

Two specimens (NMBM 562, 563; pl. 1, fig. 3) from the uppermost 5 feet of the "Longfellow limestone," west bank of the San Francisco River, three-fourths of a mile north of Clifton, east-central Arizona, are so badly preserved that informative thinsections could not be obtained, and natural vertical sections are not present. They are part of a phacelo-cerioid colony or colonies with a somewhat bushy growth, the corallites tending to radiate from a basal point. Increase is nonparricidal and peripheral, the new corallites expanding in diameter and very rapidly changing course to approximate parallelism with the parent; in places within the colony, and particularly after increase, neighboring corallites maybe in contact and prismatic, but at the periphery, they are cylindrical and separate. The corallites are rather slender, 5 mm in average diameter, in NMBM 563, and 4 mm in NMBM 562. Weathering has exposed lateral views and broken transverse sections of the corallites, but skeletal tissue has been leached out randomly, and the material filling the spaces between the plates has been made more resistant to weathering by iron or silica enrichment. In corallites that stand out on differential weathering, the epitheca and wall are mostly removed, and the major septa and edges of the tabulae are seen as grooves on the internal molds of the corallites; but the minor septa are mostly represented each by a vertical row of very fine pits, each pit apparently being the impression of the growing point of a septaltrabecula. An epitheca was not certainly observed, and some corallites where the wall was visible showed narrow vertical ridges representing the median planes of the major septa.

In large corallites in NMBM 563, 24 major septa and 24 minor septa were counted, and in NMBM 562, a corallite of 4 mm has 21 major septa. Minor septa in both specimens are not persistently developed and when present are very short. The major septa thin toward the axis and are only very slightly flexuous; there are a few discrete, small pieces of plates visible in the axial regions of some imperfect sections of corallites, but it is difficult to believe that these are not broken coral tissue; i. e. , they are not regarded as lobes springing from the axial edges of major septa. The major septa may end freely near the axis, or some may lean on others without regularity; they do not curve to outline an axial space, but rather stop short of doing so. Thin tabulae are present and appear to be almost horizontal, but with a shallow and rather wide axial depression; uncertainty is due to poor preservation. No dissepiments occur.

Comparison. From the description, it can be seen that these two specimens resemble both P. rugosum and P. thomi. The impossibility of determining the exact shape of the tabulae prevents equating them with either; in size of corallite, they are close to P. thomi and are therefore placed doubtfully with that southern species.

Palaeophyllum sp.

P1. 1, fig. 4, 5

Two specimens (NMBM 564, 565; pl. 1, fig. 4), from the uppermost 5 feet of the "Longfellow limestone," west bank of the San Francisco River, three-fourths of a mile north of Clifton, east-central Arizona, are pieces from a large phacelo-cerioid colony or colonies, with corallites 8 mm in average diameter (10 mm maximum observed). In parts of the colony, the corallites are prismatic, being in contact either in clumps or chains; in other parts, the corallites remain cylindrical and separate. The manner of increase and the epithecal characters are not determinable from these two specimens. The direction of growth of the corallites is somewhat variable.

The preservation is unfavorable. At the surface, the actual coral tissue, including epitheca and wall, has been leached out, whereas the material filling the spaces between the plates has been rendered resistant to weathering by enrichment in, or change to, hydrated iron oxides, silica, or dolomite, so that septa and tabulae are represented by grooves. Below the weathered surface, the coral tissue has been replaced by dolomite(?) and does not show the original fibrous structure.

The 8-mm corallites have 24 major and 24 minor septa, the latter very short, mere vertical ridges on the inside of the corallite wall, which maybe 0.25 mm thick; these ridges have, at close vertical intervals, very low, small projections, suggesting the growing points of trabeculae; on the weathered internal molds, the minor septa appear each as a shallow vertical indentation with minute, deeper pits therein. The major septa thin toward the axis and are somewhat flexuous; they may stop at the margin to the axial depression in the tabulae, or possibly in some corallites or parts of corallites may proceed farther toward the axis. Some corallites show discrete linear holes in the axial regions, suggesting either that thin axial lobes occur or that broken fragments of septa and tabulae are present. It is not possible, from the preservation, to determine which if either of these alternatives is correct. Tabulae are present, which could be low domes with wide axial depressions, the uncertainty being due to the preservation. There are no dissepiments .

A third specimen (NMBM 566; pl. 1, fig. 5) is weathered to show good lateral views of the corallites, which are about 8 mm in average diameter, with a straight, parallel course. Increase is nonparricidal, one or two offsets arising, rapidly attaining adult diameter and changing direction of growth just as quickly from outward and upward to parallelism with the parent, with which they may remain contiguous. Cerioid parts of the colony are few relative to phaceloid parts.

Preservation is poor, owing to patchy replacement of the coral tissue by dolomite(?) or silica. The epitheca is not preserved, but the wall below it is present in some corallites, the trace of the median plane of each major septum being seen in it as a slender vertical line. There are 24 major septa in the average corallite, but the minor septa are so short as not to be visible in many parts; when visible, they are found to have had very short, close, spine-like projections from their axial edges. The major septa thin toward the axis; in some corallites, they stop short, apparently at the margin of a wide axial depression in the tabulae; in other places , they seem to be longer and possibly to have slender axial lobes extending irregularly from their axial edges. The tabulae are thin and domed, with an axial depression that varies in width from corallite to corallite; some sections indicate that 3 or 4 are present in 3 mm. There are no dissepiments.

In view of the similar diameter and number of septa in the three specimens, they may be assumed to be conspecific, and from the composite characters, the writer concludes that they are referable to the genus <u>Palaeophyllum.</u> The large diameter and the suspected presence of slender axial lobes to the septa differentiate them from P. rugosum and P. thomi, but the material is too poorly preserved to serve as type material for a new species.

Palaeophyllum? sp.

Two fragments (NMBM 567) from the Lower Montoya (Upham dolomite) of Mud Springs Mountains, near Truth or Consequences, New Mexico, 10 feet above basal sandstone of the Montoya.

The corallum is phaceloid, the corallites cylindrical and parallel, 5 to 6 mm in average diameter and an equal distance apart, with sparse connecting processes; new corallites arise by lateral increase and rapidly curve to grow parallel with the old; just above the point of issue, the new corallites may be in contact with the old, the corallites then becoming prismatic in parts. The internal structure of the corallites is all but obliterated by dolomitization; in one, however, 21 major septa were estimated, reaching almost to the axis. No dissepiments are present. Since no tabulae survived the dolomitization, generic determination is uncertain, but the growth form is that of Middle and Upper Ordovician species of Palaeophyllum.

Note on growth form in Palaeophyllum: The type species, P. rugosum, is cerioid in inner parts of the corallum and, in places, following increase , but phaceloid in the peripheral parts of the bushy colony.

The halysitoid form of growth of P. halysitoides (Troedsson, 1928, pl. 113, fig. 28, 1-5), from the Arctic Red River Cape Calhoun formation, and of P. pasense and P. pasense parvum Stearn (1956, p. 89, pl. 16, fig. 7 and pl. 7, fig. 5), from the Manitoban Richmondian Stonewall formation, distinguishes them from the Texas and Arizona specimens.

Similarly, P. umbellicrescens Chadwick (in Williams, 1919, p. 129), from the Lower Silurian Manitoulin dolomite near Manitowaning , Manitoulin Island, Ontario, differs by having umbellar growth form.

Of the fasciculate forms pos s ibly with occasional c erioid patches (especially following budding) or occasional connecting knobs, P. williamsi Chadwick (in Williams, 1919, p. 128, pl. 8, fig. 2), from the Lower Silurian Manitoulin dolomite of Manitoulin Island, has an average adult diameter of 4 mm and tabulae as in P. rugosum, but 1 to 2 mm apart; P. troedssoni Poulsen (1941, pl. 1, fig. 9-10), from the Lower Silurian Offley Island formation of Cape Madison, northern Greenland, has larger corallites (7 mm), with 24 long major and 24 minor septa, and with rugosurn-type tabulae; P. vaurealense (Twenhofel, 1927), from the late-Richmondian Vaureal and

Ellis Bay formations of Anticosti, has very small corallites (2.5 to 3 mm) with *rugosum-type* tabulae. *P. thomi* and the New Mexico, Arizona, and Texas specimens appear to be of this group.

Fasciculate forms with numerous connecting processes usually have been called *Palaeophyllum stokesi* (Edwards and Haime), the type of which is possibly Red River.

The phacelo-cerioid form *P. rugosum* (Billings), type species of *Palaeophyllum,* is Black River rather than Trenton, and older than the group of fasciculate, more rarely cerioid, group of forms like *P.* williamsi, which the Arizona and Texas specimens resemble in form.

Palaeophyllum divaricans (Nicholson, 1875, p. 220, pl. 22, fig. 10) from the Cincinnatian of Cincinnati, Ohio, has been regarded by subsequent authors as *Streptelasma;* it has 2 to 6 conical corallites forming a compound corallum, but the writer has found no figures of thinsections of the type.

Suborder STREPTELASMATINA

Family STREPTELASMATIDAE

Genus *STREPTELASMA* Hall

Streptelasma? sp.

One specimen (NMBM 567) from the Lower Montoya (Upham dolomite) of Mud Springs Mountains, near Truth or Consequences, New Mexico, 10 feet above basal sandstone of the Montoya.

This fragment of a trochoid and probably curved corallum was encountered in cutting the corallum of *Palaeophyllum* sp. described above. The largest diameter of the fragment is 15 mm. The structure of its axial region and one-half its septate region is completely obliterated by dolomitization, so that one cannot be certain whether an axial structure was present originally, as the writer suspects, and if so, whether it was a columella, as in *Bighornia* Duncan (1957), or a structure of septal lobes, as in *Streptelasma,* though the latter seems more likely in view of the general septal arrangement. The corallum appears to be neither angulate nor flattened on one side; angulate and flattened coralla are common in the Upper Ordovician (Hill, 1951; Duncan, 1956), but nonangulate streptelasmids also occur therein.

Order TABULATA

Family FAVOSITIDAE Dana, 1846

Genus PALEOFAVOSITES Twenhofel, 1914

Type Species (by original designation). Favosites aspera d'Orbigny; holotype, Wenlock limestone, Leinthall Earls, near Ludlow, England.

Corallum cerioid, corallites with thin walls, mural pores on poral processes at the corners; pores on side walls may also occur; septal spines may be numerous; tabulae typically complete.

This genus differs from Favosites in having pores on the corners of the walls, on small conical projections or poral processes. It is common from the Upper Ordovician to the Middle Silurian in North America; thus, the age of the Arizona specimens should lie within these limits.

Paleofavosites okulitchi Stearn

Favosites intermedius Okulitch, 1943, p. 70, pl. 1, fig. 16. Gunton member , Stony Mountain formation, one-fourth mile south of Gunton Station, Manitoba; not Favosites intermedius Stewart, 1938, p. 62, pl. 13, fig. 4, 5.

Paleofavosites okulitchi nom. nov. Stearn, 1956, pl. 61, pl. 3, fig. 4, 6; pl. 8, fig. 3; includes specimens from the Richmondian Stonewall formation, southern Manitoba.

Corallum hemispherical; corallites unequal; larger corallites subrounded, 3.75 mm in mean diameter, surrounded by smaller, immature corallites; walls thin, straight; pores rimless, about 0.2 mm, on poral processes at corners, 14 in 1 cm longitudinally, and in 1 to 2 rows on the side walls; septa rudimentary to absent; tabulae plane, usually deflected marginally, crowded.

Range. Richmondian, Stony Mountain and Stonewall formations, Manitoba.

Paleofavosites okulitchi? Stearn

P1. 2, fig. 7, 8

Six partially silicified fragments of coralla from the upper part of the Cutter formation, Mud Springs Mountains, near Truth or Consequences, New Mexico; NMBM 568-570.

The fragments suggest that the corallum had the shape of a three-quarters sphere with a flattish base.

The corallites are about 2.5 to 2.75 mm in average maximum diameter, but individuals over 3 mm may occur. Smaller individuals of varying diameters (mostly about 2 mm) far outnumber the larger corallites. The corallites are five- or six-sided. Septal spines have not been observed but may have been obliterated during diagenesis . Chance surfaces show pores at the apices of short poral processes rising from the angles of the walls, about 1.5 mm vertically between each pore. Chance transverse sections show occasional gaps in the side walls that may be mural pores, but, as thinsections were not practicable, the point could not be established with certainty. Tabulae are horizontal, varying from 3 in 5 mm to 7 in 5 mm in different parts of the corallum.

To distinguish one favositid species from another is often a matter of great difficulty; success is reasonably certain only when direct comparison of fairly large suites of well-preserved material can be made by thinsection as well as by external view. Listed below are the figures of North American Upper Ordovician and Silurian Paleofavosites that the writer has been able to find, with details of horizon and locality, and summary of characters; these figured specimens appear to differ from the Arizona forms in the characters printed in italics.

Richmondian Species

P. okulitchi Stearn, 1956 (new name for *P. intermedius* Okulitch, 1943); holotype, Okulitch, 1943, p. 70, pl. 1, fig. 16, Gunton member, Stony Mountain formation, one-fourth mile south of Gunton Station, Manitoba; calices 2.3 mm, with smaller ones interspersed; walls thin; pores at angles *and in 1 or 2 rows on side walls;* tabulae flat, less than 1 mm apart, without marginal pits; *small blunt septal spines may occur.*

Stearn's figured specimens: 1956, pl. 3, fig. 4 and pl. 8, fig. 3, Stonewall formation, from mile 26.7, Flin Flon highway; show two rows of side-wall pores (commoner in the higher Stonewall formation than in the lower Gunton member of the Stony Mountain formation, where one row is the rule); 1956, pl. 3, fig. 6, from the Stonewall formation, Stonewall quarries.

Favosites ?prolificus Billings (1865, p. 429), from the "Hudson River group and throughout the Middle Silurian; Anticosti, " was said to have "tubes about one line in diameter. *Tabulae* thin and either complete or *imperfect, sometimes filling the tube with vesicular tissue."* Not figured.

Whether specimens referred to this species by later authors are correctly named awaits confirmation after a study of the holotype.
Paleofavosites prolificus (Billings) (Stearn, 1956, p. 60, pl. 10, fig. 13), from the Stonewall formation, Stonewall quarries; has corallites of fairly uniform size, 2.34 mm; abundant *prominent poral*

processes at angles; pores rare in side walls; tabulae 20 in 1 cm, commonly deflected at margin. Specimens referred here also occur in Middle Silurian formations of Manitoba.

Paleofavosites capax (Billings) (Stearn, 1956, specimen figured pl. 10, fig. 12), from the Stonewall formation, Stonewall quarries; has approximately equal corallites 3.8 mm in diameter , with very thin walls, pores in corners of corallites only, abundant; septa rare, short spines; tabulae plane. Also occurs in upper members of Stony Mountain formation.

P. poulseni Teichert (Stearn, 1956, p. 62, pl. 4, fig. 6; p1.10, fig. 16), from the Stonewall formation of mile 19, Flin Flon railway, southern Manitoba; has corallites uniform in size, 1.66 mm, septal spines well and regularly developed in longitudinal series, mural pores abundant in the corners, rare in the walls, poral processes small, 8 to 10 in 5 mm; tabulae close, 30 to 45 in 10 mm, sinuous, or rarely inosculating. Found also in early Middle Silurian of Manitoba.

Silurian Figured Specimens

Paleofavosites asper (d' Orbigny), as figured by Williams (1919, pl. 6, fig. 1), from the Lower Silurian Manitoulin dolomite near Ice Lake, Manitoulin Island, Ontario; appears to have corallites up to 2 mm diameter, with short poral processes in the corners of corallites, about 1 mm apart.

P. groenlandicus Poulsen (1941, pl. 3, fig. 12; pl. 4, fig. 13), from the Offley Island formation of Arctic Canada (Lower Silurian, zone of Monograptus sedgwicki); has corallites unequal, average diameter 2 mm, pores at corners on well-defined poral processes 0.2 to 0.4 mm apart, a few pores sporadically on side wall; septal spines short, sharp, close, with upward inclinations in 24 to 36 longitudinal rows; tabulae plane, opposite or subopposite, averaging 0.5 mm apart.

P. groenlandicus Poulsen (Stearn, 1956, p. 68, pl. 7, fig. 8), from the Middle Silurian Fisher Branch dolomite, Grand Rapids, southern Manitoba; has unequal corallites with a larger diameter than Poulsen gave, 3 to 4 mm.

P. nodosus Poulsen (1941, pl. 4, fig. 4-6), from the Offley Island formation of Arctic Canada (Lower Silurian, zone of Monograptus sedgwicki); has unequal corallites , 0.5 to 2. 5 mm diameter, seldom hexagonal; with rather irregular walls; tabulae 0. 3 to 1.7 mm distant; mural pores small, about 1 mm apart, but poral processes at corners of walls large; septal spines numerous and short.

P. arcticus Poulsen (1941, pl. 3, fig. 8-11), from the Offley Island formation of Arctic Canada (Lower Silurian, zone of Monograptus sedgwicki); has small corallites 0.5 to 1 mm in diameter with very thin walls; mural pores small, at corners, on relatively large poral processes; short septal spines present; tabulae thin, plane, regularly spaced (0.5 to 1 mm) opposite or subopposite.

P. aspera (d'Orbigny) (Poulsen, 1941, pl. 3, fig. 2-5), figured from the Offley Island formation of Arctic Canada (Lower Silurian, zone of Monograptus sedgwicki); longer diameter of corallites not exceeding 1.6 mm (p. 22); poral processes large, 0.5 mm apart; rarely a pore in a side wall; septal spines (long, sharp) numerous, inclined upwards, frequently developed in longitudinal rows.

P. poulseni Teichert (1937, p. 130, pl. 5, fig. 4; pl. 6, fig. 1), from the Middle Silurian of Douglas Bay, King William Land, Arctic Canada; has corallites 1 to 2 mm in diameter; mural pores on mural processes at corners of corallites, 0.5 mm apart in vertical series; tabulae plane, 7 to 10 in 5 mm; septal spines numerous, rather long, subhorizontal.

P. transiens Stearn (1956, p. 62, pl. 4, fig. 2, 3; pl. 7, fig. 9; pl. 10, fig. 15), from the Middle Silurian of southern Manitoba; has unequal corallites, the large ones about 2 mm; walls thin; mural pores almost equally distributed in corners and side walls; in one series (8 to 10 in 10 mm) or irregularly scattered in side walls, 14 in 10 cm in poral processes in corners; spines short, numerous; tabulae horizontal.

P. poulseni Teichert and P. poulseni minor Stearn (1956, p. 63, pl. 4, fig. 11; pl. 4, fig. 9, 10), from the early Middle Silurian Fisher Branch dolomite , Grand Rapids , southern Manitoba; the latter differs from P. poulseni described above in its smaller corallites, average diameter 0.89 mm.

P. kirki Stearn (1956, p. 63, pl. 7, fig. 1, 3, 10, 11), in the early Middle Silurian Inwood formation, Grand Rapids, southern Manitoba; has equal corallites, adult diameter 1.81 mm, with thick walls locally corrugated longitudinally; pores in both corners and side walls, poral processes small; septal spines well developed, long, in about 12 rows; tabulae irregular, 20 to 30 in 10 mm.

Of the characters usually listed in descriptions of favositids, one, uniformity or lack of uniformity in size of corallite, may be due to variation in the rate of production of new corallites, perhaps owing to differences in environment (Jones, 1936); consequently, its value in diagnosing species is doubtful. The absolute size of the corallite as a diagnostic feature may also be questioned, particularly where the range of specimens is small. Septal spines vary greatly in development within the one colony, and from specimen to specimen within the one species; nevertheless, their type and arrangement seem to be valuable diagnostic characters.

From these remarks it will be seen that the writer has little confidence in the specific name here suggested for these New Mexico specimens. They differ from the Silurian specimens figured in the works listed above in the extreme rarity or even absence of septal spines. Since the specimens are highly silicified, one is in some doubt as to whether the spines may not have been obscured, but in some surfaces where the wall is visible as a colored band, no colored projections that might be spines are seen; further, no spines are seen projecting from the walls on weathered surfaces.

Because of the paucity or absence of spines, the New Mexico specimens seem to be closer to the Richmondian species than to the Silurian forms . Of the Richmondian forms , perhaps the Stony Mountain P. okulitchi is closest, though it is uncertain whether pores occur at all in the side walls of the New Mexico species. The writer refers to these specimens, therefore, as P. okulitchi? and very tentatively suggests a Richmondian age for the upper part of the Cutter formation in which they occur.

Family SYRINGOPHYLLIDAE Počta, 1902

Subfamily SYRINGOPHYLLINAE Počta

Genus CALAPOECIA Billings, 1865

Type species (selected by Lindström, 1883). Calapoecia anticostiensis Billings, 1865, west side of Gamache Bay, Anticosti Island; division 1, Anticosti group.

Diagnosis. Corallum massive with coenenchyme; septa short, thick, typically 20, equal and trabeculate; coenenchyme formed by extensions from the tabulae and septa which intersect to enclose horizontal tubular spaces, like elongated mural pores.

Range. In North America, Arctic Canada, and Greenland, Calapoecia ranges from Black River to Richmond (Sinclair, 1956); in Norway, from 5a into 5b; in Sweden, it occurs in the Upper Leptaena (Bodes) limestone; in Estland, it is known in the Lyckholm and possibly also in the Borkholm beds; in Australia, it occurs in New South Wales in early Paleozoic rocks.

Calapoecia sp.

P1. 2, fig. 9

One fragment (NMBM 571) from the uppermost 5 feet of the "Longfellow limestone," west bank of the San Francisco River, three-fourths mile north of Clifton, east-central Arizona, is an internal mold with limonitic surfaces showing the characteristic coenenchyme of horizontal tubules arranged in vertical and horizontal series; the tabularia are up to 1.5 mm apart; this suggests that the specimen may belong to C. anticostiensis rather than to C. canadensis. Cox (1936) considered anticostiensis to be characteristic of post-Trenton and Richmond strata, but Sinclair (1956) has recently questioned his stratigraphy.

Subfamily BILLINGSARIINAE Okulitch

Genus NYCTOPORA Nicholson, 1879

Type species. Nyctopora billingsii Nicholson, 1879 (pl. 9, fig. 3a, b), Trenton, Peterborough, Ontario, Canada.

Diagnosis. Cerioid, with small 4- to 6-sided corallites; wall between corallites of vertical septal trabeculae common to both corallites, junctions between trabeculae crossing the wall completely; ridgelike extensions into the corallites from 8 or 9 trabeculae larger than the others; minute mural pores may occur; tabulae complete, horizontal, no columella.

Remarks. Two thinsections from the type material used by Nicholson, and for his illustration, have been reexamined by the author and described and figured ina paper to be published in Canada. They convince the writer that at least the type specimen of N. billingsii has minute mural pores and is related to Calapoecia, not to Favistella. The boundary between Nyctopora and Billingsaria is not easy to define, for some specimens of Nyctopora may have more than one series of trabeculae developed in the common walls between corallites, so that the wall is much thickened, as in Billingsaria. However, typical Billingsaria has a large columella, not observed in type species of Nyctopora. It appears, then, that the name Billingsaria should be used for those forms with small corallites, thick walls, and a large columella, and Nyctopora for those with, in general, thinner walls, larger corallites, and no columella. In North America, the stratigraphic occurrence of Nyctopora appears to be rare in the Chazyan and commoner in the Blackriveran and Trenton, whereas Billingsaria is Chazyan. In Europe, Nyctopora is known from the Mjøsa limestone (4,85D. clingani zone) and 5a of Stord (D. anceps zone). In Australia (Hill, 1957), it occurs in New South Wales below beds of the Nemagraptus pertenuis zone (= N. gracilis zone ?).

Nyctopora sp.

P1. 2, fig. 10-12

Four specimens (NMBM 572, 573), with their tissue obscured and partly replaced by dolomite, from the top 5 feet of the Longfellow limestone of the west bank of the San Francisco River, three-fourths mile north of Clifton, Arizona, appear to be referable to Nyctopora, but in view of the poor preservation, no specific names are given.

The coralla are small; 2 appear to have been globular, but 1 incomplete fragment 5 by 4 cm, by 1 cm thick, suggests an extensiform habit. The corallites are about 1 mm in maximum diameter and are 4- to 6-sided; thinsection suggests that the common walls were rather thick but were made of vertical trabeculae, as in N. billings ii; parts of specimens where the coral tissue has been leached out, leaving the infilling material, indicate that 8 or 9 were longer than the others alternating with them. The largest do not reach the axis, however, and no indentations on the internal molds were observed that could represent the columella of Billingsaria. Tabulae are present.

Family AULOPORIDAE Edwards and Haime

Genus REUSCHIA Kiaer, 1930

Type species (by monotypy). R. aperta Kiaer, 1930 (pl. 4, fig. 1-3, text fig. 5 and 9a, b). Stord, Ostralsten, Bergen region, Norway. Upper Ordovician. Redescribed and figured (Hill, 1953).

Diagnosis. Corallum bushy; with lateral increase and diverging cylindrical corallites, whose peripheral (septal) stereozone is so thick that the lumen may be almost or completely filled. The septa do not show free spines along their axial edges, and there are no tabulae. The walls of neighboring corallites are transversely wrinkled at regions of juxtaposition.

The genus is known only from the type locality and from Arizona. It differs from Eofletcheria Bassler, 1950 in the absence of tabulae and in the greater thickness of its stereozone.

Reuschia sp.

Pl. 2, fig. 13

Four fragments (NMBM 575, 576) from the uppermost 5 feet of the Longfellow limestone, west bank of the San Francisco River, three-fourths mile north of Clifton, east-central Arizona, ina dolomitized limestone, show cylindrical corallites subparallel and up to 5 mm apart, giving rise laterally in places to new corallites which rapidly enlarge in diameter and turn upwards. Diameters from 2 to 3 mm are characteristic. The peripheral stereozone is so thick as to leave open only an axial region about 0.5 mm in diameter. The preservation is such that on weathered surfaces the stereozone appears to consist of a series of infilling, very tall reversed cones; probable traces of septa are seen as ridgelike projections into the axial space on one weathered surface. No tabulae are visible. The only difference discernible between the Arizona and the Norwegian material is the smaller distance between the corallites in the former. However, the Arizona material is too poor to name specifically.

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PLATES 1-2

WITH EXPLANATIONS

PLATE 1

Figures Page

1. Palaeophyllum thomi (Hall) 4
   Thinsections of holotype, U. S. National Museum No.. 9851. a. Transverse section, X 4. b and c. Same, X 2. d. Vertical section, X 4. e. Same, X 2.

2. Palaeophyllum thomi (Hall) 4
   NMBM 561. a. Externalview, natural size. b. Transverse section, X 2. c. Vertical section, X 2. d. Transverse section, X 4. From spur, east side of McKelligon Canyon, El Paso, Texas; Aleman dolomite, Montoya group.

3. Palaeophyllum thomi? (Hall) 6
   NMBM 562. External view, X 1.2. Uppermost 5 feet of the "Longfellow limestone," west bank of the San Francisco River, three-fourths of a mile north of Clifton, east-central Arizona; Upper Ordovician.

4. Palaeophyllum sp. 7
   NMBM 564. External view, X 1.2. Uppermost 5 *feet* of the "Longfellow limestone ," west bank of the San Francisco River, three-fourths of a mile north of Clifton, east-central Arizona; Upper Ordovician.

5. Palaeophyllum sp. 7
   NMBM 566. External view, X 1.2. Uppermost 5 feet of the "Longfellow limestone ," west bank of the San Francisco River, three-fourths of a mile north of Clifton, east-central Arizona; Upper Ordovician.

6. Palaeophyllum rugosum Billings 4
   Thinsections of holotype, Canadian Geological Survey No. 1379. a. Transverse section. b. Vertical section. Both X 2. From Lake St. John, Little Discharge; Black River or Trenton.

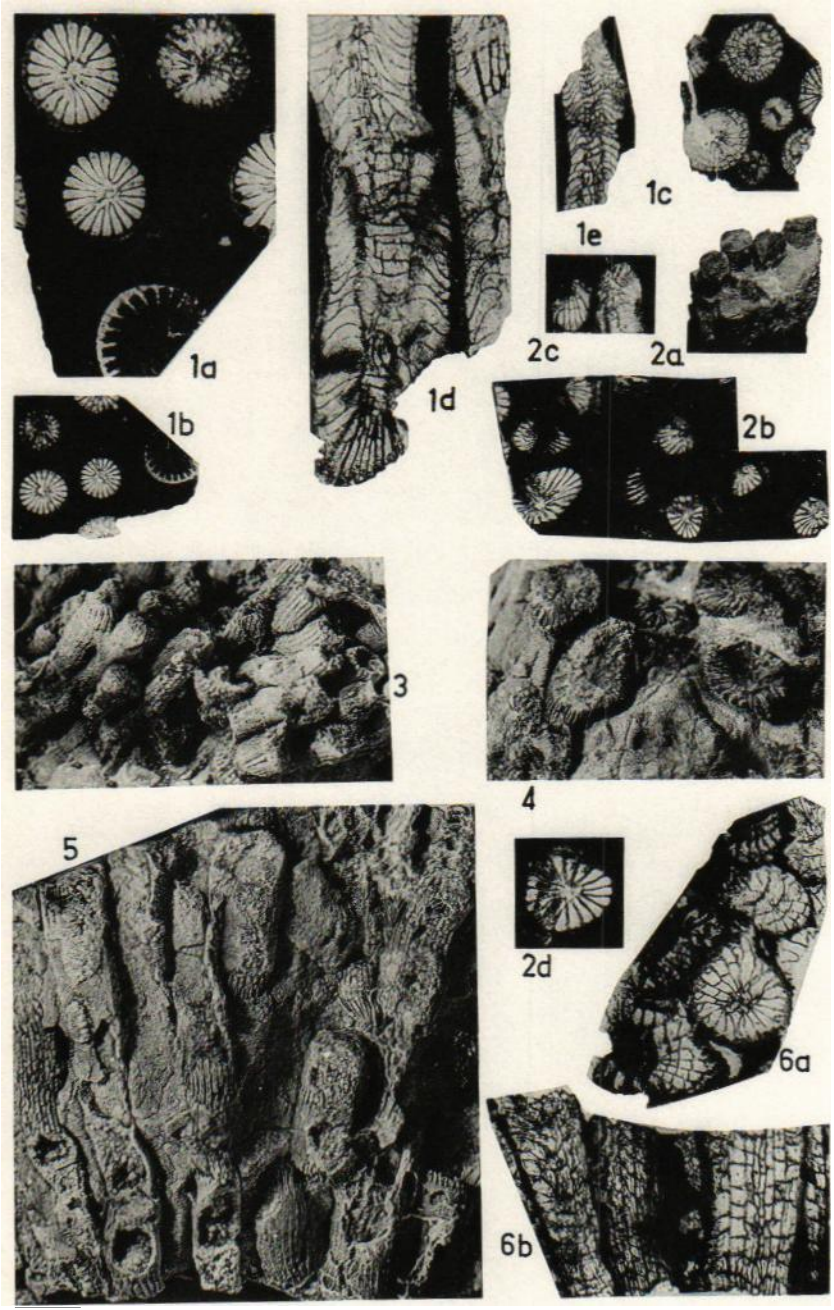

Plate 1: *Palaeophyllum*

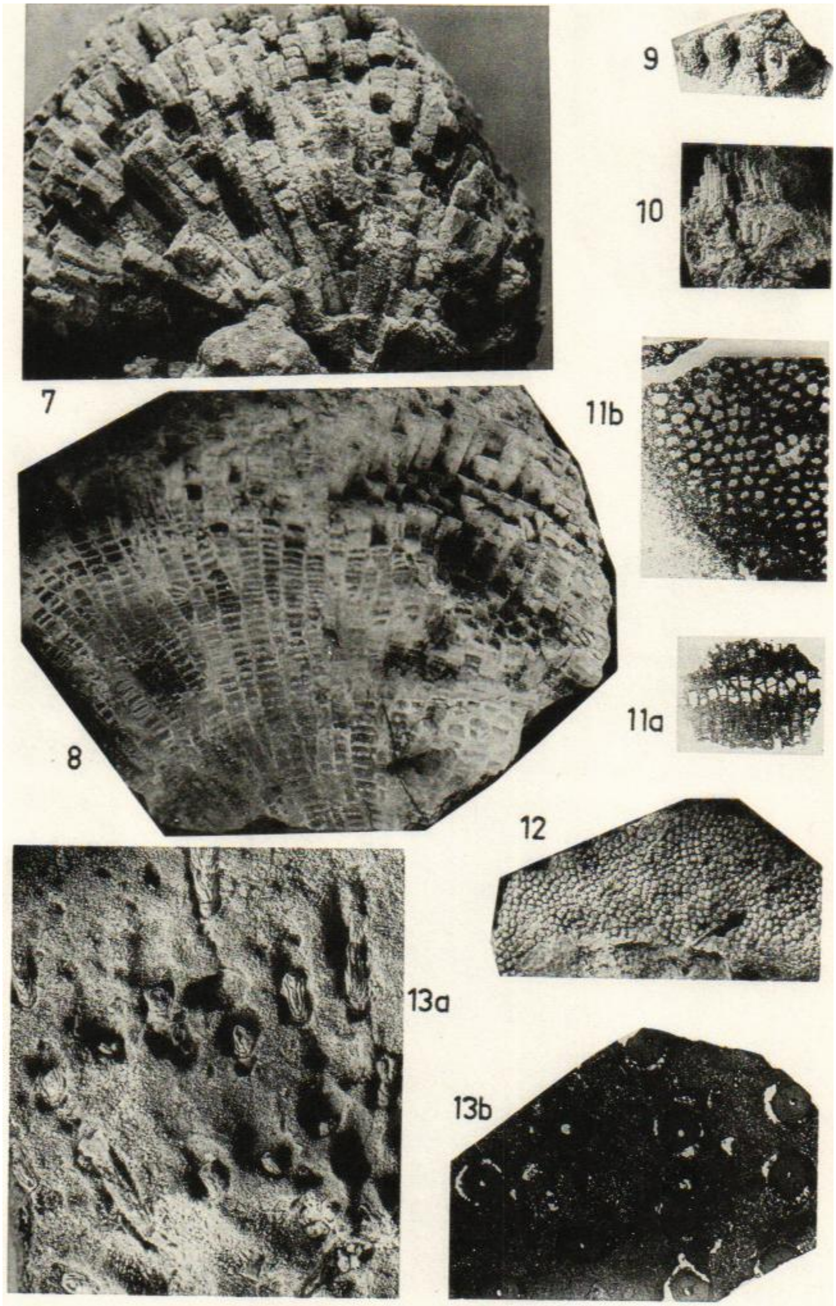

Plate 2: *Palaeofavosites, Calapoecia, N yctopora,* and *Reuschia*

PLATE 2