VOL. VI, No. 9, pp. 235–318 (17 pls., 1 fig.) APRIL 15, 1947

# THE *FAVOSITES ALPENENSIS* LINEAGE IN THE MIDDLE DEVONIAN TRAVERSE GROUP OF MICHIGAN

By DAVID H. SWANN

CONTENTS



## INTRODUCTION

THIS is the detailed study and description of a group of tabulate corals, collected from carefully determined stratigraphic positions throughout a practically continuous series of coral-bearing beds, in order to ascertain the evolutionary changes, morphological features, taxonomic relationship, and stratigraphic usefulness of the group. The paper can also serve as an introduction to the study of the large, diverse, and well-preserved tabulate fauna of the Middle Devonian Traverse group of Michigan.

ACKNOWLEDGMENTS

It is a pleasure to acknowledge indebtedness to those who have aided in this work. To Professors E. C. Case and G. M. Ehlers, of the University of Michigan, the writer is exceedingly grateful for help, encouragement, and suggestions. The late Professor H. M. MacCurdy and Dr. Paul L. Rice, of Alma College, loaned specimens, including types, from the Alexander Winchell collection in the Francis A. Hood Museum at Alma, and kindly consented to the sectioning of several corals. This material has since been acquired by the University of Michigan. Dr. W. A. Kelly, of Michigan State College, communicated information on the stratigraphy of the Traverse group in the Afton–Black Lake area, and Dr. Alfred Scott Warthin, of Vassar College, and Dr. G. Arthur Cooper, of the United States National Museum, allowed the use of their notes on the stratigraphy of the Traverse group in the Thunder Bay region and have been very generous in answering queries concerning the stratigraphic position of various outcrops.

Mr. Andros Gulde was of assistance in photographic work and the preparation of illustrations; Dr. Alonzo Quinn, of Brown University, and Mr. Robert Hatch, of the University of Michigan, kindly checked my crystallographic observations; several students employed between 1935 and 1940 on National Youth Administration projects in the Museum of Paleontology, University of Michigan, did a large share of the tedious labor of making thin sections. Judy K. Swann has devoted much time to proofreading of the manuscript and has made many valuable suggestions in the revision of early drafts of this paper.

A University Fellowship in the Department of Geology and a Horace H. Rackham Predoctoral Fellowship in the Graduate School of the University of Michigan made possible the completion of this work.

## STRATIGRAPHY OF THE TRAVERSE GROUP

The Traverse group is exposed in the northern part of the Lower Peninsula of Michigan in three areas, each separated from the others by moderate distances and each containing a rock section quite different from that of the others. The type area, the western one, borders Little Traverse Bay, Lake Michigan, in Emmet and Charlevoix counties. The stratigraphic terminology of Pohl (1930) is used for this western area, except that his "stages" are recognized as formations. In ascending order these are the Gravel Point, the Charlevoix, and the Petoskey formations. One other modification of Pohl's paper should be noted; the strata at locality 21[1] have been definitely established in their proper place in the Petoskey formation by the fortunate discovery by Dr. G. M. Ehlers of the section uncovered a few years ago at locality 18b. Although the western area contains the type Traverse section, only the upper part of the group is here represented in outcrop.

The most complete section is exposed in the eastern area, in Alpena and Presque Isle counties, near Thunder Bay, Lake Huron. Warthin and Cooper (1935a, 1935b, 1943; Cooper and Warthin, 1941, 1942) have described the section in detail and have kindly allowed the author to use material on the stratigraphic succession in this region previous to its publication. The sequence recognized here is that of their 1943 paper. In ascending order the formations are: Bell shale, Rockport Quarry limestone, Ferron Point formation, Genshaw formation, including the Killians limestone member just above the middle, Newton Creek limestone, Alpena limestone, including the Dock Street clay lens at the top, Four Mile Dam limestone, Norway Point formation, Potter Farm formation, Thunder Bay limestone, and Squaw Bay limestone. The Squaw Bay limestone carries a cephalopod–pelecypod–pteropod fauna with no corals, and is not mentioned further in this study.

The third area of outcrops of the Traverse group occurs in Cheboygan County and at the western edge of Presque Isle County, about midway between the other two regions. This was named the Afton–Black Lake area by McNair (1937, pp. 105–107), who has

[1] The locality numbers of this paper are those used currently by the Museum of Paleontology of the University of Michigan in a series referring to the Devonian sediments in the northern part of the Southern Peninsula. A few numbers beginning with the letter "G" (G1, G14) are those of A. W. Grabau. See pages 307–313 for a list of all localities mentioned in this paper.

published the only recent account of these outcrops. Dr. W. A. Kelly, who has done much field work in this area, generously allowed use of his notes on stratigraphy of the region. The section up to and including the Killians limestone member of the Genshaw formation is easily correlated with the Thunder Bay section, though the Ferron Point thins greatly to the west and is only four feet thick at Black Lake (locality 29), whereas the Genshaw below the Killians is more than twice as thick in the Afton area as it is in the eastern area.

Above the Killians limestone member, correlation is much less secure. A covered interval of five or ten feet separates the Killians member from an unnamed light-gray sparingly fossiliferous, stylolitic limestone about thirty feet thick, which is best exposed in the abandoned Campbell Stone Company quarry north of Afton, Cheboygan County (locality 25). *Welleria aftonensis* Warthin and a few cup corals are about the only fossils found in this limestone, which is stratigraphically equivalent but lithologically dissimilar to the upper part of the Genshaw formation.

Unconformably overlying this unnamed limestone is a very dark argillaceous limestone six to ten feet thick with numerous black shale partings. This dark limestone, which carries a poorly preserved coral–stromatoporoid fauna, can be considered the basal member in this region of the Gravel Point formation, although it is stratigraphically below the exposed base of the formation in the Traverse Bay region. Exposed portions of the Gravel Point formation above this member comprise chiefly gray limestones, some of which can be directly correlated with similar beds in the type area. Long continuous sections are not known, and it seems certain from well records that shaly beds are intercalated between the more resistant outcropping limestones and that the total thickness of the Gravel Point formation in this region is near eighty feet.

Outcrops of beds above the Gravel Point formation occur only in one small area near Beebe School, one-half mile west and two and one-half miles south of Afton, where about ninety feet of beds corresponding to the Norway Point formation and Potter Farm or equivalent Petoskey formation can be recognized. Several covered intervals and a dip unusually high for the Michigan basin make interpretation of this section difficult. The covered interval between the top bed, which carries a Potter Farm fauna, and the overlying Antrim shale appears to be no more than ten feet; this shows that the Thunder Bay limestone and Squaw Bay dolomite or their equivalents must be either lacking or extremely thin in the Afton region.

The section here recognized in the Afton–Black Lake area comprises, in ascending order, Bell shale (unexposed and known only from wells), Rockport Quarry limestone, Ferron Point formation, Genshaw formation up to and including the Killians limestone member, a covered interval, unnamed stylolitic limestone, Gravel Point formation with dark argillaceous limestone member at the base, a covered interval, beds equivalent to the Norway Point formation, and the Potter Farm or Petoskey formation. Since collections of fossils from this area are much less complete and more poorly organized than those from the other areas, only a few forms from here have been noted in this paper.

## RÉSUMÉ OF PREVIOUS WORK

The first mention of any members of the *alpenensis* lineage is by Alexander Winchell (1866, pp. 88–89). In the Appendix to his report on the Grand Traverse region, he describes two species, *Favosites alpenensis* and *F. dumosa,* and in the body of that report he lists *F. alpenensis* from several beds.

Rominger (1876, pp. 28–29, pl. VII, figs. 3, 4) places both of Winchell's names in the synonymy of his new species *Favosites hamiltonensis* but gives no reason for substituting his own name for the earlier ones. In his own mind at least, his name was an absolute synonym of both of Winchell's names, and therefore it has rightly been discarded by later authors in accordance with the rules of priority. One of Rominger's two syntypes, that illustrated by his figure 4, is a typical specimen of *F. dumosa* Winchell, whereas that shown by his figure 3 is of the squamulate species named in the present paper *F. romingeri.* Rominger's trivial name, *hamiltonensis,* could be resurrected by the simple procedure of naming the specimen of his figure 3 as lectotype, or equally easily be buried in synonymy by selecting his other specimen. The latter course has seemed more advisable for several reasons. The name *hamiltonensis* is similar enough to the better-known *F. hamiltoniae* Hall to cause confusion, though it must be emphasized that the two names are neither homonyms nor synonyms. The ending "*-ensis*," implying geographic location, is unfortunate, since this form is not present near Hamilton, New York, and probably does not even occur anywhere in the Hamilton group of that state. Rominger's name was proposed contrary to the law of priority and has not been recognized by later workers. Therefore the specimen figured by Rominger (1876, pl. VII, fig. 4), No. 8452 in the Museum of Paleontology, University of Michigan (see Pl. X, Fig. 4), is here chosen as the lectotype of *F. hamiltonensis* Rominger, and the species *hamiltonensis* is put in the synonymy of *F. dumosa* Winchell. The specimen of Rominger's figure 3, No. 8451 in the Museum of Paleontology, University of Michigan (see Pl. XII, Figs. 1–2), is made the holotype of *F. romingeri*, sp. nov.

Lambe (1899, p. 18) recognizes *Favosites alpenensis* Winchell in the *Favosites Gothlandica* Lamarck (var.) of Whiteaves (1892, p. 273) from the dolomitic limestone of the Middle Devonian Winnipegosan formation of Lakes Winnipegosis and Manitoba, Manitoba, Canada. The description corresponds well with the concept of the *Favosites alpenensis* lineage given in the present paper, and the identification appears correct.

Cleland (1911, p. 31) questionably identifies as *Favosites alpenensis* Winchell a specimen from his Zone C of the Milwaukee formation (= lower part of the Lindwurm member of Raasch, 1935), collected from the Milwaukee Cement Company quarry at Milwaukee, Wisconsin. His figure is of a specimen that could possibly belong to the lineage, but a more definite statement of its relationship is impossible without thin sections.

Miss Stewart (1938, p. 58) recognizes *Favosites alpenensis* Winchell from the Silica shale of Lucas County, and from the "Widder beds" of Erie County, Ohio. The Silica specimens belong to the subspecies *peninsulae*, subsp. nov. (Pl. VII, Fig. 4). The present writer has not seen specimens from the Erie County locality.

The recent works of two European authors on tabulates must be mentioned, though neither deals directly with the forms considered in this paper. The most extensive modern publications on the Tabulata are those of Lecompte (1933, 1936a, 1936b, 1939) on the fauna of the Middle Devonian of the Belgian Ardennes. Lecompte's studies are very carefully done; he cut numerous thin sections and made extensive microscopic investigations. His microscopic observations are the first to surpass those of Lindström and Nicholson of fifty years ago. His assertions are fully documented by photographs whose reproduction has been well executed. To the student of Traverse tabulates his writings are most welcome, since the general complexion of the Traverse tabulate fauna is very close to that of the Ardennes and the Eifel. The exhaustive synonymies and bibliographies of Lecompte are of inestimable value in locating the older European literature, and the generic definitions are, as a rule, the best published, since they are for the greater part based on personal study of genotype material.

In "Die Favositen Gotlands" (1933) Karl Tripp, an associate of Rudolf Wedekind at Marburg, has departed rather far from the usual type of paleontological research. He has discarded the numerous specific names that have been attached to Gotland favosites and has put by far the great majority of his five thousand specimens in one of three *Formenkomplexe,* each named after the first recognizable species of the *Formenkomplex* described. The *Formenkomplex* is then divided into three to five *Formenreihen,* each consisting of from two to seven *Gruppen.* A *Gruppe* is a rather compact group of similar specimens and is usually characteristic of a single bed or a small group of beds. The *Gruppen* and *Formenreihen* are numbered. Thus a hemispherical specimen from the Lau shale with dimorphic corallites, numerous septal spines, and certain other characters is referred to the *Favosites hisingeri-Formenkomplex,* sixth *Gruppe,* second *Formenreihe.* This *Gruppe* of *F. hisingeri* is confined to the Lau shale.

Although the present writer does not agree with all of Tripp's ideas and methods, he has followed his lead in several instances. The inflexibility of the numbered *Gruppen* and *Reihen,* the strain to force forms into orthogenetic straight-line *Reihen,* the emphasis on certain characters (e.g. inclination of septal spines), and the suppression of others seem unfortunate. However, the ideas for several of the ratios used in this paper were taken over bodily from Tripp, and the form of the two papers is quite similar. "Lineage" as here used is practically synonymous with Tripp's *Formenkomplex;* "species" corresponds less closely to *Reihe;* and "subspecies" is identical with *Gruppe.*

### METHODS OF STUDY

The use of thin sections appears to be a necessary evil in the study of tabulate corals. The grinding is laborious and time-consuming, but information that is otherwise unobtainable may thus be secured.

Plastic peels have been used and recommended by several workers on corals because of the saving of time in preparation that their use permits. They have several great disadvantages, however. Peels of corals, in contradistinction to those of certain types of fossil wood, show no traces of the microscopic details in structure. Even such relatively prominent structures as thin tabulae can be and have been only too easily missed. By suitable technique, thin sections of corals in any state of preservation can be ground; good peels can be obtained only from very compact nonporous specimens. In this present work six measurements were made on all sectioned specimens of features that cannot be measured or even seen on the best of plastic peels, and twelve or fourteen such measurements were made that are beyond the resolution of the average peel. Some of these features, for example, the width of the intramural coenozone or the presence of septal striae, are of subspecific or even specific value. Lecompte (1939, pp. 102–103) bases the distinction between the two genera *Pachypora* and *Thamnopora* on the type of growth lamellae, a feature determinable only in thin section.

Polished specimens may be better for some purposes than thin sections. In particular, the arrangement of mural pores is often more easily seen, for the wall does not have to lie entirely in the plane of the section; if it is a few tenths of a millimeter behind it, the mural pores can still be made out. Thin sections require time in preparation roughly proportional to their area, and a small thin section in conjunction with a large polished section that can be made in a short time may give all the information shown by a large thin section (Pl. III, Figs. 1, 5).

Polished sections are best examined with a binocular microscope under intense but variable illumination. A thin solution of isobutyl methacryolate polymer in xylol spread over a surface ground with 600-mesh carborundum powder gives as good results as a specimen polished with stannic oxide, alumina, or rouge, and is much easier to prepare.

Thin sections are examined with a biological microscope and measured most easily by the use of a micrometer ocular. In early stages of this study all sections were photographed at three or six diameters, and measurements were made from the photographs; the microscope proved to be so much faster that the photographic method was later dropped. A petrographic microscope was used to determine the crystallographic structure and orientation of certain features (Pl. XVII, Figs. 6–10).

## MORPHOLOGY OF THE *ALPENENSIS* LINEAGE

This section serves the triple purpose of introducing the descriptive terminology, of describing characters of a generalized member of the *alpenensis* lineage, and of discussing some points of favositid morphology that are believed to be new. For the convenience of the reader a short list giving the meaning of uncommon terms, and of the common ones that have been used by different authors with varied meanings, appears at the end of this section.

### *Generalized Descriptions*

There is as yet no standard terminology for tabulate corals. A number of British paleontologists have collaborated on a vocabulary for the Rugosa (Hill, 1935) that may well serve as a basis for tabulate terminology, at least so far as the structures of the two orders can be homologized. The terms used in this paper agree essentially with those suggested by Miss Hill, but it has been necessary to find names for some structures that are confined to the Tabulata.

The external form of the *alpenensis* lineage is quite characteristic and immediately separates the members of the lineage from the great majority of other American favositids. The corallum is typically globose; the area of attachment is very small; corallites emerge over practically the entire surface; there is no holotheca; pseudopercula are unusual and, when present, are of the concentric type (Dunbar, 1927, p. 103). In some forms the corallum is subcylindrical, and even approaches a dumose or dendroid branching shape. These are in the minority, however, and the unsectioned syntype of *Favosites alpenensis* (Pl. I, Figs. 1–2) is truly typical of the lineage in respect to external appearance. The surface is usually even; on some specimens it may be slightly irregular (Pl. III, Fig. 6), but it never has the prominent elevations and depressions characteristic of certain other lineages.

The corallites are monomorphic, with only one size of adult corallites. In Tripp's terminology (1933) there is continuous variation in the size of corallites. Dimorphic forms, those with two distinct types (typically though not necessarily of different sizes) of corallites, occur among Traverse favositids in several members of the *Favosites canadensis–placenta* lineage and in the only Traverse member of the *F. argus* lineage. The shape of the inner contour of the corallites is to a large extent dependent upon the thickness of the corallite walls; thick-walled corallites tend to be rounded but thin-walled ones are always polygonal. It is possible for sclerenchyma to be deposited in the corallite corners only, and for the walls at the sides of a rounded corallite to remain thin, but such cases are very rare. In this paper the diameter of a corallite is the distance from the center of one wall to the center of the opposite wall, and is neither the distance across the lumen nor the distance from corner to corner.

The longitudinal shape of a corallite, expressed by its curvature, is practically set by the form of the corallum. It would be more accurate to say that the form of the corallum is a result of the curvature of the corallites. If the corallites radiate, a hemispherical colony will result; if they bend outward from a more or less definite central axis, the colony is cylindrical; corallites spreading outward radially and then bending upward with a sharp flexure produce a flattened placentoid colony. Typical *alpenensis* colonies therefore are formed of radiating or gently curving corallites.

The intercorallite walls of *Favosites alpenensis* and its allies, with one exception noted later, are integrate. In thin section, even to the naked eye they may show a "dark line" (Pl. II, Figs. 10–12), which, as Jones (1937, p. 82) has pointed out, is often light rather than dark (Pl. I, Fig. 8; Pl. XI, Fig. 1). However, Dr. Jones has mistakenly identified this line, which basically separates the deposits of two different polyps, with the "dark line" found in the center of the septa of the modern Hexacoralla. This latter "dark line" is a much less fundamental feature occurring entirely within the deposits of a single polyp. Miss Ogilvie (1897, p. 128) has proved it to be but a series of centers of calcification which are almost invariably destroyed in fossilization. It is unwise to extend her results to a structure in a quite different position and in a very distantly related group of corals.

A review of the literature will show that between the lumina of adjacent corallites in other colonial anthozoa there may be as many as five structures. Different names have been applied to these structures by authorities on different groups, but if one uses Miss Hill's terms wherever possible, one can recognize a peripheral stereozone in the first corallite, the epitheca (the elemental wall in the Rugosa), an extrathecal coenenchyma (intercostal deposits or exotheca of Gregory [1900, p. 5]), the epitheca of the second corallite, and the second peripheral stereozone.

In a typical wall of a member of the *alpenensis* lineage, too, five structures are evident (Pl. III, Fig. 4), but only if the wall be examined in thin section (0.02–0.08 mm.) and under moderately high powers of the compound microscope. Under these conditions there may be seen between the lumen of one corallite and that of an adjacent corallite, first, a zone of buff sclerenchyma, the peripheral stereozone; secondly, a thin, dark line, similar in appearance and position to the epitheca of the Rugosa; thirdly, a lighter central portion, called by Lecompte (1936b, p. 15) the "*fissure axiale*" and in the present paper the "intramural coenozone"; fourthly, another thin dark definitive wall; and fifthly, the peripheral stereozone of the second corallite. The homology of these structures with the similarly placed features in the Rugosa seems evident, save for the intramural coenozone. This has no homologue in the Tetracoralla, and though it resembles the coenenchyma of the Hexacoralla in many respects, it differs in other important points. Walls of this type or some modification of it are seen in the genotypes and in most species of *Favosites*, *Emmonsia*, *Pachypora*, *Thamnopora*, *Cladopora*, and *Roemeria*, but they are seldom as evident as they are in members of the *alpenensis* lineage or in *Thamnopora cervicornis* (de Blainville) (see Lecompte, 1936b, pl. III, fig. 1d).

Because of the complicated history of the use and misuse of the terms "theca" and "epitheca" it seems better not to introduce them here. The entire series of deposits between the lumen of one corallite and that of another is called the "intercorallite wall" or, simply, the "wall." It is composed of a common axial "intramural coenozone," two "primary walls," and two "peripheral stereozones." "Intramural coenozone" is proposed for Lecompte's provisional term "*fissure axiale*" and for the author's "intramural coenenchyma" (Swann, 1941). Terms such as "axial," "inner," and "outer," though definite from the point of view of the author, may prove confusing to the reader, who would have difficulty in discovering whether they refer to the axis of the wall or of the corallite. Lecompte notes (1936b, p. 15) that "*fissure*" is not meant to imply an actual physical break between the corallites, but refers rather to the usual appearance of the feature in thin section. "Primary wall" is used with much the same significance that Nicholson (1888, p. 106) used "primordial wall." "Peripheral stereozone," which is purely descriptive, does not have the undesirable inferences of Nicholson's "secondary wall," and is the term preferred by Miss Hill.

The intramural coenozone is composed of rather homogeneous dense-appearing yellowish calcite, in some instances lighter but in others darker than the stereozone. It is cryptocrystalline, not evidently fibrous, and has a very strong preferred orientation with the *c*-axis of the calcite vertical. Extinction is marked but not perfect under crossed Nicol prisms (Pl. XVII, Fig. 9; cf. Fig.

10). The cryptocrystalline form is in some instances replaced by larger needle-shaped or prismatic crystals that have the same crystallographic orientation. Calcite is usually oriented with the *c*-axis at right angles to the surface of deposition; the implication of the orientation is that the "*fissure*" was deposited by the horizontal base of an intercorallite connecting layer or coenosarc, and that it is therefore a true coenenchyma. Dr. John W. Wells, of Ohio State University, pointed out in conversation that the coenozone differs from the coenenchyma of Hexacoralla in that it and the tissue by which it was deposited take no part in the asexual reproduction of the coral. It seems better, therefore, to substitute the new term "coenozone," meaning a zone common to two or more corallites, for "coenenchyma," which is used for the similar structure of the Hexacoralla and which has previously been suggested for use in the Tabulata (Swann, 1941). The intramural coenozone may be extremely thin, or it may increase greatly in width till it occupies the entire width of the wall to the exclusion of the primary wall and stereozone (cf. Pl. III, Fig. 4, with Pl. XVII, Fig. 5, lower left-hand corner). This maximum development produces one type of amalgamate wall that is seldom seen in the *alpenensis* lineage but is quite common in most species of *Alveolites*. The coenozone is extremely thin in most species of *Favosites* and may be absent in a few, but it can usually be seen in well-preserved specimens if a wall normal to the plane of the section be examined under rather high power (200–400 diameters) and if the section be thin enough (0.02–0.03 mm.).

A wall showing a light-colored "dark line" is simply one with a rather wide intramural coenozone (Pl. I, Fig. 8; Pl. II, Fig. 1; Pl. III, Figs. 2, 4). In this connection it should be noted that a zone of enlarged intramural coenozone is usually correlated with the death of corallites in other parts of the colony (Pl. III, Fig. 2) and is thus an indication of temporarily adverse conditions. The most likely interpretation is that at these times the corallites may have contracted and pulled slightly away from one another, leaving a relatively wide area of interpolyp tissue or coenosarc, the base of which was the surface of deposition for the calcareous intramural deposits. The environmental factor is not the only one concerned, however, since some subspecies show practically no widening of the coenozone even when conditions are so adverse as to produce death in the corallites over large areas of the colony (see *Favosites alpenensis hindshawi*, subsp. nov., Pl. IV, Fig. 1), but in others the coenozone may be greatly enlarged with little apparent relation to external conditions (*F. alpenensis* subsp.; cf. *alpenensis* Winchell of locality 95, Pl. II, Fig. 1).

The primary wall is thin, dark, and almost opaque even in the thinnest sections, and shows no structure. An exceptionally dark portion of the adjacent peripheral stereozone may not be easily differentiated from the primary wall except in extremely thin sections, in which the primary wall is invariably more opaque. It is typically 0.005 mm. in thickness, and does not exceed 0.01 mm. in any Traverse species of favositid. The opacity of the primary wall is not due to staining by carbonaceous material, since the structure is dense white in reflected light. It appears to have been deposited at the angle between the horizontal coenosarc and the vertical polyp wall.

The peripheral stereozone was deposited by the ectoderm of the polyp walls upon the primary wall, principally in the upper 0.5–2.0 mm. of the calyx. It is fibrous (Pl. II, Fig. 12); the fibers are slightly felted but in general tend to be perpendicular to the wall or, more accurately, normal to the growth lamellae, which are defined in the next paragraph. Under the higher power of the petrographic microscope the fibers are seen to be needle-like crystals of calcite, interlaced but oriented in general with the long axis (the *c*-axis) within 10 to 30 degrees of the perpendicular to the growth lamellae. If the amount of parallelism of the needles is high, as it is in several specimens of *Favosites alpenensis tenuimuralis*, subsp. nov., the entire stereozone shows a marked amount of extinction under crossed Nicol prisms; if the parallelism is less, the extinction en masse cannot be observed, but a tendency toward greater relief is commonly noted when the entire wall is placed in the vibration plane of the polarizer. The greater relief of the stereozone is at right angles to that of the coenozone, since the statistical *c*-axes of the two crystalline aggregates are perpendicular to each other; the effect of the opposed darkening and lightening of coenozone and stereozone as the slide is rotated under polarized light is quite marked in some specimens (Pl. XVII, Figs. 7–8).

In many coralla the position of the margin of the peripheral stereozone at different stages in its deposition is shown by parallel bands of clear, limpid buff-colored calcite alternating with cloudy gray bands that photograph dark. These are called "growth lamellae," and are distinguished as "low-angled" (Pl. IX, Fig. 2), "medium-angled" (Pl. VI, Fig. 4), or "high-angled" (Pl. XI, Fig. 1), according to the angle they make with the primary wall. The terms have not been rigorously defined; in general, "low-angled" here means less than 3 or 5 degrees' divergence between the primary wall and the lamellae, whereas "high-angled" is reserved for those with divergence greater than 15 or 20 degrees. Lamellae may be rather thin (Pl. II, Fig. 2; Pl. IX, Fig. 2) or quite thick (Pl. I, parts of Fig. 8; Pl. X, Fig. 3).

As Miss Hill (1937, p. 56) has noted, the presence or the absence of growth lamellae may well be a result of the conditions of fossilization. The present writer agrees, however, with Lecompte (1939, p. 103), who holds that recrystallization is apt to emphasize the crystalline fibrous structure at the expense of the noncrystalline lamellae, rather than that the lamellae are strengthened while the fibrous character is masked, as Miss Hill believes.

Septal striae are rarely seen in the *alpenensis* lineage (Pl. VI, Fig. 6). They are of rather common occurrence in *Favosites dumosa* Winchell (Pl. X, Fig. 3), but have been noted on only two or three others of the more than one thousand specimens of the lineage examined. In *F. dumosa* they are most easily seen in cross sections through the thick-walled peripheral portion of the corallum, where they show as undulations in the thick dark-colored growth lamellae. Evidently they were most prominent in the upper portions of the calyx (cf. *Striatopora* Hall) and died out before the stereozone was entirely deposited, for in the final contour of the lumen there is seldom left more than a trace of the ridges.

A single specimen, No. 21625, of *Favosites alpenensis killiansensis*, susbp. nov., has an oval area about 8 by 20 mm. in extent elevated a millimeter or two above the rest of the surface (Pl. VI, Fig. 6). The corallites of this portion of the colony are larger than the others (diameter 2.5–3.0 mm. as against 1.8–2.1 mm.) and bear 12–14 strong septal striae. A polished longitudinal section shows that this condition extends some distance down into the corallum. Two possibilities for explaining this rather unusual occurrence suggest themselves. First, the area may have developed from a planula of some other genus — possibly a *Cleistopora* — which settled down on the growing *Favosites* colony. This would seem more likely had specimens of the other genus been found in the same formation, but the nearest *Cleistopora* yet collected occurs at the top of the Bell shale, some 150 feet lower in the section. Second, the area might be a result of a mutation of DeVries, a sudden change in genetic constitution, and be similar to what the horticulturist knows as a "bud sport."

The tabulae of the *alpenensis* lineage are thin and entirely primary. They never have a superior deposit of sclerenchyma, as the tabulae of *Emmonsia radiata* (Rominger) or *Favosites turbinata* Billings often have. They may be "complete" (Pl. VI, Fig. 1), extending entirely across the lumen from one wall to the opposite one; "incomplete" (Pl. XVII, Fig. 3), abutting against the next lower and previously formed tabula and thus making a good indicator of the orientation of a longitudinal section; or "suspended" (Pl. VI, above center of Fig. 3; Pl. XI, Figs. 5–6) from squamulae. They are only very rarely attached to the ends or tops of squamulae. Tabulae are said to be "horizontal" when they are perpendicular to the direction of growth of their respective corallites, and "inclined" when they are not (Jones, 1937, p. 83).

The squamulae of *Favosites alpenensis* Winchell and of all squamulate species of *Favosites* and *Emmonsia* are of septal origin; they definitely are not incomplete and degenerate tabulae. In this view the author is in accord with Rominger (1876, p. 20), who was the first to apply the term "squamulae" to these structures, but he differs with such eminent authorities as Nicholson (1879, pp. 41–42), Smith and Gullick (1925, p. 116), and Weissermel (1939, p. 66). In structure and composition, in arrangement, and in position with respect to the polyp at the time of deposition squamulae agree very closely with the septal elements and disagree absolutely with the tabulae. Since any discussion of squamulae involves the genus *Emmonsia* Edwards and Haime, illustrations of the genotype, *Emmonsia emmonsii* (Rominger), are included among the figures.

In microscopic structure the squamulae are continuations of the peripheral stereozone (Pl. II, Fig. 12; Pl. V, Figs. 4, 6), just as the septa of Rugosa appear to be continuations of a peripheral stereozone. They are pale straw color or buff, whereas tabulae and dissepiments differ in being dark gray, as Lindström (1899, p. 10) has pointed out; the appearance of the squamulae in the Tabulata of any locality compares very closely with that of the septa in the Rugosa from the same locality, but the tabulae and the pore plates of the Tabulata look like the dissepiments and tabulae of the Rugosa. Squamulae are thick (Pl. V, Figs. 4–5; Pl. XVII, Fig. 3); tabulae are much thinner. Squamulae are horizontal or inclined upward in the *alpenensis* lineage and in *Emmonsia emmonsii* (Rominger), though not necessarily in all favositids; the tabulae are horizontal or concave, being inclined downward from the wall (Pl. XIII, Fig. 3).

Squamulae are arranged in vertical rows (Pl. XII, Fig. 2). Again, this is reminiscent of septal elements; were the squamulae narrow instead of being broad and spatulate, they would be no more than septal spines (cf. Rominger, 1876, p. 21).

Finally, the squamulae were secreted, at least in the *alpenensis* lineage, fairly well up on the sides of the polyp and not by the basal disc. This can be shown by three lines of reasoning, no one conclusive, but each confirming the others. First, tabulae are often suspended from squamulae that must obviously have been present prior to the deposition of the tabulae (Pl. III, Fig. 4; Pl. VI, Fig. 1). Secondly, in a shale-filled calyx of a typical squamulate coral the squamulae occur much closer to the calicular rim than do the tabulae (Pl. XIII, Fig. 4). Finally, zones of thickened walls or of thickened intramural coenozone, of abundant squamulae, and of closely set tabulae are all indicative of rather adverse environmental conditions and were formed contemporaneously. In a typical member of the *alpenensis* lineage with corallites 2 mm. in diameter the top of a squamulate zone may be 3 to 4 mm. below the top of the corresponding thickened coenozone, and the top of the zone of closely set tabulae may be some 2 or 3 mm. still lower (Pl. III, Fig. 2). If the zones are quite narrow, this distinction is very sharp, and even with rather wide zones it is apparent that the squamulate zone starts well within the zone of closely spaced tabulae and extends above it.

The preceding paragraphs and the accompanying illustrations have been offered as proof of the septal origin of squamulae. The commonly accepted thesis that squamulae are reduced, partial, or degenerate tabulae can be traced to several causes. Among them are the infrequency of squamulate forms among European corals, the presence of incomplete and suspended tabulae among squamulae, the confusion of accidentally broken tabulae with squamulae, the poor state of preservation of many squamulate forms, the tabulae thickened by deposition of drusy calcite in some of the best-known forms (Pl. V, Fig. 5), the lack of careful microscopic work on very thin sections, and the confusion in regard to Rominger's and Lambe's reasons for considering squamulae modifications of septa. Because of this misconception at least two recent authors, accepting the definition of squamulae as degenerate tabulae, have applied new names to true squamulae. Jones (1937, pp. 83–87) creates the term "horizontal septa" for such elements, and Pradacova (1938, p. 8) uses "lingulae."

The mural pores of the *alpenensis* lineage are typically uniserial, arranged in one row down the center of each wall of the corallite. If the wall is particularly wide, there may be two rows of mural pores, usually arranged with the pores in one row alternating with those in the other. About seven irregular rows occur around the circumference of the corallite. Contrary to the rule in *Emmonsia emmonsii* (Rominger) and *E. radiata* (Rominger), there is no fixed relation between the mural pores and the rows of squamulae (Pl. XII, Fig. 2).

Mural pores are round or oval; one subspecies usually has transversely elongate pores. The most convenient way to indicate the shape of mural pores has seemed to be by giving the ratio of the height to the width; a ratio of 1.00 indicates a round mural pore, one of 1.25 an extremely elongate one.

Elevated rims surrounding the mural pores are rather common and are often prominent in forms from the lower part of the Traverse group (Pl. II, Fig. 10). Rims are rare in specimens from the beds above the Newton Creek limestone, and the mural pores are often set in shallow pits (Pl. I, Fig. 8). Many mural pores are closed by diaphragms similar in structure and form to the tabulae (Pl. XII, Figs. 3, 5). Sometimes these diaphragms are attached to a tabula joining the wall at the lower edge of the mural pore (Pl. III, Fig. 4); they were therefore formed after that tabula but before the next higher one. As far as the writer is aware, this structure has never before been noted; it is given the name "pore plate." It is a vertical element homologous to a tabula but it differs in that it extends across and closes a mural pore.

Zones of abundant squamulae, of closely spaced tabulae, and of thickened walls are prominent on some specimens. As noted in the discussions of the intramural coenozone and of squamulae (pp. 247 and 251), these zones can usually be correlated with adverse external conditions that are apt to cause the death of corallites in other parts of the corallum (Pl. III, Fig. 2). The zones are, in general, exceptionally prominent in specimens from the bioherms. It seems reasonable to infer that the biohermal specimens, possibly because of shallower water, were more subject to modification by atmospheric and seasonal changes. In many specimens the zones indicate regular alternations of conditions that Ma (1937a, 1937b) has correlated with annual seasonal variation in temperature. The variation in spacing in coralla from different parts of the Traverse group is often greater than the variation between the annuli of Rugosa from different localities that Ma used in determining the geographic position of the Middle Devonian equator. Apparently correlation must be much more exact and the time units considered must be shorter than Middle Devonian before such work can be regarded as established on a firm basis.

*Increase of the Corallum*

It has been stated or tacitly assumed by most workers on the Favositidae that the number of corallites in a colony increases by a process which is usually called intermural gemmation or intermural budding (except in a few isolated genera such as *Alveolites* or *Chaetetes*, which have sometimes been included within the family). Thus Nicholson (in Nicholson and Lydekker, 1889, p. 312) states: "The corallum increases by the form of budding which Waagen has defined as 'inter-mural gemmation'." Weissermel (1939, p. 58) speaks of "*Zwischenknospung*" as being typical of *Favosites*, the *Knospen* ending sharply between the older corallites and not being referable to a particular mother corallite. Jones (1937, p. 84) says: "Reproduction takes place by *lateral gemmation*, the bud always being affixed to the wall of the polyp and never to the peripheral region of the calyx."

As Miss Hill (1935, p. 491) has ably shown, the corallum, being an exoskeleton, cannot "bud." Only confusion can result if such terms as "bud," "budding," "gemmation," and "fission" are used in connection with skeletal parts as well as with the soft parts. The terms "offset" (replacing "bud" or "daughter") and "increase" (replacing "gemmation," "budding," and "fission") are therefore suggested by her, and are used in this paper instead of the terminology of the articles noted in the preceding paragraph.

The increase of the *alpenensis* colony is very clearly peripheral, and not intermural (Pl. II, Figs. 7–12; Pl. III, Fig. 4). The offset appears in the angle of a corallite (Pl. II, Fig. 9), at a short distance below the rim (Pl. II, Fig. 8). The wall separating the offset from the parent corallite, the neowall, is at first relatively thin, and may not reach the normal thickness till the offset is several millimeters long. The wall separating the offset at its base from the neighboring corallites is of normal thickness, for the stereozone of this portion was deposited by the parent polyp as the bud (i.e. of the living animal, not the skeleton) was being differentiated. A millimeter or two higher the offset half of the wall between offset and neighboring corallite, whether parent corallite or just neighbor, is much thinner (Pl. II, Fig. 12), for the powers of greater deposition of the parent polyp are now expended on the other side of the wall, where the short squamulae appear in Figure 12, and the entire stereozone of the offset at this level must come from the bud.

In the *alpenensis* lineage a mural pore invariably occurs at the base of the offset (Pl. II, Figs. 7–10; Pl. III, Fig. 4). It is most frequently of the size of the regular pores but it may be somewhat larger. In portions of the coralla in which increase is extremely rapid, as where corallites are encroaching upon a dead area, the basal mural pore is almost double the diameter of the normal pores and sometimes may become so large that the neowall seems to split the parent lumen in the same manner as it does in *Chaetetes* or some *Alveolites* (Pl. XIV, near lower left-hand corner of Fig. 1). However, a portion of neowall normally occurs beneath the pore (Pl. II, Fig. 7; Pl. III, Fig. 4). Pore plates occur in about the same proportion of basal mural pores as of normal pores.

It must not be assumed that the occurrence of mural pores at the base of offsets lends support to Beecher's thesis (1893, pp. 210–211) that mural pores are aborted offsets. Rather, this entire section adds proof that the mural pores in *Favosites*, or at least in the *alpenensis* lineage, cannot possibly be directly related to processes of asexual reproduction; the mural pore allows communication between adjacent corallites, whereas the offset is the result of the differentiation of a single parent corallite.

## *Terminology*

Unusual terms and common terms that have been used by various authors with differing meanings are listed here, together with a brief definition giving the sense in which they are employed in this paper. Terms commonly occurring in the description of fossil corals and well understood by workers in the field are not included.

*Coenenchyma.* — The calcareous tissue connecting the corallites of some compound Hexacoralla and Octocoralla, not referable to any individual corallite. This is the meaning of the term as first used by Edwards and Haime (1848, p. 49) and as correctly used by most later authors. Hickson

(1924, p. 25) and others have revived a much later uncommon usage by Edwards (1857–60, Vol. I, p. 29) in which the term is equivalent to coenosarc.

*Coenosarc.* — The common soft tissue that unites the polyps of a compound hydroid or coral.

*Coenozone.* — *See* intramural coenozone.

*Concentric pseudoperculum.* — A pseudoperculum with lines of growth that are more or less parallel to the walls of the corallite and that form complete closure about the focal point (Dunbar, 1927, p. 103).

*D or diameter of the corallite.* — In this paper the diameter measured from the center of one intercorallite wall to the center of the opposite wall. The similar measurement given in some papers is that of the diameter of the lumen, and the two cannot be compared except by adding the average wall thickness to the lumen measurement. The abbreviation "D" is used in this paper for brevity and convenience in expressing ratios.

*Growth lamellae.* — Parallel bands of clear limpid buff-colored calcite alternating with cloudy gray bands and marking the position of the margins of the peripheral stereozone at successive stages in its deposition. The lamellae are distinguished as low-angled (less than 3 or 5 degrees), medium-angled, or high-angled (more than 15 or 20 degrees), according to the angle they make with the primary wall.

*Incomplete tabulae.* — Tabulae abutting against the next lower and previously formed tabula.

*Intermural increase.* — A type of increase with offsets appearing in the angles and between the walls of adjacent corallites, separated from the surrounding adult corallites by walls and not obviously referable to any given parent corallite.

*Intramural coenozone.* — The centrally located portion of the wall of favositids, situated between the primary walls of neighboring corallites and presumably deposited by the coenosarc. Possibly homologous with the coenenchyma of Hexacoralla, but taking no part in the increase of the corallum.

*Lumen.* — The space between the walls of a corallite, partially divided by squamulae and crossed by tabulae.

*Neowall.* — The wall separating the lumen of an offset from that of the parent corallite.

*Offset.* — The skeleton of a bud or daughter polyp; replacing the term "bud" when applied to skeletal tissue.

*Peripheral increase.* — A type of increase with offsets arising from the peripheral zone of the parent calyx and distinctly referable to one single parent corallite.

*Peripheral stereozone.* — A marginal zone of dilation produced by deposition of sclerenchyma and lining the epitheca of Rugosa or the primary wall of Favositidae.

*Pore plate.* — A thin vertical element homologous in structure to a tabula, but extending across and blocking a mural pore.

*Primary wall.* — The thin lateral opaque portion of the wall of a single corallite, deposited before the formation of the adjacent peripheral stereozone, covering the rest of the corallite, and delimiting the intramural coenozone. It is homologous with the epitheca of Rugosa.

*Pseudoperculum.* — An operculiform specialization of the holotheca permanently closing the apertures of abandoned corallites of Favositidae.

*Sclerenchyma.* — The tissue dilating many primary structures of the corallite.

*Squamulae.* — Linguiform or petal-shaped plates of septal origin projecting like shelves from the corallite wall into the lumen and ending in a free edge.

*Suspended tabulae.* — Tabulae attached to the lower surface of squamulae instead of extending entirely across the lumen.

*Wall* (*intercorallite wall*). — In this paper the entire series of skeletal deposits between the lumina of adjacent corallites. It is divided into an intramural coenozone common to the two corallites and centrally located in the wall, two primary walls, and two peripheral stereozones situated next to the lumina of the two corallites.

## THE LINEAGE CONCEPT: GENERA

In the past few years it has become increasingly evident to workers on fossil corals that many coral "genera" and even some "species" are polyphyletic, that the members of the taxonomic unit as now defined have come, not from a single ancestral stem, but from several different ones. Lang, Smith, and Thomas express this view very well in the Introduction to their much-needed *Index* (1940, p. 3):

> More and more it has become apparent that different coral stocks have run very rapidly, and therefore within a very short vertical range, through a series of similar stages, each of which has the characters of a different genus of the old classification. In many instances, therefore, the genus as hitherto understood is now seen to be but an aggregate of those species, or terms, of different parallel lineages, which have reached the same structural grade in evolution; and so the old genera are seen to cut across the lineages. This phenomenon is becoming increasingly recognized in many other groups of animals also as their detailed lineages are being traced by means of bed-by-bed collecting — a state of affairs not likely to be even suspected from the study of a single cross-section of the stream of life, such as that presented by the Recent flora and fauna.

Considered as separate units, certain members of the *alpenensis* lineage in the Traverse group would be placed in three different genera by most authors now working on tabulate corals. Unquestionably *Favosites alpenensis tenuimuralis*, subsp. nov. (p. 289, Pl. IX, Figs. 1–5), is a *Favosites*. But *Favosites dumosa* Winchell (p. 291, Pl. IX, Fig. 6; Pl. X, Figs. 1–5; Pl. XI, Figs. 1–2) resembles *Thamnopora cervicornis* (de Blainville), the genotype of *Thamnopora*, much more than it does *Favosites gothlandica* Lamarck. And *Favosites romingeri romingeri*, sp. et subsp. nov. (p. 293, Pl. XI, Figs. 3–6; Pl. XII, Figs. 1–3), has even more abundant squamulae than *Emmonsia emmonsii* (Rominger), the genotype of *Emmonsia*. It is evident that these three genera, *Favosites*, *Thamnopora*, and *Emmonsia*, must be considered in discussing the generic designation of the *alpenensis* lineage.

## Genus FAVOSITES Lamarck, 1816, p. 204

*Genolectotype* (see Edwards and Haime, 1850 [1850–1855], p. lx). — *Favosites gothlandica* Lamarck.

*Diagnoses* (translated from the French of Lecompte, 1939, p. 81). — "Massive tabulate corals, composed of prismatic, contiguous, but not amalgamate corallites. Walls lightly marked by a dark axis, generally thin, sometimes thickened. Septa absent or represented by spines arranged in vertical rows. Tabulae complete, horizontal or depressed (concave). Mural pores large."

(Fenton and Fenton, 1936, p. 22.) — "Corallum branched, expanded or massive. Corallites contiguous and prismatic. Walls perforated by pores. Septa absent or represented by ridges or rows of spines, their condition varying greatly within individual coralla and corallites in some cases, but uniform for species in others. Tabulae dominantly complete and approximately horizontal."

*Remarks*. — The use of the feminine gender for "Favosites" was established by Lamarck, who has been followed by most European paleontologists and by the earlier American ones. The current American practice of treating this generic name as masculine is traceable to the influence of S. A. Miller, who in the 1877 and later editions of *North American Geology and Paleontology* mistakenly regarded the suffix *–ites* as being solely masculine. He associated its gender with the masculine gender of λίθος, "stone." In this paper the original usage of Lamarck is observed.

## Genus THAMNOPORA Steininger, 1831, p. 10, and 1834, p. 338

*Genolectotype* (see Lang and Smith in Hill, 1937, p. 56). — *Thamnopora madreporacea* Steininger, 1831, p. 11, and 1834, p. 338 (= *Alveolites cervicornis* de Blainville, 1830, p. 370).

*Diagnoses* (translated from the French of Lecompte, 1939, p. 102). — "Massive, tuberose, or branching tabulate corals, formed of united polygonal corallites, with rounded inner contour. Walls thickened by stereoplasm (sclerenchyma), which is generally more pronounced distally and is amorphous or with a fibrous structure converging toward the dark axis. Septal indications lacking or septa represented by spines, generally only slightly developed. Mural pores numerous. Tabulae thin."

(Hill, 1937, p. 56.) — "Ramose Tabulate corals in which the cylindrical branches may be flattened and coalesced; the corallites are typically polygonal, and diverge from the axis of the branch and usually open normally to the surface; the corallite walls are dilated throughout, and the dilatation increases distally; typically the growth lamination in the sclerenchyme of the wall is obvious, while its fibrous nature is not; septal spines are usually obsolete, and mural pores are large."

*Remarks.* — Some of the subspecies in the *alpenensis* lineage, *Favosites alpenensis tenuimuralis*, subsp. nov., for instance, would be put in the genus *Favosites* by any investigator who has considered the two genera noted above. Other forms such as *F. dumosa* Winchell would be placed in *Thamnopora* with as little hesitation. Still others, *F. alpenensis kellyi*, subsp. nov., and *F. alpenensis alpenensis* Winchell, are intermediate in character and would be placed by some authorities in the first genus, by others in the second.

It is to be expected that transitional species will occur between closely related genera; the laws of evolution demand it. It seems better, however, not to split such a compact group as the *alpe-*

*nensis* lineage between the two genera, and hence it is retained in its entirety within *Favosites*.

Lecompte (1936b, pl. II, figs. 3–3e; pl. X, figs. 1–1b) figures the genotype of *Thamnopora* in detail.

### Genus EMMONSIA Edwards and Haime, 1851, pp. 152, 246

*Genolectotype* (see Römer, 1883, p. 423).— *Emmonsia hemispherica* (Yandell and Shumard), Edwards and Haime, 1851, p. 247 (= *Favosites alveolaris* (Goldfuss), Hall, 1843, p. 158, = *Favosites emmonsii* Rominger, 1876, p. 27, and Hall, 1877, explanation of Pl. IX) (non *Favosites hemisphericum* Kutorga, 1837, p. 40, non *Calamopora hemispherica* Troost, 1840, p. 72, non *Favosites hemispherica* (Troost), Yandell and Shumard, 1847, p. 7, non *Calamopora alveolaris* Goldfuss, 1826, p. 72).

This statement of the genolectotype differs from that of Lang, Smith, and Thomas (1940, p. 56) in several details. Hall and Rominger both described the form as *Favosites emmonsii,* not as *Favosites emmonsi.* It is true that Article 14*c* of the *International Rules of Zoölogical Nomenclature* provides that, "If the name is a modern patronymic, the genitive is always formed by adding, to the exact and complete name, an *i* if the person is a man . . ." (Schenk and McMasters, 1936, p. 29). However, the summary of Opinion 8 states: "Specific patronymics originally published as ending in *ii* (as *schrankii*, *ebbesbornii*) are, according to Article 19, to be retained in their original form, despite the provision of Article 14*c*, that they should have been formed with only one *i*" (*ibid.*, p. 42). The descriptions of Troost and of Yandell and Shumard are both so written that it seems unlikely that the authors had before them specimens of the genolectotype. The description of Yandell and Shumard sounds very much like that of *Favosites halli* Fenton and Fenton or *Favosites heliolitiformis* (Rominger) rather than like that of *alveolaris* of Hall, 1843, or *emmonsii* of Rominger's pl. VII, fig. 1 (Fig. 2 is of *Favosites heliolitiformis* (Rominger), 1862, p. 397, of which *Favosites halli* Fenton and Fenton, 1936, p. 27, is probably a synonym) or of Hall's pl. XII, fig. 5.

*Diagnoses* (Fenton and Fenton, 1936, p. 22).— "Corallum massive, expanded or branched. Corallites contiguous and prismatic, with walls pierced by pores. Septa absent or represented by rows of knobs or spines. Tabulae degenerate; chiefly represented by the discrete, flattened projections called squamulae, which appear as spines in longitudinal sections."

(Smith and Gullick, 1925, p. 119.) — "Differs from *Favosites* only in the tabulae, which are wholly or mainly represented by squamulae."

*Remarks.* — The discussion of squamulae in the preceding section shows that these cannot be considered degenerate tabulae. Rather, they are septal structures and even when as highly developed as in *Emmonsia emmonsii* are connected by very short and irregular or suspended tabular elements (Pl. V, Figs. 4–6; Pl. VII, Fig. 1). Squamulae apparently occur only in favositids from Upper Silurian and later strata.

In the *alpenensis* lineage all gradations occur from colonies with no squamulae to those with over five times as many squamulae as tabulae; in such coralla they are even more abundant than in the genotype. Squamulae may be entirely lacking; they may be very scarce and confined to rather narrow zones (Pl. VI, Fig. 3); they may be extremely abundant (Pl. XI, Figs. 4–6; Pl. XII, Fig. 2). They may be minute (Pl. II, Figs. 2, 6, 12) or quite large (Pl. XIII, Fig. 3), although in the *alpenensis* lineage they seldom overlap in the center of the corallite, as they may in the genotype (Pl. V, Fig. 5). In the *alpenensis* lineage there is no satisfactory point of division between the nonsquamulate and the abundantly squamulate specimens. Moreover, squamulate forms seem to have risen twice and possibly three or even four times in different branches of the lineage (Fig. 1). In view of these facts it seemed best not to recognize any of the lineage as belonging to *Emmonsia*, but to use *Favosites* for the entire group.

The genus *Emmonsia* as at present defined and used is perhaps the outstanding example of a polyphyletic genus among the tabulates. In the Traverse group alone there are four lineages composed in part or entirely of squamulate members which would be placed in *Emmonsia* by certain authors, yet all four are descended from separate, distinct nonsquamulate ancestors found in earlier Traverse beds or in pre-Traverse rocks. These ancestral species would all be placed in *Favosites*. This suggests that the name *Emmonsia* could well be dropped as a generic term, though it might be preserved as a genomorph, to be written in braces and added to the scientific name but to be regarded as only an indication of a morphological stage and not as part of the taxonomic name (Smith and Lang, 1930, p. 179; Lang, 1938, p. 157).

It is probably unwise, however, to discard the genus entirely at this time. Though the relative abundance of squamulae is not a good generic distinction but only an indication of a morphological stage through which several lineages have passed, a study of the genotype may show that the genus can still be considered valid. The close relationship between the mural pores and the squamulae, which are aligned in the same rows and alternate with each other in *Emmonsia emmonsii* (Rominger) and *Emmonsia radiata* (Rominger), does not occur in members of the *alpenensis* lineage (Pl. XII, Fig. 2) or in most other species which have been placed in *Emmonsia*. Species which do have this feature may prove to form a natural generic group.

THE LINEAGE CONCEPT: SPECIES AND SUBSPECIES

Swinnerton (1939), in his presidential address before the Geological Society of London, has pointed out that a lineage is not to be considered the sharp line of descent that it often appears to be in the typical "paleontological family tree," but that it is, in reality, a broad band, a plexus of interwoven and anastomosing lines. These are the lines of descent, the personal genealogies, of the individuals that go to make up the lineage. Suppose this plexus be plotted in terms of some key character of the group, a "chief differential" such as the amount of coiling of the beak of *Gryphea*, or the size of corallites or relative number of squamulae of a favositid coral. As successive generations pass, the plexus may shift to the right or to the left during the course of evolution; for purposes of illustration let it be to the left. If this shift is less than the width of the plexus, it is clear that specimens from the later generations in the geologically higher beds can be distinguished from earlier ones only if they lie at the left side of the band. An example of this is represented graphically in Figure 1 in the gradual shift of a plexus from a position in which the majority of the specimens fall into the subspecies *Favosites alpenensis alpenensis* Winchell, as they do in the Alpena limestone or upper part of the Gravel Point formation, to a position in which the majority fall into *F. alpenensis tenuimuralis*, subsp. nov. The broken line separating the two names on the chart serves to indicate the proximity of the subspecies to each other and the arbitrary nature of the identification of borderline examples with either subspecies.

The plexus of descent may take another course. It may broaden and become tenuous in the center and eventually split into two bands, producing two distinct species in the upper beds. If the dichotomy has actually occurred and there is a lacuna between the populations representing the two branches, the differentiation of species is simple. But if one considers a cross section of the lineage at some distance below the point of division, the situation is more complicated. The Recent fauna provides us with many such examples, and it is well to profit from the careful statistical work which has been done by the neobiologist in such cases. Ginsburg (1937), elaborating on an earlier suggestion by Davenport and Blankinship (1898), summarizes the views of this type of worker very well. If the chief differential for distinguishing between two closely related populations is plotted in a distribution curve, the curves for the two populations may lie side by side with no area common to both; the populations belong to unequivocal and distinct species; the bifurcation of the plexus has occurred, to use Swinnerton's expression. If the greater part of the area under either curve is common to both, the two populations can be referred to the same species. The pairs of populations in which a smaller or a greater portion of the area under the curves overlaps are the ones that have caused the many complex systems of subspecific nomenclature to arise. Intergrade, subspecies, variety, morpha, variant, ratio, race, subvariety, mutation — the terms applied to such situations are numerous. The only way out of this difficulty, in Ginsburg's mind, lies in the rigorous application of statistical methods of analysis and the setting up of an arbitrary scale of differentiation of the categories used; species are populations in which there is no intergradation or in which the intergradation is less than a certain given amount; subspecies are populations in which the intergradation is intermediate; races, those in which the area of intergradation exceeds another established limit. The two or three necessary subspecific categories can thus be used by different systematists in a mutually understandable manner.

Taxonomists will recognize that it is not wise to use only a single character as the basis for differentiation. If one favositid population shows a tendency to have slightly larger corallites and more closely spaced tabulae than another, neither of these characters may serve to separate unequivocally the two groups. If, however, the spacing of tabulae in each corallum is divided by its average corallite diameter, the resulting series of ratios may serve as a distinguishing feature. Moreover, several entirely separate ratios, counts, or measures can be combined into one character index, as was suggested by Hubbs and Whitlock (1929, p. 470). One such character index used by Hubbs (1936, p. 249) for distinguishing between two species of small fresh-water fish was made by adding five proportions that tended to be small in one of the species and dividing by the sum of the two that tended to be large in that species. By thus combining seven features a composite character index was obtained that showed no overlapping, despite the fact that the ranges of variation of each character overlapped in the two species.

Unfortunately, few fossils are as amenable to statistical treatment as are Recent fish. Not only are collections of fossil corals often insufficient, but many characters can be seen only by the use of thin sections, and the time required for grinding sections of the requisite number of specimens from each of several beds would prohibit their use in sufficient quantities to justify statistical analysis. Even here, however, these statistical concepts are of value. If there is a distinct gap between two populations, so that all or nearly all specimens can be unequivocally placed in one or the other, the two groups may well be considered specifically separate. Thus in the base of the Bell shale at locality 31 there occur one favositid with corallites about 2 mm. in diameter and with a few very short squamulae and another with slightly smaller corallites and numerous longer squamulae. Since there are no intergrading specimens, the two forms may be regarded as belonging to two distinct specific categories, which have been named *Favosites alpenensis bellensis*, and *F. valentini*. The specific designations *alpenensis* and *valentini* emphasize the essential difference between the two favosites.

When a collection of over three hundred specimens of favositids from the Potter Farm formation of locality 68 was examined, nearly one hundred were found to be members of the *alpenensis* lineage. Three or four of them had exceptionally large corallites, and when sectioned proved to be devoid of squamulae; these are members of the species *alpenensis* and are placed in the new subspecies *tenuimuralis*. They are easily separable from the other specimens of the lineage, which bear abundant squamulae. These appear at first glance to be again divisible into two groups, a small group of relatively fine-tubed patellate specimens with tabulae that tend to be concave, and a second larger group of specimens that are composed of larger corallites and tend to be globose or even elongate and to have straight tabulae. When an attempt is made to divide the lot by means of any of these characters or even by a character index, a combination of them all, it becomes apparent that there are many intermediate specimens; the distribution curve is bimodal, but the saddle between the modes is too high to enable one to recognize distinct species on either side of it. The forms are therefore assigned to the same species, *Favosites romingeri*, sp. nov., but to two different new subspecies, *vomingeri* and *patella*.

Two questions now arise: Why are the similar squamulate forms *romingeri* and *valentini* not placed in the same species? If these squamulate forms are so distinctly set off from typical *Favosites alpenensis*, why are they included in the *alpenensis* lineage? These questions can be best answered by referring to Figure 1, which shows the writer's conception of the relationships of the several Traverse forms included in the lineage. If the squamulate forms — *F. valentini* and *F. romingeri* and its subspecies — were placed in a single species separate from the typical *al-*

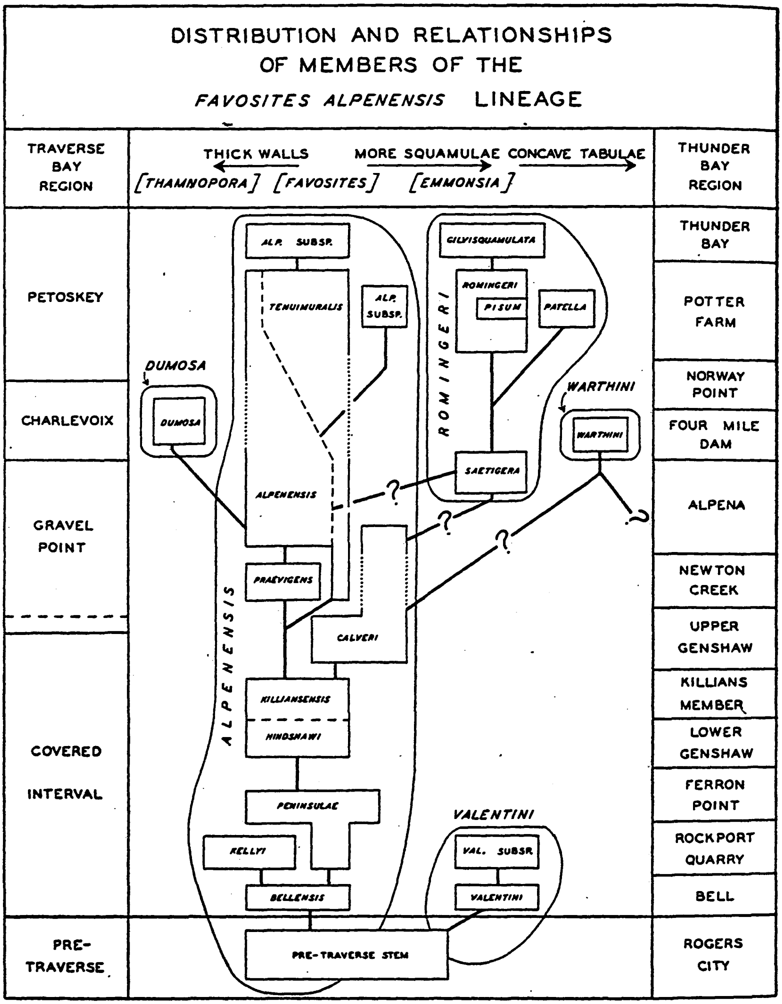


Fig. 1

Fig. 1. Relationships and stratigraphic distribution of the species and subspecies of the *Favosites alpenensis* lineage. Genomorph designations are shown in brackets at the top of the figure. Dotted lines indicate discontinuous known range; dashed lines separating subspecies indicate intergradation

*penensis*, we would find that the horizons at which this "species" and *alpenensis* are well separated by lacunae are balanced by the horizons at which intermediate forms occur. In particular, *F. alpenensis calveri*, subsp. nov., *F. alpenensis peninsulae*, subsp. nov., and an unnamed form from bioherms in the Potter Farm and Petoskey formations would cross the boundary between the two species. If we try to uphold a separate squamulate lineage, we are confronted with facts which demand that the *alpenensis* lineage and the squamulate lineage approach each other and even merge at various horizons, a phenomenon which would do violence to all commonly accepted ideas of organic evolution. The simplest solution is to consider the series *saetigera–romingeri–gilvisquamulata* one side branch of the *alpenensis* lineage that has developed more abundant and larger squamulae, and to consider *valentini* the terminal or near-terminal member of a similar but earlier series.

## TRENDS IN THE *ALPENENSIS* LINEAGE AND THE USE OF THE LINEAGE IN STRATIGRAPHIC CORRELATION

The doctrine of trends ("programme-evolution," or modified orthogenesis) in fossil coral series has been discussed thoroughly by Lang (1923, 1938), who has given many illustrations of the orthogenetic development of a character, or of several characters, through series of fossil corals from successive beds. A character may progress along its line of development quickly or slowly, or may remain stationary. If there is progress, it is always in the same general direction, along an apparently "predetermined" course (the word is Lang's). In a given series of corals the progress of one character along its course may be rapid and that of another slow, but the rates may be reversed in another series.

If the Traverse group were considered only up through the Alpena limestone, it would be very tempting to note a trend toward thicker walls. One might make a series of *alpenensis* types to show this trend: *bellensis, peninsulae, killiansensis, calveri, praevigens*, and *alpenensis*. But when one continues the series above the Alpena limestone, one notes the thin-walled *tenuimuralis* to be contrary to the trend of the orthogenetic line. Many other lines that have been investigated have similar weak spots. True trends, rather than only apparent ones, seem very scarce in the lineage.

Nevertheless, the writer believes a few trends can be recognized as real. Included in these is the trend away from the rimmed mural pore. In the lower part of the Traverse group a thin-walled form has very prominent rims around the mural pores, and a thick-walled form has rather low rims. In the upper beds a thin-walled specimen has at the most only occasional low rims, and a thick-walled specimen has the pores set in pits. There are several branches of the *alpenensis* lineage that show a trend toward an increase in the size and number of squamulae. The most prominent of these branches, that which contains *Favosites romingeri*, starts possibly with *F. alpenensis calveri*, subsp. nov., and continues through three new subspecies, *F. romingeri saetigera*, *F. romingeri romingeri*, and *F. romingeri gilvisquamulata.* A third trend, toward wider coenozones, is most noticeable in the main *alpenensis* branch, and is useful in telling whether forms come from above or below the upper part of the Genshaw formation. All other trends that the writer could imagine cannot be confirmed.

If one forgets the doctrine of trends and regards the separate subspecies as simply stratigraphic labels, the usefulness of the group becomes more evident. Most subspecies are confined to a single formation or, at the most, to two adjacent formations. Only one, *Favosites alpenensis tenuimuralis*, subsp. nov., ranges through as much as two hundred feet of rock. Most forms, whether characteristic of a formation or of only part of a formation, are found in all outcrops of the beds in question. Figure 1 will serve as an approximate indicator of the stratigraphic ranges of the various forms.

Naturally, some forms are much more useful in stratigraphic work than others. A few of the more important of these are noted here. *Favosites valentini*, subsp. nov., is confined to the Bell shale. It is moderately abundant, and is quite readily distinguished from *F. alpenensis peninsulae*, subsp. nov., from the Ferron Point formation, the shales of which are the beds that would most likely be confused with the Bell shale. Outcrops of different facies of the Ferron Point formation can be recognized by the occurrence of *peninsulae,* which is quite abundant in all exposures of the formation except those of the top fifteen or twenty feet, the *Chonetes*-bearing clay of locality 51. Its external appearance is not distinct enough for sure correlation, so that sections are necessary. The most important single fossil in the identification of the Killians limestone member of the Genshaw formation is the large globose to elongate *F. alpenensis killiansensis,* subsp. nov. The tabulate corals, including *F. alpenensis calveri,* subsp. nov., are the most distinctive part of the fauna of the upper part of the Genshaw formation, though tabulates are relatively inconspicuous in the beds of the same formation below the Killians limestone member. *F. alpenensis praevigens,* subsp. nov., is characteristic of the lower beds of the Gravel Point formation, and its presence at locality 115 confirms Kelly's extension of the Gravel Point eastward into Cheboygan County and even into westernmost Presque Isle County. *F. alpenensis alpenensis* Winchell, *F. romingeri saetigera,* subsp. nov., and *F. romingeri romingeri,* sp. et subsp. nov., confirm correlations previously made of the upper beds of the Gravel Point with the upper part of the Alpena limestone and of the Potter Farm formation with the Petoskey formation at locality 21. *F. dumosa* Winchell and *F. warthini,* sp. nov., are both confined to single formations; *dumosa* is the most important guide to the Charlevoix formation; *warthini* is fairly common in certain of the Four Mile Dam beds and is one of the principal factors in the identification of the small isolated outcrop at locality 76 with the type Four Mile Dam section.

Much detailed work will have to be done on specimens from states other than Michigan before many definite statements about extra-Traverse correlations are possible. *Favosites alpenensis peninsulae,* subsp. nov., is noted as occurring in the Silica shale of northwestern Ohio. This confirms the correlation suggested by McNair (1937, p. 163) of the Silica shale and the Ferron Point formation. Specimens of *F. romingeri* subsp., cf. *romingeri,* subsp. nov., from the Cedar Valley stage of Iowa suggest the possible equivalence of those beds with the upper part of the Traverse group. Contrary to McNair's statement (1937, p. 162) for the cryptostomatous bryozoa, the tabulate fauna of most of the Traverse group seems quite distinct from that of the Hamilton group of New York.

The Tabulata are potentially one of the most useful groups for solving problems of Traverse stratigraphy. The entire Traverse group can be divided into zones twenty or thirty feet thick by the use of the Tabulata alone. The assembling of data for the description of the tabulate fauna of the group will be slow because it will require the use of a very large number of thin sections, but the results should be well worth the effort.

## SYSTEMATIC DESCRIPTIONS

All the types mentioned in these descriptions are preserved in the Museum of Paleontology of the University of Michigan. The syntypes of *Favosites dumosa* Winchell, formerly preserved in the Francis A. Hood Museum of Alma College, are now in the possession of the University of Michigan.

### *Favosites alpenensis alpenensis* Winchell

(Pl. I, Figs. 1–7; Pl. II, Fig. 2. Cf. Pl. I, Fig. 8; Pl. II, Fig. 1)

1866. *Favosites alpenensis* Winchell, The Grand Traverse Region, p. 88, Ann Arbor, Michigan, Dr. Chase's Steam Printing House.

*Original description.* — "Related to *Calamopora polymorpha* Goldf. Always massive; mural pores arranged in one (sometimes two) irregularly or scarcely lineal series on each side — their margins indented instead of raised. Walls distinctly double, quite smooth; septa extremely thin. Cells smaller and pores more numerous than in *F. Billingsi* Rominger. Distance of pores 2.286 mm. (0.09); of septa 1.270 mm. (0.05)."

In Winchell's description "septa" is used for "tabulae," as in the terminology of Dana, rather than for "vertical radial elements" in accepted modern terminology. The measurements within parentheses are in inches.

*Revised description.* — Corallum globose, spherical to elongate; typical dimensions, height 5 cm., width 4 cm.; maximum of either dimension about 40 cm.; surface quite even and regular. Pseudopercula lacking.

Corallites subpolygonal to rounded, gently and evenly curving from a poorly defined central axis in elongate coralla, to radiating in spherical coralla, reaching adult size within 12–15 mm. of their point of origin; average adult diameter 1.5–2.1 mm., with considerable variation in size (0.3–0.5 mm.) of adults on a given surface; calices typically perpendicular, invariably meeting surface at angles greater than 45 degrees. Walls straight to slightly undulating, tendency to undulate particularly marked in coenozone, moderately thick with considerable but irregular variation in thickness of both coenozone and stereozone; dimensions, coenozone typically 0.015–0.05 mm., ranging 0.005–0.15 mm., primary wall 0.004–0.008 mm., peripheral stereozone 0.05–0.25 mm., total thickness 0.18–0.50 mm., in parts of some specimens as little as 0.12 mm.; medium-angled growth lamellae very common and prominent.

Tabulae typically horizontal, straight or slightly curving, about 95 per cent complete, 5 per cent incomplete, relatively thin (0.004 mm.), spaced on average 0.7–1.1 mm., with indistinct zones of closer and more distant spacing; average spacing : D = 0.5–0.6. Squamulae uncommon, fewer than 4 to ten tabulae, confined to rather narrow zones, stubby, straight, thick, horizontal or inclined slightly upward, 14–18 in cross section of corallite, short; length : D = 0.12–0.20. Mural pores uniserial, very rarely irregular or biserial, spaced on average 0.8–1.1 mm., rounded to slightly oval; height : width = 1.00–1.10; diameter variable, average on different specimens ranging 0.23–0.30 mm., with considerable variation even in a single specimen; diameter : D = 0.13–0.18; rims lacking, most pores set in shallow pits; pore plates present in about 50 per cent of mural pores.

Squamulate zones 2–5 mm. wide and spaced 10–24 mm. apart, occurring 2–5 mm. above indistinct zones of close tabular spacing; thickening of walls irregular with no distinct zoning.

*Types.* — Syntypes Nos. 14343, 17063; hypotypes Nos. 14342, 19652, 19677, 21626; figured specimen No. 21614 referred questionably to this subspecies, not to be considered a hypotype.

*Occurrence.* — Gravel Point formation, zone 6, bed 1 ("lower blue shale"), of Pohl (1930); localities 14 (syntypes), 14c, 14e.

Gravel Point formation, zone 6, bed 3 ("upper blue shale"), of Pohl (1930); localities 14e and 18a. Alpena limestone, upper part; localities 40, 53, 75. Somewhat similar forms do occur, but are very rare in the lower part of the Alpena limestone or the Newton Creek limestone of locality 95, in the Charlevoix formation of locality 13, and in the Potter Farm formation of localities 42 and 90.

*Remarks.* — This subspecies is typically developed in the "lower blue shale" of the Gravel Point formation, zone 6, bed 1, of Pohl (1930), where it is the only large-celled favositid. It is abundant, and the colonies are very well preserved. Winchell's syntypes and the great majority of specimens labeled "*Favosites alpenensis*" in the Winchell collections at both the University of Michigan and Alma College are from this bed, and the revised description was written from specimens collected from this stratum.

In the "upper blue shale" this subspecies is relatively scarce and is outnumbered by *Favosites romingeri saetigera*, subsp. nov. Small-celled specimens of *alpenensis* may be indistinguishable in the field from large-celled specimens of the squamulate *saetigera* occurring in the same bed, but they are easily separated in thin section by the abundant squamulae of the latter form. Favositidae from the "upper blue shale" can often be distinguished by a "rugosity" of their calyx-bearing surfaces. The walls between certain neighboring calices are raised to a greater height than the walls on other sides of the same calices, a condition apparently correlated with an increase in the thickness of the coenozone of the elevated portions. This phenomenon is not always present; when it does occur it is most evident on specimens so obscured by matrix that only the elevated part of the walls is exposed and the remainder lies buried. This "rugosity" is of practical importance in that it allows one to recognize immediately even small collections from this bed, since some of the favositid specimens are almost certain to exhibit this distinctive peculiarity.

Winchell, in his table of distribution (1866, p. 85), indicates that this species also occurs in the "Buff Magnesian Beds" of locality 865, but in the body of his report, written several months before the appendix containing the fossil descriptions, he lists *Favosites alpenensis* from the "Pleurotomaria Bed" of localities 855 and 856. When he came to write the paleontological part of his report, he established the species *F. dumosa* for these Charlevoix formation populations. Typical *F. dumosa* in the Winchell collection at Alma College bear Winchell's label "*Favosites alpenensis*." It seems probable that these were labeled before he wrote his descriptions and that the provisional labels were never changed. Provisional or manuscript names later revised before publication are attached to many Winchell specimens in both the University of Michigan and the Alma College collections; it is better to regard Winchell's specimens from the Charlevoix formation as examples of this provisional identification rather than as homeotypes.

There are a few examples of *Favosites alpenensis* cf. subspecies *alpenensis* from the Charlevoix formation, though they are outnumbered at least one hundred to one by *F. dumosa* Winchell. These specimens are too scarce to allow the generalizations necessary for establishing a new subspecies, but a sectioned specimen (No. 21626) shows rather closely spaced tabulae and somewhat larger mural pores (diameter : D = 0.20) than those of the typical Gravel Point specimens. The only close resemblance to *F. dumosa* is in the type of preservation.

Despite the specific name he used, apparently none of Winchell's material came from the Alpena area. The subspecies, however, does occur in the upper part of the Alpena limestone, both in the cores and on the flanks of the numerous bioherms. In the Alpena quarries (localities 40 and 53) only two characters show any tendency to vary from the moduli of the typical "lower blue" specimens. The corallites may be slightly larger, and the walls of the more massive coralla are apt to be thinner (Pl. I, Fig. 4). In these respects occasional specimens are transitional to the subspecies *tenuimuralis*, subsp. nov. On the other hand, the rare specimens from the bedded Alpena limestone or Newton Creek limestone of Bolton (locality 95) have rounded corallites, exceptionally thick walls with thick, low-angled growth lamellae, and distinct zones of thickening of the coenozone (Pl. I, Fig. 8; Pl. II, Fig. 1). Thus the *alpenensis* of the Alpena limestone varies, particularly in the matter of wall thickness, much more than does the same subspecies in the Gravel Point. As is often true of reef material, the specimens from the Alpena bioherms show more prominent growth zones, evidenced by such features as more closely spaced tabulae and squamulae, than do the ones from the evenly bedded limestones and shales. Prominent zoning is best considered an indication of shallower water which would allow greater influence of seasonal or climatic factors on the bottom-living forms.

Most of the members of the species *alpenensis* from the Potter Farm and Petoskey formations can be definitely referred to the subspecies *tenuimuralis*, subsp. nov. A minority of the specimens, however, fall within the limits of Winchell's subspecies as here redefined, just as some of the specimens from the Alpena limestone can be referred to *tenuimuralis*.

Numerous specimens from the bioherm in the Petoskey formation at locality 18, several from the small bioherms in the Potter Farm formation at locality 42, and one or two from the Potter Farm at locality 90 show features transitional between *Favosites alpenensis alpenensis* and *F. romingeri romingeri*, sp. et subsp. nov., but these intermediate forms appear to be lacking from other Potter Farm and Petoskey exposures. One of the sectioned specimens from the top of the Petoskey formation or Potter Farm formation of locality 23 has similar features. The corallites of these specimens are rather large; the squamulae are quite prominent and, with 8–16 to ten tabulae, are intermediate in number between *alpenensis* and *romingeri*. The specimens from the bioherm at Petoskey are, of course, strongly zoned. Pohl (1930, p. 21) probably lists this form under the *nomen nudum* of *F. transitorius* Grabau. Sufficient material has not yet been sectioned to justify defining it as a subspecies. It seems to be essentially a reef form, since it occurs in greatest abundance in the large bioherm of locality 18 and the smaller ones of locality 42, and is quite scarce or entirely lacking in contemporaneous bedded deposits.

## *Favosites alpenensis* **bellensis** Swann, subsp. nov.

(Pl. II, Figs. 3–12)

*Description.* — Corallum globose to elongate, with height tending to be greater than width, tending to be irregular in shape owing to death of portions of the corallum and subsequent overgrowth; typical dimensions, height 5 cm., width 3–4 cm., reaching maxima of height 12 cm., width 6 cm.; surface with slight irregularities in addition to the zones of overgrowth noted above. Pseudopercula of the concentric type present on small areas of a few specimens (including the holotype), situated 0.1–1.2 mm. below crests of walls.

Corallites subpolygonal, curving gradually with no sharp flexures, reaching adult size within 10–15 mm. of their point of origin; average adult diameter 1.9–2.4 mm. for specimens from locality 31, and 1.6–2.0 mm. for those from localities 55 and 38, with moderate to large variation in size (0.3–0.5 mm.) of adults on a given surface; calices absolutely or nearly perpendicular to the surface. Walls straight, varying from thin to thick in irregular zones; dimensions in thin-walled zones, coenozone 0.01 mm., primary wall 0.004 mm., peripheral stereozone 0.03–0.07 mm., total thickness 0.10–0.14 mm.; dimensions in thickened zones, coenozone 0.01–0.07 mm., primary wall 0.004 mm., peripheral stereozone 0.05–0.30 mm., total thickness 0.20–0.6 mm.; dimensions of neowall similar to those of thin-walled zone but stereozone of offset as little as 0.01 mm.; low-angled growth lamellae uncommon, seen only in thickened zones.

Tabulae horizontal, straight or slightly curved, more than 95 per cent complete, thin (0.004 mm.), spaced on average 1.0–1.4 mm., ranging from 0.3–2.5 mm., with very slight tendency toward zoning; spacing : D = 0.5–0.7. Squamulae scarce, fewer than 5 to ten tabulae, confined to rather narrow but widely spaced zones, peg-shaped, straight, rather thick, horizontal, 12–16 in cross section of corallites, short; length : D = 0.05–0.15. Mural pores uniserial, rarely biserial or irregular, spaced on average 1.3–1.6 mm., round; height : width = 1.00; average diameter 0.28–0.32 mm., diameter ranging from 0.20 to 0.35 mm.; diameter : D

= 0.12–0.18; rims very prominent in thin-walled zones, lacking in thickened zones; pore plates present in 50–75 per cent of mural pores.

Zones of squamulae very well marked, narrow, irregularly spaced 8–50 mm. apart; zones of spacing of tabulae lacking or indistinct; zones of thickened walls present, spaced 6–20 mm. apart, with but slight correlation with squamulate zones.

*Types.* — Holotype No. 19631; paratypes Nos. 21564, 21567, 21569, 21570, 21571, 21576.

*Occurrence.* — Bell shale; localities 31 (holotype), 38, 55.

*Remarks.* — This form is confined to the Bell shale, where it is present in all fossiliferous outcrops in association with *Favosites valentini*, sp. nov. Although it is quite uncommon at locality 38, still it may be considered an important guide fossil for the Bell. It is most easily distinguished from forms of *alpenensis* of the upper part of the Traverse by the prominent rims around the mural pores, and from many of them by the thin coenozone. From *F. alpenensis peninsulae*, subsp. nov., of the Ferron Point formation, the present subspecies differs in having less prominent and typically fewer squamulae and in having more prominent rims about the mural pores. It may be distinguished rather readily from the Genshaw formation forms by the variation in the thickness of its walls, and also by the prominently rimmed mural pores.

Adult coralla, those which in general are more than 2 cm. in diameter and in which corallites have reached adult size, can be distinguished from coralla of the associated *Favosites valentini*, sp. nov., by the larger corallites, by the tendency to form elongate rather than flattened colonies, and by the more uneven surface. Unless erosion has exposed the abundant squamulae of *valentini*, youthful colonies are indistinguishable in the field, and polished sections, thin sections, or plastic peels are necessary for identification.

Because of the many excellently preserved specimens and the large corallites of this form, it has been used for illustrating the discussion of the increase of the corallum in the *alpenensis* lineage.

*Favosites alpenensis* **calveri** Swann, subsp. nov.
(Pl. III, Figs. 1–6)

*Description.* — Corallum massive, varying in shape from flattened to elongate or club-shaped; dimensions so variable that generalizations are impossible, but large coralla, greater than 20 cm. in diameter, occur; surface rough, with low irregular elevations and depressions. Pseudopercula lacking.

Corallites polygonal to subpolygonal, straight and radiating or curving, dependent upon shape of corallum, reaching adult size within 5–8 mm. (?) of their point of origin; average adult diameter 1.7–2.2 mm., with little variation in size (0.2 mm.) of adults on a given surface; calices nearly or absolutely perpendicular to upper surface, inclined at angles of 30–60 degrees to lower surface. Walls commonly straight, rarely undulating, thin to moderately thick with greatest variation in coenozone; dimensions, coenozone 0.01–0.15 mm., rarely reaching 0.20 mm., primary wall 0.004–0.006 mm., peripheral stereozone 0.03–0.18 mm., total thickness 0.08–0.20 mm., rarely reaching 0.30 mm.; thin low-angled growth lamellae present in some specimens but not common, occurring only in exceptionally thick stereozone.

Tabulae horizontal, straight to concave, 80–90 per cent complete, 5–15 per cent incomplete, about 5 per cent suspended, thick (0.006–0.01 mm.), spaced on the average 1.0–1.4 mm., with very strong and prominent zones of close (0.5 mm.) and distant spacing (2–3 mm.); average spacing : D = 0.7–0.9, close spacing : D = 0.3, distant spacing : D = 1.2–1.5. Squamulae relatively abundant, 10–20 to ten tabulae, particularly abundant in, or confined to, very well marked zones, spatulate, straight, thin, horizontal or inclined upward at angles of less than 15 degrees, apparently 12–14 in cross section of corallites, moderately long; length : D = 0.20–0.40. Mural pores uniserial or biserial alternate, spaced rather evenly, on the average 1.0–1.2 mm., round; height : width = 1.00; average diameter 0.20–0.28 mm., very constant in a given specimen; diameter : D = 0.11–0.16; rims very scarce; pore plates present in about 50 per cent of mural pores.

Squamulate zones immediately above zones of closely set tabulae, spaced 6–18 mm. apart; zones of wall thickening, particularly of coenozone, 3–5 mm. above squamulate zones; all zoning quite distinct and prominent.

*Types.* — Holotype No. 21616; paratypes Nos. 21610, 21637, 21643.

*Occurrence.* — Genshaw formation above the Killians member; localities 48 (holotype), 40. Alpena limestone, bluish shale bed 20 feet above the base of the formation; locality 40. Alpena limestone, lower beds, or Newton Creek limestone; locality 95. Gravel Point formation of Cheboygan County, a few feet above the dark basal member, locality 113. Hungry Hollow formation, "encrinal limestone" at base of formation; brick and tile yard north of Thedford, Ontario.

*Remarks.* — The tabulates of the part of the Genshaw formation above the Killians limestone member are not at all reminiscent of those of the Killians or of the beds below it. In this respect the evidence derived from study of the corals is quite at variance with that of the brachiopods and mollusks. The present form, strongly squamulate with a thickened coenozone, is entirely unlike *Favosites alpenensis hindshawi*, subsp. nov., and *F. alpenensis killiansensis*, subsp. nov., from those beds. Rather, it resembles forms occurring in the upper part of the Traverse group. The most similar form is an unnamed one noted under *F. alpenensis alpenensis* Winchell and occurring in the Petoskey and Potter Farm formations of localities 18, 23, 42, and 90. *Calveri* has more widely spaced tabulae, thinner squamulae, and probably thinner walls than the latter form, which also shows a tendency toward peripheral thickening of the walls not noted in *calveri*. The only other form similar enough to *calveri* to cause confusion is *F. alpenensis peninsulae*, subsp. nov., which has a thin coenozone, more prominent rims surrounding the mural pores, and, usually, fewer squamulae. The coralla of *peninsulae* are generally smaller.

*Calveri* is on the boundary line between the species *alpenensis* and *romingeri* as the present author is using these names. In the discussion of the generic designation of the *alpenensis* lineage it is pointed out that not only do squamulate forms such as have been assigned to *Emmonsia* arise several times in different favositid lineages, but that they apparently arise even in several branches of the *alpenensis* lineage itself. This subspecies is intermediate between *alpenensis* and *romingeri* in morphology, and also seems to be the parent form of the *romingeri* branch of the *alpenensis* lineage or to be very closely related to that parent. Intermediate forms such as *calveri* could be placed equally well in either species. Whether the subspecies is named *Favosites alpenensis calveri* or *F. romingeri calveri* is a matter which must be decided arbitrarily.

This subspecies is named in honor of Dr. James L. Calver, of the University of Wichita, who, with the author, collected the holotype and several other specimens of this form from El Cajon Bay.

*Favosites alpenensis* **hindshawi** Swann, subsp. nov.

(Pl. IV, Figs. 1–5)

*Description.* — Corallum globose, usually irregular; typical dimensions, height 4 cm., width 3–4 cm., coralla exceeding 8 cm. in any dimension rare; surface even and regular. Pseudopercula lacking.

Corallites subpolygonal, radiating with only slight curvature, reaching adult size rapidly, within 6–10 mm. of their point of origin; average adult diameter 1.5–1.8 mm., with moderate variation in size (0.3 mm.) of adults on a given surface; calices perpendicular to upper surface, at an acute angle to lower surface. Walls straight, thin with very infrequent zones of moderately thick peripheral stereozone in some specimens; dimensions, coenozone 0.01–0.02 mm., very rarely more, primary wall 0.004–0.006 mm., peripheral stereozone 0.02–0.06 mm., reaching 0.2 mm. in the rare zones of excessive thickening, total thickness 0.07–0.12 mm., rarely 0.4 mm.; very faint medium-angled growth lamellae visible only in exceptional specimens.

Tabulae horizontal, with a distinct tendency toward concavity, over 95 per cent complete, relatively thin (0.004–0.006 mm.) where not altered by recrystallization and silicification, spaced on average 1.1–1.5 mm.; spacing : D = 0.7–0.9. Squamulae very rare, fewer than 1 to ten tabulae, apparently confined to narrow zones, moderately thick, horizontal or inclined slightly upward, short; length : D = 0.10–0.20. Mural pores uniserial, rarely biserial or irregular, spaced on the average 1.0–1.4 mm., round or transversely elongated; height : width = 0.95–1.00; average diameter 0.30 mm., diameters ranging from 0.25 to 0.34 mm.; diameter : D = 0.15–0.20; rims lacking or very slight; pore plates present in less than 25 per cent of mural pores.

Zones irregular, not prominent.

*Types.* — Holotype No. 19641; paratypes Nos. 21562, 21568, 21574, 21581.

*Occurrence.* — Genshaw formation below the Killians member, at horizons which in the Thunder Bay area are 30 to 65 feet above the base of the formation; localities 58 (holotype), 52, 78, 82, 99, G14, and others. Not common at any locality.

*Remarks.* — The distinctions between this subspecies and *Favosites alpenensis killiansensis*, subsp. nov., the most closely related form, are given in the remarks on the latter subspecies. *Hindshawi* lacks the prominent rims surrounding the mural pores of *bellensis*, subsp. nov., the more abundant squamulae of *peninsulae*, subsp. nov., and the enlarged coenozone of the forms of the upper part of the Traverse group.

*Hindshawi* does not appear in the lowest beds of the Genshaw in either the Thunder Bay or the Afton–Black Lake areas. Since the top 18 feet of the Ferron Point shale (the *Chonetes* clay of locality 51) does not carry members of the *alpenensis* lineage, there is nearly 50 feet of rock in which none of the lineage have been found, by far the longest gap in the entire Traverse. The only other comparable interruptions are the 25- or 30-foot covered interval between the Potter Farm and Thunder Bay formations, and the Norway Point formation of Alpena County in which favositids are but rarely found and in which no *alpenensis*-lineage types occur. Although it contains no *alpenensis* forms, the Ferron Point–Genshaw gap is not barren of favositids; in fact, a digitate favositid and a species of *Cyathophora* are among the most characteristic fossils of the lowermost beds of the Genshaw.

The hiatus in the lineage is well indicated by the sharp line separating the Ferron Point *peninsulae* from the Genshaw *hindshawi* and by the much closer connection of *peninsulae* with the preceding *bellensis*, and of *hindshawi* with the succeeding *killiansensis*.

This subspecies is named in honor of the late H. H. Hindshaw, a geologist who for many years made his home in Alpena and from whose collections several of the corals illustrated in this paper have been taken.

*Favosites alpenensis* **kellyi** Swann, subsp. nov.

(Pl. IV, Figs. 6–7; Pl. V, Figs. 1–3)

*Description.* — Corallum irregular to cylindrical, often with projecting branches which may anastomose; dimensions, length of branches reaching at least 30 cm., diameter of branches typically 1.5–3.0 cm.; surface uneven. Pseudopercula lacking.

Corallites polygonal in axial region but subpolygonal to rounded at surface, curving rather evenly without sharply differentiated flexure from an ill-defined central axis, reaching adult size very rapidly, within 5 mm. of their point of origin; average adult diameter 1.5–1.9 mm. with considerable variation in size (0.3–0.4 mm.) of adults on a given surface; calices perpendicular or inclined to the surface at angles greater than 60 degrees. Walls straight or very slightly undulating, extremely thin in the axial region but with greatly thickened peripheral stereozone toward the surface; dimensions, coenozone 0.005–0.015 mm., primary wall 0.004 mm., peripheral stereozone 0.03–0.06 mm. in the axial region, reaching 0.35 mm. near the periphery, total thickness 0.07–0.12 mm. in the axial region, reaching 0.65 mm. near the periphery; medium- to high-angled growth lamellae universally present in the peripheral thick zone, lacking in the interior of the corallum.

Tabulae often slanting and curving, rarely horizontal and straight, 60–70 per cent complete, 30–40 per cent incomplete, none suspended, moderately thick (0.006 mm.), often obscured by a coating of fine gray calcite crystals, spaced on the average 0.45–0.7 mm. but spacing irregular with tendency toward closer spacing in vague zones, particularly near the periphery; spacing :

D = 0.3–0.4. Squamulae extremely scarce, fewer than 1 to ten tabulae, confined to peripheral zone, straight, rather thick, short; length : D = 0.15. Mural pores uniserial and irregular, rarely biserial, spaced on average 0.8–1.0 mm., round to oval; height : width = 1.00–1.10; average diameter 0.18–0.23 mm.; diameter : D = 0.11–0.14; very slight rims almost universally present in axial region, pores flush or set in shallow pits in peripheral zone; pore plates present in 25–50 per cent of mural pores.

Zones indistinct except for very prominent peripheral zone of thickened stereozone.

*Types.* — Holotype No. 21651; paratypes Nos. 21648, 21649, 21650.

*Occurrence.* — Rockport Quarry limestone; localities 29 (holotype), 38, 80a, 80b.

*Remarks.* — This subspecies occurs typically in rather thin layers in the lower (black) beds of the Rockport Quarry limestone, where it is associated with *Favosites* cf. *digitatus* Rominger and with flattened colonies of stromatoporoids, which often incrust it. In the Rockport quarry (locality 38) the colonies are for the most part flattened and crushed; much better material can be obtained from the lowest layers exposed in the Black Lake quarry (locality 29) only three to four feet above the water level of the lake.

Its digitate branching, irregular shape, and its occasional areas of overgrowth separate *kellyi* easily and readily from all other members of the lineage except *Favosites dumosa* Winchell. It agrees with this form in shape, in occurrence as a biostrome builder rather than in bioherms or as isolated colonies, in possessing a peripheral zone of thickened walls, and in lacking squamulae; it approaches *dumosa* in showing a tendency toward peripheral concentration of tabulae. The thin slanting and commonly incomplete tabulae of *kellyi* are readily distinguished from the thick horizontal complete tabulae of *dumosa*. Septal striae, rather common in *dumosa*, have not been seen in *kellyi*. Apparently both forms grew as upright branches, but many branches fell over while still living, and the corallites that chanced to be on the upper side kept on growing and spread out into flat expansions that unite with one another and often cover whole coralla. (Compare Pl. X, Fig. 5, of *dumosa*.)

The tendency of cylindrical or digitate favositids to have thick-walled peripheral zones is well shown in these two members of the *alpenensis* lineage and also in several other Traverse species. Lecompte (1936b, p. 33), discussing the relation of wall thickening to corallum shape, shows that massive forms are likely to have relatively thin walls, subcylindrical forms, walls of moderate thickness, and digitate forms, thick walls with the thickening greatest in the peripheral region. That this relation is not always valid is indicated by thick-walled massive forms such as globose specimens of *Favosites alpenensis alpenensis* Winchell, which may have walls 0.7 mm. in thickness, but in most cases the correlation of thick walls and cylindrical shape is so striking as to suggest that abnormally thick walls are necessary to strengthen the more slender cylindrical and digitate colonies.

This subspecies is named in honor of Dr. W. A. Kelly, of Michigan State College, who pointed out to the author the layer in the Black Lake quarry that contains the well-preserved material on which this description is based.

*Favosites alpenensis* **killiansensis** Swann, subsp. nov.

(Pl. V, Fig. 7; Pl. VI, Figs. 1–6)

*Description.* — Corallum globose and irregular to obpyriform or subcylindrical; typical dimensions, height 7 cm., width 3–4 cm., with specimens exceeding 10 cm. in length common; surface even and regular. Pseudopercula lacking.

Corallites subpolygonal, radiating with little curvature in globose coralla to gently and evenly curving from an ill-defined central axis in subcylindrical coralla, reaching adult size within about 10 mm. of their point of origin; average adult diameter 1.7–2.2 mm., with little variation in size (0.2 mm.) of adults on a given surface; calices nearly or absolutely perpendicular to the surface. Walls straight, moderately thick with considerable variations in thickness of peripheral stereozone and with thin, often obscure coenozone; dimensions, coenozone 0.001–0.015 mm., very rarely and abruptly expanding to 0.10–0.15 mm., primary wall

0.004–0.006 mm., peripheral stereozone 0.03–0.12 mm., reaching 0.30 mm. in thickened zones, total thickness 0.07–0.20 mm., rarely 0.55 mm.; rather coarse, low- to medium-angled growth lamellae abundant and prominent.

Tabulae typically horizontal and straight, with slight tendency toward concavity, over 95 per cent complete, about 3 per cent incomplete, 1 per cent suspended, thick (0.006–0.010 mm.), spaced on the average 0.9–1.1 mm., with indistinct zones of close (0.6–0.8 mm.) and distant (1.1–1.4 mm.) spacing; average spacing : D = 0.5–0.6, close spacing : D = 0.35–0.45, distant spacing : D = 0.60–0.75. Squamulae uncommon, 1–6 to ten tabulae, confined to rather narrow zones, narrow, almost spiniform, straight, rather thick, inclined upward at angles of less than 30 degrees, 12–16 in cross section of corallite, short; length : D = 0.12–0.20. Mural pores uniserial or biserial, the tendency toward biseriality being much greater than in most members of the *alpenensis* lineage, spaced on average about 1.0 mm. but with quite irregular spacing, shape variable, round to quite oval; height : width = 1.00–1.20; average diameter 0.25–0.32 mm., diameters ranging from 0.20 to 0.35 mm.; diameter : D = 0.15–0.18; rims lacking; pore plates present in about 25 per cent of mural pores.

Squamulate zones 3–6 mm. wide, spaced 10–60 mm. apart, having no evident relationship to irregular and indistinct zones of tabular spacing and of wall thickening.

*Types.* — Holotype No. 19642; paratypes Nos. 19691, 20993, 21565, 21602; figured specimen No. 21625 not to be considered a paratype.

*Occurrence.* — Genshaw formation, Killians member; localities 52 (holotype), 50, 65, 114.

*Remarks.* — There is but little basis for making a distinction between this subspecies and *Favosites alpenensis hindshawi*, subsp. nov. The latter form usually occurs in smaller colonies, but large coralla can be collected from locality 78, and the size that a colony of massive favosites may attain is probably dependent upon the environment rather than upon any difference in genetic constitution. Growth lamellae are prominent in the subspecies from the Killians member and are only rarely shown in the other form, but, as Miss Hill (1936, pp. 33–34) has pointed out, the preservation of growth lamellae is largely a function of the type of fossilization and the extent of recrystallization.

The importance of the Killians member as a mappable unit and the fact that the large and abundant colonies of this subspecies are very useful in field identification justify the attempt to separate them from the much less common colonies in the lower beds. The points on which a separation is possible seem to be the tendencies of our present subspecies to larger sizes of corallites, greater wall thickness, closer spacing of tabulae, larger number of squamulae (though No. 21602 of the present subspecies has as few as most members of *hindshawi*), and elongation of mural pores. The range in variation of each character in *killiansensis*, however, overlaps the range in *hindshawi*, and there is no rigorous boundary between these two closely related subspecies.

An area of specimen No. 21625 showing larger corallites with septal striae has been discussed in the section on morphology (p. 249) and is illustrated in Plate VI, Figure 6. It appears to be the result either of the settling of a planula of some entirely different genus, perhaps *Cleistopora*, on the favosite colony or of a genetic mutation analogous to the "bud sport" of the horticulturist.

### *Favosites alpenensis* **peninsulae** Swann, subsp. nov.

(Pl. VII, Figs. 2–6)

1938. *Favosites alpenensis* Winchell. Stewart, Geol. Soc. Am., Spec. Pap. 8, p. 58, Pl. XI, Figs. 6–7.

*Description.* — Corallum normally elongate-globose or irregularly cylindrical, rarely depressed-globose; typical dimensions, height 6 cm., width 3–4 cm., with diameters greater than 5 cm. uncommon unless as a result of overgrowth of dead portions of colony; surface varying from even to irregular. Pseudopercula lacking or extremely rare.

Corallites subpolygonal, curving gradually with no sharp flexures, reaching adult size within 10 mm. of their point of origin; average adult diameter 1.6–2.2 mm., with moderate variation in size (0.3 mm.) of adults on a given surface; calices absolutely or nearly perpendicular to upper surface, at variable angles to lower surface. Walls straight with occasional undulations of coenozone, thin with variation in thickness in most specimens slight and noticeable chiefly in the coenozone; dimensions, coenozone 0.005–0.02 mm., very rarely reaching 0.08 mm., primary wall 0.004–0.008 mm., peripheral stereozone 0.02–0.08 mm., total thickness 0.08–0.16 mm.; one paratype, No. 19636, showing a zone of spindle-shaped thickening of the stereozone reaching 0.2–0.4 mm., total thickness reaching 0.7 mm.; indications of growth lamellae lacking except for medium-angled lamellae in thick zone of paratype No. 19636.

Tabulae typically horizontal and straight with slight tendency toward concavity, about 90 per cent complete, 5 per cent incomplete, 5 per cent suspended, thick (0.01 mm.), spaced on the average 0.9–1.3 mm., with distinct zones of close (0.6–0.9 mm.) and distant (1.3–1.8 mm.) spacing; average spacing : D = 0.5–0.8, close spacing : D = 0.3–0.5, distant spacing : D = 0.7–1.0. Squamulae rather abundant, 5–10 to ten tabulae, rarely more (No. 21095), concentrated in zones 5–8 mm. long that are spaced 10–30 mm. apart, linguiform, occasionally bent up at end, moderately thick, horizontal or inclined upward at angles of 0–30 degrees, about 12 in cross section of corallites, moderately long; length : D = 0.20–0.40. Mural pores uniserial, rarely biserial or irregular, spaced on average 1.2–1.5 mm., oval; height : width = 1.05–1.15; average diameter 0.30–0.38 mm., diameter ranging from 0.20 to 0.45 mm.; diameter : D = 0.16–0.20; rims very slight, usually lacking; pore plates present in 25–50 per cent of mural pores.

Zones of close spacing of tabulae 4–8 mm. wide, spaced 10–30 mm. apart and containing most of incomplete and suspended tabulae; zones of squamulae occur 3–5 mm. above close tabular zones, usually overlapping these. Zone of exceptionally thick peripheral stereozone noted only in No. 19636, where it corresponds to or is slightly above a squamulate zone; zones of thickening of coenozone, where present, reaching a maximum of 2–6 mm. above top of squamulate zones, with coenozone increasing gradually from below and decreasing again abruptly at top of zone.

*Types.* — Holotype No. 19637; paratypes Nos. 19636, 19687, 19690, 21095, 21096, 21566, 21582.

*Occurrence.* — Ferron Point formation; localities 38 (holotype), 51, 79. Rockport Quarry limestone; locality 38. Silica shale; quarry of Sandusky Cement Co., a quarter of a mile north of Silica, Lucas County, Ohio.

*Remarks.* — Specimens referable to this subspecies are represented sparingly in the lower part of the Silica shale of northwestern Ohio. The only sectioned specimens in the University of Michigan collections, Nos. 19687 and 19690, appear identical with the Ferron Point form except for wider spacing of the tabulae, 1.3–1.8 mm., and for slightly smaller mural pores in No. 19687. Miss Stewart (1938, p. 59) notes, however, a tabular spacing of 0.8–1.3 mm., which would put this form well within the limits of the subspecies. The present author has not seen the specimen of *Favosites alpenensis* Winchell that Miss Stewart has listed from the "Widder beds" of Erie County, Ohio.

This subspecies from the Ferron Point formation differs markedly from *Favosites alpenensis bellensis*, subsp. nov., of the Bell shale, and *F. alpenensis hindshawi*, subsp. nov., of the lower part of the Genshaw formation, in having rather numerous squamulae and frequent zones of moderate thickening of the coenozones. *F. alpenensis calveri*, subsp. nov., from the upper part of the Genshaw, resembles it more closely. The differences between these two forms are principally of degree rather than of kind. *Calveri* occurs in larger coralla, has more abundant squamulae, a more prominent coenozone, and is distinctly zoned. The walls of *calveri* are apt to be thicker than those of *peninsulae*. Rimmed mural pores occur frequently in *peninsulae*, but never in *calveri*.

### *Favosites alpenensis* **praevigens** Swann, subsp. nov.

(Pl. VIII, Figs. 1–5)

*Description.* — Corallum globose, with unusually strong tendency toward sphericity, rarely in irregular masses owing to death of parts of it and subsequent overgrowth; typical dimensions, 4 cm. by 4 cm. by 4 cm., diameters reaching 20 cm.; surface even. Pseudopercula lacking.

Corallites subpolygonal to rounded, radiating or gently and evenly curving, reaching adult size within 5 mm. of their point of origin; average adult diameter 1.6–2.1 mm., with little variation in size (0.2 mm.) of adults on a given surface; calices nearly or absolutely perpendicular to the surface. Walls undulating, moderately thick to thick with greatest variation in the stereozone; dimensions, coenozone 0.005–0.03 mm., rarely reaching 0.10 mm., primary wall 0.004–0.006 mm., peripheral stereozone normally 0.08–0.20 mm. with extremes 0.05–0.25 mm., total thickness 0.18–0.40 mm. with extremes 0.12–0.50 mm.; rather fine low-angled growth lamellae common.

Tabulae horizontal, straight or curving with very slight tendency toward concavity, about 95 per cent complete, 5 per cent incomplete or suspended, moderately thick (0.008–0.010 mm.), spaced on average 0.65–0.9 mm., with closely and distantly spaced zones in certain specimens from zone 2 of the Gravel Point formation; spacing : D = 0.35–0.60. Squamulae moderately abundant, 5–15 to ten tabulae, concentrated in indistinct zones, rather narrow, straight, thin, horizontal or inclined very slightly upward, apparently 12–14 in cross section of corallites, moderately long; length : D = 0.20–0.35. Mural pores uniserial or irregular, rarely biserial, spaced on average 1.0–1.5 mm., round; height : width = 0.95–1.05; average diameter 0.20–0.28 mm.; diameter : D = 0.13–0.16; rims absent, pores frequently set in shallow pits; pore plates present in 50–60 per cent of mural pores.

Squamulate zones usually indistinct, in some instances (zone 2 of Gravel Point formation) immediately underlain by vague zones of close tabular spacing; thickening of walls irregular and not zoned.

Commensal "worm" tubes, 0.2–0.8 mm. in diameter, following a spiral course in and near a corallite wall, commonly present.

*Types.* — Holotype No. 21605; paratypes Nos. 21607, 21615, 21641.

*Occurrence.* — Gravel Point formation, zones 2 (holotype), 3, 4, ?5, of Pohl (1930); localities 14 (holotype) and 8. Gravel Point formation, beds just above basal dark argillaceous member; locality 115.

*Remarks.* — *Praevigens* is the typical *alpenensis* form of the lower part of the Gravel Point formation. Its occurrence at locality 115 corroborates the Gravel Point age of the beds above the unnamed stylolitic limestone in the Afton area. The fact that *Favosites alpenensis calveri*, subsp. nov., and other tabulates characteristic of the uppermost part of the Genshaw formation also occur in the Gravel Point formation of Cheboygan County may indicate the equivalence of the lower part of the Gravel Point with pre-Alpena beds, although the correlation is too indirect to be more than a suggestion. *Praevigens* has not been found in the Thunder Bay region; *calveri* and the other tabulate elements of the upper Genshaw fauna do not occur in the Little Traverse Bay region.

*Praevigens* is most similar to *Favosites alpenensis alpenensis* Winchell from the upper beds of the Gravel Point formation and from the Alpena limestone. It differs in having undulating walls and, in most coralla, more abundant squamulae. The nearly invariable presence of spiral commensal "worm" tubes in this subspecies might perhaps be considered a feature of importance in recognizing it.

*Favosites alpenensis* **tenuimuralis** Swann, subsp. nov.

(Pl. IX, Figs. 1–5)

*Description.* — Corallum massive, globose with strong tendency toward sphericity; diameter 5–30 cm.; surface even. Pseudopercula lacking.

Corallites polygonal or rarely subpolygonal, straight or very gently curving, probably reaching adult size within 15 mm. of their point of origin; average adult diameter 2.0–2.5 mm., with moderate variation in size (0.3–0.4 mm.) of adults in a given section; calices perpendicular to the surface. Walls straight or with undulations that are most noticeable in coenozone, thin; dimensions, coenozone 0.006–0.03 mm., rarely expanding near the periphery to 0.15 mm., primary wall 0.004–0.006 mm., peripheral stereozone 0.02–0.06 mm., rarely reaching 0.10 mm., total thickness typically 0.06–0.12 mm., occasionally reaching 0.20 mm.;

extremely low-angled growth lamellae very scarce, lacking in most specimens.

Tabulae typically horizontal, straight or slightly curving, over 95 per cent complete, thin (0.004 mm.), spaced quite evenly and regularly for short distances on a given specimen, with great variation between different specimens and different zones of the same specimen, spaced on average 0.5–1.5 mm.; average spacing : D = 0.25–0.75. Squamulae lacking or extremely rare, invariably fewer than 1 to ten tabulae. Mural pores uniserial or biserial alternate, rarely biserial opposite, spaced on average 1.2 mm., oval; height : width = 1.10; average diameter 0.28–0.40 mm., quite variable even in a given specimen; diameter : D = 0.14–0.20; very slight rims commonly present but not prominent; pore plates present in about 25 per cent of mural pores.

Zones of closer tabular spacing prominent in some specimens, lacking in others, spaced 15–40 mm. apart; walls thickened near periphery of some specimens, thickening most prominent in coenozone.

*Types.* — Holotype No. 19662; paratypes Nos. 19656, 19679, 20999, 21597.

*Occurrence.* — Potter Farm formation; localities 89e (holotype), 68, 89a, 90. Petoskey formation; localities 7c, 18b (?), and 21. Forms approaching this subspecies occur uncommonly in the Newton Creek limestone of locality 40, and in the Alpena limestone of localities 40 and 53.

*Remarks.* — *Tenuimuralis* is characterized by large coralla, very thin walls, thin complete tabulae, and absence or scarcity of squamulae. These features easily separate it from all other Traverse forms except *Favosites alpenensis bellensis*, subsp. nov., which has very prominent rims around the mural pores, and *F. alpenensis hindshawi*, subsp. nov., the walls of which are typically thicker, and the tabulae more concave. Both these earlier subspecies have uniformly thin coenozones, whereas that of *tenuimuralis* may be relatively thick. Though typical *F. alpenensis alpenensis* Winchell is quite different, transitional forms occur rather frequently in both the Alpena limestone and the Potter Farm–Petoskey beds. *Alpenensis* and *tenuimuralis* are the end members of a continuous series of intergrading forms; the thick-walled ones near *alpenensis* are much commoner in the Alpena limestone, but the thin-walled ones are more typical of the Potter Farm–Petoskey beds. This seems to be an example of the center of gravity of a group gradually shifting through the course of time, although the width of the plexus undergoing the shift is so great that certain single specimens from either end of the series cannot be told from those of the other end.

It is possible that forms similar to *tenuimuralis* are much commoner in the Traverse than seems likely from the material in collections, but that they are confined to the limestones and so are seldom collected.

### *Favosites dumosa* Winchell

(Pl. IX, Fig. 6; Pl. X, Figs. 1–5; Pl. XI, Figs. 1, 2)

1866. *Favosites dumosa* Winchell, The Grand Traverse Region, p. 89, Dr. Chase's Steam Printing House, Ann Arbor, Michigan.
1876. *Favosites hamiltonensis* Rominger (*partim*), Geol. Surv. Mich., Vol. III, pt. II, pp. 28–29, Pl. VII, Fig. 4 (*non* Fig. 3).

*Original description.* — "Resembles *F. Alpenensis* in size and form of cells and cell-mouths, and in size and arrangement of pores, but differs in much more crowded and thicker septa, and in growing in stout, thickly clustered branches. Distance of septa .51 mm. (.02)."

For an explanation of Winchell's terminology see page 270.

*Revised description.* — Corallum subcylindrical to cylindrical, branching into broad, blunt, finger-like or bushy expansions that may anastomose or become united by layers of overgrowth; typical dimensions, height of branches 8–30 cm., diameter of branches 1.5–6 cm.; surface even and regular. Pseudopercula lacking.

Corallites subpolygonal to round where stereozone is thickest, diverging from a central axis, normally with a rather sharp flexure, distance required to reach adult size not well shown, possibly 10–15 mm.; average adult diameter 1.4–2.1 mm., with very little variation in size (0.1–0.2 mm.) of adults on a given surface; calices perpendicular to the surface. Walls straight, thin in axial region, but with peripheral stereozone becoming very thick toward periphery; dimensions, coenozone 0.005–0.02 mm., primary wall 0.006–0.008 mm., peripheral stereozone 0.04–0.08 mm. in axial region, reaching 0.25 mm. and rarely 0.40 mm. at the periphery, total thickness 0.09–0.16 mm. in axial region, reaching 0.5 mm. and rarely 0.7 mm. at the periphery; high- to medium-angled growth lamellae common and prominent in thickened zone; septal striae shown very distinctly in the growth lamellae.

Tabulae horizontal, straight or curved, over 98 per cent complete in axial region, 90–95 per cent complete and 5–10 per cent incomplete in peripheral region, comparatively thick (0.01 mm.), spaced on average in axial region 1.0–1.8 mm., in peripheral region 0.25–0.5 mm.; axial spacing : D = 0.8–1.0, peripheral spacing : D = 0.2–0.3. Squamulae (septal spines?) extremely rare, fewer than 1 to ten tabulae, confined to peripheral region, narrow, thick, inclined upward at angles of 30–40 degrees, short; length : D = 0.15. Septal striae prominent as undulatory swellings in growth lamellae in cross sections through the peripheral thickened zones, less prominent or absent in ultimate internal contour, 10–14 to a corallite, but with no inherent tendency toward the number 12 or any other number. Mural pores uniserial, rarely biserial, small, spaced on the average 0.9–1.4 mm. in both axial and peripheral regions, round; height : width = 0.95–1.05; average diameter 0.12–0.25 mm.; diameter : D = 0.09–0.12; rims consistently lacking and pores set in shallow pits in peripheral region; pore plates present in apparently less than 40 per cent of pores, the type of preservation making this feature difficult to interpret.

Indistinct zones of closer tabular spacing in the axial region spaced 10–25 mm. apart; peripheral zone of extremely close spacing of tabulae extending from sharp flexure of corallites to 2–4 mm. from periphery; stereozone increasing gradually in thickness from flexure to periphery.

*Types.* — Syntypes Nos. 23121, 23122; hypotypes Nos. 8452 (syntype and lectotype of *Favosites hamiltonensis* Rominger, 1876, Pl. VII, Fig. 4), 6356.

*Occurrence.* — Charlevoix formation, bed 4 ("Dumose Favosites Bed"), of Pohl (1930); localities 18, 18a (syntypes), 9, 13, 14e.

*Remarks.* — *Favosites dumosa* is characteristic of and confined to the Charlevoix formation. It does not occur in the Thunder Bay region.

As explained above (p. 239), one of the syntypes of *Favosites hamiltonensis* Rominger, No. 8452, his pl. VII, fig. 4 (see Pl. X, Fig. 4, of the present paper) is a typical specimen of *F. dumosa.* This specimen is here designated lectotype, and Rominger's name is reduced to synonymy with *F. dumosa.*

This species is the most marked and distinct of all the Traverse forms placed in the *alpenensis* lineage. Its cylindrical or branching shape, peripheral thickening, high-angled growth lamellae, and marginal zone of closer spacing of tabulae separate it immediately from all the other species or subspecies except *Favosites alpenensis kellyi*, subsp. nov. It differs from this in having complete tabulae and, in many specimens, septal striae.

**Favosites romingeri romingeri** Swann, sp. et subsp. nov.

(Pl. XI, Figs. 3–6; Pl. XII, Figs. 1–3)

1876. *Favosites hamiltonensis* Rominger (*partim*), Geol. Surv. Mich., Vol. III, pt. II, pp. 28–29, Pl. VII, Fig. 3 (*non* Fig. 4).

*Original description of Favosites hamiltonensis Rominger.* — "Tubes rounded-polygonal, unequal in the same specimens and in different specimens, variable from one and a half to two and a half millimeters. Walls stout. Diaphragms regular, simple, but frequently with lateral squamae interposed, which occasionally become anchylosed with them and disturb their regularity, but never to the same degree as in the former species. Connecting pores large, forming a single row on each side. Rows of lateral squamae, in some specimens very well developed. Other specimens or portions of specimens have smooth tube channels. Mode of growth globular, or tuberose, or in coarse ramifications, often incrusting other bodies with the basal portion. Abundantly found in the Hamilton group of Thunder Bay and Little Traverse Bay, and in the drift deposits.

"Plate VII. — Fig. 3 is a specimen from Stony Point, Thunder Bay. Fig. 4 is found in the limestone bluffs of Petoskey, presenting a vertical section through a specimen identical with Winchell's

*Favosites dumosus*, which is often found in more slender ramifications, but also in rounded, tuberose form, in no way differing from the typical specimens of Hamiltonensis."

*Description of Favosites romingeri romingeri.* — Corallum typically elongate, ovoid, club-shaped, or linguiform, rarely globose to flattened; dimensions of holotype, a linguiform specimen, length 11.3 cm., width 5.5–6.8 cm., thickness 2.0–2.8 cm.; more typical dimensions, length 6 cm., width 3–4 cm.; surface rather even, with slight irregularities in some specimens. Pseudopercula of the concentric type extremely rare, lacking on most specimens.

Corallites subpolygonal, curving gradually from a very poorly defined central axis in elongate colonies, reaching adult size within 5–15 mm. of their point of origin; average adult diameter 1.4–2.0 mm., with considerable variation in size (0.3–0.4 mm.) of adults on a given surface; calices on the sides of elongate specimens inclined to the surface at angles as small as 30 degrees. Walls straight or slightly undulating, moderately thick with variation in thickness most noticeable in the coenozone; dimensions, coenozone 0.002–0.18 mm., primary wall 0.004–0.008 mm., peripheral stereozone 0.03–0.10 mm., rarely reaching 0.18 mm., total thickness 0.10–0.20 mm., rarely reaching 0.30 mm.; low-angled growth lamellae of moderate thickness occurring where stereozone is rather thick, well preserved in some specimens, destroyed in others.

Tabulae horizontal or slanting, commonly curved, 50–70 per cent complete, 25–45 per cent suspended, 5 per cent incomplete, relatively thick (0.008–0.010 mm.), commonly obscured by coating of fine gray crystalline calcite, spaced on the average 0.6–1.0 mm., with slight tendency toward zones of closer and more distant spacing in some specimens; spacing: D = 0.4–0.6. Squamulae very abundant, 20–50 to ten tabulae, with tendency in some specimens toward concentration in poorly defined zones, usually linguiform, straight, thick at base but thinned toward tip, inclined upward at angles of 10–30 degrees, arranged in 8–13 vertical rows per corallite, rather long; length: D = 0.25–0.40. Mural pores uniserial or irregular, rarely biserial alternate, spaced on the average 1.2 mm., round to slightly oval; height: width = 1.00–1.10; average diameter 0.20–0.25 mm., rarely more (0.30 mm. in paratype No. 21628); diameter: D = 0.14–0.19; rims lacking or very slight; pore plates present in 25–50 per cent of mural pores.

Rather indistinct zones of more abundant squamulae, closer spacing of tabulae, and thickening of coenozone spaced irregularly, 10–35 mm. apart.

*Types.* — Holotype No. 8451 (discarded syntype of *Favosites hamiltonensis* Rominger, 1876, Pl. VII, Fig. 3); paratypes Nos. 6355, 19666, 21594, 21600, 21603, 21606, 21628.

*Occurrence.* — Potter Farm formation; localities 90 (holotype), 37, 42, 68, and 89. Petoskey formation, localities 18b, 21, and 21a?. Petoskey or Potter Farm formation, upper part; locality 23.

*Remarks.* — Rominger evidently regarded his species *Favosites hamiltonensis* as covering the entire unit that the present author is calling the *alpenensis* lineage. He included both *F. alpenensis* Winchell and *F. dumosa* Winchell in his synonymy, but he gave no reason why his name should replace the earlier ones. Of his two syntypes, one (his Pl. VII, Fig. 4, No. 8452) is a typical specimen of *F. dumosa* (Pl. X, Fig. 4 of the present paper). As is explained earlier in this paper (p. 240), it has been deemed wise to discard Rominger's name by designating this specimen the lectotype, thus making *F. hamiltonensis* Rominger a junior synonym of *F. dumosa* Winchell. The other specimen, his pl. VII, fig. 3, No. 8451, is a strongly squamulate, linguiform specimen from the Potter Farm formation at Stony Point, Alpena, locality 90 (Pl. XII, Figs. 1–2). This specimen is selected as the holotype of the species that includes most of the members of the *alpenensis* lineage with abundant squamulae. Rominger collected and figured this specimen; he was the first to apply a definite name to squamulae and was the first to recognize their significance. It is therefore fitting that the species be named in honor of Dr. Carl Rominger, physician, geologist, and paleontologist.

The subspecies is characteristic of the Petoskey and Potter Farm formations; it occurs more commonly in outcrops of these formations than does any other member of the lineage. It is distinguished from the earlier *Favosites romingeri saetigera*, subsp. nov., in having larger, broader, and usually more abundant squamulae, a greater proportion of suspended tabulae, and straighter walls with less variation in the thickness of the peripheral stereozone. It has thicker walls, thicker squamulae, and straighter tabulae than the very similar *F. romingeri gilvisquamulata*, subsp. nov., of the succeeding Thunder Bay limestone. Differences between this subspecies and the accompanying *F. romingeri patella*, subsp. nov., are noted in the remarks following the description of the latter subspecies.

*Favosites romingeri* subsp. cf. *romingeri* occurs outside the Traverse group in the Cedar Valley stage of Iowa, at several localities and probably at various horizons.

**Favosites romingeri romingeri** Swann, sp. et subsp. nov., forma **pisum** Swann, forma nov.

(Pl. XI, Figs. 7–8; Pl. XII, Figs. 4–8)

*Description.* — Corallum spherical, with corallites emerging over the entire surface except for one or two openings originally occupied by a cylindrical substratum 1–4 mm. in diameter; diameter of corallum 0.7–2.0 cm.; surface usually smooth and regular. Pseudopercula lacking.

Corallites subpolygonal, radiating except for initial curvature around substratum, probably just reaching adult size in 15 mm., which is the length of the longest tubes; average diameter of corallites at surface ranging from 0.8 mm. in the smallest specimens to 1.4–1.6 mm. in the largest, with a considerable amount of variation in size of corallites on a given surface; calices perpendicular to the surface. Walls indistinguishable from those of *Favosites romingeri romingeri*, sp. et subsp. nov.

Tabulae, squamulae, and mural pores similar to those of typical *romingeri*, the only differences being those correlated with the smaller size of the corallites.

Zoning not distinguished in any sectioned specimens.

*Types.* — Holotype No. 21624; paratypes Nos. 21619, 21620A, 21620B, 21621, 21622, 21623.

*Occurrence.* — Potter Farm formation, about twenty feet above the Alpena Cemetery shale pit horizon (locality 68); locality 89d.

*Remarks.* — The members of this forma appear to be identical with typical examples of *Favosites romingeri romingeri*, sp. et subsp. nov., except for differences that can be explained entirely by the peculiarities of the substratum upon which the planulae chanced to alight. In members of the forma *pisum* this was a cylindrical upright "stem" that has entirely disintegrated and left no traces of itself except for the mold made by the favosite colony (Pl. XI, Fig. 7; Pl. XII, Figs. 4–5). It seems most likely that this substratum was some kind of marine vegetation which, upon death and disintegration, let the favosite colonies fall to the muddy bottom and die. The fact that the largest colonies of this forma do not quite reach a corallite length equivalent to the annual zones in the normal members of the subspecies suggests that the vegetation was annual and died at some certain period of the year.

This forma is confined to and is quite abundant in a rather narrow band about twenty feet above the shale bed of locality 68; it occurs across the line from that locality on the Potter farm property (localities 89d and, probably, 89e). The narrow range is due to the limited distribution of the substratum form rather than of the favositid.

*Favosites romingeri* **gilvisquamulata** Swann, subsp. nov.

(Pl. XIII, Figs. 1–5)

*Description.* — Corallum globose, spherical to obovate; typical dimensions, height 4 cm., width 3–6 cm.; surface exceptionally smooth and even. Pseudopercula uncommon, having been observed only in thin section.

Corallites polygonal, straight and radiating to gently curving, reaching adult size within 5 mm. of their point of origin; average adult diameter 1.4–1.6 mm., with very little variation in size (0.1–0.2 mm.) of adults on a given surface; calices nearly or absolutely perpendicular to surface. Walls commonly straight, occasionally undulating, thin, with infrequent zones of moderately thickened peripheral stereozone; dimensions, coenozone, which is visible only under very favorable conditions, 0.002–0.01 mm., rarely reaching 0.12 mm., apparently only under conditions of recrystallization, primary wall 0.004–0.008 mm., peripheral stereozone 0.02–0.08 mm., reaching 0.12 mm. in infrequent zones, total thickness normally 0.08–0.14 mm., rarely reaching 0.25 mm.; growth lamellae lacking.

Tabulae often slanting, straight or curving with marked tendency toward concavity, about 80 per cent complete, 10 per cent incomplete, 10 per cent suspended, relatively thick (0.010–0.012 mm.), spaced on the average 1.0 mm., with well-marked zones of close (0.5–0.6 mm.) and distant (1.5–1.8 mm.) spacing; average spacing : D = 0.6–0.7, close spacing : D = 0.3, distant spacing : D = 1.0–1.2, all spacing quite irregular. Squamulae so light in color as to be difficult to distinguish in most sections, abundant, 20–50 to ten tabulae, concentrated in distinct zones, rather broad, often spoon-shaped, curving up toward tip, thin, inclined upward at angles of 10–30 degrees, 7–10 in cross section of corallite, long; length : D = 0.25–0.40. Mural pores uniserial, rarely biserial, spaced on the average 1.0–1.5 mm., round to slightly oval; height : width = 1.00–1.10; average diameter 0.20–0.22 mm.; diameter : D = 0.14–0.16; rims sometimes present but very low; pore plates apparently unusual, though the type of preservation makes determination of the presence or the absence of plates difficult.

Zones with closely spaced tabulae, abundant squamulae, and thickened walls very prominent, spaced 8–15 mm. apart.

*Types.* — Holotype No. 19670; paratypes Nos. 19671, 21593.

*Occurrence.* — Thunder Bay limestone; locality 35.

*Remarks.* — This subspecies is typical of the Thunder Bay limestone, although it is a rather uncommon member of the large fauna of this formation. It is characterized by its exceptionally even surface, thin walls, very slight rims around the mural pores, very abundant thin, spoon-shaped squamulae, and its concave tabulae. It is difficult to differentiate photographically the extremely light-colored sclerenchyma forming the stereozone and the squamulae from the dirty-gray calcite of the matrix, but in thin section the sclerenchyma is recognizable by its yellowish or straw-colored tint.

The form with the closest resemblance to this subspecies from the top of the Traverse group occurs, surprisingly enough, in *Favosites valentini*, sp. nov., from the Bell shale at the base of the group.

### *Favosites romingeri* **patella** Swann, subsp. nov.

(Pl. XIV, Figs. 1–5)

*Description.* — Corallum patellate, obconical with a large basal angle and a flat upper surface, or discoidal; dimensions of a rather large specimen, height 4 cm., width 8 cm.; upper surface fairly smooth, lower surface usually with growth annulations. Pseudopercula and holotheca lacking or very poorly developed.

Corallites subpolygonal, curving gently from a course paralleling the lower surface near their origin to one perpendicular to the upper surface, reaching adult size within 5–10 mm. of their point of origin; average adult diameter 1.1–1.4 mm., with very little variation in size (0.1 mm.) of adults on a given surface; calices perpendicular to upper surface, inclined very strongly to lower surface. Walls indistinguishable from those of *Favosites romingeri romingeri*, sp. et subsp. nov.

Squamulae, tabulae, and mural pores similar to those of *Favosites romingeri romingeri;* tabulae with a stronger tendency toward concavity; average diameter of mural pores 0.15–0.20 mm.; diameter : D = 0.14–0.16, this ratio remaining as in typical *romingeri.*

Rather indistinct zones, as in typical *romingeri.*

*Types.* — Holotype No. 21591; paratypes Nos. 21583, 21585, 21596, 21601.

*Occurrence.* — Potter Farm formation; localities 68 (holotype), 90. Petoskey formation; locality 21.

*Remarks.* — The relations of this subspecies to *Favosites romingeri romingeri*, subsp. nov., *F. placenta* Rominger, and *F. warthini*, sp. nov., are the chief sources of confusion in its identification and taxonomic position. In the Potter Farm exposure at locality 68 there occur numerous specimens of *F. romingeri romingeri* and of a subspecies of *F. placenta* Rominger. Intermediate between these two in almost all respects are a smaller number of patellate specimens. When these are sectioned, they are seen to differ from *placenta* in wall structure, so that the latter form need no longer be considered in this discussion, even though the two approach each other in all external features except the prominent holotheca of *placenta*. Between the patellate specimens with smaller corallites and concave tabulae and the typically globose or elongate examples of *F. romingeri romingeri* there is no absolute distinction; occasional specimens are intermediate in all respects. There are, however, clear concentrations of specimens with corallite diameters near 1.3 mm. and also 1.8 mm. There are similar concentrations of patellate as opposed to globose–elongate specimens, and of ones with strongly concave as opposed to rather straight tabulae. Since it is principally the same specimens that make the lesser maxima in graphs for corallite size, for shape, and for tabular curvature, it seems wise to distinguish them as the separate subspecies *patella*.

*Favosites warthini*, sp. nov., differs from *romingeri* in the same direction as does *patella*, but in greater degree. If *patella* were the earlier form, it would appear ancestral to *warthini*. Since it comes from higher strata, it should be considered a member on another branch radiating from the *alpenensis–romingeri* stock in the same direction as did the earlier *warthini* branch.

### *Favosites romingeri* **saetigera** Swann, subsp. nov.

(Pl. XV, Figs. 1–6)

*Description.* — Corallum globose, spherical to elongate; typical dimensions, height 4–5 cm., width 3 cm., rarely exceeding 8 cm. in any dimension; surface regular, often with slight rugosities formed by certain walls between corallites reaching to a greater height than do the neighboring walls. Pseudopercula lacking.

Corallites subpolygonal, radiating or gently curving, reaching adult size within 5–8 mm. of their point of origin; average adult diameter 1.3–1.8 mm., with little variation in size (0.2 mm.) of adults on a given surface; calices nearly or absolutely perpendicular to the surface. Walls with tendency to undulate particularly marked in coenozone, moderately thick with considerable variation in both coenozone and peripheral stereozone; dimensions, coenozone 0.01–0.05 mm., occasionally slightly more, primary wall 0.004 mm., peripheral stereozone 0.05–0.15 mm., total thickness 0.14–0.30 mm.; low-angled growth lamellae common and prominent.

Tabulae slanting to horizontal, often curving, about 80–85 per cent complete, 2 per cent suspended, the rest incomplete, relatively thick (0.008–0.010 mm.), spaced on average 0.65 –1.0 mm.; spacing : D = 0.35–0.65. Squamulae abundant, 20–40 to ten tabulae, concentrated to a slight extent in very broad and indistinct zones, linguiform to spikelike, thinned toward the tip and pointed, usually inclined upward at angles of 10–30 degrees, 12–14 in cross section of corallites, of moderate length; length : D = 0.20–0.30. Mural pores uniserial, rarely irregular or biserial alternate, spaced on average 1.0–1.5 mm. but spacing quite irregular, oval; height : width = 1.05 –1.15; average diameter 0.15–0.25 mm., quite constant in a given specimen; diameter : D = 0.10–0.14; rims uncommon, very low when present; pore plates apparently present in about 50 per cent of the mural pores.

Zones of more abundant squamulae, of closely spaced tabulae, and of thicker walls very faint or nonexistent in specimens from the Gravel Point and Charlevoix formations, more prominent and spaced 15–20 mm. apart in specimens from the Alpena limestone.

*Types.* — Holotype No. 19674; paratypes Nos. 19678, 21609, 21639.

*Occurrence.* — Gravel Point formation, zone 6, bed 3 ("upper blue shale"), of Pohl (1930); localities 14e (holotype), 14, 18a. Charlevoix formation, basal foot of formation (possibly reworked Gravel Point); locality 14. Alpena limestone; localities 40, 53, 74.

*Remarks.* — This subspecies is characteristic of the "upper blue shale" at the top of the Gravel Point formation, where it is the most abundant member of the *alpenensis* lineage. It also occurs in the nearly equivalent upper part of the Alpena limestone of the Thunder Bay region. The single specimen from the base of the Charlevoix formation may well have been removed from the "upper blue shale" during pre-Charlevoix erosion and then redeposited in the base of the overlying Charlevoix formation.

*Saetigera* typically has smaller corallites than *Favosites alpenensis alpenensis* Winchell, which accompanies it in the same beds. The ranges in corallite size of the two subspecies overlap, however, which sometimes makes it impossible to identify an individual in the field, even though the bed from which it comes is known. If the specimen is deeply weathered, the squamulae of *saetigera* may be seen in the calices, but their absence does not indicate that the specimen is necessarily assigned to *alpenensis*. Although broken sections, particularly when they are wet, may show the squamulae, polished or thin sections are often necessary. The presence of abundant squamulae in an *alpenensis* form is a character that readily enables one to distinguish between collections from the "upper blue shale" and the "lower blue shale."

The features that distinguish *saetigera* from *Favosites romingeri romingeri*, sp. et subsp. nov., are noted in remarks following the description of the latter.

The "rugosity" described under the remarks on *Favosites alpenensis alpenensis* Winchell occurs on many members of the present subspecies as well as on other favositids from the "upper blue shale."

### **Favosites valentini** Swann, sp. nov.

(Pl. XVI, Figs. 1–5)

*Description.* — Corallum depressed-spheroidal to spherical; typical dimensions, height 2.5 cm.; width 3–4 cm., reaching maximum height of 6 cm., maximum width of 7 cm.; upper surface even and regular, lower surface of many colonies irregular, with small area of attachment. Pseudopercula lacking.

Corallites polygonal to subpolygonal, radiating with little or no curvature, reaching adult size within 8–10 mm. of their point of origin; average adult diameter 1.3–1.7 mm., with little variation in size (0.1–0.2 mm.) of adults on a given surface; calices perpendicular to upper surface and sides, at an acute angle to lower surface. Walls straight, thin with greatest variation in thickness in the coenozone; dimensions, coenozone 0.005–0.15 mm., primary wall 0.004–0.006 mm., peripheral stereozone 0.01–0.10 mm., total thickness 0.05–0.25 mm.; neowall of some offsets as thin as 0.025 mm.; low-angled growth lamellae very uncommon, occurring only in the angles of corallites where the stereozone is thickest.

Tabulae horizontal, straight to slightly concave, about 75 per cent complete, 25 per cent suspended, very rarely incomplete, very thin (0.003–0.005 mm.), spaced irregularly, averaging 1.3–1.8 mm., varying 0.3–3.5 mm., with strong tendency toward closer spacing in squamulate zones; spacing : D = 1.0–1.5. Squamulae abundant, 12–40 to ten tabulae, heavily concentrated in rather wide but closely spaced zones, linguiform with length about three times width, straight or slightly curved, thick at base but thinned to point at tip, horizontal or inclined upward at angles of less than 15 degrees, relatively long; length : D = 0.30–0.40. Mural pores uniserial, rarely biserial or irregular, spaced on average 1.0 mm., oval; height : width = 1.05–1.10; average diameter 0.21 mm., ranging from 0.18–0.30 mm.; diameter : D = 0.13–0.17; rims lacking; pore plates present in 30–50 per cent of mural pores.

Zones of close spacing of squamulae and tabulae 4–6 mm. wide, spaced 7–12 mm. apart; walls with tendency toward thickening in upper part of closely spaced zones and just above them.

*Types.* — Holotype No. 20661; paratypes Nos. 21563, 21575, 21578, 21580.

*Occurrence.* — Bell shale; localities 31 (holotype), 38, 55.

*Remarks.* — Of the members of the *alpenensis* lineage from the lower part of the Traverse group, this species is the only well-marked common form that has abundant squamulae, and it is thus easily distinguishable in thin section from any other form occurring within three hundred feet of it stratigraphically. Curiously enough, it shows closer resemblances to *Favosites romingeri gilvisquamulata*, subsp. nov., from the top of the Traverse, than to any form in the intervening beds. It differs typically in having fewer and thinner tabulae and in showing more variation in the width of the coenozone. The extremely light-colored sclerenchyma of *gilvisquamulata* constitutes another difference, but this may well be due to conditions of preservation and fossilization rather than to differences in the original structure. The wide separation of these two forms in time makes it seem better to apply separate names to each. If they occurred in adjacent beds, the tendency would be to include them in the same species and to indicate their differences by subspecific names. The facts that there are no closely similar forms in the five hundred feet of highly fossiliferous strata between them and that *gilvisquamulata* seems to be the end member of the series *saetigera–romingeri–gilvisquamulata* practically force us to conclude that we have here an example of homeomorphy, and that at different times two separate branches of the *alpenensis* lineage culminated in almost identical forms (cf. Lang, 1917).

*Favosites valentini* appears to have descended directly from a squamulate member of the *alpenensis* lineage that occurs in the pre-Traverse Rogers City limestone immediately underlying the Bell shale. The next lower formation, the Dundee limestone, apparently contains no members of this lineage. The *valentini* branch of the *alpenensis* lineage appears to have lasted into Rockport Quarry time, for there is a similar form with abundant squamulae found in the Rockport Quarry limestone. It is apparently quite uncommon, and has not been found in the localities or beds in which corals are well preserved. The branch evidently became extinct during Rockport Quarry time, at least in the Traverse basin, for no members of the lineage with numerous and well-developed squamulae have been found in the upper part of the Rockport Quarry limestone, among the numerous and very well preserved favositids of the Ferron Point formation, or in the lower beds or the Killians limestone member of the Genshaw formation. The similar squamulate forms of the upper part of the Traverse appear to be a later, separate, development from the central sparingly squamulate stock of the lineage.

This species is named in honor of Joseph Valentin, personnel director of the Michigan Limestone and Chemical Company quarries and plant at Calcite, Michigan. His knowledge and interest have been very helpful to geologists working in the huge

Calcite quarry from which much of the type material of this species came.

**Favosites warthini** Swann, sp. nov.

(Pl. XVII, Figs. 1–10)

*Description.* — Corallum patellate or obconical with a large basal angle and a flat upper surface; dimensions of a large specimen, height 15 cm., diameter 25–30 cm., center of upper surface approximately 4 cm. above edges; upper surface smooth and regular, sides with growth annulations. Pseudopercula and holotheca probably entirely lacking, surely not strongly developed.

Corallites subpolygonal to rounded, curving gently from a course paralleling the lower surface near their origin to one perpendicular to the upper surface, reaching adult size by the time this flexure has occurred, probably within 6–8 mm. of their point of origin; average adult diameter 1.1–1.6 mm., with very little variation in size (0.1–0.2 mm.) of adults on a given surface; calices perpendicular to upper surface, inclined very strongly at angles of 10–45 degrees, to lower surface. Walls normally integrate, with coenozone enlarging in places to such an extent that it occupies the entire wall and produces an amalgamate appearance, straight, moderately thick to very thick where walls are amalgamate; dimensions, coenozone 0.01–0.40 mm., with thickening greatest in corners of corallites, primary walls 0.006–0.008 mm., absent where wall is amalgamate, peripheral stereozone absent where wall is amalgamate and reaching a maximum of 0.18 mm. only in places where coenozone is thin, total thickness 0.12–0.40 mm.; very low-angled growth lamellae present where stereozone is thickest.

Tabulae in widely spaced zones horizontal, straight, and complete; tabulae in closely spaced zones slanting with slight tendency toward concavity and 25–45 per cent incomplete, comparatively thick (0.008–0.012 mm.), spaced on average 1.0–1.4 mm., with prominent zones of close (0.4–0.6 mm.) and wide (1.5–2.5 mm.) spacing; average spacing : D = 1.0, close spacing : D = 0.4, distant spacing : D = 1.5. Squamulae abundant, 8–15 to ten tabulae, very strongly concentrated in zones, linguiform, often curved up at tip, thick at base but thinned toward tip, inclined upward at angles of less than 30 degrees, apparently 10–12 in cross section of corallite, long; length : D = 0.25–0.35. Mural pores uniserial, rarely biserial, probably zoned and spaced about 0.9 mm. where walls are integrate, 1.5 mm. where walls are amalgamate, round; height : width = 1.00–1.05; diameter averaging 0.25–0.32 mm., quite variable even within a single specimen; rims absent, pores usually set in shallow pits; pore plates present in about 50 per cent of mural pores.

Zones very prominent, spaced 6–15 mm. apart, consisting of a zonule of closely spaced tabulae followed by a thickly squamulate zonule followed in turn by one of amalgamate walls or of enlarged coenozone; these zonules may overlap, and where the zones are spaced closely a second interval of close tabular spacing may be superimposed on the amalgamate wall of the next lower zone.

*Types.* — Holotype No. 19649; paratypes Nos. 21590, 21608, 21612.

*Occurrence.* — Four Mile Dam limestone; localities 41 (holotype), 76.

*Remarks.* — This species is separated widely from most other members of the *alpenensis* lineage and may not belong to it at all. It is confined to the Four Mile Dam limestone and is the only member of the lineage in the formation which, unlike the rest of the Traverse group, possesses a tabulate fauna of the New York Hamilton and Onondaga relationships. The association with a New York fauna renders it still more likely that the species is not a member of the lineage, and in the earlier stages of this investigation it was considered to be of separate origin. Specimens of *Favosites romingeri patella*, subsp. nov., resemble it rather closely, however, and suggest that it may be an aberrant member of the *alpenensis* lineage with close relationship to the *romingeri* group.

*Favosites warthini* resembles *F. romingeri patella* in shape, size of corallites, size of squamulae, and possession of concave tabulae. It differs in its extremely wide and variable coenozone, strong zoning, and wider spacing of tabulae.

The specific name is in honor of Dr. Alfred Scott Warthin, of Vassar College, in recognition of his work on the stratigraphic column in Alpena and Presque Isle counties. He collected the holotype.

LOCALITY LISTS

The locality numbers in the first of the following lists are those used currently by the Museum of Paleontology of the University of Michigan in a series covering the Devonian rocks of the northern part of the Southern Peninsula of Michigan. Numbers below 53 were recorded in 1926 by a joint field party of the Michigan and United States geological surveys; the higher numbers have been established for localities visited since by expeditions from the Museum of Paleontology. Many of these numbers have been used by other authors in previous publications (Pohl, 1930; McNair, 1937; Duncan, 1939) or in manuscripts. The complete list is on file at the Museum of Paleontology.

The second list is of localities established by A. W. Grabau which have not received numbers in the Museum of Paleontology list or whose limits do not correspond to those of the localities on that list.

*Localities Established by the Michigan Geological Survey and the Museum of Paleontology, University of Michigan*

LOCALITY

7c Ledges and bluffs along Lake Michigan extending from point on shore about one mile north to point about one and one-half miles north of Norwood, Charlevoix County. NE. ¼ Sec. 27 and SE. ¼ Sec. 22, T. 33 N., R. 9 W. Petoskey formation, upper part.

8 Ledges and bluffs on shore of Lake Michigan at Gravel Point, also known as Pine River Point or South Point, one and one-half miles west of Charlevoix, Charlevoix County. Line between Sec. 28 and Sec. 29, T. 34 N., R. 8 W. Gravel Point formation, type locality.

9 Abandoned main quarry (quarry No. 1) of Charlevoix Rock Products Co., about three quarters of a mile west of, Charlevoix, Charlevoix County. SE. ¼ SE. ¼ Sec. 28, T. 34 N., R. 8 W. Gravel Point formation, "upper blue shale"; Charlevoix formation, type locality.

LOCALITY

13 Abandoned Northern Lime Co. quarry ("Main Curtiss and two smaller quarries" of Pohl, 1930) and shore bluffs to west, Emmet and Charlevoix counties near village of Bay Shore. SW. ¼ Sec. 6, T. 34 N., R. 6 W. and SE. ¼ Sec. 1, T. 34 N., R. 7 W. Charlevoix formation; Petoskey formation.

14 Quarry of Petoskey Portland Cement Co., about one and one-half miles west of Petoskey, Emmet County. SW. ¼ Sec. 2 and SE. ¼ Sec. 3, T. 34 N., R. 6 W. Gravel Point formation; lowermost Charlevoix formation at extreme east end of quarry.

14c Abandoned quarry (Rose quarry of Grabau but not of Fenton and Fenton, 1930; W. E. Smith quarry of R. A. Smith, 1915), about one mile west of the west end of the Petoskey Portland Cement Co. quarry, (locality 14) and about one eighth of a mile south of Little Traverse Bay, Emmet County. NW. ¼ NE. ¼ Sec. 9, T. 34 N., R. 6 W. Gravel Point formation, strata below "upper blue shale."

14e Abandoned "Bell" quarry (Rose quarry of Fenton and Fenton, 1930) and ledges on shore about two miles east of Bay Shore, Emmet County. Near NE. corner Sec. 8, T. 34 N., R. 6 W. Upper part of Gravel Point formation; basal Charlevoix formation.

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

18a Ledges on shore of Little Traverse Bay at Pennsylvania Railroad station, Bay View, Emmet County. NW. ¼ Sec. 33, T. 35 N., R. 5 W. Gravel Point formation above "lower blue shale"; Charlevoix formation.

18b Section exposed in 1933 in ditch on east side of Encampment Avenue, Bay View, Emmet County, but paved over before 1938. Section extended from termination of Encampment Avenue on highway (U.S.–31) in front of Pennsylvania Railroad depot to point about fifty yards south. Separated from top exposure of locality 18a by a covered interval of 300 feet horizontally, 22 feet vertically, and 25 to 35 feet stratigraphically. Base of section between 35 and 45 feet above top of Gravel Point formation. Near center of east line Sec. 32, T. 35 N., R. 5 W. Petoskey formation, beds equivalent to those of Mud Lake quarry, locality 21.

21 Kegomic quarry on south shore of Mud Lake just east of Harbor Springs road (M.–131) about a quarter of a mile north of its termination on Bay View–Alanson road (U.S.–31) one mile east of Bay View, Emmet County. SE. ¼ SW. ¼ Sec. 27, T. 35 N., R. 5 W. Petoskey formation, *Gypidula petoskeyensis* zone and beds with Potter Farm fauna.

21a Highway shoulder and creek bed on south side of U.S.–31 (Bay View–Alanson road) 200 feet east of junction with M.–131 (Harbor Springs road) and about one mile east of Bay View, Emmet County. Near center of north line Sec. 34, T. 35 N., R. 5 W. Petoskey formation, *Gypidula petoskeyensis* zone.

Locality

23 Beebe schoolyard and exposures along highway, from two and one-half to two and three-quarter miles south of road corner half a mile west of Afton, Cheboygan County. Extreme SE. corner NE. ¼, and east line SE. ¼ Sec. 14, T. 34 N., R. 2 W. Beds equivalent to Petoskey or Potter Farm formation.

25 Abandoned Campbell Stone Co. quarry, three quarters of a mile north of Afton, Cheboygan County. NE. ¼ Sec. 36, T. 35 N., R. 2 W. Unnamed gray stylolitic limestone; Gravel Point formation, basal dark argillaceous limestone member and beds immediately overlying it.

26 Exposures along highway, from two and one-eighth to almost two and one-half miles south of road corner half a mile west of Afton, Cheboygan County. East line NE. ¼ Sec. 14, T. 34 N., R. 2 W., and continuing southward one quarter of a mile to covered interval at base of locality 23. Gravel Point formation; covered interval; equivalent of Norway Point formation.

29 Abandoned quarry of Onaway Limestone Co. on shore of Black Lake, Presque Isle County. NW. ¼ Sec. 7, T. 35 N., R. 2 E. Rockport Quarry limestone; Ferron Point shale; Genshaw formation exposed in slope above quarry.

31 Quarry of Michigan Limestone and Chemical Co. at Calcite, Presque Isle County. Site of Crawford's marble quarry. Ten sections in SE. part of T. 35 N., R. 5 E., and adjacent townships. Dundee limestone; Rogers City limestone, type locality; Bell shale, lower beds.

35 Bluffs on northeast shore of Partridge Point, four miles south of Alpena, Alpena County. Extends from center into SE. ¼ Sec. 11, T. 30 N., R. 8 E Thunder Bay limestone, type locality.

37 Shallow abandoned quarry on Alpena–Hillman highway, about two miles west of Alpena Cemetery (Evergreen Cemetery), Alpena County. SE. ¼ SW. ¼ Sec. 19, T. 31 N., R. 8 E. Potter Farm formation.

38 Abandoned quarry of Kelley's Island Lime and Transport Co. (Great Lakes Stone and Lime Co.) at Rockport, Alpena County. Sec. 6, T. 32 N., R. 9 E. Upper Bell shale; Rockport Quarry limestone, type locality; lower Ferron Point shale, type locality.

40 Quarry of Michigan Alkali Co., eastern edge of Alpena, Alpena County. Sec. 13, T. 31 N., R. 8 E. Upper beds of Genshaw formation; Newton Creek limestone, type locality; Alpena limestone, approximate type locality and most complete section.

41 Exposures on banks and in bed of Thunder Bay River below Four Mile Dam, Alpena County. One-quarter mile south of center Sec. 7, T. 31 N., R. 8 E. Other names currently or formerly applied to this dam site are Fletcher Dam, Three Mile Dam, and Broadwell's Sawmill. Four Mile Dam limestone, type locality; Norway Point formation.

LOCALITY

42 Exposures on hillside (south side of Orchard Hill) on north side of Alpena–Long Rapids road about one and three-quarter miles west of North Branch bridge, Alpena County. Center Sec. 31, T. 32 N., R. 7 E. Potter Farm formation.

48 Sinkhole at El Cajon Bay (not El Cajon beach), the small inlet at the head of Misery Bay, also known as Little Thunder Bay, Alpena County. NW. ¼ SW. ¼ Sec. 15, T. 31 N., R. 9 E. Genshaw formation, beds above the Killians member.

50 Exposures along Wessel road, about one and one-quarter miles south of bridge at "The Narrows," Alpena County. NW. ¼ of SW. ¼ Sec. 25, T. 32 N., R. 8 E. Genshaw formation, including Killians limestone member.

51 Abandoned shale pit of Alpena Portland Cement Co., about one mile east and one eighth of a mile north of Genshaw School and eight miles northeast of Alpena, Alpena County. SE. ¼ Sec. 18, T. 32 N., R. 9 E. Upper Ferron Point shale; lower Genshaw formation, type locality.

52 Road cut on French road, one quarter of a mile to one half a mile south of Killians Resort, Long Lake, Alpena County. Center of east line Sec. 8, T. 32 N., R. 8 E. Genshaw formation, including Killians limestone member, type locality.

53 Quarry of Thunder Bay Quarries Co., eastern edge of Alpena, Alpena County. SE. ¼ Sec. 14, T. 31 N., R. 8 E. Alpena limestone, including Dock Street clay lens at top; overlying beds with Four Mile Dam limestone fauna.

55 Cut on private railway of Kelley's Island Lime and Transport Co., about one mile south of Bell, Presque Isle County. SW. ¼ SW. ¼ Sec. 24, T. 33 N., R. 8 E. Bell shale, probably near middle of formation.

58 Ditches beside road at southern tip of Long Lake, Alpena County. NE. ¼ Sec. 22, T. 32 N., R. 8 E. Genshaw formation, part of type section.

65 Low ridge just south of road corner two miles west of Legrand, Cheboygan County. One hundred feet south of NW. corner Sec. 30, T. 35 N., R. 1 W. Genshaw formation, Killians limestone member.

68 Small shale pit at northwest corner of Alpena Cemetery (Evergreen Cemetery), Alpena County. SW. ¼ Sec. 21, T. 31 N., R. 8 E. Potter Farm formation (part of type locality?).

74 Site of projected quarry and kiln of Foxton brothers, south of Detroit and Mackinac Railroad tracks about three quarters of a mile northwest of train yards in northwest part of Alpena, Alpena County. SE. ¼ NW. ¼ Sec. 15, T. 31 N., R. 8 E. Alpena limestone, including Dock Street clay member.

75 Road cut, two and one-half miles north of Chisholm Street bridge on "New Shore Road" (new U.S.–23) between Alpena and Long Lake, Alpena County. South ½ SE. ¼ Sec. 4, T. 31 N., R. 8 E. Alpena limestone, bioherm and flank beds.

LOCALITY

76 Low cuts and ditches on Alpena–Long Rapids road about half a mile northwest of Norway Point Dam (locality 47), Alpena County. Short distance north of center south line Sec. 1, T. 31 N., R. 7 E. Four Mile Dam limestone; possibly Norway Point formation.

78 Road cut and ditch on "New Shore Road" (new U.S.–23) two fifths of a mile east of Swan Creek and about seven miles southeast of Rogers City, Presque Isle County. Near west line of NE. ¼ Sec. 17, T. 34 N., R. 6 E. Genshaw formation, lower beds.

79 Road cut and ditch on "New Shore Road" (new U.S.–23) one and three-quarter miles east of Swan Creek and one mile west of Trout Creek, about nine miles southeast of Rogers City, Presque Isle County. Approximately ¼ mile east of center Sec. 16, T. 34 N., R. 6 E. Lower Ferron Point shales.

80a Road cut on "New Shore Road" (new U.S.–23) half a mile west of Trout Creek and about ten miles southeast of Rogers City, Presque Isle County. (This Trout Creek should not be confused with another Trout Creek, or Trout River, west of Rogers City in Presque Isle County.) E. ½ SE. ¼ Sec. 15, T. 34 N., R. 6 E. Rockport Quarry limestone, black coral beds.

80b Road cut on "New Shore Road" (new U.S.–23) about one mile east of Trout Creek and four miles directly east of Liske, Presque Isle County. South line of SE. ¼ Sec. 14, T. 34 N., R. 6 E. Rockport Quarry limestone, black coral beds.

82 Small exposure on southwest side of county road 634 about a quarter of a mile west of LeRoy resort, west side of Long Lake, Presque Isle County. S. ½ NE. ¼ Sec. 31, T. 33 N., R. 8 E. Genshaw formation, lower beds.

89 Exposures on hills on south bank of Thunder Bay River lying approximately within the boundaries of the F. N. Potter farm west of Alpena, Alpena County. NW. corner Sec. 17, E. ½ Sec. 18, E. ½ Sec. 19, all but NE. corner Sec. 20, T. 31 N., R. 8 E. Norway Point formation; Potter Farm formation, type locality. (This locality has been subdivided. Localities 37, 41, and 68 lie just outside corners of locality 89.)

89a Road cuts and ledges on and near north–south road extending about three quarters of a mile south from Four Mile Dam (locality 41), Alpena County. North–south line through center Sec. 18, T. 31 N., R. 8 E. Norway Point formation; lower Potter Farm formation, type locality.

89d Exposures on eastern slope of hill on Potter farm just west of Alpena Cemetery (Evergreen Cemetery), Alpena County. SE. ¼ Sec. 20, T. 31 N., R. 8 E. Potter Farm formation, above Cemetery bed, type locality. This is a continuation upward and westward of locality 68.

LOCALITY

89e Road cuts on Alpena–Hillman road on south side of Potter farm half a mile to one mile west of Alpena Cemetery (Evergreen Cemetery), Alpena County. South line Sec. 20, T. 31 N., R. 8 E. Potter Farm formation.

90 Excavations at the Alpena City waterworks and ledges outcropping on beach at Stony Point, south edge of city of Alpena, Alpena County. Near northwest corner Sec. 34, T. 31 N., R. 8 E. Potter Farm formation.

95 Abandoned "Griffin" or "Bolton" limestone quarry and adjacent field outcrops, on southwest side of Detroit and Mackinac Railroad tracks about one and one-quarter miles northwest of Bolton, Alpena County. SE. ¼ SW. ¼ Sec. 5, T. 32 N., R. 7 E. Alpena limestone, lower part, or Newton Creek limestone.

99 Sinkhole in bottom and outcrops on shore at south end of Devil's Lake, half a mile south of "the Narrows" and about five miles north of Alpena, Alpena County. SW. ¼ SE. ¼ Sec. 23, T. 32 N., R. 8 E. Genshaw formation.

104 Cut on East Grand Lake road (county road 405) about three tenths of a mile north of the south line of Presque Isle County. East line SE. ¼ Sec. 34, T. 33 N., R 8 E. Genshaw formation, lower beds.

113 Cut on Detroit and Mackinac Railroad half a mile north of Onaway–Tower road and 300 feet east of grade crossing of county-line road one mile west of Onaway, Presque Isle County. Three hundred feet east of center of west line Sec. 6, T. 34 N., R. 2 E. Gravel Point formation, beds a few feet above basal dark argillaceous limestone member.

114 Road cut one mile west and half a mile north of Onaway, Presque Isle County, but exposure is on Presque Isle–Cheboygan county line. SE. corner Sec. 36, T. 35 N., R. 1 E. Genshaw formation, Killians member.

115 Cut on abandoned railroad grade just west of road crossing a little over one mile south and half a mile east of Legrand, Cheboygan County. NE. ¼ NW. ¼ Sec. 28, T. 35 N., R. 1 W. Gravel Point formation, beds a few feet above basal dark argillaceous limestone member.

117 Road cuts on north–south road one quarter of a mile south of Gorbut School. One and one-fourth miles south of Legrand, Cheboygan County. One quarter mile S. of NE. corner Sec. 33, T. 35 N., R. 1 W. Gravel Point formation, Emmetensis zone.

### *Localities of A. W. Grabau*

G1 Fox and Collins quarries, eastern end of Alpena, Alpena County. Fox quarry now enlarged into Michigan Alkali Co. quarry (locality 40). Collins quarry separate till about 1936, when the quarry of the Thunder Bay Quarries Co. (locality 53) incorporated and destroyed it. SE. ¼ Sec. 14 and SW. ¼ Sec. 13, T. 31 N., R. 8 E. Bioherm and flank beds in upper part of Alpena limestone. (No other rocks exposed in Grabau's time.)

G14 Rabiteau farm, Presque Isle County. NW. ¼ Sec. 35, T. 33 N., R. 8 E. Genshaw formation. Compare locality 104, which has similar fauna, though modern collections from there are much less extensive than Grabau's were.

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# EXPLANATION OF PLATE I

PAGE

*Favosites alpenensis alpenensis* Winchell .......................... 270

1. Unpublished drawing made under Winchell's direction and preserved in the General Library of the University of Michigan. Corallum, showing globose form, even surface, and monomorphic corallites with rather thick walls. Syntype (No. 14343). Winchell's Acervularia beds, bed B; locality 861. Gravel Point formation, zone 6, bed 1 ("lower blue shale"), of Pohl (1930); east end of locality 14. × 1
2. Photograph of specimen of which drawing in Figure 1 was made. Syntype (No. 14343). × 1
3. Cross section, showing subpolygonal to rounded corallites, thick walls, and variable intramural coenozone. Hypotype (No. 14342). Winchell's Acervularia beds, bed B; locality 861. Gravel Point formation, zone 6, bed 1 ("lower blue shale"), of Pohl (1930); east end of locality 14. × 3
4. Cross section of specimen from bioherm in Alpena limestone, showing large rounded corallites. Hypotype (No. 19652). Alpena limestone, bioherm in upper part of formation; locality 53. × 3
5. Unpublished drawing made under Winchell's direction and preserved in the General Library of the University of Michigan. Polished longitudinal section, showing uniserial and rarely biserial mural pores, slightly curving corallites, and straight, complete tabulae. Syntype (No. 17063). Winchell's Acervularia beds, bed B; locality 861. Gravel Point formation, zone 6, bed 1 ("lower blue shale"), of Pohl (1930); east end of locality 14. × 1
6. Photograph of specimen of which drawing in Figure 5 was made. Syntype (No. 17063). × 1
7. Longitudinal section, showing radiating corallites, thick walls, distant tabulae, uniserial mural pores, and absence of squamulae. Hypotype (No. 19677). Gravel Point formation, zone 6, bed 1 ("lower blue shale"), of Pohl (1930); locality 14. × 3

*Favosites alpenensis* subsp. cf. *alpenensis* Winchell .................. 273

8. Longitudinal section, showing undulating walls, two zones of greatly enlarged intramural coenozones, mural pores set in shallow pits, and curved or irregular tabulae (No. 21614). Alpena limestone, lower beds, or Newton Creek limestone; locality 95. × 6

## PLATE I

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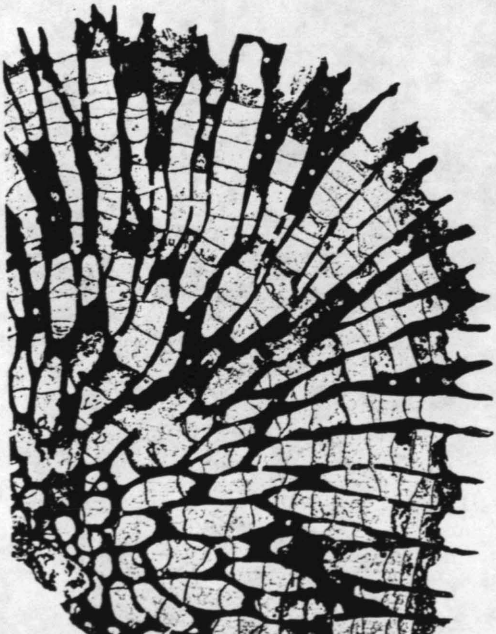

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# EXPLANATION OF PLATE II

PAGE

*Favosites alpenensis* subsp. cf. *alpenensis* Winchell .................. 273

1. Enlarged longitudinal section, showing mural pore set in pit and intramural coenozone so wide that wall almost appears amalgamate, abruptly narrowing at top of section to moderate width (No. 21614). Alpena limestone, lower beds, or Newton Creek limestone; locality 95. × 25

*Favosites alpenensis alpenensis* Winchell ........................... 270

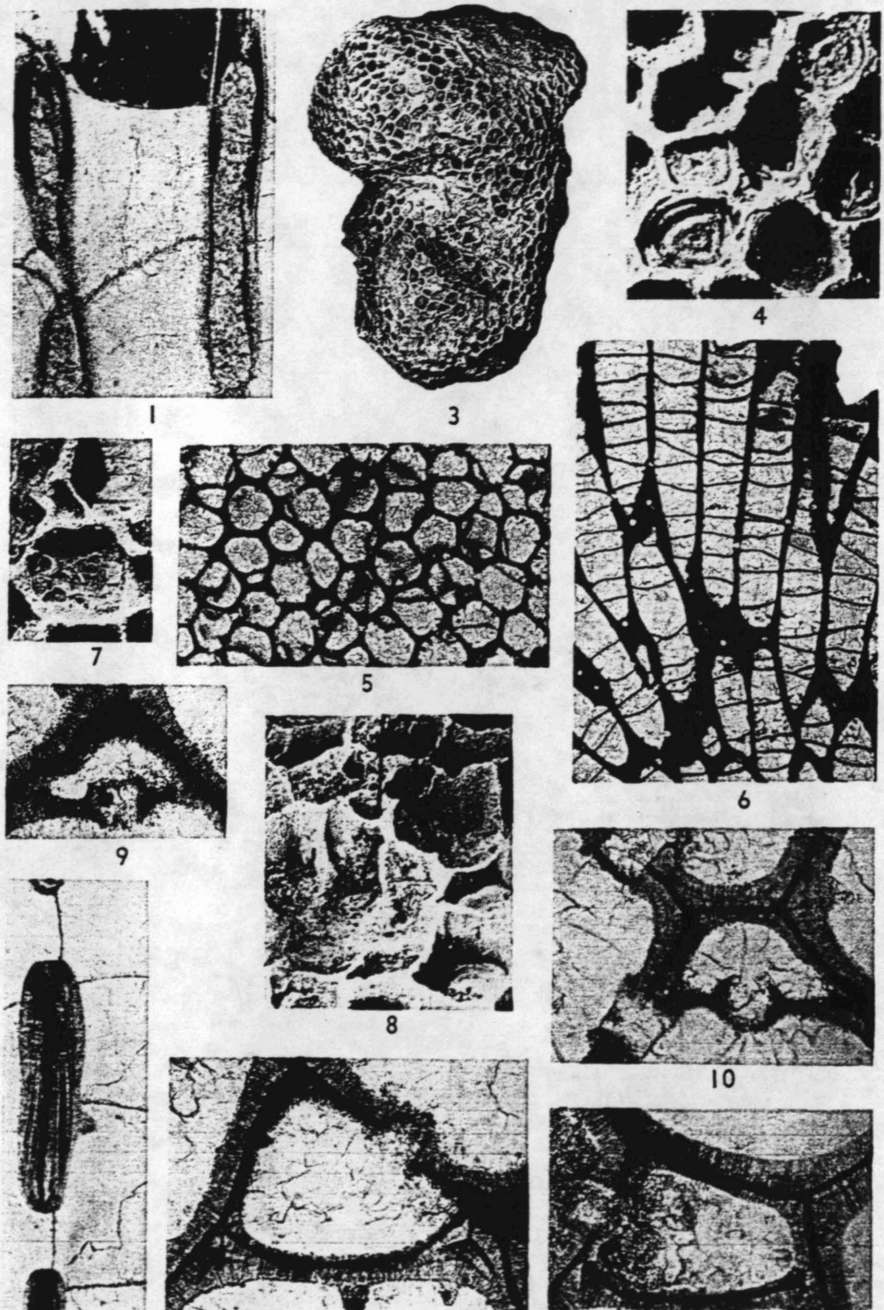
2. Enlarged longitudinal section of wall, showing variation in thickness of intramural coenozone, a very short squamula, thin low-angled growth lamellae in peripheral stereozone, and pore plates. Hypotype (No. 14342). Winchell's Acervularia beds, bed B; locality 861. Gravel Point formation, zone 6, bed 1 ("lower blue shale"), of Pohl (1930); east end of locality 14. × 25

*Favosites alpenensis bellensis* Swann, subsp. nov. .................... 275

3. Surface, showing elongate, irregular shape of corallum, and large corallites with considerable variation in size. Paratype (No. 21564). Bell shale; locality 31. × 1
4. Surface view, showing occasional pseudopercula of the concentric type. Holotype (No. 19631). Bell shale; locality 31. × 6
5. Cross section, showing large polygonal corallites and very short squamulae, 14 to 16 in cross section of corallite. Holotype (No. 19631). × 3
6. Longitudinal section, showing large corallites, moderately thick walls, complete tabulae, very short peglike squamulae, and mural pores with a slight rim. Squamulae are more abundant in this specimen, and particularly in this part of the section, than is usual with the subspecies. Holotype (No. 19631). × 3
7. Superior view of an offset in a corner of its parent corallite, showing the thin neowall and the mural pore at the base of the offset. Part of the walls of the parent corallite and of several neighboring corallites has been cut away to show the offset to better advantage. Paratype (No. 21567). Bell shale; locality 31. × 6
8. Lateral view of the offset shown in Figure 7, taken from the "north" as the specimen is oriented in that figure. A bristle has been placed through the basal mural pore. Paratype (No. 21567). × 6

9–12. Enlarged cross sections of different offsets of the same corallum, showing successive stages in development. Note that the intramural coenozone and primary walls (the "black line") of the neowall in the earlier stages do not extend through the stereozone of the older wall. Paratype (No. 21569). Bell shale; locality 55. × 25

PLATE II



# EXPLANATION OF PLATE III

PAGE

*Favosites alpenensis calveri* Swann, subsp. nov. .................... 277

1. Longitudinal section, showing prominent zones of closely spaced tabulae followed or accompanied by heavily squamulate zones. Note the variable intramural coenozone. Holotype (No. 21616). Genshaw formation, upper beds; locality 48. × 3
2. Longitudinal section, showing near the top of the figure a zone of thickened intramural coenozones above a squamulate zone, which in turn is above a zone of closely spaced tabulae. The zoning is evidently correlated with the death of the corallites at left of figure. Note the very slight rims about the mural pores, and the tabula, toward the bottom, which is shared by two corallites and which passes through a mural pore. Paratype (No. 21610). Genshaw formation, upper beds; locality 48. × 6
3. Cross section, showing thin walls and no squamulae at right of figure, moderately thick walls and squamulae at left of figure. Paratype (No. 21610). × 3
4. Enlarged longitudinal section, showing the production of an offset by peripheral increase, with the offset originally in communication with the parent corallite by a mural pore subsequently closed by a pore plate. Note the well-differentiated stereozone, primary wall, and intramural coenozone, narrow at base of figure but becoming wide toward top. The central part of the figure is in one of the heavily squamulate zones characteristic of the subspecies. Paratype (No. 21610). × 25
5. Polished section, showing prominent zones and flattened growth form. Holotype (No. 21616). × 1
6. View of uneven upper surface, showing corallites with little variation in size of adults. Holotype (No. 21616). × 1

# PLATE III

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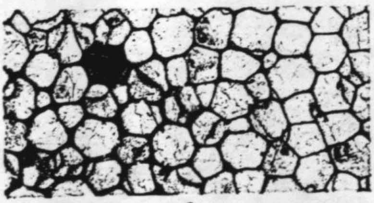

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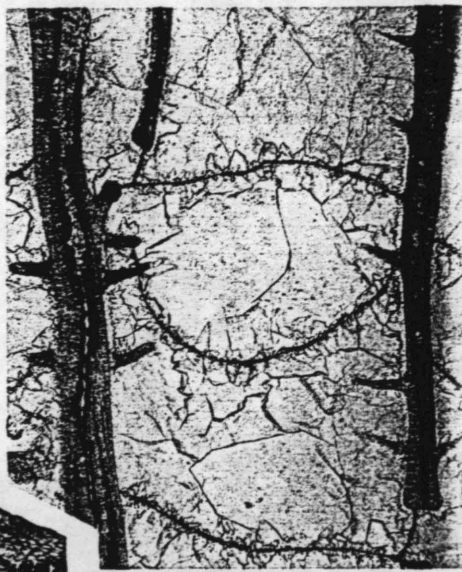

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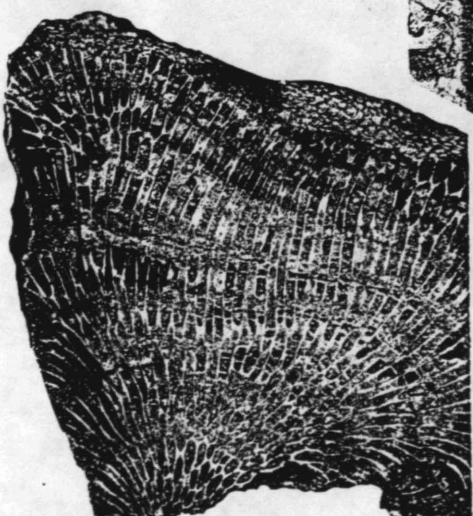

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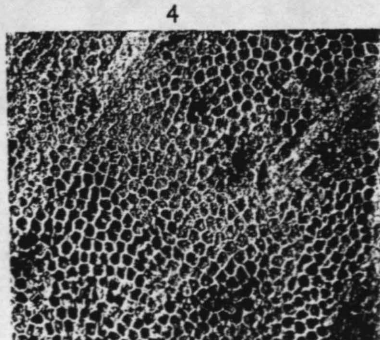

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# EXPLANATION OF PLATE IV

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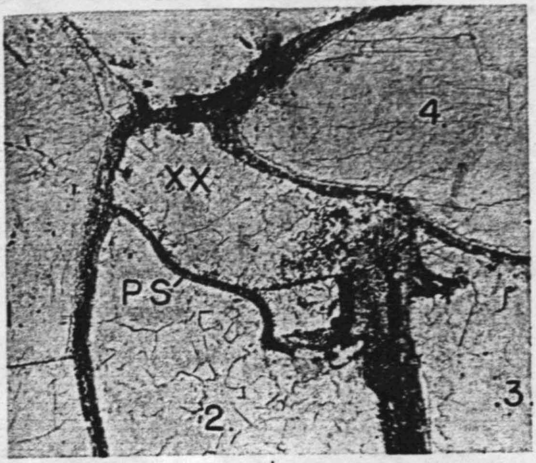
*Favosites alpenensis hindshawi* Swann, subsp. nov. ................ 279

1. Enlarged longitudinal section, showing pseudoperculum (PS) separating corallite 2 from the space XX, which is morphologically external to the corallum. Note that the pseudoperculum is homologous to half of the intercorallite wall and consists of a primary wall above and a peripheral stereozone below. Corallites 2 and 3 and others to the right, not shown in the figure, died at this point; corallites 1 and 4 continued growing and bent over above the dead portion of the colony, cutting off the extracorallite space XX. The boundary between 1 and XX is the outer wall of the colony and is identical in structure with the pseudoperculum. Paratype (No. 21562). Genshaw formation, lower beds; locality 58. × 25
2. Longitudinal section, showing gently curving corallites, thin walls, closely spaced round to transversely elongate mural pores, distantly spaced tabulae with tendency toward concavity, and no squamulae. Holotype (No. 19641). Genshaw formation, lower beds; locality 58. × 3
3. Surface, showing globose form, considerable variation in size of corallites, and relatively thin walls. Paratype (No. 21568). Genshaw formation, lower beds; locality 82. × 1
4. Longitudinal section, showing concave tabulae. Many structures in this section are thickened or obscured by silicification. Paratype (No. 21574). Genshaw formation, lower beds; locality 58. × 3
5. Cross section, showing subpolygonal corallites and walls, which are thin in axial region and thicken moderately toward periphery, but retain uniformly thin intramural coenozone. Paratype (No. 21581). Genshaw formation, lower beds; locality G 14. (See list of localities of A. W. Grabau, p. 313.) × 3

*Favosites alpenensis kellyi* Swann, subsp. nov. ..................... 281

6. Enlarged longitudinal section of thickened distal portions of walls, showing thin intramural coenozone and prominent stereozone with medium- to high-angled growth lamellae. See right margin of Plate V, Figure 1, and compare Plate V, Figure 2. Holotype (No. 21651). Rockport Quarry limestone; locality 29. × 25
7. Surface, showing irregular branching form and walls thickened at surface. The most prominent projection toward the observer is incrusted by a stromatoporoid. Paratype (No. 21649). Rockport Quarry limestone; locality 29. × 1

PLATE IV



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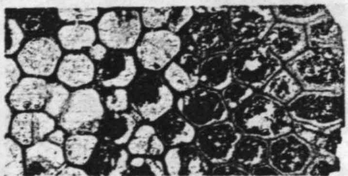
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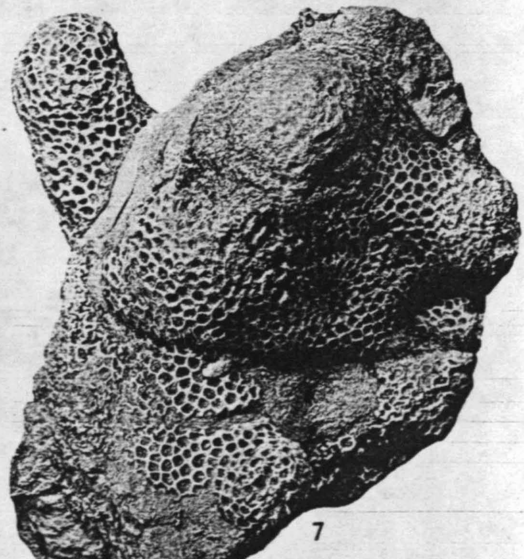
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# EXPLANATION OF PLATE V



1. Longitudinal section, showing gently curving corallites, walls that are thin in the axial region but greatly thickened at periphery, numerous incomplete tabulae, very few squamulae, and rather obscure zoning. Holotype (No. 21651). Rockport Quarry limestone; locality 29. × 3

2. Enlarged longitudinal section in the axial region, showing structure of thin walls in this region of corallum, pore plates across mural pores, and incomplete tabulae. The corallite in this section is cut near a corner and does not indicate the diameter of the normal corallite. See Figure 1, near the left margin, and compare Plate IV, Figure 6. Holotype (No. 21651). × 25

3. Cross section through axial portion of colony, showing polygonal corallites, thin walls, and numerous offsets and youthful corallites. Holotype (No. 21651). × 3

*Emmonsia emmonsii* (Rominger)

4. Enlarged longitudinal section, showing thick pale-yellowish or buff squamulae, connected by thin, dark-gray or black, suspended, irregular tabulae. Hypotype (No. 6302). Columbus limestone; northern Ohio, exact locality unknown. × 50

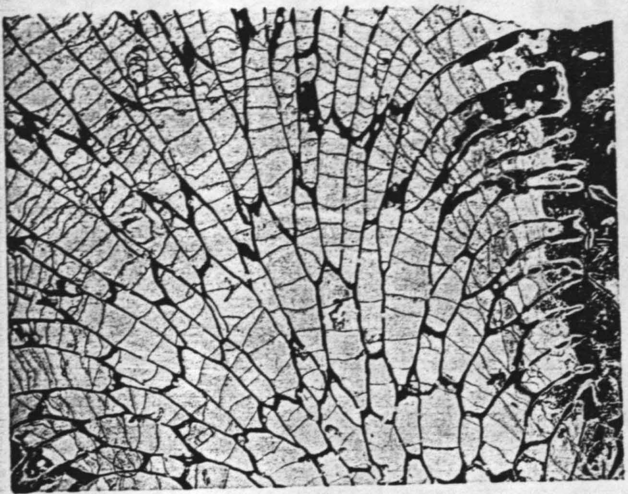
5. Enlarged longitudinal section of topotype of *Favosites alveolaris* (Goldfuss), Hall, 1843, showing that the "*planchers incomplets, obliques ou subvesiculeux*" of Edwards and Haime are formed of thick squamulae, connected by thin dark tabulae, which in this porous type of preservation are thickened by a druse of fine calcite crystals. The corallite to the left shows at this same level what appear to be complete tabulae, as the section is cut down the furrow between two rows of squamulae. Hypotype (No. 21613). Onondaga limestone; Fogelsonger's quarry, Williamsville, Erie County, New York. × 25

6. Enlarged cross section, showing one entire squamula and parts of several others in outline view, with a section across a thin highly inclined, suspended tabula. Hypotype (No. 6302). × 25



7. Enlarged longitudinal section taken in portion of colony with thin walls, showing structureless stereozone, mural pores without rims but with pore plates, and a broken and repaired tabula. Paratype (No. 21602). Genshaw formation, Killians limestone member; locality 114. × 25

PLATE V



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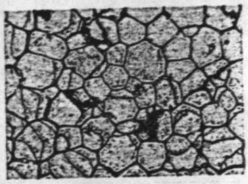

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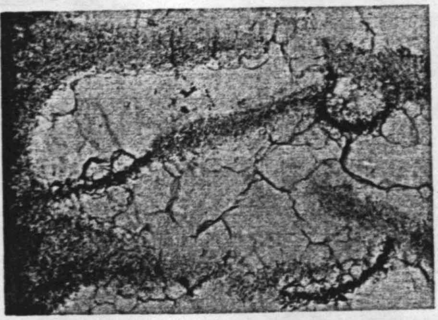

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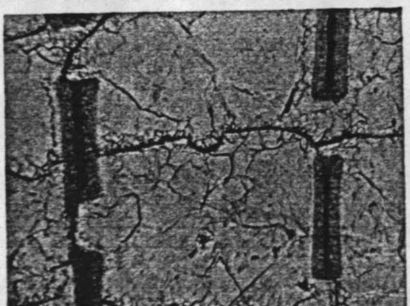

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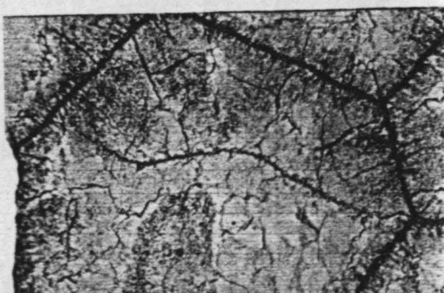

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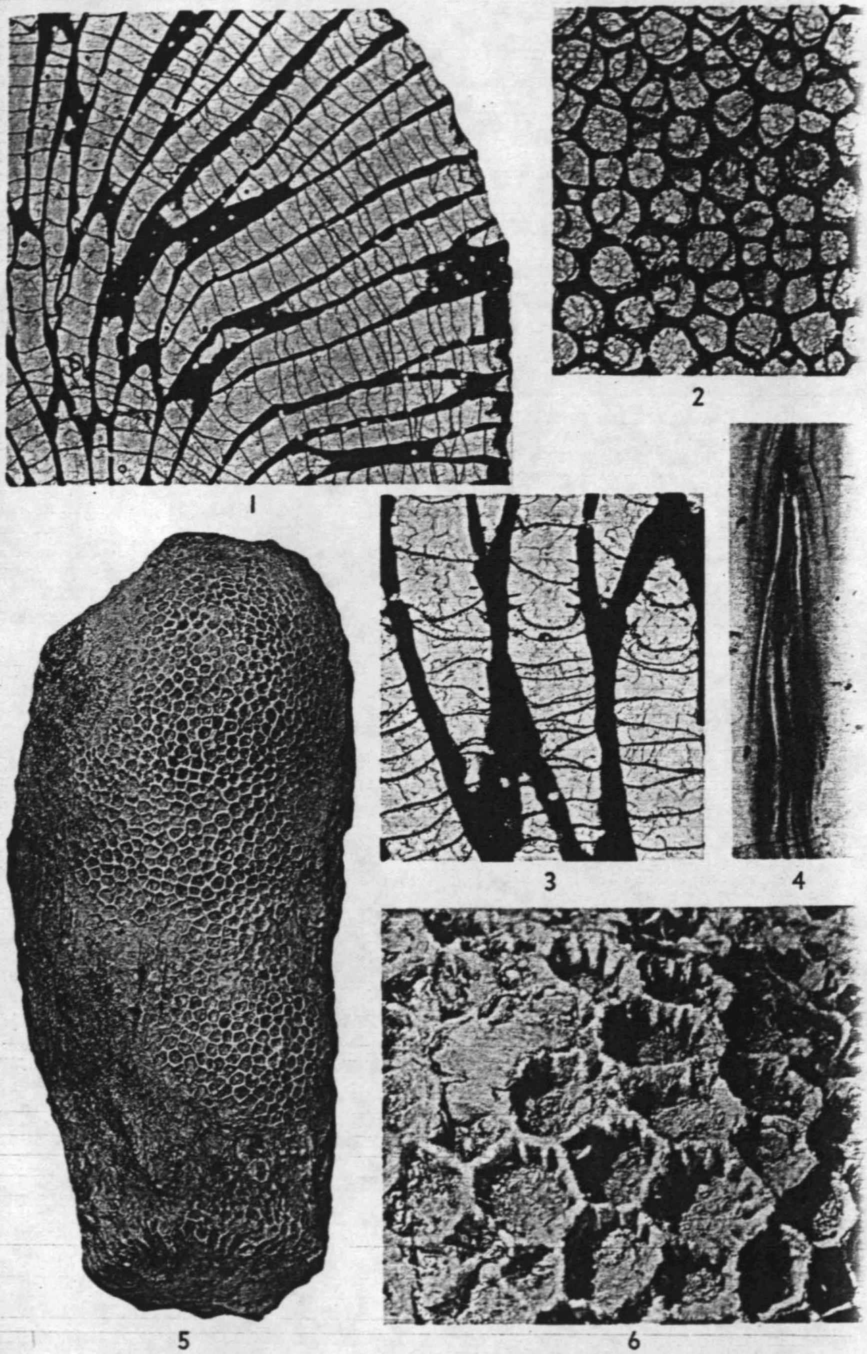
# EXPLANATION OF PLATE VI



1. Longitudinal section, showing moderately thick walls, predominantly complete tabulae, scarce squamulae, and uniserial or biserial mural pores. Holotype (No. 19642). Genshaw formation, Killians limestone member; locality 52. × 3
2. Cross section, showing rather large corallites. Twelve to sixteen very short squamulae project into the lumina of corallites in a thick-walled zone that crosses in an arc from the center of the right side to the lower left corner of the figure. Holotype (No. 19642). × 3
3. Longitudinal section, showing a zone of short peglike squamulae with tabulae suspended from them. Holotype (No. 19642). × 6
4. Enlarged longitudinal section of thickened wall, showing low- to medium-angled growth lamellae. Paratype (No. 19691). Genshaw formation, Killians limestone member; locality 52. × 25
5. Surface, showing elongate subcylindrical form, large corallites with little variation in size, and moderately thick walls. Paratype (No. 21565). Genshaw formation, Killians limestone member; locality 52. × 1
6. Surface of unique specimen, showing very large calices with septal striae occurring only on a small elevated portion of the surface. Figured specimen (No. 21625), not to be considered a paratype. Genshaw formation, Killians limestone member; locality 52. × 6

PLATE VI



# EXPLANATION OF PLATE VII

PAGE

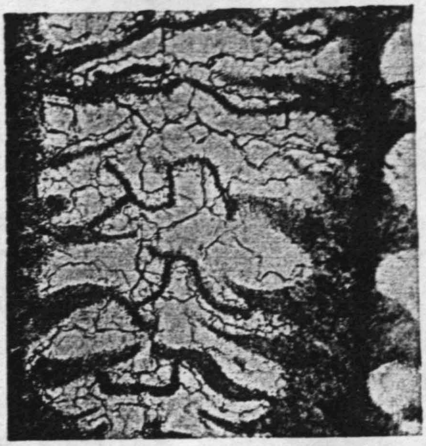
*Emmonsia emmonsii* (Rominger)

1. Enlarged longitudinal section, showing thick-based, tapering buff-colored squamulae of the same structure as the peripheral stereozone of the walls, and thin dark, incomplete or suspended tabulae. Hypotype (No. 6302). Columbus limestone; northern Ohio, exact locality unknown. × 25

*Favosites alpenensis peninsulae* Swann, subsp. nov. .................. 285

2. Surface of specimen attached to *Prismatophyllum sp.*, showing large, irregular, thin-walled corallites. Paratype (No. 21566). Ferron Point formation; locality 38. × 3
3. Longitudinal section, showing radiating corallites, rather widely spaced tabulae, zone of wall thickening correlated with death of corallites at right side of colony and overlying a squamulate zone, which in turn immediately overlies a zone of closely spaced tabulae. Holotype (No. 19637). Ferron Point formation; locality 38. × 3
4. Longitudinal section of specimen from the Silica shale of Ohio, showing thin walls, distant tabulae, mural pores with slight rims, and moderately abundant squamulae. Paratype (No. 19690). Silica shale; quarry of Sandusky Cement Co., a quarter of a mile north of Silica, Lucas County, Ohio (locality 59 of Miss Stewart, 1938). × 3
5. Cross section, showing thin-walled polygonal corallites and two round tubes of commensal "worms." Paratype (No. 21582). Ferron Point formation; locality 51. × 6
6. Enlarged longitudinal section of greatly thickened wall (for this subspecies), showing very obscurely the intramural coenozone at its thickest. Note the squamulae and the thin, rather distantly spaced tabulae. The walls at the top of this section are of the normal thickness for this form. See Figure 3, near upper left corner. Holotype (No. 19637). × 25

PLATE VII



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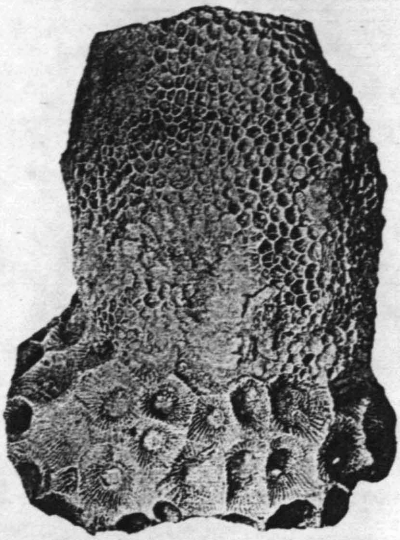

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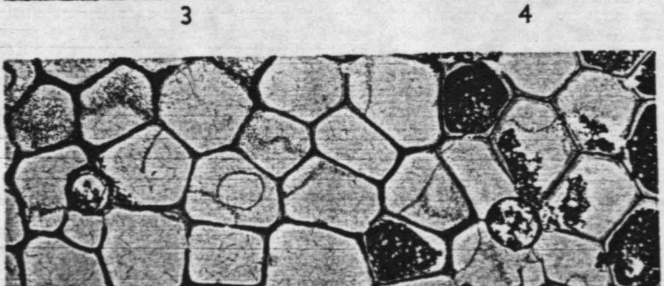

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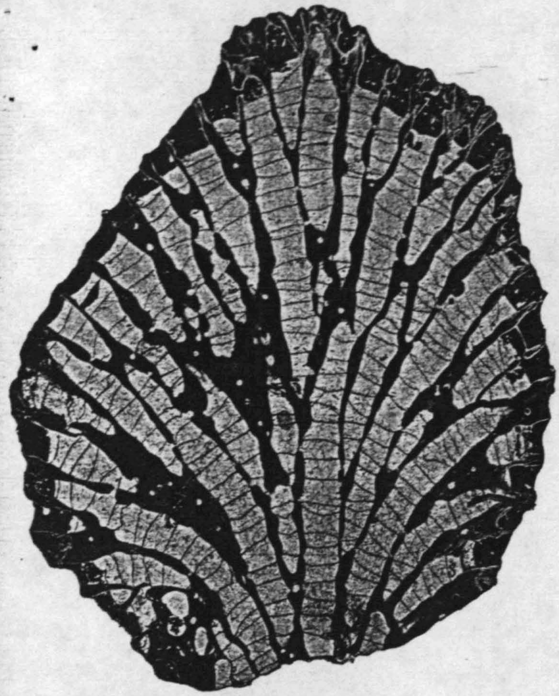
## EXPLANATION OF PLATE VIII

PAGE

*Favosites alpenensis praevigens* Swann, subsp. nov. .................. 287

1. Longitudinal section, showing radiating to gently curving corallites, thick undulating walls, complete tabulae, moderately abundant squamulae, and a commensal "worm" tube in the lower left-hand corner. Holotype (No. 21605). Gravel Point formation, zone 2 ("large Atrypa zone"), of Pohl (1930); locality 14. × 3
2. Cross section, showing rounded corallites, thick walls, and moderately abundant squamulae. Paratype (No. 21615). Gravel Point formation, zone 4, bed 3 ("coral bed"), of Pohl (1930); locality 14. × 3
3. Surface, showing variation in size of corallites and extremely thickened walls. Holotype (No. 21605). × 1
4. Longitudinal section, showing undulating walls and spiral tube of commensal "worm." Note the zone of short, pointed squamulae and the immediately underlying zone of closely spaced tabulae. Paratype (No. 21607). Gravel Point formation, zone 2 ("large Atrypa zone"), of Pohl (1930); locality 14. × 6
5. Enlarged longitudinal section, showing undulating walls, rather faint growth lamellae, and mural pore set in shallow pit. Holotype (No. 21605). × 25

## PLATE VIII



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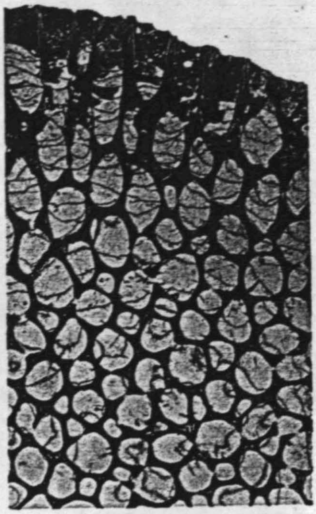

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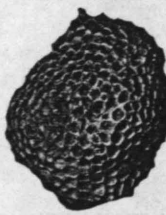

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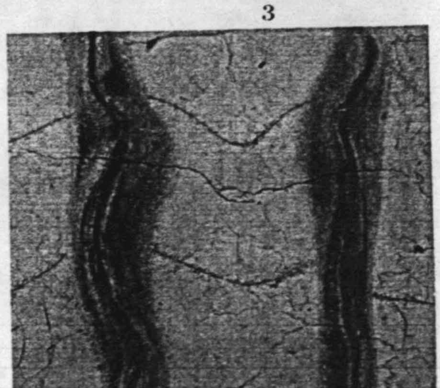

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# EXPLANATION OF PLATE IX

PAGE

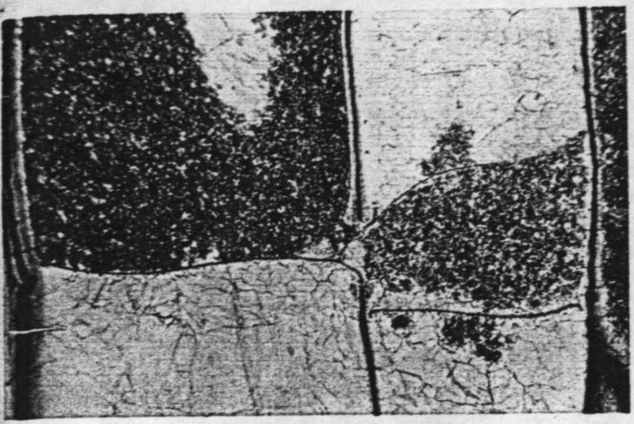
*Favosites alpenensis tenuimuralis* Swann, subsp. nov. ................ 289

1. Enlarged longitudinal section, showing thin walls, thin intramural coenozones, and thin tabulae. Paratype (No. 19679). Petoskey formation; locality 7c. × 25
2. Enlarged longitudinal section of wall, showing narrow intramural coenozone, dark primary walls, and peripheral stereozone with low-angled growth lamellae. Compare with a similar wall at the left-hand side of Figure 1, from the same portion of the same thin section, in which at 25 diameters the essential double nature of the central dark line is not shown. Paratype (No. 19679). × 100
3. Longitudinal section, showing large straight corallites, thin walls, complete tabulae that are strongly zoned, uniserial or irregularly biserial mural pores, and no squamulae. Holotype (No. 19662). Potter Farm formation; locality 89e. × 3
4. Longitudinal section of unique specimen, showing closely spaced and typically complete tabulae, and walls that at two places disappear to allow the fusion of adjacent corallites. Paratype (No. 19656). Potter Farm formation; locality 90. × 3
5. Cross section, showing large polygonal corallites with extremely thin walls. Holotype (No. 19662). × 3

*Favosites dumosa* Winchell ...................................... 291

6. Longitudinal section, showing axial zone with thin walls and very distantly spaced tabulae, opposed to peripheral zone of thick walls and closely spaced but typically complete tabulae. Note the sharp flexure of corallites between the two zones. Hypotype (No. 6356). Charlevoix formation; "Petoskey," probably locality 18 or 18a. × 3

# PLATE IX



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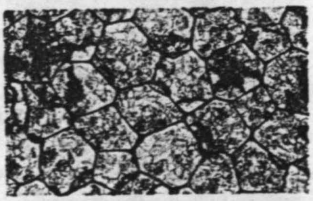

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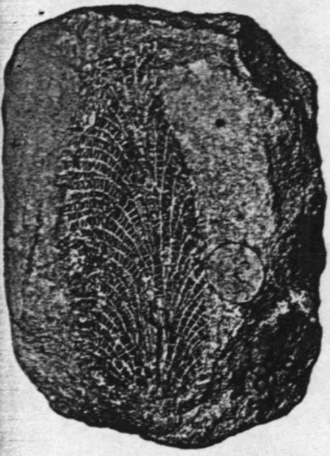
# EXPLANATION OF PLATE X

PAGE

*Favosites dumosa* Winchell . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 291

1. Natural longitudinal section, showing shape of corallum and distribution of tabulae. Syntype (No. 23121). Winchell's Pleurotomaria bed; locality 855. Charlevoix formation; locality 18a. × 1
2. Natural cross section, showing thin-walled axial region, which has been crushed to a breccia of fragments of walls and tabulae, and thick-walled peripheral region with closely spaced tabulae and mural pores set in pits. See also Plate XI, Figure 2. Syntype (No. 23122). Winchell's Pleurotomaria bed; probably Winchell's locality 855 or 856. Charlevoix formation; probably locality 18a or 18. × 2
3. Enlarged cross section, showing septal striae as undulations in the growth lamellae, and rather numerous tabulae. Hypotype (No. 6356). Charlevoix formation; "Petoskey," probably locality 18 or 18a. × 25
4. Natural longitudinal section, showing shape of corallum and distribution of tabulae and mural pores. This syntype of *Favosites hamiltonensis* Rominger, 1876, Plate VII, Figure 4, is here designated the lectotype of that species and a hypotype of *Favosites dumosa* Winchell, reducing Rominger's species to synonymy. The specimen is correctly oriented in the present figure; all figures in Rominger (1876) are reversed, left to right. Hypotype (No. 8452). Rominger's "limestone bluffs of Petoskey." Charlevoix formation; locality 18 or 18a. × 1
5. Longitudinal section (cross section of branches), showing three branches that fell over during growth. The polyps of the lower surface were killed; those of the upper surface remained alive and produced a coalesced layer of overgrowth. Note the thin walls and the few tabulae in the axial region, the thick walls and closely spaced tabulae in the peripheral region, and the intermediate walls and tabulae but small corallites in the zone of overgrowth. Hypotype (No. 6356). × 1

# PLATE X



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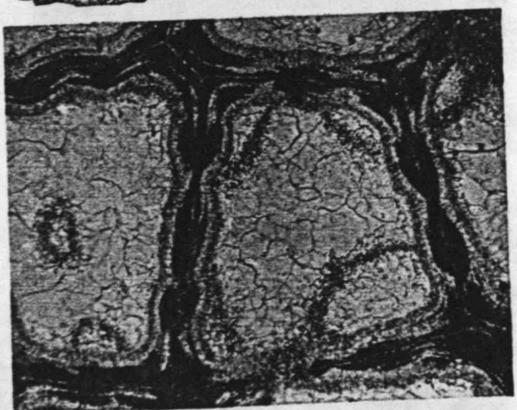

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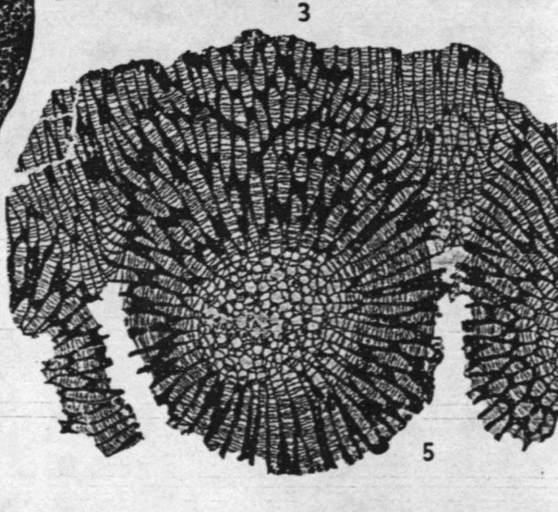

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# EXPLANATION OF PLATE XI

PAGE

*Favosites dumosa* Winchell ........................................ 291

1. Enlarged longitudinal section, showing rather narrow intramural coenozone (seen best in lower portion of photograph), prominent peripheral stereozone with high-angled growth lamellae, mural pores set in pits, and a pore plate in the upper pore. Hypotype (No. 6356). Charlevoix formation; "Petoskey," probably locality 18 or 18a. × 25

2. Surface, showing elongate shape, thick walls and rounded corallites of peripheral region, and thin walls and polygonal corallites of axial region seen in natural fracture at base. See also Plate X, Figure 2. Syntype (No. 23122). Winchell's Pleurotomaria bed; probably Winchell's locality 856 or 855. Charlevoix formation; probably locality 18 or 18a. × 1

*Favosites romingeri romingeri* Swann, sp. et subsp. nov. .............. 293

3. Cross section, showing rather thick walls and abundant short squamulae. Paratype (No. 21600). Potter Farm formation; locality 90. × 3

4. Cross section, showing particularly prominent squamulae. Paratype (No. 21594). Potter Farm formation; locality 42. × 3

5. Enlarged longitudinal section, showing thick intramural coenozone, short thin squamulae, and suspended tabulae. Paratype (No. 21606). Petoskey formation; locality 21. × 25

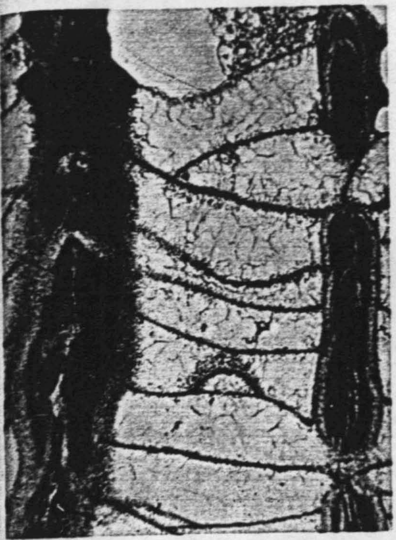
6. Longitudinal section, showing extremely abundant squamulae, complete or suspended tabulae, and rather obscure zoning. Paratype (No. 19666). Potter Farm formation; locality 68. × 3

*Favosites romingeri romingeri* Swann, sp. et subsp. nov., forma *pisum* Swann, forma nov. ............................... 296

7. Longitudinal section of corallum, showing cross section of cylindrical substratum, radiating corallites, thick walls, tabulae, abundant squamulae, and mural pores. Holotype (No. 21624). Potter Farm formation, about twenty feet above shale bed of locality 68; locality 89d. × 3

8. Section through specimen a short distance above attachment, showing rounded corallites, thick walls, and abundant squamulae. Paratype (No. 21620A). Potter Farm formation, about twenty feet above shale bed of locality 68; locality 89d. × 3

PLATE XI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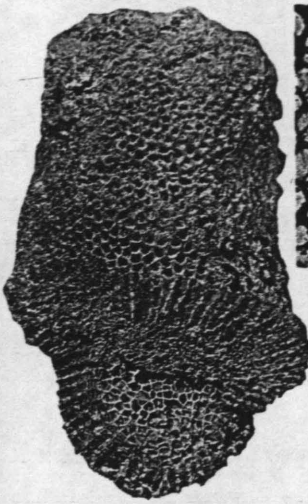
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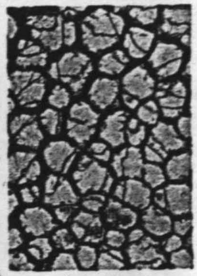
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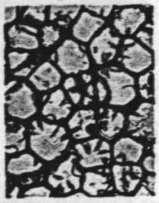
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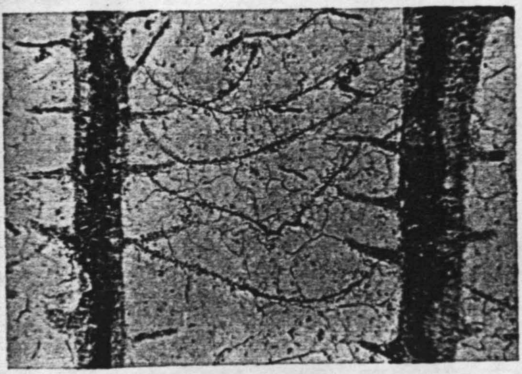
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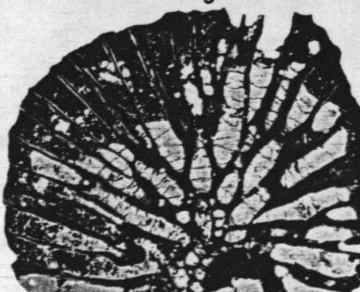
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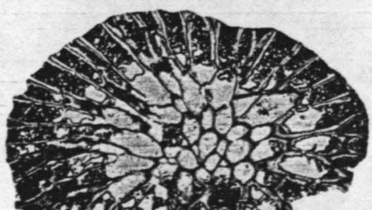
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# EXPLANATION OF PLATE XII

PAGE

*Favosites romingeri romingeri* Swann, sp. et subsp. nov. .............. 293

1. Surface, showing general form and thickened walls. See also Figure 2. This syntype of *Favosites hamiltonensis* Rominger, 1876, his Plate VII, Figure 3, is discarded in the designation of Rominger's other syntype as the lectotype, but is here selected as the holotype of *F. romingeri romingeri.* The specimen is correctly oriented in the present figure; all figures in Rominger (1876) are reversed, left to right. Holotype (No. 8451). Potter Farm formation; locality 90. × 1

2. Surface view of weathered portion near base of holotype, showing squamulae arranged in irregular vertical rows that bear no fixed relation to the mural pores. Rimmed mural pores are well shown in the figure, but are uncommon in this subspecies. Holotype (No. 8451). × 6

3. Enlarged longitudinal section, showing thickened wall with medium-angled growth lamellae, tabulae interrupted by or suspended from squamulae, and mural pore with pore plate. Paratype (No. 21603). Petoskey formation; locality 21. × 25

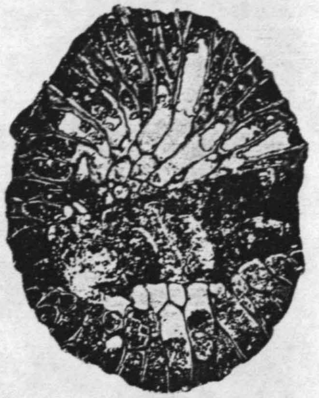
*Favosites romingeri romingeri* Swann, sp. et subsp. nov., forma *pisum* Swann, forma nov. ........................................ 296

4. Longitudinal section of corallum, showing longitudinal section of cylindrical substratum. Paratype (No. 21620B). Potter Farm formation, about twenty feet above shale bed of locality 68; locality 89d. × 3

5. Enlarged longitudinal section, showing surface of attachment to unknown substratum, walls with prominent peripheral stereozones, and numerous squamulae. Note that the space occupied by the substratum at the time of growth is now filled with shale, and that the lower surface of the colony is equivalent to half of the intercorallite wall. Paratype (No. 21619). Potter Farm formation, about twenty feet above shale bed of locality 68; locality 89d. × 25

6–8. Surface views of three specimens, showing spherical form and small calices roughly proportional in size to that of the specimen. Figure 8 is of the largest specimen of the forma collected. Figure 6, paratype (No. 21621); Figure 7, paratype (No. 21623); Figure 8, paratype (No. 21622). Potter Farm formation, about twenty feet above shale bed of locality 68; locality 89d. × 1

PLATE XII



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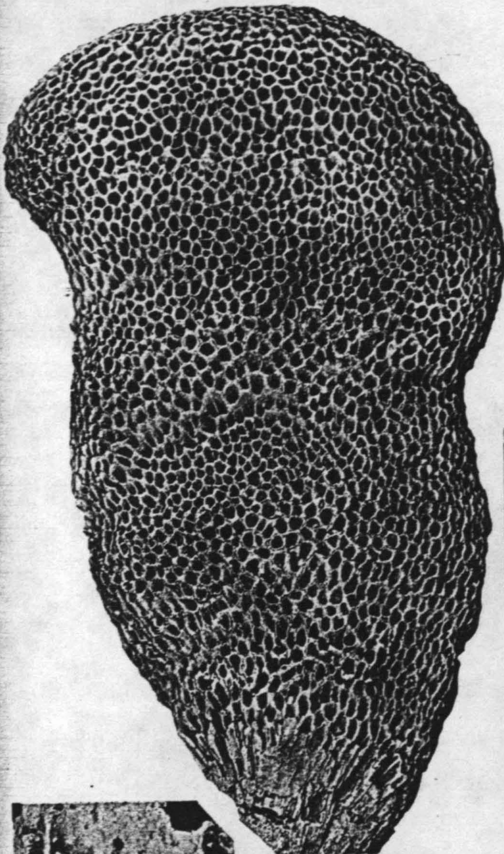

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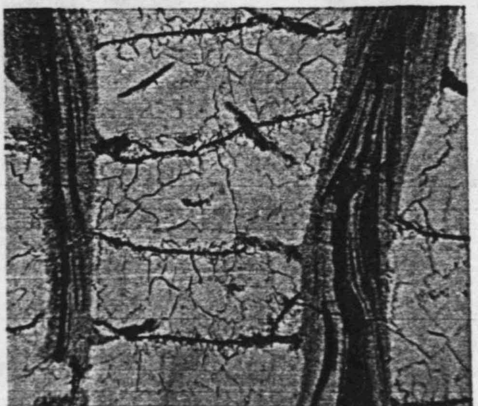

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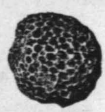

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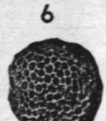

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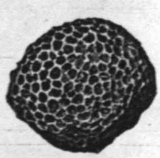

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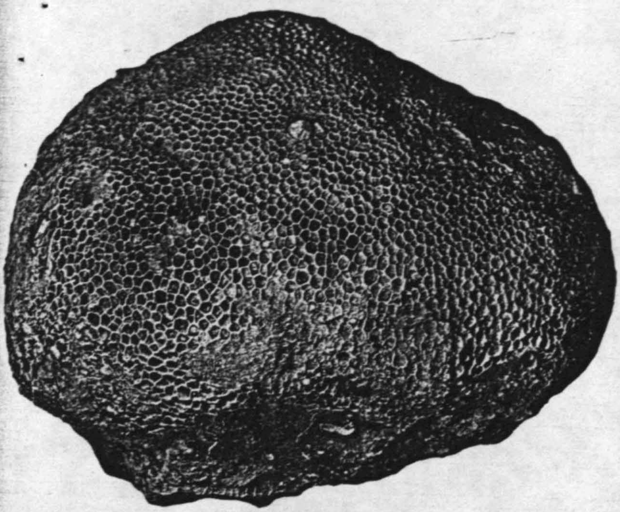
# EXPLANATION OF PLATE XIII

PAGE

*Favosites romingeri gilvisquamulata* Swann, subsp. nov. .............. 297

1. Surface view, showing flattened globose form, even surface, and corallites with little variation in size. Paratype (No. 21593). Thunder Bay limestone; locality 35. × 1
2. Cross section, showing polygonal corallites, thin walls, and very light-colored numerous squamulae. Holotype (No. 19670). Thunder Bay limestone; locality 35. × 3
3. Enlarged longitudinal section, showing wall with prominent dark line (composed of intramural coenozone and two primary walls but not differentiated in this view) and with extremely faint peripheral stereozone that extends outward as light buff-colored squamulae (light gray in photograph), short suspended or interrupted tabulae, and mural pores. See right-hand margin of Figure 5. Holotype (No. 19670). × 25
4. Longitudinal section, showing squamulae in the shaly plug of calices but only tabulae in the lower calcite-filled part of lumen, since the squamulae are too light in color to contrast with the crystalline calcite. Note the apparently broken tabulae in the lower part of the section and compare with Figure 3 to see that they are suspended from or interrupted by squamulae. Paratype (No. 19671). Thunder Bay limestone; locality 35. × 6
5. Longitudinal section, showing, in addition to features noted above, small widely spaced mural pores, zoning of tabulae and squamulae, tendency for tabulae to be concave, and peripheral increase. Holotype (No. 19670). × 3

PLATE XIII



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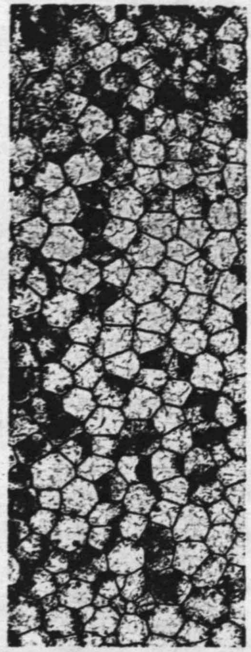

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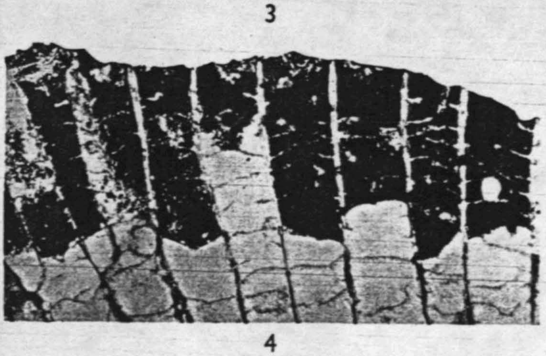

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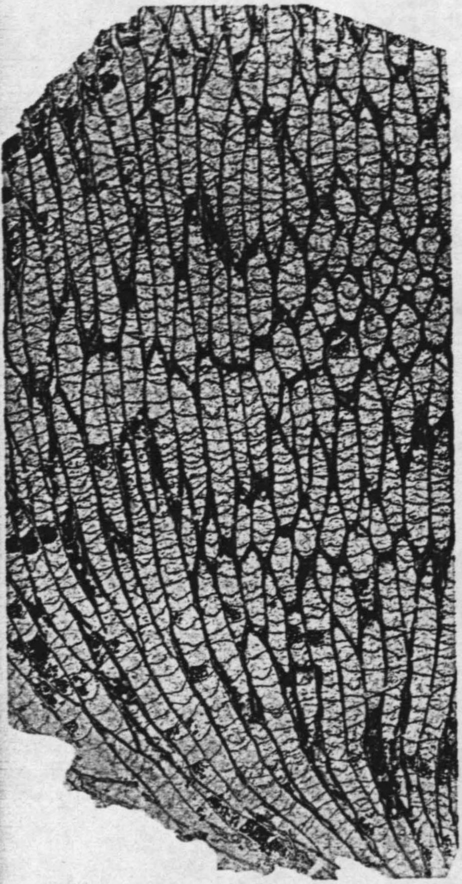
## EXPLANATION OF PLATE XIV

PAGE

*Favosites romingeri patella* Swann, subsp. nov. ........................ 299

1. Longitudinal section, showing rather small gently curving corallites, variable walls with intramural coenozone greatly enlarged in certain zones, numerous squamulae, and tabulae with strong tendency toward concavity. Holotype (No. 21591). Potter Farm formation; locality 68. × 3
2. Surface view of small specimen, showing patellate form and small corallites. Paratype (No. 21585). Potter Farm formation; locality 68. × 1
3. Enlarged cross section, showing greatly thickened intramural coenozone, faint peripheral stereozone, concave or irregular tabulae, and mural pores, two of which have pore plates. Paratype (No. 21583). Potter Farm formation; locality 68. × 25
4. Upper surface of a large specimen, showing rather small corallites, the neighboring ones being of nearly equal size, though there is considerable variation in size of corallites upon different areas of the surface. Paratype (No. 21596). Potter Farm formation; locality 68. × 1
5. Cross section, showing small corallites, thickened intramural coenozone and concave tabulae, each indicated as a concentric line within corallite wall. Holotype (No. 21591). × 3

PLATE XIV



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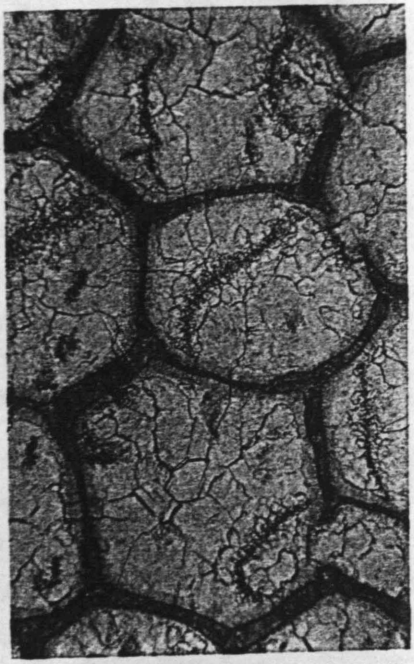

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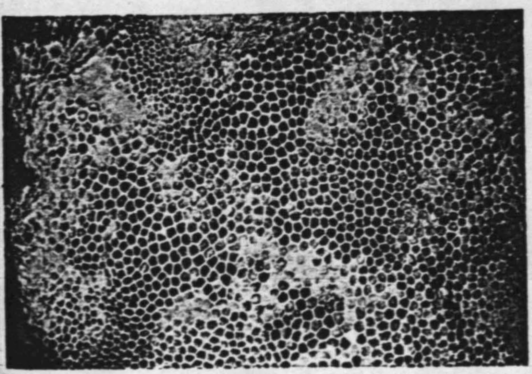

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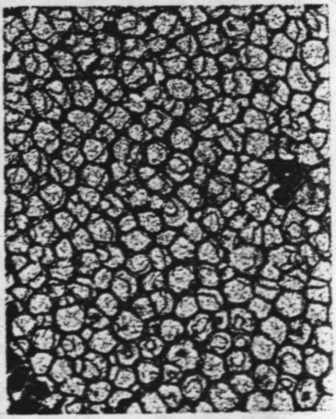

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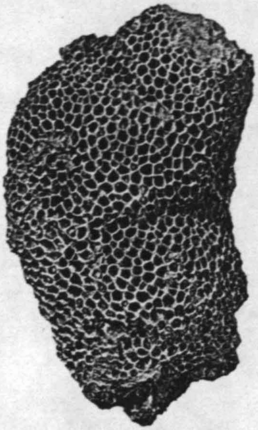
## EXPLANATION OF PLATE XV

PAGE

*Favosites romingeri saetigera* Swann, subsp. nov. .................... 300

1. Surface, showing rather elongate globose form. Holotype (No. 19674). Gravel Point formation, zone 6, bed 3 ("upper blue shale"), of Pohl (1930); locality 14e. × 1
2. Enlarged longitudinal section of wall, showing undulating coenozone and moderately thick stereozone with prominent but thin low-angled growth lamellae. Paratype (No. 19678). Gravel Point formation, zone 6, bed 3 ("upper blue shale"), of Pohl (1930); locality 18a. × 25
3. Longitudinal section from bioherm in Alpena limestone, showing features of specimens from type locality, as in Figure 6, and, in addition, prominent zoning of closely spaced tabulae and of squamulae. Paratype (No. 21609). Alpena limestone, bioherm in upper part of formation; locality 53. × 3
4. Cross section, showing rounded corallites, thickened walls, and numerous short squamulae. Holotype (No. 19674). × 3
5. Enlarged longitudinal section, showing prominent growth lamellae, relatively thick walls, short but abundant squamulae, complete tabulae, and mural pore set in shallow pit and obstructed by pore plate. Paratype (No. 19678). × 25
6. Longitudinal section, showing thick walls, widely spaced complete tabulae, and short, numerous squamulae. Holotype (No. 19674). × 3

# PLATE XV



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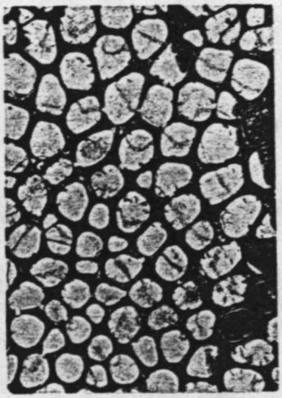

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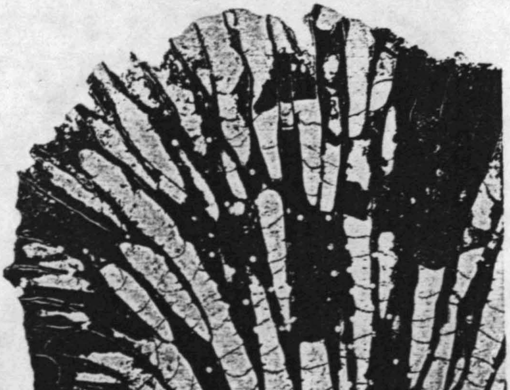

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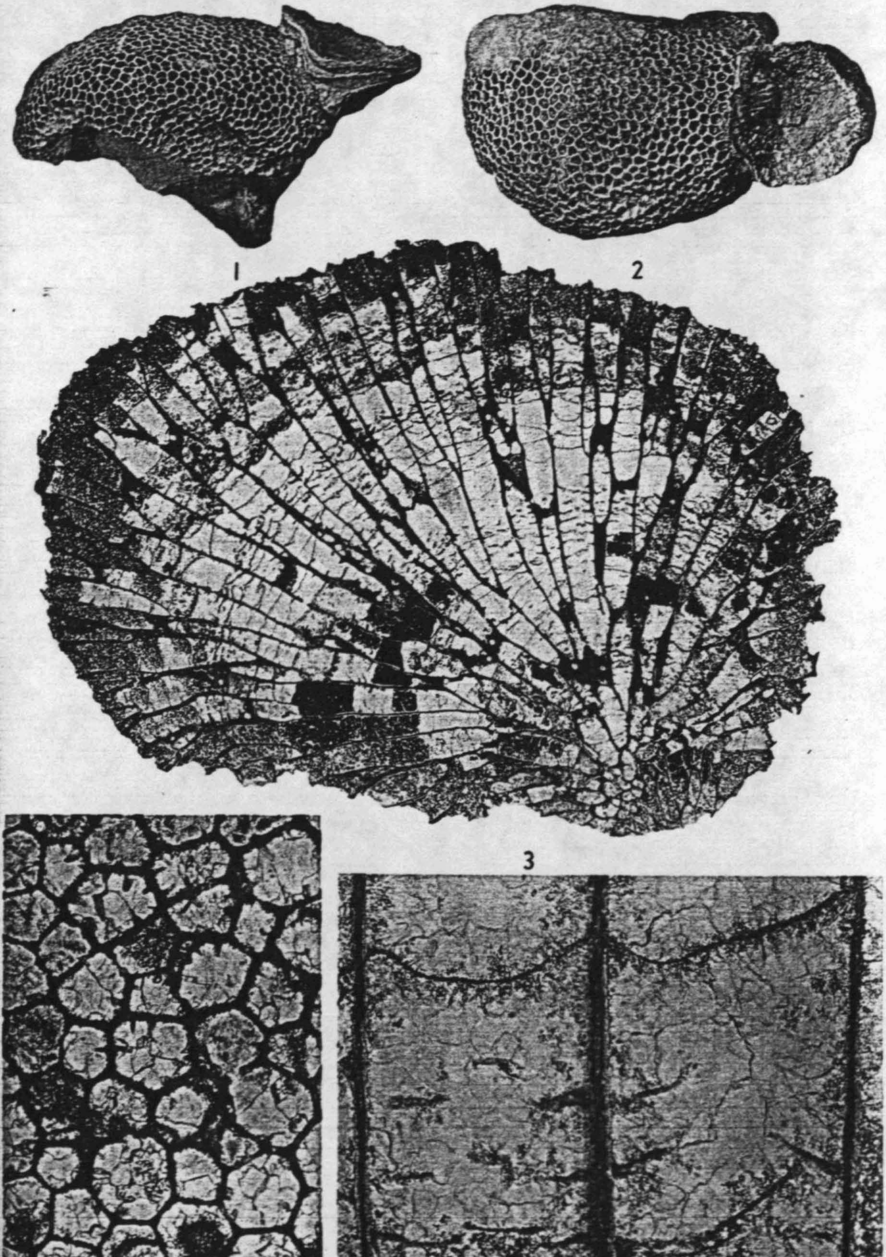
# EXPLANATION OF PLATE XVI



1. Lateral view of surface of specimen, showing flattened globose form. Paratype (No. 21563). Bell shale; locality 31. × 1
2. Superior view of surface of specimen depicted in Figure 1, showing even surface and corallites that are nearly equal in size. An incrusting bryozoan covers the upper left-hand corner, and a cup coral is attached to the right-hand side. Paratype (No. 21563). × 1
3. Longitudinal section, showing radiating corallites, thin straight walls, numerous squamulae, offsets indicating peripheral increase, and prominent zones of abundant squamulae and closely set tabulae. Holotype (No. 20661). Bell shale; locality 31. × 3
4. Cross section, showing thin-walled corallites with numerous rather short squamulae (seen best toward the top of the figure) and tabulae with a tendency toward concavity as noted by the lines concentric with, but inside, the corallite walls. Paratype (No. 21580). Bell shale; locality 55. × 6
5. Enlarged longitudinal section in a heavily squamulate zone, showing thin walls with variable coenozone, quite thin stereozone, straight, pointed squamulae, and concave tabulae. Paratype (No. 21575). Bell shale; locality 38. × 25

PLATE XVI



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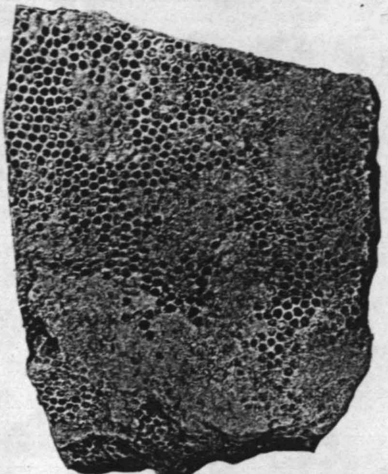
# EXPLANATION OF PLATE XVII



1. Surface, showing thick-walled corallites, all very similar in size. Paratype (No. 21608). Four Mile Dam limestone; locality 41. × 1
2. Longitudinal section, showing straight corallites, small mural pores, abundant squamulae, very prominent zoning, and tabulae which are here less concave than in many other specimens. Holotype (No. 19649). Four Mile Dam limestone; locality 41. × 3
3. Enlarged longitudinal section, showing walls with wide but variable intramural coenozone, pointed, curved squamulae, thin tabulae, and mural pore set in pit. Paratype (No. 21608). × 25
4. Cross section, showing rounded corallites and linguiform squamulae. Paratype (No. 21590). Four Mile Dam limestone; locality 76. × 3
5. Cross section, showing rounded corallites, thick walls that are amalgamate toward lower left-hand corner of the section, and concave tabulae. Paratype (No. 21608). × 6
6. Enlarged longitudinal section of wall in ordinary light, showing wide intramural coenozone, thin dark primary walls, and fibrous peripheral stereozones. Paratype (No. 21608). × 50
7. Wall section of Figure 6, photographed in plane polarized light, the direction of polarization being at right angles to the wall length. The stereozone shows relatively less relief than in ordinary light, indicating that the refractive index of the ray penetrating it is close to that of Canada balsam ($n = 1.54$) and that this ray is therefore the extraordinary ray ($\epsilon = 1.486$, a minimum reached only under perfect orientation) rather than the ordinary ray ($\omega = 1.658$, constant regardless of orientation). Since the extraordinary ray lies in the plane of the *c*-axis, the *c*-axes of the felted calcite fibers of the stereozone must be nearly parallel to the direction of polarization and thus approximately normal to the wall. This implies deposition of the stereozone by a vertical surface parallel to the wall. Conversely, the darkened coenozone indicates statistically vertical *c*-axes of the microcrystals forming it and implies deposition by a horizontal surface. Paratype (No. 21608). × 50
8. Wall section of Figure 6, photographed in plane polarized light, the direction of polarization being parallel to the wall length. The stereozone is here relatively darker and the coenozone lighter than in ordinary light. Paratype (No. 21608). × 50
9. Wall section of Figure 6, under crossed Nicol prisms, parallel and at right angles to wall length. The coenozone is in extinction, but the parallelism of the fibers of the stereozone is so slight that little tendency toward extinction is shown. Paratype (No. 21608). × 50
10. Wall section of Figure 6, under crossed Nicol prisms, inclined 45 degrees to wall length. There is no trace of extinction in either coenozone or stereozone. Paratype (No. 21608). × 50

# PLATE XVII



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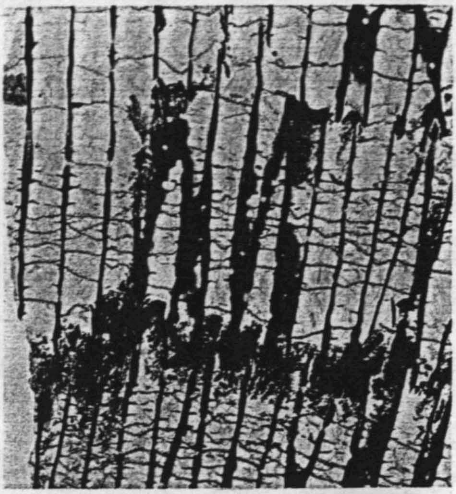

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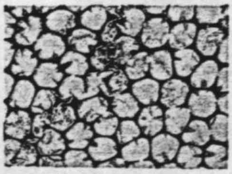

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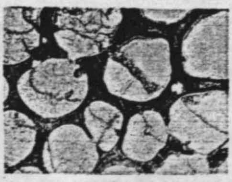

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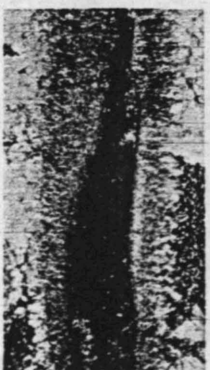

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