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CONTRIBUTIONS TO THE GEOLOGY AND PALEONTOLOGY OF THE CANAL ZONE, PANAMA, AND GEOLOGICALLY RELATED AREAS IN CENTRAL AMERICA AND THE WEST INDIES

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ON SOME FOSSIL AND RECENT LITHOTHAMNIEAE OF THE PANAMA CANAL ZONE

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ON SOME FOSSIL AND RECENT LITHOTHAMNIEAE OF THE PANAMA CANAL ZONE.

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INTRODUCTION.

The following report is based chiefly upon a number of specimens of fossil calcareous algae, of the group known to geologists as "Nullipores," from Oligocene and Pleistocene strata in the Panama Canal Zone, collected in 1911 by D. F. MacDonald and T. W. Vaughan, of the United States Geological Survey.

In this material the Pleistocene period is represented by a single collection (MacDonald, 6039), consisting of numerous excellent free specimens, "from flats near Mount Hope, five feet above tide level." These Pleistocene specimens appear to the writer to belong to a species found by him a year or two earlier to be living in the Colon region, only a few kilometers distant. This species, so far as the writer can determine, has been hitherto undescribed; in framing its diagnosis, as published below, the fossil as well as the recent material has been considered, but a recent specimen, being more complete and satisfactory for detailed study, has been named as the technical type of the species.

So far as the present writer has been able to discover, the fossil coralline algae of America, in their taxonomic aspects at least, offer a practically untouched field for research. It is, of course, possible that geological and paleontological papers in which calcareous algae have been described have escaped the attention of phycologists, but inquiry among American geologists and paleontologists and a search of accessible literature have thus far revealed to the writer but a single [1] hitherto described species of fossil Lithothamnieae from the Western Hemisphere, namely, *Lithothamnium curasavicum* K. Martin, from the Island of Curaçao, a species to which further allusion is made below in the discussion of *Archaeolithothamnium episporum.*

[1] *Stromatopora compacta* Billings (Palaeozoic Fossils, vol. 1, p. 55, 1862) from the Island of Montreal, etc., has sometimes been considered by geologists to be of corallinaceous affinities (the species has been referred to *Solenopora* by Nicholson and Etheridge, Geol. Mag., vol. 3, p. 529, 1885), but, if we may judge from published figures, the organism seems to the writer hardly a coralline alga, if indeed it is an alga at all.

The fossil Lithothamnieae of Europe have been described and figured in considerable number and with various degrees of care and detail. Most of these European descriptions and figures the writer has been able to see; some of them offer a reasonable basis for the future recognition of the forms concerned, without a reexamination of the original materials, but many of them do not. The present writer has had access to a good representation of the living Lithothamnieae of North America, the West Indies, Europe, and the East Indies, but so far as the fossil forms are concerned, he has had to depend upon descriptions and figures alone, which, as stated above, are often very unsatisfactory. In venturing to propose as new, two species of Lithothamnieae from Oligocene strata of the Panama Canal Zone, he doubtless risks the possibility that some future investigator, working with better materials or even with the same, may be able to convince himself or even to prove conclusively, that one or both of said species should be considered identical with species previously described from Europe. The diagnostic characters, the limits of variation, and the geographic range of even the living species are still very imperfectly understood. Some of the species are evidently widely distributed within certain temperature limits; others are at present known from single localities. So far as may be inferred from our present knowledge, very few, if any, of the forms of Lithothamnieae now living in tropical America occur also in European waters.

List of Species and Their Geologic Occurrence.

Archaeolithothamnium episporum, new species. Recent, Toro Point; and Pleistocene, Mount Hope; both in the Canal Zone.

Lithothamnium vaughanii, new species, Oligocene, Culebra formation at station 6026, about half way between Monte Lirio and Bohio Ridge.

Lithothamnium isthmi, new species, Oligocene, Emperador limestone at stations 6021, about 4 miles north of Gamboa Bridge, and 6024–*b*, Rio Agua Salud, Panama Railroad (relocated line).

Lithoporella melobesioides (Foslie) Foslie, Oligocene, Emperador limestone at station 6024–*c*, Rio Agua Salud, Panama Railroad (relocated line).

ARCHAEOLITHOTHAMNIUM[1] EPISPORUM, new species.

Plates 1 to 6.

Brownish red when living, the thallus forming at first widely expanded crusts 0.25–1.0 mm. thick, these in many cases repeatedly overgrown, the resulting crusts becoming 5 mm. or more thick, sometimes remaining nearly smooth or exhibiting the irregularities of the

[1] We follow Rothpletz's original spelling of the final syllable of this unfortunately long name, a spelling that, happily, agrees with Philippi's spelling of the final syllable of *Lithothamnium*.

substratum alone, but more often developing coarse, irregular rounded excrescences 5–12 mm. in diameter, or short rounded verrucae or nodules 2–5 mm. in diameter, the surface in sterile parts mostly smooth, indurated, and occasionally subnitent; hypothallia varying from weakly to strongly developed, 30–170 μ thick, their cells 17–28 μ by 8–11 μ; cells of the perithallium in distinct and regular layers except in oldest and youngest parts, the layers in more or less distinct zones, layers of short and of long cells occasionally alternating, cells mostly 8–15 μ by 5–8 μ, in decalcified condition submoniliate, sphaeroidal to ellipsoidal, 1–2½ times as high as broad, in calcified condition mostly subquadrate or oblong in vertical section; sporangia superficial, their apicula even with the surface, or slightly protruding, their cavities becoming only imperfectly and irregularly embedded, the sori slightly elevated, very irregular in outline, mostly 0.1–1.0 mm. broad, often widely confluent and anastomosing and becoming 5 mm. or more broad, the surface at length whitish and scarious, the ostioles mostly 16–22 μ in diameter, sporangia 65–96 μ high (including apiculum), 27–50 μ broad, 4-partite (occasionally 2-partite?), the spores irregularly paired or rarely subzonate.

Localities and geologic occurrence.—Covering dead corals, etc., and often forming concretionary pebbles with coral cores, from low-water mark to a depth of several meters, Point Toro, near Colon, Panama Canal Zone, Howe 6832 (type, in Herb. N. Y. Bot. Gard.), January 7, 1910; Colon, Howe 6840 (this covers continuously a mass of old coral 32 cm. long and 14 cm. in greatest width); also, as a Pleistocene fossil, "from flats near Mount Hope, five feet above tide level," D. F. MacDonald, station 6039,[1] 1911.

Paratypes.—Cat. No. 35298, U.S.N.M.

In outward form and in its habit of overgrowing old corals, *Archaeolithothamnium episporum* resembles *A. erythraeum* (Rothpletz) Foslie, f. *durum* (Heydrich) Foslie, from the Red Sea and the East Indies, especially as illustrated by Weber-van Bosse and Foslie (Corallinaceae of the *Siboga* Expedition, pl. 5). Of this species we have seen only one specimen (from near Makassar), communicated by Mme. Weber-van Bosse, but from this and from the descriptions and figures of *A. erythraeum* published by Foslie, Heydrich, and Lemoine, we infer that the Panamanian specimens represent a different species. Perhaps the most important distinctive character of *A. episporum* is to be found in its more superficial sporangia, as may be seen by comparing our photographs (pl. 2, fig. 1; pl. 3) with Heydrich's figure[2] of a vertical section through a sporangial sorus of his

[1] This is associated with minor amounts of other crustaceous corallines, including *Lithophyllum*, species, and *Goniolithon*, species.

[2] Ber. Deuts. Bot. Ges., vol. 15, p. 68, fig. 2. 1897.

Sporolithon ptychoides, which Foslie[1] and Lemoine[2] consider to be synonymous with *A. erythraeum*. The sori or the emptied sporangial cavities appear also to be much less regularly embedded or overgrown by new tissue than is the case in *A. erythraeum*, if one may judge from Rothpletz's original description,[3] Heydrich's figure 3,[4] Lemoine's figure 29,[2] and the descriptions given by the last-named writers; however, Foslie[5] remarks of *A. erythraeum* that "the sori are partly to be found overgrown in great numbers by new formed tissue, partly, however, they are not to be seen in section." In *A. episporum*, the sporangia themselves have never been seen except close to the surface; the emptied sporangial cavities do not show in a rough fracture or in an ordinary ground section, but irregular traces of them are often to be found in thin microtome sections of decalcified material. The sori of *A. episporum* are so superficial that their covering, after the discharge of the spores, appears to die and is flaked off together with more or less of the intersporangial parts, and the new tissue growing up from the base of the sorus shows only occasionally and imperfectly the outline of the former sporangial cavities.

Rothpletz's original description of his *Lithothamnium erythraeum* leaves one in some doubt as to whether he found the contents of the sporangium divided or undivided; he uses the term "Tetrasporen," but the measurements that he gives for these "Tetrasporen" are such as commonly belong to the whole sporangium in this group. In Heydrich's first description[6] of his *Sporolithon ptychoides*, the "Tetrasporangien" are said to be "meist ungetheilt, selten zweitheilig," but a little later[7] he figures four tetraspores in a sporangium, arranged in the "cruciate" manner. But this mode of division being at variance with the prevailing ideas as to the arrangement of the spores in the Corallinaceæ, Foslie,[8] a little later in writing a diagnosis of the genus *Archaeolithothamnium* inserted a question mark after "sporangia * * * unparted or cruciate?" and this sign of doubt as to the cruciate division has been repeated by later writers.[9] In *A. episporum* the mature sporangia are commonly and normally 4-parted in an irregularly "cruciate" fashion, but often the division axes of the two pairs of spores are at right angles to each other, so that only three spores are visible in a lateral view, and occasionally

[1] *Siboga* Exped. Monog., No. 61, p. 38. 1904.
[2] Ann. Inst. Océanog., vol. 2, pt. 2, p. 67. 1911.
[3] Rothpletz, A. Bot. Centralb., vol. 54, p. 5. 1893.
[4] Ber. Deuts. Bot. Ges., vol. 15, p. 68. 1897.
[5] *Siboga* Exped. Monog., No. 61, p. 41. 1904.
[6] Ber. Deuts. Bot. Ges., vol. 15, p. 69. 1897.
[7] Idem, pl. 18, fig. 3.
[8] Kgl. Norske Vidensk. Selsk. Skr. 1900, pt. 5, p. 8. 1900.
[9] De Toni, Syll. Alg., vol. 4, p. 1721, 1905; Svedelius, in Eng. & Prantl, Nat. Pflanzenfam., vol. 1, pt. 2; Nachtsäge, p. 267. 1911.

the second divisions seem to be omitted and the sporangium is apparently mature with only two spores. Very irregular types of division also occur, and rarely one finds an approach to the zonate [1] arrangement characteristic of most of the Corallinaceae.

The perithallic cells of *A. episporum* appear to be, in the decalcified state, more rounded and in more moniliform filaments than is the case in *A. erythraeum*, as may be seen by comparing our photomicrograph [2] with the photomicograph of a presumably decalcified section of *A. erythraeum*—published by Lemoine.[3] The distinct stratification of the perithallium of *A. episporum* is due, in part, to the alternation of layers of long and short cells, but we have never seen in the Panamanian species any such striking alternation of long and short cells as is shown in this photograph published by Mme. Lemoine and as is shown still more emphatically in Heydrich's figure 3 [4] of a vertical section of his *Sporolithon ptychoides*.

From *Archaeolithothamnium dimotum* Foslie and Howe,[5] the only living species of this genus previously described from the West Indian region, *A. episporum* differs widely in its thicker crusts, in its more superficial sporangial sori, which are for the most part exfoliated after maturity of the sporangia and are only obscurely and imperfectly overgrown, in the usually larger, more rounded, and more moniliately arranged cells of the perithallium, the larger and rather less widely separated sporangial ostioles, etc.

Archaeolithothamnium curasavicum (K. Martin) Foslie,[6] a Cretaceous fossil from the island of Curaçao, is described and figured as showing distinctly rows of embedded sporangial cavities, such as would not be seen even in a thin decalcified section of *A. episporum*.

A Pleistocene fossil, collected by MacDonald at station 6039, from flats near Mount Hope, came from a few kilometers from the localities where we found the plant living, and we can entertain no serious doubt as to the specific identity of the recent and the fossil forms. The living and fossil are similar in external habit, as may be seen by comparing plates 1 and 4. They are similar also in their relations to old corals, and in structure (compare fig. 1, pl. 2, and fig. 4, pl. 5) they appear to exhibit only such differences as may be ascribed to individual variation or as may be expected in comparing the recent or living with the long dead. But little remains of the fossil speci-

[1] Zonately 4-parted sporangia have been described by Foslie for the Californian *Archaeolithothamnium zonatosporum* (Foslie, Algologiske Notiser. II. Kgl. Norske Vidensk. Selsk. Skr., 1906, pt. 2, p. 14), so that it would appear that this genus exhibits a wide variety in the matter of division of its sporangia.

[2] Plate 3, fig. 2.

[3] Ann. Inst. Océanog., vol. 2, pt. 2, pl. 1, fig. 1. 1911.

[4] Ber. Deuts. Bot. Ges., vol. 15. 1897.

[5] Bull. N. Y. Bot. Gard., vol. 4, p. 128, pl. 80, fig. 1; pt. 87, 1906.

[6] *Lithothamnium curasavicum* K. Martin, Bericht über eine Reise nach Niederländisch West-Indien und darauf gegründete Studien. II. Geologie, p. 26, pl. 2, figs. 22–25, 1888.

mens after decalcification, though the outlines of the cells may be recognized here and there. As microtome sections of the decalcified fossil material are out of the question, comparisons of structure of the recent and fossil must naturally be based upon calcareous ground sections. And in comparing the cell structure in sections of the recent decalcified specimens (pl. 3) with that shown in ground sections of the calcareous fossils, it is necessary, of course, to bear in mind that cells in calcareous ground sections of the Corallinaceae commonly appear much more rectangular than in decalcified sections of the same material.[1] In the sections of the fossil material thus far made there are no certainly recognizable traces of sporangial cavities, but this is true in almost an equal degree of calcareous ground sections of the recent specimens except as to the surface of the plant (fig. 1, pl. 2), where the sori are, in fact, so decidedly superficial or even exserted that they could, perhaps, hardly be expected to persist in the fossil state.

In the same locality with the type-specimens (Howe 6832) there occurs an outwardly somewhat similar plant (Howe 6837) that we at first suspected to be the antheridial form of *A. episporum*, but certain recognizable, though possibly unimportant, differences in the form, size, and zonation of the perithallic cells have restrained us from so considering it. The antheridial conceptacle (cavities) in this 6837 are 64–95 μ broad and 60–72 μ high; they become copiously embedded by the continued upward or outward growth of the thallus.

LITHOTHAMNIUM[2] VAUGHANII, new species.

Plate 7, figs. 1 and 2, and plate 8.

Thallus forming at first expanded crusts 1–2 mm. thick, these becoming overgrown, irregularly stratified, and 10 mm. or more thick, developing finally numerous, rather coarse, crowded anastomosing branches, and forming masses 2–4 cm. or more high; branches mostly 3–12 mm. in diameter, usually much flattened, occasionally subterete, often reduced to anastomosing ridges, or sometimes appearing as dome-shaped elevations 2 cm. or more broad; primary hypothallia somewhat reduced, their cells 14–33 μ by 8–14 μ, rather irregularly arranged (i. e., not distinctly "coaxial"), cells of medullary hypothallia mostly 15–30 μ by 5–13 μ, secondary hypothallia numerous and thin; branches showing in section numerous narrow irregularly flexuous, often subelliptic-lenticular or subcrescentic zones caused by

[1] For illustrations of these differences, see Lemoine, Ann. Inst. Océanog., vol. 2, pt. 2, p. 45, figs. 19–21, 1911.

[2] The writer believes, with Mme. Paul Lemoine, that the current rules of nomenclature require that Philippi's original spelling of this generic name should be respected, even though prevailing usage has modified the final syllable. Whether the rules of nomenclature justify the use of this generic name for any of the species now bearing it is a more complicated question.

the alternation of layers of short and long perithallic cells, or by the interpolation of reduced secondary hypothallia; the larger perithallic cells mostly 13–22 μ by 11–14 μ., usually higher than broad, the smaller subquadrate, about 8 μ square, or sometimes much compressed (7 μ high, 14 μ broad); conceptacles becoming embedded; tetrasporic conceptacles much flattened, oblong or elliptic-oblong in radio-vertical section, the cavity 500–740 μ in maximum width, 130–230 μ in height; roof of the tetrasporic conceptacle rather sharply defined, its cells in regular vertical rows of 1–4 cells, often elongate vertically, becoming sometimes 25–30 μ high.

Locality and geologic occurrence.—Oligocene, Culebra formation, "about half way between Monte Lirio and Bohio Ridge, on the relocated line of the Panama Railroad," collected by D. F. MacDonald and T. W. Vaughan, 1911 (station No. 6026).

Holotype and paratypes.—Cat. Nos. 35299, 35300, U.S.N.M.

The specimens obtained are more or less embedded in a hard rock matrix, so that our photograph (fig. 1, pl. 7) can give only an imperfect idea of the outward form of the plant. With a little mental clearing away of the matrix, it seems probable that in size and external appearance, the species may be compared with rather coarse eroded conditions of the living *Lithothamnium glaciale* Kjellman, but there is little similarity in structure; the perithallic cells of *L. vaughanii* average considerably larger than those of *L. glaciale* and they are arranged in more distinct layers; the embedded tetrasporic conceptacles of *L. vaughanii* are more flattened than those of *L. glaciale*, their cavities have about twice the maximum width of those of *L. glaciale* and the specialized character of the conceptacle roof is not noticeable in *L. glaciale.*

In external habit *Lithothamnium vaughanii* may perhaps be compared also with the living *Lithophyllum racemus* (Lamarck) Foslie forma *crassum* (Philippi) Foslie[1] of the Mediterranean and Adriatic seas, especially as shown in Hauck's figure 2[2] under the name *Lithothamnium crassum* Philippi, though the Panamanian fossil sometimes develops longer and perhaps more flattened branches than this form.

Of the living Lithothamnieae now known to the present writer as occurring in the West Indian region, *Lithothamnium vaughanii* per-

[1] Kgl. Norske Vidensk. Selsk. Skr., 1898, pt. 3, p. 9, 1898. Foslie's identification of *Lithothamnium crassum* Philippi as a form of *Lithophyllum racemus* (Lamarck) Foslie was accepted by Heydrich (Bot. Jahrb., vol. 28, p. 536, 1901), but Mme. Lemoine quotes *Lithothamnium crassum* Philippi as a synonym of *Lithothamnium calcareum* (Pallas) Areschoug. It is not, however, apparent that any of these writers examined authentic material of Philippi's *Lithothamnium crassum,* if such exists. It is of some interest, also, to note that less than six months before Heydrich accepted *Lithothamnium crassum* Philippi as a form of *Lithophyllum racemus* he named it as the type of a proposed new genus *Stichospora* (Ber. Deuts. Bot. Ges., vol. 18, p. 316, 1900).

[2] Hauck, F. Die Meeresalgen Deutschlands und Oesterreichs. In Rabenhorst, L., Kryptogamen-Flora von Deutschland, Oesterreich und der Schweiz, vol. 2, pl. 1, 1885.

haps most resembles *Lithophyllum daedaleum* Foslie and Howe[1] as to general habit, but differs from it much in structure.

In the best section, No. 35299 U.S.N.M., the one from which the photographs (fig. 2, pl. 7 and pl. 8) were made, the coarse intersporangial sterile tissue of the tetrasporic conceptacles is scarcely shown, yet the roofs of the conceptacles show unmistakable canals and none of the conceptacles in section exhibits a single orifice, so that we consider ourselves justified in inferring that the specimen in question is tetrasporic and that it belongs in the genus *Lithothamnium* in the sense in which that name is currently applied to living plants. In a section from another specimen under the same collection number, traces of the sporangia and of the intersporangial sterile tissue are evident. It is to be observed also that the zonate arrangement of tissues, as observed in a section, is essentially of the character assumed by Mme. Lemoine[2] as being peculiar to the genus *Lithothamnium*. The rather distinctly specialized nature of the cells of the conceptacle roof is evidently a character of importance, in which respect it differs markedly from the plant we are describing as *Lithothamnium isthmi*, as also in the distinctly zonate structure of the thallus, the reduced hypothallium, the larger tetrasporic conceptacles, larger perithallic cells, etc.

Among the more fully described fossil Lithothamnieae, *L. vaughanii* may perhaps be compared with *Lithothamnium suganum* Rothpletz[3] from the Tertiary ("Scio-Schichten") of Val Sugana, near Borgo in the Austrian Tyrol, but the conceptacles of the Panamanian fossil are much larger (500–740 μ wide and 130–230 μ high vs. 250 μ wide and 100 μ high) and the perithallic cells appear to average considerably larger, being sometimes 13–22 μ high, while those of *L. suganum* are described as 9–12 μ long.

LITHOTHAMNIUM ISTHMI, new species.

Plate 7, fig. 3; plates 9, 10, and 11.

Thallus forming at first stratified crusts 3–12 mm. thick, but at length developing tortuous anastomosing branches and forming large rather solid, concrescent, fruticose masses; branches mostly 2–12 mm. in diameter, much flattened or subterete, often subconic-cylindric, flexed-digitiform, or molariform; hypothallia showing regular concentric layers of cells ("coaxial"); hypothallium of the crustaceous parts 160–480 μ thick, its cells 17–28 μ by 8–13 μ, transition to the

[1] Bull. N. Y. Bot. Gard., vol. 4, p. 133, pls. 83, 84, 93, 1906.

[2] Lemoine, Mme. Paul. Structure anatomique des Mélobesiées. Application à la classification. Ann. Inst. Océanog., vol. 2, pt. 2, pp. 27, 28, 1911.

[3] Zeits. Deuts. Geol. Ges., vol. 43, p. 319, pl. 17, fig. 4, 1891.

perithallium abrupt; medullary hypothallium of the branches mostly 0.6–2.0 mm. in diameter, often turning yellow and more or less disintegrated, its cells 17–44 μ by 8–13 μ, transition to the perithallium abrupt or gradual; cells of the perithallium in distinct layers, the layers in rather indistinct zones; perithallic cells of the crustaceous parts subquadrate, 8–11 μ in diameter, sometimes only 6 μ broad; perithallic cells of the branches usually a little higher than broad, 8–19 μ by 8–12 μ; conceptacles becoming embedded; tetrasporic conceptacles appearing much flattened in a vertical section, the cavity 240–550 μ in maximum width, 130–165 μ in height.

Localities and geologic occurrence.—In Emperador limestone of Oligocene age (and often constituting the dominant element in its composition) on relocated line of the Panama Railroad, opposite San Pablo, Panama Canal Zone ("first limestone outcrop just north of Caimito Station, about four miles north of Gamboa Bridge"), collected by D. F. MacDonald and T. W. Vaughan, 1911, Station No. 6021 (No. 35301, type); and "above foraminiferous marl at Agua Salud Bridge about ⅓ mile north of New Frijoles on relocated line, Panama Railroad," by the same collectors, Station No. 6024*b*.

Holotype and paratypes.—Cat. Nos. 35301 to 35303, U.S.N.M.

The material upon which the above description is based shows much variation in form and structure and it was our first impression that two or more species were represented in it. However, if this is true, the two or more species are so intergrown and entangled and are so similar in structure that it is difficult to determine where one begins and the other ends. As regards the vegetative structure, we believe that we have been able to trace the continuous organic connection of the two types shown in our photomicrographs (pl. 9 and fig. 2, pl. 11), yet it is notoriously easy in the case of overgrowing and overgrown fossil Lithothamnieae to mistake the close contact of independent plants for structural continuity.

In the tetrasporangial specimen (No. 35301—fig. 3, pl. 7 and pl. 9) that we have named as the type, the thallus presents itself in the form of irregularly superposed crusts, more or less overlaid by crusts showing a somewhat different structure and conceptacles of a different sort, these outer layers probably representing a crustaceous species of *Lithophyllum*. The hypothallium of this No. 35301 is suggestive of that figured by Foslie[1] for his living *Lithothamnium fragilissimum* from Borneo (which, however, has a much thinner thallus). It suggests also the hypothallium of *Lithothamnium lich-*

[1] Foslie, M. Lithothamnioneae, Melobesieae, Mastophoreae. In Weber-van Bosse, A., and Foslie, M. The Corallinaceae of the Siboga Expedition, *Siboga* Exped. Monog. No. 61, fig. 5, 1904.

enoides, as figured by Rosanoff[1] and by Lemoine,[2] but the crusts are evidently more massive than in that species.

Although the outward form of *Lithothamnium isthmi* is more or less obscured by being embedded in rock, it seems probable that in its typical condition (No. 35301) the external appearance of the plant may be compared with the recent plant from the Adriatic Sea figured by Hauck[3] as "*Lithophyllum decussatum* Solms," which Foslie[4] afterwards referred to his *Lithothamnium philippii*—a species that he maintained even after conceding[5] its specific identity with the earlier-published *Lithophyllum crispatum* Hauck. The typical form of Foslie's *Lithothamnium philippii* is said by him[6] "to have its hypothallium distinctly marked and vigorously developed, forming a coaxilate layer," but the "coaxial" character is essentially denied by Mme. Lemoine[7] to what she considers the same species under the name *Lithothamnium crispatum* Hauck. The perithallic cells of the crustaceous parts of *Lithothamnium isthmi* appear to average considerably smaller than those of *L. crispatum* (*L. philippii*) according to the measurements given by Lemoine and by Foslie. The tetrasporangial conceptacles of the *Lithophyllum decussatum* of Hauck (*Lithothamnium philippii* Foslie) are stated by Hauck to be "800μ bis 1 mm." in diameter, while in *Lithothamnium isthmi* they are only 240–550 μ in maximum width. Moreover, unless we are mistaken in connecting the fruticulose parts of the Panamanian fossil with the crusts, *Lithothamnium isthmi* develops numerous solid anastomosing branches, while in *L. crispatum* the short branchlike excrescences are mostly hollow, infundibuliform, or scyphiform. These fruticulose conditions, which comprise a large part of the material collected by MacDonald and Vaughan, suggest in external form certain states of the living West Indian *Lithophyllum daedaleum* Foslie and Howe, which also presents itself in both crustaceous and fruticulose conditions. Occasionally an unusually long subterete branch may resemble in form a frag-

[1] Mém. Soc. Imp. Sci. Nat. Cherbourg, vol. 12, pl. 6, fig. 14, 1866.

[2] Ann. Inst. Océanog., vol. 2, pt. 2, fig. 60, 1911. It is of interest to note that Mme. Lemoine, basing her system of classification primarily upon the vegetative structure of the thallus, leaves *Lithothamnium lichenoides* in the genus *Lithophyllum*, notwithstanding the fact that its tetrasporangia are borne as in the genus *Lithothamnium* of modern writers. In the same way she would doubtless place *Lithothamnium isthmi* in the genus *Lithophyllum*, even though this species (or its type at least) clearly has the tetrasporangial conceptacles of the conventional *Lithothamnium*.

[3] Hauck, F. Die Meeresalgen Deutschlands und Oesterreichs, pl. 1, fig. 7. See also pl. 1, fig. 1, of Foslie's Die Lithothamnien des Adriatischen Meeres und Marokkos (Wiss. Meeresuntersuch, Helgoland, vol. 7, pt. 1, 1904).

[4] Foslie, M. On some Lithothamnia. Kgl. Norske Vidensk. Selsk. Skr., 1897, pt. 1, p. 7, 1897.

[5] Wiss. Meeresuntersuch, Helgoland, vol. 7, pt. 1, pp. 13, 14, 1904.

[6] Kgl. Norske Vidensk. Selsk. Skr., 1900, pt. 1, p. 5, 1900.

[7] Ann. Inst. Océanog., vol. 2, pt. 2, p. 80, fig. 38, 1911.

ment of the living East Indian *Lithothamnium pulchrum* A. Weber and Foslie.[1]

Lithothamnium fosliei (Trabucco) De Toni (Syll. Alg., vol. 4, p. 1761, 1905), a Miocene fossil from Italy, is figured[2] as having a "coaxial" hypothallium, but from the illustrations given of the conceptacles, there is no sufficient ground for considering this plant to be a *Lithothamnium* rather than a *Lithophyllum*. In the original place of publication nothing but a figure (section) is given, from which, according to the scale of magnification given, it would appear that the conceptacles are only 140–160 μ by 80–90 μ and the perithallic cells about 16 μ high, making the cells rather larger and the conceptacles much smaller than in *L. isthmi*.

If we are correct in including with *Lithothamnium isthmi* the more ramified forms collected by MacDonald and Vaughan, the species, though commonly coarser, appears to be sometimes suggestive of plants figured as *Nullipora ramosissima* Reuss or *Lithothamnium ramosissimum* (Reuss) Schimper, from the Tertiary "*Leithakalk*" of the vicinity of Vienna, but Reuss's original figures and description[3] relate to external form only, and give no adequate basis for referring the plant to a modern genus. Unger[4] adds good figures of the vegetative structure, but shows no conceptacles. Rothpletz[5] describes the conceptacles of *L. ramosissimum* as 280 μ high, while the height of the conceptacles of *L. isthmi* is 130–165 μ and the width 240–550 μ. Rothpletz has no doubt that there are two species of Lithothamnieae in the "Leithakalk," which may have been confused.

LITHOPORELLA MELOBESOIDES (Foslie) Foslie.

Lithoporella melobesioides (Foslie) Foslie, Kgl. Norske Vidensk. Selsk., 1909, pt. 2, p. 50.

Mastophora melobesioides Foslie, Kgl. Norske Vidensk. Selsk. Aarsber., 1902, p. 24, 1903.

Locality and geologic occurrence.—This species occurs in small quantity with *Lithothamnium isthmi* in Emperador limestone of the Oligocene age, "above foraminiferous marl at Agua Salud Bridge about ½ mile north of New Frijoles on relocated line, Panama Railroad," D. F. MacDonald and T. W. Vaughan, 1911, Station No. 6024*b*.

EXPLANATION OF PLATES.

Plate 1.

Archaeolithothamnium episporum M. A. Howe.

Photograph, natural size, of the type-specimens, collected at Point Toro, near Colon, Panama Canal Zone, January 10, 1910 (Howe 6832). The technical

[1] Compare pl. 4, *Siboga* Exped. Monog. 61.

[2] *Eulithothamnium fosliei*, Trab. Boll. Soc. Geol. Ital., vol. 19, pl. 11, fig. 10, 1900.

[3] Haidinger, Naturw. Abh., vol. 2, pt. 1, p. 29, pl. 3, figs. 10, 11, 1848. Type from "Neudorfl," Hungary.

[4] Denkschr. k. Akad. Wiss. Wien, vol. 14, p. 23, pl. 5, figs. 18–22, 1858.

[5] Zeits. Deuts. Geol. Ges., vol. 43, p. 320, 1891.

8370°—18h—Bull. 103——2

type in a narrower sense is the specimen shown at the lower right-hand corner of the plate—the specimen from which figure 1 of plate 5 was obtained.

PLATE 2.

Archaeolithothamnium episporum M. A. Howe.

Photographs of radio-vertical ground (calciferous) sections of type material (Point Toro, Howe 6882).

FIG. 1. *Lithothamnium vaughanii* M. A. Howe. Photograph of the type-portion of a sporangial sorus, enlarged 42 diameters.

2. Section, enlarged 200 diameters.

PLATE 3.

Archaeolithothamnium episporum M. A. Howe.

Photographs of radio-vertical sections of decalcified material (Point Toro, Howe 6832), enlarged 200 diameters.

FIG. 1. Section showing sporangia and tetraspores.

2. Section showing emptied sporangia, form and arrangement of perithallic cells, a weakly developed hypothallium, etc.

PLATE 4.

Archaeolithothamnium episporum M. A. Howe.

A Pleistocene fossil, "from flats near Mount Hope, five feet above tide level," D. F. MacDonald 6039, 1911, natural size.

PLATE 5.

Archaeolithothamnium episporum M. A. Howe.

FIGS. 1 and 2. Photographs of the type material (Point Toro, Howe 6832).

FIG. 1. Portion of the surface, showing the more or less confluent sporangial sori, enlarged 4 diameters.

2. A smaller part of the same surface, showing the sporangial ostioles, etc., enlarged 25 diameters.

FIGS. 3 and 4. Photographs of Pleistocene specimen from Mount Hope (MacDonald, Cat. No. 35298, U.S.N.M.)

FIG. 3. Radiovertical section showing several superposed crusts and three well-developed hypothallia, enlarged 42 diameters.

4. A part of a cross section of one of the excrescences or branches, showing a single weakly developed hypothallium, enlarged 42 diameters. Compare structure of living specimen as shown in fig. 1, plate 2.

PLATE 6.

Archaeolithothamnium episporum M. A. Howe.

Photograph of section of the Pleistocene fossil from near Mount Hope (Cat. No. 35298, U.S.N.M.). A section magnified 73 diameters.

PLATE 7.

FIG. 1. *Lithothamnium vaughanii* M. A. Howe. Photograph of the type-specimens (between Monte Lirio and Bohio Ridge, MacDonald and Vaughan, Cat. No. 35299, U.S.N.M.), natural size.

2. *Lithothamnium vaughanii*. A section showing irregular zonation, tetrasporic conceptacles, etc., enlarged 42 diameters.

3. *Lithothamnium isthmi* M. A. Howe. A section, slightly enlarged (11/8 of the natural dimensions), showing the type-specimen embedded in the matrix (from about 4 miles north of Gamboa Bridge, MacDonald and Vaughan, station 6021). The type material (Cat. No. 35301, U.S.N.M.), from which the section shown in plate 9 was obtained, occupies the central portion of the light area and is overgrown by crusts of what appears to be a different plant, probably a species of *Lithophyllum*.

PLATE 8.

Lithothamnium vaughanii M. A. Howe.

An enlargement of a part of the section shown in figure 2, plate 7, illustrating form of perithallic cells, the reduced secondary hypothallia, the somewhat specialized roof of the tetrasporic conceptacles, etc. Magnification 100 diameters.

PLATE 9.

Lithothamnium isthmi M. A. Howe.

A section of the type material (MacDonald and Vaughan, station 6021, Cat. No. 35301, U.S.N.M.), enlarged 100 diameters. The section shows the well-developed "coaxial" hypothallium, the smaller-celled perithallium, and the conceptacles with the coarse intersporangial tissue characteristic of the genus *Lithothamnium*.

PLATE 10.

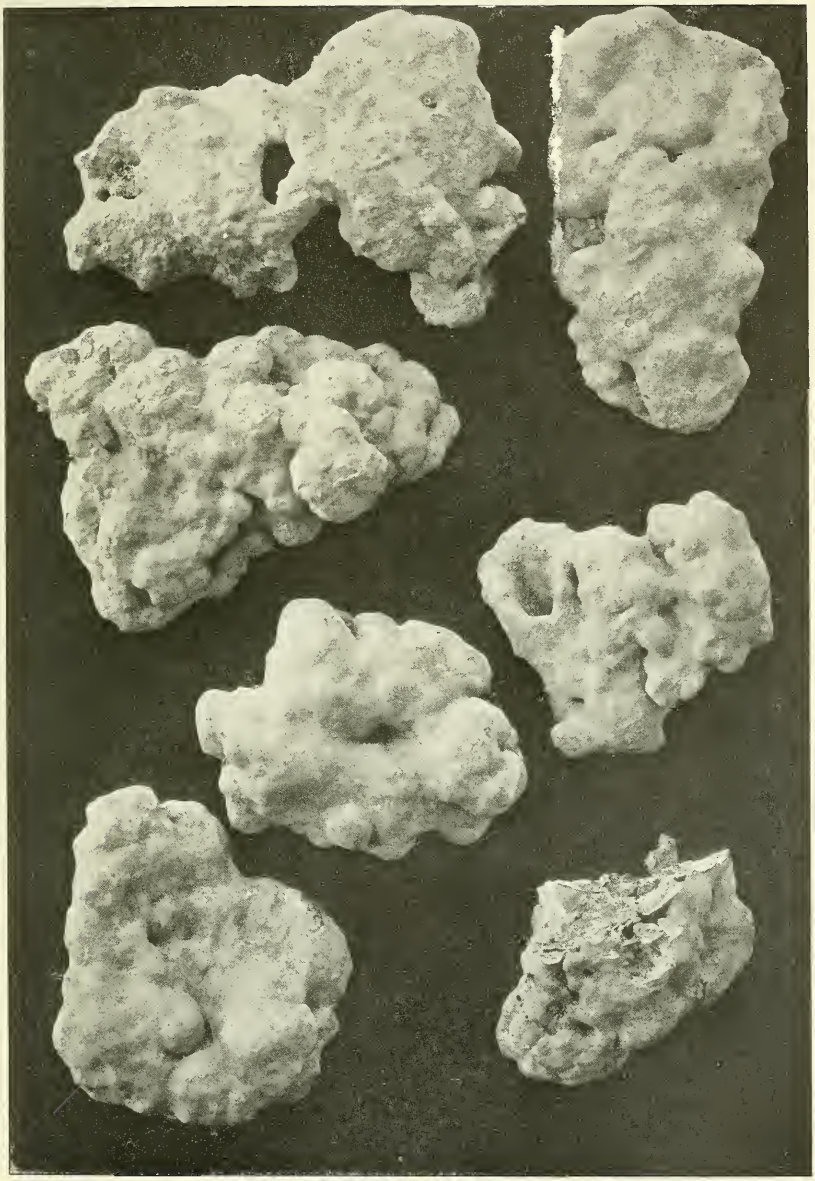
Lithothamnium isthmi M. A. Howe.

A specimen from about one-third mile north of New Frijoles (MacDonald and Vaughan, station 6024–*b*, Cat. No. 35305, U.S.N.M.), natural size, showing fossil embedded in matrix, in both weathered and freshly broken surfaces.

PLATE 11.

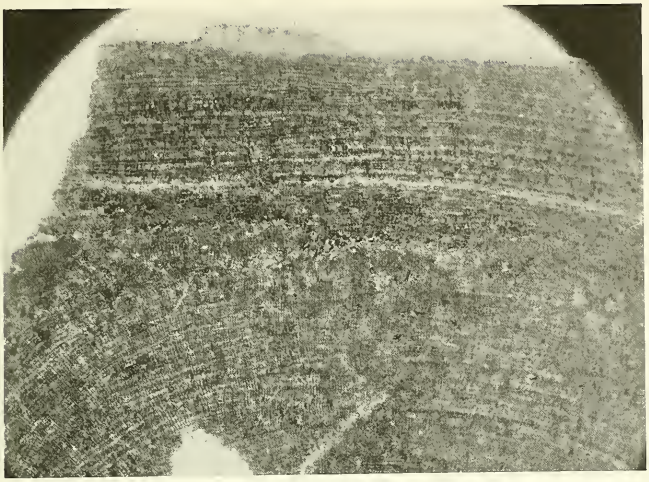
Lithothamnium isthmi M. A. Howe.

A somewhat obliquely transverse section of a branch (specimen from about 4 miles north of Gamboa Bridge, MacDonald and Vaughan, station 6021, Cat. No. 35302, U.S.N.M.), enlarged 106 diameters.



ARCHAEOLITHOTHAMNIUM EPISPORUM M. A. HOWE.

FOR EXPLANATION OF PLATE SEE PAGES 11, 12.



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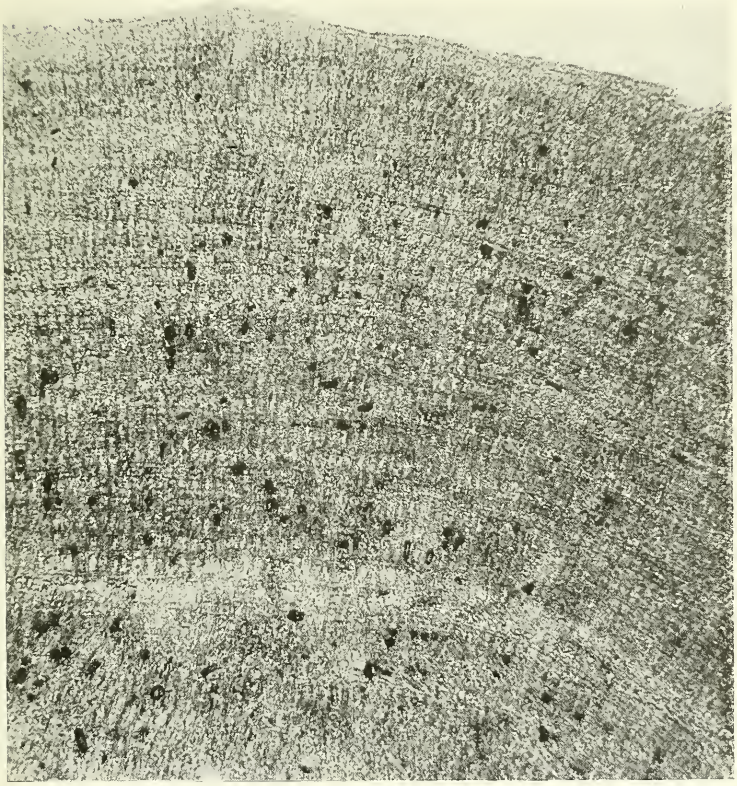

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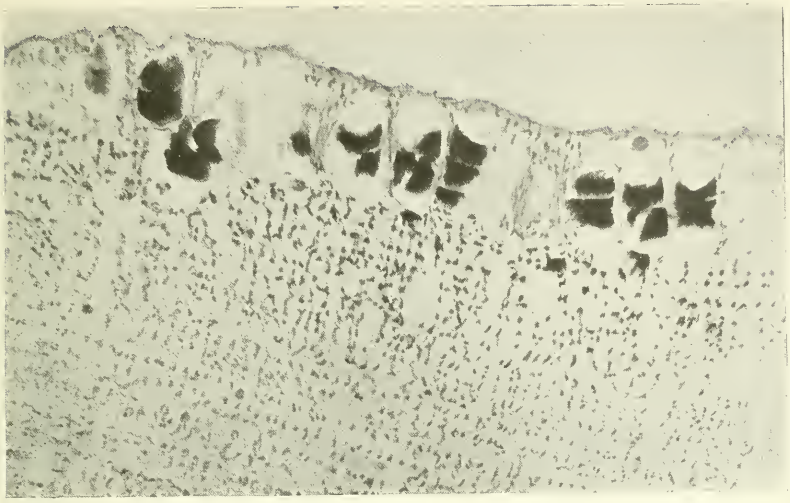
FOR EXPLANATION OF PLATE SEE PAGE 12.



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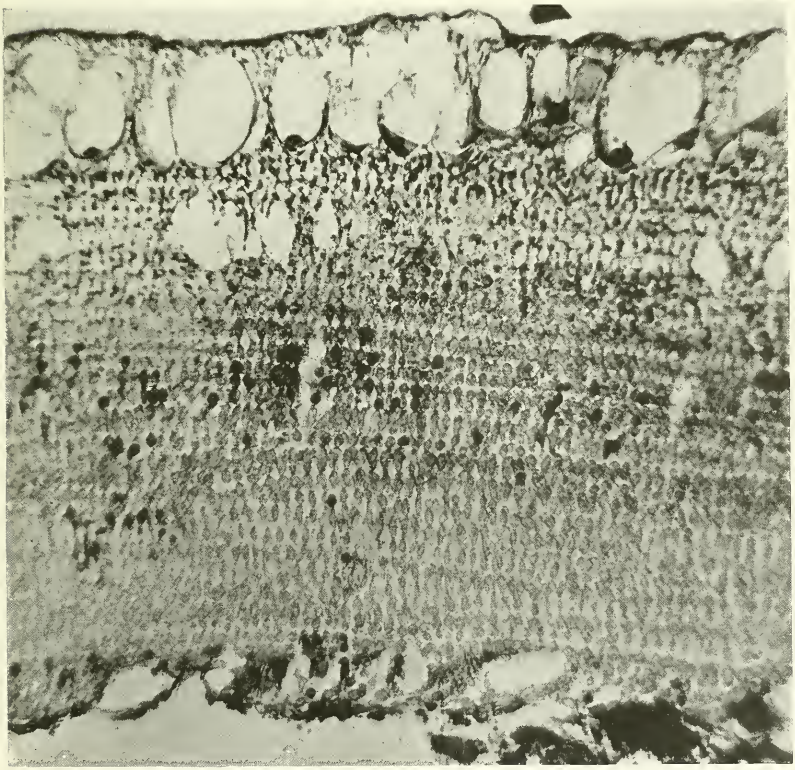

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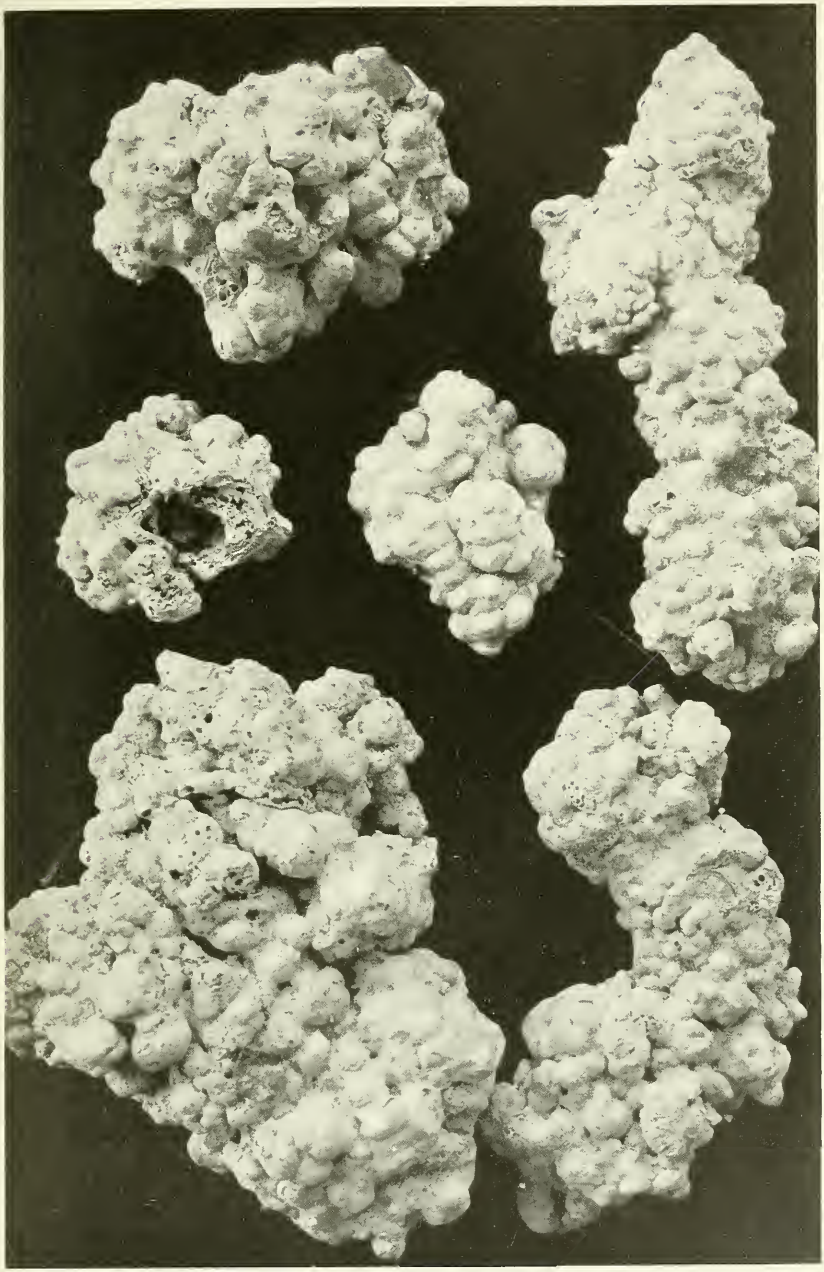
ARCHAEOLITHOTHAMNIUM EPISPORUM M. A. HOWE.

FOR EXPLANATION OF PLATE SEE PAGE 12.



ARCHAEOLITHOTHAMNIUM EPISPORUM M. A. HOWE.

FOR EXPLANATION OF PLATE SEE PAGE 12.

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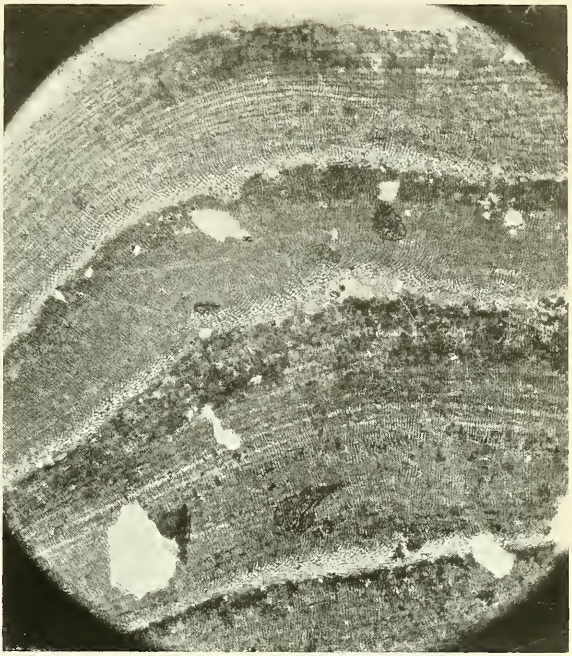

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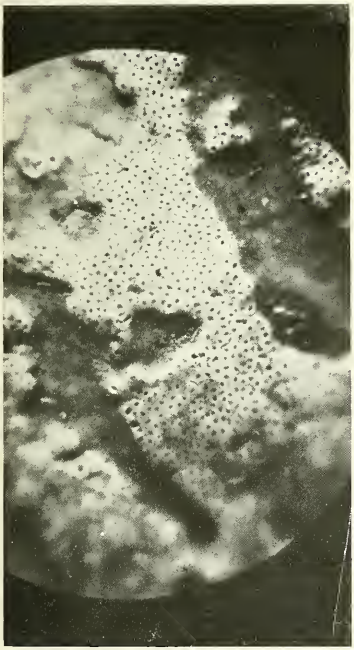

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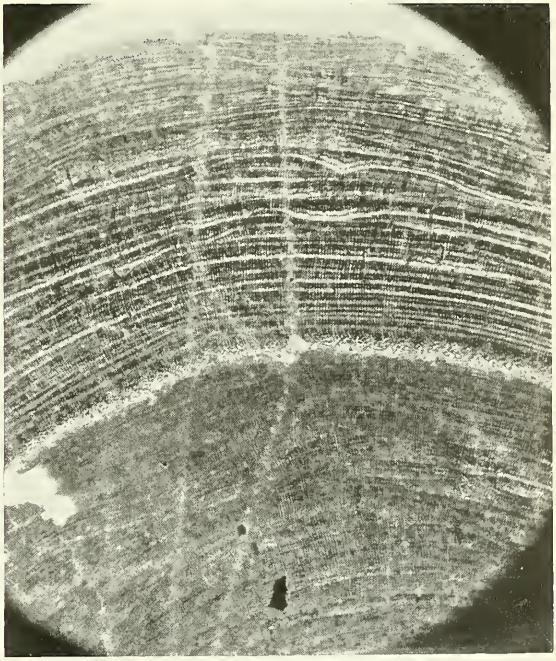

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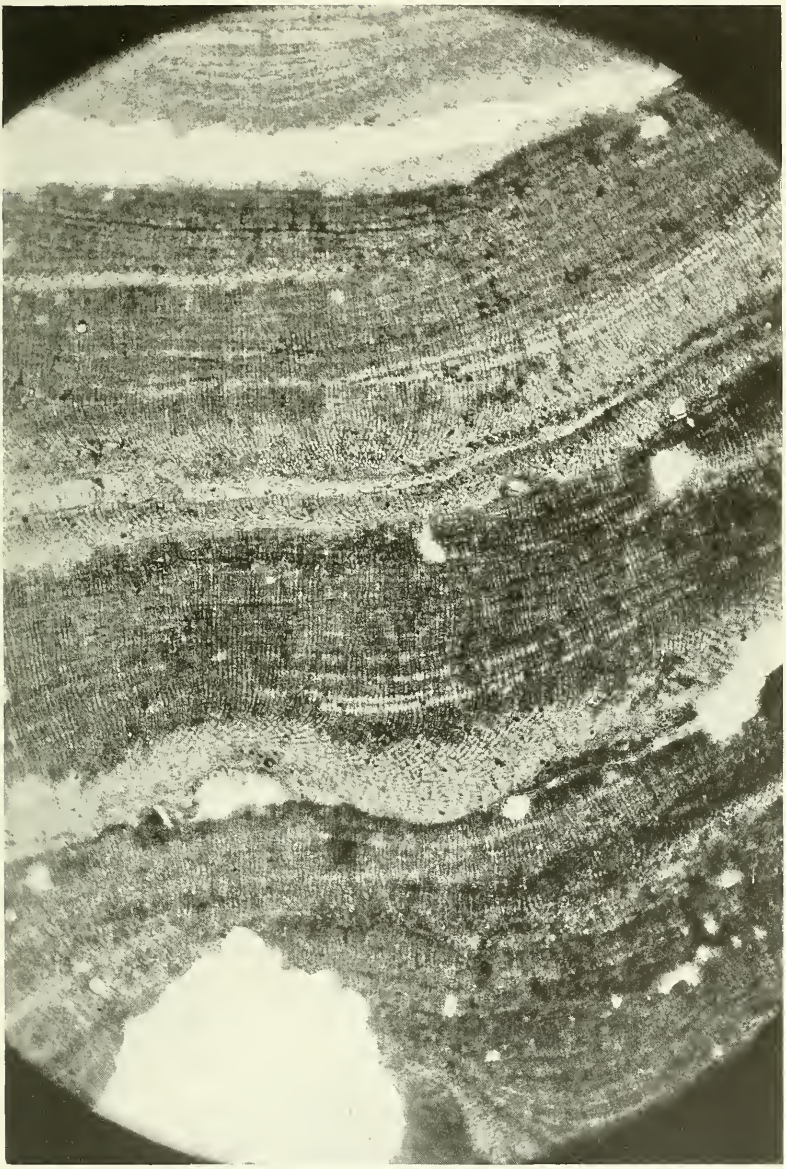
ARCHAEOLITHOTHAMNIUM EPISPORUM M. A. HOWE.

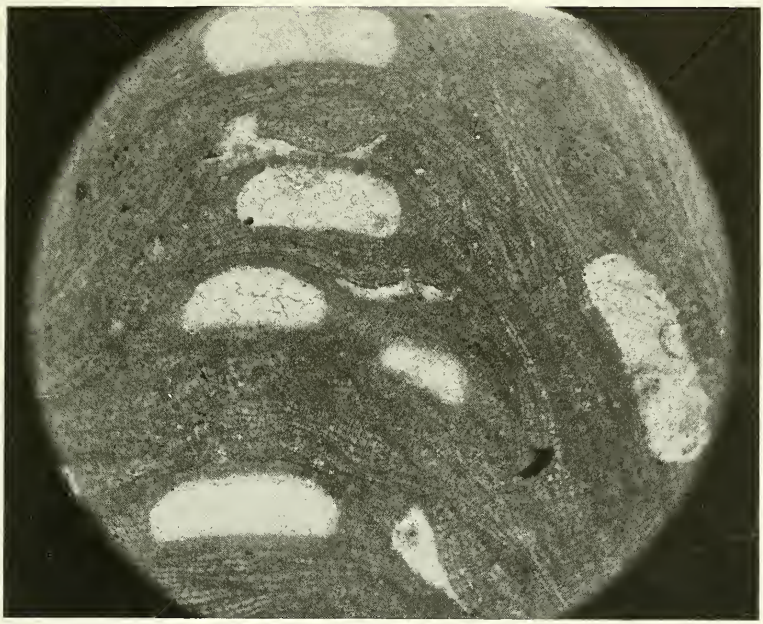
FOR EXPLANATION OF PLATE SEE PAGE 12.



ARCHAEOLITHOTHAMNIUM EPISPORUM M. A. HOWE.

FOR EXPLANATION OF PLATE SEE PAGE 12.

1



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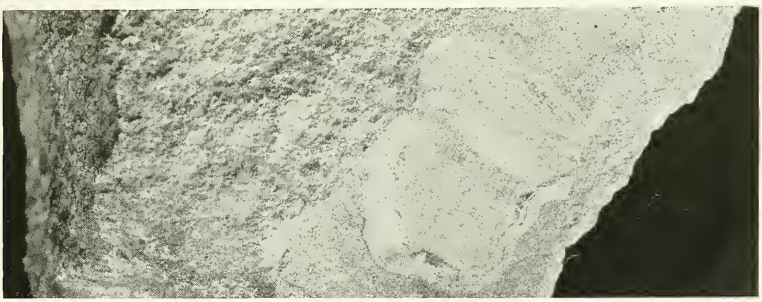
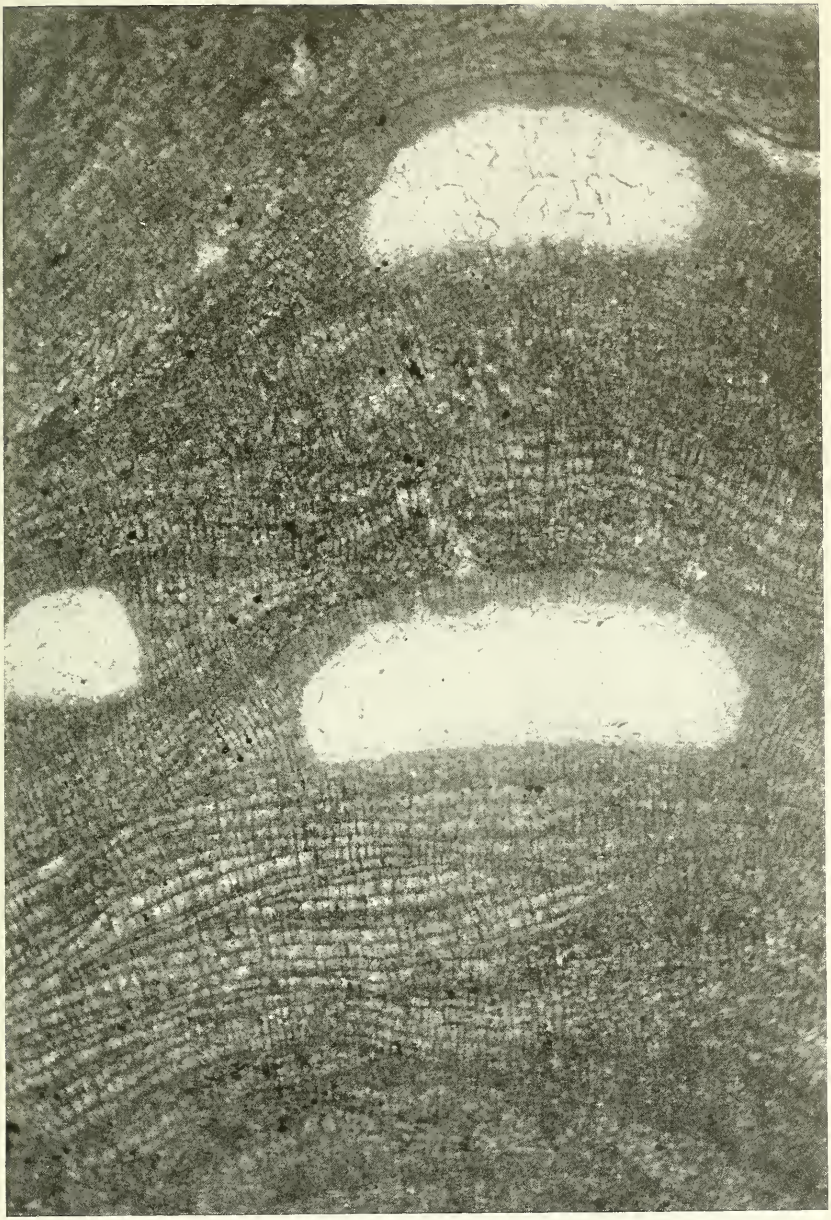


3

1, 2. LITHOTHAMNIUM VAUGHANII M. A. HOWE. 3. LITHOTHAMNIUM ISTHMI M. A. HOWE.

FOR EXPLANATION OF PLATE SEE PAGE 13.



LITHOTHAMNIUM VAUGHANII M. A. HOWE.

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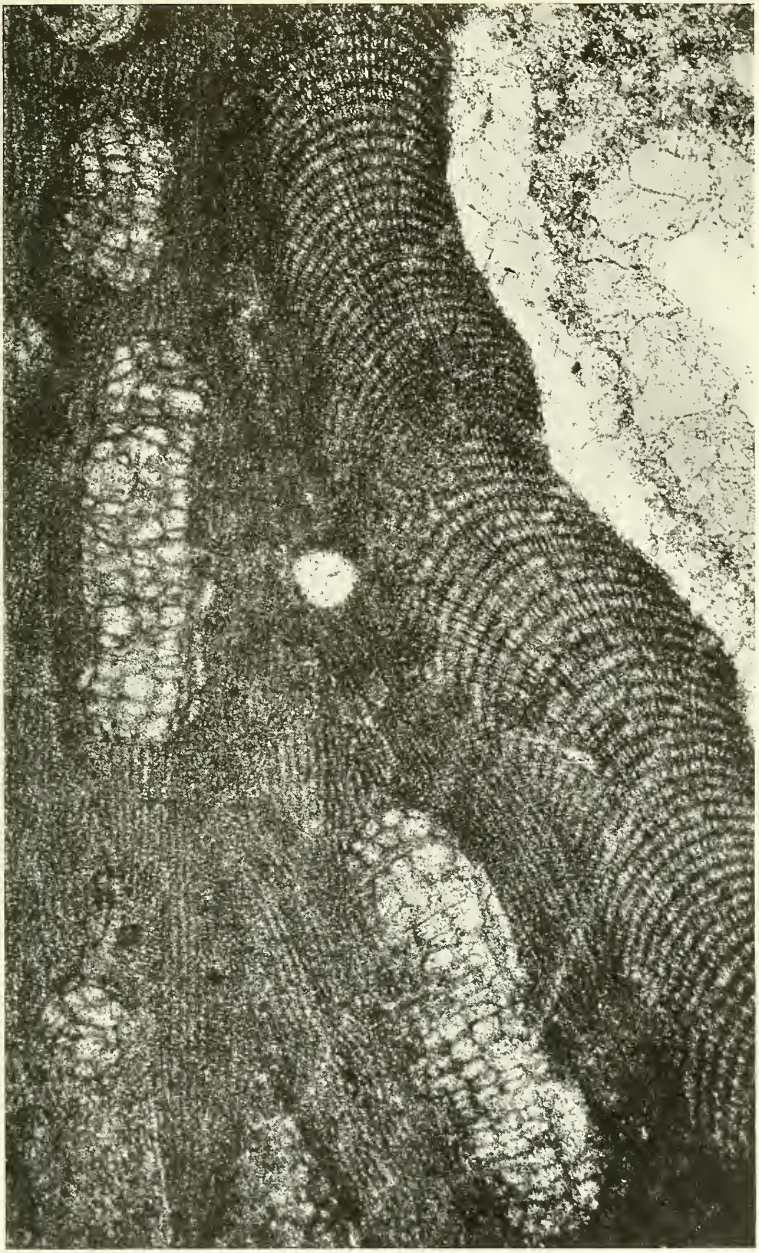

LITHOTHAMNIUM ISTHUI M. A. HOWE.

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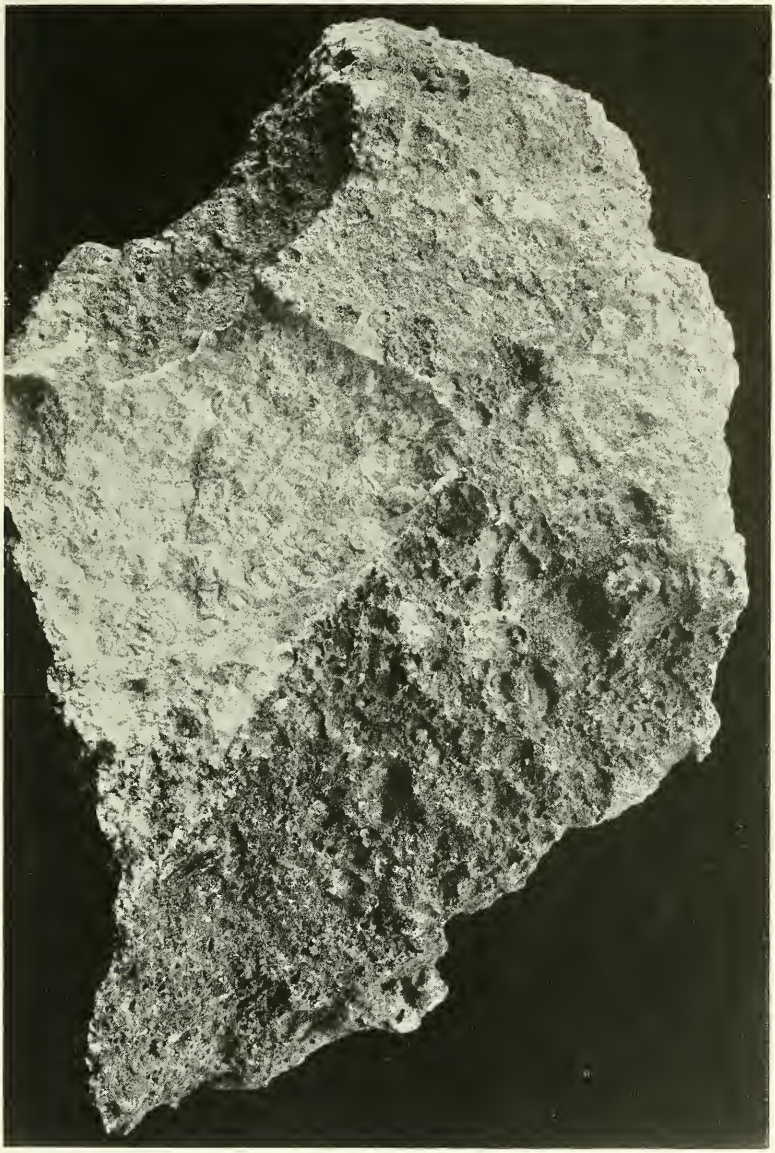

LITHOTHAMNIUM ISTHMI M. A. HOWE.

FOR EXPLANATION OF PLATE SEE PAGE 13.

LITHOTHAMNIUM ISTHMI M. A. HOWE.

FOR EXPLANATION OF PLATE SEE PAGE 13.

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