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CORALLINE ALGAE FROM THE EOCENE ATASCADERO LIMESTONE

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ABSTRACT—The upper Eocene Atascadero limestone of northwestern Peru locally contains abundant well-preserved coralline algae. Thirteen species are described of which six are new. They include representatives of the genera *Archaeolithothamnion*, *Lithothamnion*, *Lithophyllum*, *Mesophyllum* and *Lithoporella*.

INTRODUCTION

THIS study is based on a small collection of limestone specimens collected by Benton Stone and sent to the Colorado School of Mines Museum through the kindness of W. E. Wallis, both of the International Petroleum Company.

The specimens are from an outcrop of the Atascadero limestone, a facies equivalent to the upper Eocene Talara formation. It was obtained along the Las Cruces-Atascadero road a few kilometers south of Atascadero, Department of Piura, N.W. Peru. This locality is the type for all new species described. The limestone is a brownish gray organic limestone. Algal debris comprises from 15 to 35 percent of the rock in the specimens studied. In addition there are numerous Foraminifera both large and small, ostracods, fragments of shells of mollusks, echinoid spines, and Bryozoa, all in a gray matrix of fine calcium-carbonate paste.

Repository.—The specimens described here are deposited in the Johnson Collection at the Colorado School of Mines.

SYSTEMATIC DESCRIPTIONS

The algal material consists of small pellets, broken pieces of branches, and thin crusts coating large Foraminifera and other fossil fragments. Most of the material is beautifully preserved and an unusually large percentage show fruits.

Genus ARCHAEOLITHOTHAMNION (Rothpletz) Foslie

Tissue composed of rectangular cells arranged in transverse rows. The hypothallus, always basal, consists of horizontal rows of cells. The perithallus usually shows a neat rectilinear cell pattern. Branches are composed entirely of perithallus. Sporangia arranged in concentric rows in the tissue. They are not grouped in conceptacles.

ARCHAEOLITHOTHAMNION LUGEONI Pfender
Plate 62, figs. 1, 4

Archaeolithothamnion lugeoni PFENDER, J., 1926, p. 321.
Archaeolithothamnion lugeoni LEMOINE, 1928, p. 94.
Archaeolithothamnion lugeoni RAMA RAO and PIA, 1936, p. 35.
Archaeolithothamnion lugeoni LEMOINE, 1939, p. 52.

Nodular masses 2.5 to 8.0 mm. across with rounded protruberances but not true branches, composed of a number of superimposed thalli. Hypothallus thin, of curved loosely packed rows of irregularly sized

cells 0.015–0.030 mm. long, and 0.007–0.010 (12) mm. wide. Perithallus tissue of regular rows of rectangular cells 0.012–0.015 (17) mm. long and 0.008–0.012 mm. wide. Sporangia oval, abundant in fairly regular rows. They measure 0.055–0.085 mm. high and 0.035–0.045 mm. in diameter.

Discussion.—The structure, measurements, and growth habits perfectly fit this species. To date it has been reported from beds ranging in age from Upper Cretaceous (Danian) to lower Oligocene. It is abundant in the Eocene of Spain and Algeria.

The species is represented in our collection by seven specimens. Several of them are sections through large nodules.

Type.—Homoeotype, slide 1281. Johnson Collection, Colorado School of Mines.

Genus LITHOTHAMNION (Philippi)

Representatives of this genus are rather scarce in the collection studied. The majority are encrusting forms, although one highly branching form is present.

LITHOTHAMNION LIMAENSUM Johnson and Tafur, n. sp.
Plate 64, fig. 4

Crustose; thallus consisting of a thin hypothallus and a well-developed perithallus. Hypothallus consisting of curved rows of cells which measure 0.007–0.012 mm. long and 0.008–0.010 mm. wide. Perithallus consists of regularly arranged rows of rectangular cells 0.010–0.015 mm. long and 0.009–0.012 mm. wide. Conceptacle large, 0.580 mm. in diameter and 0.150 mm. high.

Discussion.—Resembles *L. concretum* Howe from the Oligocene of the West Indies but differs in growth habit and in having smaller conceptacles.

Type.—Holotype, slide 1285. Johnson Collection, Colorado School of Mines.

LITHOTHAMNION FAURAI Lemoine
Plate 62, fig. 5

L. faurai LEMOINE, 1928, p. 97, fig. 8.
L. faurai LEMOINE, 1939, p. 74, figs. 36, 37.

A strongly branching form. Tissue of branches shows growth zones. Cells in well-defined vertical rows. Cells vary considerably in length, even adjoining cells in a row. Sizes range from 0.009–0.023 mm. long and 0.009–0.013 mm. wide. Conceptacle measurements listed below:

Specimen 1	0.370×0.125 mm.	to	0.190×0.090
2	0.223×0.124		0.205×0.140
3	0.310×0.180		0.225×0.165

Discussion.—The material studied consists entirely of fragments of branches. In appearance, growth habit, and dimensions they closely fit Lemoine's descriptions based on material from the Eocene of France and Spain, except that the maximum cell length is slightly less in the Peruvian specimens.

Type.—Homoeotype, slide 1289a. Johnson Collection, Colorado School of Mines.

LITHOTHAMNION cf. L. CONCRETUM HOWE

Several pieces of a crustose form which has a fair hypothallus and a well-developed perithallus occur. Hypothallus cells measure 0.012–0.018 mm. by 0.008–0.013 mm. The perithallus cells are 0.009–0.014 mm. long and 0.007–0.012 mm. wide. No conceptacles observed.

In growth habit and cell dimensions these fit the description of *L. concretum* Howe described from the Oligocene of the West Indies, but without conceptacles it is impossible to say definitely that they belong to that species.

Type.—Homoeotype, slide 1340. Johnson Collection, Colorado School of Mines.

LITHOTHAMNION WALLISIUM Johnson and Tafur, n. sp.
Plate 62, fig. 3

Crustose; hypothallus moderately developed consisting of curved irregular rows of rounded to nearly rectangular cells, which measure 0.011–0.016 mm. long and 0.008–0.011 mm. wide. Perithallus shows numerous irregular growth zones. Cells arranged in fairly regular vertical rows. Cells vary in size, ranging from 0.009–0.019 mm. long and 0.009–0.015 mm. wide. Conceptacles wide and flat, 0.250–0.500 mm. in diameter, and 0.116–0.130 mm. high.

Discussion.—This suggests *L. isthmi* Howe from the Oligocene of Panama in cell dimension and conceptacles but differs in the character of the hypothallus which is strongly coaxial in *L. isthmi* but consists of only moderately curved cell rows in *L. wallisium.*

Type.—Holotype, slide 1355. Johnson Collection, Colorado School of Mines.

Genus MESOPHYLLUM Lemoine 1928

Characterized by a clearly stratified, zonate branch tissue similar to the genus *Lithophyllum* and conceptacles with multiple openings similar to the genus *Lithothamnion*. Usually the branches consist entirely or almost entirely of medullary hypothallus with little or no marginal perithallus which is usually well developed on a typical *Lithophyllum*. Growth zones are usually more pronounced and the conceptacles are often larger in proportion to the mass of the tissue than in either *Lithophyllum* or *Lithothamnion*.

MESOPHYLLUM ATASCADERUM Johnson and Tafur, n. sp.
Plate 64, fig. 3

A small branching form with short stubby branches. Tissue strongly zoned. Each growth zone lenticular or crescent-shaped and usually contains four to seven rows of cells. Longitudinal partitions between the cell rows more pronounced than the transverse. Cells rectangular, measuring 0.012–0.025 mm. long and 0.09–0.016 mm. wide (average 0.020×0.012 mm.). Conceptacles oval, and rather high. They measure 0.208–0.212 mm. in diameter, and 0.134×0.142 mm. high on one specimen, and 0.278×0.134 mm. on another. There are suggestions of mutiple apertures in the roof of the conceptacles.

Discussion.—The cell dimensions of this form are within the range of *M. vaughanii* described by Howe (1918, p. 6) from the Oligocene of Panama, but the conceptacles of *M. atascaderum* are much smaller and its tissue does not show the alternation of rows of long and short cells mentioned by Howe. Named for the Peruvian town close to the type locality.

Type.—Holotype slide 1362. Johnson Collection, Colorado School of Mines.

MESOPHYLLUM PUERANUM Johnson and Tafur, n. sp.
Plate 63, fig. 4

Forms a basal crust from which develop long relatively slender branches. Basal hypothallus thin and poorly developed. Branches composed of slender lenticular growth zones each containing 5 to 12 layers of rectangular cells. Cells 0.018–0.029 mm.×0.012–0.021 mm. (average 0.022 ×0.015 mm.). Conceptacles show considerable size range as indicated below:

0.345×0.150 mm.
0.355×0.120 mm.
0.395×0.185 mm.
0.607×0.225 mm.
0.290×0.118 mm.
0.375×0.145 mm.
0.395×0.120 mm.

0.290–0.607 mm.×0.120–0.225 mm.

Discussion.—This species differs considerably in cell dimension and conceptacle size from all previously described Eocene and Oligocene species of *Mesophyllum*. Named for the Peruvian province containing the type locality.

Type.—Holotype, slide 1361. Johnson collection, Colorado School of Mines.

MESOPHYLLUM PERUVIANUM Johnson and Tafur, n. sp.
Plate 63, fig. 2

A form with short, slender branches. Tissue consists mainly of medullary hypothallus with distinct lenticular growth zones. Cells rectangular, measuring 0.009—0.019 mm. ×0.009–0.015 mm. Conceptacles large and prominent as compared with the mass of the tissue, measuring 0.200–0.500 mm. in diameter and 0.100–0.160 mm. high. There are a number of apertures piercing the roof of the conceptacle.

Discussion.—This species closely resembles *M. vaughanii* Howe, except in growth habit. *M. vaughanii* develops thick crusts with coarse anastomosing branches. *M. peruvianum* is represented in our collection by five specimens, all fragments of round, rather slender branches. The observed conceptacles also are much smaller in diameter than those of *M. vaughanii*. It differs from *M. atascaderum* in having slightly smaller cells, smaller and proportionately higher conceptacles, and in developing more slender branches.

Type.—Holotype, slide 1363. Johnson Collection, Colorado School of Mines.

LITHOPHYLLUM SIERRA-BLANCAE Howe
Plate 64, fig. 1

Lithophyllum sierra-blancae HOWE, 1934, Geol. Soc. America, Bull., vol. 45, p. 514, pl. 56.

Thallus mammillated or slightly branching. A section through one of the mammillae or a short stubby branch shows the tissue to consist of a well defined medullary hypothallus and a marginal perithallus. Hypothallus consists of thin arched zones each containing five to ten rows of cells. Cells in well-defined transverse rows and fairly defined longitudinal rows. Cells rectangular. In upper row of each zone they decrease in size from center to top of a margin zone. There is also a slight decrease in height of cell rows from the base. They measure 0.013–0.022 mm. high, and 0.008–0.011 mm. wide (average 0.016–0.010 mm.). Perithallus consists of thin slightly irregular zones, each built of short tangential rows of cells. Cells square to rectangular, measuring 0.009–0.016 mm. high (average 0.0116) and 0.008–0.013 mm. wide (average 0.010). Conceptacles unknown.

Discussion.—Our infertile fragments fit the description and illustration given by Howe.

Type.—Homoeotype, slide 1282. Johnson Collection, Colorado School of Mines.

LITHOPHYLLUM INCAENSUM Johnson and Tafur, n. sp.
Plate 63, fig. 1

A nodular form which develops short stubby bifurcating branches. Tissue shows strong growth zones. Hypothallus poorly developed, consisting of short curving rows of irregular cells. Perithallus forms most of the tissue. It consists of rectangular cells 0.019–0.032 mm. long and 0.016–0.024 mm. wide, arranged in rows. Along the axes of the branches the longitudinal partitions between cell rows are more strongly developed than the transverse, and there is a suggestion of a radial structure. Along margins of the branches, a rectilinear pattern is suggested with transverse and longitudinal partitions about equally developed.

Conceptacles numerous, round to rectangular with rounded corners, unusually short and high. Sizes range 0.320–0.550 mm. wide (diameter) and 0.300–0.400 mm. high. A single opening is suggested but is not clearly shown on the large section of a nearly complete colony.

Discussion.—*L. incaensum* suggests *L. zonatum* J. & F. from the Eocene of Florida in having large cells and strong growth zones, but differs in cell dimension and growth habit.

Type.—Holotype, slide 1283a. Johnson Collection, Colorado School of Mines.

LITHOPHYLLUM sp. A.
Plate 63, fig. 3

Encrusting; thallus thin with both a hypothallus and a perithallus. Hypothallus consists of curving and sometimes contorted rows of cells. The cells are rounded and irregular at base, becoming rectangular at top. They measure 0.016–0.022 mm. long and 0.010–0.013 mm. wide. The perithallus consists of layers of rectangular cells with well-defined horizontal and vertical partitions. Cells measure 0.012–0.020 mm. long and 0.008–0.013 mm. wide. Often the cells in the upper layer are shorter than those in the middle layers. Conceptacles very small, bean-shaped in vertical section, abundant, measuring 0.039–0.082 mm. wide and 0.022–0.038 mm. high. A single roof

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EXPLANATION OF PLATE 62

FIG. 1—*Archaeolithothamnion lugeoni* Pfender, Homoeotype (slide 1281) ×40. Section through a nodular mass showing tissue and rows of sporangia. (p. 537)

2—*Lithoporella melobesioides* Foslie. Figured specimen (slide 1282) ×75 showing typical thalles. (p. 541)

3—*Lithothamnion wallisium* Johnson and Tafur, n. sp. Holotype (slide 1355) ×100. Shows conceptacles, perithallus. (p. 538)

4—*Archaeolithothamnion lugeoni* Pfender. Homoeotype (slide 1289) ×75, showing detail of tissue and sporangia. (p. 537)

5—*Lithothamnion faurai* Lemoine. Homoeotype (slide 1289a) ×100, giving detail of tissue and conceptacles. (p. 538)

aperture is suggested but is not clearly shown.

Figured specimen.—Slide 1362. Johnson Collection, Colorado School of Mines.

LITHOPHYLLUM sp. B.
Plate 64, fig. 2

Thallus probably forming a branching or mammillated crust. Tissue shows growth zones composed of regular rows of rounded rectangular cells measuring 0.010–0.18 mm. long and 0.008–0.012 mm. wide. Horizontal partitions between cells thin and often indistinct. Conceptacle measured approximately 0.300 mm. in diameter and 0.150 mm. high.

Discussion.—Recognized in only one slide, the section is probably oblique, so data are considered too uncertain to give a specific name.

Figured specimen.—Slide 1283a. Johnson Collection, Colorado School of Mines.

Genus LITHOPORELLA Foslie

This genus shows the simplest structure of any of the Melobesieae. It also develops the largest cells and conceptacles.

A number of names have been applied to the genus. Madame Lemoine uses the name *Melobesia*, but most recent writers follow Foslie's use of *Lithoporella*.

The collection contains numerous specimens belonging to this genus. Mr. Tafur took a great interest in them and carefully studied every piece he could find. He measured hundreds of cells.

LITHOPORELLA (MELOBESIA) MELOBESIOIDES Foslie
Plate 62, fig. 2; plate 64, fig. 1

Lithoporella (*Mastophora*) *melobesioides* Foslie (Weber van Bosse and Foslie, 1904, pp. 73–77, figs. 30–32).

Melobesia (*Lithoporella*) *melobesioides* Foslie (Lemoine, 1939, pp. 108–110, figs. 78, 79).

Lithoporella melobesioides (Foslie) Foslie (Lignac-Grutterink, 1943, pp. 292–293, pl. 2, fig. 8).

Lithoporella (*Melobesia*) *melobesioides* J. & F., 1949, p. 196, pl. 37, figs. 4–5; and pl. 39, fig. 2.

Lithoporella (*Melobesia*) *melobesioides* J. & F., 1950, p. 18, pl. 8, fig. A.

Thallus thin, often less than 0.1 mm. thick, growing attached to other calcareous algae, Foraminifera, and other objects. In many cases they apparently started attached, then grew free.

Normally each thallus is formed of a single layer of cells, although sometimes, especially around conceptacles and at points where new thalles bud off, there is a local thickening of the tissue, and it may consist of several rows of smaller cells (plate 62, fig. 2). The cells are rectangular and are larger than in most genera of *Melobesia*. They show a great range in size in a single specimen as the cell layers swell and taper. The following table shows the measurements obtained from a number of specimens. Several thousand cells were measured. The average given in the last column is the mathematical average of all the cells in the row, not the mean between the extremes.

With such variation in cell size it is impossible to separate species unless there are differences in the conceptacles. Consequently, these are all considered to belong to one species which fits the description of the modern *L. melobesioides* Foslie. No conceptacles were observed.

Discussion.—This form was very common. Practically every slide contained at least one example. In some cases a number of thalles grew superimposed one upon another.

Type.—Homoeotypes, slides 1280, 1282, 1289, 1355, 1360. Johnson Collection, Colorado School of Mines.

EXPLANATION OF PLATE 63

FIG. *1*—*Lithophyllum incaensum* Johnson and Tafur, n. sp. Holotype (slide 1283a) ×25. A section through a mass showing pronounced growth zones, character of tissue, and conceptacles. (p. 540)

2—*Mesophyllum peruvianum* Johnson and Tafur, n. sp. Holotype (slide 1363) ×75. Shows detail of tissue and conceptacles. (p. 539)

3—*Lithophyllum* sp. *A*. Figured specimen (slide 1362) ×100. A section of the tissue with many spaces formerly occupied by conceptacles. (p. 540)

4—*Mesophyllum pueranum* Johnson and Tafur, n. sp. Holotype (slide 1361) ×100. Section of a branch showing tissue with growth zones and conceptacles. (p. 539)

(*Plate 64 and its description will be found on page 548*)

Slide number	Length (mm.)	Width (mm.)	Average (mm.)
1280 row a	0.036–0.039	0.014–0.017	0.038×0.016
b	0.045–0.047	0.010–0.016	0.046×0.015
c	0.045–0.050	0.014–0.023	0.048×0.017
d	0.040–0.046	0.013–0.017	0.043×0.015
e	0.022–0.040	0.007–0.010	0.027×0.085
f	0.025–0.030	0.007–0.010	0.027×0.087
g	0.048–0.049	0.012–0.018	0.048×0.0155
h	0.046–0.047	0.012–0.016	0.046×0.0145
i	0.032–0.039	0.011–0.016	0.033×0.014
j	0.042–0.045	0.011–0.015	0.044×0.013
k	0.033–0.034	0.011–0.018	0.033×0.014
l	0.028–0.035	0.011–0.017	0.031×0.014
m	0.055–0.056	0.012–0.020	0.055×0.0155
n	0.065–0.065	0.016–0.021	0.065×0.018
o	0.050–0.052	0.014–0.020	0.051×0.016
p	0.030–0.050	0.011–0.022	0.041×0.015
q	0.035–0.065	0.013–0.020	0.047×0.0146
r	0.024–0.045	0.011–0.020	0.039×0.0163
s	0.040–0.054	0.014–0.020	0.044×0.015
t	0.033–0.040	0.014–0.018	0.034×0.143
1289 row a	0.062–0.073	0.013–0.026	0.071×0.018
b	0.071–0.091	0.010–0.023	0.082×0.016
c	0.064–0.084	0.013–0.022	0.074×0.016
d	0.051–0.064	0.015–0.024	0.056×0.020
1282 row a	0.031–0.042	0.017–0.026	0.038×0.021
b	0.024–0.035	0.010–0.021	0.028×0.016
c	0.021–0.038	0.010–0.021	0.032×0.018
d	0.045–0.082	0.024–0.032	0.058×0.027
e	0.047–0.061	0.027–0.036	0.050×0.030
f	0.047–0.064	0.024–0.033	0.054×0.026
g	0.018–0.038	0.019–0.029	0.033×0.023
h	0.034–0.048	0.012–0.025	0.042×0.021
1355 row a	0.040–0.045	0.013–0.023	0.042×0.017
b	0.036–0.048	0.014–0.023	0.042×0.018
c	0.036–0.051	0.018–0.027	0.042×0.023
d	0.046–0.054	0.016–0.025	0.052×0.020
e	0.063–0.067	0.014–0.018	0.064×0.016
1360 row a	0.031–0.039	0.011–0.018	0.035×0.015
b	0.028–0.033	0.011–0.020	0.031×0.015
c	0.032–0.037	0.010–0.022	0.030×0.014
d	0.028–0.037	0.011–0.022	0.033×0.015
e	0.036–0.039	0.011–0.022	0.036×0.015
f	0.032–0.041	0.011–0.027	0.039×0.019

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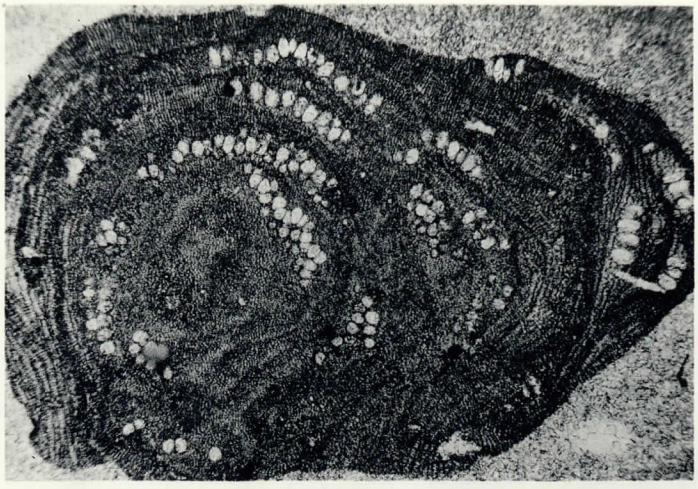

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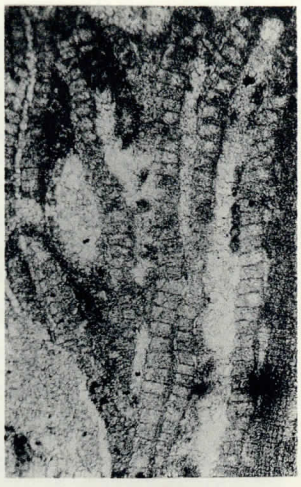

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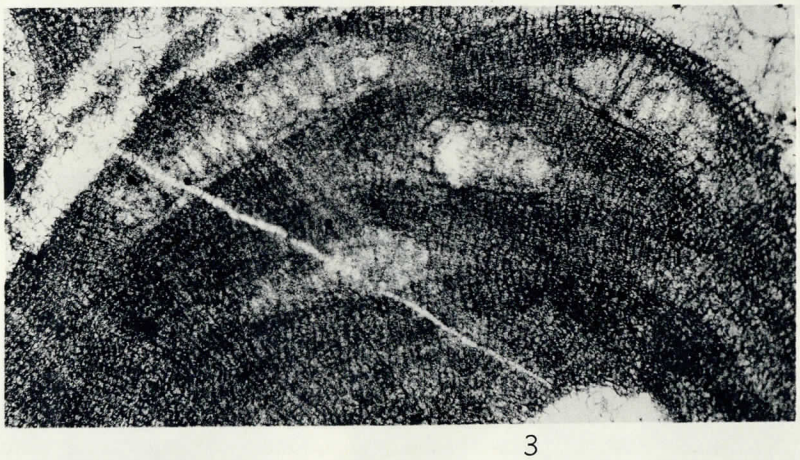

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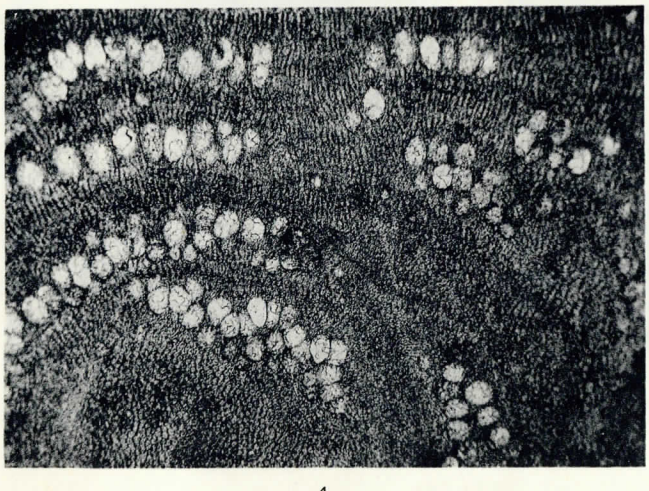

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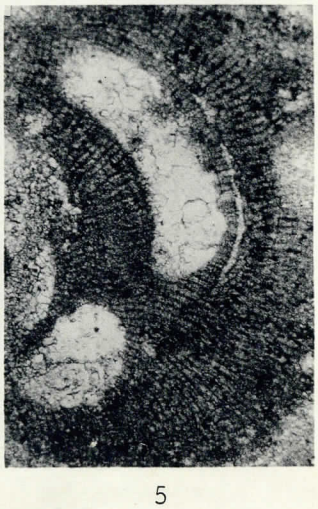

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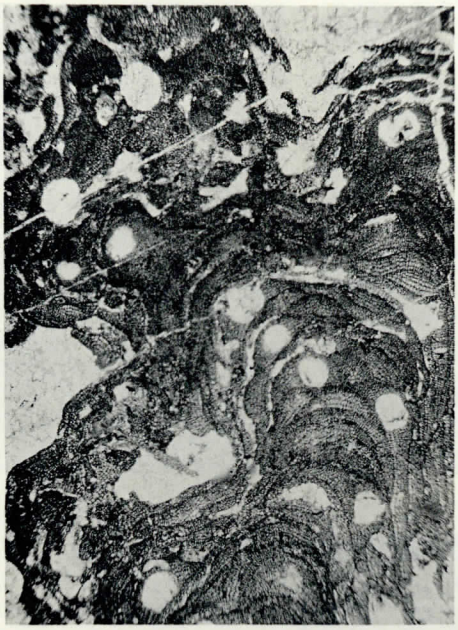
Johnson and Tafur, Eocene Algae from Peru



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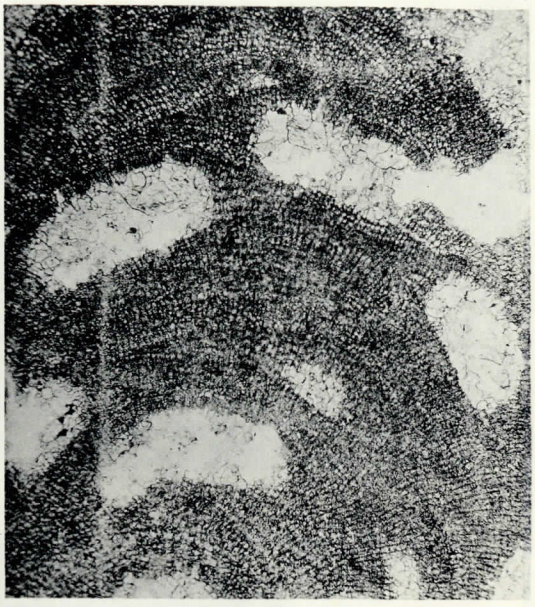

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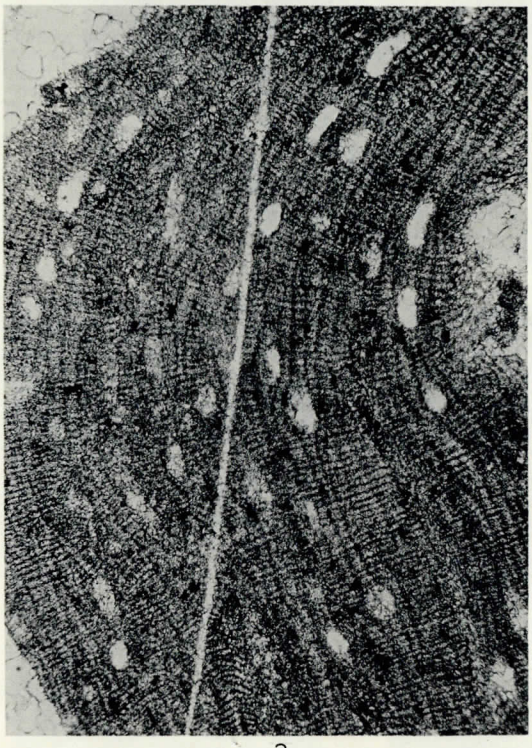

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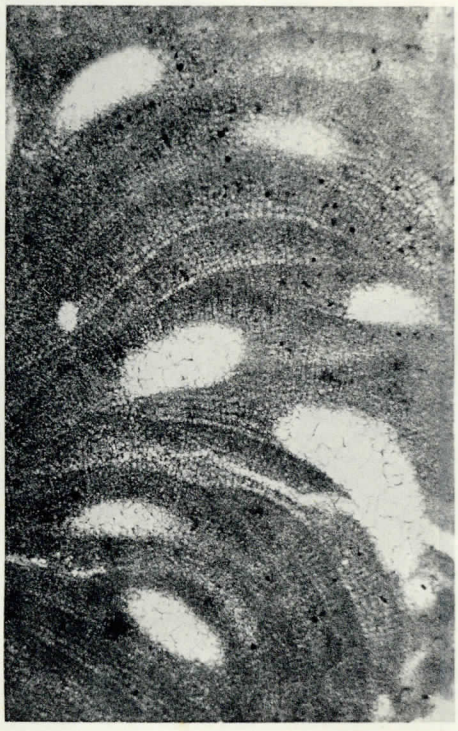

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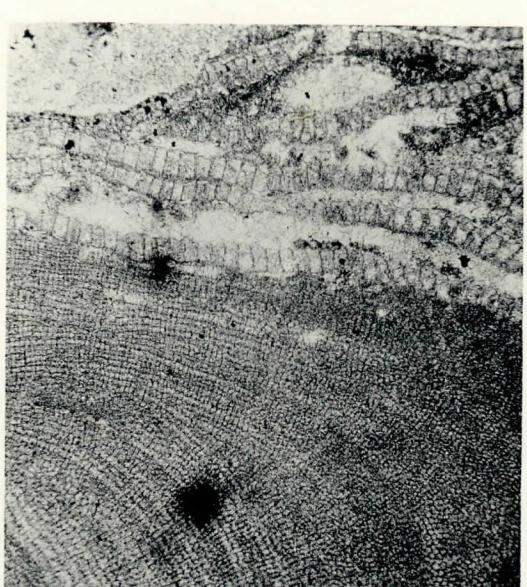
Johnson and Tafur, Eocene Algae from Peru



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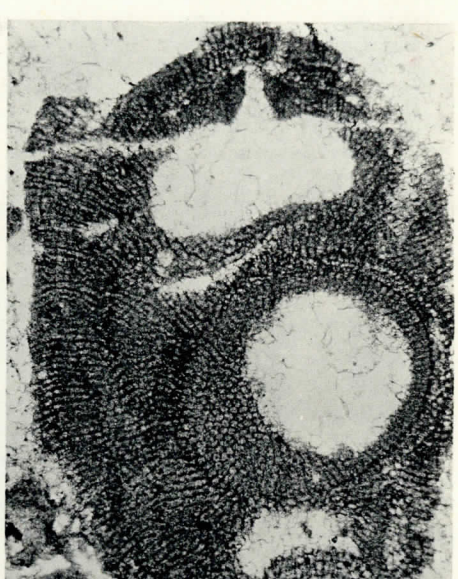

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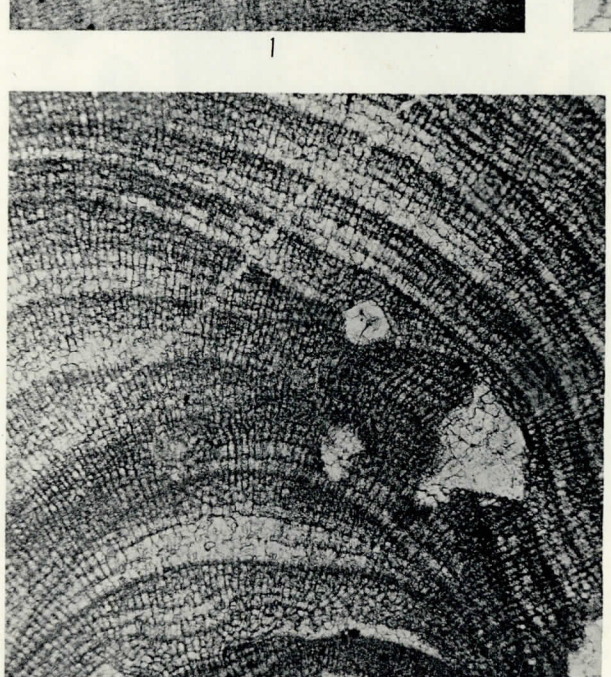

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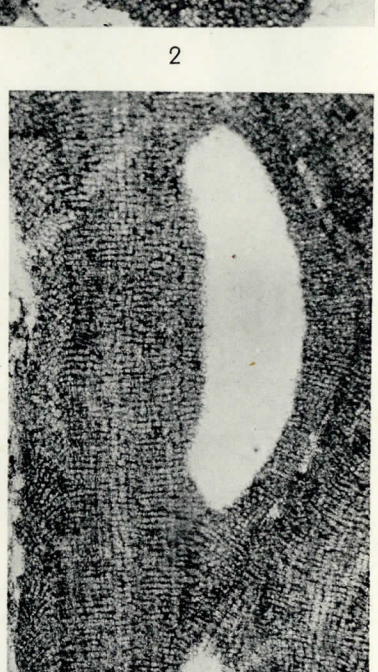
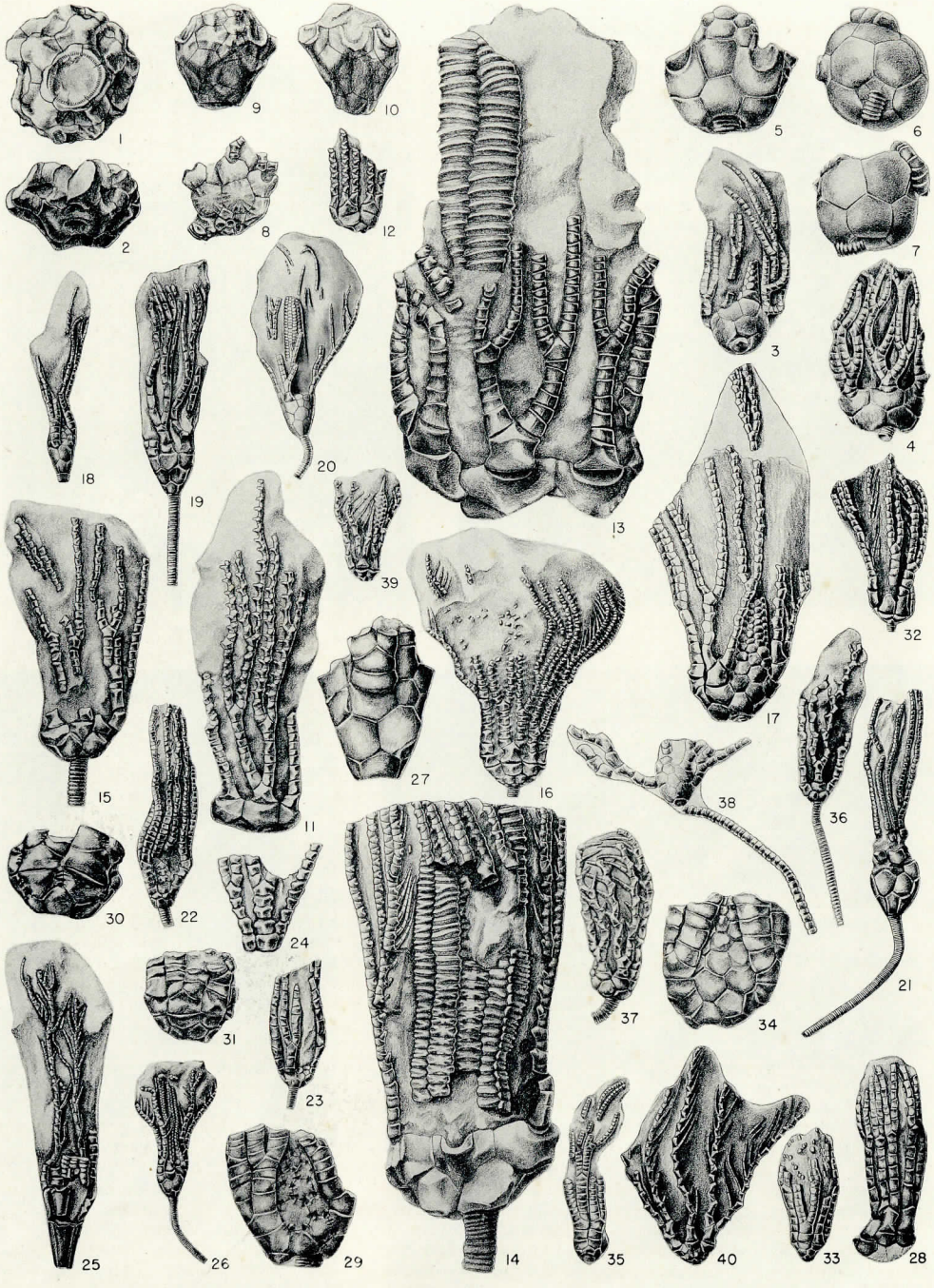


4

Johnson and Tafur, Eocene Algae from Peru



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EXPLANATION OF PLATE 64

FIG. *1*—*Lithophyllum sierra-blancae* Howe and *Lithoporella melobesioides* Foslie. Homoeotype (slide 1282) ×75. A portion of a branch of *Lithophyllum* showing the tissue with several thalles of the *Lithoporella* above. (p. 540)

2—*Lithophyllum* sp. *B*. (slide 1283a) ×100. An oblique section showing tissue and a conceptacle. (p. 541)

3—*Mesophyllum atascaderum* Johnson and Tafur. Holotype (slide 1362) ×100. A detail of the tissue showing growth zones and a conceptacle. (p. 539)

4—*Lithothamnion limaensum* Johnson and Tafur, n. sp. Holotype (slide 1285) ×100. A portion of a crust showing hypothallus (at left), perithallus, and conceptacle scar. (p. 538)