TERTIARY AND PLEISTOCENE CORALLINE ALGAE FROM LAU, FIJI

BY

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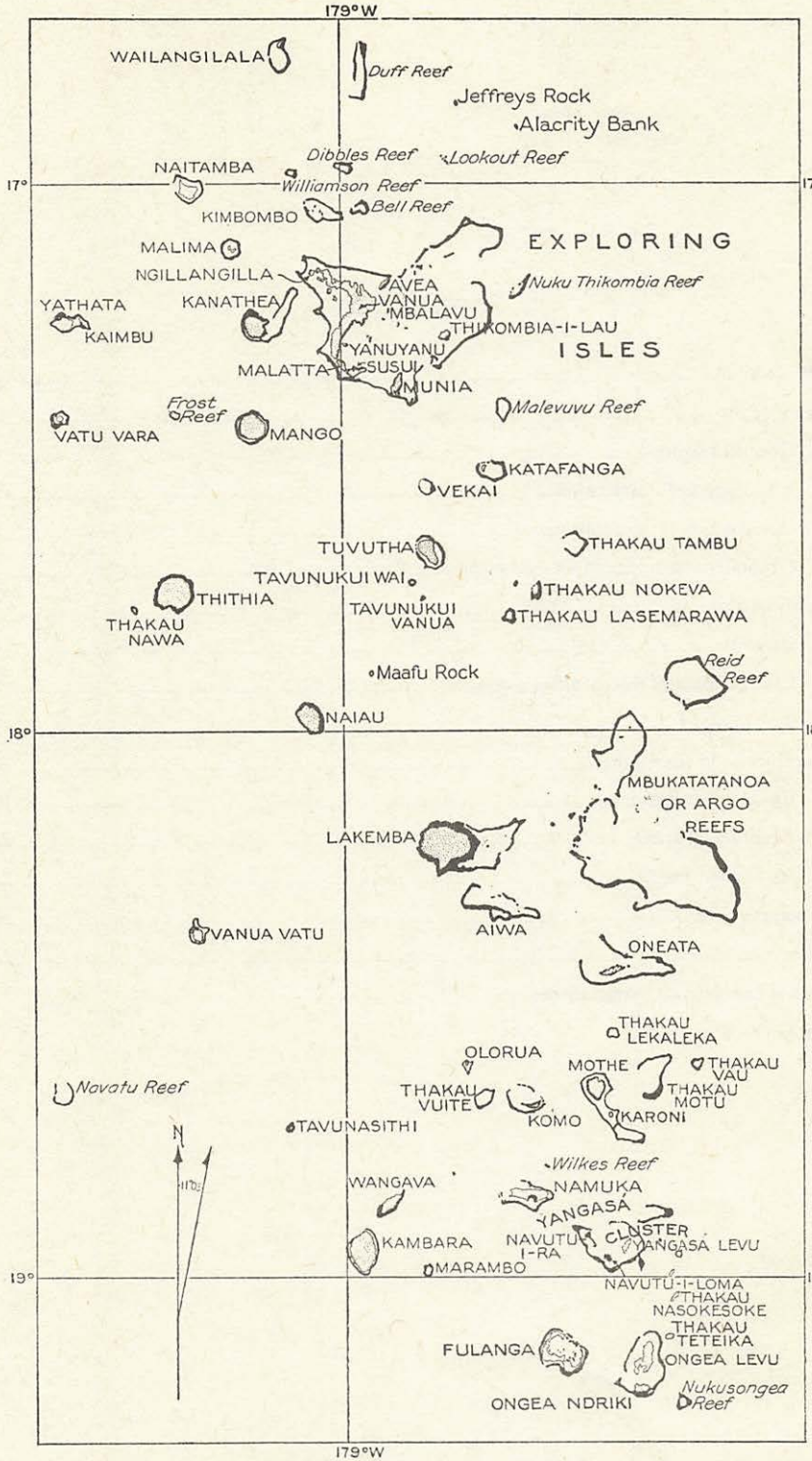
CONTENTS



Map of Lau, showing main islands (stippled) and reefs (black). Traced from U. S. Hydrographic Office Charts, numbers 2851 and 2852.

Tertiary and Pleistocene Coralline Algae from Lau, Fiji

By

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INTRODUCTION

This study of the coralline algae collected by Harry S. Ladd and J. Edward Hoffmeister in 1934 during their geological studies of the Lau Islands in eastern Fiji is based on about 50 specimens and 150 slides. The descriptions include: *Archaeolithothamnion,* two species; *Lithoporella,* two species; *Mesophyllum,* three species; *Lithophyllum,* six species; *Lithothamnion,* five species; *Amphiroa,* six species; *Corallina,* one species; and *Jania,* one species. One species of the green alga *Halemeda* included in the collection is also described. Of these 27 species, 16 are new. All of the other fossils obtained are described in the "Geology of Lau" by Ladd and Hoffmeister and others (11)[1], published by Bishop Museum in 1945.

Dr. W. A. Setchell of the University of California had planned to study the material dealt with in this paper, but his death occurred before much work had been done. The collections were turned over to Mr. Johnson late in 1946 and were studied by him during 1947 and 1948. Mr. K. C. Chandiok, a graduate student, assisted him during one semester in 1947 but was forced to discontinue because of the pressure of other work. Mr. Ferris then took over and assisted with the detailed laboratory work during the school year of 1947-1948.

The brief statement on the stratigraphy, the map reproduced as the frontispiece, and the chart used as table 1 are taken from the Lau report, as are the designations of stations from which specimens were collected.

We are grateful to Dr. Ladd and Dr. Hoffmeister for the opportunity to study and describe the material, and to the Colorado School of Mines, which generously supplied laboratory and photographic facilities. Dr. William Randolph Taylor of the University of Michigan offered helpful suggestions and looked over some puzzling specimens.

[1] Numbers in parentheses refer to Literature Cited, page 26.

TABLE 1.—SUBDIVISIONS OF THE TERTIARY IN THE EAST INDIES AND POSSIBLE EQUIVALENTS IN FIJI, TONGA, ETC. (AFTER LADD AND HOFFMEISTER)

	Van der Vlerk-Umbgrove stages		Percentages of species still living (Martin)	Possible equivalents in Fiji		Possible equivalents in Tonga (Eua)	
				Western Fiji (Vitilevu)	Eastern Fiji (Lau)		
Quaternary		"Recent"	100		Mango odinite		
		"Pleistocene"	70-100		Fulanga limestone		
Upper Tertiary	h	"Pliocene"	50-70±		Ndalithoni limestone	Coral reef limestone	Neogene
	g	"Upper Miocene"	20-50±	Suva formation	Koro Mbasanga volcanics	Fossiliferous tuff	
	f	"Lower Miocene"	8-20±		Futuna limestone		
	e			Viti limestone	Lau volcanics		
Lower Tertiary	d	"Oligocene"				Foraminiferal limestone	Eogene
	c						
	b	"Eocene"	0				
	a			Sambeto series		Tuffs and flows	
Mesozoic? Cretaceous?				Tholo plutonics		Diabasic norites (boulders)	
				Wainimala series			

STRATIGRAPHY

GENERAL FEATURES

"The rocks of Lau are of two main types, volcanics and limestones. Volcanic activity was concentrated in three periods, during each of which a more or less characteristic type of rock was produced. In the intervals that separated the periods of volcanism, limestones were laid down; but these limestones cannot be easily recognized. It is probable that limestones of some sort have been forming in Lau throughout its history." (From Ladd and Hoffmeister, 11, p. 11.)

The stratigraphic units recognized in the present report are included in table 1.

LITHOLOGY AND DISTRIBUTION

"Rocks of the Lau or first period of volcanism are chiefly andesites and occur widely throughout the islands. Those of the second or Koro Mbasanga period are chiefly olivine basalts and are less widely distributed. Agglomerate was the commonest type of rock formed during the earlier periods of volcanic activity. Odinites that represent a third period of volcanism are known only on the islands of Mango and Kambara. The lower portion of the Futuna limestone is a bedded rock made up largely of algae and Foraminifera but the upper part is coralliferous and, on at least two islands, includes elevated coral reefs. The two younger limestone formations are richly coralliferous, the Fulanga limestone consisting entirely of elevated reef rock. The distribution of the various formations is summarized in table 2.

"The stratigraphic relations between the four Tertiary formations are most clearly shown on the large island of Vanua Mbalavu in the Exploring Isles. For this reason, most type localities have been chosen there and local names utilized. Detailed descriptions of type localities are given in the sections devoted to Vanua Mbalavu, Fulanga, and Mango." (From Ladd and Hoffmeister, 11, pp. 11-12.)

COMPOSITION OF LAU LIMESTONES

The primary constituents of the Lau limestones are: (1) organic material, (2) calcareous paste, (3) oolites, and (4) volcanic detritus. Some of the limestones are made up of one of these constituents to the exclusion of the others, but generally there is more or less mixing of materials. Volcanic detritus is notably lacking in the all-limestone islands.

TABLE 2.—KNOWN DISTRIBUTION OF ROCK FORMATIONS IN LAU (11, p. 12)

	Mango odinite	Fulanga limestone	Ndalithoni limestone	Koro Mbasanga volcanics	Futuna limestone	Lau volcanics
NORTHERN LAU						
Exploring Isles Vanua Mbalavu			×	×	×	×
Malatta					×	×
Susui			×	×	×	×
Avea					×?	×
Thikombia-i-lau				×?	×	×
Munia				×		
Mango	×				×	×
Katafanga					×	×
Tuvutha			×		×?	×
Thithia					×?	×
Naiau					×?	×
SOUTHERN LAU						
Lakemba					×	×
Aiwa					×	
Vanua Vatu					×	
Oneata				×?	×	×
Mothe-Karoni					×	×
Komo					×?	×
Wangava		×?			×?	
Kambara	×				×?	
Namuka					×	
Yangasa					×	
Fulanga		×			×?	
Ongea		×			×	

ORGANIC CONSTITUENTS OF LAU LIMESTONES

The petrography of the Lau limestones is described by Geoffrey W. Crickmay (11, pp. 211-250), but a brief statement of the importance of various groups as rock formers is in order here. Table 3, after Crickmay, gives the average composition of typical rock types. The percentages must be regarded as only approximate, for no thin section is entirely representative of the rock from which it was cut. This is particularly true of the limestones, for large shells (especially mollusks) were intentionally avoided in selecting section chips. The percentages are by volume, and the results are therefore not closely comparable to the analyses of recent calcareous deposits which are in weight percentage.

TABLE 3.—ORGANIC CONSTITUENTS OF COMMON ROCK TYPES FROM LAU ISLANDS (11, p. 229)

	1	2	3	4
Algae	3.1	6.5	14.4	4.6
Larger and beach Foraminifera	18.5	2.0	2.0	6.6
Pelagic Foraminifera	6.6	1.0	0.5	10.4
Corals	1.5	35.0	1.0	tr.
Mollusks and brachiopods	.....	0.5	tr.	1.5
Echinoids	0.5	1.5	1.0	1.4
Unidentified	3.1	5.5	3.0	4.2
Total	33.3	52.0	21.9	28.7

1. Average of 6 tuffaceous limestones.
2. Average of 6 coralgal calcarenites.
3. Average of 8 algal calcalutites.
4. Average of 4 foraminiferal calcalutites.

CORALLINE ALGAE

GENERAL

The coralline algae are a family of the red algae (Rhodophyta) which have made some interesting structural developments. They differ from other calcareous algae in that $CaCO_3$ is secreted within and between the cell walls as well as (in most cases) being deposited around the plant tissues. For this reason they usually make good fossils which show recognizable microstructure.

Such fossils have been observed by geologists and paleontologists for over a century in rocks ranging in age from Cretaceous to Recent. However, until recently they have not been studied. The work of Lemoine (12-16) shows that such fossils have both stratigraphic and ecologic significance, and that they

have possibilities of being used as time fossils. Before they can be so used, however, much basic work must be done in describing the fossils from beds of known age in many areas. The present collection is valuable in that respect, as an abundance of other fossils were collected from the same beds as the algae and have been described and dated (Ladd and Hoffmeister *et al.*, 11). Few such collections have been described from the Pacific area. Lignac-Grutterink (17) and Johnson and Ferris (10) describe small collections from the Dutch East Indies; Howe (8), from the Eocene of California. A few species have been described from Japan.

Students of modern algae make use of the growth habits of the plant; the structure of the tissue; the size and shape of the cells; and the structure, size, shape, and position of the conceptacles on the plant. Unfortunately, the paleobotanist seldom gets so much data. Usually he obtains only fragments of the plants, pieces of branches broken from the basal crust in most cases or small morsels of the crust. And frequently the fragments are sterile. Consequently, if he is to determine genera and name species he may have to do so without all the data he would like to have.

Without conceptacles, it is often impossible to separate *Lithophyllum* from *Lithothamnion,* or *Archaeolithothamnion* from *Lithothamnion,* or *Mesophyllum* from *Lithophyllum.*

CLASSIFICATION OF THE CORALLINE ALGAE

The classification of coralline algae (Lemoine, 16) in general use is given below. It includes all the genera described in this report and a number of others.

Class Rhodophyta
- Family Corallinaceae
  - Subfamily Melobesieae
    - Genera
      - Archaeolithothamnion
      - Mesophyllum
      - Lithophyllum
      - Epilithon
      - Melobesia
      - Tenarea
      - Lithothamnion
      - Porolithon
      - Pseudolithophyllum
  - Subfamily Corallineae
    - Amphiroa
    - Arthrocardia
    - Corallina
    - Cheilosporum
    - Jania

TERMINOLOGY

In descriptions of the coralline algae, the entire plant or plant tissue is spoken of as the *thallus*. Among the Melobesieae, or inarticulate corallines, this is usually composed of two types of tissue, the *hypothallus* and the *perithallus*. The basal portion of the plant is usually composed of cells of a different size than the tissue above and having a different arrangement. This forms the *basal hypothallus*. In some genera, especially *Lithophyllum*, the central portion of branches and stems shows a similar development, forming the *medullary hypothallus*. Above the basal hypothallus in encrusting forms the tissue is composed of cells of a different size than the hypothallus and usually more regularly arranged in rows or layers. This is the *perithallus*. Similar tissue develops around the outside of the branches.

The plants reproduce by spores, which develop in spore cases or *conceptacles*.

The various genera have characteristic developments in the character and structure of the hypothallus and perithallus, and in the structure and arrangement of the conceptacles; so these structures are of basic importance in classification and identification. Species are usually differentiated on the basis of differences in cell size, size and shape of the conceptacles, and peculiarities in texture and structure of the tissue.

Among the Corallineae, or articulated corallines, the thallus usually consists of a small basal crust from which arise many branching stems forming a small, often bushy, tuft. The branches are segmented, consisting of alternations of uncalcified and calcified segments which are respectively called *geniculа* (or *nodes*) and *intergenicula*. Both of these consist of a central or medial portion built of rows of long cells and a thin outer *dermal* or *cortical* portion. The spores develop in spore cases or *conceptacles* which, however, develop externally or in the uncalcified portions, so are practically never found in the fossils.

The identification table given below was published in 1943 by Lignac-Grutterink (17, pp. 284-285). In addition to its usefulness to readers, it illustrates the use of the terms just defined.

Key to Some Fossil Genera of Coralline Algae
(after Lignac-Grutterink, 17)

I. Non-articulated; cells less than 50 μ high.....Melobesieae
  A. Rows of cells combined into a tissue.
    a. Hypothallium filaments horizontal or slightly curved upward, rather irregularly arranged and unattached to each other.
      (a) Cells of the vertical perithallium filaments distinctly in horizontal rows. Sporangia separate, in long horizontal rows.....
      .....**1. Archaeolithothamnion**

(aa) Cells of the vertical perithallium filaments not at one horizontal level, filaments separate from each other. Sporangia united in conceptacula.....2. **Lithothamnion**

aa. Rows of hypothallium cells in half circles; hypothallium compact. Cells of the vertical perithallium filaments in distinct horizontal rows. Sporangia in conceptacula.....3. **Lithophyllum**

AA. Cells not clearly united into a tissue.
1-8 long rows of cells, at several places not touching one another; width of cells very diverse in each filament.....4. **Lithoporella**

II. Articulated; cells more than 50 μ high.....CORALLINEAE VERAE

A. Joints consisting of a certain number of rows of high cells, regularly alternating with one row of low cells; cells in the nodes of the same height as those in the joints.....5. **Amphiroa**

AA. Joints consisting of cells of the same height; cells in the nodes of different height, as are those in the joints.

a. In the joints cell rows curved.....6. **Corallina**

aa. In the joints cell rows straight, horizontal, curving down at a blunt angle at each end.....7. **Arthrocardia**

The present collection consists mainly of encrusting Melobesieae and Corallineae. Unfortunately, the modern encrusting forms of the East Indies, or even the entire Pacific, have received little study and are practically unknown; hence, it is impossible to compare the fossil and modern forms. On the other hand, the modern Corallineae have been studied by A. Weber van Bosse (19) and by Manza (18), permitting such a comparison.

The type material collected by Ladd and Hoffmeister is the property of the University of Rochester and is deposited in the United States National Museum on an indefinite loan basis.

DESCRIPTIONS OF THE FOSSILS

FAMILY CORALLINACEAE

SUBFAMILY MELOBESIEAE

Genus **Archaeolithothamnion** Rothpletz

This genus is represented in the collections by only a few clearly recognizable specimens. Several other small shreds of tissue which were found may belong to the genus.

Archaeolithothamnion fijiensis, new species (pl. 1, *B, C, E*).

Thallus forms a crust which probably bears rounded or mammillary projections. Thickness of thallus 8.5 mm. to 19.4 mm. Some areas of the tissue consist of quite regular rows of cells; other areas, of irregular and contorted rows.

Hypothallus fairly well-developed, but poorly preserved on the specimens studied. Consists of small, nearly square cells which measure (approximately) 0.008-0.012 by 0.006-0.01 mm. There are 6 to 20 very irregular rows of cells.

Perithallus tissue has a peculiar appearance because in much of it the cell rows are irregular and contorted with areas which are fairly regularly arranged. In the contorted areas the cross (horizontal) partitions are thin and indistinct, although they

are well-defined in areas with regular arrangement. Cell dimensions: 0.008 to 0.018 mm. long by 0.07 to 0.012 mm. wide (average 15 by 12).

Conceptacles oval to circular, in crowded rows, and locally several rows crowded together (pl. 1, *B, C*). The circular ones range in diameter from 0.067 to 0.135 mm. The ovoid ones measure 0.09 to 0.147 mm. long by 0.085 to 0.128 mm. wide.

Holotype: Univ. Rochester, Mus. Nat. Hist. no. 13541.

Age: Futuna limestone.

Type locality: Station 32 [32A], Vanua Mbalavu, top of ridge about 0.33 miles south of Vindikoi Bay.

In cell dimension this species resembles the form Lignac-Grutterink describes (17) from the Miocene of Borneo under the name of *A. intermedium* Raineri, but differs in the shape of the sporangia. It suggests the modern *A. erythraeum* (Rothpletz) Foslie now found in the East Indies and in the central Pacific, but differs from it by having much smaller cells of the hypothallus and a more irregular tissue.

Archaeolithothamnion lauensum, new species (pl. 1, *A, D*).

Thallus forms a crust 5 to 9 mm. thick. Several thalles may be superimposed.

Hypothallus poorly developed, consists of 7 to 12 rows of small, nearly square cells which measure 0.013 to 0.021 mm. long by 0.0063 to 0.016 mm. wide. The basal cells are tiny and nearly square. From the base, the rows curve from horizontal until they join the vertical rows of the perithallus; and the size of the cells gradually increases from base to top of the rows.

Perithallus has a compact tissue of rectangular cells measuring 0.013 to 0.017 mm. long by 0.009 to 0.011 mm. wide. The vertical (longitudinal) walls are distinct; the cross walls are very fine and frequently indistinct. The tissue appears quite homogeneous, except around the conceptacles where the cell rows are often irregularly crowded and contorted.

Conceptacles much longer than wide, ovoid to egg-shaped, and measure 0.14 to 0.22 mm. high by 0.066 to 0.13 mm. wide. They occur in closely packed rows (pl. 1, *D*). The holotype shows six rows of conceptacles separated by bands of tissue about as wide as the conceptacles are high (pl. 1, *A*).

Holotype: Univ. Rochester, Mus. Nat. Hist. no. 13542.

Age: Miocene; Futuna limestone.

Type locality: Station L-508, Vanua Vatu, Narewa, in central basin near northern edge.

Only a few Miocene species of *Archaeolithothamnion* have been described. This species differs from all those described in cell size and in size and shape of conceptacles. The closest described species is *A. intermedium* Raineri from Libia, but *A. lauensum* differs in lacking alternations in size of cells of perithallus and in having slightly smaller cells. Also, it has much larger conceptacles. Lignac-Grutterink (17, p. 287) lists an Oligocene specimen from the East Indies under *A. intermedium* which has about the same cell size as our form, but smaller and relatively wider conceptacles.

Genus **Lithothamnion** Philippi

Lithothamnion fijiensum, new species (pl. 2, *C*).

Fragments of a crust. Tissue consists of fairly regular rows of irregular, rounded cells measuring 0.025 to 0.036 mm. long and 0.016 to 0.024 mm. wide.

Conceptacles 0.185 to 0.220 mm. wide and 0.115 to 0.130 mm. high. Conceptacles show indications of a number of roof openings.

Holotype: Univ. Rochester, Mus. Nat. Hist. no. 13543.

Age: Miocene; Futuna limestone.

Type locality: Station L2, Mango, north coast; altitude 0-5 feet.

The cell and conceptacle dimensions differ from any described fossil species. It somewhat suggests the modern *L. bandanum* Foslie, but differs from it by having larger cells and smaller conceptacles.

Lithothamnion heterothallum, new species (pl. 2, *A*).

Thallus forms crusts and nodular masses which often consist of superimposed thalles. Tissue formed of irregular to lenticular growth zones containing three to 12 rows of cells. Cells irregular in shape and variable in size. In some zones the lower rows are of large cells and the upper rows of small cells. In other zones there is an irregular mixture of large and small cells. Small cells measure 0.012 to 0.020 mm. long and 0.014 to 0.018 mm. wide; large cells 0.034-0.043 mm. by 0.018-0.027 mm.

Conceptacles numerous, irregularly distributed through the tissue; 0.172 to 0.250 mm. wide and 0.117 to 0.165 mm. high. Many of the conceptacles are filled with long slender objects suggestive of the spore capsules.

Holotype: Univ. Rochester, Mus. Nat. Hist. no. 13544.

Age: Miocene; Futuna limestone.

Type locality: Station L304, Lakemba, conglomeratic limestone caps hill at Vatuloa on southwest coast; altitude 84-99 feet.

The irregular tissue with its peculiar cell distribution makes this species very distinctive. The only known Miocene species which it resembles is *L. pennyi* Howe from the West Indies. It differs from it, however, in having smaller cells and a more irregular arrangement of cells.

Lithothamnion laminithallum, new species (pl. 9, *A, B, E*).

Thallus encrusting, forms nodular masses. In section tissue composed of thin, irregular growth layers or zones. Each layer is composed of 3 to 12 superimposed rows of rectangular to rounded cells. Hypothallus absent or poorly developed.

Perithallus cells 0.013 to 0.018 mm. long and 0.006 to 0.0135 mm. wide. Partitions between rows distinct, but poorly developed between the cells in a row.

Conceptacles 0.20 to 0.325 mm. long and 0.10 to 0.150 mm. high. The roof is pierced by a number of openings for the escape of spores. One section shows at least 6 such openings (pl. 9, *B*).

Holotype: Univ. Rochester, Mus. Nat. Hist. no. 13545.

Age: Miocene; Futuna limestone.

Type locality: Station L487, Oneata, southwest tip, fossils from various exposures above inner edge of coastal flat; altitude 5-50 feet.

So little work has been done on the encrusting and nodular species of *Lithothamnion* of the Pacific area that there is little described recent material with which to compare fossil forms. The nearest known fossil form is *L. tenuiseptum* Capeder from the Pliocene of Italy. However, it differs from *L. laminithallum* in having well-developed branches and a better-developed thallus.

The name is suggested by the thin laminated growth structure.

Lithothamnion lauensum, new species (pl. 7, *A, B*).

Plant forms a thin crust. Thallus consists of a poorly developed hypothallus and a perithallus. Hypothallus consists of only one or two rows of long inclined cells (pl. 7, *A*) measuring 0.042 to 0.065 mm. long and 0.011 to 0.016 mm. wide. The perithallus is formed of rows of rectangular cells 0.018 to 0.021 mm. long and 0.008 to 0.013 mm. wide. The cell rows are quite irregular around the conceptacles but are fairly regular in the sterile portions of the tissue.

Conceptacles measure 0.165 to 0.310 mm. wide and 0.058 to 0.115 mm. high. Some show several roof openings.

Holotype: Univ. Rochester, Mus. Nat. Hist. no. 13546.

Age: Possibly Miocene (Futuna limestone?).

Type locality: Station L72, Fulanga, southeast slope of Ndelai Korolevu; altitude 210 feet.

This species differs considerably in dimension of cells and conceptacles from any described Pleistocene form. The species, the dimensions of which most closely resemble it is the modern *L. crispatum* Hauck, but it differs considerably in the general appearance of the tissue.

Lithothamnion leptum, new species (pl. 2, *D*).

Thallus forms thin crusts. Numerous thalles may be superimposed. Hypothallus thin or absent, composed of irregular to curved rows of rectangular cells 0.009 to 0.012 mm. by 0.01 to 0.019 mm. Perithallus of fairly regular rows of rectangular cells 0.012 to 0.016 (18) mm. long and 0.009 to 0.014 mm. wide.

Conceptacles 0.320 to 0.365 mm. wide and 0.130 to 0.190 mm. high with a number of roof openings indicated.

Holotype: Univ. Rochester, Mus. Nat. Hist. no. 13547.

Age: Miocene; Futuna limestone.

Type locality: Station T10, Thikombia-i-lau, base of eastern ridge; altitude 250 feet.

This species differs in cell dimensions and size of conceptacles from any previously described Miocene *Lithothamnion.* It resembles considerably *L. aggregatum* described by Lemoine (16) from the Oligocene of Algeria.

Lithothamnion species A (pl. 3, *A, C*).

Thallus forms a thin crust containing a hypothallus and a perithallus. Hypothallus consists of irregular curving rows of cells measuring 0.025 to 0.028 mm. long and 0.008 to 0.009 mm. wide. The perithallus composed of regular rows of rectangular cells 0.017 to 0.019 mm. long and 0.013 to 0.016 mm. wide. Conceptacles unknown.

Figured specimens: Univ. Rochester, Mus. Nat. Hist. no. 13548.

Age: Miocene; Futuna limestone.

Locality: Station L463, Oneata, near southeastern shore of western lake; altitude 35 feet.

Genus **Mesophyllum** Lemoine

This genus was erected by Lemoine (14) to include Melobesieae, having tissue similar to *Lithophyllum* but conceptacles closely resembling those of *Lithothamnion.* It includes crustose and branching forms. The hypothallus of the crust is formed of rows of cells. In branches, or mammilla, the tissue is formed of rows of cells and is usually arranged in distinct zones. The conceptacles of sporangia show several openings in the roof, but the conceptacles of cystocarps have only a single opening.

Mesophyllum fecundus, new species (pl. 3, *D, E*).

Thallus consists of short thick branches 20 to 26 mm. long and 10 to 15 mm. wide, arising from a thin basal crust. Basal hypothallus thin (0.15 to 0.20 mm.) composed of curved rows of cells (0.013 to 0.023 mm. long by 0.008 to 0.015 mm. wide). The tissue of the branch consists of strongly arched crescent- or cup-shaped layers. These are composed of rows of rectangular cells (16 to 27 mm. long [average 17] by 6 to 9 mm. high). No secondary hypothalles were observed.

Conceptacles large, numerous, irregularly disposed through the tissue. They measure 250 to 385 mm. long and 150 to 200 mm. high. The roof is pierced by numerous openings, 4 to 6 being visible on some of the sections.

Holotype: Univ. Rochester, Mus. Nat. Hist. no. 13549.

Age: Possibly Miocene (Futuna limestone?).

Type locality: Station L77, Fulanga, northeastern slope of Ndelai Korolevu; altitude 35 feet.

The Miocene form most closely resembling this form is *M. ehrmanni* described by Lemoine (16) from Algeria. *M. ehrmanni* differs from *M. fecundus,* however, in having smaller cells of the perithallus. No known modern form closely resembles *fecundus* in structure and cell dimension.

Mesophyllum mangoensum, new species (pl. 4, *A-C*).

Thallus develops as a mammillated crust. Mammillae measure about 2.0 mm. long and 1.5 mm. high. The basal hypothallus is rather narrow and is composed of curved layers of thick-walled cells 0.013 to 0.02 mm. long and 0.009 to 0.017 mm. wide. Secondary hypothalles occur irregularly through the tissue and around the margins. The main tissue (perithallus) consists of irregular zones or layers, composed of rows of rectangular cells. The cells measure 0.025 to 0.032 mm. long by 0.007 to 0.010 mm. wide.

Numerous large conceptacles occur irregularly through the tissue. They measure 0.292 to 0.509 mm. long and 0.152 to 0.189 mm. high. The roof is pierced by numerous openings.

Holotype: Univ. Rochester, Mus. Nat. Hist. no. 13550.

Age: Miocene; Futuna limestone.

Type locality: Station M7, Mango, near eastern coast.

This species differs from all previously described Miocene species in structure and cell dimensions. The cells of the perithallus are unusually large. In structure, it closely resembles some forms of the modern *M. australe* (Foslie) of the south Pacific, except that it has much longer cells of the perithallus.

Mesophyllum prepulchrum, new species (pl. 5, *A, B*).

Thallus starts as a crust from which develop short, stubby branches, or mammillary projections. The largest fragment observed was a branch about 15 mm. long growing from a crust 3 to 4 mm. thick.

The basal hypothallus is composed of curved and contorted rows of elongated cells. Above the basal hypothallus are localized several similar secondary hypothalles. Other secondary hypothalles occur irregularly disposed in the tissue especially around the edges. Hypothallus cells are irregular in length. They measure 0.020 to 0.045 mm. long and 0.008 to 0.014 mm. wide.

The tissue of the branches consists of rows of rectangular cells arranged in pronounced crescent- or saucer-shaped layers or zones. The cells vary considerably in length from row to row; usually the lower rows in a layer have longer cells than the upper rows. The cells measure 0.014 to 0.027 mm. long by 0.007 to 0.013 mm. wide (average about 0.010 by 0.023).

The conceptacles measure 0.185 to 0.308 mm. long and 0.130 to 0.180 mm. high. Their roofs are pierced by numerous openings (pl. 5, *B*).

Holotype: Univ. Rochester, Mus. Nat. Hist. no. 13551.

Age: Miocene; Futuna limestone.

Type locality: Station L463, Oneata, near southeastern shore of western lake; altitude 35 feet.

Among the previously described Miocene forms, this species most closely resembles *M. savornini* Lemoine from the Miocene of Algeria; but it differs in having somewhat smaller cells and conceptacles. It closely resembles the modern *M. pulchrum* (W. v. Bosse and Foslie) of the south Pacific in both structure and growth habits, but differs in having a smaller average cell size and slightly smaller conceptacles.

Genus **Lithophyllum** Philippi

The thallus may develop as a crust, or as a mammillated or highly branching form. The hypothallus of the crust or basal portion is usually formed of concentric rows of cells, rarely of a row of irregular cells, or of a thin layer of curved or contorted rows of cells. In branching forms the central portion (medullary hypothallus) consists of concentric rows of cells. The upper parts of the crust and outer portions of branches (perithallus) are formed of rows of cells. The conceptacles of sporangia have only a single opening in the roof.

Lithophyllum fulangasum, new species (pl. 6, *A*).

Thallus forms a thin crust (0.4 to 0.9 mm. thick).

Hypothallus of curved rows of large cells (0.02 to 0.035 mm. long and 0.013 to 0.017 mm. wide). Perithallus of rectangular cells in fairly regular rows. Cells measure 0.009 to 0.013 mm. long by 0.007 to 0.010 mm. wide. Several small secondary hypothalles have

developed in the tissue with cells measuring 0.014 to 0.016 mm. long by 0.007 to 0.010 mm. wide. A space filled with clear calcite suggests an old conceptacle and measures 0.290 mm. long by 0.095 mm. high.

Holotype: Univ. Rochester, Mus. Nat. Hist. no. 13552.

Age: Possibly Miocene (Futuna limestone?).

Type locality: Station L77, Fulanga, southeastern slope of Ndelai Korolevu; altitude 35 feet.

Lithophyllum fulangasum suggests the modern *L. dentatum* Kutzing of the Mediterranean region, but has wider hypothallus cells, narrower cells of the perithallus, and larger conceptacles.

Lithophyllum megacrustum, new species (pl. 7, *D, E*).

Thallus forms a thick crust or nodular mass several centimeters thick.

Hypothallus not shown on our specimens. Perithallus consists of very regular rows of long rectangular cells with thick partition walls separating the rows of cells. The cells are slightly oblique to the row walls. There is a suggestion of alternation, or rows of cells of slightly different lengths.

Many conceptacles present, irregularly spaced throughout the tissue. Around the conceptacles, the cells are smaller and more irregular than in the rest of the tissue. Typical cells measure 0.047 to 0.058 mm. long and 0.015 to 0.018 mm. wide.

The conceptacles are 0.297 to 0.396 mm. long and 0.079 to 0.115 mm. high.

Holotype: Univ. Rochester, Mus. Nat. Hist. no. 13553.

Age: Pleistocene; Fulanga limestone.

Type locality: Station L35, Fulanga, elevated reef on seaward side of Nasuthu and Southeast Horn; altitude 0-25 feet.

Lithophyllum premoluccense Lemoine (pl. 4, *D*).

Available specimens of the thallus are fragments of short, thick, rounded branches consisting of a well-developed medullary hypothallus and perithallus. The hypothallus consists of alternating arched rows of long and short cells. The long cells measure 0.078 to 0.097 mm. long by 0.008 to 0.010 mm. wide, while the short ones measure 0.031 to 0.039 mm. long by 0.008 to 0.011 mm. wide. The perithallus consists of regular rows of rectangular cells 0.019 to 0.024 mm. long and 0.009 to 0.014 mm. wide. Conceptacles unknown.

Figured specimen: Univ. Rochester, Mus. Nat. Hist. no. 13554.

Age: Miocene; Futuna limestone.

Locality: Station M23, Mango, southern rim.

In appearance and cell dimension, this species fits the description of *L. premoluccense* given by Lemoine (13, p. 272) from the Miocene of Martinique. It is very close to the modern *L. moluccense* Foslie of the tropical Pacific.

Lithophyllum tenuicrustum, new species (pl. 6, *C, E*).

Thallus forms of a thin crust which usually consists of only a hypothallus. Rarely a thin hypothallus is present consisting of only a few layers of cells. Hypothallus consists of very regularly developed arched rows of cells measuring 0.019 to 0.023 mm. long by 0.007 to 0.015 mm. wide (average 0.020 by 0.012). Conceptacles unknown.

Holotype: Univ. Rochester, Mus. Nat. Hist. no. 13555.

Age: Miocene; Futuna limestone.

Type locality: Station T16, Thikombia-i-lau, southeastern coast; altitude 10-12 feet.

This form was found on a number of slides, showing as long slender hypothalles. In character, appearance, and cell dimensions, it closely resembles forms described by Lemoine (13, 15, 16) as *L. prelichenoides*. However, it seems desirable to give the Fiji form another name, at least until the conceptacles are known, because (1) *L. prelichenoides* is known only from the Mediterranean and adjoining areas and (2) the name implies a relationship to the modern *L. lichenoides,* the reproductive organs of which show it to be a *Mesophyllum.*

Lithophyllum thikombian, new species (pl. 6, *B, D*).

Thallus forms a crust and consists of a well-developed hypothallus of concentric rows of large cells (0.030 to 0.036 mm. long by 0.018 to 0.027 mm. wide), and a thick perithallus of regularly arranged rectangular cells (0.012 to 0.020 mm. by 0.010 to 0.017 mm.). Conceptacles unknown.

Holotype (pl. 6, *D*): Univ. Rochester, Mus. Nat. Hist. no. 13556.

Age: Miocene; Futuna limestone.

Locality: Station T11, Thikombia-i-lau, inner base of northern side of rim; altitude 325 feet. Also station T10, on same island, base of east ridge; altitude 250 feet.

This species differs considerably in cell dimension from any previously described Miocene or Pliocene form and is not close to any known modern form.

A small specimen from station T10 consisting of only a small hypothallus appears to represent a young form of the same species (pl. 6, *B;* Univ. Rochester, Mus. Nat. Hist. no. 13557).

Lithophyllum species A (pl. 5, *C*).

This species is represented in the Lau slides by a single small fragment of tissue which shows part of the perithallus and a single conceptacle. The tissue is too poorly preserved to permit accurate measuring of the cells. They are approximately 0.036 mm. long, using the widths of the rows of cells, but the widths of the individual cells are not determinable. The conceptacle is filled with clear calcite. It measures 0.325 mm. long and 0.114 mm. high and shows the large single orifice characteristic of this genus.

Figured specimen: Univ. Rochester, Mus. Nat. Hist. no. 13558.

Age: Possibly Miocene (Futuna limestone?).

Locality: Station L77, Fulanga, southeast slope of Ndelai Korolevu; altitude 35 feet.

The specimen does not give sufficient data to permit specific identification, but is included because it clearly shows a conceptacle.

Genus **Lithoporella** Foslie

This genus has the simplest structure of any of the Melobesieae, as the thallus consists of only a single row of cells in the sterile portions. Crusts are developed by a number of superimposed thalles. They usually develop on other algae.

Lithoporella melobesioides (Foslie) (pl. 8, *A*).

Lithoporella (*Mastophora*) *melobesioides* Foslie, *in* Weber van Bosse and Foslie, Siboga Exped. 41 : 73-77, figs. 30-32, 1904.

Melobesia (*Lithoporella*) *melobesioides* Foslie, *in* Lemoine, Mat. pour la Carte geologique de l'Algérie, 1st ser., Paleont. (9) : 108-110, figs. 78, 79, 1939.

Lithoporella melobesioides (Foslie) Foslie, *in* Lignac-Grutterink, Vehr. Geol. Mijnb. Gen. Geol. Serie 13 : 292-293, pl. 2, fig. 8, 1943.

Lithoporella (*Melobesia*) *melobesioides* Foslie, *in* Johnson and Ferris, Jour. Paleontology 23 : 196-197, pl. 37, figs. 4-5, pl. 39, fig. 2, 1949.

Thallus forms a thin encrustation. A number may be superimposed. The thallus consists of a row of large cells in the sterile portions, with sometimes an additional layer or two around the conceptacles. The cells are rectangular, usually elongated vertically, rarely square with thick walls, and often with rounded corners. They vary greatly in size even in one section of one layer.

Cells measured ranged from 0.040 to 0.063 mm. long and 0.016 to 0.028 mm. wide. Spaces formerly occupied by conceptacles measured from 0.260 to 0.360 mm. long and 0.030 to 0.050 mm. wide.

Figured specimen: Univ. Rochester, Mus. Nat. Hist. no. 13559.

Age: Miocene; Futuna limestone.

Locality: Station 32 [32A], Vanua Mbalavu, top of ridge about 0.33 mile south of Vindikoi Bay.

Everyone who has studied either modern or fossil members of this genus has noted the great variation of cell size, even in one section of an individual thallus. Howe (6) discusses this at length and concludes that unless conceptacles are present it is not wise to attempt to differentiate species. Lignac-Grutterink (17, p. 292), who described material of this type from the Dutch East Indies, and obtained from rocks ranging in age from Eocene to Pleistocene, assigned them all to the modern species *L. melobesioides*.

In a recent study of Tertiary algae from Java and Borneo (Johnson and Ferris, 10, pp. 196-197) we encountered a number of specimens and discussed them at some length.

The specimens from Lau, like the material from Java and Borneo, have a range of cell size which falls within the range given by Foslie for the modern Pacific form, *L. melobesioides*. However, the conceptacles are smaller on the one fertile specimen studied. This may be a specific difference, but considering

the wide size range in the modern form and having only one good fossil specimen available from Lau, we do not feel justified in calling it a new species.

Lithoporella species? (pl. 3, *C*).

Thallus consists of a layer of rectangular, nearly square cells with thick walls. Cells measure 0.022 to 0.026 mm. high and 0.011 to 0.014 mm. wide. The single specimen observed was sterile.

Figured specimen: Univ. Rochester, Mus. Nat. Hist. no. 13560.

Age: Miocene; Futuna limestone.

Locality: Station L463, Oneata.

This may be a variant of the highly variable *L. melobesioides*. However, the cells in the specimen studied were consistently shorter than in the numerous specimens of *L. melobesioides* observed by the authors. The cells appear almost square instead of long, narrow oblongs and are smaller than in any of the three better known modern species. Without a knowledge of the conceptacles, it does not seem wise to name this species.

Subfamily CORALLINEAE

Genus **Amphiroa** Lamouroux (emend. Weber van Bosse)

Amphiroa anchiverricosa, new species (pls. 5, *D; 7, C*).

Intergenicula (joints) long and relatively wide. Consisting of alternating rows of long and short cells. Long cells measure 0.088 to 0.097 mm. by 0.008 to 0.010 mm. wide on one specimen and 0.061 to 0.078 mm. by 0.008 to 0.011 mm. on several others. Marginal layers not clearly defined. Conceptacles not known.

Holotype: Univ. Rochester, Mus. Nat. Hist. no. 13561.

Age: Possibly Miocene (Futuna limestone?).

Localities: Station L4, Thithia, east of Tarakua on northern coast; altitude 0-8 feet. Also occurs at station L37, Fulanga, west coast; altitude 0-10 feet. There are some shreds which probably belong to this species from a number of other localities.

This species differs from any previously described fossil *Amphiroa*. It strongly suggests the modern *A. verricosa* Kutz. of the Pacific; but without a knowledge of the conceptacles, it does not seem wise to attribute it to that species.

Amphiroa fragilissima (Linnaeus) Lamouroux (pls. 2, *B;* 3, *B;* 6, *F;* 8, *B, F*).

Intergenicula long and relatively wide. Medial portion consists of alternations of 3-1, 4-1, or 5-1 rows of long and short cells. These rows are nearly straight, arching mainly close to the edges. Long cells show considerable variation, but are mainly around 0.064 to 0.070 mm. by 0.008 to 0.013 mm.; 0.070 to 0.073 by 0.010 to 0.014 mm.; 0.074 to 0.077 by 0.008 to 0.011; 0.084 to 0.090 by 0.008 to 0.013 mm. Short cells are 0.018 to 0.020 by 0.009 to 0.012 mm.; 0.015 by 0.010 mm.; 0.022 to 0.027 by 0.011 to 0.014 mm.; 0.042 to 0.045 by 0.015 to 0.016 mm. Cortical layer thick, often composed of 3 or 4 regular rows

of elongated rectangular cells measuring 0.030 to 0.035 by 0.007 to 0.009 mm.; 0.039 to 0.044 by 0.006 to 0.010 mm.; 0.056 to 0.060 by 0.007 to 0.011 mm. Conceptacles unknown.

Age: Miocene; Futuna limestone.

Localities: Stations A17 [A17A], Avea, 0.17 mile northeast of A16 [near southwest tip of island; altitude 410 feet], altitude 85 feet; L4, Thithia, east of Tarakua on north coast, altitude 0-8 feet; M23, Mango, southern rim; M25, Mango, southwestern rim, altitude 400 feet; L333, Tuvutha, on volcanic rock on northeast side of island, altitude about 225 feet.

This species fits the description of the modern *Amphiroa fragilissima* (Linnaeus) of the tropical Pacific. It is common in many of the Miocene limestones of the East Indies.

Amphiroa pacifica, new species (pl. 8, fig. *D*).

Intergenicula relatively slender. Medial portion consists of alternations of two rows of long cells and one row of short cells. Long cells measure 0.068 to 0.087 mm. long and 0.009 to 0.011 mm. wide; short cells 0.029 to 0.033 mm. long and 0.010 to 0.013 mm. wide. The cortex or marginal area consists of 4 or 5 rows of rectangular cells 0.014 to 0.017 (20) mm. long and 0.009 to 0.014 mm. wide. Conceptacles unknown.

Holotype: Univ. Rochester, Mus. Nat. Hist. no. 13562.

Age: Probably Miocene (Futuna limestone?).

Type locality: Station L23, Fulanga, calcareous sandstone, hill north of Muanaithake; altitude 80-90 feet.

In appearance this species suggests the modern *Amphiroa rigida* Lamouroux of the Pacific, but differs slightly in cell dimension.

Amphiroa regularis, new species (pls. 5, *E;* 8, *E*).

Intergenicula relatively broad and straight. Medial portion consists of alternations of rows of long and short cells following the formula 2L, 1S; 3L, 1S; 2L, 1S; 3L, 1S (rarely 4L, 1S). Long cells measure 0.054 to 0.081 mm. long and 0.008 to 0.026 mm. wide; short cells are 0.016 to 0.027 mm. long and 0.009 to 0.014 mm. wide. Cortical layers thin, cells irregular, measuring 0.014 to 0.018 mm. by 0.010 to 0.019 mm. Conceptacles unknown.

Holotype: Univ. Rochester, Mus. Nat. Hist. no. 13563.

Age: Miocene; Futuna limestone.

Locality: Station T16, Thikombia-i-lau, southeastern coast; altitude about 80-90 feet.

This species characterized by the regularity of outline, the alternation pattern of cell rows, and the cell dimensions. It suggests the modern *Amphiroa foliacea* Lamouroux which is widespread in the East Indies, but it has a narrower cortex and slightly different cell dimensions.

Amphiroa species **A.**

Intergenicula slender, consisting of alternating rows of long and short cells. Long cells measure 0.055 to 0.063 mm. by 0.009 to 0.012 mm.; short cells 0.020 to 0.023 mm. by 0.008 to 0.011 mm. Marginal cells not clearly defined on our worn specimens. Conceptacles unknown.

Age: Possibly Miocene (Futuna limestone?).

Locality: Station L37, Fulanga, west coast; altitude 0-10 feet. Also L4, Thithia, east of Tarakua on northern coast; altitude 0-8 feet.

This form closely resembles *A. anchiverricosa,* differing mainly in smaller cell size and more delicate structure. However, as Weber van Bosse (19) and Manza (18) found considerable variation in cell size and structure among modern species, both within a species and among various segments of a single plant, it seems wise to record these fragments but not to name them.

Amphiroa species B (pl. 8, *C*).

Intergenicula have a medial portion consisting of alternations of two rows of long cells and one layer of short cells. Long cells measure 0.042 to 0.057 mm. long and 0.010 to 0.014 mm. wide; short cells 0.026 to 0.034 mm. long and 0.011 to 0.014 mm. wide. Cortex cells not shown on the worn specimens. Conceptacles unknown.

Figured specimen: Univ. Rochester, Mus. Nat. Hist. no. 13564.

Age: Miocene; Futuna limestone.

Locality: Station U5, Susui, limestone boulder, center western part of island; altitude 230 feet.

Resembles *A. pacifica,* new species, in general appearance of intergenicula, but has slightly smaller cells. They may belong to the same species, but without knowledge of the cortical cells and conceptacles it does not seem wise to name it.

Genus **Corallina** Lamouroux

Corallina species? (pl. 4, *E*).

Intergenicula with medial portion of rows of long, rectangular cells 0.074 to 0.099 by 0.007 to 0.011 mm. Cortical layer thin, apparently a single layer of irregular cells. Conceptacles unknown.

Age: Miocene; Futuna limestone.

Locality: Station T16, Thikombia-i-lau, southeastern coast; altitude 10-12 feet.

Known only from a few badly frayed fragments. Only two Miocene species have been described. The cell dimensions of this form fall within the size of *C. crossmanni* Lemoine from Martinique, but the material is too poor to permit a reasonable identification.

Genus **Jania** Lamouroux

Jania species? (pl. 2, *E*).

In the many slides studied a number of fragments of *Jania* were observed. All were small and most of them were badly frayed and worn.

One fragment which approximates a complete segment is illustrated (pl. 2, *E*). The segment is 0.70 mm. long and 0.250 mm. wide, and contains 12 rows of cells measuring 0.036 to 0.053 mm. long and 0.017 to 0.027 mm. wide.

Age: Miocene; Futuna limestone.

Locality: Station T16, Thikombia-i-lau, southeastern coast; altitude 10-12 feet.

Family CODIACEAE

Genus **Halimeda** Lamouroux, 1812

Halimeda species? (pl. 9, *C, D*).

The Lau slides yielded only two specimens which can be attributed to the genus *Halimeda*. Unfortunately, they have suffered considerable wear and are too fragmentary to permit specific description. They are mentioned and illustrated here only to indicate the occurrence. The specimen figured in plate 9, *D* is catalogued as Univ. Rochester, Mus. Nat. Hist. no. 13565.

Age: Probably Miocene.

Locality: Station L378, Katafanga, Globigerina limestone on northeastern coast just above sea level.

ASSOCIATED FOSSILS

Table 4 shows the fossils associated with each species of algae.

TABLE 4.—ALGAE AND ASSOCIATED FOSSILS

NAME OF ALGA	AGE	FORMATION	ISLAND	ASSOCIATED FOSSILS
Archaeolithothamnion, fijiensis, n. sp.	Miocene	Futuna ls.	Vanua Mbalavu	Pecten (Pallium) waluensis Hertlein
Archaeolithothamnion, lauensum, n. sp.	Miocene	Futuna ls.	Vanua Vatu	.....
Mesophyllum fecundus, n. sp.	Miocene(?)	Futuna ls.(?)	Fulanga	.....
Mesophyllum mangoensum, n. sp.	Miocene	Futuna ls.	Mango	.....
Mesophyllum prepulchrum, n. sp.	Miocene	Futuna ls.	Oneata	Phyllacanthus imperialis (Lamarck) Metalia sternalis (Lamarck) Lovenia gigantea H. L. Clark Lovenia similis H. L. Clark Retepora species B Ostrea (Lopha) oneatensis Ladd Pecten (Chlamys) nausorensis Ladd Hemipristis serra Agassiz
Lithophyllum fulangasum, n. sp.	Miocene(?)	Futuna ls.(?)	Fulanga	.....
Lithophyllum megacrustum, n. sp.	Pleistocene	Fulanga ls.	Fulanga	Phyllacanthus imperialis (Lamarck) Platybrissus parvus H. L. Clark Pecten (Cryptopecten?) histrionicus (Gmelin) Lithophaga species Neritopsis radula (Linnaeus) Cypraea (Ipsa) childreni Gray
Lithophyllum premo-luccense Lemoine	Miocene	Futuna ls.	Mango	.....

TABLE 4.—ALGAE AND ASSOCIATED FOSSILS—*Continued*

NAME OF ALGA	AGE	FORMATION	ISLAND	ASSOCIATED FOSSILS
Lithophyllum tenuicrustum, n. sp.	Miocene	Futuna ls.	Thikombia-i-lau	.....
Lithophyllum thikombian, n. sp.	Miocene	Futuna ls.	Thikombia-i-lau	.....
Lithoporella melobesioides (Foslie)	Miocene	Futuna ls.	Vanua Mbalavu	Pecten (Pallium) waluensis Hertlein
Lithothamnion fijiensum, n. sp.	Miocene	Futuna ls.	Mango	.....
Lithothamnion heterothallum, n. sp.	Miocene	Futuna ls.	Lakemba	Phyllacanthus imperialis (Lamarck) Fibularia excavata H. L. Clark Oligopodia tapeina H. L. Clark Retepora species A Ostrea (Lopha) crista-galli (Linnaeus) Pecten (Chlamys) pallium (Linnaeus) Pecten (Pallium) waluensis Hertlein
Lithothamnion laminithallum, n. sp.	Miocene	Futuna ls.	Oneata	Phyllacanthus imperialis (Lamarck) Chondrocidaris problepteryx H. L. Clark Metalia sternalis (Lamarck) Retepora species B Cellepora species Ostrea (Lopha) crista-galli (Linnaeus) Pecten (Chlamys) nausorensis Ladd Pecten species Balanus (Austrobalanus) species Pyrgoma species Medaeus mbalavuensis Rathbun Menippe oceanica Rathbun

TABLE 4.—ALGAE AND ASSOCIATED FOSSILS—*Continued*

NAME OF ALGA	AGE	FORMATION	ISLAND	ASSOCIATED FOSSILS
Lithothamnion lauensum, n. sp.	Miocene(?)	Futuna ls.(?)	Fulanga	.....
Lithothamnion leptum, n. sp.	Miocene	Futuna ls.	Thikombia-i-lau	.....
Amphiroa anchiverricosa, n. sp.	Miocene(?)	Futuna ls.(?)	Thithia & Fulanga	.....
Amphiroa fragilissima Linnaeus (Lamouroux)	Miocene	Futuna ls.	Avea	Pecten (Pallium) waluensis Hertlein
Amphiroa pacifica, n. sp.	Miocene or Pleistocene	Futuna ls.(?)	Fulanga	.....
Amphiroa regularis, n. sp.	Miocene	Futuna ls.	Thikombia-i-lau	

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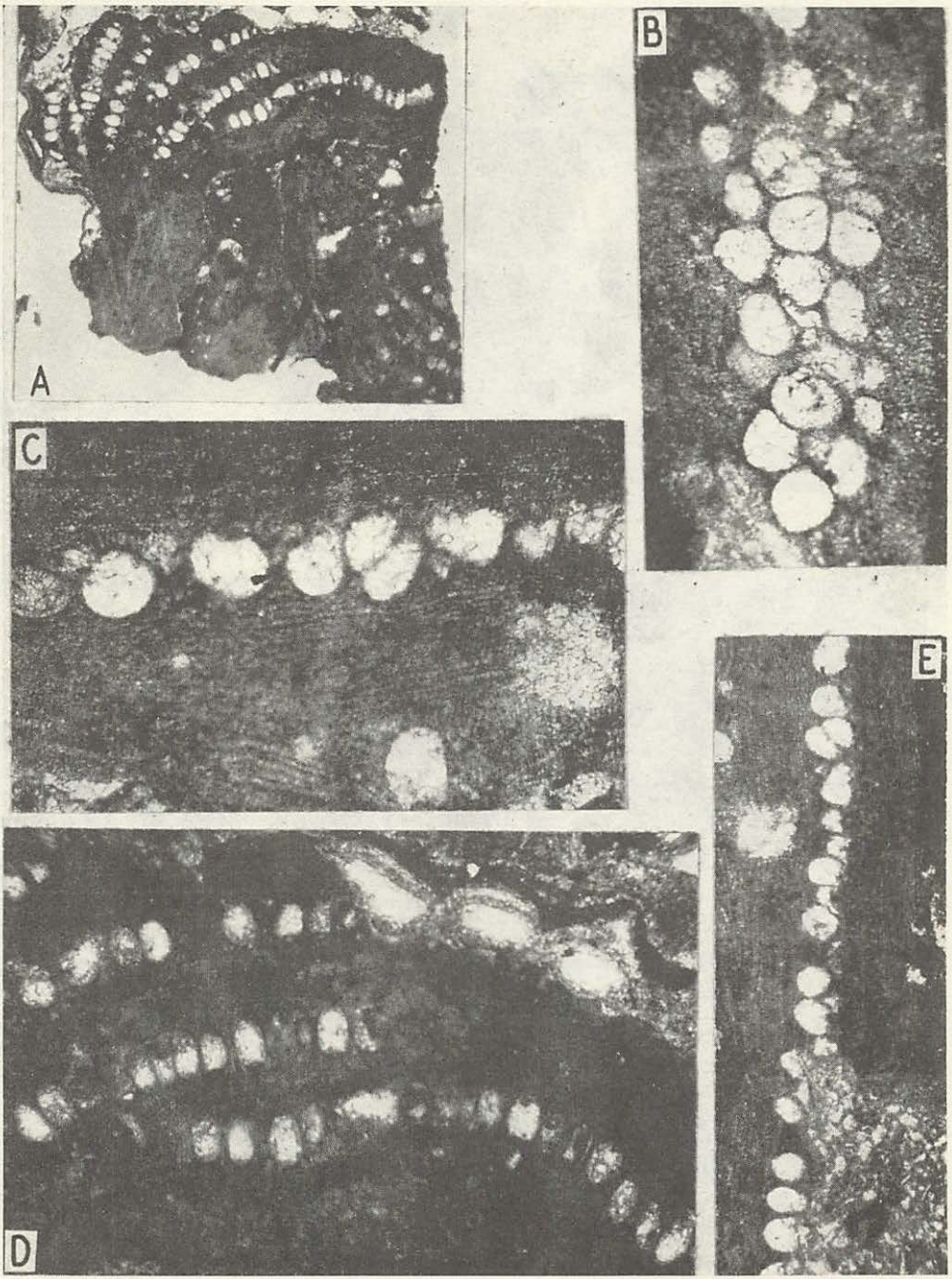
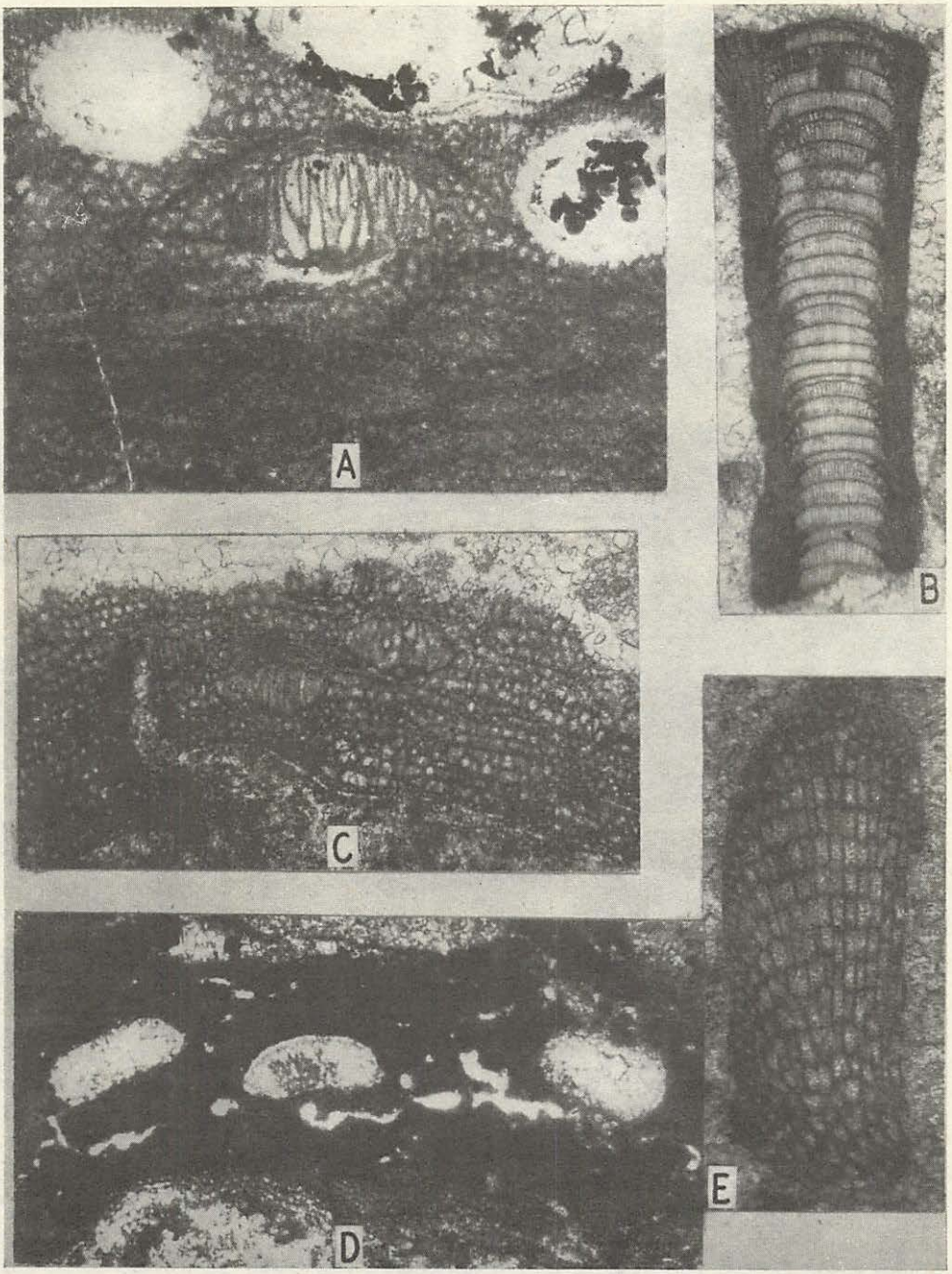
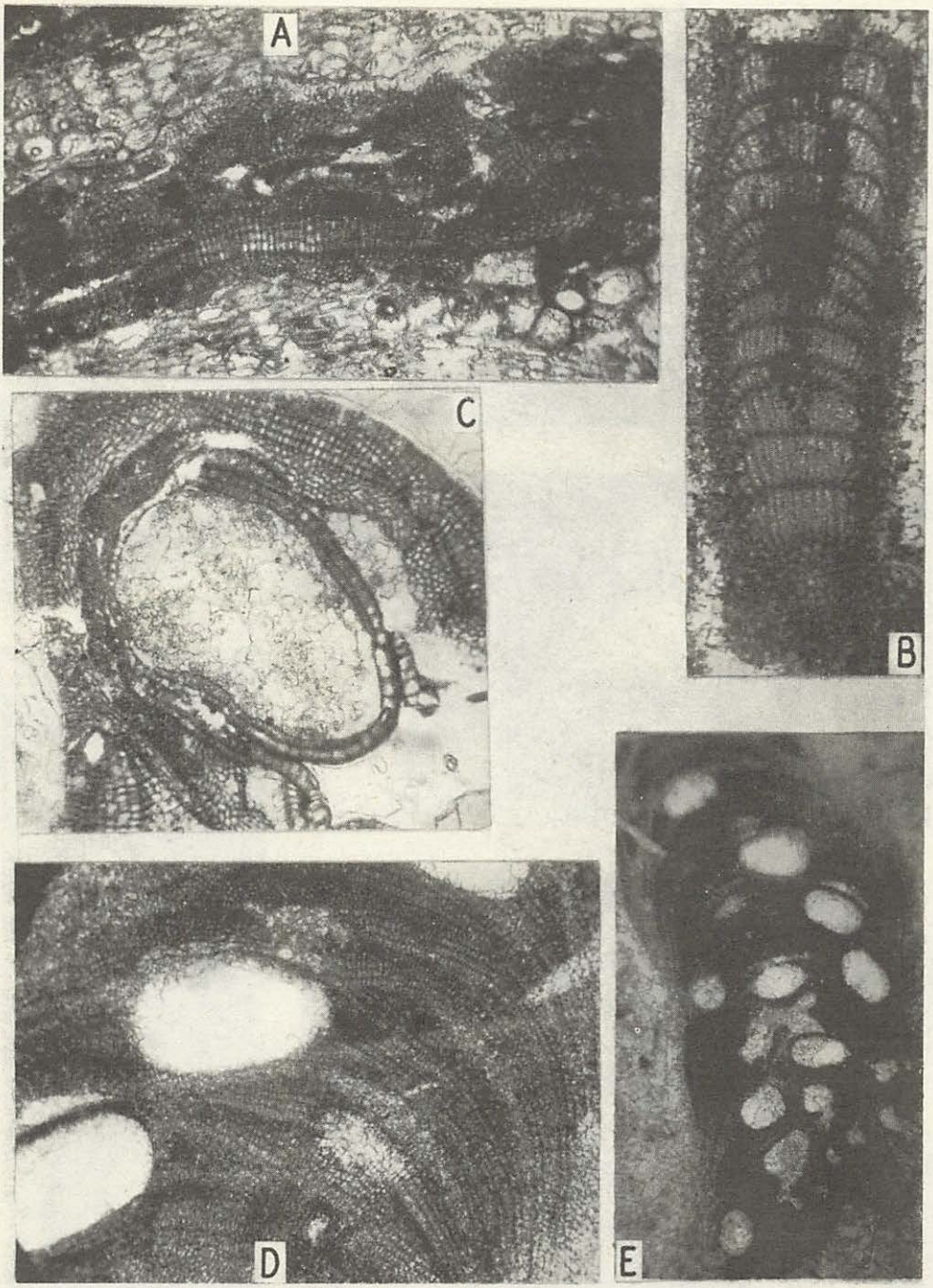
INDEX



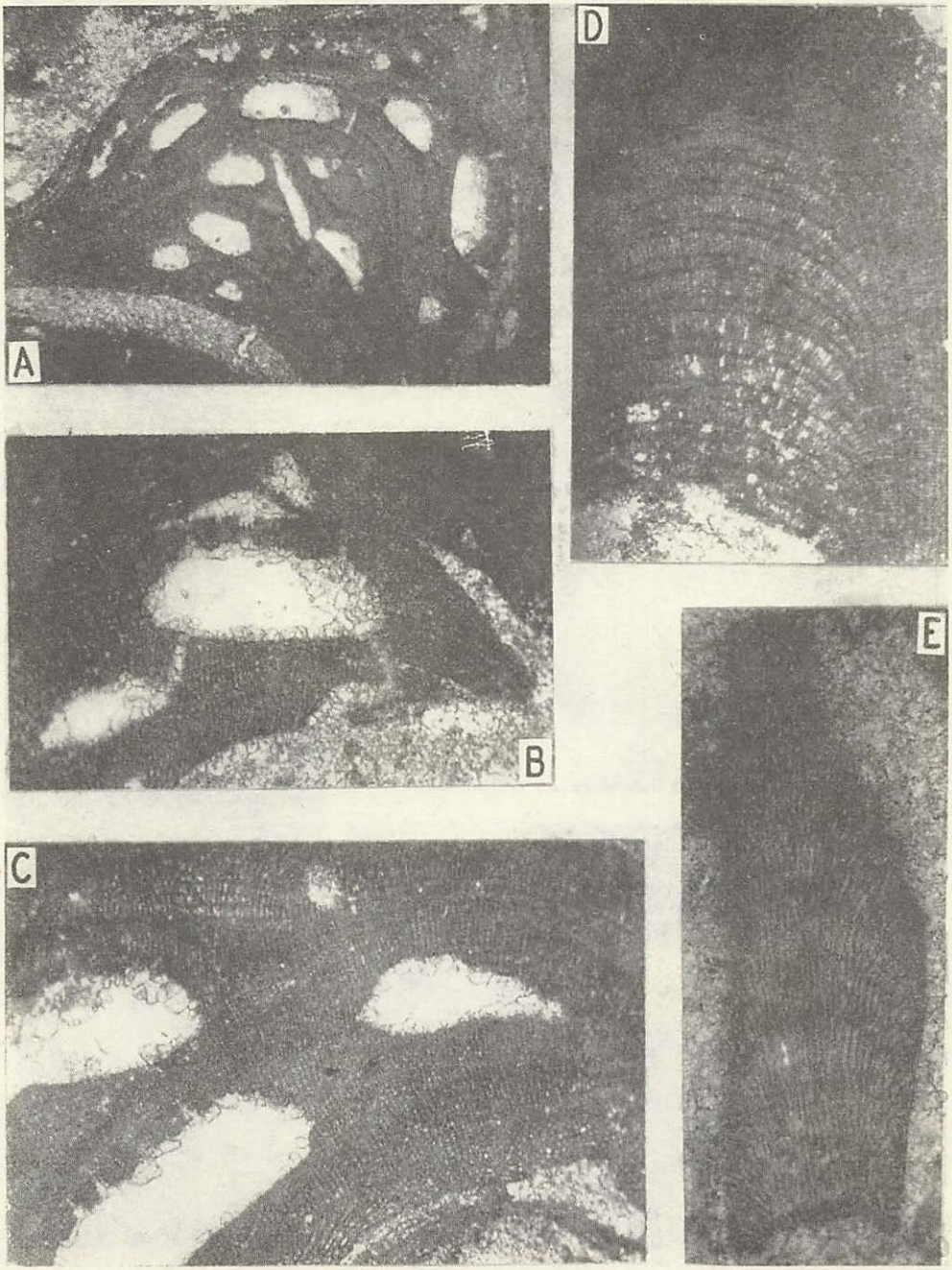
A, *ARCHAEOLITHOTHAMNION LAUENSUM:* GENERAL VIEW OF PIECE OF TISSUE WITH ROWS OF SPORE CASES, × 15; B, C, *A. FIJIENSIS,* DETAIL OF TISSUE AND ROWS OF SPORE CASES, × 75; D, *A. LAUENSUM,* DETAIL OF SPECIMEN SHOWN IN FIGURE A, × 40; E, *A. FIJIENSIS,* × 40.



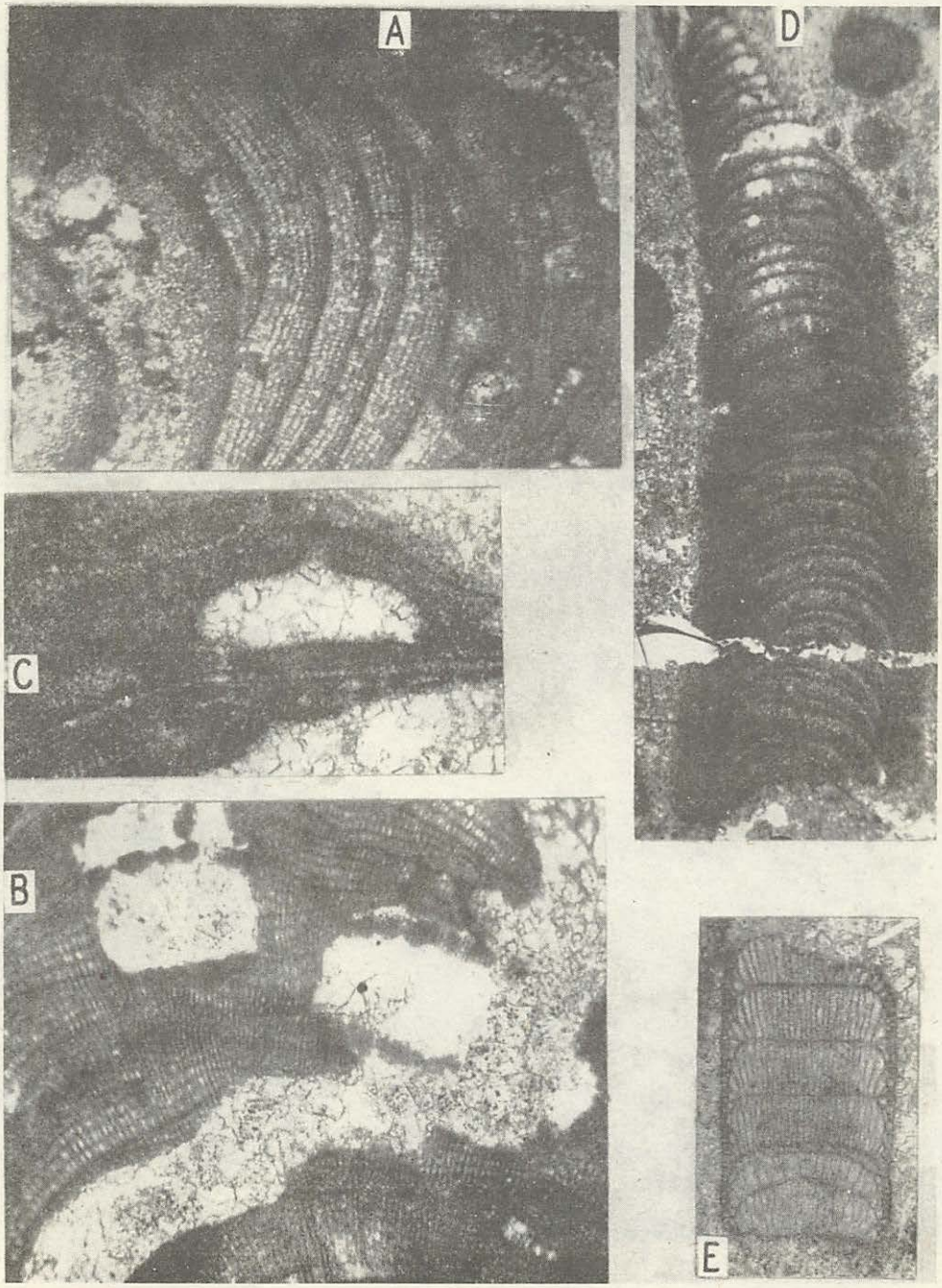
A, *LITHOTHAMNION HETEROTHALLUM*, DETAIL SHOWING HETEROGENEOUS STRUCTURE OF TISSUE AND SEVERAL CONCEPTACLES, × 125; B, *AMPHIROA FRAGILISSIMA*, NEARLY COMPLETE SEGMENT (INTERGENICULA), × 40; C, *LITHOTHAMNION FIJIENSUM*, DETAIL OF FRAGMENT SHOWING WELL-DEVELOPED PERITHALLUS AND CONCEPTACLES, × 75; D, *L. LEPTUM*, SECTION OF THIN CRUST SHOWING HYPOTHALLUS, PERITHALLUS, AND SEVERAL CONCEPTACLES, × 40; E, *JANIA* SP.?, DETAIL OF A NEARLY COMPLETE BUT SOMEWHAT FRAYED SEGMENT, × 100.



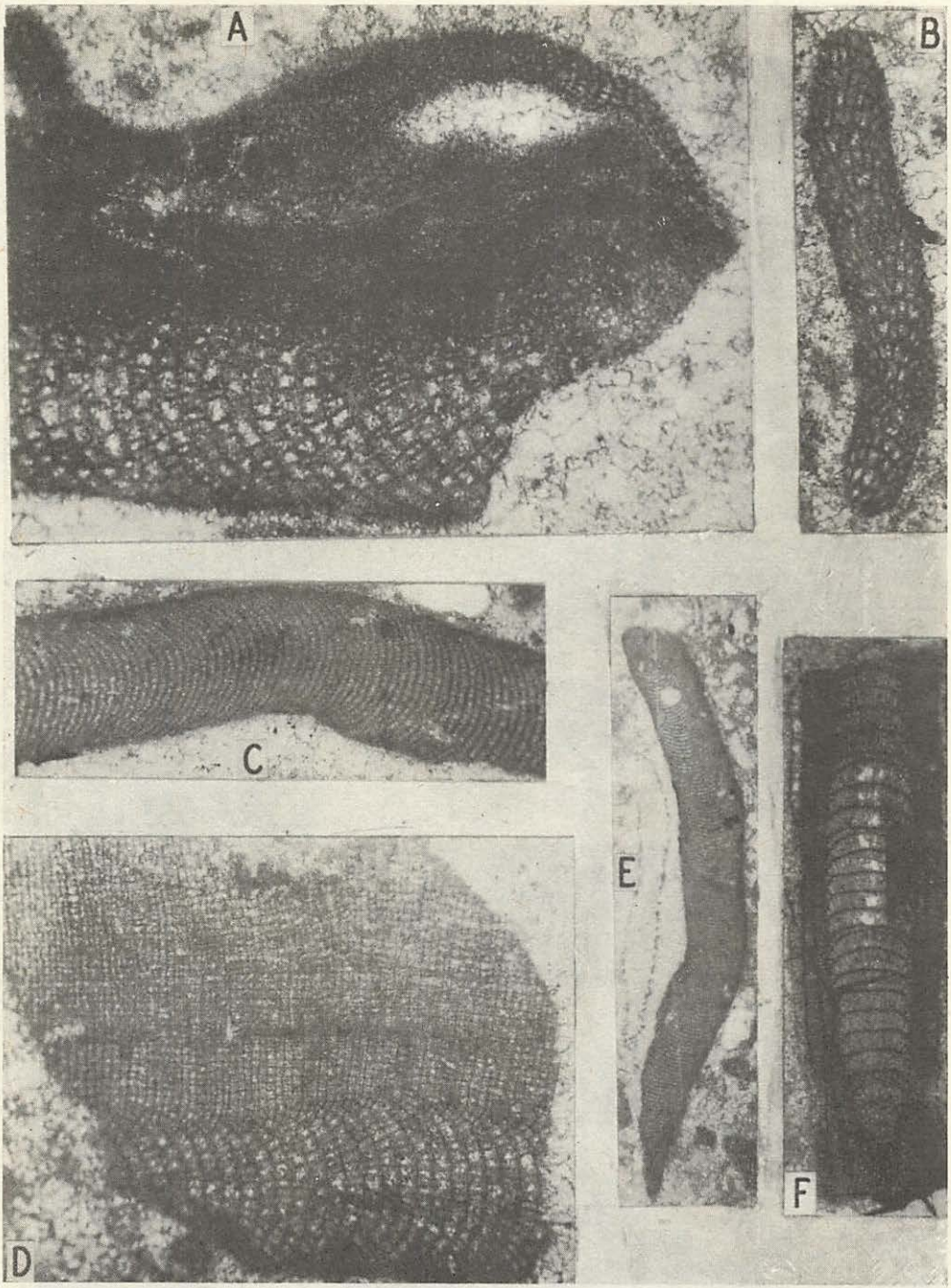
A, *LITHOTHAMNION* SP. *A*, THIN CRUST COMPOSED OF SEVERAL SUPERIMPOSED HYPOTHALLES AND PERITHALLES COATING LARGE FORAMINIFERA, × 75; B, *AMPHIROA FRAGILISSIMA*, NEARLY COMPLETE SEGMENT (INTERGENICULA), × 100; C, *LITHOTHAMNION* SP. *A* (× 75) AND *LITHOPORELLA* SP.?; D, *MESOPHYLLUM FECUNDUS*, DETAIL OF TISSUE AND SPACES OCCUPIED BY CONCEPTACLES, × 75; E, *M. FECUNDUS*, SECTION OF NEARLY COMPLETE BRANCH SHOWING ABUNDANT LARGE CONCEPTACLES AND THE STRONGLY ZONED TISSUE, × 25.



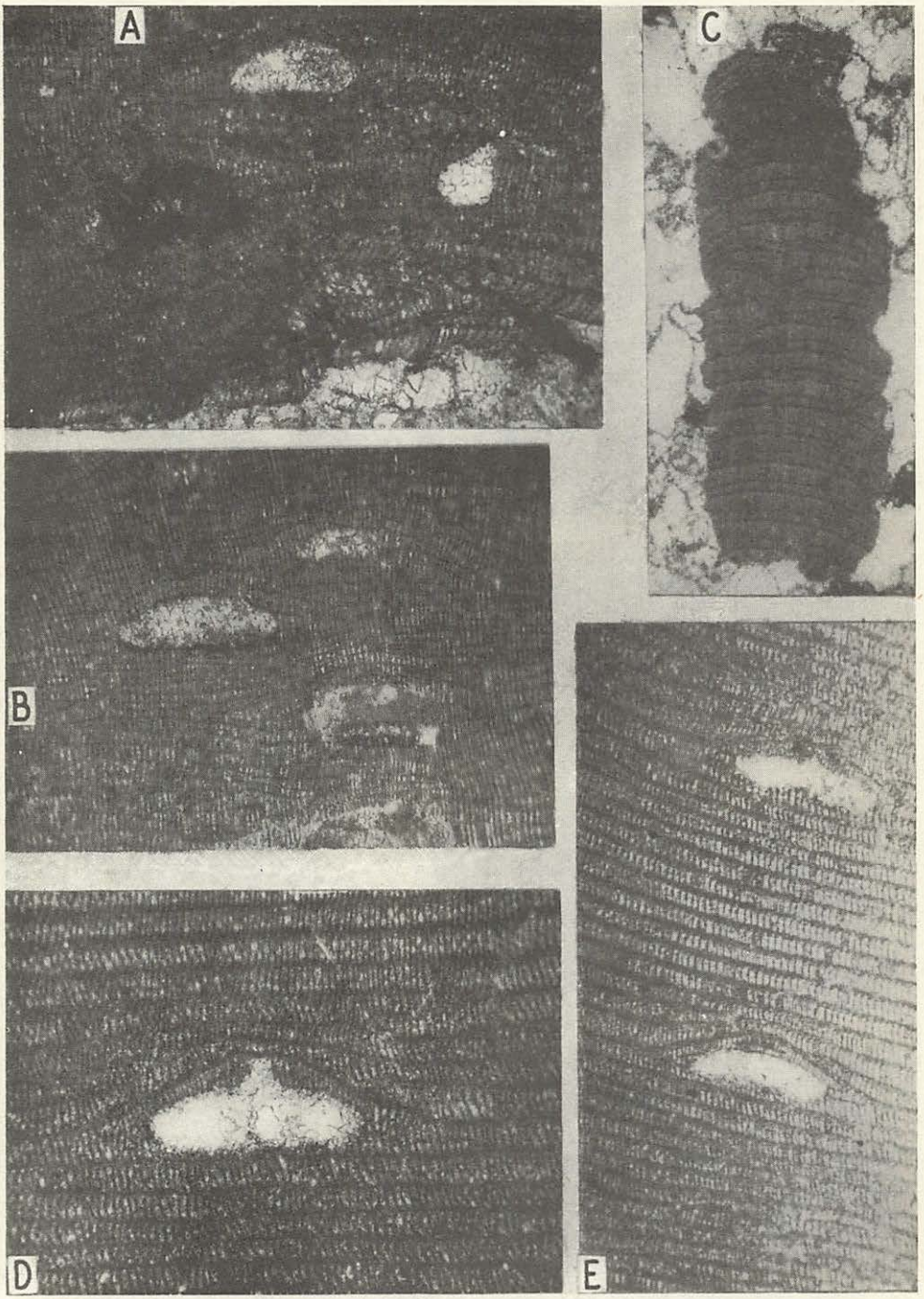
A, *MESOPHYLLUM MANGOENSUM*, SECTION OF BRANCH SHOWING CHARACTER OF TISSUE AND ARRANGEMENT OF CONCEPTACLES, × 25; B, C, *M. MANGOENSUM*, DETAILS OF TISSUE AND SPACES OF CONCEPTACLES, × 75; D, *LITHOPHYLLUM PREMOLUCCENSE*, SECTION OF BRANCH SHOWING MEDULLARY HYPOTHALLUS WITH ALTERNATING OF LONG AND SHORT CELLS, × 40; E, *CORALLINA* SP.?, NEARLY COMPLETE SEGMENT (INTERGENICULA), × 100.



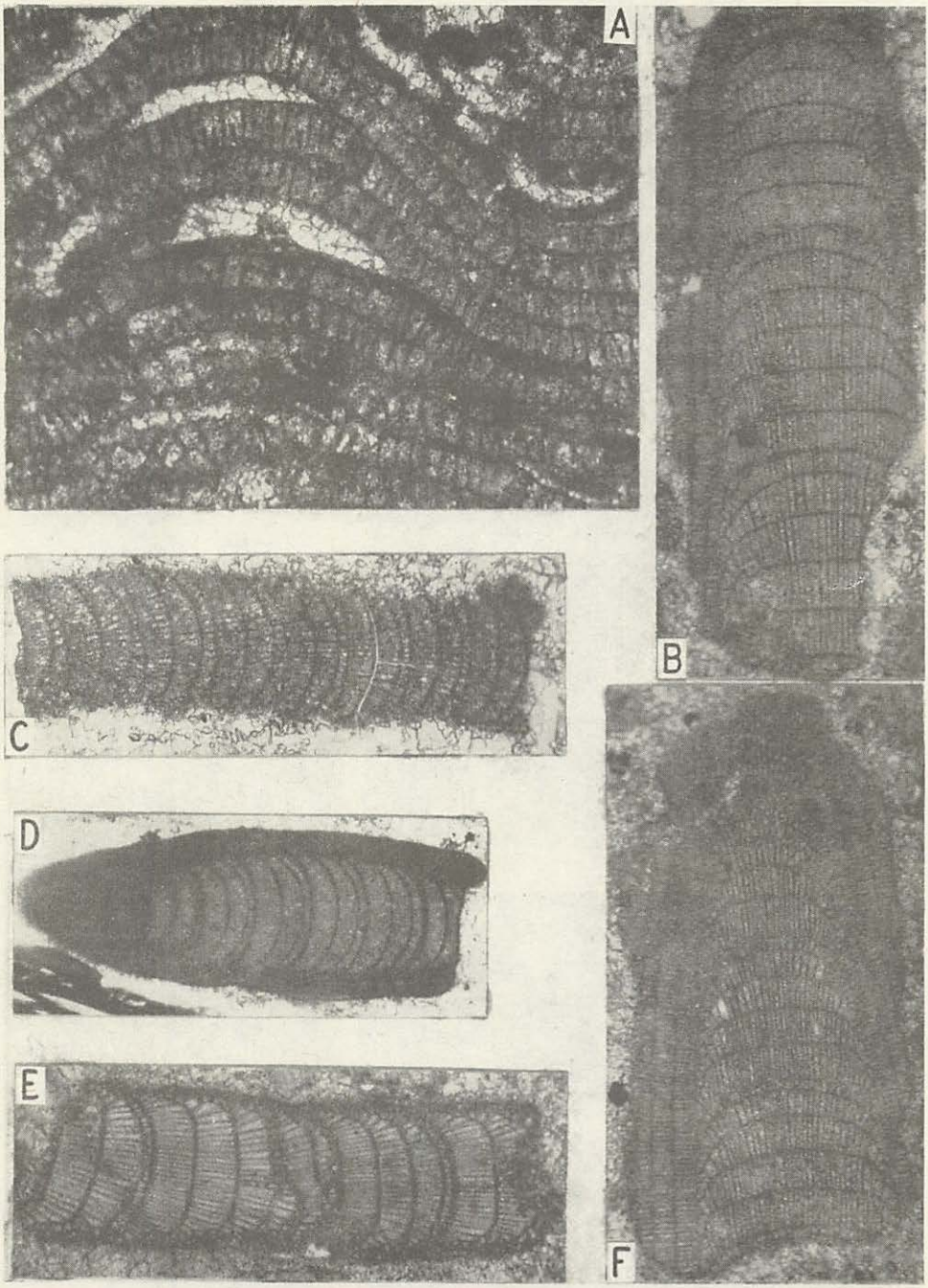
A, *MESOPHYLLUM PREPULCHRUM*, GENERAL VIEW OF TISSUE, × 40; B, *M. PREPULCHRUM*, DETAIL SHOWING TISSUE AND CONCEPTACLES, × 75; C, *LITHOPHYLLUM* SP. *A*, FRAGMENT OF TISSUE WITH CONCEPTACLE, × 75; D, *AMPHIROA ANCHIVERRICOSA* (HOLOTYPE), LONG SEGMENT SHOWING ALTERNATING ROWS OF LONG AND SHORT CELLS IN AXIAL PORTION, × 40; E, *A. REGULARIS*, PORTION OF SEGMENT, × 75.



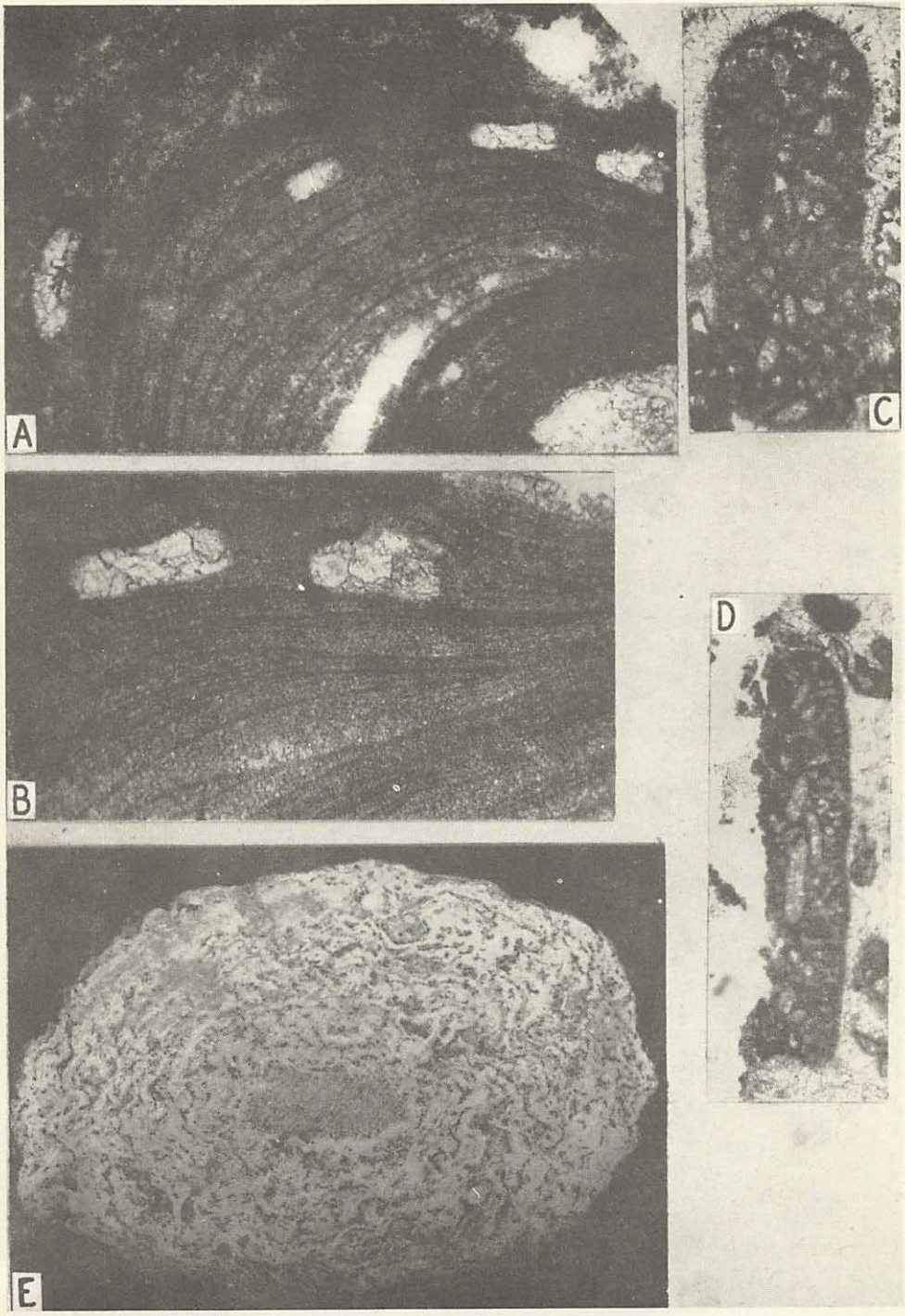
A, *LITHOPHYLLUM FULANGASUM,* FRAGMENT OF CRUST SHOWING WELL-DEVELOPED HYPOTHALLUS, PERITHALLUS WITH SECONDARY HYPOTHALLUS, AND CONCEPTACLE CAVITY, × 75; B, *L. THIKOMBIAN,* DETAIL OF YOUNG HYPOTHALLUS, × 75; C, *L. TENUICRUSTUM,* DETAIL OF THIN CRUST CONSISTING ONLY OF HYPOTHALLUS, × 60; D, *L. THIKOMBIAN,* PIECE OF MATURE CRUST SHOWING WELL-DEVELOPED HYPOTHALLUS AND PERITHALLUS, × 75; E, *L. TENUICRUSTUM,* SECTION OF LONG, THIN CRUST COMPOSED ONLY OF HYPOTHALLUS, × 25; F, *AMPHIROA FRAGILISSIMA,* NEARLY COMPLETE SEGMENT (INTERGENICULA), MARGINAL CORTICAL LAYERS WELL SHOWN (STATION L4, THITHIA), × 40.



A, *LITHOTHAMNION LAUENSUM,* SECTION OF CRUST SHOWING HYPOTHALLUS, PERITHALLUS, AND CONCEPTACLES, × 40; B, *L. LAUENSUM,* DETAIL OF PORTION OF CRUST SHOWING TISSUE AND CONCEPTACLES, × 75; C, *AMPHIROA ANCHIVERRICOSA,* BADLY FRAYED SEGMENT SHOWING REGULAR ALTERNATION OF ROWS OF LONG AND SHORT CELLS IN AXIAL PORTION (STATION L37, FULANGA), × 40; D, *LITHOPHYLLUM MEGACRUSTUM,* DETAIL OF TISSUE SHOWING UNUSUALLY LONG CELLS AND A CONCEPTACLE, × 75; E, *L. MEGACRUSTUM,* PORTION OF CRUST SHOWING TISSUE AND TWO CONCEPTACLES, × 40.



A, *LITHOPORELLA MELOBESIOIDES*, NUMBER OF SUPERIMPOSED THALLES, × 75; B, *AMPHIROA FRAGILISSIMA*, NEARLY COMPLETE SEGMENT (INTERGENICULA), SHOWING ALTERNATION FORMULA 4L, 1S; 5L, 1S; 5L, 1S (STATION A17A, AVEA), × 75; C, *AMPHIROA* SP. *B*, BADLY FRAYED SEGMENT SHOWING ALTERNATION FORMULA 2L, 1S; 2L, 1S; 2L, 1S; 2L, 1S, × 75; D, *A. PACIFICA*, WITH FORMULA 2L, 1S; 2L, 1S, × 40; E, *A. REGULARIS*, WITH FORMULA 2L, 1S; 3L, 1S; 2L, 1S (HOLOTYPE) × 60; F, *A. FRAGILISSIMA*, WITH FORMULA 4L, 1S; 4L, 1S (STATION A17A, AVEA), × 75.



A, *LITHOTHAMNION LAMINITHALLUM*, SHOWING GENERAL CHARACTER OF TISSUE AND CONCEPTACLES, × 40; B, *L. LAMINITHALLUM*, DETAIL OF TISSUE AND CONCEPTACLES, SHOWING NUMEROUS OPENINGS IN ROOF OF ONE CONCEPTACLE, × 75; C, *HALIMEDA* SP.?, BADLY FRAYED FRAGMENT, × 40; D, *HALIMEDA* SP.?, FRAGMENT NOT SO BADLY WORN AS *C*, × 40; E, AN ALGAL NODULE BUILT MAINLY OF *LITHOTHAMNION LAMINITHALLUM*, × 1.