Fossil and Recent Calcareous Algae From Guam

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By J. HARLAN JOHNSON

GEOLOGY AND HYDROLOGY OF GUAM, MARIANA ISLANDS

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Of the 82 species-groups listed or described, 20 are new; discussion includes stratigraphic distribution and correlation with Saipan floras

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FOSSIL AND RECENT CALCAREOUS ALGAE FROM GUAM

By J. Harlan Johnson

ABSTRACT

Eighty-two species of calcareous algae belonging to 16 genera are described and 68 are named specifically. Of these, 1 genus *Aethesolithon,* and 20 species are described as new.

Remains of calcareous algae occur in all the Cenozoic limestones of Guam. Locally the algae are sufficiently abundant to be considered as rock builders. Each formation has a distinctive flora. The algal floras are similar to those found in beds of similar age on Saipan.

The evidence indicates that fossil algae are useful as environmental indicators and also for dating the strata.

INTRODUCTION

The term "calcareous algae" has been applied to those algae that have developed the ability to secrete or deposit calcium carbonate within or around their tissues. Remains of such algae have been found in appreciable numbers in most of the limestones of Cenozoic age that have been studied on Guam. At some localities, algae occur in sufficient abundance to be important contributors to the building of the limestones.

The geological work on Guam furnished an opportunity to study a large series of specimens of algae from rocks that have been dated by means of Foraminifera, which increases our knowledge of the stratigraphic distribution of these fossils.

This study is based on a collection of large thin sections of limestone obtained from localities on Guam, representing material collected by the various members of the Guam field party from June 1952 to October 1954, as part of the Pacific Geological Mapping Program of the U.S. Geological Survey and Corps of Engineers of the U.S. Army. Additional material was obtained by the author on visits made to the island in 1949, 1951, and 1952. The thin sections have an average area of 3 square inches and show many unoriented sections of fragments of fossil algae. Selected specimens exhibiting the structure necessary for identification were photographed and studied.

Species illustrated in the recent U.S. Geological Survey Professional Papers on Bikini (Prof. Paper 260) and Saipan (Prof. Paper 280) are not illustrated in this report unless they show additional features.

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Mr. A. P. Bronson, manager of "Shells of Micronesia," the aquarium and curio store on Guam, greatly assisted the author in excursions to the modern reef and helped him obtain many excellent specimens. H. S. Ladd made valuable suggestions on the arrangement and preparation of the manuscript. The Colorado School of Mines supplied the laboratory and photographic studies for the work.

CLASSIFICATION OF CALCAREOUS ALGAE

Recent algae are classified into several broad groups on the basis of the structure and physiology of the plants and the basic chemical ingredients of their normal pigments. Only four of these contain members that have developed the ability to secrete or deposit calcium carbonate. These are the Rhodophyta or red algae, the Phaeophyta or brown algae, the Chlorophyta or green algae, and the Cyanophyta or blue-green algae. The Rhodophyta and Chlorophyta include most of the lime-secreting and lime-depositing algae which form readily identifiable fossils. They include all the forms discussed from Guam. Table 1 shows the classification used in this report. A previous report discusses terminology, structure, and a key for identification of fossil algae (Johnson, 1957, p. 210, 216).

STRATIGRAPHIC DISTRIBUTION OF GUAM ALGAE

The characteristic features of each formation are summarized in the following paragraphs followed by a list showing the algal flora of each. Table 2 shows the stratigraphic distribution of the various species.

TABLE 1.—*Genera of calcareous algae found in the Cenozoic deposits of Guam*

Phylum	Family	Subfamily	Genera
Rhodophyta (red algae).	Corallinaceae	Melobesioideae (crustose coral-lines).	*Archaeolithothamnium*
			Lithothamnium
			Mesophyllum
			Lithophyllum
			Porolithon
			Goniolithon
			Aethesolithon n. gen.
			Lithoporella
			Dermatolithon
			Melobesia
		Corallinoideae (articulate cor-allines).	*Calliarthron*
			Amphiroa
			Corallina
			Arthrocardia
			Jania
Chlorophyta (green algae).	Dasycladaceae	----------	*Cymopolia*
	Codiaceae		*Halimeda*

EOCENE AND OLIGOCENE, TERTIARY *b*

Alutom Formation.—This formation is a series of volcanic lava flows, reworked tuffaceous sandstone and shale, and volcanic breccia. Scarce limestone beds in the formation and abundant limestone pebbles and fragments in the breccia contain calcareous algae and Foraminifera. Although a part of the formation contains Foraminifera oı Tertiary *c* age, the limestone fragments contained a fauna of Tertiary *b* age only (Cole, 1963).

Algal flora of the Alutom Formation

Archaeolithothamnium saipanense Johnson
Lithothamnium cf. *L. aggregatum* Lemoine
crispithallus Johnson
marianae Johnson
tagpotchaenses Johnson
sp. A Johnson
Lithophyllum sp. A Johnson
Lithoporella melobesioides Foslie
Dermatolithon nitida Johnson
Arthrocardia? sp.
Corallina matansa Johnson
prisca Johnson
Jania? sp.
Cymopolia cf. *C. pacifica* Johnson
Perforating algae
Halimeda? sp.

TABLE 2.—*Stratigraphic distribution of the fossil algae of Guam*

Species	Formation or member						
	Eocene and Oligocene	Miocene		Miocene and Pliocene		Pliocene and Pleistocene	Recent
	Alutom Formation	Maemong Limestone Member of Umatac Formation	Bonya Limestone	Alifan Limestone	Barrigada Limestone	Mariana Limestone	Recent reefs
Archaeolithothamnium lauense Johnson and Ferris		×					
cf. *A. putiense* Airoldi				×			
taiwanensis Ishijima		×		×			
saipanense Johnson	×						
Lithothamnium cf. *L. aggregatum* Lemoine	×						
bonyense Johnson n. sp			×				
bourcarti Lemoine		×					
funafutiense Foslie						×	
maemongense Johnson n. sp		×					
alifanense Johnson n. sp				×			
cf. *L. peleense* Lemoine		×					
cf. *L. saipanense* Johnson				×			
tagpotchaense Johnson	×						
sp. G		×					
crispithallus Johnson	×						
sp. A	×						
cf. *L. araii* Ishijima		×					
cf. *L. crispatum* Hauck		×					
sp. H				×			
marianae Johnson	×						
sp. F		×					
Mesophyllum commune Lemoine		×					
grande Johnson n. sp		×					
guamense Johnson n. sp		×					
pacificum Johnson		×					
savornini Lemoine				×			
sp. C			×				
sp. D		×					

TABLE 2.—*Stratigraphic distribution of the fossil algae of Guam*—Continued

Species	Formation or member: Eocene and Oligocene	Miocene		Miocene and Pliocene		Pliocene and Pleistocene	Recent
	Alutom Formation	Maemong Limestone Member of Umatac Formation	Bonya Limestone	Alifan Limestone	Barrigada Limestone	Mariana Limestone	Recent reefs
Lithophyllum alternatum Johnson n. sp.				×			
alternicellum Johnson n. sp.			×				
alifanense Johnson n. sp.				×			
bonyense Johnson n. sp.			×				
cf. *L. glangeaudi* Lemoine				×			
cf. *L. kladosum* Johnson		×					
kotschyanum (Unger) Foslie							×
maemongense Johnson n. sp.		×					
moluccense Foslie						×	×
cf. *L. obliquum* Lemoine		×					
prelichenoides Lemoine		×	×				
pseudoamphiroa Johnson n. sp.		×					
quadrangulum var. *welschi* Lemoine			×				
schlangeri Johnson n. sp.		×					
traceyi Johnson n. sp.		×					
sp. A	×						
sp. B		×					
sp. C		×					
sp. E					×		
sp. F				×			
sp. G				×			
Porolithon craspedium (Foslie) Foslie						×	×
onkodes (Heydrich) Foslie							×
Goniolithon cf. *G. fosliei* (Heydrich) Foslie							×
frutescens Foslie						×	×
medioramus Johnson n. sp.							×
miocenicum Johnson n. sp.		×	×				
reinboldi W. V. Bosse and Foslie							×
sp. C				×			
Aethesolithon n. gen.							
problematicum Johnson n. sp.			×				
grandis Johnson n. sp.				×			
Lithoporella melobesioides (Foslie) Foslie	×	×	×	×	×	×	
sp. A		×					
Dermatolithon nitida Johnson	×						
guamensis Johnson n. sp.		×					
sp. A		×					
sp. B				×			
Melobesia guamensis Johnson n. sp.		×					
Calliarthron antiquum Johnson		×					
Amphiroa anchiverricosa Johnson and Ferris			×				
prefragilissima Lemoine				×			
cf. *A. regularis* Johnson and Ferris				×			
tan-i Ishijima			×				
cf. *A verricosa* Kützing					×		
sp. C						×	
sp. D					×		
Corallina matansa Johnson	×						
prisca Johnson	×						
neuschelorum Johnson		×					
sp. A				×			
Arthrocardia sp.	×	×					
Jania vetus Johnson		×					
guamensis Johnson n. sp.		×	×				
Cymopolia cf. *C. pacifica* Johnson	×						
Halimeda	×	×	×	×	×	×	×

LOWER MIOCENE, TERTIARY *e*

Maemong Limestone Member of the Umatac Formation.—Limestone tongues in the Facpi Volcanic Member of this formation contain abundant calcareous algae and Foraminifera that have been dated by Cole (1963) as Tertiary *e*. Pebbles, fragments, and angular blocks of the limestone incorporated in the overlying Bolanos Pyroclastic Member of the Umatac Formation contain the same fauna and flora and in this report will all be referred to as Maemong Limestone Member. This limestone contains the richest algal flora of any of the Guam limestones, with a total of 36 species.

Algal flora of the Maemong Limestone Member

Archaeolithothamnium lauense Johnson and Ferris
  taiwanensis Ishijima
Lithothamnium cf. *L. araii* Ishijima
  bourcarti Lemoine
  cf. *L. crispatum* Hauck
  maemongense Johnson, n. sp.
  cf. *L. peleense* Lemoine
  sp. F
  sp. G
  sp.
Mesophyllum commune Lemoine
  grande Johnson, n. sp.
  guamense Johnson, n. sp.
  pacificum Johnson
  sp. D
Lithophyllum cf. *L. kladosum* Johnson
  maemongense Johnson, n. sp.
  cf. *L. obliquum* Lemoine
  schlangeri Johnson, n. sp.
  traceyi Johnson, n. sp.
  prelichenoides Lemoine
  pseudoamphiroa Johnson, n. sp.
  sp. B
  sp. C
  sp.
Goniolithon miocenicum Johnson, n. sp.
Lithoporella melobesioides Foslie
  sp. A
Dermatolithon guamensis Johnson, n. sp.
  sp. A
Melobesia guamensis Johnson, n. sp.
Calliarthron antiquum Johnson
Corallina neuschelorum Johnson
Arthrocardia? sp.
Jania guamensis Johnson, n. sp.
  vetus Johnson
Halimeda? sp.

LOWER MIOCENE, TERTIARY *f*

Bonya Limestone.—This detrital limestone contains a foraminiferal fauna closely similar to that in the Futuna Limestone of Fiji, according to Cole (1963). Calcareous algae are reasonably abundant, but the flora is rather restricted in variety.

Algal flora of the Bonya Limestone

Lithothamnium bonyense Johnson, n. sp.
Mesophyllum sp. C
Lithophyllum alternicellum Johnson, n. sp.
  bonyense Johnson, n. sp.
  cf. *L. prelichenoides* Lemoine
  quadrangulum var. *welschi* Lemoine
Aethesolithon problematicum Johnson, n. sp.
Lithoporella melobesioides Foslie
Amphiroa anchiverricosa Johnson and Ferris
  tan-i Ishijima
Amphiroa? sp.
Jania guamensis Johnson, n. sp.
Halimeda? sp.

UPPER MIOCENE AND PLIOCENE, TERTIARY *g*

Alifan Limestone.—The lower part of this formation is a pink detrital limestone that contains a species of larger Foraminifera, *Rotalia atjehensis*, that is found throughout the Bonya Limestone (Cole, 1963), the lower part of which contains a good Tertiary *f* fauna. The lower part of the Alifan therefore may be as old as Tertiary *f* but probably is Tertiary *g* in age. No calcareous algae are described from the upper part of the formation.

Algal flora of the Alifan Limestone

Archaeolithothamnium cf. *A. puntiense* Airoldi
  taiwanensis Ishijima
Lithothamnium alifanense Jonhson, n. sp.
  saipanense Johnson
  sp. H
Mesophyllum savornini Lemoine
Lithophyllum alifanense Johnson, n. sp.
  alternatum Johnson, n. sp.
  cf. *L. glangeaudi* Lemoine
  sp. F
  sp. G
Goniolithon sp. C
Aethesolithon grandis Johnson, n. sp.
Lithoporella melobesioides Foslie
Dermatolithon sp. B
Amphiroa prefragilissima Lemoine
  cf. *A. regularis* Johnson and Ferris
Corallina sp. A
Perforating algae
Halimeda? sp.

Barrigada Limestone.—This white detrital bank-type limestone contains a larger foraminiferal assemblage which is thought by Cole (1963) to indicate deposition in banks probably during Tertiary *g* time. Field relations suggest that the Barrigada Limestone is contemporaneous with a part of the Alifan Limestone. Macerated fragments of calcareous algae, too small and worn to permit specific determination, are fairly numerous, but few species could be identified.

Algal flora of the Barrigada Limestone

Lithophyllum sp. E
Lithoporella melobesioides Foslie
Amphiroa cf. *A. verricosa* Kützing
  sp. D
Halimeda? sp.

PLIOCENE AND PLEISTOCENE

Mariana Limestone.—This limestone forms most of the reeflike deposits of the north plateau of the island. A reef facies, a detrital (lagoonal) facies, a molluscan (lagoonal) facies, and a fore-reef facies were mapped, but in the samples studied, calcareous algae were found only from the reef and fore-reef facies. The Mariana Limestone probably formed during both Pliocene and Pleistocene time; according to Cole (1963), larger Foraminifera from the fore-reef facies of the Mariana Limestone are of Pleistocene age. All the determinable algae are of Recent species, practically all of which can be found growing on the Recent reefs around the island.

The selected samples of the Mariana Limestone from Guam do not contain algae as abundantly as the similar deposits on Saipan (Johnson, 1957), and the number of forms identified is smaller. All the species identified from the limestone of Guam also occurred on Saipan, but Saipan had many additional species.

Algal flora of the Mariana Limestone

Lithothamnium funafutiense Foslie
Lithophyllum moluccense Foslie
? sp.
Porolithon craspedium (Foslie) Foslie
Goniolithon frutescens Foslie
Lithoporella melobesioides Foslie
Amphiroa sp. C
Halimeda segments

CORRELATION

The accompanying tables 3–5 compare the Eocene, Miocene, and Mariana Limestone floras of Guam and Saipan.

Eocene.—It will be noted that all the Eocene species identified from the Alutom Formation on Guam were found in Saipan. There most of them occurred in both the Densinyama and Matansa Formations, and a few also occurred in the lower Hagman Formation. An unusual feature of the Guam flora is the scarcity of *Archaeolithothamnium*, which normally is abundant in the Eocene floras.

TABLE 3.—*Stratigraphic distribution of Eocene algae on Guam and Saipan*

[Saipan data from Johnson, 1957, p. 212, table 2]

Species	Guam	Saipan		
	Alutom Formation	Hagman Formation	Densinyama Formation	Matansa Limestone
Archaeolithothamnium chamorrosum Johnson			×	×
cf. *A. liberum* Lemoine			×	×
oulianovi Pfender				×
saipanense Johnson	×		×	×
Lithothamnium cf. *L. abrardi* Lemoine		×	×	×
cf. *L. aggregatum* Lemoine	×		×	×
crispithallus Johnson	×		×	×
cymbicrustum Johnson			×	
marianae Johnson	×		×	×
moreti Lemoine				×
cf. *L. nanosporum* Johnson and Ferris				×
tagpotchaense Johnson	×		×	×
wallisium Johnson and Tafur			×	×
sp. A	×	×	×	×
Lithophyllum ovatum (Capeder) Lemoine			×	×
sp. A	×			×
melobesioides (Foslie) Foslie	×		×	×
Melobesia cuboides Johnson			×	×
Dermatolithon nitida Johnson	×		×	×
Jania sp	×		×	×
Arthrocardia? sp	×			×
Corallina matansa Johnson	×	×		×
prisca Johnson	×	×	×	×
Cymopolia cf. *C. pacifica* Johnson	×		×	×
Halimeda sp	×	×	×	×
Perforating algae	×			

Miocene.—All the Miocene limestones of Guam carried some algae, but algae were most abundant in the Maemong and least common in the Barrigada. It is rather surprising to note that the algal flora of each formation is distinct, very few species occurring in more than one formation. The Maemong has the richest Miocene flora the author has seen from the tropical Pacific.

Pliocene and Pleistocene.—In the Mariana Limestone, algae were found only in the reef and fore-reef facies. All the species identified are Recent species. All were found in the Mariana Limestone of Saipan, which also included a number of additional species.

TABLE 4.—*Stratigraphic distribution of Miocene algae on Guam and Saipan*

[Saipan data from Johnson, 1957, p. 212–213, table 2]

Species	Guam				Saipan					
						Tagpochau Limestone				
	Maemong Limestone Member	Bonya Limestone	Alifan Limestone	Barrigada Limestone	Transitional	Tuffaceous	Marly facies	Rubbly facies	Equigranular	Inequigranular
Archaeolithothamnium cf. *A. fijiensis* Johnson and Ferris	--	--	--	--	--	--	--	--	--	×
lauense Johnson and Ferris	×	--	--	--	--	--	--	--	--	×
cf. *A. lugeoni* Pfender	--	--	--	--	--	--	--	--	--	×
myriosporum Johnson	--	--	--	--	--	--	×	--	--	×
cf. *A. puntiense* Airoldi	--	--	×	--	--	--	--	--	--	--
taiwanensis Ishijima	×	--	×	--	--	--	--	--	×	×
Lithothamnium alifanense Johnson n. sp	--	--	×	--	--	--	--	--	--	--
cf. *L. araii* Ishijima	×	--	--	--	--	--	--	--	--	--
bonyense Johnson n. sp	--	×	--	--	--	--	--	--	--	--
bourcarti Lemoine	×	--	--	--	--	×	--	--	--	×
cf. *L. crispatum* Hauck	×	--	--	--	--	--	--	--	--	×
cf. *L. disarmonicum* Conti	--	--	--	--	--	--	×	--	--	--
cf. *L. fumigatum* Foslie	--	--	--	--	--	--	--	--	--	×
ladronicum Johnson	--	--	--	--	--	--	--	--	--	×
cf. *L. lecroixi* Lemoine	--	--	--	--	--	--	--	--	--	×
maemongense Johnson n. sp	×	--	--	--	--	--	--	--	--	--
cf. *L. mirabile* Conti	--	--	--	--	--	--	--	--	--	×
cf. *L. peleense* Lemoine	×	--	--	--	--	--	--	--	--	--
saipanense Johnson	--	--	×	--	--	--	--	--	--	×
subtile Conti	--	--	--	--	--	--	--	--	--	×
undulatum Capeder	--	--	--	--	--	--	--	--	--	×
sp. F	×	--	--	--	--	--	--	--	--	--
sp. G	×	--	--	--	--	--	--	--	--	--
sp. H	--	--	×	--	--	--	--	--	--	--
Mesophyllum commune Lemoine	×	--	--	--	--	--	--	--	--	--
grande Johnson n. sp	×	--	--	--	--	--	--	--	--	--
guamense Johnson n. sp	×	--	--	--	--	--	--	--	--	--
pacificum Johnson	×	--	--	--	--	--	--	×	--	--
savornini Lemoine	--	--	×	--	--	--	--	--	--	×
sp. C	--	×	--	--	--	--	--	--	--	--
sp. D	×	--	--	--	--	--	--	--	--	--
Lithophyllum cf. *L. kladosum* Johnson	×	--	--	--	--	--	--	--	--	--
alifanense Johnson n. sp	--	--	×	--	--	--	--	--	--	--
alternatum Johnson n. sp	--	--	×	--	--	--	--	--	--	--
alternicellum Johnson n. sp	--	×	--	--	--	--	--	--	--	--
bonyense Johnson n. sp	--	×	--	--	--	--	--	--	--	--
glangeaudi Lemoine	--	--	×	--	--	--	--	--	--	×
maemongense Johnson n. sp	×	--	--	--	--	--	--	--	--	--
cf. *L. obliquum* Lemoine	×	--	--	--	--	--	--	--	--	--
prelichenoides Lemoine	×	×	--	--	--	×	×	--	--	×
pseudoamphiroa Johnson	×	--	--	--	--	--	--	--	--	--
quadrangulum v. *welschi* Lemoine	--	×	--	--	--	--	--	--	--	--
schlangeri Johnson n. sp	×	--	--	--	--	--	--	--	--	--
traceyi Johnson n. sp	×	--	--	--	--	--	--	--	--	--
sp. B	×	--	--	--	--	--	--	--	--	--
sp. C	×	--	--	--	--	--	--	--	--	--
sp. E	--	--	--	×	--	--	--	--	--	--
sp. F	--	--	×	--	--	--	--	--	--	--
sp. G	--	--	×	--	--	--	--	--	--	--
Goniolithon miocenicum Johnson n. sp	×	--	--	--	--	--	--	--	--	--
sp. C	--	--	×	--	--	--	--	--	--	--

TABLE 4.—*Stratigraphic distribution of Miocene algae on Guam and Saipan*—Continued

Species	Guam				Saipan					
					Tagpochau Limestone					
	Maemong Limestone Member	Bonya Limestone	Alifan Limestone	Barrigada Limestone	Transitional	Tuffaceous	Marly facies	Rubbly facies	Equigranular	Inequigranular
Aethesolithon grandis Johnson n. sp	--	--	X	--	--	--	--	--	--	--
problematicum Johnson n. sp	--	X	--	--	--	--	--	--	--	--
Lithoporella melobesioides (Foslie) Foslie	X	X	X	X	--	--	X	X	X	X
sp. A	X	--	--	--	--	--	--	--	--	--
Dermatolithon guamensis Johnson n. sp	X	--	--	--	--	--	--	--	--	--
nitida Johnson	--	--	--	--	--	--	--	--	--	X
saipanense Johnson	--	--	--	--	--	--	--	X	--	X
sp. A	X	--	--	--	--	--	--	--	--	--
sp. B	--	--	X	--	--	--	--	--	--	--
Amphiroa anchiverricosa Johnson and Ferris	--	X	--	--	--	--	--	--	--	--
prefragilissima Lemoine	--	--	X	--	--	--	--	--	--	--
cf. *A. regularis* Johnson and Ferris	--	--	X	--	--	--	--	--	--	--
tan-i Ishijima	--	X	--	--	--	--	--	--	--	--
cf. *A. verricosa* Kützing	--	--	--	X	--	--	--	--	--	--
sp. D	--	--	--	X	--	--	--	--	--	--
Arthrocardia? sp	X	--	--	--	--	--	--	--	--	X
Melobesia guamensis Johnson, n. sp	X	--	--	--	--	--	--	--	--	--
Calliarthron antiquum Johnson	X	--	--	--	--	--	--	--	--	X
Corallina neuschelorum Johnson	X	--	--	--	--	--	--	--	--	X
sp. A	--	--	X	--	--	--	--	--	--	--
Jania guamensis Johnson n. sp	X	X	--	--	--	--	--	--	--	--
vetus Johnson	X	--	--	--	--	--	--	--	--	X

TABLE 5.—*Algae of the Mariana Limestone on Guam and Saipan*

[Saipan data from Johnson, 1957, p. 212–213, table 2.]

Species	*Guam*	*Saipan*
Archaeolithothamnium megasporum Johnson	----	X
puntiense Airoldi	----	X
Lithothamnium cf. *L. aucklandicum* Foslie	----	X
cf. *L. engelhartii* Foslie	----	X
funafutiense Foslie	X	X
lichenoides (Ellis and Solander) Foslie	----	X
tanapagense Johnson	----	X
madagascariense Foslie	----	X
Lithophyllum stefaninii Airoldi	----	X
expansum Philippi	----	X
cf. *L. racemus* (Lamarck) Foslie	----	X
megacrustum Johnson and Ferris	----	X
yendoi Foslie	----	X
moluccense Foslie	X	X
cf. *L. rovertoi* Airoldi	----	X
Goniolithon frutescens Foslie	X	?
Porolithon craspedium (Foslie) Foslie	X	X
onkodes (Heydrich) Foslie	----	X
Lithoporella melobesioides (Foslie) Foslie	X	X
Dermatolithon sp	----	X
Amphiroa foliacea Lamouroux	----	X
fragilissima (Linneaus) Lamouroux	----	X
sp	X	X
Jania sp	----	X
Halimeda segments	X	X

Previous studies of the fossil algae from the Pacific area have shown that on most of the islands that have been studied to date, there are well-developed Eocene, Miocene, and Pleistocene floras which are very distinct. Stratigraphically, they are separated by unconformities representing considerable lengths of time. The Eocene flora appears to have been the most widespread geographically. It contained identical species whose habitat was from the Mediterranean region to the Marshall Islands and from Saipan southward to the East Indies. The Miocene flora had a similar although slightly less extensive distribution. The Pleistocene flora was more restricted and is almost identical with the Recent flora, except that it appears to contain a larger number of species. This may, however, only reflect a lack of knowledge of the Recent floras, which have not been thoroughly studied.

Tables 3 and 4 show the composition and known distribution of the Eocene and the Miocene floras. It will be noted that these floras consist mainly of genera which have survived to the present day, but there is some difference in their relative importance. In most regions *Archaeolithothamnium* is most abundant in the Eocene, is still abundantly represented in the Miocene but is rare in Recent floras. *Lithothamnium* was more commonly represented in the early Cenozoic and has gradually decreased in importance in warmer waters as the Cenozoic progressed. *Lithophyllum* was common in the Eocene but has become more important and varied with the passage of time. At the present, *Lithophyllum* has its greatest development in the tropics, whereas *Lithothamnium* grows best in colder waters. *Mesophyllum* appears to have reached its greatest development during the Miocene. *Porolithon* and *Goniolithon* are abundant in and characteristic of the late Pliocene, Pleistocene, and Recent. *Goniolithon* appears in the Miocene. Specimens attributed to *Porolithon* have been recorded from the late Miocene. Representatives of these two genera, however, were not abundant until middle or late Pliocene times, and their abundant occurrence in the limestones seems always to indicate a Pleistocene or Recent age.

The articulated corallines occur throughout the Cenozoic and are locally abundant even in the Eocene rocks. They are represented in the Eocene floras by the genera *Amphiroa*, *Corallina*, and *Jania*. Members of the last two genera appear to be similar to Recent forms except for minor specific differences. However, most of the members of the Eocene *Amphiroa* were built of cell layers of equal length. This continued to be true until about the end of the Miocene when alternate layers of different lengths became more and more abundant, a characteristic feature of virtually all the Pleistocene and Recent species.

LOCALITIES

Localities where the algae were collected are given on the sample-collecting locality map (fig. 1). The localities referred to in this report are listed as follows.

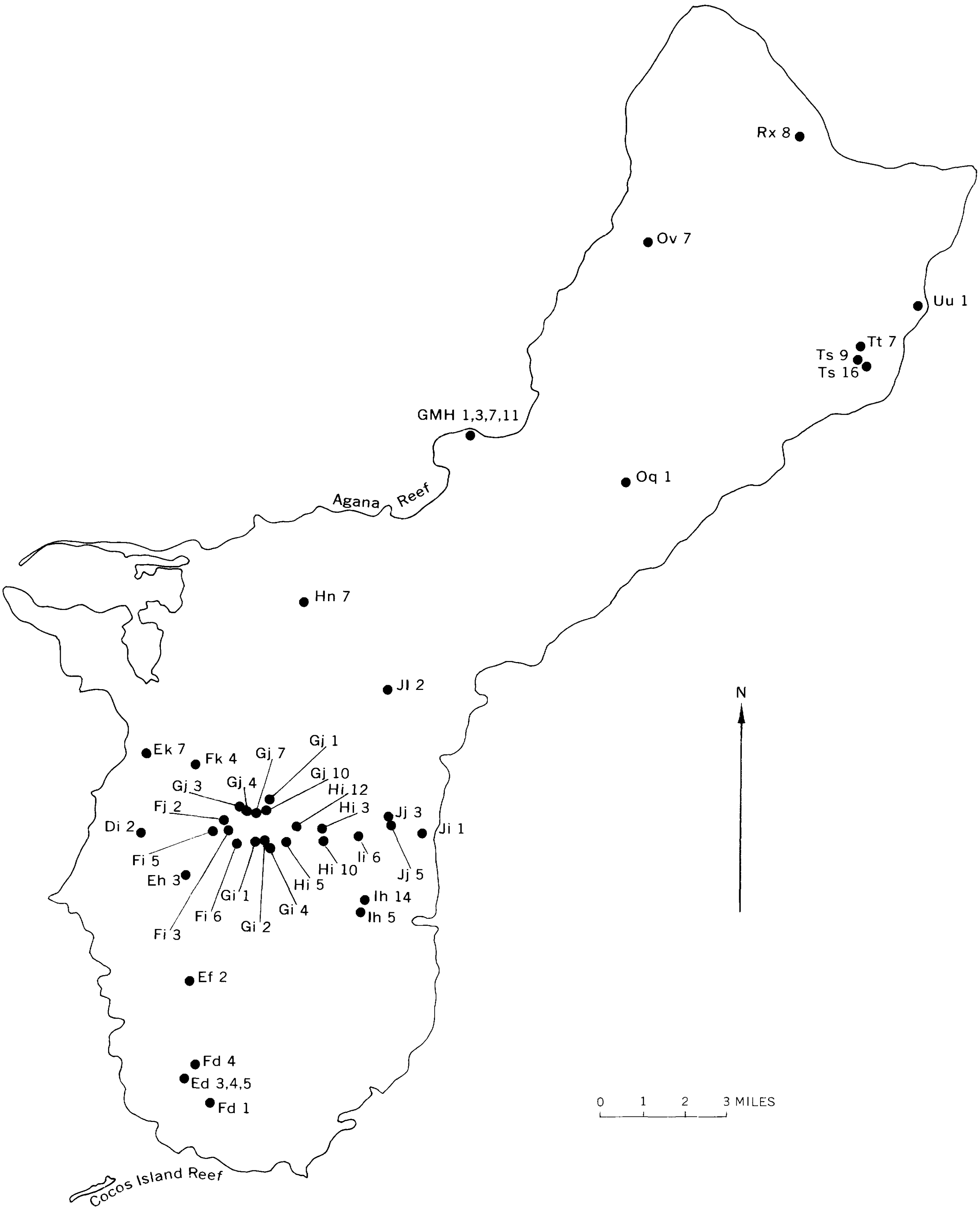

FIGURE 1.—Map of Guam showing sample-collecting localities of calcareous algae.

Collecting localities for algae samples

Di 2–1	Fi 6–5	Gi 1–3	GMH 11
Ed 3–1	Fi 6–6	Gi 2–7	Hi 3–4
Ed 4–1	Fi 6–7	Gi 4–1	Hi 3–5
Ed 5–1	Fj 2–1	Gi 4–2	Hi 3–6
Ef 2–1	Fj 2–4	Gj 1–1	Hi 5–1
Eh 3–3	Fj 2–5	Gj 3–1	Hi 5–2
Eh 3–8	Fk 4–1	Gj 4–1	Hi 5–3
Ek 7–2	Fk 4–2	Gj 4–4	Hi 10–1
Fd 1–1	Fk 4–3	Gj 7–2	Hi 12–2
Fd 4–1	Fk 4–4	Gj 10–1	Hi 12–3
Fi 3–2	Fk 4–7	GMH 1(d. 30–35)	Hn 7–1
Fi 3–4	Fk 4–8	GMH 3(d. 10–15)	Hn 7–2
Fi 5–1	Fk 4–9	GMH 7	Hn 7–3
Fi 6–1	Fk 4–11		Ih 5–6
Fi 6–4	Gi 1–1		Ih 14–1

Collecting localities for algae samples—Continued

Ih 14–2	Ii 6–27	Jj 3–1	Ts 16–3
Ii 6–2	Ii 6–28	Jj 5–1	Ts 16–4
Ii 6–8	Ii 6–31	Jl 2–2	Ts 16–5
Ii 6–9	Ii 6–32	Oq 1–1	Ts 16–6
Ii 6–13	Ii 6–33	Ov 7–2	Ts 16–9
Ii 6–16	Ii 6–34	Ov 7–3	Ts 16–11
Ii 6–17	Ii 6–36	Rx 8–2	Ts 16–12
Ii 6–18	Ii 6–37	Ts 9–1	Tt 7–4
Ii 6–25	Ii 6–38	Ts 16–1	Uu 1–1
Ii 6–26	Ji 1–1	Ts 16–2	Agana Reef

Table 6 gives the equivalent field and permanent catalog numbers of material herein described and illustrated (first two columns). The last three columns apply only to type and figured specimens.

TABLE 6.—*Field and permanent catalog numbers for fossil algae from Guam*

USGS paleobotanical locality	Field No. on locality map	USGS type algae number	Type of new species	Other figured specimens
D891	Ed 4–1	A721		*Lithophyllum maemongense* Johnson n. sp.
D892	Eh 3–3	A767		*Aethesolithon grandis* Johnson n. sp.
D892	Eh 3–3	A767		*Amphiroa prefragilissima* Lemoine.
D893	Eh 3–8	A760		Do.
D894	Fd 1–1	A755		*Goniolithon miocenicum* Johnson n. sp.
D895	Fi 3–2	A762		*Aethesolithon problematicum* Johnson n. sp.
D896	Fi 3–4	A754	*Aethesolithon problematicum* Johnson n. sp.	*Goniolithon miocenicum* Johnson n. sp.
D897	Fd 4–1	A778		*Jania guamensis* Johnson n. sp.
D898	Fi 5–1	A763		*Aethesolithon problematicum* Johnson n. sp.
D899	Fi 6–7	A698	*Lithothamnium maemongense* Johnson n. sp.	
D899	Fi 6–7	A698	*Lithophyllum traceyi* Johnson n. sp	
D900	Fj 2–4	A697	*Lithophyllum pseudoamphiroa* Johnson n. sp.	*Lithophyllum pseudoamphiroa* Johnson n. sp.
D900	Fj 2–4	A697		*Lithothamnium bourcarti* Lemoine.
D900	Fj 2–4	A697		*Lithophyllum* sp. B.
D901	Fj 2–5	A703		*Dermatolithon* sp. A.
D902	Fk 4–9	A772		*Cympolia* cf. *C. pacifica* Johnson.
D903	Cocos Island Reef.	A740		*Lithophyllum moluccense* f. *flabelliformis* Foslie.
D904	Gi 1–1	A753	*Goniolithon miocenicum* Johnson n. sp	
D905	Gi 2–7	A742		*Amphiroa anchiverricosa* Johnson and Ferris.
D906	Gj 1–1	A696	*Lithothamnium bonyense* Johnson n. sp	
D907	Gj 4–1	A780		*Halimeda* sp.
D908	Gj 4–4	A768		*Lithoporella* sp. A.
D909	Gj 7–2	A713		*Mesophyllum* sp. C.
D909	Gj 7–2	A713		*Amphiroa anchiverricosa* Johnson and Ferris.
D909	Gj 7–2	A735	*Lithophyllum alternicellum* Johnnson n. sp.	
D910	Hi 3–4	A727		*Lithophyllum* sp. B.
D911	Hi 3–5	A712		*Mesophyllum guamense* Johnson n. sp.
D912	Hi 5–1	A720		*Lithophyllum maemongense* Johnson n. sp.
D913	Hi 12–3	A777	*Jania guamensis* Johnson n. sp	
D914	Hi 10–1	A702b		*Lithothamnium* cf. *L. peleense* Lemoine.
D914	Hi 10–1	A702a		cf. *L. araii* Ishijima.
D915	Hn 7–1	A776		*Corallina* sp. A.
D916	Hn 7–2	A748		*Lithophyllum* sp. F.
D916	Hn 7–2	A775		*Corallina* sp. A.
D917	Hn 7–3	A704		*Dermatolithon* sp. B.
D918	Ii 6–8	A709	*Mesophyllum grande* Johnson n. sp	
D919	Ii 6–25	A719	*Lithophyllum maemongense* Johnson n. sp.	
D919	Ii 6–25	A743		*Lithophyllum pseudoamphiroa* Johnson n. sp.
D920	Ii 6–26	A714a		*Mesophyllum* sp. D.
D920	Ii 6–26	A714b		*Jania guamensis* Johnson n. sp.
D921	Ii 6–27	A705		*Lithothamnium* cf. *L. araii* Ishijima.
D922	Ii 6–28	A711	*Dermatolithon guamensis* Johnson n. sp	*Mesophyllum guamense* Johnson n. sp.

TABLE 6.—*Field and permanent catalog numbers for fossil algae from Guam*—Continued

USGS paleobotanical locality	Field No. on locality map	USGS type algae number	Type of new species	Other figured specimens
D923	Ii 6–32	A722	*Melobesia guamensis* Johnson n. sp.	
D924	Ii 6–33	A699		*Lithothamnium maemongense* Johnson n. sp.
D925	Ii 6–34	A723		*Lithophyllum* cf. *L. obliquum* Lemoine.
D925	Ii 6–34	A745		*traceyi* Johnson n. sp.
D926	Ii 6–36	A700		*Lithothamnium maemongense* Johnson n. sp.
D926	Ii 6–36	A700		sp. G.
D926	Ii 6–36	A700		*Dermatolithon guamensis* Johnson n. sp.
D926	Ii 6–36	A707		*Lithothamnium* sp. F.
D927	Ii 6–37	A710a	*Mesophyllum guamense* Johnson n. sp.	
D927	Ii 6–37	A710a	*Lithophyllum schlangeri* Johnson n. sp.	*Lithophyllum* sp. C.
D927	Ii 6–37	A710b		Do.
D928	Ii 6–38	A708		*Mesophyllum commune* Lemoine.
D928	Ii 6–38	A708		*Lithophyllum* cf. *L. obliquum* Lemoine.
D929	Ih 5–6	A731		*bonyense* Johnson n. sp.
D929	Ih 5–6	A736		*alternicellum* Johnson n. sp.
D930	Ih 14–1	A724		*quadrangulum* v. *welschi* Lemoine.
D930	Ih 14–1	A729	*Lithophyllum bonyense* Johnson n. sp.	
D930	Ih 14–1	A770		*Amphiroa tan-i* Ishijima.
D931	Ih 14–2	A730		*Lithophyllum bonyense* Johnson n. sp.
D931	Ih 14–2	A730		*Amphiroa tan-i* Ishijima.
D932	Ji 1–1	A733		sp. C.
D933	Ov 7–2	A771		cf. *A verricose* Kützing.
D934	Ov 7–3	A732		*Lithophyllum* sp. E.
D935	Rx 8–2	A774		*Amphiroa* sp. D.
D936	Ts 9–1	A706		*Lithothamnium* sp. H.
D936	Ts 9–1	A715	*Lithophyllum alifanense* Johnson n. sp.	*Goniolithon* sp. C.
D936	Ts 9–1	A737		*Lithophyllum* aff. *L. glangeaudi* Lemoine.
D937	Ts 16–1	A734		*alternatum* Johnson n. sp.
D937	Ts 16–1	A761		*Amphiroa prefragilissima* Lemoine.
D937	Ts 16–1	A765, A766		*Aethesolithon grandis* Johnson n. sp.
D938	Ts 16–2	A716		*Lithophyllum alifanense* Johnson n. sp.
D939	Ts 16–3	A733	*Lithophyllum alternatum* Johnson n. sp.	
D940	Ts 16–5	A718		*alifanense* Johnson n. sp.
D940	Ts 16–5	A764	*Aethesolithon grandis* Johnson n. sp.	
D941	Ts 16–6	A701	*Lithothamnium alifanense* Johnson n. sp.	
D942	Ts 16–9	A747		*Amphiroa prefragilissima* Lemoine.
D943	Ts 16–12	A728		*Lithophyllum* sp. G.
D944	Tt 7–4	A769		*Amphiroa* cf. *A. regularis* Johnson and Ferris.
D945	Uu 1–1	A781		*Halimeda* sp.
D946	Agana Reef	A738, A739		*Lithophyllum kotschyanum* (Unger) Foslie.
D946	Agana Reef	A749		*Goniolithon* cf. *G. fosliei* (Heydrich) Foslie.
D946	Agana Reef	A750, A751		*medioramus* Johnson n. sp.
D946	Agana Reef	A752	*Goniolithon medioramus* Johnson n. sp.	
D946	Agana Reef	A756, A757		*reinboldi* Weber von Bosse and Foslie.
D946	Agana Reef	A758, A759		*reinboldi* Weber von Bosse and Foslie.
D946	Agana Reef	A741, A782		*Lithophyllum moluccense* f. *pygmaea* Foslie.

SYSTEMATIC DESCRIPTIONS

Phyllum RHODOPHYTA (Red algae)
Family CORALLINACEAE (Coralline algae)

Subfamily MELOBESIOIDEAE (Crustose coralline algae)

The crustose coralline algae typically are strongly calcified. They develop a large number of growth forms ranging from thin crusts to large branching forms.

Genus ARCHAEOLITHOTHAMNIUM Rothpletz, 1891

Structurally this genus shows the most primitive features of any of the Corallinaceae (table 7). It includes crustose, mammillate, and branching forms. The hypothallus of the crust is formed of curved rows of cells. Commonly it is not strongly developed. The tissue of the crusts and branches normally appears to be formed of layers of cells. In some specimens this is not very evident. In some branching forms the tissue contains rows of cells rather than layers. Faint suggestions of growth zones are occasionally seen. The sporangia are not collected into conceptacles but are isolated in the tissue, commonly in lenses or layers.

The geologic range of *Archaeolithothamnium* is from the Late Jurassic to the Recent. It had its greatest development during the Late Cretaceous and Eocene but continued abundantly in most regions during the Oligocene and Miocene. Since then, it has slowly but steadily declined in numbers and variety. Today it is represented by about a dozen species. Throughout its history, *Archaeolithothamnium* seems to have been restricted to warm marine waters.

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TABLE 7.—*Measurements, in microns, and distribution of species of* Archaeolithothamnium *from Guam*

[From random sections]

Species	Hypothallus cells		Perithallus cells		Sporangia		Localities	Age
	Length	Width	Length	Width	Height	Diameter		
Division 1.—Simple crusts [Commonly thin. In some instances several thalli superimposed]								
Archaeolithothamnium lauense Johnson and Ferris	12–15	11–13	12–17	9–15			Fi 6-1, Ii 6-32, Ii 6-36	Miocene.
cf. *A. puntiense* Airoldi	11–20	6–11	10–11	8–11			Hn 7-2	Miocene(?)
taiwanensis Ishijima	19–26	9	9–17	8–12	41–60	36–52	Di 2-1, Fd 4-1	Miocene.
Division 2.—Crusts with warty protuberances or mammillae								
Archaeolithothamnium saipanense Johnson	11–17	9–12	9–16(22)	9–12	82–135	64–100	Fk 4-1, Fk 4-2, Fk 4-4	Eocene.

Archaeolithothamnium lauense Johnson and Ferris

Archaeolithothamnion lauensum Johnson and Ferris, 1950, B.P. Bishop Mus. Bull. 201, p. 11, pl. 1, figs. A, D.

Archaeolithothamnium lauense Johnson and Ferris. Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 218, pl. 46, fig. 7.

Description.—Thallus forms thin crust. Hypothallus thin or absent; if present, consists of few curved rows of cells 12μ–15μ by 11μ–13μ. Perithallus consists of regular compact tissue with cells 12μ–17μ by 9μ–15μ. No sporangia observed.

Remarks.—The Guam specimens are similar to those ascribed to this species from Saipan.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Locs. Fi 6–1, Ii 6–32, and Ii 6–36.

Archaeolithothamnium cf. A. puntiense Airoldi

Archaeolithothamnion puntiense Airoldi, 1933, Palaeontographia Italica, Mem. Palaeont., v. 32, p. 83, pl. 7, fig. 1.

Archaeolithothamnium puntiense Airoldi. Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 218, pl. 53, figs. 3, 4.

Description.—Thallus forms irregular crust. Hypothallus thin, consisting of few curved rows of irregular cells 11μ–20μ by 6μ–11μ. Perithallic tissue quite regular, cells 10μ–11μ by 8μ–11μ. No sporangia present.

Remarks.—Represented by a single fragment of a young thallus that appears to represent the same species described under this name from Saipan, although it has a more regular perithallic tissue.

Occurrence: Upper Miocene and Pliocene, Alifan Limestone. Loc. Hn 7–2.

Archaeolithothamnium cf. A. taiwanensis Ishijima

Archaeolithothamnion taiwanensis Ishijima, 1942, Taiwan Tigaku Kizi, v. 13, no. 4, p. 120, fig. 2.

Archaeolithothamnium taiwanensis Ishijimi. Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 218, pl. 46, figs. 4–6.

Description.—Thallus forms thin crust, commonly covering other organisms. Several thalli may be superimposed. Hypothallus thin or absent; at most a few irregular rows of cells 19μ–26μ long and 9μ wide. Perithallus consists of regular rows of rectangular cells 9μ–17μ by 8μ–12μ. Normally vertical partitions are more prominent than horizontal ones. Sporangia round to ovoid, 41μ–60μ by 36μ–52μ, moderately spaced in well-defined layers.

Remarks.—The Guam specimens closely resemble the material described from Saipan but tend to have more rounded sporangia and have slightly longer cells.

Occurrence: Miocene, Maemong Limestone Member of Umatac Formation and Alifan Limestone. Locs. Fd 4–1 and Di 2–1.

Archaeolithothamnium saipanense Johnson

Archaeolithothamnium saipanense Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 220, pl. 38, figs. 1–4, 6.

Description.—Thallus develops moderately thick crust with mammelons. Tissue regular with regular rows of sporangia. Hypothallus thin (14μ–53μ), consisting of few curved rows of cells 11μ–17μ by 9μ–12μ. Perithallus 350μ–1,000μ thick, tissue regular, composed of rows of rectangular cells with well-defined, regularly spaced horizontal and vertical walls, cells 9μ–16μ (22)μ by 9μ–12μ. Sporangia elliptical to circular, commonly abundant and closely packed, 82μ–135μ high and 64μ–100μ in diameter.

Remarks.—This species is characterized by the poorly developed hypothallus, the very regular perithallic tissue with small nearly square cells and relatively large sporangia. The Guam specimens are identical with those described from Saipan.

Occurrence: Upper Eocene, Alutom Formation. Locs. Fk 4–1, Fk 4–2, and Fk 4–4.

Tribe LITHOTHAMNIEAE

Genus LITHOTHAMNIUM Philippi, 1837

The genus *Lithothamnium* is characterized by having a tissue formed of many layers of cells which commonly can be differentiated into a hypothallus and a perithallus. Normally, the hypothallus consists of curved rows of cells, but in a few species it has a development which is almost similar to the coaxial hypothallus characteristic of the genus *Lithophyllum*. In these species the rows of hypothallic cells bend from the center both upward and downward and are quite regularly arranged. The perithallic tissue consists of rows of cells which are mainly vertical in the crustose forms. This is in marked distinction to the horizontal layers of cells which characterize the genus *Lithophyllum*. The conceptacles normally are fairly large and have a roof pierced by many apertures for the escape of spores. Fossil representatives of the genus have been reported from rocks as old as Late Jurassic, but they did not occur abundantly until Late Cretaceous times. From the Eocene to the Recent they have been numerous and widespread, being found in almost all seas, though with the passage of time they have become more and more restricted to the cooler and cold waters, so that today their greatest development is in the cool temperate and polar waters.

Lithothamnium is abundantly represented in the Cenozoic limestones of Guam. Seventeen species were recognized.

For convenience, the species from Guam are arranged in four divisions based on growth habit: division 1, simple crusts; division 2, free crusts; division 3, crusts with warty protuberances or mammillae; and division 4, strongly branching forms.

The dimensions and distribution of the species occurring on Guam are shown in table 8.

TABLE 8.—*Measurements, in microns, and distribution of species of* Lithothamnium *from Guam*

[From random sections]

Species	Hypothallus cells		Perithallus cells		Conceptacles		Localities	Age
	Length	Width	Length	Width	Diameter	Height		
Division 1.—Simple crusts [Commonly thin, many may occur superimposed]								
Lithothamnium cf. *L. aggregatum* Lemoine	11–14	8–13	(8)10–16	8–14			Fk 4–2	Eocene.
bonyense Johnson n. sp		12–13	12–20	8–11	220–298	46–57	Gj 1–1	Miocene.
bourcarti Lemoine	29–48	10–15	12–17	10–13	409–475	121–127	Fi 6–1, Fj 2–4	Do.
funafutiense Foslie	11–20(32)	9–17	7–14	7–10			GMH–3 (d. 10–15)	Pleistocene.
maemongense Johnson n. sp	14–25	11–15	7–11	9–13	450–550		Fi 6–7, Ii 6–33, Ii 6–36	Miocene.
alifanense Johnson n. sp	12–18	8–11	10–18	6–11	?		Ts 16–6	Do.
cf. *L. peleense* Lemoine	8–11	7–11	9–15	6–11			Hi 10–1	Do.
cf. *L. saipanense* Johnson			8–12	6–10			Ts 16–1	Do.
tagpotchaense Johnson	18–24	9–11(13)	13–16	8–13			Fk 4–11	Eocene.
sp. G	21–23	7–13	8–10	8–10			Ii 6–36	Miocene.
Division 2.—Free crusts								
Lithothamnium crispithallus Johnson	7–12	6–8	8–10	6–9	222–270	109–172	Fk 4–2, Fk 4–3	Eocene.
sp. A	9–16	8–11	8–11	7–10			Fk 4–2, Fk 4–3, Fk 4–11	Do.
Division 3.—Crusts with warty protuberances or mammillae								
Lithothamnium cf. *L. araii* Ishijima	11–25	11–18	12–19	12–18			Hi 10–1, Ii 6–27	Miocene.
cf. *L. crispatum* Hauck	14–15	8–10	9–14	9–12			Hi 10–1, Ii 6–27	Do.
sp. H	22–29	10–13(17)	14–21	11–16			Ts 9–1	Do.
Division 4.—Strongly branching forms								
Lithothamnium marianae Johnson			10–25	8–14	250–510	150–180	Fk 4–2	Eocene.
sp. F			14–21	11–15	450		Ii 6–36	Miocene.

Division 1—Simple crusts

Lithothamnium cf. L. aggregatum Lemoine

Lithothamnion aggregatum Lemoine, 1939, Mat. Carte géol. de l'Algerie, ser. 1, Paléont., no. 9, p. 66, 79, pl. 1, figs. 12, 27.
Lithothamnium cf. *L. aggregatum* Lemoine. Johnson, 1957, U.S. Geol. Survey Prof. Paper 280-E, p. 221, pl. 40, figs. 2, 4.

Description.—Thallus forms thin crust. Hypothallus 150μ–190μ thick, consisting of curved rows of rounded rectangular cells 11μ–16μ by 7μ–14μ. Perithallus 70μ–300μ thick, regular tissue with well-defined vertical and horizontal partitions, rectangular cells 8μ–17μ by 9μ–14μ. No conceptacles present.

Remarks.—Guam specimens are identical with those described under this name from Saipan. Without knowledge of the conceptacles, it does not seem desirable to give this form a specific name.

Occurrence: Upper Eocene, Alutom Formation. Loc. Fk 4–2.

Lithothamnium bonyense Johnson n. sp.

Plate 1, figure 6

Description.—Thallus develops as a rather irregular crust. Hypothallus absent or represented by few curved rows of cells; hypothallus poorly preserved with cells about 12μ–13μ wide (lengths not accurately measurable). Perithallus 450μ–750μ thick. Tissue quite regular, giving appearance of well-defined horizontal layers of cells as well as vertical rows. Conceptacle chambers numerous, small—220μ–298μ in diameter.

Remarks.—This crustose species is characterized by its poorly developed hypothallus, its unusually regular perithallic tissue, and its small conceptacles and cell dimensions. The cell dimensions and regular perithallic tissue suggest *L. lecroixi* Lemoine from the Miocene of Martinique, but *L. lecroixi* is a branching or mammillated form and has larger conceptacles.

Occurrence: Lower Miocene, Bonya Limestone. Loc. Gj 1-1 (D906).
Figured specimen: Holotype A696.

Lithothamnium bourcarti Lemoine

Plate 1, figure 5

Lithothamnion bourcarti Lemoine, 1923, Soc. géol. France Bull., ser. 4, v. 23, p. 277–278, fig. 3.

Description.—Thallus forms thick mammillated crust. Hypothallus thin, secondary developments of hypothallic scar also present, cells 29μ–48μ by 10μ–15μ. Perithallic tissue of mammillae shows numerous growth zones, cells 11μ–17μ by 10μ–13μ. Conceptacle chambers wide and flat, 400μ–594μ in diameter.

Remarks.—The specimens from Guam closely fit the material originally described by Madame Lemoine from the Miocene (Burdigalian and lower Helvetian) of Albania. The cells of the Guam specimens average a little larger but fall within the size range recorded for the type.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Locs. Fi 6-1 and Fj 2-4 (D900).
Figured specimen: A697.

Lithothamnium funafutiense Foslie

Lithothamnion funafutiense Foslie, 1900a, K. norske vidensk. selsk. Skr., no. 1, p. 5.
Foslie and Printz, 1929, K. norske vidensk. selsk. mus. Mon., p. 41, pl. 12, figs. 3–4.
Lithothamnium funafutiense Foslie. Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 222, pl. 54, fig. 3.

Description.—Thallus forms irregular crust. Hypothallus poorly developed, cells 11μ–20(32)μ by 9μ–17μ. Perithallus 130μ–450μ thick, dense tissue of small rectangular cells 7μ–14μ by 7μ–10μ. No conceptacles present.

Remarks.—The few specimens from Guam fit Foslie's rather loose description quite well. They differ from the specimens attributed to this species from Saipan by showing some hypothallus, which, however, is present in Foslie's type specimen.

Occurrence: Pleistocene, Mariana Limestone. Loc. GMH–3 (d. 10–15).

Lithothamnium maemongense Johnson n. sp.

Plate 1, figures 1–3

Description.—Thallus forms crust with well-developed hypothallus and perithallus. Hypothallus 150μ–200μ thick, composed of rows of cells, some of which curve upward and others downward from near middle; cells rectangular 14μ–25μ by 11μ–15μ. Perithallus 125μ–160μ thick, very regular tissue of nearly square cells 7μ–11μ by 9μ–13μ. Conceptacles wide and flat, circular in plan, reniform in vertical sections, 450μ–550μ in diameter.

Remarks.—This species resembles *L. ladronicum* Johnson in growth habit, general appearance, and size of the perithallic cells, but differs in size and shape of the hypothallic cells and in having a much more regular perithallic tissue.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Locs. Fi 6-7 (D899), Ii 6–33 (D924), and Ii 6–36 (D926).
Figured specimens: Holotype A698. Also figured: A699 and A700.

Lithothamnium alifanense Johnson n. sp.

Plate 1, figure 7

Description.—Thallus crustose, fairly thick in some specimens, well-developed hypothallus and perithallus. Hypothallus, 80μ–140μ thick, consists of curved rows of cells 12μ–18μ by 8μ–11μ. Perithallic tissue 800μ–1,200μ thick, quite regular, with suggestions of thin growth zones; cells 10μ–18μ by 6μ–11μ. Conceptacles unknown.

Remarks.—In all dimensions, this species resembles *L. betieri* described by Lemoine from the Pliocene of Algeria (except the cells of Guam specimens average slightly less in width). *L. betieri* develops as a strongly mammillated crust, whereas *L. alifanense* appears to form rather smooth crusts.

Occurrence: Upper Miocene, Alifan Limestone. Loc. Ts 16–6 (D941).
Figured specimen: Holotype A701.

Lithothamnium cf. L. peleense Lemoine

Plate 2, figure 1

Lithothamnion peleense Lemoine, 1917, Soc. géol. France Bull., ser. 4, v. 17, p. 268, fig. 16.

Description.—Thallus forms thin crust. Hypothallus 118μ–130μ thick, composed of curved rows of cells which continue vertically into perithallus with little or no change. Hypothallic cells 8μ–11μ by 7μ–11μ. Perithallus consists of slightly sinuous vertical rows of cells having pronounced vertical walls and faint horizontal partitions, cells 9μ–15μ by 6μ–11μ. No conceptacles observed.

Remarks.—This form closely resembles *L. peleense* in growth habit and character of perithallic tissue and in cell dimensions (except that the hypothallic cells of *L. peleense* are longer). Without knowledge of the conceptacles of either, it is uncertain whether or not the two belong to the same species.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Loc. Hi 10–1 (D914).
Figured specimen: A702b.

Lithothamnium cf. L. saipanense Johnson

Lithothamnium saipanense Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 222, pl. 49, fig. 3.

Description.—Thallus forms thin slightly irregular crust. Hypothallus only slightly developed and not well preserved. Perithallus 130μ–185μ thick, cells 8μ–12μ by 6μ–10μ. No conceptacles present.

Remarks.—Represented by a single piece of a young infertile plant. The perithallic tissue resembles *L. saipanense* Johnson in character and cell dimensions.

Occurrence: Upper Miocene, Alifan Limestone. Loc. Ts 16–1.

Lithothamnium tagpotchaense Johnson

Lithothamnium tagpotchaensis Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 223, pl. 37, fig. 7, pl. 39, fig. 7.

Description.—Thallus thin, encrusting. Hypothallus thin but distinct, cells 18μ–24μ by 9μ–13μ. Perithallus irregular, tissue composed of well-defined rows of cells, cross partitions not distinct, cells 13μ–18μ by 7μ–12μ. No conceptacles observed in Guam material.

Remarks.—Only a few fragments observed in the Guam collection. They are similar to the specimens described from Saipan.

Occurrence: Upper Eocene, Alutom Formation. Loc. Fk 4–11.

Lithothamnium sp. G

Plate 1, figure 8

Description.—Thallus develops into thick crust or plate 400μ–700μ thick. Hypothallus 100μ–150μ thick, composed of curved rows of cells 12μ–23μ by 7μ–14μ. Perithallus as much as 600μ thick, with a very regular tissue; cells nearly square 8μ–10μ by 8μ–10μ, with well-defined walls and horizontal partitions. Conceptacles unknown.

Remarks.—This species is quite distinctive with its characteristic measurements and very regular perithallic tissue. However, with only a couple of specimens to study and without knowledge of conceptacles, it does not seem desirable to give it a specific name.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Loc. Ii 6–36 (D926).
Figured specimen: A700.

Division 2—Free crusts

Lithothamnium crispithallus Johnson

Lithothamnium crispithallus Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 223–224, pl. 42, figs. 6–8.

Description.—Thallus thin, curved, may branch; apparently attached at first, then growing free. Hypothallus well developed, 75μ–130μ thick consisting of curved rows of cells 8μ–14μ by 7μ–12μ. Perithallus thin but irregular, thickening considerably around conceptacles; cells rectangular 6μ–14μ by 6μ–12μ. Conceptacles wide and flattened, 275μ–400μ in diameter.

Remarks.—Similar to the specimens described from Saipan. A fairly common species in the Guam collection.

Occurrence: Upper Eocene, Alutom Formation. Locs. Fk 4–3 and Fk 4–2.

Lithothamnium sp. A

Lithothamnium sp. A Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 224, pl. 40 figs. 8–9.

Description.—Thallus thin foliate crust that apparently grew unattached or nearly so. Hypothallus 70μ–175μ thick, well-developed, forming ⅓–½ of the crust; consisting of curved rows of irregular rounded to rectangular cells 9μ–16μ by 8μ–11μ. Perithallus 90μ–170μ thick, fairly regular rows of rectangular cells with well-defined vertical walls and poorly marked horizontal partitions, cells 8μ–11μ by 7μ–10μ. Conceptacles unknown.

Remarks.—This is the most abundant Eocene form. It appears to be the same species indicated as sp. A in the Saipan report. However, until the conceptacles are known, it does not seem wise to name it specifically.

Occurrence: Upper Eocene, Alutom Formation. Locs. Fk 4–2, Fk 4–3, and Fk 4–11.

Division 3—Crusts with warty protuberances or mammillae

Lithothamnium cf. L. araii Ishijima

Plate 1, figure 4; plate 2, figure 2

Lithothamnium araii Ishijima, 1954, p. 26, pl. 8, figs. 3–4; pl. 9, figs. 1–3.

Description.—Thallus forms irregular crust. Hypothallus slightly developed, consists of curved rows of cells 11μ–25μ by 11μ–18μ. Perithallic tissue moderately regular but with numerous growth zones; cells 12μ–19μ by 12μ–18μ. No conceptacles present.

Remarks.—Represented in the Guam collections by only a few infertile specimens. The cell dimensions and general character of the tissue of these are very similar to Ishijima's species from the Miocene of Japan, but without a knowledge of the conceptacles, the two forms cannot be definitely said to be identical.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Locs. Hi 10–1 (D914) and Ii 6–27 (D921).
Figured specimens: A702a, and A705.

Lithothamnium cf. L. crispatum Hauck

Lithothamnion crispatum Hauck, 1878, Botanische Zeitschr., v. 28, p. 289, pl. 3, figs. 1–4.
Lignac-Grutterink, 1943, Geol. mijnb. genootsch. Nederland en Kolonien Verh., Geol. ser., v. 113, p. 288, fig. 4.
Lithothamnium cf. *L. crispatum* Hauck. Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 224, pl. 48, fig. 4.

Description.—Thallus thick irregular crust. Hypothallus poorly developed, few curved rows of irregular cells 14μ–15μ by 8μ–10μ. Perithallus 300μ–600μ thick with irregular growth zones, cells 9μ–12μ. No conceptacles observed.

Remarks.—Several infertile specimens, which closely resemble the material from the East Indies and from Saipan, were observed.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Locs. Hi 10–1 and Ii 6–27.

Lithothamnium sp. H

Plate 2, figure 4

Description.—Thallus forms thick irregular crust, possibly with knobs or mammillae. Hypothallus 100μ–150μ thick, almost coaxial; strongly curved rows of cells; cells 22μ–29μ by 10μ–13 (17)μ. Perithallus 500μ–1,000μ thick with pronounced growth zones; tissue fairly regular with clearly defined vertical cell rows, cross partitions well developed and moderately regularly spaced; cells 14μ–21μ by 11μ–16μ. Conceptacles unknown.

Remarks.—This species has cell dimensions quite different from any previously described late Miocene or Pliocene species of *Lithothamnium.* It somewhat suggests *L. araii* Ishijima but has a much better developed hypothallus and forms appreciably thicker crusts.

Occurrence: Upper Miocene, Alifan Limestone. Loc. Ts 9–1 (D936).
Figured specimen: A706.

Division 4—Strongly branching forms

Lithothamnium marianae Johnson

Lithothamnium marianae Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 226, pl. 41, figs. 1–3.

Description.—Thallus develops bifurcating branches. Hypothallus absent or poorly developed. Branches composed of pronounced lenticular growth zones containing slightly curved rows of cells, rectangular and ranging considerably in size, both within a zone and between rows; cells 10μ–25μ by 8μ–14μ. Conceptacles abundant, 250μ–510μ in diameter and 150μ–180μ high.

Remarks.—This is the only branching species of *Lithothamnium* observed in the Eocene of Guam.

Occurrence: Upper Eocene, Alutom Formation. Loc. Fk 4–2.

Lithothamnium sp. F

Plate 2, figure 6

Description.—Thallus forms short thick branches. Hypothallus unknown. Branches show numerous irregular growth zones; cells rectangular with well-defined walls and partitions 14μ–21μ by 11μ–15μ in slightly oblique section. Conceptacle chambers about 450μ in diameter.

Remarks.—Represented by a single well-preserved fragment in the collection studied. The nearest described Miocene species is *L. mirabile* Conti. A somewhat similar specimen was described from Saipan. However, both of the specimens represent oblique sections of fragments so no specific name is proposed.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Loc. Ii 6–36 (D926).
Figured specimen: A707.

Genus MESOPHYLLUM Lemoine, 1928

Structurally this genus lies between *Lithothamnium* and *Lithophyllum*, having a tissue quite similar to *Lithophyllum* and multiple apertured conceptacles resembling those of *Lithothamnium.* The genus contains both crustose and branching forms.

The basal hypothallus generally is formed of layers of cells, but in a few species this arrangement is absent or only poorly developed. The tissue of mammillated crusts or branches is composed of layers of cells and normally shows pronounced growth zones. These may be lenticular in branching forms. The conceptacles of sporangia have many apertures in the roof for the escape of spores.

The known geologic range of the genus is from Eocene to Recent, with probably the greatest development during the Miocene.

Mesophyllum commune Lemoine

Plate 2, figure 3

Mesophyllum commune Lemoine, 1939, Mat. Carte géol. de l'Algerie, ser. 1, Paléont., no. 9, p. 86. figs, 55–57.

Description.—Thallus develops short, thick branches probably from basal crust. Branches composed mainly of a perithallic tissue showing pronounced lenticular growth zones, each formed of 6–10 layers of rectangular cells 11μ–15μ by 7μ–10μ. Conceptacles numerous, 340μ–425μ in diameter and 145μ–180μ high. One specimen showed conceptaces filled with sporangia 45μ–54μ high and 18μ–29μ in diameter.

Remarks.—The material from Guam exactly fits the description given by Lemoine (1939) for the type from the Miocene of Algeria. It differs from *M. guamense* Johnson n. sp. by having smaller cells and conceptacles and shorter wider branches.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Loc. Ii 6–38 (D928).
Figured specimen: A708.

Mesophyllum grande Johnson n. sp.

Plate 2, figure 5

Description.—Thallus consists of thick moderately long branches of perithallic tissue with pronounced growth zones, wide and gently arched, containing 10–16 layers of rectangular to rounded cells 15μ–17μ high and 9μ–12μ wide. Conceptacles large, wide, and terminal, with diameters of 720μ–876μ.

Remarks.—This species has unusually large conceptacles. Only one other branching form with such large conceptacles has been described. *M. laffittei* Lemoine (1939). *M. grande* differs from *M. laffittei* in cell dimensions and in having a much more regular tissue.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Loc. Ii 6–8 (D918).
Figured specimen: Holotype A709.

Mesophyllum guamense Johnson n. sp.

Plate 2, figure 7; plate 3, figures 6, 7

Description.—Thallus develops moderately long fairly thick branches, having a thick central part and thin outer layers. Both show pronounced rather irregular growth zones with tissues formed of layers of cells. Central area 800μ–1,000μ in diameter with cells 17μ–26μ long and 9μ–16μ wide. Marginal layers up to 230μ thick, cells 9μ–16μ by 8μ–11μ. Conceptacles 560μ–590μ in diameter and 230μ–246μ in height.

Remarks.—The long thick branches and relatively large conceptacles characterize this species. It is close to *M. savornini* Lemoine but differs by developing longer more spinelike branches and has less of a basal crust. Both forms have cells of about the same size and relatively large conceptacles.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Locs. Hi 3–5 (D911), Ii 6–28 (D922), Ii 6–37 (D927), and Ii 6–38.
Figured specimens: Holotype A710a. Also figured: A711 and A712.

Mesophyllum pacificum Johnson

Mesophyllum pacificum Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 226, pl. 52, fig. 7.

Description.—Thallus formed of long narrow spines or branches having pronounced highly arched growth zones, each containing 10–12 layers of cells 11μ–19μ by 7μ–13μ. Conceptacles abundant and terminal, 215μ–370μ in diameter and 165μ–200μ in height.

Remarks.—This is similar to the species described and illustrated from Saipan.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Locs. Hi 12–2 and Ii 6–36.

Mesophyllum savornini Lemoine

Mesophyllum savornini Lemoine, 1939, Mat. Carte géol. de l'Algerie, ser. 1, Paléont., no. 9, p. 83, figs. 43–46.
Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 227, pl. 52, fig. 8.

Description.—Thallus forms crust with warty protuberances or short, stubby branches. Basal hypothallus absent on Guam specimens. Tissue strongly developed, lenticular growth zones; regular rows of cells, showing considerable range in length, both in different layers and from center to margin of single layer; cells 13μ–24μ by 8μ–12μ. No conceptacles present.

Remarks.—Represented in the Guam collection by a single specimen that in cell dimensions and character of tissue resembles both the type species and the material from Saipan attributed to this species.

Occurrence: Miocene, Alifan Limestone. Loc. Gj 10–1.

Mesophyllum sp. C

Plate 3, figure 1

Description.—Thallus develops long, slender branches 190μ–850μ thick, pronounced lenticular growth zones of 12–15 layers of rectangular cells 18μ–26μ by 11μ–18μ. Marginal perithallus absent or worn off the specimens observed. No conceptacles present.

Remarks.—Cell dimensions of this form differ from any previously described Miocene species. It does not seem wise, however, to give it a specific name without a knowledge of the conceptacles.

Occurrence: Lower Miocene, Bonya Limestone. Loc. Gj 7–2 (D909).
Figured specimen: A713.

Mesophyllum sp. D.

Plate 3, figure 8

Description.—Thallus develops long moderately wide branches, pronounced strongly arched growth zones of 17–23 layers of rectangular cells 22μ–32μ high, and 11μ–16μ wide. Moderately developed marginal perithallus consists of layers of cells 19μ–26μ high and 11μ–13μ wide. No conceptacles present.

Remarks.—This form is quite similar to sp. C but forms longer and wider branches which have a moderately developed marginal perithallus. The cells of the medullary hypothallus in this species are appreciably longer than in sp. C.

Occurrence: Lower Miocene, Maemong Limestone. Member of Umatac Formation. Loc. Ii 6–26 (D920).

Figured specimen: A714a.

Tribe LITHOPHYLLEAE

Genus LITHOPHYLLUM Philippi, 1837

In this genus the tissue is clearly differentiated into hypothallus and perithallus. The basal hypothallus characteristically is coaxial, although in a few species it is reduced to a few irregular or curved rows of cells. The medullary hypothallus of the branches is also coaxial. Normally the perithallus is formed of layers of cells, very regularly arranged. However, a few species are known which have a perithallus composed of rows of cells, similar to the perithallus of *Lithothamnium*. The sporangia are collected into conceptacles which are pierced by a single large aperture in the roof for the escape of spores.

The genus is represented in the Cenozoic by more than a 100 species. It is the most important genus of coralline algae in the warm seas today. From it have developed the genera *Goniolithon* and *Porolithon* which are also very important in tropical waters today. Twenty-one species are described from the Guam collections.

For convenience in study, the species found on Guam are arranged in four divisions, which are based on their habit of growth.

Division 1—Simple crusts.
Division 2—Crusts free (unattached) or nearly free.
Division 3—Crusts with warty protuberances or mammillae.
Division 4—Strongly branching forms.

The dimensions and distribution of the species found on Guam are shown in table 9.

TABLE 9.—*Measurements, in microns, and distribution of species of* Lithophyllum *from Guam*

[From random sections]

Species	Hypothallus cells		Perithallus cells		Conceptacles		Localities	Age
	Length	Width	Length	Width	Diameter	Height		
Division 1.—Simple crusts [Commonly thin, some may grow superimposed]								
Lithophyllum alifanense Johnson n. sp.	15–27	9–13	7–17	7–11	300–402	86–270	Hn 7–3, Ts 9–1, Ts 16–1, 2, 5, and 12	Miocene.
maemongense Johnson n. sp.	16–30	7–16	9–22	6–15	460–480	135–186	Ed 4–1, Fj 2–5, Hi 3–5, Hi 5–1, Ii 6–25	Do.
cf. *L. obliquum* Lemoine	20–27	11–15	9–11	8–10			Ii 6–34, Ii 6–37, Ii 6–38	Do.
quadrangulum var. *Welschi* Lemoine	23–36	16–24	13–18	13–22			Ih 14–1	Do.
schlangeri Johnson n. sp.	15–19	8–10	11–15	6–8	264–337	185–193	Ii 6–37	Do.
sp. A	11–23	8–11	8–11	5–10			Ek 7–2, Fk 4–3	Eocene.
sp. B	32–48	12–24					Fj 2–4, Hi 3–4	Miocene.
sp. G	24–30	16–22	14–18	14–15			Ts 16–12	Do.
Division 2.—Crusts free (unattached) or nearly free								
Lithophyllum prelichenoides Lemoine	21–40	10–20	8–20	7–13	160–350		Ed 3–1, Ed 5–1, Gi 1–3, Ii 6–2, Ii 6–28, Ii 6–32, Ii 6–34, Ii 6–36, Ii 6–37.	Miocene.
							Jj 3–1.	Do.
Division 3.—Crusts with warty protuberances or mammillae								
Lithophyllum bonyense Johnson n. sp.	19–31	9–20	11–20	8–18			Ih 5–6, Ih 14–1, Ih 14–2	Miocene.
sp. E			11–16	9–16	320	110	Ov 7–3	Do.
Division 4.—Strongly branching forms								
Lithophyllum alternatum Johnson n. sp.	{L 41–56 {S 16–24	9–14 9–14	} 10–15	9–10			Ts 16–3, Ts 16–1, Jl 2–2	Miocene.
alternicellum Johnson n. sp.	{L 32–41 {S 22–25	8–13 8–13	} 9–16	9–14	208–224	66–71	Gj 7–2, Ih 5–6	Do.
cf. *L. glangeaudi* Lemoine		8–12	9–26	7–11			Ts 9–1	Do.
cf. *L. kladosum* Johnson	40–52	13–21	13–15	11–15			Ef 2–1	Do.
kotschyanum (Unger) Foslie	23–37	10–14	9–16	6–13	300–450		Agana Reef	Recent.
moluccense Foslie	{L 34–58 {S 14–28	6–15 6–14	} 10–20	6–12	200–310		Agana Bay, Meritzo Bay, Cocos Island, GMH–1 (30–35 ft.).	Recent and Pleistocene.
pseudoamphiroa Johnson n. sp.	36–63	13–21					Fj 2–4, Gj 3–1, Ii 6–25, Fi 6–5, Ii 6–26	Miocene.
traceyi Johnson n. sp.	12–30	7–15	10–18	8–13	220		Fi 6–7, Fj 2–1, Gi 1–3, Hi 3–6, Hi 10–1, Ii 6–31, Ii 6–34, Ii 6–38.	Do.
sp. C	18–24	10–14	16–19	7–11	275+		Ii 6–37	Do.
sp. F	17–27	9–11	9–16	6–9			Hn 7–2	Do.

Division 1—Simple crusts (commonly thin), some may grow superimposed

Lithophyllum alifanense Johnson n. sp.

Plate 3, figures 3–5

Description.—Thallus irregular, crust with well-developed coaxial hypothallus and thick perithallus. Hypothallus 100μ–250μ thick (average about 130μ), cells 15μ–27μ by 9μ–13μ. Perithallus 150μ–700μ thick (average about 220μ), fairly regular layers of cells 7μ–13(17)μ by 7μ–11μ. Conceptacle chamber diameters 300μ–402μ, heights 86μ–270μ.

Detailed dimensions, in microns, of Lithophyllum alifanense *Johnson n. sp.*

[From random sections. Cleared entries indicate absence of conceptacles]

Locality	Hypothallus cells		Perithallus cells		Conceptacles		Thickness	
	Length	Width	Length	Width	Diameter	Height	Hypothallus	Perithallus
Hn 7–3	19–27	10–11	8–10	7–10			251	194–210
Hn 7–3	----------	----------	7–17	9–11	600?	----------	----------	----------
Ts 9–1	16–19	7–11	8–15	7–19	349	86	110+	396+
	18–24	10–12	8–10	7–11			228	192
Ts 16–1	15–21	9–11	----------	----------	----------	----------	132	----------
Ts 16–2	23–27	9–12	----------	----------	----------	----------	175–200	----------
	15–18	9–10	9–13	7–10	320–402	270	182	250–430
Ts 16–5	15–23	11–13	----------	----------	----------	----------	125+	----------
	19–23	9–13	6–11	6–9	----------	----------	125–140	150–200
Ts 16–12	16–21	9–11	9–11	7–9	300–385	150–180	100–150	250–700

Remarks.—This is the most abundantly represented species in the Alifan limestone. It is close to *L. fulangasum* Johnson and Ferris but differs by having smaller hypothallic cells, larger conceptacles, and a thicker perithallus. It also resembles closely *L. bonyense* Johnson but has smaller cells. It is similar in cell dimensions to *L. hanzawaii* Johnson from the Pleistocene of the Kita-Daitō-Jima but differs by having much larger conceptacles.

Occurrence: Upper Miocene, Alifan Limestone. Locs. Hn 7–3, Ts 9–1 (D936), Ts 16–1, Ts 16–2 (D938), Ts 16–5 (D940), and Ts 16–12.

Figured specimen: Holotype A715. Also figured: A716 and A718.

Lithophyllum maemongense Johnson n. sp.

Plate 4, figures 1–3

Description.—Thallus forms thin crust, may grow superimposed on other specimens or species; well-developed hypothallus and perithallus tissue. Hypothallus 140μ–225μ thick, coaxial; arched layers of cells 16μ–26(30)μ by 7μ–12(16)μ. Perithallus 150μ–550μ thick, commonly about 200μ; regular layers of rectangular cells 9μ–22μ by 6μ–15μ. Conceptacle chambers 460μ–480μ in diameter and 135μ–186μ high.

Detailed dimensions, in microns, of Lithophyllum maemongensis *Johnson n. sp.*

[From random sections]

Locality	Hypothallus cells		Perithallus cells		Conceptacles		Thickness	
	Length	Width	Length	Width	Diameter	Height	Hypothallus	Perithallus
Ed 4–1	(1)	(1)	10–19	6–15	460	140	----------	333–527
Fj 2–5	19–22	12–16	10–20	7–14	480	186	124	437–442
Hi 3–5	17–26	10–12	13–22	9–13	(2)	(2)	205	153
Hi 5–1	19–30	7–17	9–19	7–13	(2)	(2)	140–176	276–282
Ii 6–25	16–23	8–11	14–18	11–12	480	135	150	200

1 Hypothallus cells absent.
2 Conceptacles absent.

Remarks.—This species differs in the combination of cell dimensions and conceptacle size from any other Miocene crustose *Lithophyllum*. It is similar to *L. prelichenoides* Lemoine but has larger conceptacles and different-sized cells.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Locs. Ed 4–1 (D891), Fj 2–5, Hi 3–5, Hi 5–1 (D912), and Ii 6–25 (D919).

Figured specimens: Holotype A719. Also figured: A720 and A721.

Lithophyllum cf. L. obliquum Lemoine

Plate 4, figures 4, 6

Lithophyllum obliquum Lemoine, 1930, Soc. geol. France Bull., ser. 4, v. 29, p. 266, figs. 1, 2.
Lithophyllum cf. *L. obliquum* Lemoine, 1939, Mat. Carte géol. de l'Algerie, ser. 1, Paléont., no 9, p. 97–98, fig. 64; p. 107.

Description.—Thallus crustose, well-developed hypothallus and thick perithallus. Hypothallus 125μ–218μ thick, coaxial; cell layers not strongly arched; cells 20μ–27μ by 11μ–15μ. Perithallus thickness 400μ–450μ; vertical rows of cells instead of horizontal layers normal for *Lithophyllum;* cells 9μ–11μ by 8μ–10μ. No conceptacles present.

Detailed measurements, in microns, of Lithophyllum *cf.* L. obliquum *Lemoine*

[From random sections]

Locality	Hypothallus cells		Perithallus cells		Conceptacles	Thickness	
	Length	Width	Length	Width		Hypothallus	Perithallus
Ii 6-34	20-25	9-15	5-10	7-11	Absent	218	350
Ii 6-37	27-34	11-17	10-14	7-12	do	218-280	477-492
Ii 6-38	20-27	11-15	8-10	9-11	do	125-150	400-458

Remarks.—This species belongs to that division of the genus *Lithophyllum* in which the perithallus contains vertical rows of cells rather than horizontal layers. It appears to fit Lemoine's description of the type from the lower Miocene of Spain and Algeria.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Locs. Ii 6-34 (D925), Ii 6-37, and Ii 6-38 (D928).
Figured specimens: A708 and A723.

Lithophyllum quadrangulum var. welschi Lemoine

Plate 4, figure 5

Lithophyllum quadrangulum Lemoine, 1934, Czechoslovakia Státního Geol. Ústavu Véstník, v. 9, no. 5, p. 279, fig. 1.
Lithophyllum quadrangulum var. *Welschi* Lemoine, 1939, Mat. Carte géol. de l'Algerie, ser. 1, Paléont., no. 9, p. 96, fig. 63.

Description.—Thallus crustose, well-developed coaxial hypothallus 250μ–300μ thick, perithallus same size. Hypothallus unusual in that cell layers almost vertical rather than strongly arched; unusually large rounded cells 23μ–36μ by 16μ–24μ. Perithallus rectangular cells 13μ–18μ high by 13μ–22μ wide. Conceptacles unknown.

Remarks.—The Guam specimen closely fits the description given by Lemoine (1939) of the type of the variety from the middle Miocene of Algeria and of a specimen from Persia.

Occurrence: Lower Miocene, Bonya Limestone. Loc. Ih 14-1 (D930).
Figured specimen: A724.

Lithophyllum schlangeri Johnson n. sp.

Plate 3, figure 2

Description.—Thallus forms very thin crust, consisting largely of a coaxial hypothallus, overlain by thin perithallus, normally with few layers of cells except around conceptacles. Hypothallus 119μ–131μ thick, cells 15μ–19μ long and 8μ–10μ wide. Perithallic cells 11μ–15μ by 6μ–8μ. Conceptacles highly arched, 264μ–337μ in diameter and 185μ–193μ high.

Remarks.—This belongs to the same general type as *L. prelichinoides* which it resembles considerably. It differs, however, by having smaller hypothallic cells and considerably longer perithallic cells.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Loc. Ii 6-37 (D927).
Figured specimen: Holotype A710a.

Lithophyllum sp. A

Lithophyllum sp. A, Johnson, 1957, U.S. Geol. Survey Prof. Paper 280-E p. 229, pl. 43, figs. 3, 5.

Description.—Thallus forms thin crust with well-developed hypothallus and perithallus. Hypothallus coaxial, cells 11μ–23μ by 8μ–11μ. Perithallus consists of fairly regular rows of cells 8μ–11μ by 5μ–10μ. No conceptacles present.

Remarks.—This represents the same form described from the Upper Eocene of Saipan as species A.

Occurrence: Upper Eocene, Alutom Formation. Locs. Ek 7-2 and Fk 4-3.

Lithophyllum sp. B

Plate 4, figures 7, 9

Description.—Thallus thin (215μ–310μ), consisting only of a well-developed coaxial hypothallus, cells rectangular 32μ–48μ by 12μ–24μ. Conceptacles unknown.

Remarks.—This species closely resembles *L. quadrangulum* Lemoine (1939, p. 96) from the western Mediterranean region but differs by having the coaxial hypothallus formed of more strongly curved layers of longer cells. It may represent a young form of a species close to *L. thikombian* Johnson and Ferris (1950, p. 17) or to *L. prelichinoides* Lemoine but having longer cells.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Locs. Fj 2-4 (D900) and Hi 3-4 (D910).
Figured specimens: A697 and A727.

Lithophyllum sp. G

Plate 4, figure 10

Description.—Thallus crustose, consists of well-developed coaxial hypothallus and perithallus with vertical rows of cells rather than horizontal layers. Hypothallus 150μ–270μ thick, cells 24μ–30μ by 16μ–22μ. Perithallus 300+μ thick, cells 14μ–18μ by 14μ–15μ. Conceptacles unknown.

Remarks.—Represented by a single, well-preserved, unfertile specimen. This species is closely related to *L. quadrangulum* Lemoine in having large cells, a well-developed coaxial hypothallus, and a perithallus with rows of cells rather than layers. It differs in cell dimensions and by having more strongly arched layers of hypothallic cells. It is an interesting and distinctive form, but without more material and a knowledge of the conceptacles, no specific name is suggested.

Occurrence: Upper Miocene, Alifan Limestone. Loc. Ts 16-12 (D943).
Figured specimen: A728.

Division 2—Crusts free or nearly free

Lithophyllum prelichenoides Lemoine

Lithophyllum prelichenoides Lemoine, 1917, Soc. géol. France Bull., ser. 4, v. 17, p. 262, figs. 8, 9 [1918].

Lemoine, 1939, Mat. Carte géol. de l'Algerie, ser. 1, Paléont., no. 9, p. 99, figs. 65, 66; p. 107.

Johnson, 1957, U.S. Geol. Survey Prof. Paper 280-E, p. 229, pl. 49, figs. 1, 2.

Description.—Thallus crust or leafy plate, possibly free or unattached, well-developed coaxial hypothallus may be as thick as 300μ. Only hypothallus present in young specimens, but mature specimens have thin perithallus on one or both sides of hypothallus. Perithallus seldom more than eight layers thick except around conceptacles, generally less than 250μ thick (commonly less than 150μ). Cells show unusual size range; hypothallic cells 21μ–40μ by 10μ–20μ, perithallic cells 8μ–20μ by 7μ–13μ. Conceptacles 160μ–350μ in diameter.

Detailed measurements, in microns, of Lithophyllum prelichenoides *Lemoine*

[From random sections. Cleared entries indicate absence of conceptacles]

Locality	Hypothallus cells		Perithallus cells		Conceptacles		Thickness	
	Length	Width	Length	Width	Diameter	Height	Hypothallus	Perithallus
Ed 3-1	23–26	10–14	11–17	10–13	230	150	80–103	218–280
Ed 5-1	34–41	9–13					196–234	Absent
Gi 1-3	24–39	10–15	12–18	7–13	161–163	91–113	120–142	182–214
Gi 1-3	31–41	13–18	11–15	8–13	220–350	121–123	196–225	54–94
Ii 6-2	24–33	11–14	11–15	8–13			250–275	150–250
Ii 6-2	20–25	11–15	9–10	7–9			200	65–78
Ii 6-28	19–23	9–11	10–12	9–10			132–159	110–166
Ii 6-32	24–30	12–18	15–20	9–13			173–198	230–240
Ii 6-34	18–24	9–14	9–15	10–13	250	128	150	145–170
Ii 6-36	18–29	12–15	8–11	7–11			71–106	305
Ii 6-37	25–30	11–18	11–18	10–12			130–224	92–130
Ii 6-37	21–25	13–17	13–17	9–12			92–110	95–120
Ii 6-37	16–22	9–17	11–15	8–12	263	126	110–141	219–259
Jj 3-1	24–31	9–16	10–11	5–7			162–199	140–152

Remarks.—This species occurs abundantly in the Maemong Limestone Member. The Guam specimens agree in appearance and cell dimensions with the material previously described by Lemoine from Algeria and by Johnson from Saipan.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Locs. Ed 3-1, Ed 5-1, Gi 1-3, Ii 6-2, Ii 6-28, Ii 6-32, Ii 6-34, Ii 6-36, and Ii 6-37. Lower Miocene, Bonya Limestone. Loc. Jj 3-1.

Division 3—Crusts with warty protuberances or mammillae

Lithophyllum bonyense Johnson n. sp.

Plate 4, figure 8; plate 5, figures 1, 2

Description.—Thallus forms irregular crust with low mammillae composed of well-developed coaxial hypothallus and irregularly developed perithallus. Hypothallus 150μ–350μ thick, normally about 300μ, cells 19μ–31μ by 9μ–20μ. Perithallus may be more than 600μ thick, cells 11μ–20μ by 8μ–18μ. Conceptacles not present.

Detailed measurements, in microns, of Lithophyllum bonyense *Johnson n. sp.*

[From random sections]

Locality	Hypothallus cells		Perithallus cells		Conceptacles	Thickness	
	Length	Width	Length	Width		Hypothallus	Perithallus
Ih 5-6	19–28	9–14	12–20	11–14	Absent	150–200	500–650
Ih 14-1(5)	17–27	10–18	11–14	8–11	do	250–275	300–500
Ih 14-1(6)	21–27	13–15	13–16	10–13	do	300–350	250–350
Ih 14-2	30–31	11–16	11–18	11–12	do	250–275	75+
Ih 14-2	20–27	14–20	15–19	13–16	do	300±	300–535
Ih 14-2(5)	19–27	12–16	15–20	9–14	do	300+	Up to 300

Remarks.—This is the most abundant species found in the Bonya limestone. It is strongly suggestive of *L. prelichenoides* Lemoine but differs by having larger cells, especially in the perithallus, a thicker hypothallus, and well-developed irregular perithallus. The cell dimensions are about the same as in *L. albanense* Lemoine, but the two forms differ in the tissue structure. *L. bonyense* has a coaxial hypothallus and a thick perithallus composed of regular layers of cells. In *L. albanense* the cells are not in regular layers in either the hypothallus or the perithallus.

Occurrence: Lower Miocene, Bonya Limestone. Locs. Ih 5-6 (D929), Ih 14-1 (D390), and Ih 14-2 (D931).

Figured specimens: Holotype A729. Also figured: A730 and A731.

Lithophyllum sp. E

Plate 5, figure 4

Description.—Fragment apparently representing outer part of mammillated crust, consisting entirely of perithallic tissue, cells 11μ–16μ by 9μ–16μ arranged in regular layers with unusually thick walls separating the layers; vertical partitions distinct and quite regularly spaced. A conceptacle chamber has diameter of 320μ and height of 110μ, shows large single aperture.

Remarks.—In growth habit and character of the perithallic tissue, the thick horizontal walls suggest *L. sphaeroides* described by Lemoine from the Burdigalian of Albania, but it differs somewhat in cell dimensions. The conceptacles of *L. sphaeroides* are not known.

The Guam species is represented by a single fragment which does not show the hypothallus or much of the growth form. Consequently it does not seem advisable to give it a specific name.

Occurrence: Upper Miocene, Barrigada Limestone. Loc. Ov 7-3 (D934).

Figured specimen: A732.

Division 4—Strongly branching forms

Lithophyllum alternatum Johnson n. sp.

Plate 5, figures 3, 5, 6

Description.—Branches consist of thick medullary hypothallus surrounded by well-developed marginal perithallus. Hypothallus, 700μ–900μ thick, composed of regularly alternate rows of long and short cells; long cells 41μ–56μ by 9μ–14μ, short cells 16μ–24μ by 9μ–14μ. Perithallus fairly regular layers of cells 10μ–15μ by 9μ–10μ. Conceptacles not observed.

Remarks.—This is another member of the small group of branching *Lithophyllum* characterized by having a medullary hypothallus with regularly alternate layers of long and short cells. To date only seven members of this group are known. Of these, four are Miocene, one Pleistocene and Recent, and two Recent. They are compared in the following table. *L. alternatum* is very close to the Recent *L. moluccense.* However, without a knowledge of the conceptacles it seems desirable to consider it as a separate species.

Occurrence: Upper Miocene, Alifan Limestone. Locs. J1 2-2, Ts 16-3 (D939), and Ts 16-1(4) (D937).

Figured specimens: Holotype A733. Also figured: A734.

Comparison of measurements, in microns, of species of Lithophyllum *having hypothallus with alternate layers of long and short cells*

[From random sections]

Species	Medullary hypothallus				Perithallus		Conceptacles	Age
	Long cells		Short cells					
	Length	Width	Length	Width	Length	Width	Diameter	
Lithophyllum								
bamleri Heydrich [1]	27–60	7–15	12–30	16–20	6–120	8–10	600–700	Recent.
platyphyllum Foslie	22–36	9–14	11–22	7–14	9–18	9–14	240–400	Do.
moluccense Foslie	34–58	6–14	14–28	6–14	10–20	6–12	200–310	Recent and Pleistocene.
premoluccense Lemoine	50–85	10–12	15–30	10–12	15–130	10	100–160	Miocene.
alternatum Johnson n. sp	41–56	9–14	16–24	9–14	10–15	9–10	[2]	Do.
alternicellum Johnson n. sp	32–41	8–13	22–25	8–13	9–16	9–14	208–224	Do.
lemoini Raineri	100–130	10–13	30–33	10–13	10–12	12–13	[2]	Do.

[1] In *L.* bamleri there is an alternation of two layers of long cells with one layer of short cells; in all the others the alternation is one long with one short.
[2] Not known.

Lithophyllum alternicellum Johnson n. sp.

Plate 6, figures 3, 4

Description.—Branches contain thick coaxial medullary hypothallus and moderately developed marginal perithallus. Hypothallus consists of regularly alternate layers of long and short cells; long cells 32μ–41μ by 8μ–13μ, short cells 22μ–25μ by 8μ–13μ. Perithallus 9μ–16μ by 9μ–14μ. Conceptacles 208μ–224μ in diameter and 66μ–71μ high.

Remarks.—This species belongs to the small group of *Lithophyllum* characterized by having the hypothallic tissue formed of alternate layers of long and short cells. The only other known Miocene species of this group is *L. premoluccense* Lemoine which, however, has much longer hypothallic cells and appreciably smaller conceptacles.

Occurrence: Lower Miocene, Bonya Limestone. Locs. Gj 7-2 (D909) and Ih 5-6 (D929).

Figured specimens: Holotype A735. Also figured: A736.

Lithophyllum aff. L. glangeaudi Lemoine

Plate 6, figure 6

Lithophyllum glangeaudi Lemoine, 1939, Mat. Carte géol. de l'Algerie ser. 1, Paléont. no. 9, p. 102–103, pl. 2, fig. 15, text fig. 70; p. 107.

Description.—Strongly branching form has a thick perithallic layer, cells with a considerable range in size, 9μ–26μ by 7μ–11μ. Hypothallic tissue does not show a strongly defined layered structure; cells in rows 8μ–12μ wide with very poorly defined cross partitions. No conceptacles present.

Remarks.—The character of the perithallic tissue, size of perithallic cells, and the branching habit suggest *L. glangeaudi* described by Lemoine from the middle Miocene of Algeria. However, without a better knowledge of the hypothallus and conceptacles only a resemblance can be suggested.

Occurrence: Upper Miocene, Alifan Limestone. Loc. Ts 9–1 (D936).
Figured specimen: A737.

Lithophyllum cf. L. kladosum Johnson

Lithophyllum kladosum Johnson, 1954a, U.S. Geol. Survey Prof. Paper 260–M, p. 539, pl. 192, figs. 1–8.

Description.—Fragments of long, slender branches containing well-developed medullary hypothallus and marginal perithallus. Hypothallus formed of gently arched layers of cells 40μ–52μ by 13μ–21μ. Perithallic cells nearly square 13μ–15μ by 11μ–15μ. Conceptacles unknown.

Remarks.—The Guam specimens closely resemble the material described as *L. kladosum* from the lower Miocene of Bikini. They are identical in cell measurements and growth habit but differ by having a thinner marginal perithallus.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Loc. Ef 2–1.

Lithophyllum kotschyanum (Unger) Foslie form madagascariensis Foslie

Plate 14, figures 1–2; plate 15, figure 3

Lithophyllum madagascarense Heydrich, 1902, Quelqu. Nouv. Melob., p. 473.
Lithophyllum kotschyanum (Unger) Foslie, 1909, K. norske vidensk. selsk. Skr., no. 2, p. 34 .
Foslie and Printz, 1929, K. norske vidensk. selsk. mus. Mon., p. 35, pl. 65.

Description.—Plant develops as flattened hemispherical or very flattened conical mass; closely packed branches as much as 6 inches in diameter and 3 inches in height form thick platy or leaflike masses. Plant grows firmly attached to hard object, commonly coral; some plants develop into flat shelflike or bracketlike masses; numerous conceptacles on upper surfaces of some specimens. Section through branch shows medullary hypothallus and marginal hypothallus that grade one into the other. Hypothallus wide, tissue quite regular, arched layers of rectangular cells 23μ–37μ by 10μ–14μ. Perithallus regular layers of cells 9μ–16μ by 6μ–13μ. Conceptacles numerous, diameters 300μ–450μ; tops flattened or slightly depressed with single short wide aperture.

Remarks.—*Lithophyllum kotschyanum* is a highly variable species widely distributed in the Indian Ocean and the tropical Pacific. Foslie described five growth forms. The Guam specimens closely fit his form "madagascariensis" which was characterized by having wide platelike branches. They differ only in that the branches are wider than the type from Madagascar. In other words, they are more extreme than the type of the form. The cell dimensions and conceptacle sizes agree with the types both of the form and the species.

It is interesting to note that in the collections from Saipan studied by the author forms *typica* and *subtilis* were observed to be more extreme than Foslie's types of those forms, whereas at Guam the form *madagascariensis* is more extreme than the type. In comparing a suite of specimens, resemblances can be seen between form *subtilis* and form *typica* and between *typica* and *madagascariensis*, but the differences in appearance between *subtilis* and *madagascariensis* are so great that they would be considered entirely different species were it not for identical microstructure, cell dimensions, and shape and size of conceptacles.

The form is quite abundant on Guam, on the quiet inner side of the Agana Reef, where it grows at depths of 1–10 feet below low-tide levels.

Occurrence: Agana Reef (D946).
Figured specimens: A738 and A739.

Lithophyllum moluccense Foslie

Plate 13, figures 1, 3

Lithophyllum moluccense Foslie, 1901, Kl. norske vidensk. selsk. Skr., no. 6, p. 24.
Weber van Bosse and Foslie, 1904, *Siboga*-Expeditie Mon. 61, p. 67, pl. 12.
Foslie and Printz, 1929, Kl. norske vidensk. selsk. mus. Mon., p. 36, pl. 50.
Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 230, pl. 58, figs. 2–5.

Description.—Plant strongly branching, bushy, commonly compact hemispherical or spherical masses, some small tufts; average diameter 3–4 inches, maximum 6–7 inches; large plants are wide and flat.

Normally plants start growing attached to hard object such as coral, later may become detached and grow loose on bottom; broken branches may develop new plants. At a few localities around Guam nearly spherical masses were growing loose on bottom, especially abundant on inside of Cocos Island reef of Merizo Bay at depths of 6–15 feet.

Three varieties or growth forms recognized around Guam. Foslie named these *typica*, *flabelliformis*, and *pygmaea;* form *typica* develops relatively long strong thick branches rather widely spaced (Johnson, 1957, pl. 58, figs. 2–4); form *flabelliformis* has tightly packed short, stubby, flattened branches (pl. 13, fig. 3); form *pygmaea* has short slender tightly packed branches (pl. 13, fig. 1). In both *typica* and *pygmaea* branches tend to bifurcate at wide angle (75°–100°) and have gently rounded or blunt ends. Typical specimens of the three forms are quite distinct and differ appreciably in general appearance. However, in a large collection specimens can be found intermediate between the types. In the Guam collections *typica* and *flabelliformis* are common; *pygmaea* is much less abundant.

Branches contain well-developed medullary hypothallus and marginal perithallus. Hypothallus forms 50–60 percent of branch diameter; alternate layers of long and short cells rectangular in section; short cells 14μ–28μ by 6μ–14μ; long cells 34μ–58μ by 6μ–15μ. Lengths are measured at center of row; cells become shorter toward margins.

Marginal perithallus commonly 0.350–0.400 mm thick; smaller cells 10μ–20μ by 6μ–12μ (average 18μ by 10μ). In section, cells of inner layers oblong, cells of outer layers square. Conceptacle chambers 0.200–0.310 mm in diameter (average 0.250–0.275 mm). Roof pierced by single large pore.

Remarks.—This species is common at all localities from which collections of Recent algae were made and is the most abundantly represented species in the Guam collections.

Occurrence: All reefs where collections of Recent algae were made; also Pliocene and Pleistocene, Mariana Limestone. Loc. GMH-1, depth 30–35 ft; Agana Reef (D946) and Cocos Island Reef (D903).

Figured specimens: A740, A741, and A782.

Lithophyllum pseudoamphiroa Johnson n. sp.

Plate 7, figures 1–4

Description.—Thallus starts with basal crust from which develop long, slender branches, may branch repeatedly. Basal hypothallus coaxial, 250μ–300μ thick, cells 39μ–57μ by 14μ–19μ. Branches consist of medullary hypothallus of gently arched layers, large rectangular cells 36μ–63μ by 13μ–21μ (average about 53μ by 20μ). Suggestions of single outer dermal layer of smaller cells. Most branches had diameters of 800μ–$1{,}000\mu$. No conceptacles observed.

Detailed dimensions, in microns, of three typical specimens of Lithophyllum pseudoamphiroa *Johnson n. sp.*

[From random sections]

Locality	Basal hypothallus cells		Medullary hypothallus cells		Thickness of branches
	Length	Width	Length	Width	
Fi 6-5	----------	----------	36–59	13–22	933
Fj 2-4	39–57	14–19	56–63	17–22	800–988
Fj 2-4	----------	----------	50–55	14–19	875–910
Gj 3-1	----------	----------	41–53	17–25	765–1, 101
Ii 6-26	----------	----------	52–62	13–19	1, 016

Remarks.—Superficially, fragments of branches of this species strongly suggest segments of a long, slender *Amphiroa*. However, the lack of articulation (alternation of long calcified segments with short uncalcified nodes) and the well-developed coaxial basal hypothallus place it in the genus *Lithophyllum*. The cells are longer than most species of *Lithophyllum* but are shorter than those of most *Amphiroa*.

A number of pieces of this species were observed in the Miocene collections from Saipan but were too fragmentary or too poorly preserved to permit an adequate description.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Locs. Fi 6–5, Fj 2–4 (D900), Gj 3–1, Ii 6–25 (D919), and Ii 6–26.

Figured specimens: Holotype A697 (the slide contains two specimens figured). Also figured: A743.

Lithophyllum traceyi Johnson n. sp.

Plate 6, figures 1, 2

Description.—Strongly branching form; branch lengths more than a centimeter, widths 450μ–1200μ. Wide medullary hypothallus, 300μ–1100μ thick; moderately developed marginal perithallus. Hypothallus coaxial of gently arched layers of cells; most specimens show distinct growth zones; considerable range in size both in same layers and between adjoining layers of cells, 12μ–30μ by 7μ–15μ. Perithallus regular layers of cells 10μ–18μ by 8μ–13μ. Conceptacle chambers 221μ–288μ in diameter, 149μ–168μ in height.

Remarks.—This species belongs in the same general group as *L. oblongum*, *L. kladosum*, and *L. profundum*, described by Johnson (1954a) from the Miocene of Bikini. It differs from them, however, by having shorter cells.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Locs. Fi 6–7 (D899), Fj 2–1, Gi 1–3, Hi 3–6, Hi 10–1, Ii 6–31, Ii 6–34 (D925), and Ii 6–38.

Figured specimens: [Holotype] A698. Also figured: A745.

Detailed measurements, in microns, of Lithophyllum traceyi *Johnson n. sp.*

[From random sections]

Locality	Hypothallus cells		Perithallus cells		Conceptacles		Thickness	
	Length	Width	Length	Width	Diameter	Height	Hypothallus	Perithallus
Fi 6-7	9–30	8–12	10–14	9–11	220		550–700	180–250
Fj 2-1	17–28	12–15	13–16	8–11			1, 066–1, 256	333–488
Gi 1-3	24–31	12–15	9–12	9–13	221–288	149–168	304–415	115–360
Hi 3-6	20–27	10–13	10–16	10–13			791–823	160–195
Hi 10-1	19–26	7–10	7–15	9–10			579–614	186–278
Ii 6-31	22–26	11–13					256–305	80–120
Ii 6-34	14–25	9–11	11–14	6–12			600±	100–150
Ii 6-34	23–29	8–10	14–18	8–10			775–787	282–298
Ii 6-38	21–26	10–11	14–17	6–9			878–926	505–593

Lithophyllum sp. C

Plate 6, figure 5; plate 7, figure 5

Description.—Long, slender branches, well-developed medullary hypothallus and marginal perithallus. Hypothallus has strongly arched layers of cells with thick walls between layers; cells 18μ–24μ by 10μ–14μ. Perithallus has slightly wavy layers of cells, also separated by thick walls; strong suggestion of alternation of layers of longer cells with layers of slightly shorter cells; cells 16μ–19μ by 7μ–11μ. Conceptacle chamber with a diameter of 275μ present on the slide, but conceptacle probably not cut through center.

Remarks.—Represented by a single tangential section (pl. 6, fig. 5) and an oblique section which does not show the true relative widths of hypothallus and perithallus. This form suggests *L. premoluccense* Lemoine but has much shorter cells.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Loc. Ii 6-37 (D927).
Figured specimens: A710a, and A710b.

Lithophyllum sp. F

Plate 12, figure 7

Description.—Strongly branching form, unusually regular tissue. Medullary hypothallus thickness 394μ–410μ, regular layers of cells suggest growth zones; cells 17μ–27μ by 9μ–11μ. Marginal perithallus 98μ–187μ thick, well-defined layers of cells 9μ–16μ by 6μ–9μ. Conceptacles unknown.

Remarks.—The cell dimensions and regularity of the tissue separate this from any known Miocene or Pliocene species, but with only one good specimen available for study and without a knowledge of the conceptacles, it does not seem wise to give it a specific name.

Occurrence: Upper Miocene, Alifan Limestone. Loc. Hn 7-2 (D916).
Figured specimen: A748.

Genus POROLITHON Foslie, 1909

Porolithon resembles *Lithophyllum* in having, normally, a coaxial hypothallus, a perithallus composed of layers of cells, and conceptacles of sporangia each possessing a single large aperture in the roof for the escape of spores. It differs from *Lithophyllum* primarily by having in the perithallic tissue lenses of megacells parallel to the layers of cells. The horizontal grouping of the megacells distinguishes *Porolithon* from *Goniolithon*, in which megacells occur singly or in short vertical rows perpendicular to the cell layers. As a result of the presence of the megacells, the perithallic tissue is not as regular as is commonly the case with *Lithophyllum*. Another distinctive feature of *Porolithon* is the common presence of lateral pores connecting adjoining cells.

The genus contains both encrusting and branching forms. It is known from the Pleistocene and Recent and is represented today in the tropical Pacific by a few widely distributed species.

Several Recent species were observed on the reefs at Guam, and one Pleistocene species was studied.

Porolithon onkodes (Heydrich) Foslie

Lithothamnion onkodes Heydrich, 1897a, Deutsche bot. Gesell. Ber., v. 15, p. 410.
Heydrich, 1897b, Bibliotheca Botanica, v. 41, p. 6, fig. 11.
Weber van Bosse and Foslie, 1904, *Siboga*-Expeditie Mon. 61, p. 57, pl. 11.
Foslie and Printz, 1929, K. norske vidensk. selsk. mus. mon., p. 33, pl. 67, figs. 1–8.
Porolithon onkodes (Heydrich) Foslie. Taylor, 1950, Michigan Univ. Studies, Sci. Ser., v. 18, p. 125, pls. 9, 61–63.
Johnson, 1954a, U.S. Geol. Survey Prof. Paper 260–M, p. 537, 542, pl. 194, figs. 1–4; pl. 195, fig. 4.
Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E p. 232–233, pl. 55, figs. 6, 7; pl. 59, fig. 6.

Description.—Plants encrusting; individual crusts thin but superimposed thalli may develop as thick crust or nodular mass. Surface smooth to rough with dull or semidull luster. Thin crusts conform to irregularities of substratum; thick crusts flat or gently rounded. Hypothallus thin, ranging from few rows of cells up to 300μ thick; cells rounded to rectangular, elongated, 12μ–21μ by 7μ–12μ. Most of crust is perithallic tissue, well-defined layers of rectangular cells, 6μ–14μ by 6μ–7μ. Abundant megacells occur in lenticular clusters. Conceptacles numerous, flattened tops, diameters of 175μ–300μ.

Remarks.—The Guam material agrees with Foslie's description and is similar to that from Saipan. The conceptacles are slightly larger than those described by Taylor from Bikini but are within the range given by Foslie.

Occurrence: Found at all localities where Recent collections were made.

Porolithon craspedium (Foslie) Foslie

Lithophyllum craspedium Foslie, 1900b, K. norske vidensk. selsk. Skr., no. 5, p. 26, 27.

Lithophyllum (*Porolithon*) *craspedium* Foslie. Foslie, 1909, K. norske vidensk. selsk. Skr., no. 2, p. 43, 44.

Lithophyllum craspedium Foslie. Foslie and Printz, 1929, K. norske vidensk. selsk. mus. Mon., p. 33, pl. 69, figs. 1–7.

Porolithon craspedium (Foslie) Foslie. Taylor, 1950, Michigan Univ. Studies, Sci. Ser., v. 18, p. 126–128, pls. 64, 65.

Johnson, 1954a, U.S. Geol. Survey Prof. Paper 260–M, p. 541, pl. 193, figs. 1–5; pl. 194, fig. 5.

Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 232, pl. 56; figs. 4–5; pl. 59, figs. 1–3.

Description.—Variety of growth forms, commonly cushion-shaped subconical or flattened cylindrical. Branches coarse, fingerlike, wedge shaped, or forming rounded protuberances. Grows very firmly attached to hard firm mass, commonly coral or other crustose corallines; very solid and massive. Surface slightly rough, semilustrous. Living plants commonly have gray tinge. Conceptacles small, not prominent. Tissue not noticeably differentiated into medullary hypothallus and perithallus, dense, not very regular layers of rectangular cells 8μ–15μ by 7μ–11μ. Lenses of megacells rather regularly spaced throughout tissue. Megacells irregular, rounded, 15μ–34(40)μ long and 7μ–15μ in diameter, 6–12 in a row in sections. Conceptacles abundant, small, flattened tops, 200μ–285μ in diameter.

Remarks.—In appearance, structure, and cell dimensions, the Guam material resembles Foslie's descriptions. The conceptacle size averages a little larger than Foslie's specimens from the South Pacific and Indian Ocean.

Occurrence: Pleistocene, Mariana Limestone. Recent reefs.

Genus GONIOLITHON Foslie, 1900

In appearance, growth habit, and general structure *Goniolithon* closely resembles *Lithophyllum*. It has similar single-apertured conceptacles and commonly, though not always, has a coaxial hypothallus. The generic distinctions stressed by Foslie deal entirely with minute structural features of the sporangia and their position within the conceptacles, features seldom seen in fossils. The most distinctive structural feature seen in thin sections is a development of megacells in the perithallic tissue. These megacells are long and have diameters two or three times as large as the ordinary cells. They may occur singly or in short rows perpendicular to the layers of the tissue.

From the present study the author would also add the following features: All the Recent specimens of the genus from Guam have a dull luster on the surface of dried specimens which is quite a contrast to the shiny luster of most *Lithophyllum*. Also in *Goniolithon* the development of secondary hypothallic scar tissue over injuries, foreign objects, and conceptacles seems to occur much more commonly than in other genera.

The first recorded fossil occurrence of *Goniolithon* is from the early Miocene; it developed steadily during the Pliocene and is common in Pleistocene beds and in Recent tropical seas where it is represented by numerous individuals of a few widely distributed species. It develops both crustose and branching forms.

The dimensions and distribution of the species found on Guam are given in table 10.

TABLE 10.—*Measurements in microms, and distribution of species of* Goniolithon *(from Guam)*

Species	Hypothallus cells		Perithallus cells		Megacells		Conceptacles		Localities	Age
	Length	Width	Length	Width	Height	Width	Diameter	Height		
Goniolithon cf. *G. fosliei* (Heydrich) Foslie.	29–41	11–18	28–41	11–18	20–40	18–33	750–1,250	200–325	Agana Reef	Recent.
frutescens Foslie	17–34	11–23	12–25	9–16	25–45	18–29	350–425	----------	All reefs	Recent and Pleistocene.
medioramus Johnson n. sp	22–27	13–22	9–21	8–18	25–68	22–32	480–670	300–475	Agana Reef	Recent.
miocenicum Johnson n. sp	12–26	6–14	5–18	4–14	13–30	9–21	69–87	58–77	Fd1-1, Fd4-1, Fi3-4, Fj2-4, Gl-1, Gi4-2, Hi 10-1, Ii6-31, Ii 6-34.	Miocene.
reinboldi W.v Bosse and Foslie	----------	----------	15–33	15–20	30–42	26–30	250–400	150–230	All reefs	Recent.
sp. C	22–33	9–15	10–18	9–13	11–18	18–28	----------	----------	Ts 9-1	Miocene.

Goniolithon cf. G. fosliei (Heydrich) Foslie

Plate 13, figure 2

Lithothamnion fosliei Heydrich, 1897a, Deutsche bot. Gesell. Ber., v. 15, p. 58.

Goniolithon fosliei (Heydrich) Foslie. Weber van Bosse and Foslie, 1904, *Siboga*-Expeditie Mon. 61, p. 46, pl. 9, figs. 1–5.

Description.—Thin rather even crust on corals and other coralline algae. In section well-developed moderately coaxial hypothallus 0.250–0.400 mm thick and much thicker perithallus. Hypothallic cells long, rectangular, or wedge shaped, 29μ–41μ by 11μ–18μ. Perithallic rectangular cells with rounded corners and abundant short vertical clusters of megacells; considerable range in size, 28μ–41μ by 11μ–18μ. Barrel- or cushion-shaped megacells, generally in vertical groups of three to five; size range 20μ–40μ in length and 18μ–33μ in diameter. Conceptacles large, wide, and flat, long nipples leading to aperture; chambers 750μ–1,250μ in diameter and 200μ–325μ in height.

Remarks.—In appearance, growth habit, and general structure this species resembles Foslie's descriptions and illustrations of specimens from the Indian Ocean and East Indies. However, the Guam material has appreciably larger cells, smaller conceptacles, and less perfectly developed coaxial hypothallus. Possibly it is a new species. This may be decided by later more extensive collections.

Occurrence: Recent, Agana Reef (D946).
Figured specimen: A749.

Goniolithon frutescens Foslie

Goniolithon (*Cladolithon*) *frutescens* Foslie, 1900a, K. norske vidensk. selsk. Skr., no. 1, p. 9–10.

Goniolithon frutescens Foslie. Foslie, 1900c, The fauna and geography of the Maldive and Laccadive Archipelagoes, p. 468, pl. 25, figs. 5–6.

Weber van Bosse and Foslie, 1904, *Siboga*-Expeditie Mon. 61, p. 53, pl. 10, figs. 10–11.

Foslie and Prinz, 1929, K. norske vidensk. selsk. mus. Mon., p. 30, pl. 48.

Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 231 pl. 59, fig. 4; pl. 60, fig. 3.

Description.—Bushy tufts or loose rounded masses; branches long delicate irregular, fused at base but separated for most of length, commonly 3.5 cm long and as thick as 3 mm, surface dull, nearly smooth, or somewhat irregular. Plant starts attached to hard object such as a coral, pebble, or another alga. Later, plant may become detached and grow loose on bottom. Plants fragile, branches separating and breaking easily. Branches distinct, medullary hypothallus generally composes 50–70 percent of diameter and marginal perithallus; few specimens very thin epithallus. Medullary hypothallus gently curving layers of rectangular cells nearly flat at center; layers quite uniform in size and arrangement; cells 17μ–34μ by 11μ–23μ, walls fairly thick; patches of secondary hypothallic scar tissue noted on many specimens. Perithallus rather irregular, 0.300–0.400 mm thick; irregular layers of cells varying considerably in size 12μ–25μ long by 9μ–16μ wide. Megacells irregularly distributed throughout perithallic tissue especially near margins, rounded or barrel-shaped, appearing singly or in rows of 2, 3, or 4 perpendicular to cell layers; cells 25μ–45μ long by 18μ–29μ in diameter. Several slides showed presence of thin epithallus, single layer of flattened cells about 10μ high. Conceptacles rare; 350μ–425μ in diameter.

Remarks.—In appearance and cell dimensions the Guam material agrees with Foslie's description of the species from Funafuti, the East Indies, and the Indian Ocean. It differs by developing larger more luxuriant plants, with longer branches. Megacells occur more abundantly in the Guam specimens than in Foslie's type from Funafuti. All the Guam species belong to Foslie's form *typica*.

Occurrence: Pleistocene, Mariana, and Recent. The species is relatively common in shallow backreef areas around Guam where it is found associated with corals.

Goniolithon medioramus Johnson n. sp.

Plate 13, figures 4, 7; plate 15, figures 1, 2

Diagnosis.—*Thallus compactus vel nodulosus ramorum brevium condensatorumque; rami* 3–5 mm *ad basim crassi*, 1–1.5 cm *longi, hypothallo medullari et perithallo marginali amplis; tela hypothalli regularis, cellulis* 22μ–27μ *longis*, 13μ–22μ *latisque; perithallus irregularis, cellulis* 9μ–21μ *longis*, 8μ–18μ *latisque; megacellulae* 25μ–68μ *altae*, 22μ–32μ *lateaque; conceptacula* 350μ–475μ *alta*, 570μ–670μ *lataque, foraminibus longis.*

Description.—Plants form bushy to nodular masses of short branches averaging 3–5 mm thick at base, tapering toward ends; branches tightly packed, commonly bifurcated, ends rounded, as much as 2.5 cm long with average length 1–1.5 cm. Plants start growing around hard object, commonly end of coral branch or loose piece of coral. Nodular masses attain lengths of 3–8 cm. Sections of branches show well-developed medullary hypothallus and thin irregular basal hypothallus of arched layers of rectangular cells, regularly arranged; cells 22μ–27μ long by 13μ–22μ wide. Perithallus irregular, composed of irregular rows of rectangular to rounded cells varying considerably in size, 9μ–21μ long by 8μ–18μ in diameter. Megacells numerous in perithallic tissue, 25μ–68μ long by 22μ–32μ wide. Conceptacles terminal in medullary tissue; ratio of height to diameter large; they have unusually long nipplelike apertures. Measurements (in microns) of conceptacle chambers follow.

Diameter	*Height*	*Diameter*	*Height*
650	400	600	350
600	350	575	350
480	300	550	330
625	340	590	450
570	[1] 325	670	[2] 475
620	450		

[1] Aperture of nipple 230μ long.
[2] Aperture of nipple 260μ long.

Remarks.—This species is close to *G. breviclavium* described by Foslie from Hawaii but has larger cells and longer and more tightly packed branches and slightly smaller conceptacles.

It is intermediate between *G. laccadivicum* and *G. frutescens* in most features (cell dimensions, size of conceptacles, and character of branches). *G. frutescens* has long, relatively slender branches and *G. laccadivicum* has short round warty branches, whereas *G. medioramus* has medium-length branches, thick at the base but tapering toward the tips. The conceptacles of *G. medioramus* resemble those of *G. laccadivicum* but are smaller. They differ both in shape and size from those of *G. frutescens*.

Occurrence: Recent. This species is fairly common on the Agana Reef and the reefs along the southwest side of the island. Agana Reef (D946).

Figured specimen: Holotype A752. Also figured: A750 and A751.

Goniolithon miocenicum Johnson n. sp.

Plate 8, figures 1–3

Description.—Thallus is an irregular crust with moderately developed hypothallus and considerably thicker perithallus. Hypothallus coaxial 109μ–484μ thick, cells 12μ–26μ by 6μ–14μ. Perithallus 176μ–836μ thick, tissue fairly regular, layers of cells 5μ–18μ by 4μ–14μ. Megacells sized 13μ–30μ by 9μ–21μ fairly abundant; normally single (rather than in vertical groups) and fairly regularly spaced in cell layers. Conceptacles small 69μ–87μ in diameter and 58μ–77μ high.

Detailed measurements, in microns, of Goniolithon miocenicum *Johnson n. sp.*

[From random sections. Cleared entries indicate absence of conceptacles]

Locality	Hypothallus cells		Perithallus cells		Megacells		Conceptacles		Thickness	
	Length	Width	Length	Width	Length	Width	Diameter	Height	Hypothallus	Perithallus
Fd 1–1	13–120	6–9	8–11	4–8	14–18	12–18			81–104	484–704
Fd 1–1	17–26	9–14	6–13	8–12	18–25	13–18			136–115	583–704
Fd 1–1	-------	-------	9–18	8–12	18–22	17–18			109–118	220
Fd 4–1	20–26	7–12	7–11	6–11	16–22	11–16			171	211
Fi 3–4	19–26	9–12	9–13	7–11	21–30	13–18			154–176	352–492
Fj 2–4	-------	-------	8–13	8–11	18–25	11–15			-------	484
Fj 2–4	17–26	10–13	6–11	6–10	13–18	11–12			340	290
Gi 1–1	17–26	7–11	9–14	8–14	18–26	15–21	69–87		132–176	836
Gi 4–2	-------	-------	7–11	5–10	15–26	11–17			-------	-------
Hi 10–1	16–22	7–19	8–11	5–7	9–13	9–11			484	308
Ii 6–31	12–21	8–13	10–18	8–10	14–28	11–16			160+	792+
Ii 6–34	20–24	9–11	5–9	6–9	8–14	11–14			117–130	176–184
Range	12–27	6–14	5–18	4–14	13–30	9–21	69–87	58–77	109–484	176–836

Remarks.—This is the first unquestionable species of *Goniolithon* the writer has observed in beds of Miocene age. The structure is similar to that of Recent members of the genus except that the megacells occur singly rather than in vertical groups or columns and they are more regularly spaced. The species occurs abundantly in the Maemong Limestone Member.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Locs. Fd 1–1 (D894), Fd 4–1, Fj 2–4 Gi 1–1 (D904), Hi 10–1, Ii 6–31, and Ii 6–34. Lower Miocene, Bonya Limestone. Locs. Fi 3–4 (D896) and Gi 4–2.

Figured specimens: Holotype A753. Also figured: A755 and A754.

Goniolithon reinboldi Weber van Bosse and Foslie

Plate 13, figures 5–6; plate 15, figure 4, 5

Goniolithon reinboldi Weber van Bosse and Foslie. Foslie, 1901, K. norske vidensk. selsk. Skr., no. 6, p. 5.

Weber van Bosse and Foslie, 1904, *Siboga*-Expeditie Mon. 61, p. 49, fig. 21; pl. 10.

Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 231, pl. 59, fig. 5.

Description.—The plant commences as a thin crust on coral, crustose coralline algae, or some other hard object; later warty excrescences develop which may be widely or closely packed; the surface often is covered by tiny pimplelike conceptacles as the plant seems to fruit at all seasons. Perithallic structure is unusual, hence characteristic. Perpendicular section shows thin hypothallus with 1–6 layers of greatly elongated nearly rectangular cells. Perithallus forms most of the tissue, thin but irregular layers of irregularly arranged rounded cells having quite a size range (15μ–33μ long by 15μ–30μ in diameter). Streaks of secondary hypothallic scar tissue may occur over conceptacles, injured areas, or bits of foreign material. Megacells are not abundant and, because of irregular tissue, not conspicuous as in *G. frutescens* or *G. medioramus;* megacells occur irregularly throughout tissue, 30μ–42μ long by 26μ–30μ wide. Conceptacles are very abundant, circular in plan, and highly arched in vertical section; commonly 250μ–400μ in diameter and 150μ–230μ high.

Remarks.—This species is common and easily recognized in section. Superficially it resembles *Lithophyllum okamurai* Foslie with which it is frequently associated.

The Guam material agrees with Foslie's description and illustrations of specimens from the East Indies and the Indian Ocean except that it commonly has a slightly thicker hypothallus.

Occurrence: Recent. Found at all the Guam reef localities. Agana Reef D946.

Figured specimens: A756, A757, A758, and A759.

Goniolithon sp. C

Plate 8, figure 4

Description.—Represented by single fragment of thick irregular crust, mainly perithallic tissue but showing several patches of hypothallic scar tissue with coaxial hypothallus up to about 200μ thick and cells 22μ–33μ by 9μ–15μ. Perithallus has moderately regular layers of cells 10μ–18μ by 9μ–13μ. Megacells in short vertical rows or columns commonly containing 4 or 5 cells; wide flattened rounded or rectangular cells 11μ–18μ high by 18μ–28μ wide; columns fairly regularly spaced through certain zones of perithallus. Conceptacles unknown.

Remarks.—This form shows structural details similar to those of Recent species. It is a very interesting find. However, with only a single fragment to study and without a knowledge of the conceptacles it does not seem desirable to give it a specific name.

Occurrence: Upper Miocene, Alifan Limestone. Loc. Ts 9–1 (D936).

Figured specimen: A715.

Genus AETHESOLITHON Johnson, n. gen.
(Aethes—strange, unusual; lithon—stone)

Description.—Plants crustose, branching. Tissue irregular, with irregular layers or lenses of cells. Cells rounded to polygonal, frequently large. Branching forms show well-developed medullary hypothallus of large polygonal cells and marginal perithallus of irregular layers of rounded to polygonal cells. Conceptacles small and highly arched. Detailed measurements are given in table 11.

Remarks.—This genus is very different from any Cenozoic coralline algae known to the writer. Large polygonal cells are common in Paleozoic algae but are seldom found in Cenozoic ones. Only one other Cenozoic genus of coralline algae has large polygonal cells, *Subterraniphyllum* Eliott, 1957, which is a member of the articulate coralline algae (Corallinoideae), not the crustose coralline algae (Melobesioideae), and has an entirely different tissue structure.

Maslov's (1956, p. 107) genus *Mesolithon* Maslov, 1955, from the Late Cretaceous also has polygonal cells. This genus is characterized by having the tissue differentiated into three zones: the hypothallus, mesothallus, and perithallus. The mesothallus contains polygonal cells of varying size, showing a lack of any orderly arrangement. This is quite distinctive but very different from the tissue of *Aethesolithon,* in which the cells are arranged in definite layers of rows in the individual lenticular growth zones of the crustose forms and in very regular layers in the branches.

Two species have been recognized in the Guam collections, one from the lower Miocene and one from the upper Miocene.

Occurrence: Lower Miocene, Bonya Limestone; and upper Miocene, Alifan Limestone.

Type species: Aethesolithon problematicum Johnson, n. sp.

TABLE 11.—*Detailed measurements, in microns, of species of* Aethesolithon *from Guam*

[From random section]

Locality	Hypothallus cells		Perithallus cells		Conceptacles		Growth form
	Length	Width	Length	Width	Diameter	Height	
Aethesolithon problematicum							
Fi 3–2(1)			16–32	16–23	140–180	100–113	Crustose.
Fi 3–4			17–34	16–25			Do.
Fi 3–4	52–73	19–37					Branch.
Fi 3–4(3)	41–89	32–40	18–45	18–32			Do.
Fi 5–1	45–74	24–36	17–48	15–31			Do.
Gi 4–1	32–60	15–33	(1)	(1)			Do.
Ih 5–6			17–48	10–32			Mammillated crust.
Jj 3–1(2)			19–27	14–20	170–180		Crustose.
Jj 5–1			17–58	16–25			Mammillated crust.
Aethesolithon grandis							
Eh 3–3	26–110	26–57	11–26	9–27			Branch.
Ts 16–1			39–43	21–29	230	145–155	Crustose.
Ts 16–1			25–65	20–32	175–225	125–150	Mammillated crust.
Ts 16–1			22–68	22–31	175–250	125–175	Crustose.
Ts 16–4	[2] 15–23	[2] 12–26	19–27	13–18	210–240		Thin crust.
Ts 16–5	27–130	54–77	25–41	23–37			Branch.

[1] Perithallus cells worn off.
[2] Single layer of cells.

Aethesolithon problematicum Johnson n. sp.

Plate 9, figures 1–3

Description.—Plant starts as irregular crust with warty protuberances or small mammillae, then develops definite branches.

Crusts appear to start with single layer of horizontally elongated and slightly oblique basal cells; unfortunately the few specimens showing this were so recrystallized that details are not clear and cell measurements uncertain. Rest of crust formed of very irregular layers or lenticular masses of polygonal cells with great range in size, 10μ–70μ in height by 8μ–40μ in diameter. Commonly, these lenses or irregular zones are about

100μ thick and composed of three layers of cells. In general, lower layer of large cells, next layer of cells somewhat smaller, and layer above still smaller.

Branches attain lengths of more than 6 mm with diameters of 2.5–3.0 mm; show well-defined medullary hypothallus and marginal perithallus. Thickness of medullary hypothallus 1,200μ–1,300μ; strongly arched layers arranged in definite growth zones which in some specimens appear almost like thick lenses, each zone 3–5 (commonly 4) layers of large polygonal cells. In long section cells appear as vertically elongated hexagons; cells alternate in position in successive rows so that the point of one cell fits between the points of those above and below (pl. 9, fig. 4). Lowest layer contains largest cells, uppermost the smallest; thus, in one lens length of cells in four rows measured as follows: lowest layer 89μ–95μ, second layer 80μ–85μ, third layer 45μ–57μ, fourth and top layer 41μ–45μ with widths 30μ–42μ. In another lens (with five layers) maximum lengths were 68μ, 53μ, 40μ, 39μ, and 36μ. In another specimen, three-layered zone showed lengths of 82μ, 65μ, and 50μ. In a given layer, cells also decrease in size from center to margins.

Marginal perithallus of branches formed of very irregular layers, commonly 2 or 3 layers to a growth zone. Cells rounded to polygonal, 20μ–35μ high, rarely as much as 50μ high. Conceptacles develop in outer layers of crusts and in perithallic tissue of branches, small and highly arched, 140μ–200μ in diameter and 100μ–140μ high. Several specimens showed traces of enclosed sporangia. No specimen was observed which clearly showed aperture in roof for escape of spores, but small size and highly arched roof suggests probability of single opening.

Remarks.—This species is common in the Bonya Limestone. The form described as *Lithothamnium heterothallum* by Johnson and Ferris from the Miocene of Lau, Fiji, should be included in this genus and quite probably to this species.

Occurrence: Lower Miocene, Bonya Limestone. Locs. Fi 3–2 (D895), Fi 3–4 (D896), Fi 5–1 (D898), Gi 4–1, Jj 3–1, Jj 5–1, and Ih 5–6.

Figured specimens: Holotype A754. Also figured: A762, and A763.

Aethesolithon grandis Johnson n. sp.

Plate 9, figures 4, 5; plate 10, figures 7, 8

Description.—Plant forms irregular crust that may become mammillated or develop branches. In crusts and mammillae tissue is irregular, containing lenticular growth zones with 3–5 layers of rounded or polygonal cells 21μ–70μ by 21μ–29μ. Branches have well-developed medullary hypothallus surrounded by marginal perithallus. Hypothallus diameters as great as 3 mm; pronounced growth zones containing 6–8 (commonly 8) layers of large polygonal cells, as large as 27μ–130μ high by 21μ–77μ wide in center of layers, commonly largest cells are in center of second or third layer from bottom of zone and become smaller toward top and margins. Perithallus moderately regular zones, each containing 2–4 layers of rounded to polygonal cells 17μ–27μ by 9μ–29μ wide.

Conceptacles develop in outer layers of the crusts, mammillae, and branches; relatively small and highly arched, 175μ–250μ in diameter and 125μ–175μ high.

Remarks.—*A. grandis* resembles *A. problematicum* in general appearance and growth habit. It differs by having larger cells, longer and thicker branches, and larger conceptacles.

Occurrence: Upper Miocene, Alifan Limestone. Locs. Eh 3–3 (D892), Ts 16–1 (D937), Ts 16–4, and Ts 16–5 (D940).

Figured specimens: Holotype A764. Also figured: A767, A765, and A766.

Genus LITHOPORELLA Foslie, 1909

The genus *Lithoporella* is characterized by having thalli that form very thin crusts generally less than 100μ thick which grow attached to other calcareous algae, corals, Foraminifera, bryozoa, or other organisms. On some specimens numerous thalli grow superimposed and form thick crusts or nodular masses. Also, similar masses have been observed that were formed by interstratified thalli of *Lithoporella* with incrusting Foraminifera or, rarely, bryozoa. The conceptacles are similar to those of *Lithophyllum*.

Each thallus of *Lithoporella* is formed by a single layer of long cells, except around the conceptacles where they thicken and several layers of smaller cells may be present. The cells are elongated vertically and commonly slightly oblique. Most fossil specimens observed in thin sections are infertile; hence, the only feature available for use in classification is the size of the cells. Unfortunately, there is commonly a great range in cell length even in a single specimen. When conceptacles are present, these also show a considerable range in size. This can readily be seen in the resume of the characteristics of the principal Recent species listed as follows.

Lithoporella melobesioides Foslie, cells 25μ–85μ by 15μ–30μ. Conceptacles 600μ–1,000μ.
atlantica Foslie, cells 32μ–60μ by 18μ–40μ. Conceptacles 500μ–800μ.
conjuncta Foslie, cells 36μ–55μ by 14μ–30μ. Conceptacles 400μ–800μ.

It will be noted that each of these species shows great variation and they overlap one another so much that they could easily be considered as representing one quite variable species.

The same is true in most of the observed fossil species. Most fossil *Lithoporella*, in appearance and in dimensions of cells and conceptacles, easily fall within the range of *Lithoporella melobesioides* Foslie. Therefore, it seems only logical to attribute them to that one highly variable species which has a time range extending from the Eocene to Recent.

Lithoporella melobesioides (Foslie) Foslie

Mastophora (*Lithoporella*) *melobesioides* Foslie. Weber van Bosse and Foslie, 1904, *Siboga*-Expeditie Mon. 61, p. 73–77, figs. 30–32.

Melobesia (*Lithoporella*) *melobesioides* Foslie. Lemoine, 1939, Mat. Carte géol. de l'Algerie, ser. 1, Paléont., no. 9, p. 108–110, figs. 78, 79.

Lithoporella melobesioides (Foslie) Foslie. Lignac-Grutterink, 1943, Geol.-mijnb. genootsch. Nederland en Kolonien Verh., Geol. ser., v. 113, p. 292–293, pl. 2, fig. 8.

Lithoporella (*Melobesia*) *melobesioides* (Foslie) Foslie. Johnson and Ferris, 1949, Jour. Paleontology, v. 23, no. 2, p. 196–197, pl. 37, figs. 4–5; pl. 39, fig. 2.

Lithoporella melobesioides (Foslie) Foslie. Johnson and Ferris, 1950, B. P. Bishop Mus. Bull. 201, p. 18, pl. 8, fig. A.
Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 234, pl. 37, fig. 5; pl. 43, fig. 1–2; pl. 49, fig. 4; pl. 56, fig. 6.

Description.—Thallus single layer of large vertically elongated cells, except in vicinity of conceptacles where several layers of smaller cells may develop. Cells rectangular, commonly with rounded corners. Conceptacles with single large aperture.

The following tables give dimensions of 44 representative specimens from the various limestones of Guam.

Measurements, in microns, of Lithoporella melobesioides
[From random sections. Cleared entries indicate absence of conceptacles]

Locality	Cell dimensions		Conceptacles	
	Height	Width	Diameter	Height
EOCENE SPECIMENS				
Fk 4-8	42-53	16-24	276	131
Fk 4-11	26-29	10-19	257	147
Fk 4-11	49-75	10-17		
Fk 4-11	26-53	10-18	227	150
Fk 4-2	33-39	12-20		
Fk 4-3	45-59	12-31		
Fk 4-7	37-57	20-27		
Fk 4-11	28-58	18-27	550	200
MIOCENE SPECIMENS				
Maemong Limestone Member of Umatac Formation				
Fi 6-1	35-51	15-26		
Fi 6-4	40-66	10-17		
Fi 6-6	59-77	29-59		
Fi 6-6	61-96	16-30		
Fj 2-5	58-63	18-26		
Fj 2-5	51-60	19-27	280	188
Fj 2-5	56-65	14-16		
Hi 5-3	28-40	13-17		
Hi 12-3	55-69	30-34		
Ii 6-9	37-57	20-28		
Ii 6-16	39-48	18-27	350	150
Ii 6-17	44-59	16-25		
Ii 6-18	90-97	23-28		
Ii 6-18	61-63	19-21		
Ii 6-18	73-89	15-23		
Ii 6-18	48-63	28-35	309	216
Ii 6-32	34-56	18-21		
Ii 6-33	41-43	18-23		
Ii 6-33	44-56	23-29		
Ii 6-33	50-59	18-20		
Ii 6-34	37-55	11-17		
Ii 6-37	38-49	51-70		
Ii 6-37	31-54	11-26		
Ii 6-38	41-47	16-21		

Measurements, in microns, of Lithoporella melobesioides—Con.

Locality	Cell dimensions		Conceptacles	
	Height	Width	Diameter	Height
MIOCENE SPECIMENS—Continued				
Bonya Limestone				
Fi 3-2(2)	29-60	9-19		
Gj 7-2(2)	39-66	12-20	616-660	220-264
Alifan Limestone				
Eh 3-8	20-33	11-15	286	105
Hn 7-3	49-57	12-18		
Ts 9-1(1)	33-50	8-11	250-343	77-82
Ts 9-1(2)	36-70	9-15		
Ts 16-1	18-35	8-14		
Ts 16-6	33-53	14-28		
Barrigada Limestone				
Oq 1-1	22-28	9-18		
Ov 7-2(2)	25-45	11-18		
PLIOCENE AND PLEISTOCENE SPECIMENS				
Mariana Limestone				
GMH 7	17-31	9-13	119-120	105-106
GMH 11	26-40	10-17		
Hn 7-3(2)	53-61	13-16		

Remarks.—It is quite possible that several true species may be grouped together in this assemblage, but at present it is not possible to separate them.

The Pliocene and Pleistocene specimens have an appreciably smaller average cell size but form an overlapping series with the Miocene specimens (pl. 4, fig. 4).

Occurrence: Eocene to Recent. Localities are given in the tables.

Lithoporella sp. A

Plate 10, figure 2

Description.—A typical *Lithoporella* consisting of a single layer of vertically elongated cells; a fragment of a young and infertile thallus. Cells are unusually long, 104μ–128μ by 36μ–46μ.

Remarks.—This form has the largest cells observed in any Tertiary specimen. The material available, however, is inadequate to justify giving it a specific name.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Loc. Gj 4-4 (D908).
Figured specimen: A768.

Genus DERMATOLITHON Foslie, 1899

In this genus the plants develop very thin crusts, circular or irregular in outline, that grow on other algae, coral, shell, or almost any hard object. Thalli may grow superimposed. The hypothallus consists of a single layer of vertically and obliquely elongated cells. The perithallus is built of a few layers of nearly cubic cells. Conceptacles are slightly to strongly convex, with a single large aperture.

The genus has a geologic range extending from Eocene to Recent.

Dermatolithon nitida Johnson

Dermatolithon nitida Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 235, pl. 57, figs. 2–3.

Description.—Thallus thin, encrusting, several may grow superimposed. Hypothallus single layer of vertically elongated cells 48μ–70μ by 12μ–21μ. Perithallus few layers of nearly cubic cells 14μ–30μ by 13μ–24μ. No conceptacles observed.

Remarks.—In general appearance and cell dimensions the Guam specimens agree with the material described as *D. nitida* from beds of the same age on Saipan.

Occurrence: Upper Eocene, Alutom Formation. Loc. Fk 4–3.

Dermatolithon guamensis Johnson n. sp.

Plate 10, figures 4, 5

Description.—Thallus a very thin crust. Hypothallus a single layer of obliquely elongated and slightly curved cells 18μ–36μ by 11μ–18μ. Perithallus 3–5, commonly 4, layers of cells 18μ–21μ by 11μ–17μ. A conceptacle chamber present on one specimen measured 330μ in diameter and 237μ high. Inasmuch as section showed single large central aperture, it probably showed approximately full diameter.

Remarks.—Represented by two specimens, one a basal section and the other approximately longitudinal. The species differs appreciably in cell size and dimensions of conceptacles from any hitherto described Miocene species.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Locs. Ii 6–28 (D922) and Ii 6–36 (D926).
Figured specimens: Holotype A711. Also figured: A700.

Dermatolithon sp. A

Plate 10, figure 1

Description.—Thallus a very thin irregular crust. Hypothallus a single layer of vertically and slightly obliquely elongated cells 30μ–50μ by 14μ–19μ. Perithallus two or three layers of nearly cubic cells 24μ–28μ by 22μ–27μ. Conceptacles unknown.

Remarks.—This species is close to *D. saipanense* Johnson from the Miocene of Saipan but differs by having smaller and narrower hypothallic cells and slightly smaller perithallic cells.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Loc. Fj 2–5 (D901).
Figured specimen: A703.

Dermatolithon sp. B

Plate 10, figure 3

Description.—Thallus thin irregular crust. Hypothallus single layer of elongated cells 40μ–54μ by 13μ–16μ Perithallus 3–6 layers of nearly cubic cells 19μ–23μ by 4μ–21μ. No conceptacles present.

Remarks.—Represented by a single specimen in the collection studied.

Occurrence: Upper Miocene, Alifan limestone. Loc. Hn 7–3 (D917).
Figured specimen: A704.

Genus MELOBESIA Lamouroux, 1812

The plant consists of a small thin crust, circular or irregular in outline. The thallus consists normally of a single layer of cubic or horizontally elongated cells, except in the vicinity of conceptacles. Conceptacles have several to many apertures in roof for the escape of spores.

The genus has a geologic range extending from Eocene to Recent and is represented in the Guam collections by a single Miocene specimen.

Melobesia guamensis Johnson n. sp.

Plate 10, figure 6

Description.—Thallus a single layer of horizontally elongated cells 9μ–11μ by 12μ–16μ. No conceptacles present.

Remarks.—This is the first Miocene species of this genus to be described from the Pacific area. It is characterized by the small-sized horizontally elongated cells.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Loc. Ii 6–32 (D923).
Figured specimen: Holotype A722.

Subfamily CORALLINOIDEAE (articulate coralline algae)

The Guam limestones contain abundant fragments of the articulate coralline algae. In a few places these algae are so abundant as to be important contributors to the rock. In most places, however, they are distinctly subordinate to the crustose coralline algae. Their study has presented many problems. The principal difficulty is that the classification of Recent forms is based largely on the shape of the plant and on the position and nature of the conceptacles, whereas the fossils consist almost entirely of fragments, generally separate segments of the plants. On a few specimens several such segments joined together may be found but never enough to give much idea of the size and shape of the entire plant. In a study of more than 5,000 thin sections of limestone from the Pacific, which contained many thousands of fragments of articulate coralline algae, the author has only seen 15 or 20 specimens that contained conceptacles. Consequently, the only common data that may be obtained from the fossils for use in identifying species are the segments, their size, shape, and character of tissue, plus the cell dimensions of the medullary hypothallus and of the marginal cells.

Most descriptions of Recent species give the size and shape of the plants and the dimensions of some of the segments, but very few give the size of the cells, except in the nodes. Also, most Recent genera and species show a considerable range in size and even in the shape of the segments. The shape may vary considerably according to the position of the particular segment in the plant.

The key to genera given below attempts to emphasize as many of the features that are found in fossils as possible, but it will be noted that great emphasis is placed upon the conceptacles and the nodes, features which are seldom preserved in the fossils. This key is based largely on the work of Manza and Yendo.

Relatively few species of articulate coralline algae have been described as fossils. However, it is difficult to compare material with most of these as some of the descriptions are altogether too brief, whereas others have been based on single segments and are quite useless.

Fourteen species belonging to five genera have been recognized from the Guam limestones.

Key to the important genera of the articulate Coralline algae
[J. Harlan Johnson, 1956]

I. a. Segments consist of several or many tiers of cells _ II
   b. Segments consist of a single tier of long cells _ _ _ *Lithotrix*

II. a. Each tier composed of regular cells with straight walls _ _ _ III
   b. Tiers composed of irregular, sinuous, and interlacing cells. (Conceptacles lateral. Nodes formed of a single tier of cells) _ _ _ [1] *Calliarthron*

III. a. Boundaries between tiers of cells essentially regular _ _ _ IV
   b. Boundaries between tiers of cells irregular, commonly more or less stepped. Cells commonly wedge shaped. Segments small, slender, cylindrical. Conceptacles terminal _ _ _ [1] *Jania*

IV. a. Tiers of cells of principally the same length _ _ _ V
   b. Commonly tiers of long and short cells variously alternating. Segments show considerable variation in size and some variation in shape. Commonly they are cylindrical or flattened cylindrical. Nodes rather inconspicuous, of one or several tiers of cells. Conceptacles lateral [1] *Amphiroa*

V. a. Tiers of cells gently but evenly arched _ _ _ VI
   b. Tiers of cells flattened in central area, curving downward sometimes abruptly, toward the margins. Nodes of a single tier of cells, Branching regular, pinnate. Conceptacles are terminal _ _ _ [1] *Arthrocardia*

VI. a. Segments not of same shape in different areas of the same plant _ _ _ VII
   b. Segments cylindrical or flattened cylindrical. In section commonly wider at top than at base. Nodes conspicuous with a single tier of very long cells. Branching commonly in a plane, pinnate. Conceptacles terminal _ _ _ [1] *Corallina*

[1] *Calliarthron, Jania, Amphiroa, Arthrocardia,* and *Corallina* are the only genera so far known to be represented by fossils.

Key to the important genera of the articulate Coralline algae—Continued

VII. Segments commonly clavate, but may be oval, rounded, flattened, or polygonal in section.
   1. Bifurcating branching. Conceptacles on margins of upper lobes of segments _ _ _ *Cheilosporum*
   2. Segments commonly cylindrical or nearly so near base of the frond, becoming trapezoidal above. Branching pinnate. Conceptacles at the end of the lateral branches _ _ _ *Joculator*
   3. Segments cylindrical or compressed cylindrical below, becoming flattened above with oval cross section. Branching dichotomous or alternating. Nodes consist of a single zone of cells. Conceptacles lateral _ _ _ *Bossea*

Genus CALLIARTHRON Manza, 1937

This genus suggests *Corallina* but differs in that the cells of the medullary hypothallus instead of being straight are flexuous and interlacing. Segments are commonly rather short as compared to the width. Nodes conspicuous, of a single tier of very long cells. Conceptacles develop along the sides of the segments.

The genus is known from the Miocene to the Recent.

Calliarthron antiquum Johnson

Calliarthron antiquum Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 237, pl. 52, figs. 1, 9.

Description.—Segments 217μ–440μ long by 440μ–705μ wide; contain 5–8 tiers of cells. Hypothallic cells near center measure 51μ–73μ by 8μ–16μ. Nodes large, 22μ–270μ high by 315μ–417μ wide, cells 220μ–260μ long. Marginal cells abraded. No conceptacles present.

Remarks.—A number of fragments were observed in the Guam collection, including several which contained 2 and 4 connected segments. They are identical with the species described from Saipan.

Occurrence. Lower Miocene, Maemong Limestone Member of Umatac Formation. Loc. Fi 6–4.

Genus AMPHIROA Lamouroux, 1812

The plants develop as clusters of segmented fronds that branch dichotomously or trichotomously at regular intervals. The segments are cylindrical to flattened or may develop a relatively thick center and thinner margin. The segments consist of a well-developed medullary hypothallus and a marginal perithallus. In Recent and most fossil species, the medullary hypothallus is built up of arched layers of cells that show rhythmic alternations of layers of long cells and layers of short cells. In a given species this seems to follow a quite definite formula. In some of the very ancient species from the Upper Cretaceous and Eocene, the formula is less definite. The alternation of layers of long cells and layers of short cells is expressed as a formula L–S. For example, 3L–1S means 3 layers of long cells are followed by 1 layer of short cells. In the tables merely the numbers are shown, 3L–1S is shown as 3–1. Variable alternations are shown by a sequence, for example, 3L–1S, 4L–1S, 5L–1S.

Some species contain very long cells. In fact, the longest cells found in any of the coralline algae occur in the genus *Amphiroa*. Normally the marginal perithallus is moderately to well developed, although in a few species it is reduced to one or two layers of cells. The conceptacles are lateral.

The genus has a geologic range extending from the Cretaceous to the present. It is abundantly represented by a number of species in the seas today. Some of these are very widespread.

Seven species were recognized in the limestone from Guam.

Amphiroa anchiverricosa Johnson and Ferris

Plate 11, figures 9, 10

Amphiroa anchiverricosa Johnson and Ferris, 1950, B. P. Bishop Mus. Bull. 201, p. 19, pl. 5, fig. D; pl. 7, fig. C.
Ishijima, 1954, p. 61–62, pl. 39, figs. 2, 3.

Description.—Segment lengths more than 3.3 mm, widths ranging 1.0–1.37 mm; wide medullary hypothallus, well-developed marginal perithallus. Hypothallus of gently arched layers of cells, formula 1L–1S; long cells 42μ–104μ by 8μ–13μ, short cells 22μ–55μ by 6μ–15μ. Marginal perithallus 117μ–220μ thick with cells 10μ–26μ by 8μ–15μ. Conceptacles unknown.

Detailed measurements, in microns, of Amphiroa anchiverricosa *Johnson and Ferris*

[From random sections]

Locality	Formula L–S	Long Cells		Short Cells		Marginal Cells		Hypothallus	Perithallus
		Length	Width	Length	Width	Length	Width	Diameter	Thickness
Gi 2–7	1–1	78–104	9–11	27–33	9–15	----------	----------	1, 056	----------
Gi 4–1	1–1	49–61	10–12	39–50	8–10	12–25	8–10	1, 077	220
Gj 7–2	1–1	48–84	8–11	22–41	6–11	14–26	8–11	1, 276	210
Ih 5–6	1–1	42–50	9–13	22–27	9–11	10–14	9–12	1, 000	----------
Ih 5–6	1–1	72–90	8–9	32–55	8–10	10–16	8–15	1, 060	117
Range	----------	42–104	8–13	22–55	6–15	10–26	8–15	----------	----------

Remarks.—This distinctive form is the same as that described as *A. anchiverricosa* by Johnson and Ferris from the Miocene of Lau, Fiji. It is moderately abundant in the Bonya Limestone of Guam.

Occurrence: Lower Miocene, Bonya Limestone. Locs. Gi 2–7 (D905), Gi 4–1, Gj 7–2 (D909), and Ih 5–6.
Figured specimens: A742 and A713.

Amphiroa prefragilissima Lemoine

Plate 11, figures 2, 3, 5, 11

Amphiroa prefragilissima Lemoine, 1917, Soc. géol. France Bull., ser. 4, v. 17, p. 275–277, fig. 23.

Description.—Highly variable species, segments attain lengths of several millimeters, diameters 136μ–698μ, (commonly 400μ–500μ). Medullary hypothallus shows variable formula (both in different segments and a single long segment), some 3L–1S; some 4L–1S; some 4L–1S, 5L–1S; one 2L–1S, 3L–1S, 4L–1S, 5L–1S, 6L–1S, 7L–1S; another 5L–1S, 7L–1S; and one 7L–1S, 8L–1S, 7L–1S; most 4L–1S. Cells also show great size range; long cells 32μ–108μ by 8μ–16μ, short cells 11μ–41μ by 9μ–15μ. Marginal perithallus commonly present, 1–8 layers of cells, commonly 3 or 4; cells 13–23(38)μ by 7μ–15μ. Conceptacles suggested on one specimen (pl. 11, fig. 11), marginal with diameters 300μ–325μ.

Detailed measurements, in microns, of Amphiroa prefragilissima *Lemoine*

[From random sections]

Locality	Formula L–S	Long cells		Short cells		Marginal cells		Segment diameter	Conceptacle diameter
		Length	Width	Length	Width	Length	Width		
Eh 3–3	7–1, 8–1, 7–1	73–95	7–11	32–38	9–13	13–18	--------	435	----------
Eh 3–3	2–1, 3–1, 4–1, 5–1, 6–1.	48–84	8–12	11–41	9–13	(1)	--------	215	----------
Eh 3–8	4–1	65–90	9–10	25–54	9–11	(2)	--------	250	----------
Eh 3–8	5–1, 3–1, 5–1	68–81	12–14	16–30	10–13	15–25	12–15	350–450	285–347
Ts 9–1	4–1	54–102	9–11	23–31	9–16	15–25	7–9	600–650	----------
Ts 9–1	4–1	58–108	11–14	23–28	12–15	12–15	7–10	800	----------
Ts 16–1	5–1, 7–1	52–88	9–16	17–25	11–14	12–23	8–11	453	----------
Ts 16–6	4–1, 5–1, 4–1	90–110	10–15	23–28	11–16	--------	--------	502	----------
Ts 16–9	5–1	34–80	10–15	16–23	10–15	13–23	7–11	675	----------
Ts 16–9	3–1, 4–1	50–78	9–12	14–21	8–13	23–38	7–13	700	----------
Ts 16–11	4–1, 4–1, 5–1	32–78	10–13	15–26	8–13	14–21	7–11	700	----------

[1] Marginal cells absent. [2] Marginal cells worn off.

Remarks.—This species fits Lemoine's species from the upper Tertiary of Martinique and closely resembles the highly variable Recent species *A. fragilissima* (Linnaeus) Lamouroux.

Occurrence: Upper Miocene, Alifan Limestone. Locs. Eh 3-3 (D892), Eh 3-8 (D893), Ts 9-1, Ts 16-1 (D937), Ts 16-6, Ts 16-9 (D942), and Ts 16-11.
Figured specimens: A747, A767, A760, and A761.

Amphiroa cf. A. regularis Johnson and Ferris

Plate 11, figure 1

Amphiroa regularis Johnson and Ferris, 1950, B. P. Bishop Mus. Bull. 201, p. 20, pl. 5, fig. E; pl. 8, fig. E.

Description.—Segments 1,700μ–1,950μ long. Medullary hypothallus formula 3L–1S, 3L–1S, 2L–1S, 3L–1S, with long cells 43μ–87μ by 10μ–15μ, short cells 16μ–35μ by 9μ–13μ with 27 cells to the row. Marginal perithallus 2 or 3 rows of cells 18μ–26μ by 8μ–13μ. No conceptacles present.

Remarks.—This form resembles *A. regularis* in formula and cell dimensions. It differs in the structure of the marginal perithallus which is composed of a single layer of marginal cells in *A. regularis* but contains several layers of cells in the Guam specimens.

Occurrence: Upper Miocene, Alifan Limestone. Loc. Tt 7-4 (D944).
Figured specimen: A769.

Amphiroa tan-i Ishijima

Plate 11, figures 6, 12

Amphiroa tan-i Ishijima, 1954, p. 55–56, pl. 41, figs. 1–3.

Description.—Segments slender, lengths more than 1.6 mm, diameters 200μ–250μ; medullary hypothallus surrounded by single layer of marginal cells; layers of cells have formula 5L–1S, 4L–1S; layers commonly flattened on top, then arching sharply at edges. Long cells 45μ–86μ by 9μ–13μ, short cells 17μ–40μ by 9μ–19μ. Marginal cells 14μ–25μ by 8μ–18μ. Conceptacles unknown.

Detailed measurements, in microns, of Amphiroa Tan-i *Ishijima*

[From random sections]

Locality	Formula L–S	Long cells		Short cells		Marginal cells		Hypothallus diameter	Segment diameter
		Length	Width	Length	Width	Length	Width		
Ih 14–1	5–1	45–77	8–13	17–26	9–13			220–242	225–250
Ih 14–2	3–1, 5–1	65–81	9–13	24–35	10–19	18–25	8–13	211	239
Ih 14–2	5–1	72–86		27–40		14–16	14–18	250±	
Ih 5–6	4–1, 3–1	65–77	9–16	21–41	9–15			230	235

Remarks.—This appears to represent the same species as described by Ishijima from the Miocene of Formosa. Isijima's material appears to have been badly abraded, whereas the Guam fragments are broken but have suffered little wear and consequently show details absent on the type material. However, the most characteristic features—slender rather flexuous segments, virtual absense of a marginal perithallis, and flat tops of the medullary cell layers—are the same. The cell dimensions are of the same magnitude, although slightly wider in the Guam specimens. The Formosa specimens have a formula of 3L–1S, 5L–1S, whereas most of the Guam specimens have 5L–1S.

Occurrence: Lower Miocene, Bonya Limestone. Locs. Ih 14–1 (D930), Ih 14–2 (D931), and Ih 5–6
Figured specimens: A730 and A770.

Amphiroa cf. A. verricosa Kützing

Plate 11, figure 7

Amphiroa verricosa Kützing, 1845–71, Tab. Phye, v. 8, p. 25, pl. 51.
Pfender, 1924, Soc. géol. France Bull., ser. 4, v. 24, p. 194, pls. 8–9.
Ishijima, 1954, p. 62, pl. 37, figs. 12–16.

Description.—Fragments of long relatively wide segments, formula 1L–1S (in a few 2L–1S). Segments 550μ–650μ wide. Long cells 64μ–108μ by 9μ–15μ, short cells 21μ–42μ by 9μ–15μ. No marginal cells present. Conceptacles unknown.

Remarks.—Represented by small worn fragments in the Guam collection. In appearance, formula, and cell dimensions, this form closely resembles the Recent *A. verricosa* Kützing. Similar material attributed to the same species has been described by Ishijima (1954, p. 62) from the Pliocene of Formosa.

Occurrence: Upper Miocene, Barrigada Limestone. Loc. Ov 7-2 (D933).
Figured specimen: A771.

Amphiroa sp. C

Plate 12, figure 5

Description.—Segments 1.1–1.6 mm long, composed entirely of a medullary hypothallus consisting of alternate layers of long and short cells. Long cells 63μ–70μ by 27μ–33μ, short cells 27μ–33μ by 11μ–14μ. Cell walls unusually thick and prominent; in section about 28 cells form layer. No marginal cells or conceptacles present.

Remarks.—In cell lengths and formula (1L–1S) this resembles *A. anchiverricosa* Johnson and Ferris described from the upper Miocene of Fiji and by Ishijima from the Pleistocene of Formosa, but it differs from them by having much wider cells (2 to 3 times as wide) and by having much thicker and more conspicuous cell walls.

Represented by only a few worn fragments in the Guam collection which are inadequate to name the species.

Occurrence: Pleistocene, fore-reef facies of the Mariana Limestone. Loc. Ji 1–1 (D932).
Figured specimen: A773.

Amphiroa sp. D

Plate 11, figure 8

Amphiroa regularis Johnson and Ferris, 1950, B. P. Bishop Mus. Bull. 201, p. 20, pl. 5, fig. E; pl. 8, fig. E.

Description.—Fragments of segments having a formula of 2L–1S or 3L–1S; segments 187μ–357μ wide; long cells 34μ–60μ by 8μ–14μ, short cells 9μ–22μ by 8μ–12μ. Cortical layer badly abraded or absent. No conceptacles observed.

Remarks.—Represented in the Guam collections by a number of small fragments. These strongly suggest but are not identical with the material described as *A. regularis* by Johnson and Ferris from the upper Miocene of Lau, Fiji, which had somewhat larger cells and had a 2L–1S formula more commonly than a 3L–1S.

Occurrence: Upper Miocene, Barrigada Limestone. Locs. Oq 1–1 and Rx 8–2 (D935).
Figured specimen: A774.

Genus CORALLINA Linnaeus, 1758

Plants small, bushy, composed of segmented stems that branch frequently (normally in a plane); branching pinnate. Segments cylindrical or flattened, commonly wider at top than at base. Nodes conspicuous, consisting of a single tier of very long cells. Segments consist mainly of medullary hypothallus surrounded by a thin layer of perithallic tissue.

The genus has a geologic range extending from the Late Cretaceous to the present time. Fossil *Corallina* was observed in most of the Guam limestones and was locally abundant.

Corallina matansa Johnson

Corallina matansa Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 238–239, pl. 44, figs. 3, 4.

Description.—Segments flattened, moderately wide, mainly hypothallic tissue. Cells in center of hypothallic layers 52μ–66μ by 7μ–11μ. Perithallic cells 10μ–22μ by 7μ–11μ; 20–28 tiers of cells to a segment. Size of node 125μ by 110μ.

Detailed measurements, in microns, of Corallina matansa *Johnson*

[From random sections. Cleared entries indicate absence of nodes]

Locality	Segment size		Hypothallus cells		Perithallus cells		Tiers of cells in a segment	Node size	
	Length	Width	Length	Width	Length	Width		Length	Width
Fk 4–3	1, 465	418	60–66	7–11	--------	--------	26		
Fk 4–3	1, 700	200	52–60	10–11	10–22	7–11	28	125	110
Fk 4–4	1, 672	352	62	8–10	--------	--------	28		
Fk 4–8	1, 350	350	60–62	9–10	--------	--------	20		

Remarks.—These are identical with the material described from Saipan.

Occurrence: Upper Eocene, Alutom Formation. Locs. Fk 4–3, Fk 4–4, and Fk 4–8.

Corallina prisca Johnson

Corallina prisca Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 239–240, pl. 37, fig. 4; pl. 40, fig. 10; pl. 44, figs. 1–2, 7–11.

Description.—Segments slender, nearly cylindrical, commonly slightly flattened, largely medullary hypothallus surrounded by a layer or two of perithallic cells. Cells near center of hypothallic tiers 65μ–101μ by 7μ–12μ.

Remarks.—The specimens from Guam appear to be identical with those described from Saipan.

Occurrence: Upper Eocene, Alutom Formation. Locs. Fk 4–3, Fk 4–8, and Fk 4–11.

Detailed measurements, in microns, of Corallina prisca *Johnson*

[From random sections. Cleared entries indicate absence of nodes]

Locality	Segment size		Hypothallus cells		Tiers of cells in a segment	Node size	
	Length	Width	Length	Width		Length	Width
Fk 4–3	752	176	65–91	9–11	11		
Fk 4–3	2, 600	350	80–90	9–11	30	150	200
Fk 4–8	546	211	41–101	7–11	8		
Fk 4–11	1, 500	450	67–70	9–12			

Corallina neuschelorum Johnson

Corallina neuschelorum Johnson, 1957, U.S. Geol. Survey Prof. Paper 280-E, p. 239, pl. 37, fig. 3; pl. 50, figs. 1–4.

Description.—Segments normally flattened clavate, consisting mainly of hypothallic tissue. Cells in center of tiers 47μ–107μ long by 6μ–20μ wide (commonly 8μ–10μ). Perithallus slightly developed, normally single layer of marginal cells 10μ–26μ by 7μ–12μ. Conceptacles present on three specimens, two marginal and one terminal; marginal conceptacle diameters 71μ–150μ and heights 27μ–71μ.

Detailed measurements, in microns, of 17 specimens of Corallina neuschelorum *Johnson*

[From random sections. Cleared entries indicate absence of nodes]

Locality	Segment size		Node size		Hypothallus cells		Perithallus cells		Tiers in a segment	Approximate number of cells in section of tier
	Length	Width	Length	Width	Length	Width	Length	Width		
Fi 6-4	256–270	194–238	129–136	171–176	55–82	7–9			5	26–38
Fi 6-6	365–630	175–210	101–120		53–61	10–12	9–15	9–10	8–10	28–36
Fi 6-7	194–272	160–163	96	106	36–62	6–10			6	15–19
Fi 6-7	213-337	123–141	62–96	75–96	42–72	6–9			6–14	20–31
Fi 6-7	709	203			63–82	5–9			10	14–19
Fj 2-4	1181	596			81–99	8–10			15	55-60
Hi 5-2	611–629	426–460	168	205	51–61	8–11			11	35–50
Hi 5-3	1276	652–636	Not preserved		37–48	13–20			29	48
Hi 12-2	698	308			44–69	7–10			7	20–30
Hi 12-3	770	264		220	94–119	10–14			7	20–25
Ii 6-13	396–796	264–308	Not preserved		48–92	8–13			6–9	30–40
Ii 6-25	616	206			26–80	7–10			10	25+
Ii 6-26	1100	520			45–90	8–11	21–26	7–11	14	50–60
Ii 6-26	378	308			51–65	7–10			8	30–40
Ii 6-26	759	455			62–84	7–12			11	50
Ii 6-26	616–602	440–475	255	352	47–107	7–11	18–22	11–12	9	40–60
Ii 6-31	516–559	321–440	215	303	50–77	7–10			8–10	30–50

Remarks.—This species is abundantly represented in the Maemong Limestone Member at most localities. It is the same species originally described from Saipan. The details presented here supplement the Saipan data and in addition give a knowledge of the conceptacles of this species.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Locs. Fi 6-4, Fi 6-6, and Fi 6-7; Fj 2-4, Hi 5-2, and Hi 5-3; Hi 12-2 and Hi 12-3; Ii 6-13, Ii 6-25, Ii 6-26, and Ii 6-31.

Corallina sp. A

Plate 11, figure 4; plate 12, figure 6

Description.—Segments relatively long and slender, about 500μ–1300μ long, mainly a medullary hypothallus with cells in center of tiers 40μ–78μ long by 6μ–11μ wide. Conceptacles unknown. Detailed dimensions of the five best specimens observed are given as follows.

Detailed measurements, in microns, of Corallina *sp. A Johnson*

[From random sections. Cleared entries indicate absence of nodes]

Locality	Segment size		Node size		Hypothallus cells		Tissue of cells in a segment	Approximate number of cells in a section across a tier
	Length	Width	Height	Width	Length	Width		
Hn 7-1	854	220			51–74	8–11	13–14	26–30
Hn 7-1	924	282			57–78	7–11	16	35–40
Hn 7-2	1, 254	343			42–53	6–11	30	50
Hn 7-2	513	422	106	198	40–55		13	28
Hn 7-2	481	284			42–56		7	40

Remarks.—The specimens included in this group all have dimensions that fall within the range of those given for *C. neuschelorum*. However, the segments are commonly longer, and the cells of the medullary hypothallus are considerably shorter (range 42μ–78μ versus 47μ–107μ). With only a few specimens available for study and considering the considerable range in size of segments and cells in Recent species, it does not seem desirable to give it a specific name.

Occurrence: Upper Miocene, Alifan Limestone. Locs. Hn 7-1 (D915) and Hn 7-2 (D916).

Figured specimens: A775 and A776.

Genus ARTHROCARDIA Decaisne, 1842, emend. Areschoug, 1850

In scanning the great numbers of fragments of articulated coralline algae present in the slides of Guam limestones, a few that belong to the genus *Arthrocardia* were observed. They occurred in the Eocene and Oligocene Alutom Formation and in the lower Miocene Maemong Limestone Member of Umatac Formation. However, the material was inadequate to permit description of the species represented.

Genus JANIA Lamouroux, 1812

The plants form small bushy masses of tiny slender fronds which branch dichotomously. Each frond consists of a series of relatively long, slender segments formed of tiers of hypothallic cells surrounded by a single layer of small rectangular cells. The hypothallic cells are commonly wider in proportion to their length than in other genera of articulated corallines and tend to be wedge shaped in longitudinal sections. The junction between the tiers is seldom smooth. It frequently is very irregular. The segments are commonly longer and relatively more slender than in most articulated corallines.

Today *Jania* is represented by many species in the tropical and temperate seas. It is known from the Late Cretaceous to the Recent time.

Fragments attributed to this genus were observed in Guam limestones ranging in age from Eocene to Pleistocene, but the only material adequate for description was found in some of the Miocene limestones.

Jania vetus Johnson

Jania vetus Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 237, pl. 52, fig. 2.

Description.—Segments 1,395μ–1,585μ long by 394μ–448μ wide. Hypothallic cells 66μ–77μ by 11μ–20μ. Marginal cells 13μ–17μ by 18μ–25μ.

Remarks.—Represented by a few fragments in the Guam collection. These are identical with the specimens described from Saipan.

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Loc. Fi 6–5.

Jania guamensis Johnson n. sp.

Plate 12, figures 1–3

Description.—Segments attaining lengths of at least 3,000μ. Hypothallic cells 32μ–46μ by 10μ–22μ (commonly 36μ–40μ by 10μ–18μ). Dimensions of six typical specimens are given in the table.

Detailed measurements, in microns of Jania guamensis *Johnson n. sp.*

[From random sections. Plus sign indicates fragments of segments not showing total length]

Locality	Segment size		Hypothallus cells		Perithallus cells	
	Length	Width	Length	Width	Length	Width
Maemong Limestone Member of Umatac Formation						
Fd 4-1	1,250+	247	39–46	13–18		
Fd 4-1	968+	246	39–45	10–18		
Hi 12-3	3,080	294	31–40	14–18		
Ii 6-25	1,320+	250	32–40	9–18		
Ii 6-26	2,034+	287	36–48	14–18		
Ii 6-26	1,452	345	37–53	15–22	14–19	10–13
Bonya Limestone						
Ih 14-1	1,400+	350	27–41	16–21	14–19	13–18

Remarks.—The only other described Miocene species of *Jania* known by the author is *J. vetus* Johnson from Saipan. It differs from the present species by having much longer hypothallic cells (54μ–78μ versus 32μ–46μ).

Occurrence: Lower Miocene, Maemong Limestone Member of Umatac Formation. Locs. Fd 4–1 (D897), Hi 12–3 (D913), Ii 6–25, and Ii 6–26 (D920). And Lower Miocene, Bonya Limestone. Loc. Ih 14–1.

Figured specimens: Holotype A777. Also figured: A778 and A714b.

CHLOROPHYTA (green algae)

The Chlorophyta are represented in the Guam collections by two genera belonging to two different families, the Codiaceae and the Dasycladaceae.

Family DASYCLADACEAE

Dasycladaceae are rare in the Guam limestones. These were studied and described by Richard Rezak, U.S. Geological Survey, who contributed data for the following description.

Genus CYMOPOLIA Lamouroux, 1816

Cymopolia cf. C. pacifica Johnson

Plate 12, figures 9, 10

Cymopolia pacifica Johnson, 1957, U.S. Geol. Survey Prof. Paper 280–E, p. 240, pl. 45, figs. 1–12.

Description.—Thallus consists of series of short nearly cylindrical segments 1.39 mm long by 1.53 mm wide, containing central stem 0.4–0.6 mm thick, surrounded by regular whorls of primary branches. Diameter of primary branches 35μ–47μ, whorls spaced 93μ apart. Tufts of secondary branches inflated at ends forming cortex. Sporangia ovoid size 121μ by

173μ to 155μ by 242μ, located at apices of primary branches between secondary branches.

Remarks.—This is very close to *C. pacifica* Johnson described from Saipan. The Guam material is too scarce and fragmentary to permit exact determination.

Occurrence: Eocene Alutom formation. Loc. Fk 4-9 (D902). *Figured specimen:* A772.

Family CODIACEAE

Genus HALIMEDA Lamouroux, 1812

Plate 12, figures 4, 8

Plants belonging to this genus are composed of segmented branching stems or fronds. The segments take on a variety of shapes. They may be broad and leaflike, flattened, subcylindrical, or even subconical. The older segments become strongly calcified. Calcification starts at the outside of a plant and works inward. In very old specimens it may be complete, but in most of the specimens observed only the outer part is calcified. Consequently, the internal structure may not be shown. The classification of Recent species is based largely on the branching habit, the shape of the segments, and, particularly, on the structure of the node. The fossils normally consist of individual segments with little or no indication of the structure of the node. Therefore, in thin sections which show random cuts through the segments, it is, for all practical purposes, impossible to distinguish species. The generic structure is very distinctive and *Halimeda* segments, as such, can be recognized easily, but beyond that, little can be done with fragmentary fossil material.

The genus has a geologic range extending from the Cretaceous to the Recent. It is abundantly represented by numerous species in tropical and warm-temperate seas. Locally the plants may grow in enormous numbers and literally cover large areas of shallow sea bottom.

Halimeda fragments are recognized in the limestones of Guam, ranging in age from Eocene to Pleistocene. However, it is only in the Pleistocene rocks that they occur in such abundance as to form true *Halimeda* limestones.

Occurrence: Eocene, Alutom Formation. Loc. Fk 4-2. Lower Miocene, Maemong Limestone Member of Umatac Formation. Loc. Gj 4-1 (D907). And Pliocene and Pleistocene, Mariana Limestone. Loc. Uu 1-1 (D945).
Figured specimens: A780 and A781.

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INDEX

[Italic numbers indicate descriptions]

PLATES 1 – 15

PLATE 1

FIGURES 1–3. *Lithothamnium maemongense* Johnson n. sp. (p. G12). Lower Miocene, Maemong Limestone Member of Umatac Formation.

1. Vertical section of a very thin crust, × 100, consisting mainly of hypothallus. Loc. D924 (Ii 6–33), holotype specimen A699.
2. Vertical section, × 50, showing the hypothallus, perithallus, and two conceptacle chambers. Loc. D899 (Fi 6–7), specimen A698.
3. Vertical section showing two superimposed thalli, × 100; the upper one has a well-developed hypothallus and perithallus. Loc. D926 (Ii 6–36), specimen A700.

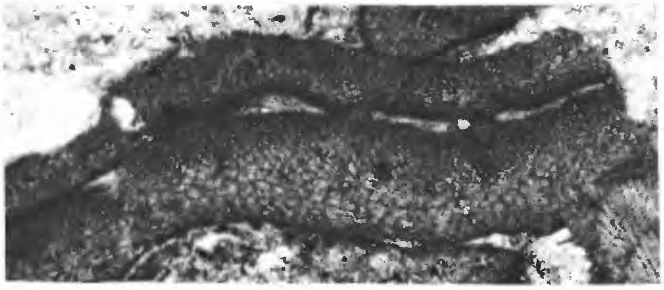
4. *Lithothamnium* cf. *L. araii* Ishijima (p. G13).
Vertical section of thallus, × 50. Lower Micoene, Maemong Limestone Member of Umatac Formation; loc. D914 (Hi 10–1), specimen A702a.

5. *Lithothamnium bourcarti* Lemoine (p. G12).
A nearly vertical section, × 50, showing the thin thallus and two conceptacle chambers. Lower Miocene, Maemong Limestone Member of Umatac Formation; loc. D900 (Fj 2–4), specimen A697.

6. *Lithothamnium bonyense* Johnson n. sp. (p. G11).
A vertical section, × 50, showing the tissue consisting mainly of hypothallic tissue, with six partly filled conceptacle chambers. Lower Miocene, Bonya Limestone; loc. D906 (Gj 1–1), holotype specimen A696.

7. *Lithothamnium alifanense* Johnson n. sp. (p. G12).
Specimen, × 50, showing a thin basal hypothallus and thick perithallus with suggestions of growth zones. Upper Miocene and Pliocene, Alifan Limestone; loc. D941 (Ts 16–6), holotype specimen A701.

8. *Lithothamnium* sp. G (p. G13).
A nearly vertical section, × 100, showing the hypothallus of curved rows of cells and the thicker regular perithallus. Lower Miocene, Maemong Limestone Member of Umatac Formation; loc. D926 (Ii 6–36), specimen A700.



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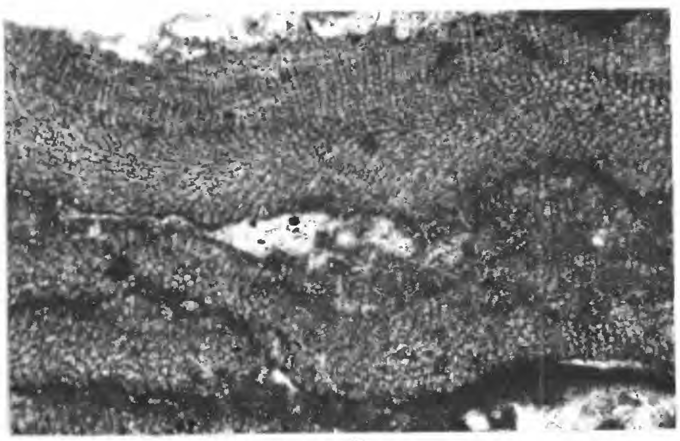

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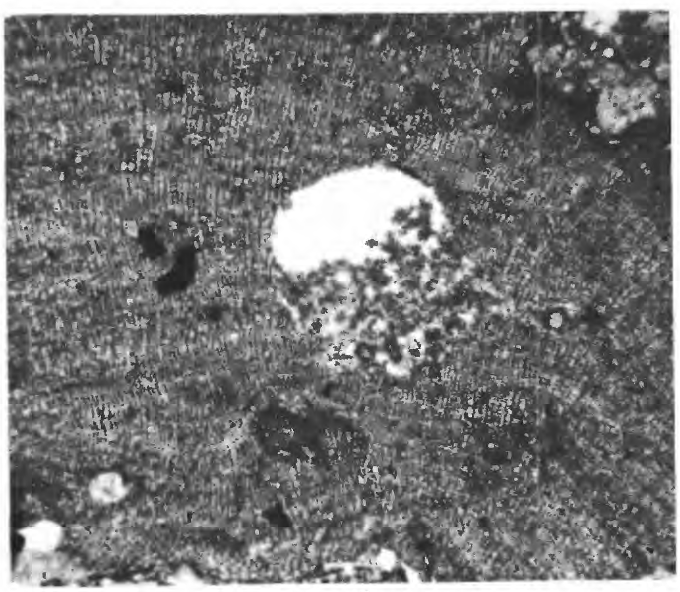

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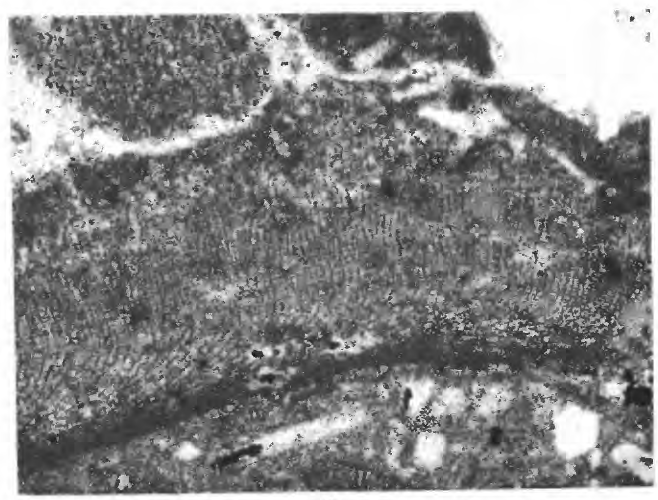

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MIOCENE *LITHOTHAMNIUM*

PLATE 2

FIGURE 1. *Lithothamnium* cf. *L. peleense* Lemoine (p. G12).

A vertical section, × 100, showing the hypothallus and perithallus. Lower Miocene, Maemong Limestone Member of Umatac Formation; loc. D914 (Hi 10–1), specimen A702b.

2. *Lithothamnium* cf. *L. araii* Ishijima (p. G13).

A nearly vertical section, × 50, showing the hypothallus and the thick perithallus with its well-defined growth zones. Lower Miocene, Maemong Limestone Member of Umatac Formation; loc. D921 (Ii 6–27), specimen A705.

3. *Mesophyllum commune* Lemoine (p. G14).

Tangential section of a branch, × 50. The tissue contains pronounced growth zones and four conceptacles with sporangia. Lower Miocene, Maemong Limestone Member of Umatac Formation; loc. D928 (Ii 6–38), specimen A708.

4. *Lithothamnium* sp. H (p G14.).

A vertical section, × 50. Upper Miocene and Pliocene, Alifan Limestone; loc. D936 (Ts 9–1), specimen A706.

5. *Mesophyllum grande* Johnson n. sp. (p. G15).

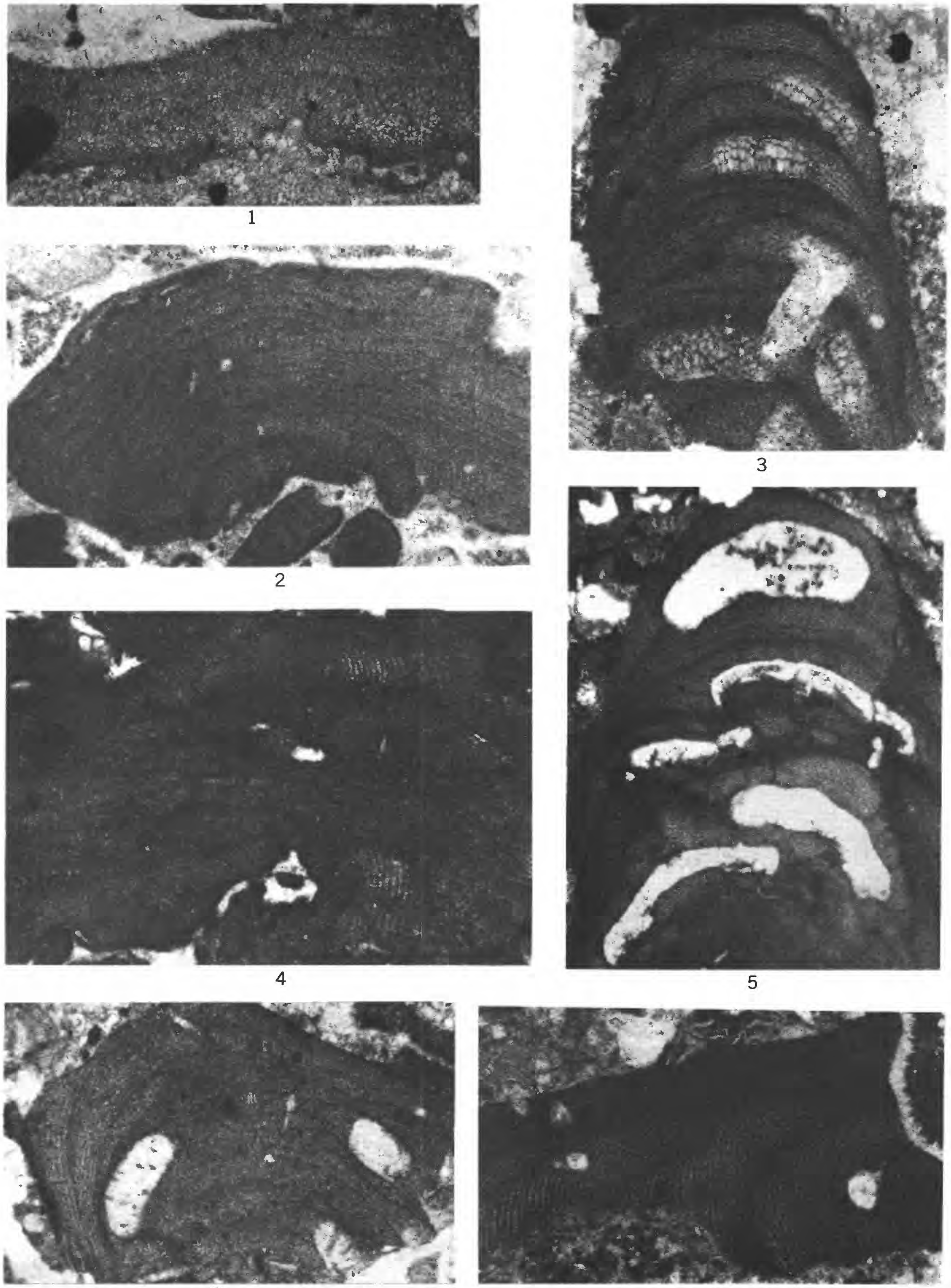
Longitudinal section, × 50, of a branch showing growth zones and large conceptacle chambers (the lower ones partly filled). Specimen badly recrystallized. Lower Miocene, Maemong Limestone Member of Umatac Formation; loc. D918 (Ii 6–8), holotype specimen A709.

6. *Lithothamnium* sp. F (p. G14).

Slightly oblique section, × 50. Lower Miocene, Maemong Limestone Member of Umatac Formation; loc. D926 (Ii 6–36), specimen A707.

7. *Mesophyllum guamense* Johnson n. sp. (p. G15).

Fragment of a branch, × 50, showing structure of the tissue. Lower Miocene, Maemong Limestone Member of Umatac Formation; loc. D922 (Ii 6–28), specimen A711.



MIOCENE *LITHOTHAMNIUM* AND *MESOPHYLLUM*

PLATE 3

FIGURE 1. *Mesophyllum* sp. C (p. G15).

A slightly oblique tangential section of a worn branch, × 50. Lower Miocene, Bonya Limestone; loc. D909 (Gj 7–2), specimen A713.

2. *Lithophyllum schlangeri* Johnson n. sp. (p. G18).

Vertical section, × 50, showing the well-developed hypothallus, the thin perithallus, and two conceptacles with sporangia. Lower Miocene, Maemong Limestone Member of Umatac Formation; loc. D927 (Ii 6–37), holotype specimen A710a.

3–5. *Lithophyllum alifanense* Johnson n. sp. (p. G17).

Upper Miocene and Pliocene, Alifan Limestone.

3. *Lithophyllum alifanense* Johnson n. sp. and *Lithoporella melobesioides* Foslie (at top). Specimen slightly recrystallized, × 50. Loc. D936 (Ts 9–1); holotype specimen A715.
4. An oblique section, × 100, giving details of the tissue and two conceptacles with sporangia. Loc. D938 (Ts 16–2), specimen A716.
5. Section of a young plant, × 50. Loc. D940 (Ts 16–5), specimen A718

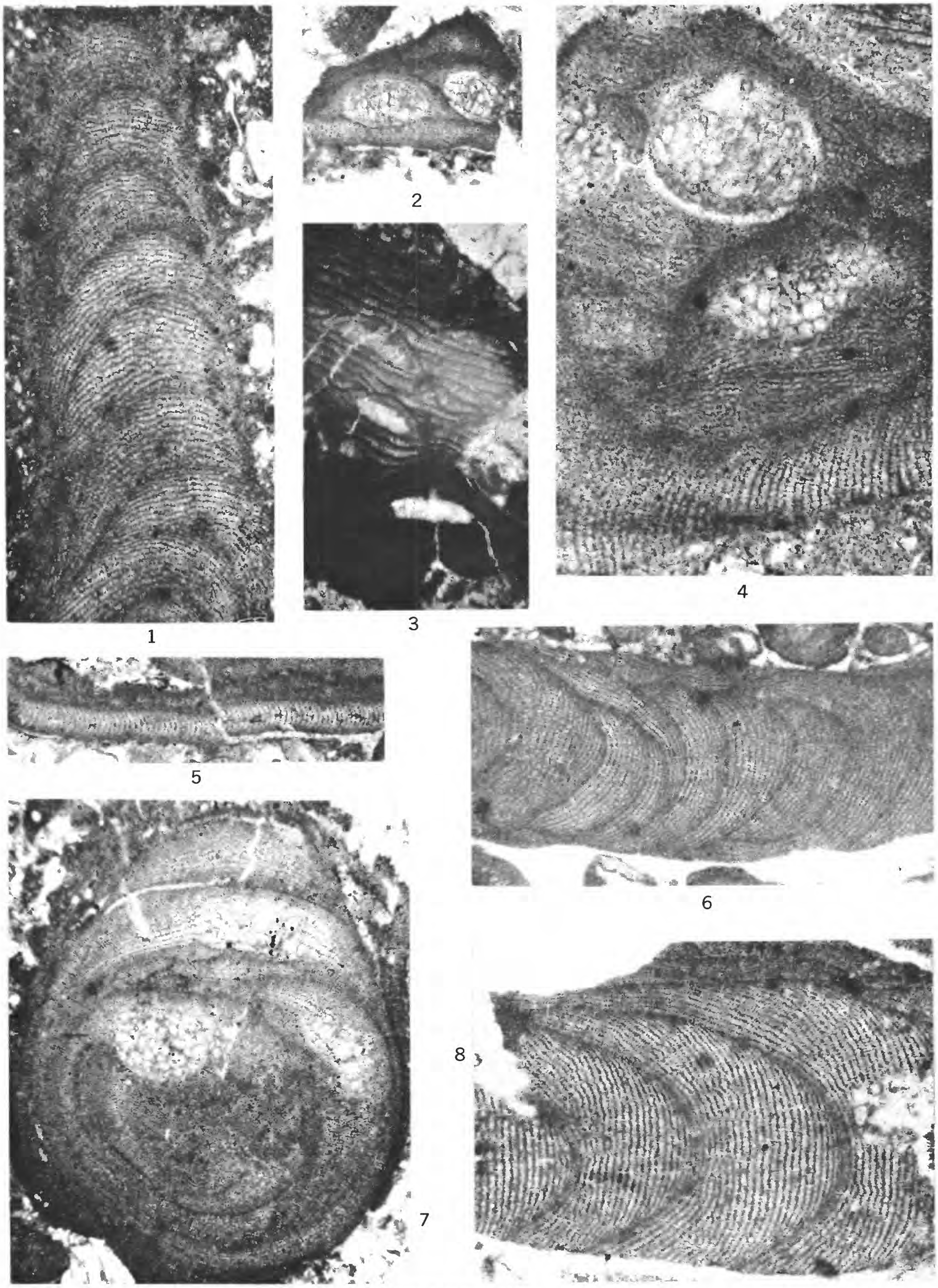
6, 7. *Mesophyllum guamense* Johnson n. sp. (p. G15).

Lower Miocene, Maemong Limestone Member of Umatac Formation.

6. Section of a branch, × 50, with strong lenticular growth zones. Loc. D911 (Hi 3–5), specimen A712.
7. An oblique section, × 50, of a fertile branch. Loc. D927 (Ii 6–37), holotype specimen A710a.

8. *Mesophyllum* sp. D (p. G15).

Fragment of a branch, × 50. Lower Miocene, Maemong Limestone Member of Umatac Formation; loc. D920 (Ii 6–26), specimen A714a.



MIOCENE *MESOPHYLLUM* AND *LITHOPHYLLUM*

PLATE 4

FIGURES 1–3. *Lithophyllum maemongense* Johnson n. sp. (p. G17).
Lower Miocene, Maemong Limestone Member of Umatac Formation.
1. Section of a typical crust, × 50, with distinct hypothallus and perithallus. Loc. D912 (Hi 5–1), specimen A720.
2. Several thalli with a *Lithoporella* between, × 30, conceptacle chamber in upper right. Loc. D891 (Ed 4–1), specimen A721.
3. Specimen, × 50, somewhat recrystallized with well-developed coaxial hypothallus, perithallus, and a conceptacle chamber. Loc. D919 (Li 6–25), holotype specimen A719.

4, 6. *Lithophyllum* cf. *L. obliquum* Lemoine (p. G18).
Lower Miocene, Maemong Limestone Member of Umatac Formation.
4. Detail of hypothallus and perithallus, × 100, and a *Lithoporella melobesioides* Foslie below. Loc. D928 (Ii 6–38), specimen A708.
6. Section, × 50, with well-developed hypothallus and thick perithallus. Loc. D925 (Ii 6–34), specimen A723.

5. *Lithophyllum quadrangulum* var. *welschi* Lemoine (p. G18). Specimen, × 100. Lower Miocene, Bonya Limestone; Loc. D930 (Ih 14–1), specimen A724.

7, 9. *Lithophyllum* sp. B (p. G18).
Lower Miocene, Maemong Limestone Member of Umatac Formation.
7. Section, × 40. Locality D910 (Hi 3–4), specimen A727.
9. Detail of tissue, × 100. Loc. D900 (Fj 2–4), specimen A697.

8. *Lithophyllum bonyense* Johnson n. sp. (p. G19).
Detail of tissue, × 100. Lower Miocene, Bonya Limestone, loc. D931 (Ih 14–2), specimen A730.

10. *Lithophyllum* sp. G (p. G18).
Detail of tissue, × 100. Upper Miocene and Pliocene, Alifan Limestone; loc. D943 (Ts 16–12), specimen A728.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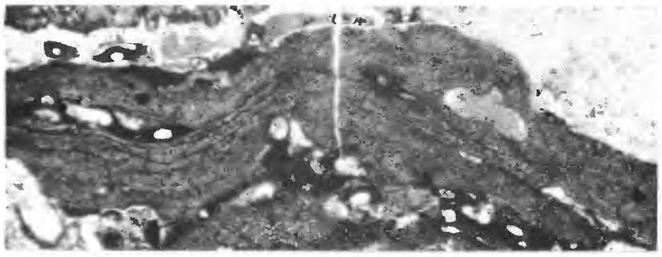
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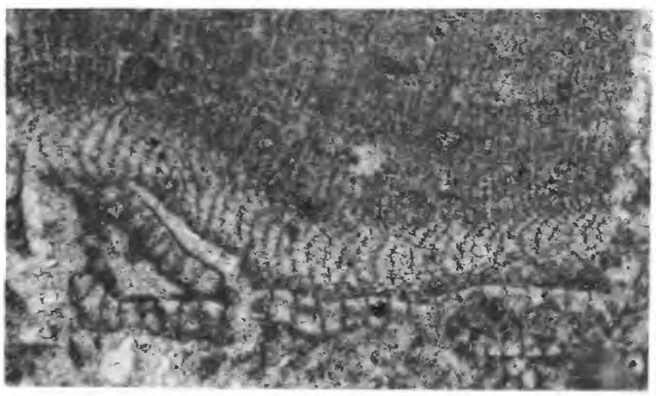
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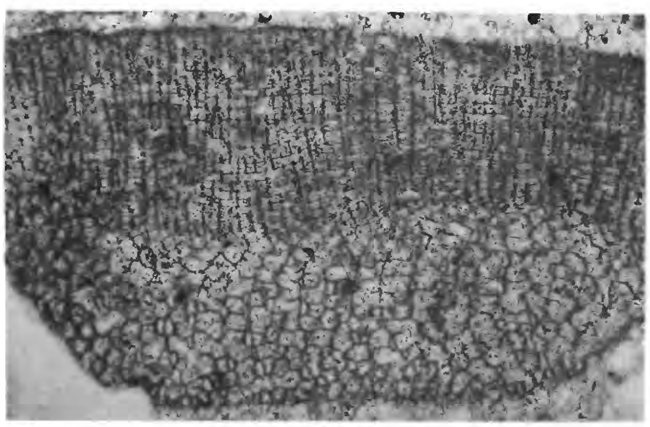
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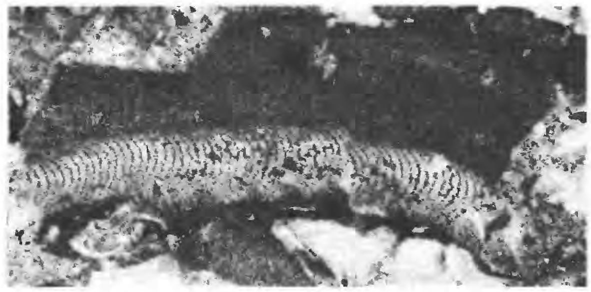
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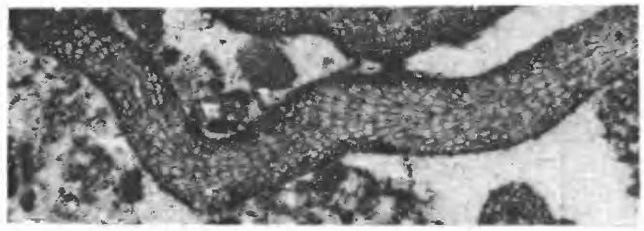
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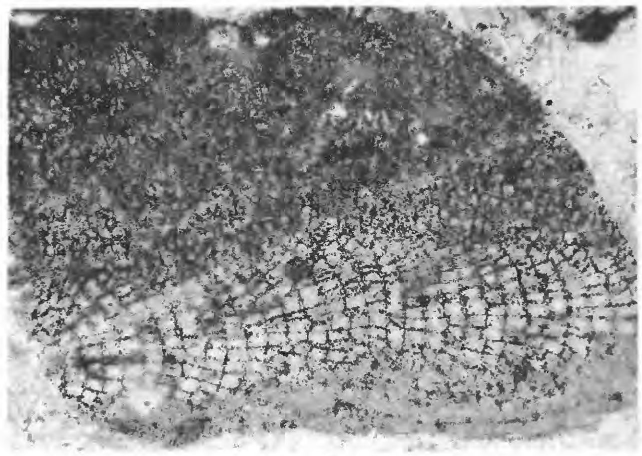
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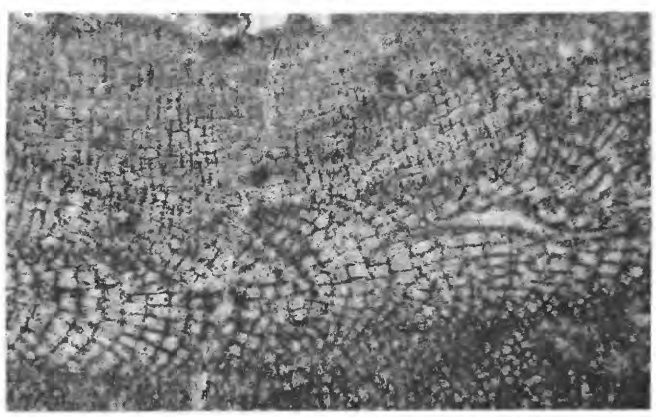
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MIOCENE *LITHOPHYLLUM*

PLATE 5

FIGURES 1, 2. *Lithophyllum bonyense* Johnson n. sp. (p. G19).

Lower Miocene, Bonya Limestone.

1. Section, × 100, with large hypothallus and rather thin perithallus. Loc. D930 (Ih 14–1), holotype specimen A729.
2. Slightly oblique section of a thick crust, × 100. Locality D929 (Ih 5–6), specimen A731.

3, 5, 6. *Lithophyllum alternatum* Johnson n. sp. (p. G20).

Upper Miocene and Pliocene, Alifan Limestone.

3. Detail from same specimen shown in fig. 6, × 100, showing the cells and alternate layers of long and short cells. Loc. D937 (Ts 16–1), specimen A734.
5. A tangential section, × 50, of a nearly complete branch with medullary hypothallus of alternate long and short cells and a marginal perithallus. Loc. D939 (Ts 16–3), holotype specimen A733.
6. A nearly vertical section, × 50. Loc. D937 (Ts 16–1), specimen A734.

4. *Lithophyllum* sp. E (p. G20).

Fragment of a fertile crust, × 50. Upper Miocene and Pliocene, Barrigada Limestone; loc. D934 (Ov 7–3), specimen A732.


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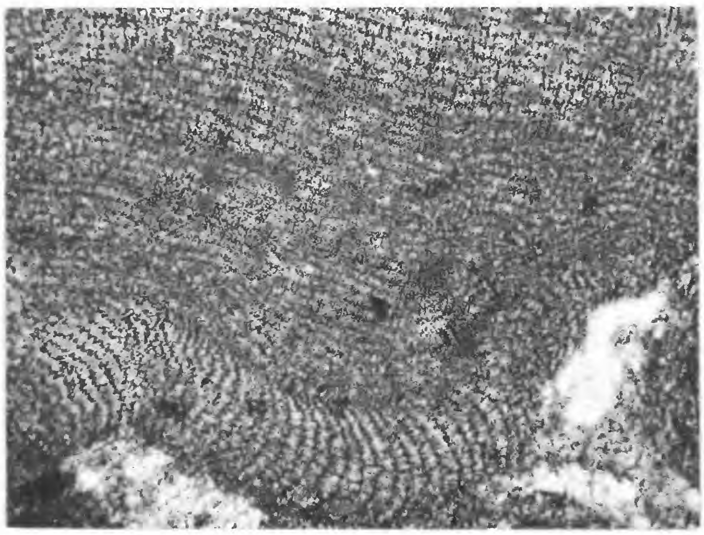
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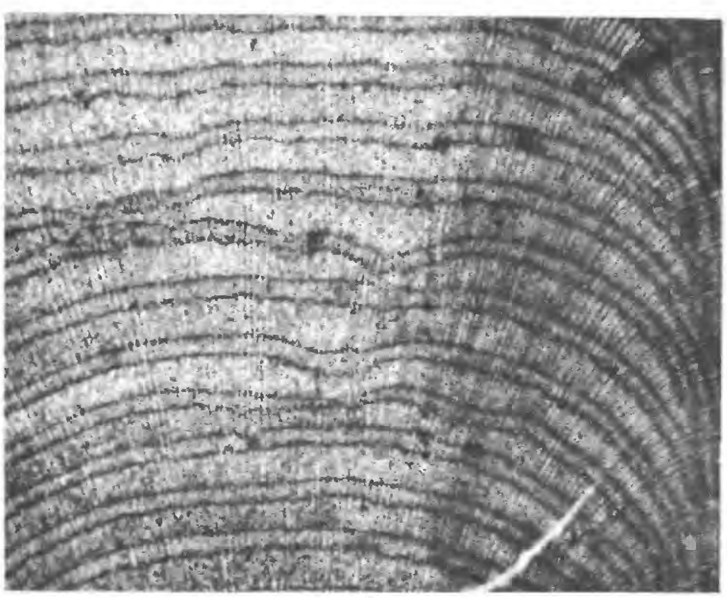
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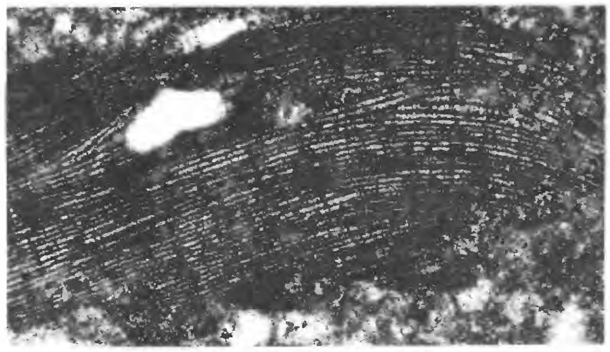
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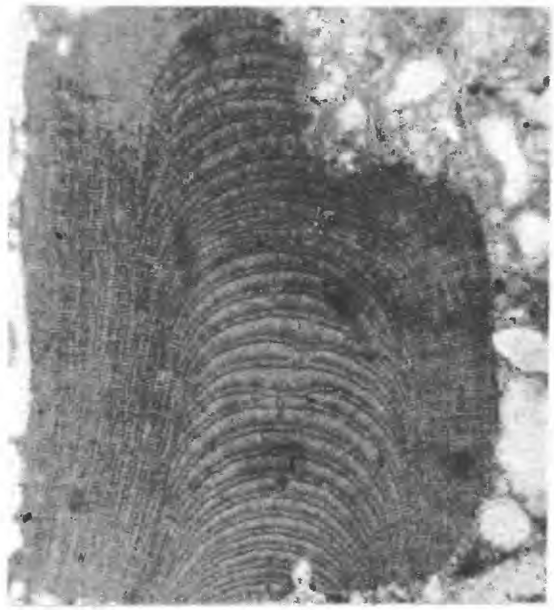
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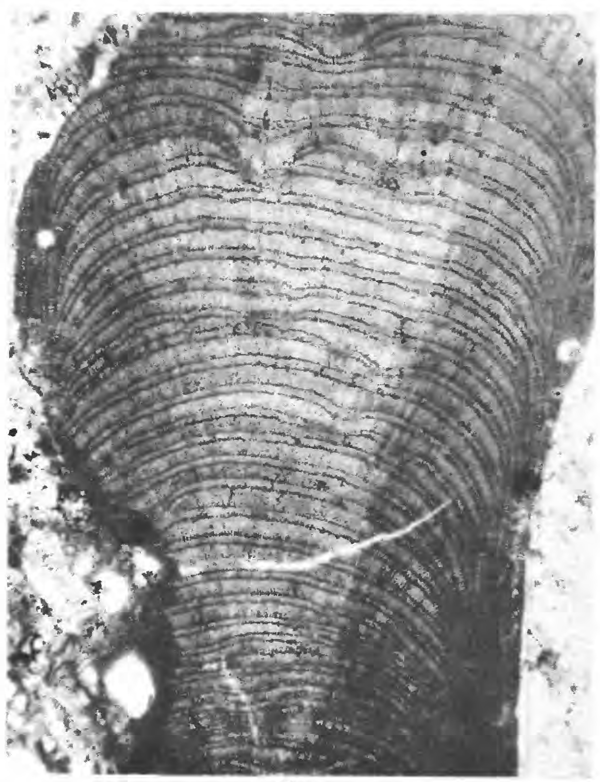
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MIOCENE *LITHOPHYLLUM*

PLATE 6

FIGURES 1, 2. *Lithophyllum traceyi* Johnson n. sp. (p. G20).

Lower Miocene, Maemong Limestone Member of Umatac Formation.

1. Longitudinal section of a branch, × 50, with medullary hypothallus, marginal perithallus, and a conceptacle chamber. Loc. D899 (Fi 6–7); holotype specimen A698.
2. Worn fragment of a branch, × 50. Loc. D925 (Ii 6–34), specimen A745.

3, 4. *Lithophyllum alternicellum* Johnson n. sp. (p. G20).

Lower Miocene, Bonya Limestone.

3. A slightly oblique nearly longitudinal section, × 50, of a fertile branch. Loc. D909 (Gj 7–2), holotype specimen A735.
4. Detail, × 100, of the tissue of a branch. Loc. D929 (Ih 5–6), specimen A736.

5. *Lithophyllum* sp. C (p. G23).

Slightly oblique tangential section of a branch, × 50. Lower Miocene, Maemong Limestone Member of Umatac Formation; loc. D927 (Ii 6–37), specimen A710b.

6. *Lithophyllum* aff. *L. glangeaudi* Lemoine (p. G21).

A slightly oblique longitudinal section, × 50. Upper Miocene and Pliocene, Alifan Limestone; loc. D936 (Ts 9–1), specimen A737.

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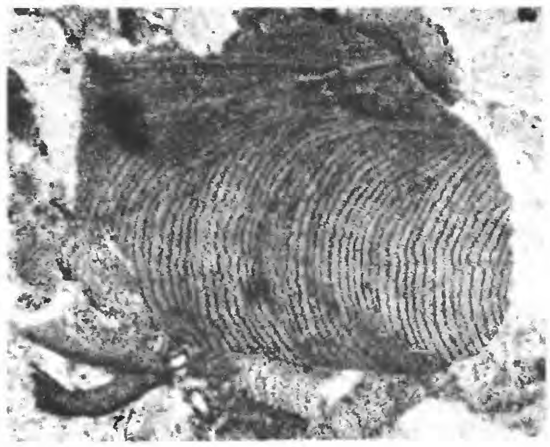

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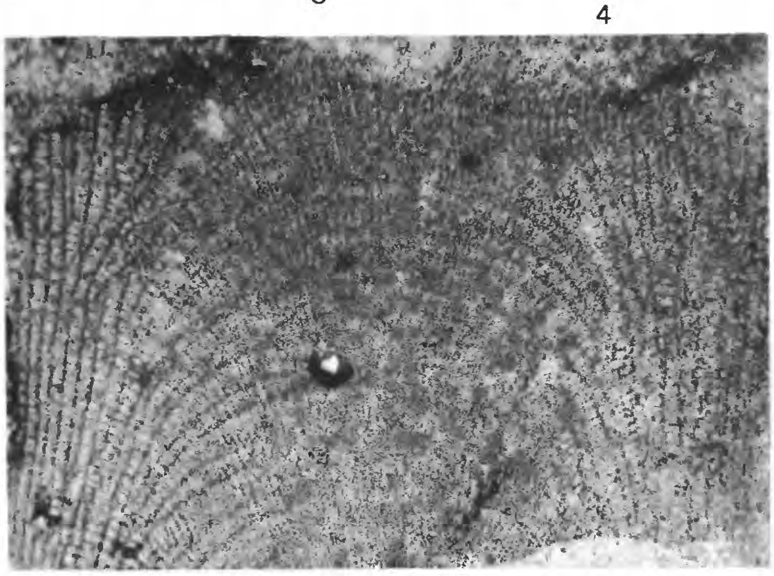


MIOCENE *LITHOPHYLLUM*

PLATE 7

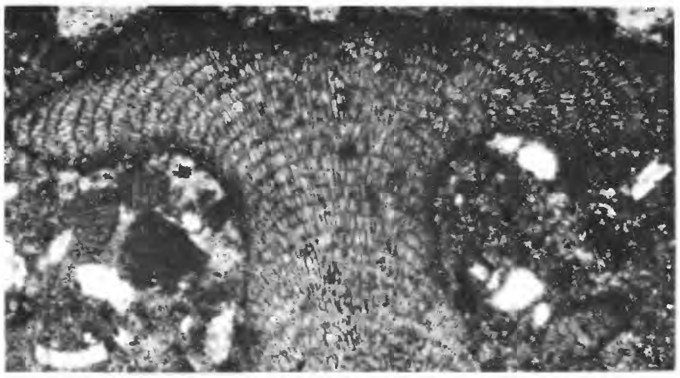
FIGURES 1–4. *Lithophyllum pseudoamphiroa* Johnson n. sp. (p. G22).

Lower Miocene, Maemong Limestone Member of Umatac Formation.

1. Slightly oblique specimen, ×40, showing young branches. Loc. D919 (Ii 6–25) specimen A743.
2. Branch arising from the basal hypothallus, ×50. Loc. D900 (Fj 2–4), specimen A697.
3. Slightly oblique section, × 40. Loc. D919 (Ii 6–25), specimen A743.
4. Specimen showing details of branching, × 50. Loc. D900 (Fj 2–4), holotype specimen A697.

5. *Lithophyllum* sp. C (p. G23).

Oblique section, × 100. Lower Miocene, Maemong Limestone Member of Umatac Formation; loc. D927 (Ii 6–37), specimen A710a.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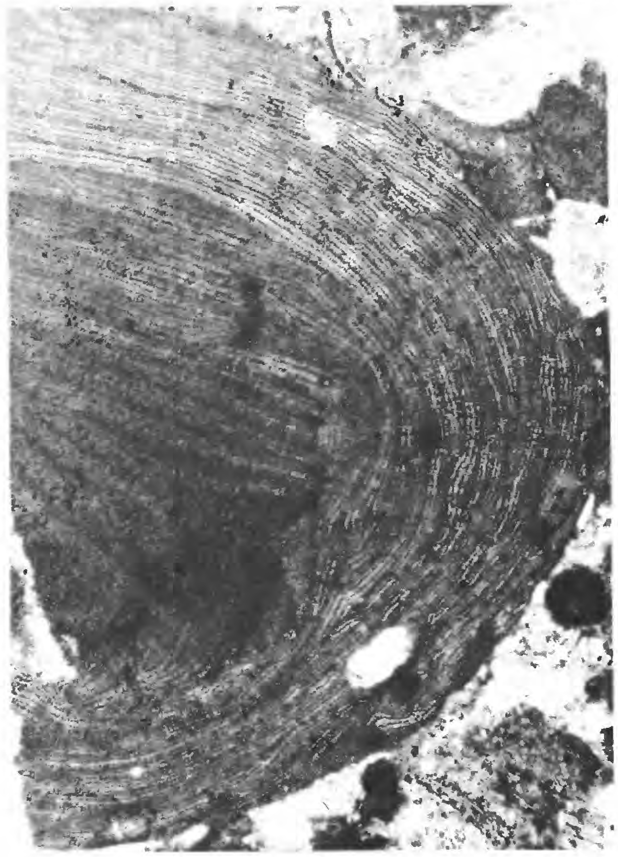
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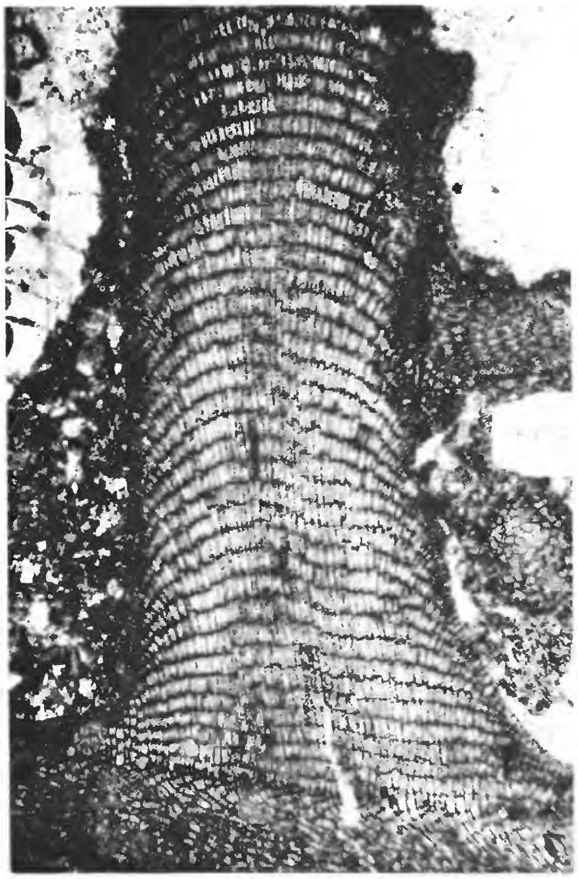
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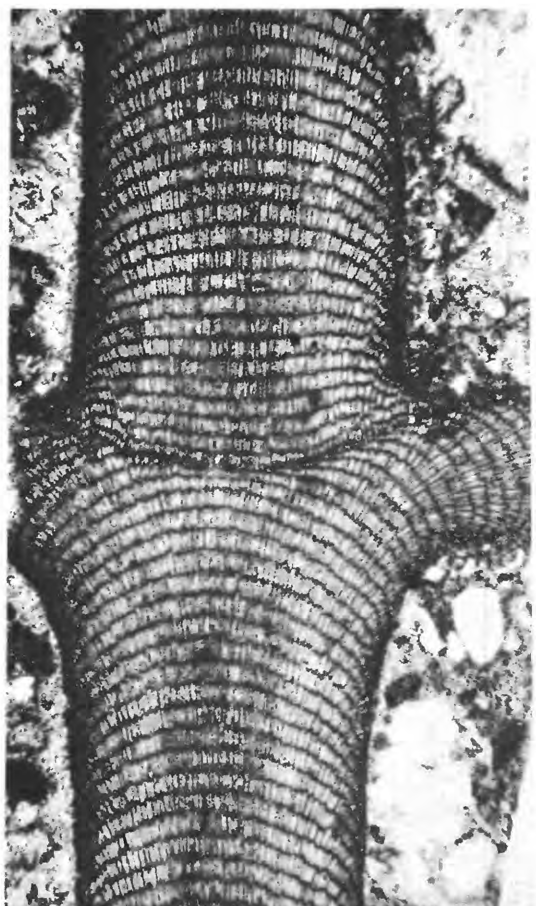

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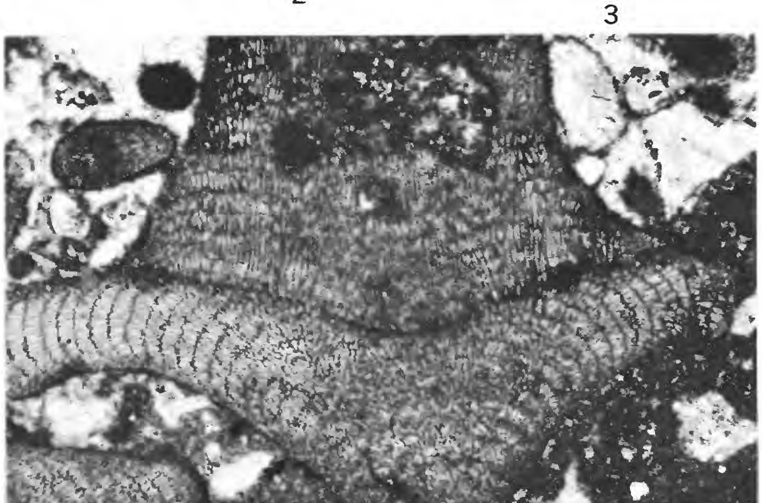


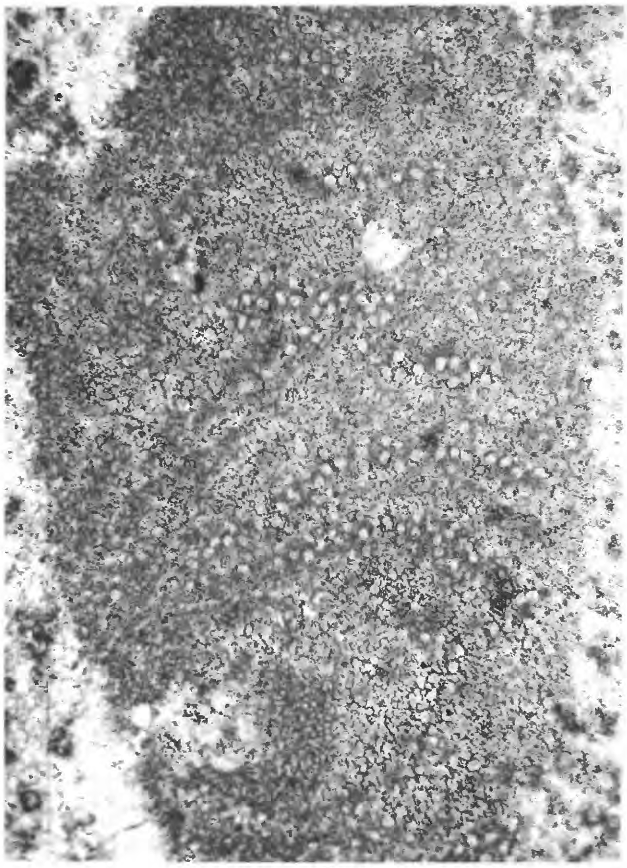
MIOCENE *LITHOPHYLLUM*

PLATE 8

FIGURES 1–3. *Goniolithon miocenicum* Johnson n. sp. (p. G26).

1. A basal section, × 100. Lower Miocene, Maemong Limestone Member of Umatac Formation; loc. D894 (Fd 1–1), specimen A755.
2. A perpendicular section, × 100. Lower Miocene, Bonya Limestone; loc. D896 (Fi 3–4), specimen A754.
3. Perpendicular section, × 100, showing hypothallus, perithallic tissue with megacells, and numerous conceptacle chambers. Lower Miocene, Maemong Limestone Member of Umatac Formation; loc. D904 (Gi 1–1), holotype specimen A753.

4. *Goniolithon* sp. C (p. G27).
Section, × 50, showing tissue with several secondary patches of hypothallus developed as scar tissue. Upper Miocene and Pliocene, Alifan Limestone; loc. D936 (Ts 9–1), specimen A715.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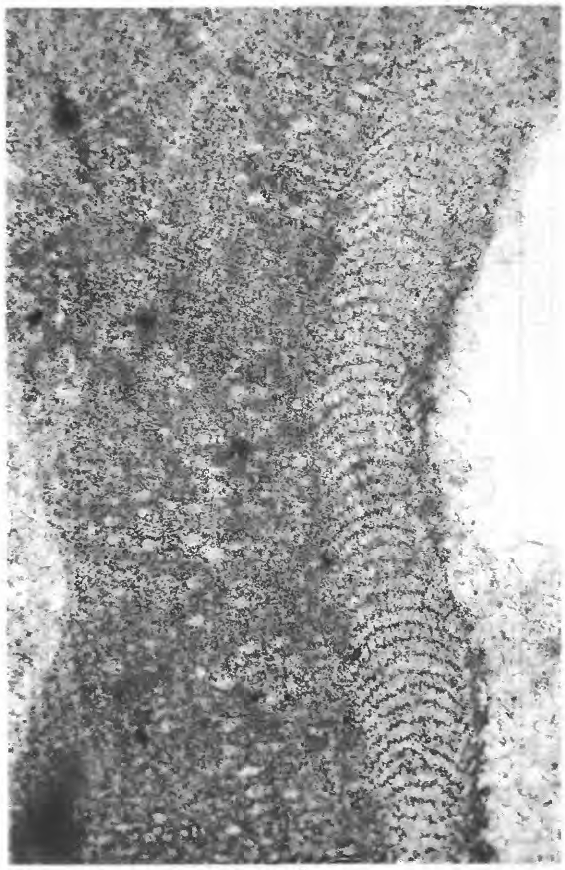
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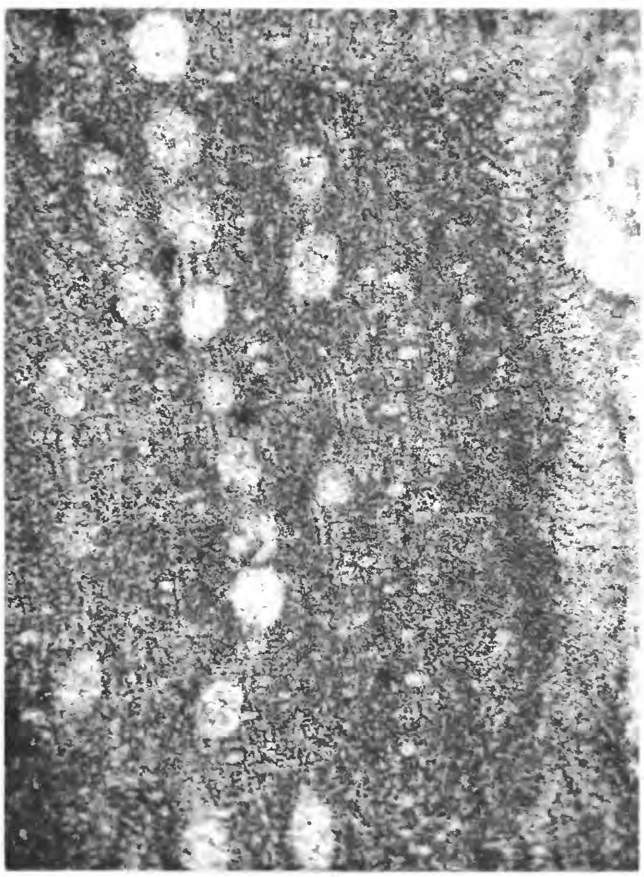
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MIOCENE *GONIOLITHON*

PLATE 9

FIGURES 1–3. *Aethesolithon problematicum* Johnson n. sp. (p G27).

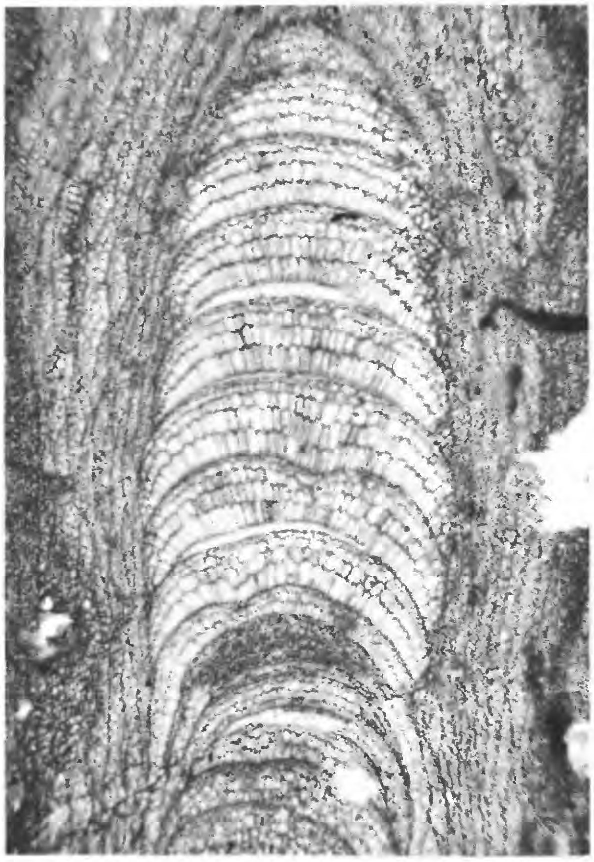
Lower Miocene, Bonya Limestone.

1. A slightly oblique nearly longitudinal section of a branch, × 40, showing the medullary hypothallus with its growth zones and layers of large polygonal cells and the irregular marginal perithallus. Loc. D896 (Fi 3–4), holotype specimen A754.
2. Slightly oblique section, × 50, through side of a short branch showing perithallic tissue and conceptacles with sporangia. Loc. D895 (Fi 3–2), specimen A762.
3. Section of a branch, × 50. Loc. D898 (Fi 5–1), specimen A763.

4, 5. *Aethesolithon grandis* Johnson n. sp. (p. G28).

Upper Miocene and Pliocene, Alifan Limestone.

4. A part, × 50, showing details of the medullary hypothallus and the transition from the hypothallus to the marginal perithallus. Loc. D940 (Ts 16–5), holotype specimen A764.
5. Margin of a mammillated crust, × 50, with conceptacles containing sporangia. Loc. D937 (Ts 16–1), specimen A765.



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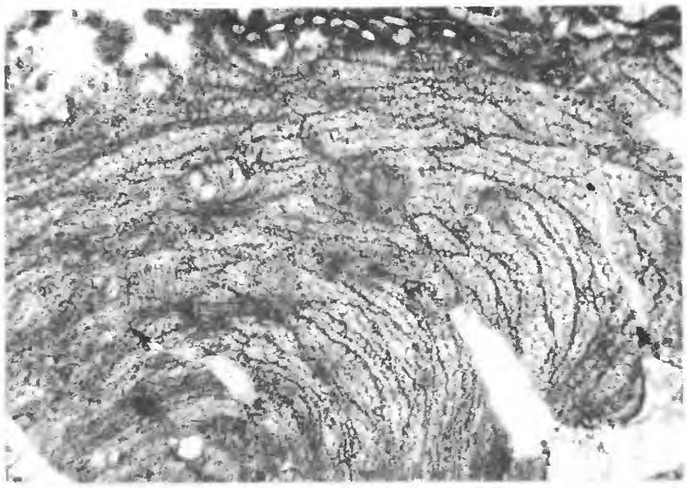

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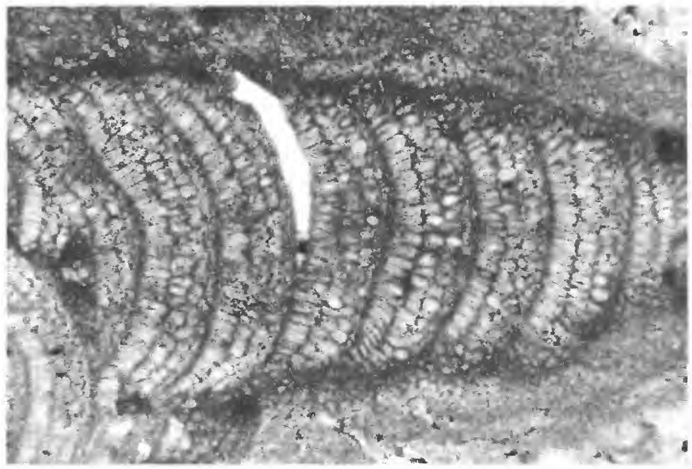

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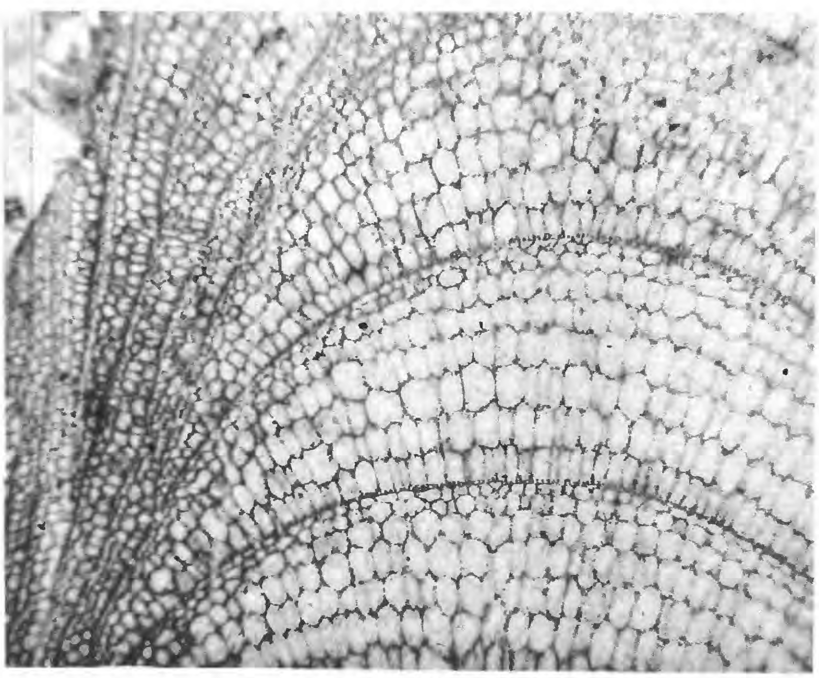

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MIOCENE *AETHESOLITHON* N. GEN.

PLATE 10

FIGURE 1. *Dermatolithon* sp. A (p. G30).
A nearly basal section, × 50. Lower Miocene, Maemong Limestone Member of Umatac Formation; loc. D901 (Fj 2–5), specimen A703.

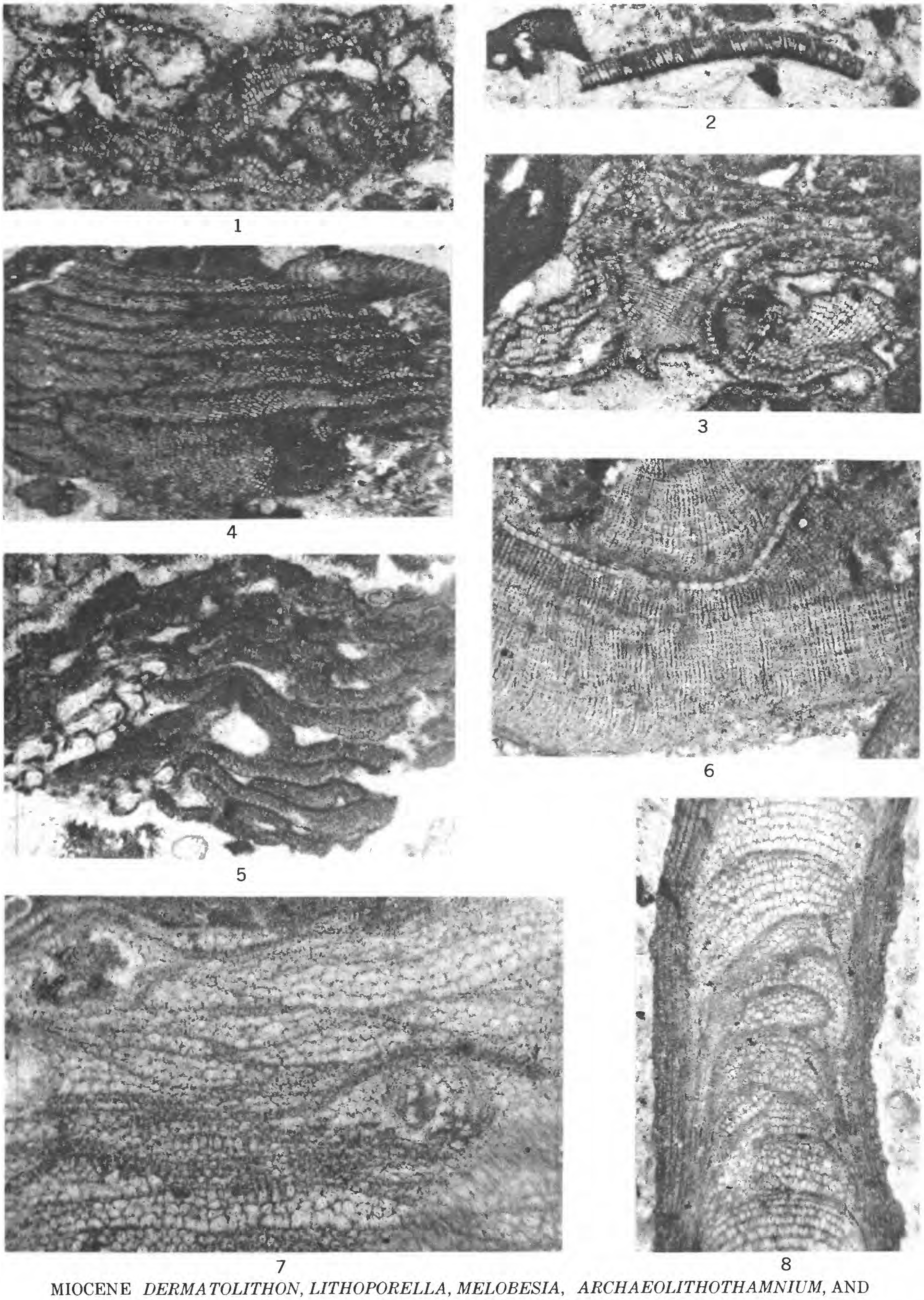
2. *Lithoporella* sp. A (p. G29).
Section of a young plant, × 50. Lower Miocene, Maemong Limestone Member of Umatac Formation; loc. D908 (Gj 4–4), specimen A768.

3. *Dermatolithon* sp. B (p. G30).
A slightly oblique section of a curved platy thallus, × 50. Upper Miocene and Pliocene, Alifan Limestone; loc. D917 (Hn 7–3), specimen A704.

4, 5. *Dermatolithon guamensis* Johnson n. sp. (p. G30).
Lower Miocene, Maemong Limestone Member of Umatac Formation.
4. A nearly basal section, × 50. Loc. D926 (Ii 6–36), specimen A700.
5. A nearly vertical slice, × 50 showing tissue and a conceptacle. Loc. D922 (Ii 6–28), holotype specimen A711.

6. *Melobesia quamensis* Johnson n. sp. (p. G30).
Between two thalli of *Archaeolithothamnium lauense* Johnson and Ferris, × 100. Lower Miocene, Maemong Limestone Member of Umatac Formation; loc. D923 (Ii 6–32), holotype specimen A722.

7, 8. *Aethesolithon grandis* Johnson n. sp. (p. G28).
Upper Miocene and Pliocene, Alifan Limestone.
7. Detail of outer part of a crust, × 100, showing the irregular perithallic tissue and two conceptacles. Loc. D397 (Ts 16–1), specimen A766.
8. Section of a long branch, × 25. Loc. D892 (Eh 3–3), specimen A767.



MIOCENE *DERMATOLITHON, LITHOPORELLA, MELOBESIA, ARCHAEOLITHOTHAMNIUM*, AND *AETHESOLITHON*; AND PLIOCENE AND PLEISTOCENE *DERMATOLITHON*

PLATE 11

FIGURE 1. *Amphiroa* cf. *A. regularis* Johnson and Ferris (p. G33).
A nearly complete segment, × 50. Upper Miocene and Pliocene, Alifan Limestone; loc. D944 (Tt 7–4), specimen A769.

2, 3, 5, 11. *Amphiroa prefragilissima* Lemoine (p. G32).
Upper Miocene and Pliocene, Alifan Limestone.
2. A broken segment, × 50. Loc. D937 (Ts 16–1), specimen A761.
3. A segment, × 40, with the medullary hypothallus but most of the marginal perithallus worn off. Loc. D942 (Ts 16–9), specimen A747.
5. A nearly complete segment, × 40. Loc. D892 (Eh 3–3), specimen A767.
11. A slightly oblique section of a segment, × 50. Loc. D893 (Eh 3–8), specimen A760.

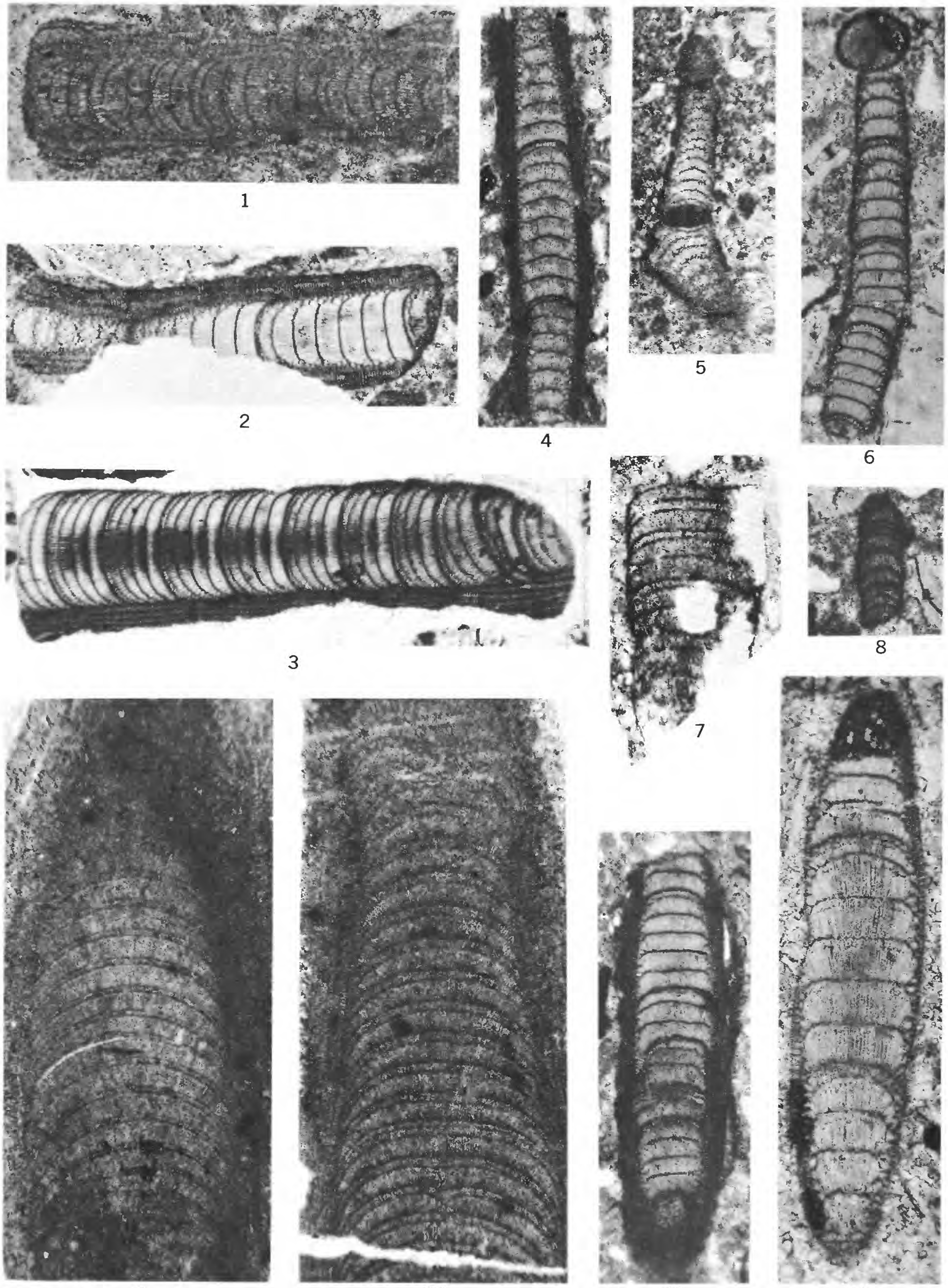
4. *Corallina* sp. A (p. G35).
Two segments and connecting node, × 40. Upper Miocene and Pliocene, Alifan limestone, loc. D916 (Hn 7–2), specimen A775.

6, 12. *Amphiroa tan-i* Ishijima (p. G33).
Lower Miocene, Bonya Limestone.
6. A nearly complete segment, × 50. Loc. D930 (Ih 14–1), specimen A770.
12. A segment, × 100. Loc. D931 (Ih 14–2), specimen A730.

7. *Amphiroa* cf. *A. verricosa* Kütsing (p. G33).
A worn fragment, × 50. Upper Miocene and Pliocene, Barrigada Limestone; loc. D933 (Ov 7–2), specimen A771.

8. *Amphiroa* sp. D (p. G34).
An abraded fragment, × 50. Upper Miocene and Pliocene, Barrigada Limestone; loc. D935 (Rx 8–2), specimen A774.

9, 10. *Amphiroa anchiverricosa* Johnson and Ferris (p. G32).
Lower Miocene, Bonya Limestone.
9. An oblique section, × 40. Loc. D905 (Gi 2–7), specimen A742
10. Part of a segment, × 50, showing typical structure of tissue. Loc. D909 (Gj 7–2), specimen A713.



MIOCENE *AMPHIROA* AND *CORALLINA*

PLATE 12

FIGURES 1–3. *Jania guamensis* Johnson n. sp. (p. G36).

Lower Miocene, Maemong Limestone Member of Umatac Formation.

1. A nearly complete terminal segment, × 40. Loc. D913 (Hi 12–3), holotype specimen A777.
2. Pieces of two segments, × 50. Loc. D920 (Ii 6–26), specimen A714b.
3. Detail, × 100. Loc. D897 (Fd 4–1), specimen A778.

4. *Halimeda* sp. (p. G37).

A nearly complete segment, × 25. Lower Miocene, Maemong Limestone Member of Umatac Formation; loc. D907 (Gj 4–1), specimen A780.

5. *Amphiroa* sp. C (p. G33).

A worn fragment, × 100. Pleistocene fore-reef facies of Mariana Limestone; loc. D932 (Ji 1–1), specimen A773.

6. *Corallina* sp. A (p. G35).

Several segments, × 40, somewhat recrystallized. Upper Miocene and Pliocene, Alifan Limestone; loc. D915 (Hn 7–1), specimen A776.

7. *Lithophyllum* sp. F (p. G23).

Section of a branch, × 100. Upper Miocene and Pliocene, Alifan Limestone; loc. D916 (Hn 7–2), specimen A748.

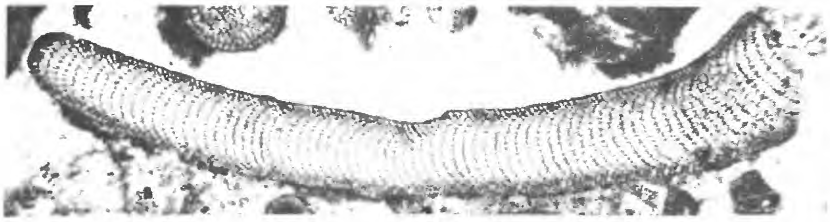
8. *Halimeda* sp. (p. G37).

A segment, × 25. Pliocene and Pleistocene, Mariana Limestone; loc. D945 (Uu 1–1), specimen A781.

9, 10. *Cymopolia* cf. *C. pacifica* Johnson (p. G36).

Upper Eocene and Oligocene, Alutom Formation; loc. D902 (Fk 4–9), specimen A772.

9. A nearly horizontal section, × 25.
10. A slightly oblique vertical section, × 25.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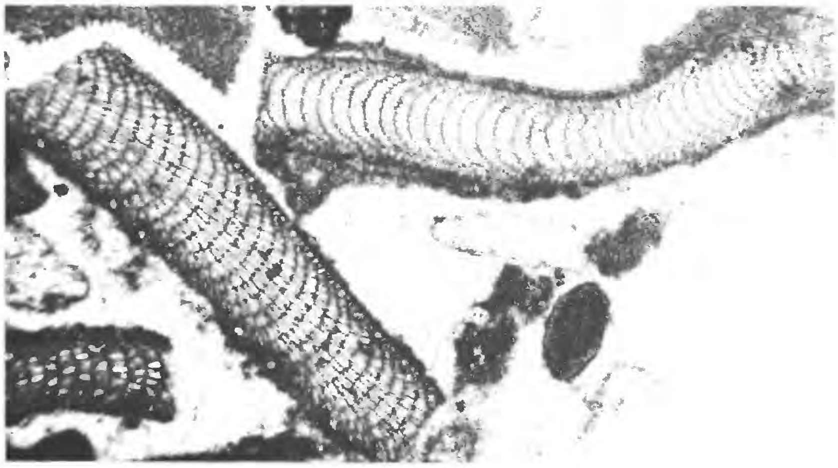
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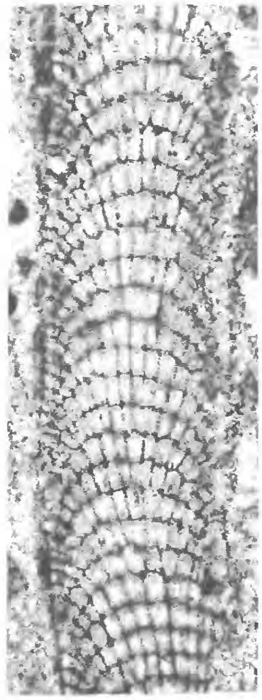
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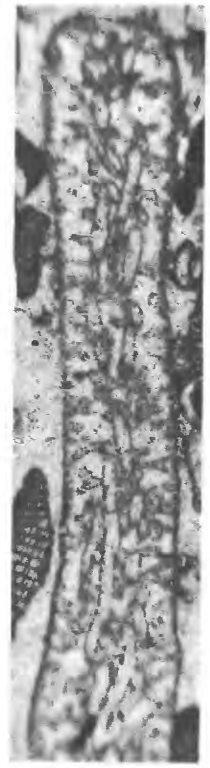
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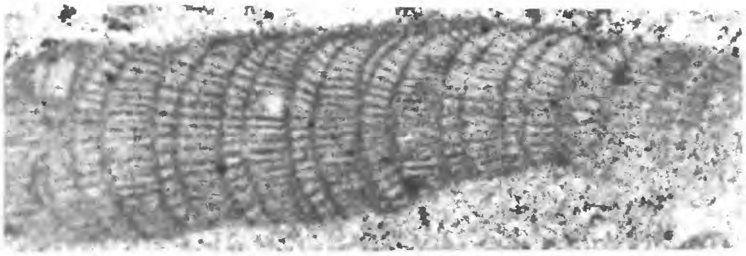
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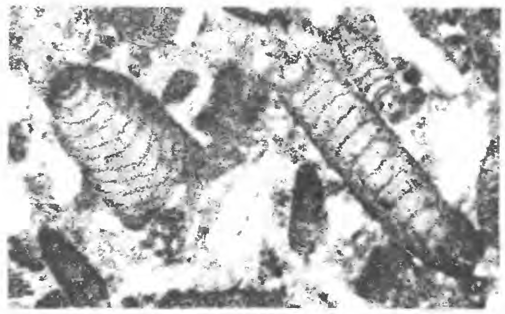
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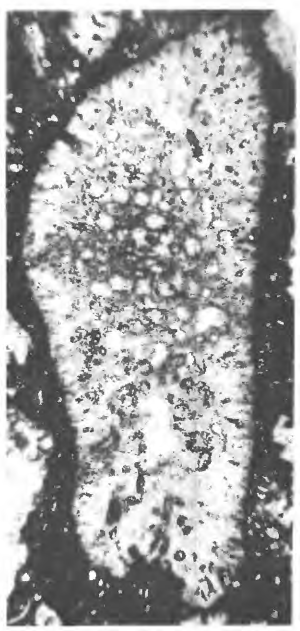
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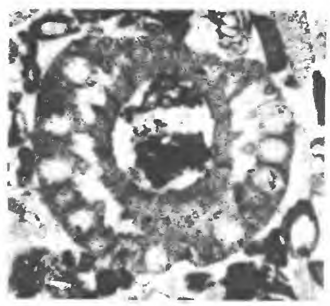
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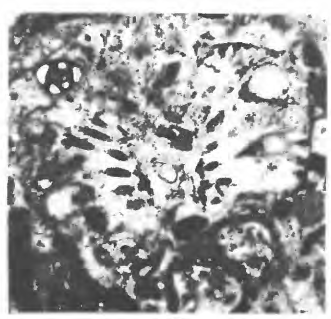
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EOCENE *CYMOPOLIA;* MIOCENE *JANIA, HALIMEDA, CORALLINA,* AND *LITHOPHYLLUM;* PLIOCENE AND PLEISTOCENE *HALIMEDA;* AND PLEISTOCENE *AMPHIROA*

PLATE 13

FIGURE 1. *Lithophyllum moluccense* f. *pygmaea* Foslie (p. G21). On a piece of coral, × 1. Agana Reef (D946), specimens A741 and A782.

2. *Goniolithon* cf. *G. fosliei* (Heydrich) Foslie (p. G25). Coating a piece of dead coral, × 1. Agana Reef (D946), specimen A749.

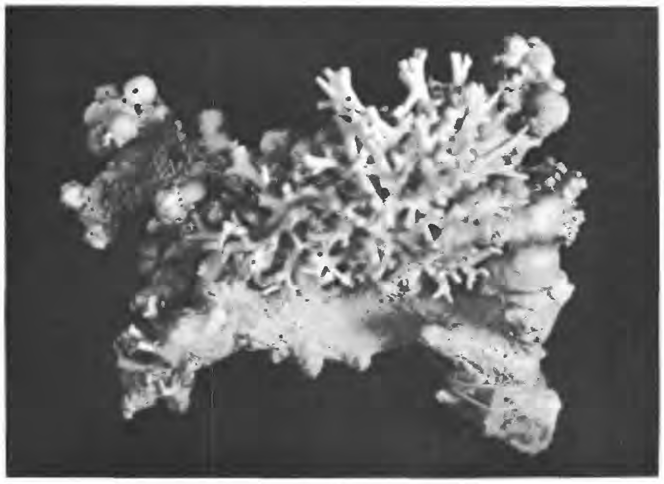
3. *Lithophyllum moluccense* f. *flabelliformis* Foslie (p. G21). Cocos Island Reef (D903), specimen A740, × 1.

4, 7. *Goniolithon medioramus* Johnson n. sp. (p. G25).

- 4. A small growth on coral, × 1. Agana Reef (D946), specimen A751.
- 7. A larger colony, × 1. Agana Reef (D946), specimen A750.

5, 6. *Goniolithon reinboldi* Weber van Bosse and Foslie (p. G26).

- 5. Agana Reef (D946), specimen A757, × 1.
- 6. A colony coating coral, × 1. Numerous conceptacles give a postulate surface appearance to this and the specimen above. Agana Reef (D946), specimen A756.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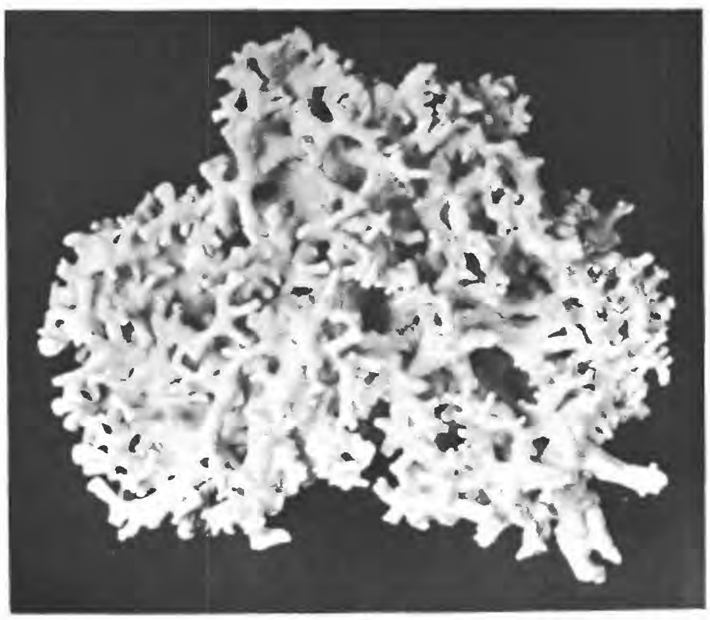
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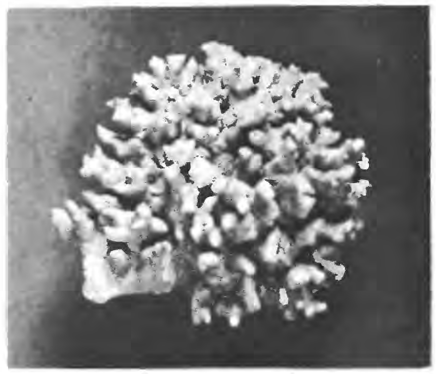
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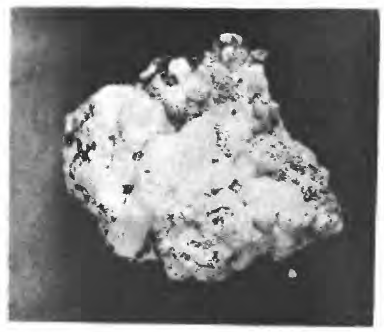
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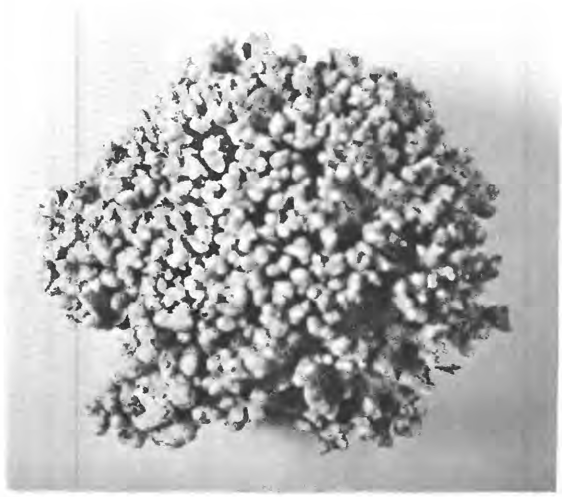
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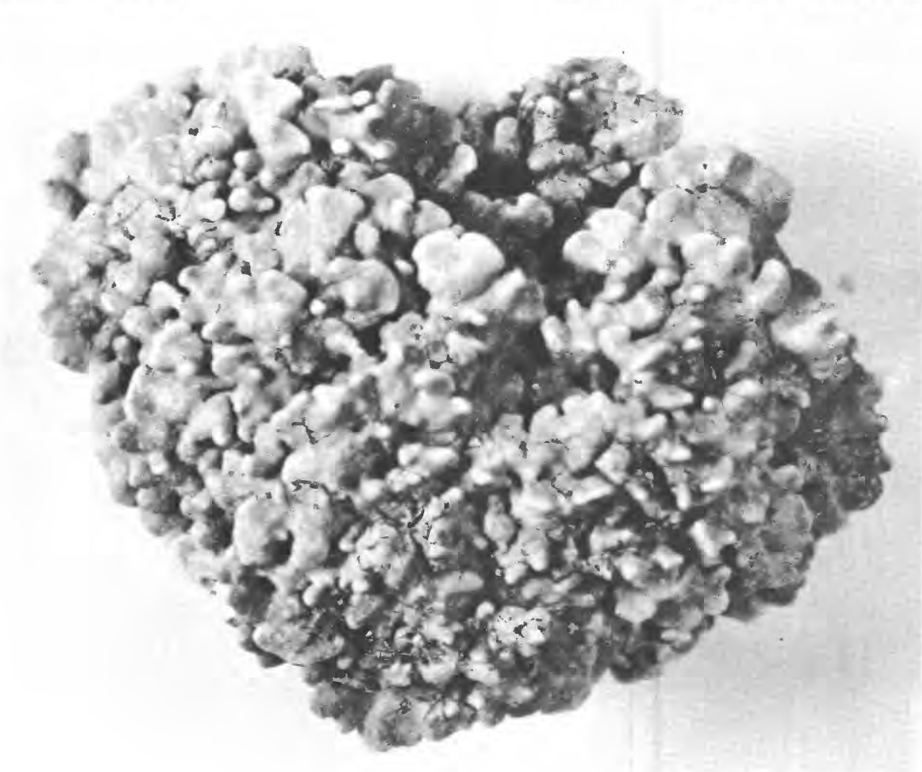
RECENT *LITHOPHYLLUM* AND *GONIOLITHON*

PLATE 14

FIGURES 1, 2. *Lithophyllum kotschyanum* Unger form *Madagascariensis* Foslie (p. G21).

A large specimen showing the wide platy branches characteristic of this growth form. Agana Reef (D946), specimen A738.

1. Side view, × 1.
2. Top view, × 1.



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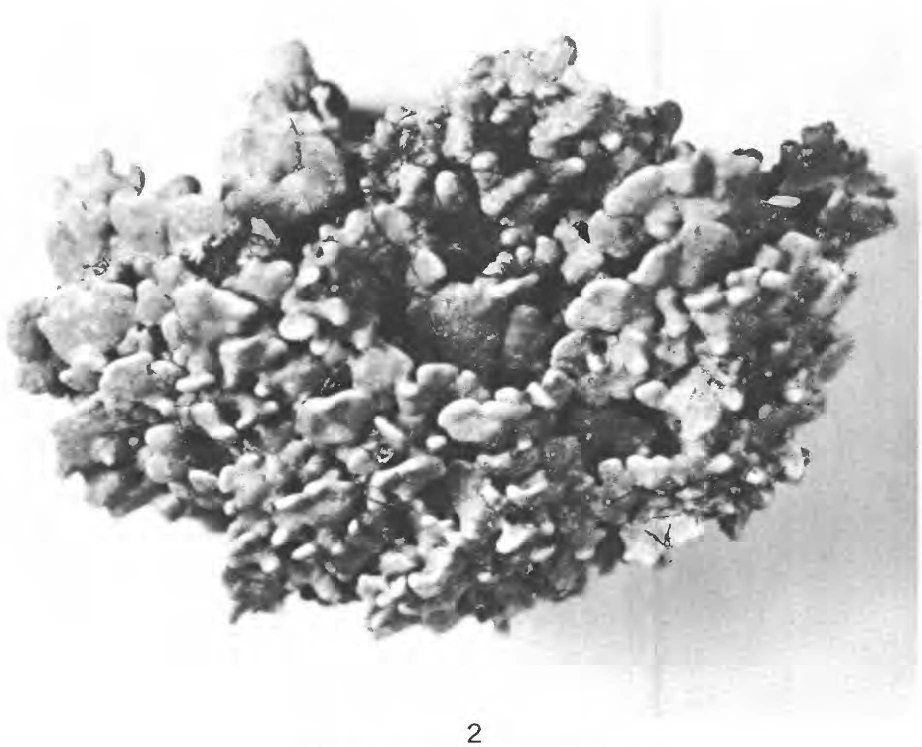

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RECENT *LITHOPHYLLUM*

PLATE 15

FIGURES 1, 2. *Goniolithon medioramus* Johnson n. sp. (p. G25).

Agana Reef (D946), holotype specimen A752.

1. A nearly vertical section, × 50, showing structure of the tissue. Note the several patches of secondary hypothallus to right of center. They are scar tissue.
2. A slightly oblique vertical section, × 50.

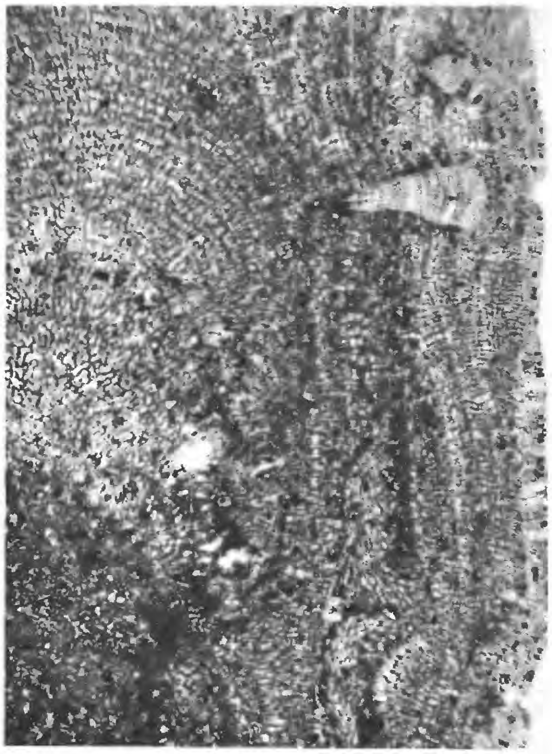
3. *Lithophyllum kotschyanum* (Unger) Foslie (p. G21).

Section of outer part of a branch, × 50, showing the marginal perithallus with conceptacles and part of the medullary hypothallus. Agana Reef (D946), specimen A739.

4, 5. *Goniolithon reinboldi* Weber van Bosse and Foslie (p. G26).

Agana Reef (D946).

4. Section of crust, × 50, showing the irregular tissue and numerous conceptacle chambers. Specimen A759.
5. Detail, × 100, of crust with basal hypothallus, the irregular perithallic tissue and a conceptacle. Specimen A758.



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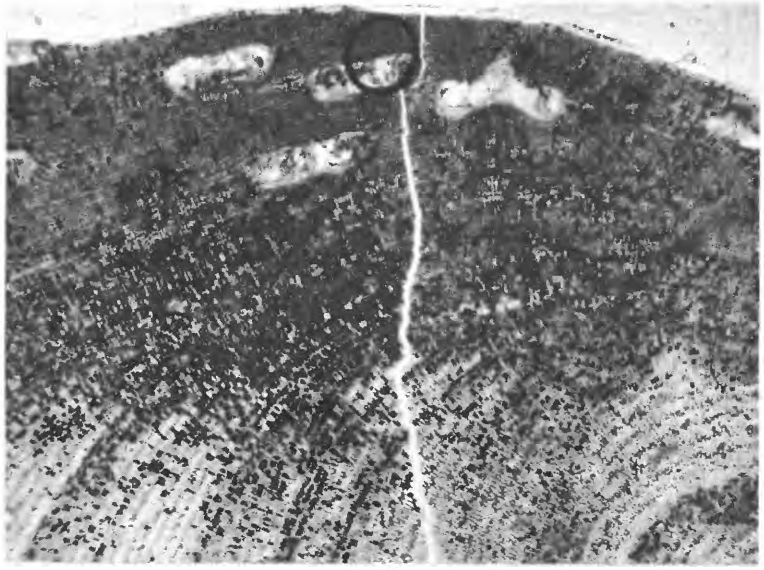

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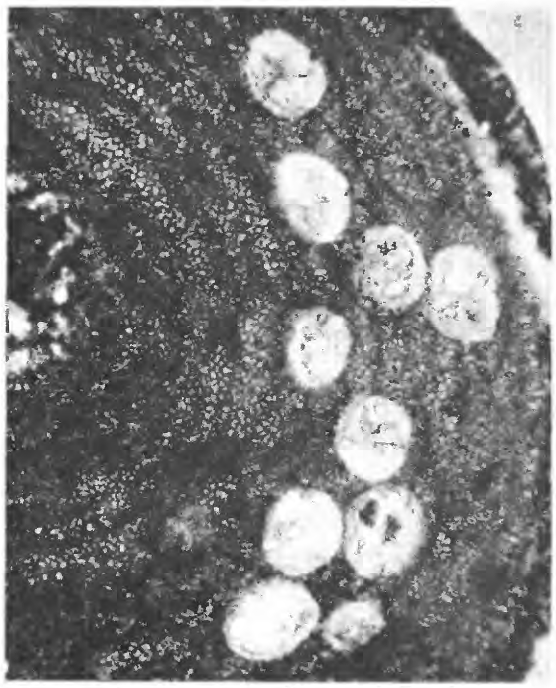

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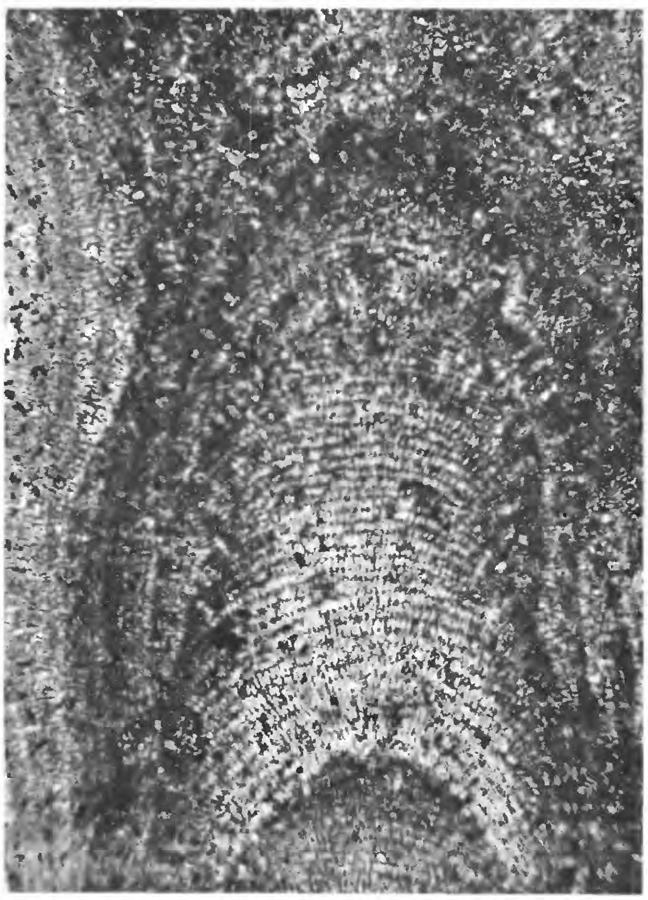

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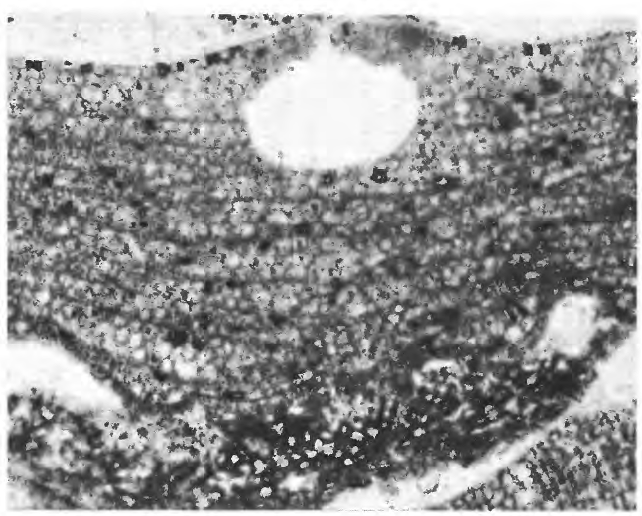

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RECENT *GONIOLITHON* AND *LITHOPHYLLUM*