

No. X.—THE LITHOTHAMNIA.

By M. FOSLIE.

(Communicated by Mr. J. STANLEY GARDINER, M.A., F.L.S.)

(Plates 19 & 20.)

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GREAT areas of the Indian Ocean, and of other oceans as well, are still unexplored or but little known as regards the occurrence of calcareous algæ of the groups of Lithothamnionæ and Melobesicæ. These algæ appear everywhere in suitable localities from Spitzbergen and Ellesmere Land in the north to South Victoria Land and Louis Philip Land in the south. They are known to occur in enormous quantities in many places, in the arctic and temperate zones often forming large banks, and in the tropics essentially contributing to the formation of reefs. Their occurrence in masses in fossil and subfossil layers further shows us what important part they have also played in former times. But our knowledge of the different species and of their geographical distribution is as yet rather imperfect, and only the circumstance that during these ten years upwards of 200 new species have been described shows their great abundance of forms.

During the Sealark Expedition Mr. J. Stanley Gardiner collected a rich material of these algæ in an area of the Indian Ocean from which they were hitherto almost unknown. This material he has kindly left me to determine. As to the occurrence of the algæ in the above area, he has given much interesting information*. Below I take permission to quote some of these particulars, with running comments stating the occurrence of different species in various places.

Of the thirteen species collected and mentioned below, two are new to science, viz. *Lithothamnion gibbosum* and *Lithophyllum Gardineri*. They have been provisionally described in 'Algologiske Notiser,' iii.

THE CHAGOS ARCHIPELAGO.

The parts explored of this Archipelago, from which Lithothamnia have been brought home, are the Salomon and Egmont Atolls. Mr. Stanley Gardiner remarks (*l. c.* p. 2):—
“The reefs of the Chagos are in no way peculiar, save in their extraordinary paucity of

* *Investigations in the Indian Ocean.*—First Report of the Committee, consisting of Sir JOHN MURRAY (Chairman), Mr. J. STANLEY GARDINER (Secretary), Captain E. W. CREAK, Professors W. A. HERDMAN, S. J. HICKSON, and J. W. JUDD, Mr. J. J. LISTER, and Dr. H. R. MILL, appointed to carry on an Expedition to investigate the Indian Ocean between India and Africa, in view of a possible land-connection, to examine the deep submerged banks, the Nazareth and Saya de Malha, and also the distribution of Marine Animals.—*British Association Report*, York, 1906.

animal life. Green weed, too, of every sort is practically absent. However, this barrenness is amply compensated for by the enormous quantity of Nullipores (*Lithothamnia*, &c.), incrusting, massive, mammillated, columnar, and branching. The outgrowing seaward edges of the reefs are practically formed by their growths, and it is not too much to say that, were it not for the abundance and large masses of these organisms, there would be no atolls with surface reefs in the Chagos. The lagoon shoals of Egmont are covered by them, and are the only lagoon reefs in the Chagos that reach the surface; having once done so, they die and become hollowed out, finally resembling miniature atolls." Concerning Salomon, which was carefully surveyed, he remarks that "its face was everywhere singularly barren; *Lithothamnion*, *Polytrema*, and, of course, reef-corals were not obtained below 50 fathoms." Further, he observes in another paper * as to the Chagos:—"Individually the reefs present the same general characters as those of the Maldives. They differ, however, in detail in that their outgrowing edges are, *practically entirely*, formed of Nullipores, though corals are important builders from 5 to 30 fathoms." (Cp. the photo *l. c.* p. 331, from Ile de la Passe, Salomon Atoll, showing Nullipore buttress growing out from the seaward edge of the reef.)

The species of calcareous algæ of the group in question occurring so numerously in the Chagos are *Lithophyllum onkodes*, *L. craspedium*, *L. Gardineri*, and *Goniolithon frutescens*. These species thus are important reef-builders, especially the two or three first-mentioned ones, comprising the incrusting, massive, mammillated, and columnar forms, whereas the species last mentioned is a more delicate branching species. It is possible that, besides the species mentioned, other species are also to be found, which the collector may have failed to notice. If so, they are certainly playing no prominent part in the formation of reefs.

At Diego Garcia three species have been collected by the German 'Valdivia' Expedition †, viz.:—small specimens of *Lithoph. onkodes* attached to corals, a specimen of the small crust-like *Lithothamnion simulans* (earlier only known from the Gulf of Siam), and a young specimen of *Lithophyllum Kaiseri* (*pallescens*) mentioned below.

CARGADOS CARAJOS.

Near Cargados is, according to the Report (*l. c.* p. 5), "a wonderfully constant depth of 30–35 fathoms over the body of the bank . . . the bottom was either coral rubble, white sand, shell rubble, or weed. The three latter occurred only in the central parts of the bank . . . From this rubble, which is of a bright red colour, due to an encrusting nullipore, we obtained a rich variety of animal life, nearly all forms tinted with red."

In this bank, where more than 30 hauls were made, *Lithothamnion indicum* occurred in four localities (No. B 8, B 9, B 13, and B 14), and in two of the same localities (No. B 8 and B 14) also *Lithothamnion australe*, both together with a number of young, stunted or dead and undeterminable specimens not unlikely belonging to the first-named species.

* J. Stanley Gardiner, "The Indian Ocean," *The Geographical Journal*, October and November, 1906, p. 323.

† The species collected by this expedition at Diego Garcia and Mahé will be mentioned by Mr. Th. Reinhold in *Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition.*

Besides, in one of the localities (No. B 9), as well as in two others (No. B 28 and B 29), have been collected three larger pieces of calcareous rubble with young crusts of undeterminable Lithothamnia.

SAYA DE MALHA BANKS.

From a depth of 55 fathoms (No. C 15) was brought up several specimens of *Lithothamnion australe* growing gregariously with *Lithothamnion gibbosum*. Here also occurred numerous fragmentary or dead and undeterminable specimens, some of which perhaps are stunted forms of *Lithothamnion indicum*. Several of these specimens are in part covered with Squamariaceæ. In a depth of 26 fathoms (No. C 16) was dredged a solitary specimen of *Archæolithothamnion erythræum* and three specimens of *Lithophyllum Okamurai* f. *ptychoides*, together with a calcareous Squamariacea, *Halimeda*, crust-like Foraminifera, &c. In addition, from a depth of 29 fathoms (No. C 19) was picked up one specimen perhaps belonging to *Lithophyllum Okamurai* f. *ptychoides*, in company with a few stunted and undeterminable forms, a calcareous Squamariacea, and some coral-rubble and other rubble with crusts of Lithothamnia, Squamariacea, Foraminifera, &c.

COETIVY.

About this island is remarked in the Report (*l. c.* p. 6):—"Although situated only about 130 miles to the south of the Seychelles Islands, the land fauna and flora are almost the same as on the islands of the Chagos Archipelago, being scarcely richer On the other hand, the reefs of Coetivy showed in every group of marine animals a more varied fauna than those of the Chagos, while very nearly all the species of the latter seemed to be present. The reef on the eastern or seaward face of the island was of a rather different character from any we had as yet seen, being covered with *Zostera* *. There was also on the same part a considerable variety of algæ, but the edge and outer slope were, as elsewhere, covered by corals and nullipores."

Also with reference to the calcareous algæ in question, Coetivy shows almost the same state of things as the Chagos. The following species have been collected here:—*Lithophyllum onkodes*, particularly occurring on the western reef, *Lithophyllum craspedium*, *L. Gardineri*, and *Goniolithon frutescens*, mainly on the eastern reef, but *Lithophyllum craspedium* apparently less abundant than in the Chagos.

PROVIDENCE.

A number of small but rather well-developed specimens of *Lithothamnion indicum* have been picked up from a depth of 29–30 fathoms (No. D 3 and D 24), and from a depth of 50–78 fathoms (No. D 4) some stunted specimens of the same species together with some undeterminable ones.

* [This is a mistake for *Cymodocea*.—J. STANLEY GARDINER.]

AMIRANTE.

As to the Amirante Bank, Mr. Stanley Gardiner remarks in *Ind. Oc.* (p. 332): "Its surface is decidedly irregular, as masses of growing corals and nullipores may be found anywhere, but nowhere attains a greater depth than 37 fathoms. On its edges, where nullipores flourish, there is perhaps a greater tendency to growth, but the term 'atoll' cannot as yet be applied to it."

It seems as if well-developed *Lithothamnia* are not abundant in this place, apart, however, from its surface-reefs, where *Lithothamnia* probably occur, though they have not been collected. Thus in a depth of 45–60 fathoms (No. E 27) has been dredged a solitary specimen of *Lithothamnion purpurascens* together with a few pieces of small calcareous rubble with young and undeterminable crusts of *Lithothamnia* and a crust-like Foraminifer in habit reminding of certain forms of *Lithothamnia* *. From a depth of 30 fathoms (No. E 21) have been brought home small specimens of a calcareous Squamariacea and a Foraminifer of the same kind as mentioned above. Besides, from a depth of 20–25 fathoms (No. E 13) an uncertain stunted specimen of *Lithothamnion indicum*, and from about the same depth (No. E 3) a few pieces forming a conglomerate of stunted, undeterminable *Lithothamnia*, corals, Bryozoa, as well as the above-mentioned Foraminifer.

THE SEYCHELLES ARCHIPELAGO.

According to Mr. Stanley Gardiner (*l. c.* p. 456), this Archipelago comprises two coral-islands and seventeen granite-islands. "Immediately around the granite-islands are here and there fringing reefs, especially in bays . . . Nullipores practically do not enter into their composition, and such coral masses as grow are of comparatively small size. Indeed, most owe their origin to the piling up of calcareous and siliceous sand in bays, or to the cutting down and removal of the granite above the sea-level. Yet the absence of nullipores is the important point, nothing else really being wanting for the formation of true coral flats. In no case do these calcareous plants grow well in lagoons or enclosed waters, and their absence from the centre of the Seychelles bank—they grow well on the edges—is presumably due to the churning up of the water and to the removal from it of all carbonic acid gas by seaweeds, etc., before it reaches the islands."

In a depth of 31 fathoms (No. F 2) have been taken three well-developed specimens of *Archæolithothamnion timorense* and two rather stunted specimens of *Lithothamnion indicum*, in company with a few pieces of calcareous rubble partly covered with Squamariacea, partly with the Foraminifera mentioned above. Some specimens of *Lithophyllum Kaiseri* and a couple of specimens of *Lithophyllum moluccense* have been brought home from the reef of Praslin Island. In addition, the German 'Valdivia' Expedition † collected on the coast, or in the neighbourhood, of Mahé Island a

* A similar Foraminifer seems to be abundant at several places in the West Indies, particularly St. Jan and St. Croix, also here growing gregariously with *Lithothamnia*. It is presumed to represent a species of the genus *Gypsina*.

† Cf. the footnote, p. 178.

small specimen of *Goniolithon Fosliei* attached to a piece of coral, together with *Lithothamnion simulans*, small and not well-developed (partly uncertain) crusts of *Goniolithon myriocarpon*, *Lithophyllum Yendoi* f. *mahëica*, and a very young specimen of *Lithophyllum affine* (i. e. *L. Kaiseri* (*pallescens*), cf. below).

On comparing the area in question with other parts of the Indian Ocean we find a close correspondence particularly with the Maldives, the only area in this ocean which was formerly comparatively well known, owing to the collections made by Mr. Stanley Gardiner in the years 1899-1900. This correspondence chiefly concerns the three reef-building species mentioned above, viz., *Lithophyllum onkodes*, *L. craspedium*, and *Goniolithon frutescens*—the fourth species, *Lithophyllum Gardineri*, having hitherto only been found in the Chagos and at Coetivy.

As is observed below, the forms of *Goniolithon frutescens* occurring in the area in question are more consistent with forms of the same species from the Maldives than the forms of the species occurring at the Ellice Islands (Funafuti) in the Pacific Ocean. The same is the case with *Lithophyllum onkodes* and *L. craspedium*, which are also in structure fully consistent with specimens of the same species from the Maldives, whereas, in this respect particularly, the specimens from the area in question and some of those collected at the Maldives are in part a little diverging from the specimens picked up at the Ellice Islands (cf. Lithoph. Mald. & Laccad. p. 468).

Thus in rather great areas of the Indian Ocean these three or four species are shown to be important reef-builders in the littoral region and in the uppermost part of the sublittoral region. Besides, also *Lithophyllum Kaiseri* (*pallescens*) and other species here and there contribute to the formation of reefs, but apparently in far less degree than the species mentioned. Farther down in depths of up to about 60 fathoms, *Lithothamnion indicum* as well as *L. australe* seem to be rather essential builders of new strata in places suitable for them, partly alone, partly gregariously, and here and there associated with other species in smaller number.

To judge from our present knowledge of the Lithothamnia within the tropics, it seems that in places where these algæ occur in such abundance and so large masses that atolls with surface-reefs are practically entirely formed by them, as, e. g., in the Chagos, or in places where they are of essential importance for the consolidation of corals into true reefs the number of species is frequently small, but each of them appearing in an enormous number of individuals. Besides in the Chagos, this is the case at Coetivy, at certain places in the Maldives, and at the Ellice Islands (Funafuti), as well as the Gilbert Islands in the Pacific Ocean. In banks which are formed of freely-developed branching specimens in the lowermost part of the littoral region, as, e. g., at Haingsisi in the Malay Archipelago *, or, more frequently, at different depths in the sublittoral region, one species will predominate †. On the other hand, in places where the Lithothamnia do not appear in such quantities, on exposed as well as on protected and suitable localities, a larger variety of species is often found.

* Cf. A. Weber van Bosse in 'Siboga' Exp. n. lxi. livr. 18. p. 4.

† In boreal or arctic areas such banks are often formed of only one species.

There seems to be a considerable correspondence as to the Lithothamnia in the Indian Ocean and large areas of the Pacific Ocean within the tropics. This concerns several of the species themselves as well as their mode of occurrence, peculiarly such as determine the general aspect of the vegetation. Thus the three reef-building species mentioned above occur at the Ellice Islands, one of them also at the Gilbert Islands, nearly under the same conditions as at the localities mentioned in the Indian Ocean. At the former islands *Lithophyllum onkodes* is known from, *e. g.*, "reef-platform," "ocean-platform," "thick growth of nullipore from the shoals in the lagoon," and "consolidated rock, forming platform, Hurricane Beach" at Funafuti, from Fualopa and from Pava Islet. *Lithophyllum craspedium* partly grows gregariously with the former species or with *Goniolithon frutescens*, partly alone, *e. g.*, "ocean-platform" Funafuti, and at Fualopa. Besides, at Onoatoa, Gilbert Island, it is "a very abundant type and the most important reef-former," no living coral having been seen there, but "everywhere on the lagoon and ocean-face immense masses" of this calcareous alga. *Goniolithon frutescens* occurs, *e. g.*, on the ocean-platform of Funafuti, at Fualopa, and "is very abundant on the leeward (W.) islets of Funafuti Atoll." It appears on the beach S. of the village, Funafuti lagoon, and on the lagoon-platform at Funafala. Here it is "an important rock-former" and it is "also an important reef-former." Some species, however, which are common to both oceans seem to be more largely distributed in one than in the other, and as a matter of course there are several species which are as yet known only from one of these oceans, and which are rather local and seem to appear in no large numbers anywhere.

Our knowledge of the occurrence of these calcareous algæ in both oceans is, however, as yet so inconsiderable that at present no thorough comparison can be made which can lay claim to any particular interest.

CORALLINACEÆ, (Gray) Harv.

Tribe LITHOTHAMNIONEÆ, Fosl.

Genus LITHOTHAMNION, Phil. (emend.).

Subgenus EULITHOTHAMNION, Fosl.

1. *Lithothamnion purpurascens*, Fosl.

'Siboga' Exp. n. lxi. livr. 18 (1904), p. 18, in obs.

Lithothamnion funafutiense f. *purpurascens*, Fosl. Corall. in Fl. Koh Chang, in Bot. Tidsskr. xxiv. (1901) p. 18.

With some reservation, I refer a solitary specimen to the above species. It is 3-4 cm. in diameter, and surrounds irregularly crust-like calcareous masses of some kind or other, with rather numerous excrescences mostly small and irregularly wart-like, some of which at least have risen owing to the unevenness of the substratum. It is rather richly furnished with conceptacles of sporangia, which are 400-700 μ in diameter, and essentially agree with those of the species in question, intersected with about 100 muciferous canals.

Conceptacles of cystocarps do not occur. The specimen in structure also mainly resembles *Lithothamnion purpurascens*, forming feebly-marked layers of tissue. It has been dredged at a depth of 45–60 fathoms together with a couple of stunted pieces of another calcareous alga and a crust-like Foraminifer.

Locality. Indian Ocean: the Amirante Bank, No. E 27 (*Stanley Gardiner*).

Area. The Gulf of Siam.

2. *Lithothamnion indicum*, Fosl.

Kgl. Norske Vidensk. Selsk. Skrift. 1906, n. 8 (1907), p. 7 (in Norwegian).

Resembles *Lithoth. fruticosum* f. *crassiuscula*, but the bottom of the conceptacles of sporangia almost plane or feebly convex according to the shape of the layers of tissue, and particularly the lower corners in a median-vertical section often not or but feebly rounded; conceptacles of cystocarps almost superficial, conical.

f. *typica*.

Syn. *Lithothamnion fruticosum* f. *crassiuscula*, Fosl. Lithoth. Mald. & Laccad. in Gardiner, Fauna and Geogr. of the Mald. & Laccad. Archip. i. p. 464, pl. 24. figs. 2, 3; Lithoth. Adriat. Meer. in Wissensch. Meeresuntersuch. vii. (1905) Helgoland, t. f. 1. figs. 7–9; Lithoth. in 'Siboga' Exp. n. lxi. livr. 18, p. 19, pl. 2. figs. 1–4.

f. *subtilis*, Fosl.

L. c.

Shape and size of the branches corresponding to *Lithoth. fruticosum* f. *clavulata*.

Syn. *Lithothamnion fruticosum* f. *clavulata*, Fosl. Corall. in Fl. Koh Chang, in Bot. Tidsskr. xxiv. (1901) p. 17; Lithoth. Adriat. Meer. *l. c.* t. 1. figs. 16–17; Lithoth. in 'Siboga' Exp. *l. c.* pl. 2. figs. 5–9.

This alga has previously been referred to *Lithoth. fruticosum*, which it resembles both in habit and as to the form and size of the conceptacles of sporangia,—apart, however, from the fact that these organs, as I have earlier observed, in *Lithoth. indicum* for the most part show a more even bottom with sharper corners than usual in *Lithoth. fruticosum*. This is not, however, a well-defined character, as typical *Lithoth. fruticosum* shows sometimes the same state of things as to these organs, and, on the other hand, specimens of *Lithoth. indicum* occur, especially feebly developed ones, in which the conceptacles in a median-vertical section now and then show nearly the same form as in *Lithoth. fruticosum*. As to the cystocarpic conceptacles, I remarked in Lithoth. Mald. & Laccad. *l. c.*, that the only point of difference from *Lithoth. fruticosum* "appears to be the fact that the conceptacles of cystocarps are more acute than generally seen in specimens from the region last named" (the Mediterranean and the Adriatic). The specimens in which these organs were found corresponded, however, with a rather delicate and not well developed f. *clavulata*. Therefore I could attach no special importance to this character. In 'Siboga' Exp. n. lxi. p. 22, I also mentioned a form in which I found a few cystocarpic conceptacles which proved a little diverging from those of typical *Lithoth. fruticosum*. But these specimens also were not well developed, in part even quite stunted and bearing only one or two of the organs in question. I have not till quite recently succeeded in finding them well developed and occurring in some

numbers in typical specimens from Australia, and less well developed and scanty in specimens from Providence. They diverge from the same organs in *Lithothamnion fruticulosum* by being almost superficial and conic or almost conic, always more pointed than in the latter species. They are finally quite dissolved, and thus they are not overgrown by new-formed tissue, as is often the case in *Lithoth. fruticulosum*. Accordingly I must consider the Indian and Pacific forms as independent species.

In the area in question *Lithoth. indicum* occurs in comparatively great depth. But it is generally smaller and not so vigorous and well developed as, *e. g.*, in Port Philip Bay, on the south coast of Australia, where it seems to be abundant in a depth of 2–5 fathoms. Thus at Cargados Carajos and at Providence it attains to a size of only about 4 cm. Here it bears sporangia in the months of August and September. In the former of these localities it occurs scantily in a depth of 30 fathoms, partly associated with *Lithoth. australe*, but particularly with rather numerous indeterminable and mostly dead calcareous algæ, in part attached to shells of mussels. At Providence it also occurs in a depth of about 30 fathoms and in rather large numbers. Here it has also been picked up from a depth of 50–78 fathoms, though only a few certain specimens together with some uncertain and indeterminable ones. From Amirante has been brought home an uncertain specimen, and from the Seychelles have been brought home two specimens not well developed.

Localities. Indian Ocean: Cargados Carajos, No. B 8 (30 fathoms), No. B 9 (30 fathoms), No. B 13 (30 fathoms), No. B 14 (30 fathoms); Providence, No. D 3 (29 fathoms), No. D 4 (50–78 fathoms), No. D 24 (30 fathoms); Amirante, No. E 13 (20–25 fathoms), uncertain; the Seychelles, No. F 2 (31 fathoms) (*Stanley Gardiner*).

Area. Mauritius; the Maldives; the south coast of Australia (Port Philip Bay); and several places in the Pacific Ocean, particularly the Malay Archipelago.

3. *Lithothamnion gibbosum*, Fosl.

Kgl. Norske Vidensk. Selsk. Skrift. 1906, n. 8 (1907), p. 7 (in Norwegian).

Thallus freely developed at the bottom, roundish, 1.5–4 cm. in diameter; branches subdichotomous, radiating from the centre, short, frequently crowded, partly rather anastomosing, partly not, subfastigiate, upper parts irregularly roundish-thickened or subcompressed, knotty, 2–7 mm. thick, smooth, and feebly shining; conceptacles of sporangia convex, but little prominent, 400–650 μ in diameter; sporangia unknown.

f. *parvula*, Fosl.

L. c.

Thallus 1.5–2 cm. in diameter, branches 2–3 mm. thick.

f. *crassa*, Fosl.

L. c.

Thallus 3–4 cm. in diameter, branches 4–7 mm. thick.

In a median section of a branch the medullar hypothallic cells are mostly 18–25 μ or up to about 30 μ long, and 11 (9)–14 μ broad. The perithallic cells are partly vertically

elongated, 11–18 or up to 22 μ long, and 9–11 or up to 14 μ broad, partly and chiefly in the external layers often subsquarish, about 9 μ in diameter, here and there a little horizontally elongated. The cells, as a general rule, are rather thick-walled, in part forming layers of tissue rather strongly defined.

The form *parvula*, which possibly represents the typical form of the species, bears in habit a considerable resemblance to small specimens of *Lithophyllum racemus* f. *typica*. It also approaches certain forms of *Lithoth. fruticosum*, but the surface is smoother and, at any rate partly, feebly shining. The alga is freely developed on the bottom; but when it comes into contact with other calcareous algæ or other detached objects it partly develops a feeble crust, like several other species (*cf.* ‘Siboga’ Exp. n. lxi. p. 41).

Of the form *crassa* only a single specimen was found, which had also been lying loose at the bottom. In habit this form somewhat approaches *Lithoth. brachycladum* from the West Coast of Africa, *Lithoth. validum* from the Pacific Coast of North America, and *Lithoth. floridanum* from Florida, a group of species distinguished by coarse and short branches. Also as to structure it comes near to the species last mentioned.

In this respect it also, as well as f. *parvula*, approaches *Lithoth. indicum*. The form in question bears a great resemblance in habit to certain forms of *Arch. erythræum* (*cf.* ‘Siboga’ Exp. n. lxi. pl. 5. figs. 8, 9).

In both forms a partial decortication of the external layers of tissue of the branches occurs here and there rather closely recalling dissolved sori of sporangia of *Archæolithothamnion*.

Only the single specimen of f. *crassa* bears a few conceptacles of sporangia. The conceptacles finally, at any rate now and then, become overgrown by new-formed tissue, and are in a median-vertical section rather flat-bottomed with corners in part scarcely rounded. A few specimens of f. *parvula* show scars from dissolved conceptacles.

The species occurred at a depth of 55 fathoms, associated with *Lithoth. australe* and Squamariacea.

Locality. Indian Ocean: Saya de Malha, No. C 15 (*Stanley Gardiner*).

4. *Lithothamnion australe*, Fosl.

Lithothamnion coralloides f. *australis*, Fosl. Norw. Lithoth., in Kgl. Norske Vidensk. Selsk. Skrift. 1894 (1895), p. 92, ex parte; New or Crit. Lithoth., l. c. 1899, n. 5 (1900), p. 8, figs. 6–7.

Lithothamnion australe, Fosl. Rev. Syst. Surv. Melob., l. c. 1900, n. 5, p. 13; ‘Siboga’ Exp. n. lxi. livr. 18, p. 24, pl. 2. figs. 10–62.

As to the rather uncertain circumscription of this species and its varying forms, I refer to my remarks in ‘Siboga’ Exp. l. c. Also the specimens collected by Mr. Stanley Gardiner are sterile. Besides there are often developed thin crusts round specimens that are wholly or partly dead, and it is impossible to decide whether these crusts are new layers of accretion issuing from the part of the alga still living or, when the specimen is wholly dead, may represent young crusts of the same or another species.

The form occurring at Saya de Malha is most nearly connected with f. *tualensis*, in part, however, coarser than typical specimens of that form. There are also some finely branching specimens which very nearly approach f. *minutula* and are perhaps

identical with that form. Here the species occurs rather abundantly, particularly associated with *Lithoth. gibbosum* and numerous fragmentary undeterminable specimens. At Cargados Carajos it occurs in a form which partly also approaches f. *brachiata*, and some specimens are almost always consistent with typical f. *minutula*.

Localities. Cargados Carajos, No. B 8 (30 fathoms), No. B 14 (30 fathoms); Saya de Malha, No. C 15 (55 fathoms) (*Stanley Gardiner*).

Area. Several places in the Pacific Ocean, particularly the Malay Archipelago.

Genus ARCHÆOLITHOTHAMNION (Rothpl.), Fosl.

5. *Archæolithothamnion erythræum* (Rothpl.), Fosl.

Rev. Syst. Surv. Melob., in Kgl. Norske Vidensk. Selsk. Skrift. 1900, n. 5, p. 8.

Lithothamnion erythræum, Rothpl. in Bot. Centralbl. liv. (1893) p. 5.

Of this species only a single specimen occurs, feebly developed, attached to a piece of coral and coalesced with another calcareous alga which is undeterminable.

It was picked up from a depth of 26 fathoms, apparently in company with *Lithoph. Okamurai*.

Locality. Saya de Malha, C 16 (*Stanley Gardiner*).

Area. The Red Sea; the Gulf of Aden; the Maldives, and many places in the Pacific Ocean.

6. *Archæolithothamnion timorense*, Fosl.

'Siboga' Exp. n. lxi. livr. 18, p. 42, pl. 8. figs. 1-11.

Of the above species three specimens were brought home, which most nearly resemble figs. 4 and 11, *l. c.* They were dredged at a depth of 31 fathoms and provided with sporangia in October.

Locality. The Seychelles, No. F 2 (*Stanley Gardiner*).

Area. Timor and a few other places in the Pacific Ocean.

Tribe MELOBESIEÆ, Aresch. (mut. char.).

Genus GONIOLITHON, Fosl.

Subgenus EUGONIOLITHON, Fosl.

7. *Goniolithon frutescens*, Fosl.

Calc. Alg. Funafuti, in Kgl. Norske Vidensk. Selsk. Skrift. 1900, n. 1, p. 9.

The forms of this species occurring on the reefs of the Salomon and Egmont Atolls in the Chagos Archipelago and at Coetivy are generally more finely branching than at Funafuti, the place where the alga was first found. In this respect they are most closely connected with the forms from the Malay Archipelago figured in 'Siboga' Exp. n. lxi. pl. 10, but they are mostly more densely branching. On the other hand, a couple of small specimens from a lagoon shoal at Egmont are of about the same coarseness as

those from Funafuti, though more densely branching than the typical form as it appears at Funafuti and at the Maldives (*cf.* Fosl. Lithoth. in Gardiner, Mald. & Laccad. i. pl. 25. fig. 4)*. The species is probably more densely branched, the more exposed the locality is in which it is growing. Almost all the specimens collected are so far most nearly connected with *f. congesta* (*cf. op. c.* pl. 25. figs. 5, 6). Several of them, however, bear branches compressed or flabellate, for which reason they are to be referred to *f. flabelliformis*, though they are not wholly consistent with typical specimens of this form. Besides, some specimens approach much more to *f. subtilis* (*cf.* 'Siboga' Exp. n. lxi. pl. 10. figs. 12, 13). *Gon. frutescens* thus proves to be a species varying much, like many other calcareous algæ. This is no doubt partly due to local conditions.

The alga appears to have grown in association with *Lithoph. Gardineri*, several of the specimens brought home having been accrete with that species or with corals. It probably occurs in large numbers, particularly at the Salomon Atoll and at Coetivy. At the former locality and at Egmont Atoll it seems for the most part to be sterile in the months of May and June, while some are richly fructifying at Coetivy in September.

Localities. Chagos Archipelago; Salomon Atoll, reef; Egmont Atoll, reef and lagoon shoal; Coetivy, E. reef and other places (*Stanley Gardiner*).

Area. The Maldives and Laccadives, and some places in the Pacific Ocean.

Genus LITHOPHYLLUM, Phil. (emend.).

Subgenus EULITHOPHYLLUM, Fosl.

8. *Lithophyllum Okamurai*, Fosl.

Five new Calc. Alg., in Kgl. Norske Vidensk. Selsk. Skrift. 1900, n. 3, p. 4.

f. ptychoides, Fosl.

Kgl. Norske Vidensk. Selsk. Skrift. 1906, n. 8 (1907), p. 29 (in Norwegian).

This form is nearly connected with *f. trincomaliensis* from Ceylon, but diverges from it by being less branching and by having partly smaller cells. The specimens are rather encumbered with extraneous objects and particularly much attacked by worms. In consequence they are somewhat stunted and bear conceptacles sparsely. Also the conceptacles have been attacked by organisms, and consequently sporangia are not to be found. Conceptacles overgrown by new-formed tissue, on the other hand, occur in rather large numbers.

The forms hitherto known of *Lithoph. Okamurai* occur in the littoral region or in shallow water, whereas *f. ptychoides* is found in a depth of about 26 fathoms.

Locality. Saya de Malha, No. C 16 (26 fathoms), and No. C 19 (29 fathoms), uncertain (*Stanley Gardiner*).

Area. Ceylon, and several places in the Pacific.

* J. Stanley Gardiner, 'The Fauna and Geography of the Maldive and Laccadive Archipelagoes,' vol. i. part 4.

9. *Lithophyllum Kaiseri*, Heydr.

Lithothamnion Kaiserii, Heydr. in Ber. Deutsch. bot. Ges. xv. (1897) p. 64.

Lithophyllum Kaiserii, Heydr. *l. c.* p. 412.

f. *typica*.

Lithophyllum Kaiserii, Heydr. in Ber. Deutsch. bot. Ges. xv. (1897) p. 412.

f. *subplicata*, Fosl.

Vidensk. Selsk. Aarsber. for 1900, p. 14.

Syn. *Lithophyllum madagascarense*, Heydr. Nouv. Mélob., in Bull. Mus. Hist. Nat. Par. viii. (1902) p. 473.

As I have already pointed out, it is scarcely possible to draw a line between *Lithoph. Kaiseri* and *Lithoph. pallescens*, Fosl., the latter occurring in the Gulf of California. The same is the case with *Lithoph. affine*. It proves more and more evident that both *L. Kaiseri* and *L. affine* must be sunk under *Lithoph. pallescens*, while, on the other hand, this species is very nearly allied to *Lithoph. racemus* and *Lithoph. Okamurai*. I do not unite them here, as I must first go over the material, now somewhat increased, which I have not yet had an opportunity of doing. Also *Lithoph. madagascarense*, Heydr. *, must be referred to the same species. According to the type specimen, which by the kindness of Mr. P. Hariot I have had the opportunity of examining, it only represents a coarse f. *subplicata*.

The specimens collected are rather well developed and up to about 8 cm. in diameter; but they are partly burdened with other algæ which have attached themselves to them. They belong partly to the typical form of the species, partly to f. *subplicata*. In the month of November they bore ripe sporangia.

Locality. The Seychelles Archipelago: Praslin Island, reef (*Stanley Gardiner*) †.

Area. Madagascar, Réunion, Mauritius, and Rodriguez; the Red Sea; the Maldives and the Laccadive groups; Cocos-Keeling Island; and some places in the Pacific Ocean.

10. *Lithophyllum moluccense*, Fosl.

On some Lithoth., in Kgl. Norske Vidensk. Selsk. Skrift. 1897, n. 1, p. 12; Calc. Alg. Funafuti, *l. c.* 1900, n. 1, p. 10; New Melob., *l. c.* 1900, n. 6 (1901), p. 12; 'Siboga' Exp. n. lxi. livr. 18, p. 67, pl. 12. figs. 2-13.

Of this species there have been brought home but two small specimens, rather feebly developed, attached to pieces of corals. One of them is most nearly connected with f. *pygmæa*, and the other belongs to f. *flabelliformis*. The alga was furnished with ripe sporangia in the month of November.

Locality. The Seychelles Archipelago: Praslin Island, reef (*Stanley Gardiner*).

Area. Mauritius, and several places in the Pacific Ocean.

* F. Heydrich, "Quelques nouvelles Mélobésiées du Muséum d'Histoire Naturelle de Paris," Bulletin du Muséum d'Histoire Naturelle, viii. (1902) p. 473.

† Also collected by the German 'Valdivia' Expedition at Mahé (*Lithoph. affine*) and at Diego Garcia (*Lithoph. Kaiseri*).

Subgenus POROLITHON, Fosl.

11. *Lithophyllum onkodes*, Heydr.

Ber. der Deutsch. bot. Ges. xv. (1897) p. 410.

Lithothamnion onkodes, Heydr. Neue Kalkalg. (1897) p. 6, partim (Bibl. Bot. vii. Heft 41).

This no doubt important reef-builder occurs in the Chagos Archipelago and at Coetivy in an unusually vigorously developed form. It forms massive and more or less uneven crusts, and probably covers the reefs to a considerable extent. It often also incrusts other objects and on the whole rather varies in shape. Thus it sometimes even forms small cap-shaped coverings on the apices of branches of corals. The species is generally of very firm consistency, and therefore rather heavy proportionately to the size.

At Salomon Atoll it was also picked up from a depth of 10–14 fathoms in the lagoon, incrusting shells of mussels or pieces of coral, but the specimens, however, are small and feebly developed. It is not known whether specimens vigorously developed occur at this depth.

In Lithoth. Mald. & Laccad. p. 468, I mentioned that in a vertical section of some of the crusts "the cells are here and there larger than is generally found, more regular, and with their longest diameter in a vertical direction." This is also in part the case with the specimens in hand. In several of the most vigorously developed ones the cells also form here and there rather distinct layers of tissue, sometimes even irregularly alternating short and long cells. Frequently small groups of enlarged cells are numerous.

Old specimens of this species are mostly sterile, but younger ones are provided with reproductive organs in the months of May and June at Salomon and Egmont Atolls, and at Coetivy in September.

Localities. Chagos Archipelago: Salomon Atoll, reef, and lagoon 10–14 fathoms; Egmont Atoll, reef; Coetivy, W. reef (*Stanley Gardiner*).

Area. The Mauritius; the Maldives and Laccadives; Ceylon; and widely dispersed in the Pacific Ocean.

12. *Lithophyllum craspedium*, Fosl.

New or Crit. Calc. Alg., in Kgl. Norske Vidensk. Selsk. Skrift. 1899, n. 5 (1900), p. 26 Lithoth. in Gardiner, Mald. & Laccad. i. p. 466, pl. 25. figs. 1, 2.

This species also appears to be an important reef-builder, forming, when most vigorously developed, sometimes almost columnar masses with coarse branches. The specimens brought home partly belong to the typical form of the species with branches almost terete, but rather anastomosing, with transitions to f. *compressa*, partly to f. *abbreviata* with smaller and shorter branches.

As is remarked below under *Lithoph. Gardineri*, the latter and *Lithoph. craspedium* are closely connected with each other, though *Lithoph. craspedium* is in general much coarser and a more vigorously developed alga. There are, however, cases in which they are with certainty distinguishable only by their anatomic structure. In *Lithoph. Gardineri*, in a median section of a branch, the medullar hypothallic cells prove to

alternate, forming one row of short cells and two or four or sometimes up to seven rows of long ones. Also in *Lithoph. craspedium* the cells are alternately short and long, but the latter form only one or two, sometimes three, rows. The short cells in the species in question are subquadrate or vertically elongated, 9-14 μ long and 7-11 μ broad, the long ones 18-22, sometimes up to 29 by 7-11 μ . The perithallic cells are subquadrate, elongated vertically or horizontally, 7-11 μ , or up to 14 μ long in a vertical direction. Short groups of enlarged cells are frequently numerous.

The alga appears to occur most abundantly in the Chagos Archipelago, but it is found well developed also at Coetivy. It bears reproductive organs in the months of May, June, and September, but old specimens are, as usual, almost always sterile.

Localities. The Chagos Archipelago: Salomon Atoll, reef; Egmont Atoll, reef and reef-edge; Coetivy, E. reef.

Area. The Maldives and Laccadives; and the Ellice Islands (Funafuti) in the Pacific Ocean.

13. *Lithophyllum Gardineri*, Fosl., sp. n.

Ggl. Norske Vidensk. Selsk. Skrift. 1906, n. 8 (1907), p. 30 (in Norwegian).

Thallus forming masses partly and most frequently densely, partly somewhat spreadingly branching, 3-5 cm. high and 4-10 cm. in diameter, attached at a younger stage by a crust-like hypothallus 1-3 mm. thick, at an older stage the hypothallus often almost disappearing; branches repeatedly subdichotomous, frequently rather anastomosing, sometimes forming in the basal part an almost solid mass, subfastigate, terete or subcompressed, short or somewhat elongated, straight or somewhat curved, knotty or here and there developing short side-branches, 2.5-4, seldom up to 5 mm. thick, feebly tapering and rounded, or the apices roundish-thickened; conceptacles of sporangia convex, but little prominent, 240 (200)-360 μ in diameter; sporangia four-parted, 50-70 μ long and 30-40 μ broad (Pl. 19. figs. 1-4).

f. *subhemisphaerica*, Fosl., f. n.

Thallus almost hemispherical, about 15 cm. high and 22-25 cm. in diameter; branches crowded and rather anastomosing, subfastigate, short and rather curved, knotty, 2-3 mm. thick, with the apices rounded or subtruncate and sometimes depressed in the centre (Pl. 20).

f. *obpyramidata*, Fosl., f. n.

Thallus more or less obpyramidal, 4-6 cm. in diameter; branches frequently much anastomosing, subterete or compressed, with the apices roundish-thickened or subtruncate, often depressed in the centre, or irregularly dilated upwards and retuse (Pl. 19. figs. 5-8).

The typical form of this species, which I have named in honour of Mr. Stanley Gardiner, approaches in habit certain and particularly coarse forms of *Lithoph. Kaiseri* (cf. Pl. 19. figs. 1, 2, and Lithoth. in Mald. & Laccad. i. pl. 24. fig. 5). It is,

however, essentially, different from that species, peculiarly in structure. It is actually most nearly connected with *Lithoph. craspedium*. This is particularly the case with f. *obpyramidata*, which is sometimes hardly distinguishable from a *Lithoph. craspedium* f. *abbreviata* feebly developed, the latter sometimes showing as thin branches as those of f. *obpyramidata*. In structure, however, there is some difference between the two species, as the medullar hypothallic cells of *Lithoph. craspedium* form a row of short cells, rather regularly alternating with one or two or up to three rows of long ones, whereas in the species in question the corresponding long cells, as above mentioned, frequently form more rows. When these rows of elongated cells occur in numbers of six to seven, a longitudinal section sometimes gives the impression of a faint cup-shaped stratification, as is usual particularly in branching species of the genus *Lithothamnion*. The form *subhemisphærica* is vigorously developed and much larger than any of the other forms. The branches are a little thinner, more crowded, and more curved than is usual in the typical form. A single specimen only of this form is known from the reef of Egmont Atoll. There are also forms of *Lithoph. Gardineri* which bear in habit rather close resemblance to *Lithoph. craspedium* f. *subtilis*. The latter, however, is a form as yet insufficiently known, which may perhaps represent a separate species, but, being in structure in all essentials consistent with *Lithoph. craspedium*, is for the present to be regarded as a feebly developed or stunted form of this species.

Lithoph. Gardineri seems to occur abundantly on reefs, and particularly associated with *Lithoph. craspedium* and *Goniolithon frutescens*, sometimes coalescing especially with the species last mentioned. Specimens are also found coalesced with corals. No doubt it is an important reef-builder, though perhaps less so than *Lithoph. craspedium* and *Lithoph. onkodes*. The species seems to occur most numerously and best developed in the Chagos Archipelago, particularly on the reefs. Small specimens have been brought home from "Nullipore shoal in lagoon" of Egmont Atoll. However, it is also found well developed at Coetivy. But some of the specimens brought home from this locality have no doubt grown under conditions different from those at Salomon Atoll, partly appearing as a well-defined f. *obpyramidata*.

The species is scantily furnished with ripe sporangia in the month of September. Most of the specimens collected on Salomon Atoll in May-June are sterile or provided with empty conceptacles.

Localities. Chagos Archipelago: Salomon Atoll, reef, f. *typica*, f. *obpyramidata*; Egmont Atoll, reef and lagoon shoal, f. *typica*, f. *subhemisphærica*, f. *obpyramidata*; Coetivy, E. reef and other localities, f. *typica*, f. *obpyramidata* (*Stanley Gardiner*).

EXPLANATION OF THE PLATES.

All the figures from photographs about $\frac{2}{3}$ natural size.

PLATE 19.

Lithophyllum Gardineri, Fosl., f. *typica*.

Figs. 1-3. Specimens from Salomon Atoll, Chagos.

Fig. 4. A rather young specimen attached to a fragment of a decaying root : Coetivy.

Lithophyllum Gardineri, Fosl., f. *obpyramidata*.

Fig. 5. A specimen forming a transition to the typical form : Salomon Atoll, Chagos.

Figs. 6, 8. Specimens with much anastomosing and in part rather delicate branches : Egmont Atoll, Chagos.

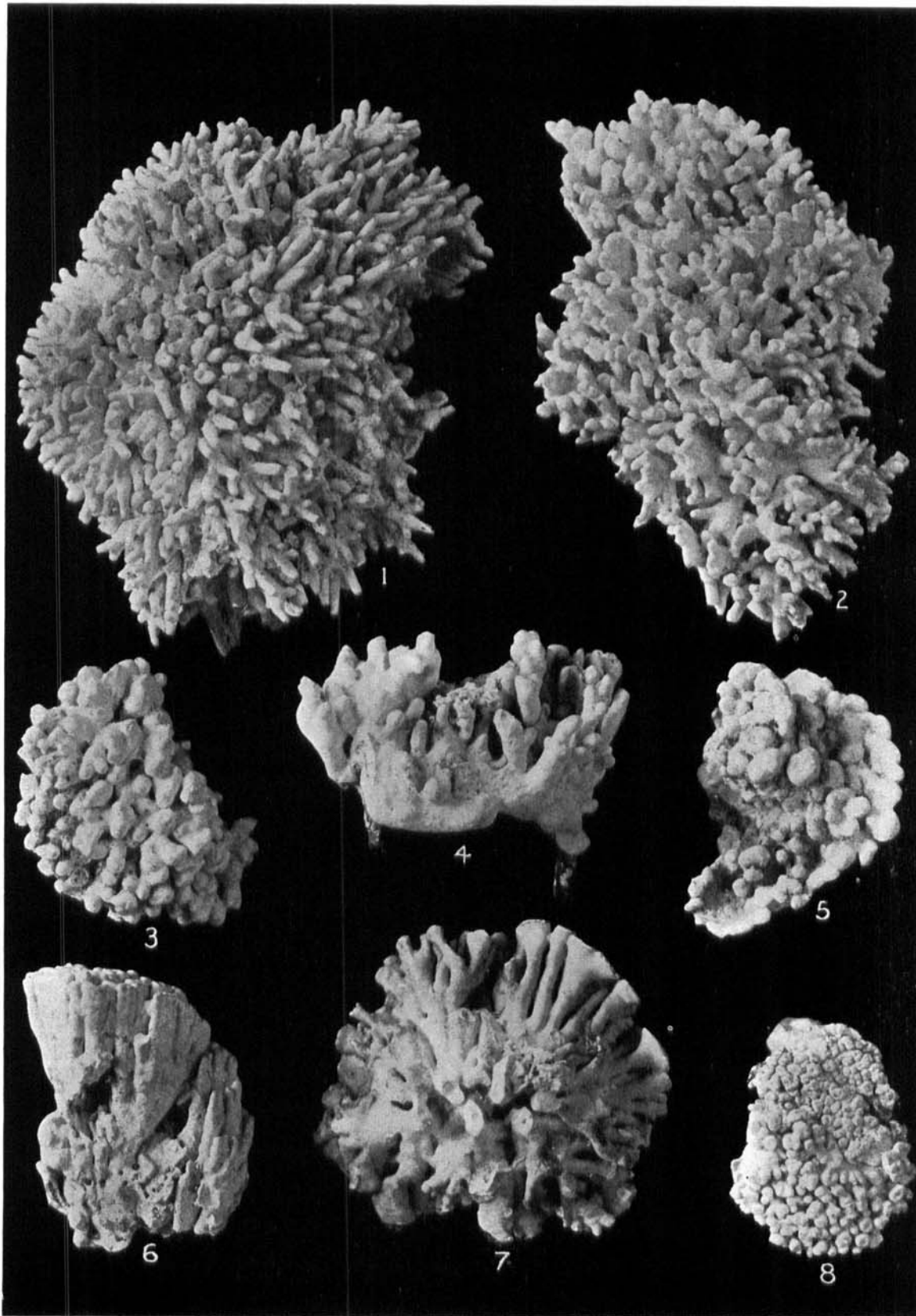
Fig. 7. A specimen seen from below, with the outer branches partly rather dilated at their ends : Coetivy.

PLATE 20.

Lithophyllum Gardineri, Fosl., f. *subhemisphærica*.

Part of the alga seen from above : Egmont Atoll, Chagos.

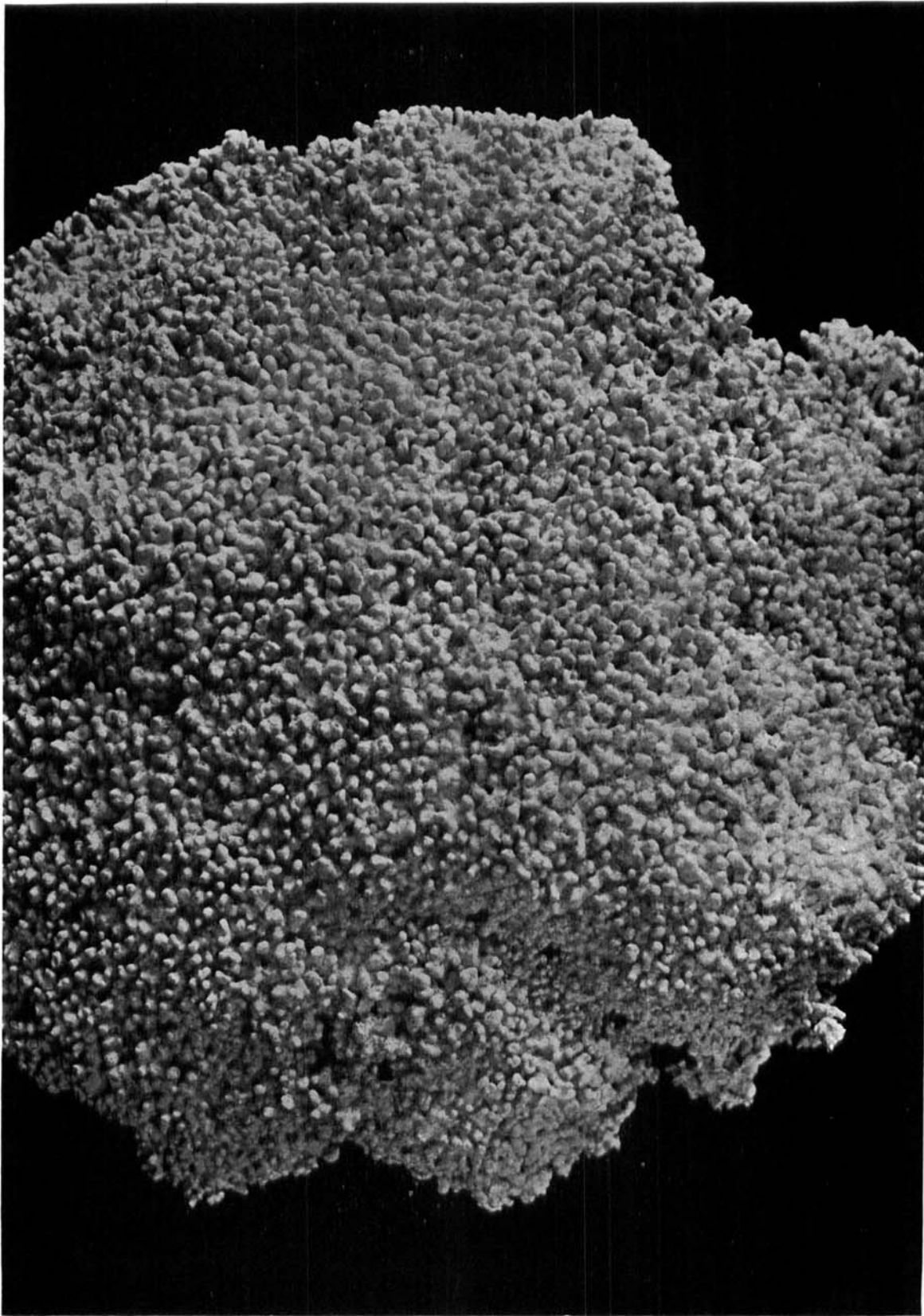
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pp. 93-108, plates 15 and 16, as indicated by the pagination at the foot of each page.]



Foslie photo.

LITHOPHYLLUM GARDINERI, Fosl.

Grout Engr. Co.



M. Foslie photo.

LITHOPHYLLUM GARDINERI, Fosl.

Grout Engr. C