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On Some Fossils from the Islands of Formosa and Riu-Kiu (=Loo Choo).

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With Plates I—IV.

(Communicated by Prof. Kotō).

CONTENTS.

I. INTRODUCTION.

The following report on some fossils from Formosa and the Riū-Kiū Islands has been drawn up from material collected by Mr. S. YOSHIWARA, and entrusted to us for examination and description by Professor Dr. KOTŌ of the Science College, Imperial University, Tōkyō, Japan. Three groups of organisms are represented in the collection, *viz.*, Bryozoa, Foraminifera and plants, the different members of which exhibit certain characters enabling us to recognize particular geological horizons.

The oldest rock identified is an Orbitoidal-limestone which occurs in both the Pacific areas referred to; an example from Riū-Kiū (Iriomoté Island) exhibiting an abundance of organisms of an exceedingly dwarfed character (see Pl. I, fig. 4). We have already called attention to the presence of this limestone at Formosa,[1] in which we recognized *Orbitoides* (*Lepidocyclina*) *Verbeeki* associated with *Lithothamnium* (*Rosenbergi*=) *ramosissimum*, and other microzoa, and which we regarded as of Miocene age.

On the present occasion we have determined similar and additional fossils in this material, all of which appear to confirm our first views as to its geological horizon; moreover the presence of *Lithothamnium ramosissimum* so abundantly represented in the "Leithakalk" of the Vienna Basin, would strongly suggest that these Pacific limestones might be referred to the "Tortonian" stage of the Miocene epoch, that is, according to the European standard of geological nomenclature.

Of presumably much later date than the Orbitoidal rock first referred to, the collection contains examples of a raised

1. NEWTON and HOLLAND: *Journ. Geol. Soc. Tōkyō*, 1900, Vol. VII, pp. 1–4.

coral-reef formation which enters into the structure of the Riū-Kiū Islands. A certain modern facies possessed by this material has inclined us to regard it as of Pleistocene age. It is in fact very similar lithologically to some of the reef limestones of Christmas Island (Indian Ocean) which immediately succeed the Miocene beds of that area and which have been ably described by Dr. ANDREWS and his co-adjutors in "The Christmas Island Report" of 1900.

A slight variation in colour and lithological character is observed in our specimens of the Riū-Kiū reef-limestones, and they differ sometimes with regard to the prevailing Foraminifera contained in them. Thus the rock from Unten on the west coast of Okinawa is crowded with *Operculina complanata* and *Pulvinulina repanda*. On the other hand in the rock from Motubu near Unten the *Operculina* is absent though the *Pulvinulina* is plentiful. In addition to these organisms, there occurs a modern type of *Lithothamnium*.

The age of the raised reef-limestones of the Pacific Islands has always been a troublesome problem to the geologist, insuperable difficulties becoming manifest when he attempts to divide up these deposits into the various horizons of the Tertiary and Quaternary systems.

Such a result can only be attained by an examination of carefully collected material from the different terraces of elevation, so that each assemblage or colony of organisms would be available for study and comparison. The present samples are by no means sufficient to allow us, with any certainty to make a definite statement on this subject and we prefer, tentatively, to regard our specimens from the Riū-Kiū Group as favouring the view that they belong to some part of the Post-Pliocene series.

This collection contains a third material consisting of a loose, sand earth of dark colour, which was obtained from Itoman, Southern Okinawa, where it is said to be "overderlaid discordantly by raised coral-reefs." Whether this represents detrital matter brought down from the interior or a mere surface accumulation such as a beach deposit, the fact remains that it is largely composed of foraminiferal tests belonging to forms found in the surrounding seas.

So far as the literature is concerned very little is apparently known of the palæontoloy of either Formosa or the Riū-Kiū Islands.

One of the earliest references on this subject is by Mr. ARTHUR CORNER who[1] recorded the occurrence of "*Monstis Hawai*" in Formosa, on the top of a high cliff of fossiliferous limestone at a place called the Dragon's Head, which he thought indicated the "Permian period of Palæozoic times."

According to H. B. GUPPY[2] a modern limestone formation at Ape's Hill, Takaw, S.W. Formosa, has yielded *Scutella*, *Cyclolites*, *Ostrea*, *Pecten*, etc., although none of them properly determinable and therefore of little importance for horizonal purposes. KLEINWÄCHTER[3] follows with a coloured geological map of southern Formosa, and alludes to "*Lithostrotia*" occurring in the Mountain limestone of that area, besides recording "*Nummus lævigata*," as an additional fossil to GUPPY's list of specimens found in the limestone of Ape's Hill. In the "Geological Remarks" of this same memoir mention is made of the

1. *Proc. Roy. Geogr. Soc.* (London) 1875. Vol. XIX, p. 515. *Monotis Hawai* was originally described by Meek and Hayden from the Permian rocks of north-eastern Kansas (*Trans. Albany Institute* 1858. Vol. 4).

2. *Journ. North China Branch Roy. Asiatic Soc.* 1882, Vol. 16 (*n. s.*), pp. 13–16.

3. Same Journal, 1884, Vol. 18 (*n. s.*), pp. 37–53, with a geological map of South Formosa.

reef-limestones of southern Formosa, occurring at various altitudes above the sea level forming a compact rock "built up by generations of Zoophytes."

Several fossils [*Pecten, Ostrea, Lutraria ?, Cardium ?, Echinodiscus* (*Amphiope*) *bioculatus* Agassiz, *E. bisperforatus*, and ? Crustacean fragment] found in association with the coal-beds by Mr. DAVID TYZACK, at Kelung, North Formosa, were determined as of Miocene age by Professor G. A. LEBOUR[1] in 1885.

Prof. KOTŌ,[2] next, briefly refers to the raised coral reef-limestones of Formosa and Riū-Kiū, and also recognizes in the latter-named Group a three-fold zonal structure, synonomous with that observed by Prof. E. SUESS in the Lesser Antilles: (1) the volcanic belt; (2) the mountainous islands; (3) the exterior belt, which comprises the Miocene and Quaternary formations.

Further, as previously mentioned, the presence of an Orbitoidal-limestone in the northern part of Formosa was made known by ourselves, rather more than twelve months since, after an examination of some microscopical sections of fossiliferous rocks forwarded to us by Professor Kotō. From the character of the organisms detected in those sections we were inclined to regard the limestone as of Miocene age.

In concluding these preliminary observations we desire to express our best acknowledgments to Mr. H. W. BURROWS, F.G.S., for the interest he has taken in our work and the help he has afforded us more especially in the preparation of many of those beautiful photographs which adorn our plates. We wish to thank, also, Professor Dr. KOTŌ for the privilege of being allowed to work out this material, our report upon which, we hope, may

1. *Trans. North England Instit. Min. Engineers Newcastle*, 1885. Vol. 34, pp. 77–81, etc.
2. Journ. Coll. Sci. Imp. Univ. Tokyo, 1899. Vol. XI, Part 2, pp. 90, 98.

form an acceptable contribution to the palæontological history of these Islands.

II. DESCRIPTION OF THE FOSSILS.

A. Bryozoa.

Cellepora formosensis, sp. nov.

(Plate II, figs. 2, 4, 5 and 6; Plate III, fig. 1; Plate IV.)

In some rough "Notes on Microscopic Sections of Limestones" from Formosa which we furnished to Dr. Korō of Japan in 1900 and which (although we had not prepared them for publication) Dr. Korō kindly published in the *Journ. Geol. Soc. Tokyo,* June 1900, Vol. VII, we referred several times to the occurence of a large "chambered organism." The material which Dr. Korō has now sent to us includes the Formosa fossil which is shown of the natural size in Plate II, figs. 4, 5, and 6. This fossil is very dense and highly crystalline; it is entirely free from matrix and had been cut in two directions before it reached our hands. On polished surfaces and in thin sections it still furnishes details of its microscopic structure. Figure 6 of Plate II gives the vertical view of the specimen, but the cutting process has robbed it of some of its height; fig. 4 gives the basal view and there the loss sustained by cutting is shown by plaster filling; fig. 5 gives the actual view of the basal section of the upper segment shewn in fig. 6; Plate IV is a reproduction of an enlarged photograph of the central portion of fig. 5; fig. 2 of Plate II presents a microscopic section of the fossil viewed by transmitted light; and fig. 1 of Plate III gives

another portion of the same section as seen by reflected light with a black back-ground. The fossil is identical with the "chambered organism" referred to in the notes mentioned above and proves to be an undescribed species of Bryozoa of the genus *Cellepora* which we designate, from the place of its origin, *Cellepora formosensis.*

It is notoriously difficult to distinguish accurately for purposes of diagnosing species, the "characters" of fossil specimens of such Bryozoa as the Celleporæ. This is so even in the case of specimens from beds such as those of the English Coralline Crag where the fossils have suffered no very great change in their calcareous parts during the process of fossilization. It is more especially difficult where, in cases like the present, the organisms have become thoroughly mineralised and all the chambers have become filled up with crystalline calcite.

By cutting such a specimen however in two directions at right angles to each other and viewing the polished surfaces as solid objects by reflected light it is possible to see some of the characteristic features of the individual cells. This is made possible by the fact that the polished crystalline calcite reveals the microscopic structure for a short distance below the surface and so the apertures and other features of some of the earlier formed cells, which have become imbedded but not altogether obscured by the subsequent growth of overlying chambers, are brought to light. In a word the presence of clear crystalline calcite in the chambers of the fossil, *to the exclusion of an opaque substance,* furnishes an approach to the opportunity for examination by section which is given by the comparatively unaltered Celleporæ from the English Crags. Failing a cut and polished surface of a crystalline specimen it has been found serviceable to examine as an opaque object an ordinary microscopic section if it be not cut too thin.

Figure 1 of Plate III shows such a section cut from our Formosan specimen and viewed by reflected light and with a black background. Fig. 2 of the same Plate, placed beside it for comparison, is a micro-photograph of the same magnification from the cut surface of a solid segment of a specimen of *Cellepora tubigera* BUSK, from the English Coralline Crag of Broom Hill, Suffolk. It will be observed that in this latter specimen, in several places *at the bottom of the cells cut through*, there can be plainly seen the orbicular orifice of the cell below with its sinus in front; and in other places can be seen the vestiges of the avicularia. Not so clearly, but nevertheless far more plainly than in the same slide viewed by transmitted light (compare Plate II, fig. 2, and Plate III, fig. 1) the main zoœcial characters are shown in the section from the Formosan specimen (Plate III, fig. 1, and Plate IV). After a careful examination of several sections as well as the cut surfaces of our specimen we are able to give the "characters" of the species as follows:—

Zoarium: Massive; surface mammillate. The base of the specimen under description was free. The whole was supported by growing around some branched organism which became imbedded along the long axis of the fossil, and whose place is now occupied by the cores of stalagmitic material shown in section in the middle portions of Plate IV and of fig. 5 of Plate II. The mammillate character of the surface is indicated not only by the present exterior aspect of the fossil, which might conceivably be due to erosion, but also by the lines of growth shown in the horizontal section, Plate II, fig. 5. Dimensions of specimens:—Height=75 millim. Base=75×80 millim.

Zoœcia: Urceolate; contiguous; walls thin; aperture not more than one half the diameter of the cell; orbicular, with a sinus in front.

Avicularia: Numerous; irregularly distributed over the zoarium, arising sometimes in front and sometimes at the sides of the apertures.

Cellepora formosensis is undoubtedly allied to the *Cellepora pumicosa* Linn. of our present seas; to the *C. tubigera* of the English Crag, which is by some authors looked upon as identical with *C. pumicosa;* and to *C. mammillata* Busk. Generally, *C. formosensis* differs from these in the relatively larger dimensions of the zoœcia and the more delicate walls, and in the arrangement of the avicularia.

Occurrence: The figured specimen was obtained by Mr. Yoshiwara from the limestones of Sha-kō-kō near Roku-ryo, North of Kee-lung harbour, North Formosa. We found the same species in the limestones from Rei-suiko, 10 miles S.W. of Tai-hoku, the chief town of Formosa; also in the limestones from Shin-ko-gai, 10 miles due S. of Tai-hoku. We have now found it in the Orbitoidal limestone from Sonai, Iriomoté Island, Riū-Kiū (=Loo Choo Islands of European maps). All these limestones appear to be of Miocene age.

Cellepora sp. (Pl. III, fig. 7.)

Our slides contain a few specimens of another species of *Cellepora* with smaller cells but we have not had sufficient material to enable us to work out the species.

One of the specimens is shown in fig. 7 of Plate III, associated with *Orbitoides* (*Lepidocyclina*) *angularis.*

Occurrence: In the Orbitoidal limestone from Sonai, Iriomoté Island, Riū-Kiū.

B. Foraminifera.

Orbitoides.

The genus *Orbitoides* is represented in the limestone from Iriomoté Island by innumerable specimens—the rock being crowded with them throughout (see Plate I, fig. 4)—but there appear to be but two, or at the most three, species present. The striking feature about them is their small size. The dimensions of the specimens are remarkably uniform and there is no trace in our slides of large examples. All the specimens belong to the *Lepidocycline* group which is characterised by the possession of lozenge-shaped or spatuliform chambers in the median plane.

Orbitoides (Lepidocyclina) angularis, sp. nov.

(Pl. I, figs. 1 and 6, Pl. III, fig. 7.)

Characters: The species is dimorphic—that is to say, some individuals have the initial chamber large, while in others it is very small, practically invisible. They are distinguished here as Form A and Form B respectively.

Form A.—Shell discoidal; central area of disc somewhat flattened and slightly tuberculate; from edge of this flattened area the shell rapidly decreases in thickness; margin of disc thin, slightly swollen and rounded at the extreme edge. Chambers above and below the median plane irregular in shape but somewhat regularly disposed. External dimensions of shell 3 mm. in

width by 1 mm. in thickness; inside dimensions of the two central chambers taken together about .21 mm. in width by .14 mm. in depth; chambers of the median plane very minute; long axis of lozenge about .02 mm.

Form B.—Similar to the Form A in all respects save that the initial chamber is too small to be measured.

Occurrence: Very common in the limestone from Sonai, Iriomoté Island, Yayeyama Group. The Form A in our slides is more common than the Form B.

Orbitoides (Lepidocyclina) sumatrensis, BRADY.

(Pl. I, fig. 7.)

O. sumatrensis, BRADY: *Geol. Mag.,* 1875, p. 536, Pl. XIV, fig. 3; and *Jaarb, Mijn. Ned. Oostè-Indië,* 1878, Vol. VII, Pt. II, Pl. II, fig. 3.

O. (*Lepidocyclina*) *sumatrensis,* NEWTON and HOLLAND: *Ann. Mag. Nat. Hist.,* 1899. Ser. VII, Vol. III, p. 259, Pl. X, figs. 7–12.

O. (*Lepidocyclina*) *Sumatrensis,* JONES and CHAPMAN: *Monograph of Christmas Island,* 1900, p. 244, Pl. XX, fig. 6.

To this species we refer the form shown in fig. 7 on Plate I. It differs from the Sumatran and Bornean specimens only in its smaller dimensions which are 1.5 mm. by .85 mm.

Occurrence: Met with rarely in the Iriomoté limestone. The Sumatran specimens were collected by Dr. VERBEEK from the marl-rock of Nias Island, off the West coast of Sumatra.

Those from Borneo were obtained from the Gomanton Hill limestone and from pebbles taken from the bed of the River Malinam. The examples recorded by Messrs. JONES and CHAPMAN came from the Tertiary limestenes of Christmas Island.

Orbitoides (Lepidocyclina) Verbeeki, NEWTON and HOLLAND.

O. papyracca, BRADY: *Geol. Mag.,* 1875. Pl. XIV, fig. 1, p. 535 (*non* Boubée).

Lepidocyclina species g. and k., VERBEEK et FENNEMA: *Descr. géol. de Java et Madoura,* 1896. Vol. I, Pl. XI, figs. 173–175, 177–180; Vol. II, p. 1178.

O. (*Lepidocyclina*) *Verbeeki,* NEWTON and HOLLAND: *Ann. Mag. Nat. Hist.,* 1899. Ser. VII, Vol. III, p. 257, Pl. IX, figs. 7–11; Pl. X, fig. 1.

O. (*Lepidocyclina*) *Verbeeki,* JONES and CHAPMAN: *Monograph of Christmas Island,* 1900, p. 245.

One or two very small forms, which are probably to be referred to this species, occur in the Iriomoté limestone. The Sumatran specimens were collected by Dr. VERBEEK from limestones on the W. coast of that Island and from the adjacent Island of Nias. The Bornean specimens were obtained from pebbles found in the bed of the River Malinam. The examples recorded by Messrs. JONES and CHAPMAN came from the Tertiary limestones of Christmas Island. We have ourselves noted it from the Formosan limestones (Journ. Geol. Soc. Tōkyō, June 1900, Vol. VII).

Operculina complanata, (DEFRANCE).

(Plate I, figs. 3 and 5, Plate III, fig. 3.)

Lenticulites complanata, DEFRANCE: *Dict. Sci. Nat.*, 1822. Vol. XXV, p. 453.

Operculina complanata, ORBIGNY: *Ann. Sci. Nat.*, 1826. Vol. VII, p. 281, Pl. XIV, figs. 7–10.

The *Operculinæ* from the Riū-Kiū material are numerous and very interesting. In some cases the rock specimens described as from "raised coral reefs" are very largely composed of them and the reef at Kamé-zu on the south coast of Tokuno-shima has yielded the gigantic specimen shown on Plate I. Figs. 3 and 5, a specimen which in its unbroken condition, must have been one of the largest Operculines yet known. Fig. 5 gives the exact present size of this noteworthy specimen and the dotted line indicates what its dimensions must have been before the later chambers had been for the most part broken away. Some part of these later chambers have been destroyed since the specimen came into our possession. In order to determine the fossil at all we were obliged to grind away each surface so as to render the interior chambering visible. The irregularity and brittle character of the test made it impossible to proceed as far as could have been desired with the grinding process but enough has been done to allow of a photograph being taken which shows clearly the Operculine chambers.

We have considered it best on the whole to refer these examples to the species *complanata* because they undoubtedly belong to the group of which *O. complanata* (DEFRANCE) may be taken as the type. At the same time we think there has

been a tendency, particularly among English authors, to make this species include too great a variety of forms. There is for instance a very considerable and constant difference between the modern *Operculina complanata* as figured in the Challenger Report (Vol. IX, Pl. CXII, figs. 3, 4, 5, and 8) and the *O. complanata* from the Burdigalian (=Langhian) of Bordeaux. The whole genus needs careful revision. This, however, is not the occasion for any attempt in that direction.

Occurrence: *Operculina complanata* in recent seas is essentially a shallow water form and is met with only in tropical and sub-tropical latitudes. As a fossil it is recorded from the chalk of Mæstricht and Minnesota, from the Eocene of Central Europe and India, from the Miocene of Italy and of Muddy Creek (Victoria) and in great profusion in the Burdigalian (=Langhian) of the Bordeaux area. The Riū-Kiū specimens are from the "raised coral reefs" of Tokuno-shima and Okino-yerabu; and from a "10 foot thick bed in raised coral reef" from Unten, west coast of the Island of Okinawa.

Operculina complanata, (DEFRANCE) var **granulosa,** LEYMERIE.
(Pl. III, figs. 4 and 5.)

Operculina granulosa, LEYMERIE: *Mem. Soc. géol. France*, 1846. Ser. II, Vol. I, p. 359, Pl. XIII, fig. 12 *a*, *b*.
O. complanata, var. *granulosa*, H. B. BRADY: *Chall. Report*, 1884. Vol. IX, p. 743, Pl. CXII, figs. 6, 7, 9 and 10.

This species is exceedingly numerous in the dark earthy looking material from Itoman, S. Okinawa, which is described as "overlaid discordantly by the raised coral reefs." Besides the

Operculinæ it has yielded numerous other species of Foraminifera as will be seen from the appended "Tabular Statement of Determinations."

Occurrence: Itoman, Southern Okinawa, Riū-Kiū Islands.

Carpenteria, sp. (Pl. II, fig. 3; Pl. III, fig. 6.)

The genus *Carpenteria* has played an important part in building up the Orbitoidal-limestone of Iriomoté Island. Fragments are very numerous in the sections and possibly two or more species are present. We have however not had sufficient material at our disposal to satisfy us in referring our examples to definite "species." The specimen shown in Pl. II, fig. 3 appears to bear a strong resemblance to the *Carpenteria capitata* described by Messrs. JONES and CHAPMAN from the Tertiary limestones of Christmas Island (Monograph of Christmas Island, p. 246, Pl. XX, fig. 7). The specimen figured on Plate III, fig. 6, does not at first sight look like a *Carpenteria*, but from numerous specimens in our slides connecting it with undoubted examples of the genus there can be no question as to its affinities.

Occurrence: Iriomoté limestone, Riū-Kiū Islands.

Linderina, sp.? (Pl. I, fig. 2).

We are in some doubt as to the proper affinities of the organism represented in the figure quoted above. It certainly bears a very striking resemblance to the horizontal section of *Linderina brugesi* SCHLUMBERGER, as figured by M. SCHLUMBERGER (Bull. Soc. géol. France, 1893, Sér. III, Vol. XXI, Pl. III, fig. 9); and in the Orbitoidal limestones of Gomanton Hill,

Borneo, we found numerous undoubted specimens of the genus (Ann. Mag. Nat. Hist., 1899, Sér. VII, Vol. III, p. 262, Pl. X, fig. 6). The most careful search through our slides cut from the Orbitoidal limestone of Iriomoté Island, however, yields no specimen which will throw further light on the organism here represented and we can only assign it provisionally to the genus *Linderina*.

Occurrence : Iriomoté limestone, Riū-Kiū Island.

Amphistegina vulgaris ORBIGNY. (Pl. II, fig. 1.)

Amphistegina vulgaris, d'ORBIGNY : 1823, Modèles, Liv. 2e No. 40, *Ann. Soc. Nat.*, 1826. Vol. VII, p. 305, No. 8.
Amphistegina lessonii, d'ORBIGNY : 1823, Modèles, Liv. 4, No. 98, *Ann. Sci. Nat.*, 1826. Vol. VII, p. 304, No. 3.
Amphistegina lessonii, BRADY : 1884, *Chall. Report*, pp. 740, 741, Pl. CXI, figs. 1–7.

Associated with the *Orbitoides*, *Carpenteria* and *Lithothamnium* which make up the great mass of the Iriomoté Island limestone, are a few other Foraminifera among which *Amphistegina vulgaris* is the most conspicuous. The specimens are small in common with most of the other organisms in the limestone, but they are fairly numerous.

Occurrence : *Amphistegina vulgaris* (including *lessonii*) is in recent seas mostly confined to tropical and subtropical latitudes and as a rule is found in shallow water. It has been recorded as a fossil from the Eocene of France and Bavaria. It is very characteristic of the Miocene deposits generally and has been

found in the Pliocene of many localities. Our examples are from the Iriomoté limestone, Riū-Kiū Islands.

Pulvinulina repanda, (F. and M.)

Nautilus repandus, FICHTEL and MOLL: 1798, *Test. Micr.*, p. 35, Pl. III, figs. *a–d.*

Pulvinulina repanda, H. B. BRADY: *Chall. Report,* 1884, Pl. CIV, fig. 18, p. 684.

Pulvinulina repanda, JONES and CHAPMAN: *Report Christmas Island,* 1900, p. 228, Pl. XX, Fig. 1.

This well known form occurs plentifully in the "raised Coral-reefs" at Tokuno-shima, Unten and Motubu. At Tokuno-shima it is found in association with *Operculina complanata.* In the other localities mentioned the *Operculinæ* are absent.

C. PLANTÆ.

Lithothamnium ramosissimum, REUSS.
(Plate I, fig. 8.)

Nullipora ramosissima, REUSS: *Nat. Abhandl. Haidinger,* 1848. Vol. II, Part I, Pl. III, figs. 10, 11, p. 29.

Nullipora ramosissima, UNGER: *Denkschr. K. Akad. Wiss.* (Wien), 1857. Vol. XIV, Pl. V, figs. 18–22, pp. 23, 38.

Lithothamnium ramosissimum, GÜMBEL: *Abhandl. K. bayerischen Akad. Wiss. München,* 1871. Vol. XI, Part I, p. 34, Pl. I, fig. 1.

Cumulipora Rosenbergi, MARTIN : *Samml. Geol. Reichs-Mus. Leiden*, 1881. Vol. I, Part I, pp. 12–14, 64, Pl. III, fig. 7.

Lithothamnium Rosenbergi, MARTIN : *Samml. Geol. Reichs-Mus. Leiden*, 1881. Vol. I, Part II, pp. 70, 79 ; and *ibid.*, 1882. Vol. I, Part III, pp. 153, 155.

Lithothamnium ramosissimum, ROTHPLETZ : *Zeitsch. Deutsch. Geol. Ges.*, 1891. Vol. XLIII, p. 320.

Lithothamnium ramosissimum, K. NISHIWADA : *Journ. College Sci. Imp. Univ. Tokyo*, 1894. Vol. VII, Part III, p. 233, Pl. XXIX, figs. 1–3.

Lithothamnium (*Cumulipora*) *Rosenbergi*, NEWTON and HOLLAND : *Journ. Geol. Soc. Tokyo*, 1900. Vol. VII, No. 81, p. 1.

Lithothamnium Rosenbergi, S. YOSHIWARA : *Journ. Geol. Soc. Tokyo*, 1900. Vol. VII, No. 81, p. 22.

Besides the organisms already referred to as occurring in the Orbitoidal-limestones of the Riū-Kiū Islands we have to add that of the well-known Nullipore.

Lithothamnium ramosissimum. Our illustration (Pl. I, fig. 8) exhibits a vertical section (× 70) of one of the branches made up of the innumerable rectangular cells and arranged in the usual concentric layers. Among fossil Calcareous Algæ this species is of considerable importance as a reef-building organism. At Leitha near Vienna it enters largely into the structure of the so-called "Leithakalke," a limestone belonging to the Middle Miocene and which according to Prof. DE LAPPARENT[1] may be included in the Tortonian division of that formation. It is of

1. Traité de Géologie, 1900, Ed. 4, p. 1547.

frequent occurrence in the limestones of many of the islands lying off the eastern coast of the Asiatic Continent, Mr. NISHIWADA having first recognized it in the rocks of Japan, although Dr. MARTIN at a much earlier period had reported its presence in the Pacific area, at Timor, New Guinea, Amboina, etc., but under the name of *L. Rosenbergi*, a form which we now consider structurally equivalent to the *ramosissimum* of REUSS. The difficulty of defining the species of *Lithothamnium* found in a fossil state, has already been alluded to by Solms-Laubach[1] and others so that until the whole subject has been more systematically treated than heretofore, we have thought it advisable to place MARTIN's name in synonomy. Under MARTIN's species, also, we ventured to call attention last year to the appearance of this organism in the limestones of northern Formosa. The species is of interest from a stratigraphical point of view, because it is so far known only from rocks of the Miocene Period and probably indicates the middle portion known in Europe as the " Tortonian " stage.

Occurrence: Species of Miocene age have been recorded from Europe, Timor, New Guinea, Formosa, Japan, etc.; we have now identified it in the Orbitoidal-limestone of Sonai, Iriomoté Island, Riū-Kiū.

1. Fossil Botany by Solms-Laubach; English translation by H. E. F. GARNSEY, 1891 p. 45.

III. TABULAR STATEMENT OF DETERMINATIONS.

Genera and Species.	Orbitoidal Limestones.		"Raised Coal Reefs."		Material "overlaid discordantly by Raised Coral Reefs."
	Formosa.	Iriomoté Island.	Tokunoshima & Unten.	Motubu near Unten.	Itoman, S. Okinawa.
A. Bryozoa.					
Cellepora formosensis, sp. nov....	×	×			
„ *species*...		×			
B. Foraminifera.					
Amphistegina vulgaris, ORB.		×			×
Biloculina bulloides, ORB....					×
„ *depressa*, ORB....					×
Bolivina costata, ORB.					×
„ *robusta*, BRADY....					×
Bulimina aculeata, ORB.					×
„ *elegans*, ORB.					×
Carpenteria sp.		×			
Cristellaria calcar, (LINN.)					×
„ *crepidula*, (F. and M.)...					×
„ *fragaria*, (GÜMBEL)					×
„ *tenuis*, (BORNEMANN)					×
Globigerina bulloides, ORB.					×
Linderina, sp.		×			
Marginulina glabra, ORB.					×
Miliolina oblonga, (MONTAG.)					×
„ *pulchella*, (ORB.)...					×
„ *seminulum*, (LINN.)					×
„ *tricarinata*, (ORB.)					×
„ sp.		×			
Nodosaria (*Dentalina*) *communis*, ORB.					×
„ *pyrula*, ORB.					×
„ *radicula*, LINN.					×
„ (*Dentalina*) *vertebralis*, (BATSCH)					×
Nonionina umbilicatula, (MONTAG.)...					×
Operculina complanata, (DEFRANCE)		×			
„ „ var. *granulosa*, LEYMERIE.					×
Orbitoides (*Lepidocyclina*) *angularis*, sp. nov. ...		×			
„ „ *sumatrensis*, BRADY. ...		×			
„ „ *Verbeeki*, NEWT. & HOLL.		×			
Planorbulina mediterranensis, ORB....					×
Polymorphina lactea, W. and J.					×
„ *communis*, ORB....					×
Polystomella craticulata, (F. and M.)					×
Pulvinulina repanda, (F. and M.)...			×	×	×
Rotalia Beccarii, (LINN.)...					×
„ *papillosa*, BRADY.					×
Sagraina raphanus, P. and J....					×
Sphæroidina dehiscens, P. and J.					×
Textilaria gramen, ORB.					×
„ *quadrilatera*, SCHWAGER					×
Truncatulina præcincta, (KARRER)...					×
„ *ungeriana*, (ORB.)					×
„ *Wuellerstorfi*, (SCHWAGER)...					×
Uvigerina pygmæa, ORB....					×
C. Plantæ.					
Lithothamnium ramosissimum, REUSS	×	×			
„ sp.			×	×	

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NOTE.—With the exception of specimen represented in Plate III, fig. 2, which is in the collection of Mr. H. W. BURROWS, the whole of the material described in this paper has been returned to Professor KOTŌ of Tokyo, Japan.

PLATE I.

V. EXPLANATION OF THE PLATES.

Plate I.

Orbitoides (*Lepidocyclina*) *angularis*, sp. nov., Form B. From Sonai, Iriometé Island, Yayeyama Group, Riū-Kiū.

FIG. 1.—Horizontal section ... ... × 40.

FIG. 6.—Vertical section ... ... × 35.

? *Linderina*, sp. From same locality as above.

FIG. 2.—Horizontal section ... ... × 60.

Operculina complanata, (DEFRANCE). Found in an elevated coral-reef at Kamézu, south coast of Tokuno-shima between Okinawa and Oshima, Riū-Kiū.

FIG. 3.—Side view ... ... × 2.

FIG. 5.— Do. ... ...nat. size.

Orbitoidal Limestone of Sonai, Iriomoté Island, Yayeyama Group, Riū-Kiū.

FIG. 4.—Section showing the small and crowded character of the organisms ... ... × 7.

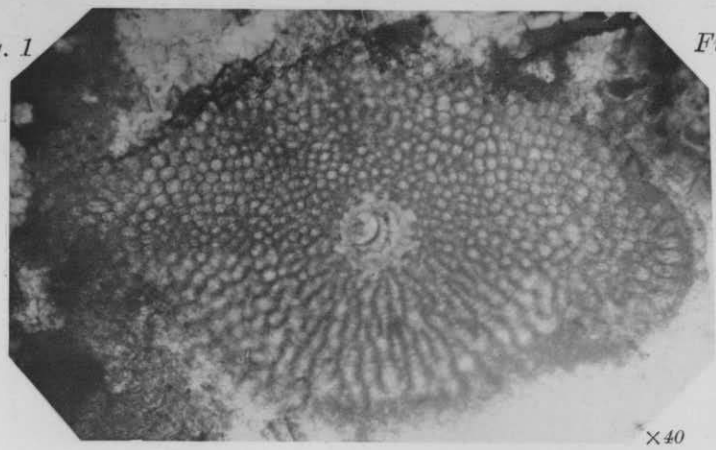
Orbitoides (*Lepidocyclina*) *sumatrensis*, BRADY. Form B. From the Orbitoidal limestone as above.

FIG. 7.—Vertical section ... ... × 60.

Lithothamnium ramosissimum, (REUSS). From same limestone and locality as before.

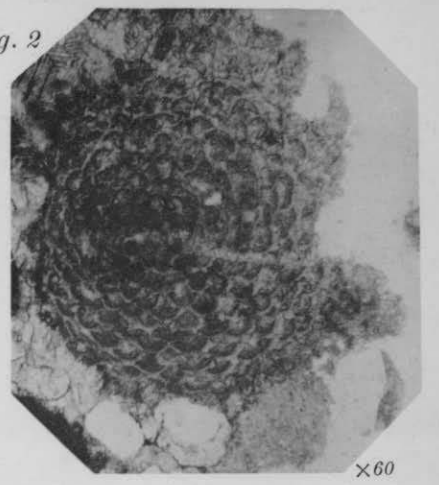
FIG. 8.—Vertical section of a branch, showing the concentrically-arranged layers of rectangular cells.

Fig. 1



×40

Fig. 2



×60

Fig. 3

×2

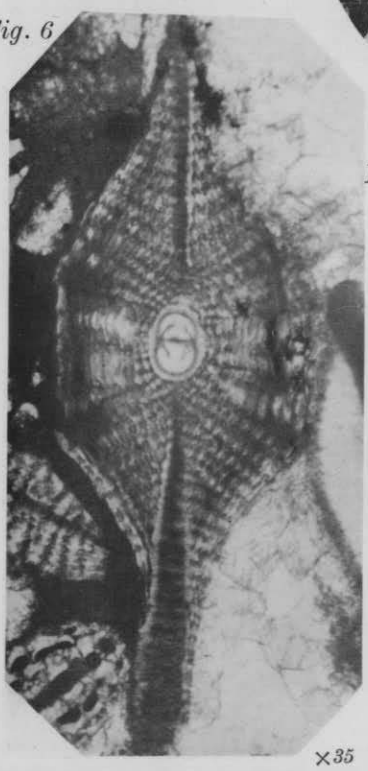
Fig. 4

×7

Fig. 5

Nat. size.

Fig. 6



×35

Fig. 7

×60

Fig. 8

×70

H. W. Burrows, P. Highley, } Photo.

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ORGANISMS (FORAMINIFERA, &c.)
of the RIÛ-KIÛ LIMESTONES.

PLATE II.

Plate II.

Amphistegina vulgaris, ORBIGNY. From the same Orbitoidal-limestone as before.

FIG. 1.—Oblique section ... ... × 60.

Cellepora formosensis, sp. nov. From the limestone of Sha-kō-kō, south east of Tō-shi-yen, Northern Formosa.

FIG. 2.—Section of specimen viewed by transmitted light ... × 20.

FIG. 4.—Basal view ... ...nat. size.

FIG. 5.—Horizontal section ... ...nat. size.

FIG. 6.—Side view ... ...nat. size.

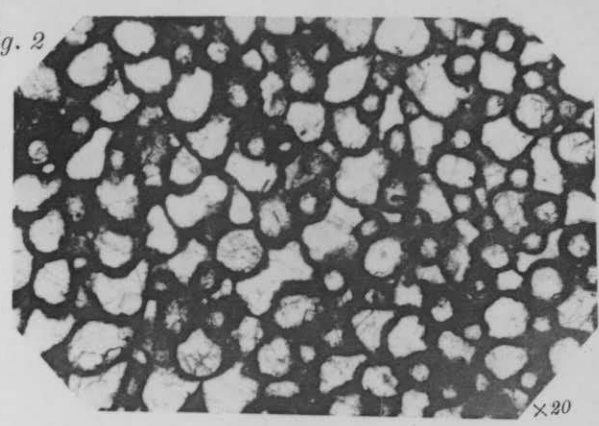
Carpenteria sp. From the Orbitoidal limestone of Iriomoté Island, previously mentioned.

FIG. 3.—Vertical section ... ... × 20.

Fig. 1

×60

Fig. 2



×20

Fig. 3

×20

Fig. 4

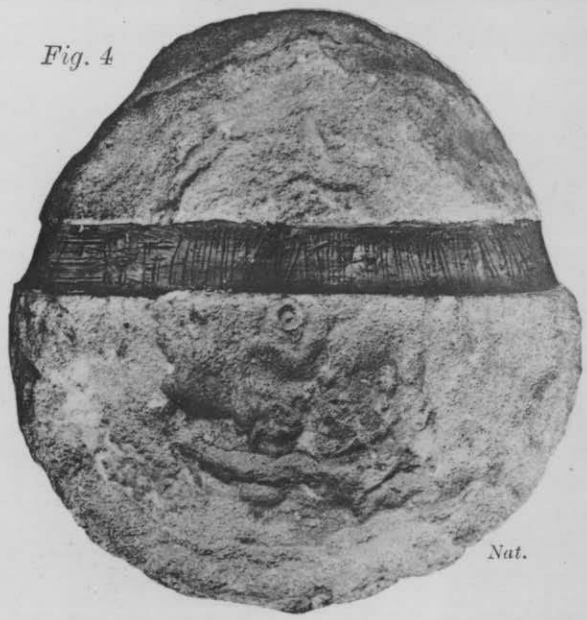


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Fig. 5

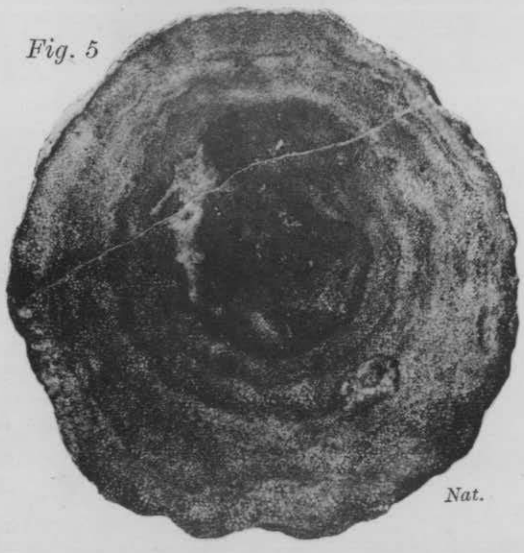

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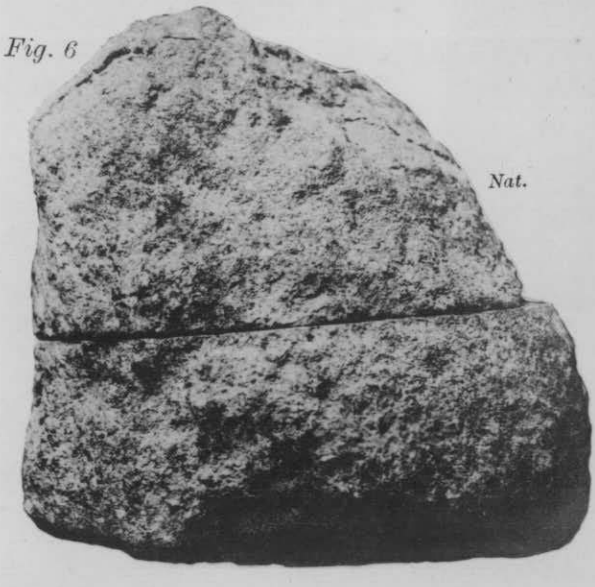
Fig. 6



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H. W. Burrows, H. R. Holder, } Photo.

BRYOZOA AND FORAMINIFERA
from the LIMESTONES of FORMOSA and RIÛ-KIÛ.

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PLATE III.

Plate III.

Cellepora formosensis, sp. nov.

FIG. 1.—Section of specimen from Formosa figured on Plate II, viewed by reflected light.

Cellepora tubigera, BUSK. From the English Crag deposits—for comparison.

FIG. 2.—Section of a solid segment viewed by reflected light. × 20.

Operculina complanata, (DEFRANCE). Occurring in a 10 feet thick bed in raised coral reef; from Unten. West coast of the Island of Okinawa, Riū-Kiū.

Fig. 3.—Vertical sections... ... ... × 20.

Operculina complanata var. *granulosa*, LEYMERIE. Isolated form, from a loose sandy material occurring at Itoman, Southern Okinawa, Riū-Kiū.

FIG. 4.—Horizontal section ... ... × 15.

FIG. 5.—External view ... ... × 15.

Carpenteria sp. From the Iriomoté Island, Orbitoidal limestone, previously alluded to.

FIG. 6.—Vertical section... ... ... × 35.

Cellepora sp. Associated with *Orbitoides* (*Lepidocyclina*) *angularis*. Found in the Iriomoté Island Orbitoidal Limestone previously mentioned.

FIG. 7.—Section viewed by transmitted light ... ... × 20

Fig. 1

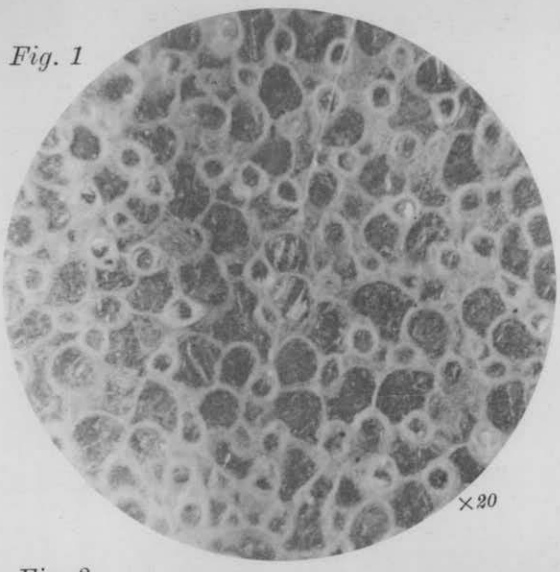


Fig. 2

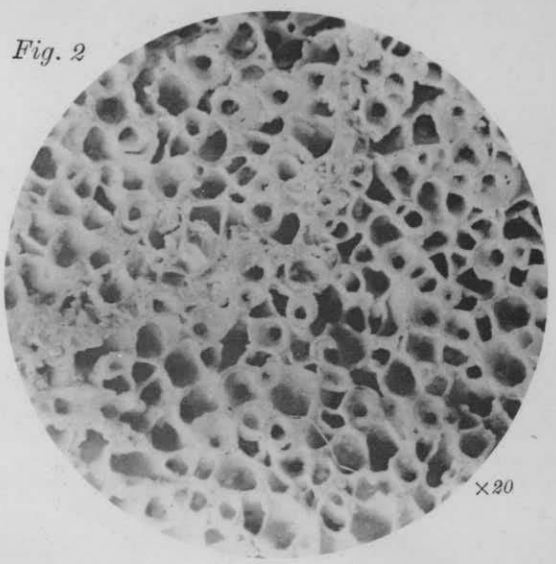


Fig. 3

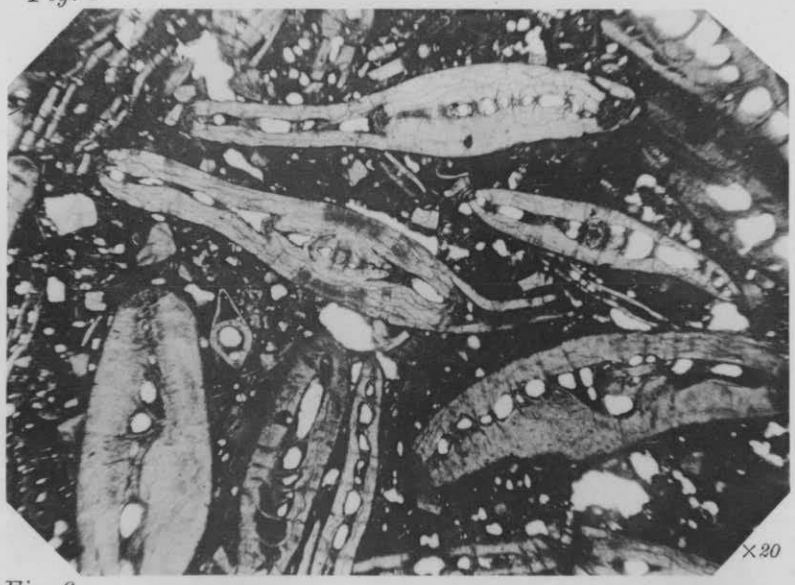


Fig. 4

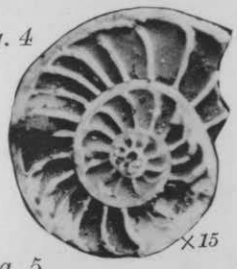


Fig. 5

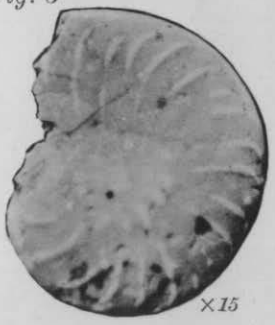
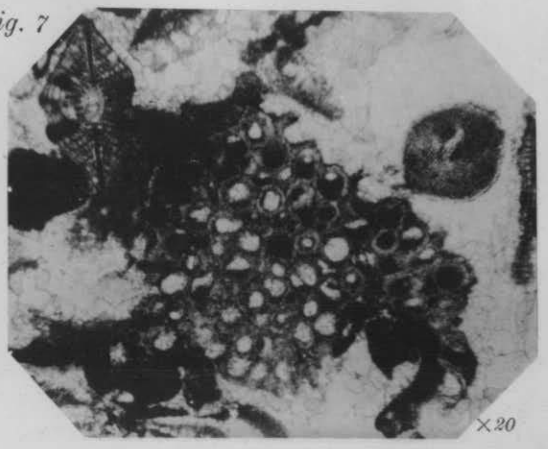


Fig. 6

Fig. 7



H. W. Burrows, Photo.

BRYOZOA AND FORAMINIFERA
from the LIMESTONES of FORMOSA and RIÛ-KIÛ.

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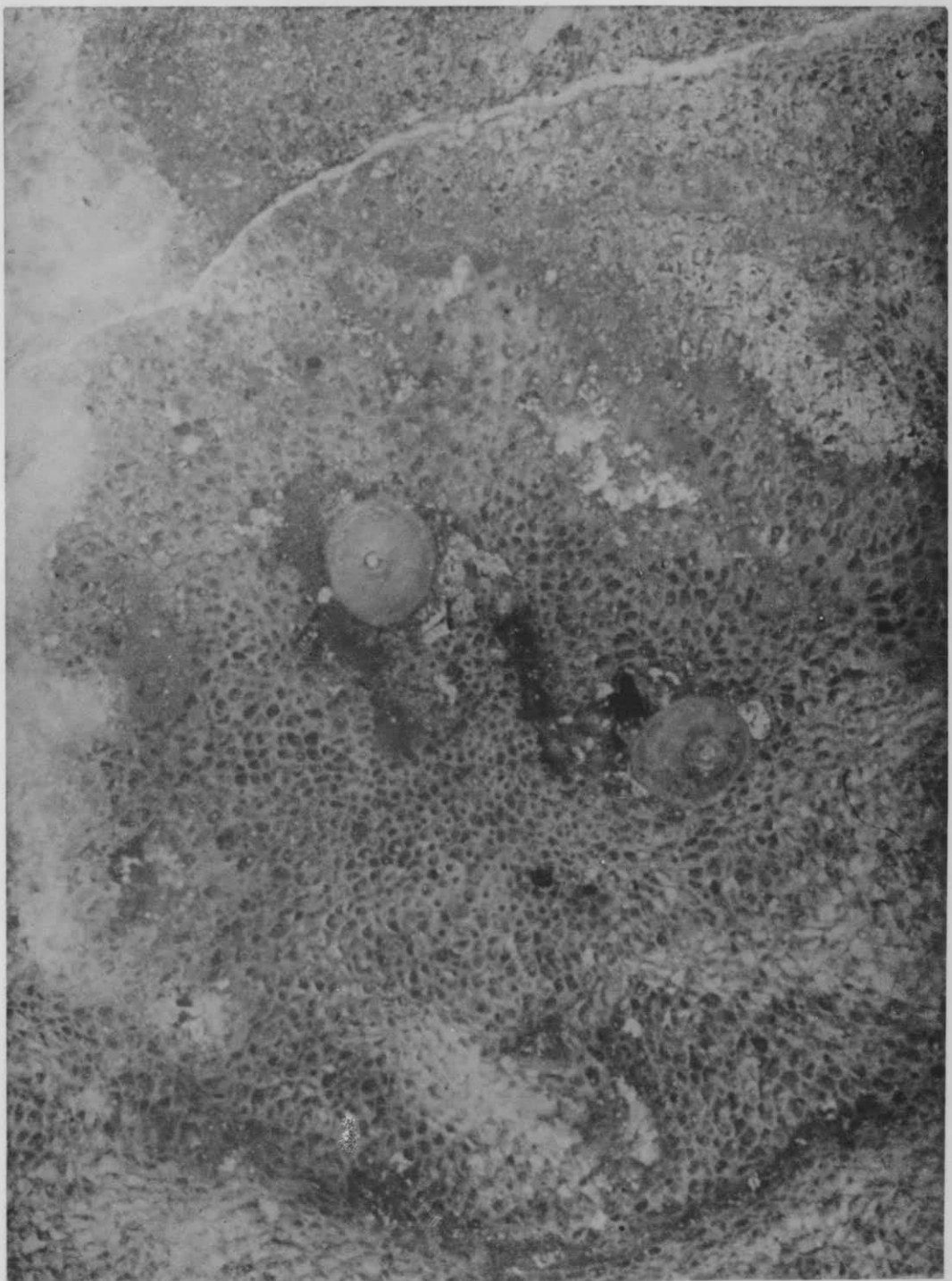
PLATE IV.

Plate IV.

Cellepora formosensis, sp. nov. Central portion of specimen represented by Fig. 5 of Plate II, showing stalagmitic cores round which the organism has developed ... ... × 7



H. R. Holder, Photo.

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CELLEPORA FORMOSENSIS, sp. nov.
Central part, magnified 7 diameters.