

## Notes on a Lepidocyclina-Limestone from Cebu

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## Notes on a *Lepidocyclina*-Limestone from Cebu.

BY

H. YABE.

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*With 2 Plates.*

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While my Notes on a *Carpenteria*-Limestone from B. N. Borneo<sup>1)</sup> were in press, I received from Mr. S. NODA two other samples of fossiliferous rocks for study, one of which is from Borneo and the other from the island of Cebu, Philippine Islands. The latter is a compact limestone, yellowish grey in colour and mottled with flecks of a bluish tinge, and was collected by Mr. SH. NISHIHARA from Pauting Botow near the City of Cebu, Cebu Island; the fossil content of this material will be stated in the present paper.

The limestone is essentially composed of several species of *Lepidocyclina* and of *Lithothamnium ramosissimum* REUSS. There are a number of smaller forms of foraminifera contained in the rock; but most of them are of no great importance in the constitution of the rock and also of not much geological significance. More important fossils are:—

<i>Lepidocyclina</i> ( <i>Eulepidina</i> ) <i>monstrosa</i> YABE, sp. nov.	Common.
<i>L.</i> ( <i>E.</i> ) <i>formosa</i> SCHLUMBERGER.	Very common.
<i>L.</i> ( <i>E.</i> ) <i>gibbosa</i> YABE, nom. nov.	Common.
<i>L.</i> ( <i>E.</i> ) sp. indet. cf. <i>inermis</i> DOUVILLÉ.	Rare.
<i>L.</i> ( <i>E.</i> ?) sp. indet.	Rare.
<i>L.</i> ( <i>Nephrolepidina</i> ) <i>angulosa</i> PROVALE.	Rare.
<i>Spiroclypeus</i> cf. <i>margaritatus</i> SCHLUMBERGER.	Common.
<i>Cycloclypeus</i> ? or <i>Heterostegina</i> ?	Common.
<i>Amphistegina lessoni</i> D'ORBIGNY.	Common.
<i>Gypsina inhoerens</i> SCHLUTZE.	Rare.
<i>Carpenteria protiformis</i> GOES.	Rare.
<i>Orbitolites</i> sp. indet.	Rare.
<i>Lithothamnium ramosissimum</i> REUSS.	Very abundant.

Of the fossils enumerated above, *Amphistegina lessoni*, *Gypsina inhoerens* and *Lithothamnium* are not specially described in the following pages, as these types are too well known and moreover have been fully illustrated in the paper on the *Carpenteria* limestone, cited above. *Cycloclypeus*? (or *Heterostegina*?) sp. and *Orbitolites* sp. also are not described below, the materials at hand being too incomplete for the purpose.

As to the occurrence of the limestone, we are informed that it lies upon the coal-bearing series of

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1) Science Reports (Geological Series) vol. V., No. 1, 1918.

the Cebu field<sup>1)</sup>; therefore it may almost correspond to the Middle limestone (Miocene) of Mr. W. D. SMITH,<sup>2)</sup> and this correlation is confirmed by its fossil content as to be explained later on.

The named authority of the Philippine geology tabulated the Tertiary stratigraphy of the Islands as follows in the work referred to above:

Period.	Formation.	Type Locality.	Distribution.	Economic Deposit.	Characteristic Fossils.
Pleistocene and Pliocene.					
Unconformity.	.....	.....	.....	.....	.....
Miocene.	Limestone (Upper).	Cebu.		Burned for lime, very pure.	Shells very similar to recent forms. Chiefly coral reefs.
Unconformity.	Andesite flows.	Cebu.	Cebu, Masbate, etc.	Gold, silver, manganese, lead.	
Miocene.	Limestone (Middle).	Cebu.	Cebu, Central Luzon, S. W. Luzon, N. and E. Mindanao, Romblon.	Romblon marble, Montalban limestone.	<i>Lepidocyclina insular-natalis</i> , <i>Lithothamnium ramosissimum</i> .
	Sandstone.	Batan Island.	—	Oil in Tayabas and Cebu.	<i>Cyclocypus communis</i> , <i>Orbitolites</i> , etc.
	Shale.	Batan Island.	—	Coal deposits Cebu, Batan, Polillo, Masbate, Mindanao, Luzon, etc.	<i>Arca</i> , <i>Callianassa dijhi</i> , <i>Vicarya callosa</i> .
Oligocene.	Limestone (Lower).	Cebu, Batan Island.	—		<i>Nummulites niasi</i> .
Age uncertain, probably Tertiary.	Crystalline schists and gneisses.	Camarines.	Camarines, Ilocos N., Cebu, Zamboanga Pen., Romblon Is.		
	Iron formation.	Bulacan.			
	Granites.	—	—		
Unconformity (?) Pre-tertiary.	.....	.....	.....	.....	.....

Further, he stated that "recently some Foraminifera and field notes were submitted by the writer

1) Mr. F. A. DALBURG gave the following statements about the Cebu coal field in "The Coal Resources of the World" 1913, vol. I, pp. 116-8:

"Cebu Island:—The Cebu field is probably the most promising in the island. The field is situated on the eastern side of the Cordillera, which traverses the central portion of Cebu. It extends from Mt. Lantauan on the north to Mt. Alpaco on the south, and embraces an area of coal-bearing rocks of nearly 80 square miles. The distance from tide-water is from 8 to 15 miles."

"The commercial coals are included in folded and faulted rocks of Tertiary age (Oligocene and Miocene) including sandstones, shales, and locally, a large amount of conglomerate, the whole series being over 2,000 ft. thick. The coals of this field are sub-bituminous. The largest areas and those which have been most extensively prospected and worked are: (1) Camujumayan, (2) Camansi, (3) Mt. Licos, (4) Uling."

"The Camujumayan district is a narrow basin with a strike of nearly N. 45° E. and 35° dip. . . ."

"The Camansi district is situated six miles due west from Danao. . . . The rocks are shales, sandstone, and limestone. . . . The field is monoclinical with some minor folds."

"The Mt. Licos district is about six miles due west from Compostela which is situated on the sea coast. The Coal Measures rest on a basal conglomerate and are composed of gray shales which merge into a grit near the coal seams. Higher, stratigraphically, in the section these shales and grits are succeeded by a coarse gray sandstone, which continues to the base of the limestone capping."

"The general strike of the Coal-Measures is N. 25 E. with dips to the southeast from 30° to 90°. . . ."

"The Uling district is situated 8 miles north-west from Naga, which in turn 12 miles south of the city of Cebu. The rocks exposed at the surface consist of shales, sandstones and conglomerate, with interstratified coal-seams. The thickness of the whole series is nearly 1,500 ft. The lower portion is made up of a massive bluish shale cut in every direction by innumerable calcite veins. The upper portion consists of thin beds of red shales, sandstones and, locally, a conglomerate and contains the workable coal-beds."

"The coal-bearing rocks are slightly flexed and folded, and are monoclinical. The conditions are such that continuity cannot be depended upon. The strike is nearly N. 15 E. and beds dip at angles from 30° to 40° to the westward."

2) W. D. SMITH: The Philippine Islands. Handbuch der Regionalen Geologie edited by G. S. STEINMANN and O. WILCKENS, vol. VI., pt. 5. 1910, p. 3.

to Prof. DOUVILLÉ of Paris, who has studied them, and on the basis of this has prepared the following table :”

“The Division of the Philippine Tertiary (after H. DOUVILLÉ),”

II.	a. Upper Limestone with small <i>Lepidocyclina</i> .	<i>L. cfr. verbecki, Miogypsina.</i>	Burdigalian.
	b. Sandstone and shale.	<i>Cycloclypeus communis, Orbitolites, Alveolinella, Miogypsina.</i>	Aquitanian.
	c. Middle Limestone with large <i>Lepidocyclina</i> .	<i>L. insulae-natalis, formosa, richthofeni.</i>	
I.	Lower Limestone with <i>Nummulites</i> . Coal Measures.	<i>Nummulites niasi, Amphistegina cfr. niasi, Lepidocyclina.</i>	Stampian.

If we compare this table with the foregoing one, we find 1. that the Coal Measure is assigned in one case to the Stampian and in the other to the Miocene (Aquitanian), and 2. that the order of II. b and II. c is given in the reverse order.

One year later, the palaeontological result of the well known French palaeontologist appeared in the Philippine Journal<sup>1)</sup>; the materials studied by him comprise :

I. Limestone of Caracaran, Batan Island. Stampian.

The limestone is intercalated in the coal-bearing formation, and contains

- Nummulites subniasi* DOUVILLÉ,  
*Amphistegina niasi* VERBEEK,  
*Polystomella* sp.,  
*Lepidocyclina (Nephrolepidina) smithi* DOUVILLÉ.

II. 1. Sandstone of Sibud Gulch (old Alpaco Mine, Island of Cebu). Lower Aquitanian?

The sandstone overlies the coal-bearing formation and underlies the *Lepidocyclina* limestone; its foraminifera fauna is essentially composed of *Orbitolites* and *Alveolinella*; besides, *Operculina costata* D'ORB. var. *tuberculata* DOUVILLÉ, *Rotalia* and *Polystomella*.

II. 2 a. Limestone of Guila-Guila, Island of Cebu. Aquitanian.

It contains large *Lepidocyclina*, namely :

- Lepidocyclina (Eulepidina) insulae-natalis* J. and CH.,  
*L. (E.) richthofeni* W. D. SMITH,  
*L. (E.) formosa* SCHLUMBERGER.

To the same horizon may also belong :

2 b. Limestone of Barrio of Mesaba (Island of Cebu) with

- L. (E.) insulae-natalis* J. and CH.,

2 c. Limestone of the valley of Cumajumayan (Island of Cebu) with

- L. (E.) richthofeni* SMITH,

1) H. DOUVILLÉ: Les foraminifères dans le Tertiaire des Philippines. Philippine Jour. Sci., vol. VI, No. 2, sec. D, 1911.

According to SMITH (l.c., p. 2), there is no sedimentary formations throughout the Philippine Islands known with certainty to be older than the Eocene. “That there are any sediments older than Oligocene is not positively established. *Nummulites* were reported by ABELLA and RICHTHOFEN. In their type localities abundant orbitoidal forms have been collected but no *Nummulites*.”

L. (E.) *formosa* SCHLUMBERGER,

and

2 d. Limestone from near the Compostela mines (Island of Cebu) with

L. (E.) *richthofeni* SMITH

L. (E.) *formosa* SCHLUMBERGER,

L. (E.) *inermis* DOUVILLÉ.

II. 3. Limestone exposed along the route of Toledo on the river bank of the Minanga (Island of Cebu). Aquitanian; decidedly younger than the preceding Limestone with large *Lepidocyclina*.

It contains

*Operculina costata* D'ORB.

*Cycloclypeus communis* MARTIN.

II. 4. Sandy limestone of Gaba Bay, Island of Batang. Burdigalian.

It occupies a stratigraphical position upper than the coal bearing formation and contains:

*Lepidocyclina* (*Nephrolepidina*) *verbeeki* N. and H.,

L. (N.) *inflata* PROVALE,

*Miogypsina irregularis* MICHELOTTI race *orientalis* DOUVILLÉ,

*Cycloclypeus communis* MARTIN,

*Amphistegina* cf. *mamillata* D'ORB.

and *Globigerina*, etc.

In the same paper, we find the following correlation table of the Tertiary foraminiferal rocks of the Philippines, which is essentially, but not exactly identical with the second table quoted above from SMITH's paper.

II.	Upper limestone with small <i>Lepidocyclina</i> .	<i>L. verbeeki</i> , <i>Miogypsina</i> , <i>Cycloclypeus communis</i> .	Burdigalian.
	Middle limestone.	<i>Cycloclypeus communis</i> , <i>Operculina complanata</i> .	Aquitanian.
	Lower limestone with large <i>Lepidocyclina</i> .	<i>L. insulae-natalis</i> , <i>L. richthofeni</i> , <i>L. formosa</i> .	
I.	Coal Measure and Lower limestone with <i>Nummulites</i> .	<i>Nummulites subniasi</i> , <i>Amphistegina niasi</i> , <i>L. smithi</i>	Stampian.

The "lower limestone with large *Lepidocyclina*" of this table is the "middle limestone" of SMITH; the "middle limestone" of the former may also represent a part of the latter.

The foraminifera fauna from the limestone of Pauting Botow, now in question, is essentially similar in its constitution to that contained in the limestones enumerated by DOUVILLÉ in his II. 2.; he, however, did not find any nephrolepidine *Lepidocyclina* and *Spiroclypeus* in his material, while these fossils are found in the former. On the other hand, the foraminifera fauna from the limestone of Pauting Botow is exactly similar to that recorded by DOUVILLÉ from Central Nias,<sup>1)</sup> which comprises *Eulepidina insulac-*

1) DOUVILLÉ: Les foraminifères de l'île de Nias. Samm. Geol. Reichs-Mus., ser. I, vol. VIII, p. 274. 1912.

*natalis*, *E. formosa*, *Nephrolepidina sumatrensis*, *N. verbeeki*, *N. angulosa*, *Cycloclypeus communis* and *Spiroclypeus*; the latter being assigned by the named authority to the Upper Aquitanian, the same geological correlation can be directly applied to the former.

## Description of the Fossils.

### *Lepidocyclina*, SCHLUMBERGER.

H. DOUVILLÉ's latest subdivision of *Orbitoides*, established in 1915,<sup>1)</sup> is the most elaborate one of the kind ever proposed, and certainly shows considerable progress in many respects over previous ones of his own and of other authors. To my great regret, this important work was unknown to me during the preparation of the notes on *Carpenteria* limestone in which his older subdivision was quoted; hence a brief account of the new subdivision will be given at this place as a supplement.

- I. *Orbitoides* s.s.                      Campanian.
1. *Orbitella*.                      Genotype *O. media*.  
Nucleoconch divided into 3 or 4 chamberlets by thin partitions, which are more or less regularly arranged.
  2. *Simplorbites*.                      Genotype *O. gensacica*.  
N. considerably larger, including numerous chamberlets.
  3. *Lepidorbitoides*.                      Genotype *O. socialis*.  
N. of two chamberlets; the first one spherical, but slightly embraced by the second.
  4. *Clypeorbis*.                      Genotype *O. mamillata*.  
Asymmetrical shell with central boss on one side of the median plane; N. small, composed of a large chamberlet and a few smaller ones surrounding the former in a rosette.
- II. *Orthophragmina*.                      Danian-Eocene.
5. *Discocyclina*                      Genotype *O. archiaci*.  
Lenticular shell; N. large, thin walled, the first chamberlet embraced by the second in very variable amounts.
  6. *Asterodiscus*.                      Genotype *O. pentagonalis*.  
Stellate shell; N. surrounded by a number of rounded chamberlets; median chamberlets occupying the rays much elongated in the direction of the ray.
- III. *Lepidocyclina*.                      Upper Eocene-Burdigalian.
7. *Isolepidina*.                      Genotype *O. mantelli*. Upper Eocene.  
N. spherical, divided into two halves by a straight partition in the typical examples; there are two variations, one toward *Eulepidina* and the other toward *Nephrolepidina*.
  8. *Eulepidina*.                      Genotype *O. dilatata*. Stampian-Aquitania.  
First chamberlet of N. wholly embraced by and in internal contact with the second one.
  9. *Nephrolepidina*.                      Genotype *O. marginata*. Stampian-Burdigalian.  
First chamberlet of N. but slightly embraced by the second.

1) DOUVILLÉ: Les *Orbitoides*: développement et phase embryonnaire: leur évolution pendant le Crétacé.—Les *Orbitoides* du Danian et du Tertiaire: *Orthophragmina* et *Lepidocyclina*. Comptes rendus Acad. Sc., vol. CLXI., 1915, pp. 664-670, 721-728.

10. *Pliolepidina*. Genotype *O. tobleri*. Stampian.

N. of considerable size, thin walled, and partitioned into a number of small side-chamberlets along the margin.

The original paper gives the distinctive features shown by the median chamberlets peculiar to each group; for the sake of brevity, however, they are not quoted at this place.

The specific distinction of the foraminifera of this group depends for the most part upon the general outline of the shell, and its surface sculpture, the latter varying in respect to the difference of the lateral chamberlets in size, and in respect to the difference of the conical pillars in size and number; hence proper recognition of a species can only be made by the use of isolated specimens as well as by oriented sections, and in a strict sense, the specific determination of the foraminifera by means of thin sections alone, especially of random sections, is hardly possible. The long list of the so-called species of *Lepidocyclina* previously recorded from the Tertiary rocks of the Indo-Pacific region may include many invalid ones based on insufficient material and accompanied by unsatisfactory specific diagnosis.

## Eulepidina Group.

***Lepidocyclina (Eulepidina) monstrosa* YABE sp. nov.**

Pl. VI. (I.), fig. 5-A; Pl. VII. (II.), figs. 11, 12-A, 13.

Shell 8 mm. or more in diameter, consisting of a large central boss and a narrow peripheral flange around it. Central boss globular, almost 6 mm. in diameter and more in height; transition to the periphery abrupt. Peripheral flange thin and wavy. Outline circular? Surface apparently smooth.

Median chamberlets rather small; those from the median portion of the shell 0.1 mm. broad and long in average. Lateral chamberlets relatively large, those of the central part of the boss measuring 0.22-0.28 mm. in diameter near the surface.

In adult stage, wall of the lateral chamberlets of a definite position so much thickened as finally quite to obliterate the inner space; these chamberlets form a broad ring on the surface of the central boss, around a group of the chamberlets at the very center, whose wall is quite free from such a thickening. Seen on transvers section the chamberlets with the thickened wall form two cones, each with its apex on one side of the nucleoconch.

A complete specific diagnosis of such foraminifera as *Orbitoides* can not be made by the use of the microscopic sections alone, but there must be also the simultaneous inspection of isolated specimens; in the present instance, however, the fossil is so characteristic that I considered that I was warranted in establishing a new species only on the microscopical examination of the material, although the isolation of the specimens from the matrix was quite hopeless.

This species and that foraminifera described by H. DOUVILLÉ<sup>1)</sup> from the Miocene of the Philippines under the name *L. formosa* SCHLUMBERGER seem to possess many features in common; both agree in the general outline of the shell as well in most points of the internal structure. A single marked distinction is provided by the ring of the chamberlets with thickened wall, cited above, which is characteristic of the present species in adult stage, but never shown by DOUVILLÉ's specimens. The latter, which attains 12 mm. in diameter, is almost circular in outline and possesses a large central boss which often measures 6 mm. in diameter and 4.5-6 mm. in height. It is characterised as "cette espèce est nettement caractérisée par l'épaisseur des cloissons qui entourent les logettes latérales; la surface paraît lisse et les piliers semblent faire défaut ainsi que les granulations superficielles qui leur correspondent."

1) H. DOUVILLÉ: Les foraminifères dans le tertiaires des Philippines, P. 72, Pl. D, figs. 2-5. 1911.

The type specimens of *L. formosa* from the Miocene (?) of Tewel in Borneo have been described by SCHLUMBERGER<sup>1)</sup> as a stellate form, exquisitely four rayed. "Le plasmostracum se compose d'une partie centrale quadrangulaire, en forme de coussin, très épaisse au centre, amincie sur les bords et prolongée aux quatre angles par de longs rayons raccordés aux côtés par une courbe élégante." These specimens from Borneo attain 18 mm. in diameter, including the rays, and their central boss 6 mm.

As to the outline of the Bornean examples, however, DOUVILLÉ<sup>2)</sup> has already pointed out that they are in reality circular in outline, but give stellate median sections on account of the curved state of their shells; an interpretation which is quite plausible. He further stated that the lateral chamberlets of the Bornean specimens attain 0.2 mm. in diam., while the wall between them measures 0.1 mm. in average thickness.

Although DOUVILLÉ identified his Philippine material of *L. formosa* with the Bornean type, yet there are certain differences recognisable between them; first, the central boss is more conspicuous in the former than in the latter, and secondly, the lateral chamberlets near the surface of the boss are almost twice as large in the former as in the latter. These features usually undergo a certain amount of individual variation, yet in the present case, the difference is somewhat conspicuous and suggests the specific distinction of the Bornean specimens from those of the Philippines, as has been already suspected by RUTTEN.<sup>3)</sup>

There is no known species of *Lepidocyclina* which is liable to be confounded in any way with this species now under consideration.

#### ***Lepidocyclina (Eulepidina) formosa* SCHLUMBERGER.**

Pl. VI. (I.), figs. 1-B, 2, 4 B, 6, 7-B, 8-B; Pl. VII. (II.), figs. 1-B?, 4-6, 12-B, 14-B.

1902. *Lepidocyclina formosa* SCHLUMBERGER: Note sur un *Lepidocyclina* nouveau de Bornéo. Samm. Geol. Reichs-Mus., Leiden, ser. 1, vol. IV., p. 251, pl. VII., figs. 1-3.
1905. *L. formosa* DOUVILLÉ: Les foraminifères dans le Tertiaire de Borneo. Bull. Soc. Géol. France, ser. 4, vol. V., p. 445.
- ? 1906. *L. richthofeni* SMITH: *Orbitoides* from the Binangonan Limestone. Phil. Jour. Sci, vol. I., No. 2, p. 205, pl. I., fig. 1.
- ? 1908. *L. raulini* PROVALE: Di alcuni Nummulitine e Orbitoidine dell' Isola di Borneo. Riv. Ital. Pal., anno XIV., p. 76, pl. VI., figs. 6-8.
1909. *L. formosa* PROVALE: l.c., Riv. Ital. Pal., anno XV.
- ? 1910. *L. formosa* SCHOLZ: Beiträge zur Kenntnis der deutschen Ostafrikanischen Tertiärlagerungen I. Zeitsch. d. deutsch. Geol. Gesell., vol. LXII., Monatsberichte, p. 372, figs. 3-5.
- Non 1911. *L. formosa* DOUVILLÉ: Les foraminifères dans le Tertiaire des Philippines. Philippine Jour. Sci., vol. IV., No. 2, sec. D, p. 72, pl. D, figs. 2-5.
- ? 1911. *L. richthofeni* DOUVILLÉ: l.c. p. 71, pl. C, figs. 1-3.
1912. *L. formosa* RUTTEN: Studien über Foraminiferen aus Ost-Asien. Samm. Geol. Reichs-Mus., Leiden, ser. 1, vol. IX., p. 214.
1912. *L. formosa* DOUVILLÉ: Les foraminifères de l'île de Nias. Samm. Geol. Reichs-Mus., Leiden, ser. 1, vol. VIII. p. 264.
1914. *L. formosa* RUTTEN: Studien. l.c., p. 297.

1) C. SCHLUMBERGER: Note sur un *Lepidocyclina* nouveau de Borneo. Samm. des geol. Reichs-Mus. Leiden, ser. I, vol. VI., p. 251, pl. VII., figs. 1-3. 1902.

2) DOUVILLÉ: l.c. p. 64.

3) RUTTEN: Studien über Foraminiferen aus Ost-Asien. Samm. Geol. Reichs-Mus., Leiden, ser. 1, vol. IX., p. 299.



These figures represent another species of *Eulepidina* which is distinguished from the preceding form by its larger shell with a smaller central boss and a broader, often very flexuous peripheral flange. It is megalospheric, the nucleoconch attaining 8 mm. or more in diameter. The lateral chamberlets are smaller than those of the preceding form; the wall of the lateral chamberlets is thick being composed of numerous solid polygonous prisms arranged in a chain, but never so thickened as to obliterate the interspaces. Surface smooth?, possibly very finely pustulated.

In all the essential features, the present form agrees quite well with *L. formosa* first described by SCHLUMBERGER from Teweh, Borneo, and reported subsequently by DOUVILLÉ, PROVALE, and RUTTEN from various parts of the same island.

Of various species of *Eulepidina*, there are few, besides *L. formosa*, with a central boss like our form, probably *L. insulae-natalis* var. *inequalis* JONES and CHAPMAN being the one most nearly resembling ours. These two authors distinguished the said variety from *L. insulae-natalis* "in being altogether stouter, and more compressed in internal structure with regard to the peripheral chamberlets" and further essentially "in being uncequally developed and much thicker on one side of the median layer".<sup>1)</sup> This shell, with undulated contour and attaining 16.8 mm. in diameter, seems to me very like the Philippine form under consideration; the considerable asymmetry of the former in section (pl. XXI., fig. 12) may be ascribed to the obliquity of the section to the median plane and the great development of the central boss rather than to the asymmetrical development of the latter. This variety is, however, distinguished from the present form by a lateral shell layer more delicate in construction.

According to CHAPMAN,<sup>2)</sup> var. *inequalis* represents probably the megalospheric individuals of *L. insulae-natalis* (which includes the corresponding microspheric ones) and is closely comparable, if not identical, with *L. murrayana* JONES and CHAPMAN and *L. formosa* SCHLUMBERGER. NEWTON<sup>3)</sup> also expressed his belief that the latter two forms are similar or closely allied, whereas RUTTEN<sup>4)</sup> was convinced of the specific identity of *L. formosa* SCHLUMBERGER and *L. richthofeni* SMITH.

The type section<sup>5)</sup> of *L. murrayana* from Christmas Island is four rayed, and NEWTON<sup>6)</sup> lately figured one with very similar aspect from New Guinea; but as this species appears in all transverse sections quite symmetrical as to the axis vertical to the disc, it is certainly not a stellate form, but a form with strongly undulated shell like *L. formosa* SCHLUMBERGER. It is at present hard to decide whether *L. murrayana* from Christmas Island is identical with *L. formosa* or not; it must, however, be borne in mind that CHAPMAN,<sup>7)</sup> who together with JONES first described the former species, maintained their specific identity. In this connection, also the great similarity shown by *L. ephippioides* JONES and CHAPMAN<sup>8)</sup> from Christmas Island to *L. formosa* must not be overlooked.

DOUVILLÉ<sup>9)</sup> distinguished *L. ngembaki* from *L. insulae-natalis*; the type specimens of the former are those described by SCHLUMBERGER<sup>10)</sup> under the name *L. insulae-natalis*; SCHLUMBERGER's fig. 4 which represents a tangential slice taken near the surface of the shell shows numerous white dots, some 1.5

1) T. R. JONES and F. CHAPMAN: On the Foraminifera of the Orbitoidal Limestones and Reef Rocks of Christmas Island, in Monograph of Christmas Island published from the British Museum, Nat. Hist. Dep., p. 254, pl. XXI., fig. 12. 1900.

2) F. CHAPMAN: Notes on the Older Tertiary Foraminiferal Rocks on the West Coast of Santo, New Hebrides. Proc. Linn. Soc. N.S.W., 1905, pt. 2, p. 271.

3) R. B. NEWTON: Organic Limestones etc. from Dutch New Guinea, p. 13. 1916.

4) RUTTEN: Studien über die Foraminiferas aus Ost-Asien. Samm. Reichs-Mus. Leiden, ser. I, vol. IX, p. 301. This author, further assigned the foraminifera described by PROVALE from Borneo under the name of *L. raulini* LEMOINE and DOUVILLÉ to *L. formosa*.

5) T. R. JONES and F. CHAPMAN: l.c., p. 253, pl. XXI., fig. 10.

6) NEWTON: l.c., p. 12, pl. I, figs. 1A, 2A, 3A, 4A, 5A, 6A, 7A, 8-10.

7) CHAPMAN: Description of a Limestone of Lower Miocene Age from Bootless Inlet, Papua. Jour. Proc. Roy. Soc. N. S. WALES, vol. XLVIII., 1914, p. 296.

8) JONES and CHAPMAN: l.c., p. 250, pl. XX., fig. 9.

9) DOUVILLÉ: l.c., p. 63.

10) SCHLUMBERGER: Notes sur deux espèces de *Lepidocyclina* des Indes Néerlandaises. Samm. Reichs-Mus. Leiden, ser. I., vol. 6, p. 128, pl. VI., figs. 1-4.

mm. in diameter, surrounded by smaller dark coloured cells arranged in a chain and forming a network. A comparison of this figure with his fig. 2 makes it evident that the white dots represent the lateral chamberlets—but not the pillars—and the dark cells the prism of compact calcareous matter composing the wall—but not the chambers; thus we see on figure 4 only the wall-structure, but no trace of pillars.

On the contrary, *L. insulae-natalis* is postulated on the surface as clearly represented on the original figure<sup>1)</sup> given by JONES and CHAPMAN and far more excellently on that given by DOUVILLÉ<sup>2)</sup> of a specimen from the Philippines; these pillars are isolated, in spite of the contrary description given by JONES and CHAPMAN.<sup>3)</sup> DOUVILLÉ also stated that in *L. insulae-natalis*, the granules are relatively large, come in contact with each other and thus surround the lateral chamberlets, while in *L. ngembaki*, they are smaller and isolated, and are surrounded by the lateral chamberlets; this statement does not seem to me to hold good.

RUTTEN is probably justified in considering the conical pillars as a feature not constant in each species, as they are believed to be by DOUVILLÉ; the former author thus maintained *L. insulae-natalis* to be inseparable from *L. ngembaki*. But when he takes *L. provalei* OSIMO<sup>4)</sup> and *L. insulae-natalis* also to be conspecific, his manner of treatment seems precarious.

As to *L. richthofeni*, if it is a megalospheric form, there is great possibility of its identity with *L. formosa*.

From the foregoing paragraphs, we see two forms or groups of forms, one microspheric and the other megalospheric, of extensive distribution and of common occurrence in the Older Miocene and Oligocene deposits of the Indo-Austro-Eastern-Asiatic region, namely:

Microspheric forms:

*L. insulae-natalis*

*L. ngembaki*

? *L. provalei*

Megaspheric form:

*L. formosa*

*L. richthofeni*

*L. murrayana*

? *L. ephippioides*

E. SCHOLZ<sup>5)</sup> who recorded the occurrence of *L. formosa* from a Lower Miocene rock of German East Africa, stated that *L. formosa* is dimorphous, his specimens of 10–20 mm. diameter being megalospheric and those of 20–30 mm. microspheric. The microspheric form is also described as being almost smooth on the surface. He did not bring his microspheric form of *L. formosa* into comparison with *L. insulae-natalis*.

The geological and geographical distribution of *L. formosa* is, as follows:

Teweh, South Borneo: in limestone. (Lower Aquitanian after DOUVILLÉ).

South Borneo: in limestone and marl; Stampian and Lower Aquitanian (after RUTTEN).

P. Soreng, Southeast Borneo; Lower Miocene? (after RUTTEN).

Balik Papan, East Borneo: in the Pamaloean beds (after RUTTEN).

Oedjoe Halang, Central Borneo: in marl; Oligocene? (after RUTTEN).

1) JONES and CHAPMAN: l.c., pl. XX., fig. 5.

2) DOUVILLÉ: l.c., pl. B, figs. 1 b, 3 b.

3) "When the test is cut through tangentially these conical pillars appear as fibrous shell-substance surrounding the polygonal chamberlets."

4) OSIMO: Di alcuni foraminiferi dell'Eocene superiore di Celebes. Riv. Ital. Pal., anno XIV., p. 40, pl. I., figs. 10–12.

5) E. SCHOLZ: Beiträge zur Kenntnis der deutschen Ostafrikanischen Tertiärlagerungen I. Zeitsch. d. geol. Gesell., XXII., 1910, Monatsberichte p. 372, figs. 3–5.

Pic of Maros, Celebes (after RUTTEN).

Kei Island (after RUTTEN).

Nias: found together with *L. insulae-natalis*, *L. (Nephrolepidina) sumatrensis*, *L. (N.) verbeeki*, and *Cycloclypeus communis*; Upper Aquitanian (after DOUVILLÉ).

German East Africa; Lower Miocene (after SCHOLZ).

Trinity Island; Aquitanian (after DOUVILLÉ).

**Lepidocyclina (Eulepidina) gibbosa** YABE nom. nov.

Pl. VI. (I.), figs. 3, 4c, 7c ?

1911. *Lepidocyclina (Eulepidina) formosa* DOUVILLÉ: Les foraminifères dans le Tertiaire des Philippines, p. 72, pl. D, figs. 2-5.

This is an ally of *L. monstrosa*, described above, being very similar in general external aspect and size of the shell as well as in its internal structure, except in the ring structure characteristic of *L. monstrosa*. The central boss of the present species, however, is less prominent than that of *L. monstrosa*, its height being always inferior to the breadth. Internally, the present species is distinguished from all the other known species by the lateral chamberlets which attain a considerable size (0.65 mm. in a shell the diameter of which is about 8 mm.); these chamberlets are surrounded by a thick wall, 0.26 mm. broad. Having no particular conical pillars, the surface of its shell must be almost smooth, possibly having only the more or less elevated reticulation due to the thick wall of the lateral chamberlets. Outline unknown; but probably circular or almost circular.

*L. monstrosa* is distinguished from this species by its characteristic ring structure and the smaller lateral chamberlets, which are only about half as broad as those of the present species. *L. formosa* of DOUVILLÉ from the Philippines is a species most nearly approaching the latter, and I think, these two are probably conspecific. As *L. formosa* of DOUVILLÉ from the Philippines seems to me to be distinct from the type of *L. formosa* SCHLUMBERGER, I think it is better to give a new name to the present species.<sup>1)</sup>

**Lepidocyclina (Eulepidina) sp. indet. cfr. inermis** DOUVILLÉ.

Pl. VII. (II.), fig. 2D.

Fig. 2D on Plate II. shows an eulepidina *Lepidocyclina* in transverse section; it does not belong to either of the foregoing species, as its lateral chamberlets are relatively spacious, and their wall is conspicuously thin. Like them, it has no particular pillars of solid calcareous substance, and the surface of its shell is probably smooth. All these features indicate a close affinity existing between the present fossil and that described by DOUVILLÉ from the Philippines under the name *L. (E.) inermis*.<sup>2)</sup>

1) During the press of this paper, I received from Mr. W. F. F. OPPENOORTH an important paper on a foraminifera rock from the north coast of Atjeh, Java, in which an eulepidine *Lepidocyclina* was described under the name *L. stereolata* OPPENOORTH. This species much resembles the present form in several features. The shell of the Java species possesses a large prominent central boss; the lateral chambers which constitute the central boss are also conspicuously large, even being larger than those of the present form. However, the Java species is easily distinguished from the present form by being provided with strong conical pillars through the lateral shell layers. OPPENOORTH: Foraminiferen van noordkust van Atjeh. Verhand. Geol.—Mijnbouwkundig Genootschap voor Nederland en Kolonien. Geol. ser., vol. II., 1918, p. 254, pl. VIII, figs. 1-6.

2) DOUVILLÉ: l.c., 1911, p. 72, pl. D, fig. 5.

**Lepidocyclina (Eulepidina?)** sp. indet.

Pl. VII. (II.), fig. 1E.

The figure shows a *Lepidocyclina* characterised by its globular central boss and broad, thin peripheral flange; the lateral chamberlets are large and provided with a thick wall. This is distinguished from *L. gibbosa* on account of its peripheral flange which is considerably wider than the corresponding part of the named species, though there is a possibility of the present examples being young individuum of it.

The transverse section shows an outline similar to that of *L. andrewsiana* figured by JONES and CHAPMAN from Christmas Island, which, in spite of its broad peripheral flange, was considered by LEMOINE and R. DOUVILLÉ to be identical with *L. sumatrensis* BRADY provided with a considerably narrower peripheral flange. If such treatment is correct, then the present fossil also can safely find its place in the species *L. gibbosa*.

As to *L. andrewsiana*, there is, however, no evidence of its belonging to *Nephrolepidina*; at least it is quite certain that the nucleocoach of *L. sumatrensis* does not show such an outline in any transverse section as that shown by *L. andrewsiana* as figured by JONES and CHAPMAN on their plate XXI, fig. 14. For the same reason, the foraminifera from the Riukiu Islands figured by NEWTON and HOLLAND<sup>2)</sup> under the name *L. sumatrensis* can not be assigned to *L. andrewsiana*, as CHAPMAN<sup>3)</sup> once did.

**Nephrolepidina Group.****Lepidocyclina (Nephrolepidina) angulosa** PROVALE.

Pl. VII. (II.), figs. 8, 9G?

1875. *Orbitoides dispansa* H. B. BRADY: Fossil Foraminifera of Sumatra. Geol. Mag., London, dec. II., vol. II., p. 536, pl. XIV., figs. 2a-c.
1909. *Lepidocyclina tournoueri* var. *angulosa* PROVALE: Di alcuni Nummulitine e Orbitoidine dell'Isola di Borneo. Pt. II. Riv. Ital. Pal., vol. XV., p. 90.
1912. *L. (Nephrolepidina) angulosa* DOUVILLÉ: Les Foraminifères de l'île de Nias. Samm. Reichs-Mus. Leiden, ser. I., vol. VIII., pl. XXI, figs. 4, 5.
1913. *L. angulosa* RUTTEN: Studien über Foraminiferen aus Ost-Asien, p. 291, pl. XXI, figs. 1-4.

Three or four transverse sections are assigned to this species on account of peculiar pustulation; it resembles *L. (N.) verbeeki* in a section of the same orientation, but is distinguished from the latter by its conical pillars which are few in number and extremely thick. *L. angulosa* has polygonal outline.

*L. angulosa* is known from Java, Borneo and Nias. The marly rock of Nias with *L. angulosa* contains in addition *L. (Eulepidina) ngembaki*, *L. (Nephrolepidina) sumatrensis*, and *Miogypsina irregularis* var. *orientalis*, and is assigned by DOUVILLÉ to the Upper Aquitanian. RUTTEN recorded it from strata of Borneo ranging between the Older Miocene and the Younger Miocene and in association with *Cycloclypeus communis*, *Miogypsina*, several species of nephrolepidine *Lepidocyclina*, and a few species of eulepidine.<sup>4)</sup>

1) P. LEMOINE et R. DOUVILLÉ: Sur le genre *Lepidocyclina* GÜMBEL. Mém. Soc. Géol. France (Paléontologie), No. 32. p. 18. B. NEWTON: Organic Limestones etc. from Dutch New Guinea, p. 11.

2) R. B. NEWTON and R. HOLLAND: On Some Fossils from the Islands of Formosa and Riukiu. Jour. Sci. Coll., Imp. Univ. Tokyo, vol. XVII, art. 6, 1902, p. 11, pl. I, fig. 7.

3) CHAPMAN: A Limestone of Lower Miocene Age from Bootless Inlet, Papua, p. 296.

4) In the recent publication of Mr. OPPENOORTH, once referred to above, this species was also reported from the north coast of Atjeh, Java, in association with *Cycloclypeus neglectus* MARTIN, *Lepidocyclina (Nephrolepidina) verbeeki* N. and H., *L. (N.) sumatrensis* var. *inornata* RUTTEN, *L. (N.) parva* OPPENOORTH, *L. (N.) atjehensis* OPPENOORTH, *L. (Eulepidina) stereolata* OPPENOORTH and *L. (E.) planata* OPPENOORTH.

**Spiroclypeus**, H. DOUVILLÉ emend BOUSSAC.

1905. *Spiroclypeus* DOUVILLÉ: Les Foraminifères dans le Tertiaire de Borneo. Bull. Soc. Géol. France, ser. 4, vol. V., p. 455.

1906. *Spiroclypeus* BOUSSAC: Développement et morphologie de quelques foraminifères de Priabona. Ibid. ser. 4, vol. VI., p. 93.

Genotype *S. orbitoides* DOUVILLÉ.

Shell discoidal, swollen at central portion; generally circular in larger specimens and oval in smaller. Composed of one median and numerous lateral layers of chamberlets; chamberlets of the median layer quadratic in median section and arranged as in *Heterostegina*; those of the lateral layers polygonal and flat, arranged in numerous, more or less regular piles.

*Spiroclypeus* represents a very interesting type of foraminifera; it simulates *Orthophragmina* to a considerable degree in its general aspect as well as in the internal structure.

It is essentially *Heterostegina*, although its outer whorl completely embraces the inner one, leaving always a narrow space between the shell layers of the consecutive whorls, where the septa and transverse partitions are so developed as to give rise to numerous flat chamberlets with irregularly polygonous outlines. In this last feature, the shell of *Spiroclypeus* is constructed somewhat similar in plan to that of a *Nummulites* of the reticulate group.

There is a *Heterostegina*-like foraminifera, found in a limestone of the Priabona beds which was collected by myself at Mathias Hills near Budapest, Hungary. It is not a typical *Heterostegina*, as the septa give rise to lateral chamberlets, but it is certainly a transitional form from *Heterostegina* to typical *Spiroclypeus*. Whether it is to be called a *Heterostegina* or a *Spiroclypeus*, is at present unimportant; it is interesting, however, to point out the feature shown by a portion of its shell which is somewhat similar to that visible on the lateral surface of the shell of a reticulate *Nummulites*. This form will be illustrated in another paper on the Tertiary foraminifera from the Riukiu and the Bonin Islands to be immediately published.

In the arrangement of lateral chamberlets, *Spiroclypeus* shows a striking resemblance to *Orbitoides* (in a wide sense), since the lateral chamberlets are arranged in regular layers parallel to the surface of the shell and at the same time in more or less regular piles vertical to it. Detailed examination, however, reveals certain distinctive features existing between *Spiroclypeus* and *Orbitoides*. In the former genus, the lateral shell layers—of heterostegine or nummulitic shells—are persistent as such, at least in early stages of growth, and are usually much thicker than the interspace in alternation; consequently, all the chamberlets of different piles occupy definite levels. Sooner or later, however, in more advanced stages of growth, the lateral shell layers show a tendency to split into thinner ones towards the central part of the shell, thus multiplying there in number; then the shell becomes more and more like *Orbitoides* in general aspect. In the latter genus, however, from the very beginning of growth, there is no trace of such lateral shell layers, as a distinct structure, in alternation with the interspace, but in general the chamberlets show an aspect of being provided with their own walls, and those of different piles are as a rule on different levels; hence, in this respect, *Orbitoides* shows a more advanced stage of development than *Spiroclypeus*, and the lateral layers of chamberlets in *Orbitoides* and *Spiroclypeus* are the equivalent of the lateral side of the whorl together with the alar prolongation in nummulitic shells.

When *Spiroclypeus* was first established by DOUVILLÉ,<sup>1)</sup> he assigned to it, besides the genotype cited above, also *Heterostegina pleurocentralis* CARTER and an undescribed species from the Miocene of Martinique. Subsequently, J. BOUSSAC<sup>2)</sup> extended this genus so as to include *Heterostegina margaritata*

1) DOUVILLÉ: l.c.

2) J. BOUSSAC: Développement et morphologie de quelques foraminifères de Priabona. Bull. Soc., Géol. France, sér. IV., vol. VI., 1906, p. 93.

SCHLUMBERGER and described a new species, *S. granulatus*, with which the fossil from Budapest, cited above, is apparently identical; but he did not determine whether to *Spiroclypeus* or *Heterostegina* two other allied species known from earlier times under the name *H. reticulata* RÜTIMEYER and *H. carpenteri* UHLIG may properly belong. The reason why BOUSSAC extended the genus *Spiroclypeus* so as to include such forms as *H. margaritata* will be found in the following statement quoted from his paper:

"Ainsi les *Spiroclypeus* DOUV. ne sont pas seulement des Hétérostégines chez lesquelles la phase nummulitifforme persiste pendant tout le développement, ce sont en outre des Hétérostégines où la lame spirale est subdivisée dans la région du bouton, dont elle produit ainsi la protubérance. Et alors la question se pose de savoir si le nom de *Spiroclypeus* doit être donné à toutes les Hétérostégines à tours embrassants où s'il doit être réservé aux formes où lame spirale est subdivisée. Mais si on considère: 1 que nous ne savons pas actuellement si la lame spirale, chez les espèces à tours embrassants déjà décrites, est subdivisée ou non; 2 que la subdivision de la lame spirale est un phénomène suffisamment important pour caractériser un genre, et qu'il se trouve précisément dans le type du genre *Spiroclypeus* DOUV., il semble préférable de limiter ce genre aux Hétérostégines à spire embrassante et à lame spirale subdivisée dans la région du bouton; d'autant plus que la spire étant toujours complètement embrassante dans le jeune, elle peut continuer à l'être pendant une période de développement plus ou moins longue suivant les espèces, et qu'on n'a pas la un caractère de grande valeur. Je propose d'appeler *Heterostegina* D'ORB, toutes les formes où la lame spirale reste simple dans la région du bouton, que la spire soit embrassante ou non."

Likewise, SILVESTRI<sup>1)</sup> although with doubt assigned his new species *S. ? tugertus* to *Spiroclypeus*. More recently, DOUVILLÉ<sup>2)</sup> introduced yet another new species, *S. pustulosus*, and recorded the occurrence of an unnamed species in the Miocene of Trinidad. The above enumeration covers all the species now known of the genus, and the following list shows their geographical distribution and geological range.

<i>S. ? reticulatus</i> RÜTIMEYER.	Switzerland <sup>3)</sup> , Hungary <sup>4)</sup> , Galicia <sup>5)</sup> , Borneo <sup>6)</sup> , Celebes <sup>7)</sup> ; Upper Eocene to Oligocene.
<i>S. granulatus</i> BOUSSAC.	Italy <sup>8)</sup> , Hungary <sup>9)</sup> ; Upper Eocene (Priabonian).
<i>S. pustulosus</i> DOUVILLÉ.	France <sup>10)</sup> ; Upper Eocene (Priabonian).
<i>S. ? carpathicus</i> UHLIG.	Galicia <sup>11)</sup> ; Upper Eocene.
<i>S. ? margaritatus</i> SCHLUMBERGER.	Borneo <sup>12)</sup> , Nias <sup>13)</sup> , New Guinea <sup>14)</sup> , Miocene (Upper Aquitanian-Burdigalian ?)
<i>S. orbitoides</i> DOUVILLÉ.	Borneo <sup>15)</sup> ; Miocene (Upper Aquitanian).

1) SILVESTRI: La questione della *Lepidocyclina* nell' Umbria. Atti Pont. Accad. Rom. Nuovi Lincei, vol. LX., 1907. Cited after SCHUBERT.

2) DOUVILLÉ: Le Crétacé et le Tertiaire aux environs de Thonon (Haute Savoie Comp. rendus Acad. Sci. vol. CLXIII., p. 324. DOUVILLÉ: Les *Orbitoides* de l'île de la Trinité. Comp. rendus, vol. CLXIV., p. 841. 1917.

3) A. HEIM: Die Nummuliten und Flyschbildungen der Schweizeralpen. Abh. d. Schweiz. Pal. Gesell., vol. XXXV., p. 254.

4) MAX v. HANTKEN: Die Fauna der *Clavulina szaboi*-Schichten. Mitth. Ung. Geol. Anstalt, vol. IV., No. 1, 1875, p. 81, pl. XII., fig. 3.

5) V. UHLIG: Ueber einer Mikrofauna aus dem Alttertiär der westgalizischen Karpathen. Jahrb. d. k.k. Geol. Reichsanstalt, Wien, vol. XXXVII., 1886, p.

6) M. v. HANTKEN in POSEWITZ'S Borneo (cited after DOUVILLÉ). DOUVILLÉ: l.c. 1905.

7) G. OSIMO: Di alcuni foraminiferi dell'Eocene superiore di Celebes, p. 33, pl. I., fig. 9.

8) BOUSSAC: l.c.

9) This paper.

10) DOUVILLÉ: l.c., 1916.

11) UHLIG: l.c.

12) SCHLUMBERGER: Note sur un *Lepidocyclina* nouveau de Borneo. Samm. Geol.-Reichs-Mus. Leiden, ser. I., vol. VI., p. 252, pl. VII., fig. 4.

13) DOUVILLÉ: Les foraminifères de l'île de Nias. Samm. Geol. Reichs-Mus., Leiden, ser. I., vol. VIII., p. 275, 1912.

14) CHAPMAN: Limestone of Lower Miocene Age from Bootless Inlet, Papua. Jour. Proc. R. Soc. N.S. Wales, vol. XLVIII., p. 293, pl. IX., fig. 11.

15) DOUVILLÉ: l.c., 1905

<i>S. pleurocentralis</i> CARTER.	Borneo <sup>1)</sup> , Arabia; Miocene (Upper Aquitanian).
<i>S. sp.</i>	Trinidad <sup>2)</sup> , Miocene (Aquitanian).
<i>S. sp.</i>	Martinique <sup>3)</sup> ; Miocene (Burdigalian).
<i>S. ? tugertus</i> SILVESTRI.	Italy <sup>4)</sup> ; Miocene?

Thus *Spiroclypeus* has a geological range extending from the Upper Eocene to the Miocene; it is not definitely known whether *Spiroclypeus* became extinct before the Pliocene, but it is a fact that we have no record of the occurrence of its living representatives in the present seas. The allied *Cycloclypeus* appeared earlier and is still existing, although its geographical distribution was and is confined to the tropical and subtropical seas of the Australasian province. *Spiroclypeus*, on the contrary, had a world wide distribution in warm seas.

***Spiroclypeus* cfr. *margaritatus* SCHLUMBERGER.**

Pl. VI. (I), figs. 4G, 5G, Pl. VI. (II), figs. 1G, 3, 7, 10G, 14G.

1902. *Heterostegina margaritata* SCHLUMBERGER: Note sur un *Lepidocyclina* nouveau de Borneo. Samml. Geol. Reichs-Mus., Leiden, ser. 1, vol. VI, p. 252, pl. VII., fig. 4.
1906. *Spiroclypeus margaritatus* BOUSSAC: Développement et morphologie de quelques foraminifères de Priabona. Bull. Soc. Géol. France, ser. 4, vol. VI, p. 94.
1914. *Heterostegina margaritata* CHAPMAN: Limestone of Lower Miocene Age from Bootless Inlet, Papua. Jour. Proc. Roy. Soc. N.S. Wales. vol. XLVIII., p. 293, pl. IX., fig. 11.

There are a number of sections in varied orientations that are believed to represent one and the same form of foraminifera which is very similar to *Spiroclypeus margaritatus*. Fig. 3 on Pl. II. is a transverse section through the nucleoconch; it is heterostegine in appearance and is more elongated toward one end than toward the other, the lateral shell layers, which are best developed at the umbilical portion, vanishing almost entirely toward the distant end. This figure gives us an impression of a smooth shell surface; but there are other sections of similar orientation with more or less well developed granules recognisable at the head of conical pillars. Fig. 7 on the same plate is another section cut through the peripheral flange of the shell; it shows a median layer bordered on both sides by lateral layers, 1-5 in number. Fig. 10G on Pl. II shows the same organism in a section cut somewhat along the median layer.

It is with some reservation that the present form is assigned to *S. margaritatus*; though it agrees very well with the type specimen of the named species excellently illustrated by SCHLUMBERGER, yet there is a considerable difference in size between them, the former being smaller and more delicate in structure than the latter. At least, it is certain that our fossils are quite distinct from both *S. orbitoides* DOUVILLÉ and *S. pleurocentralis* CARTER, and most resemble *S. margaritatus*.

*S. margaritatus* is now known to occur in the Miocene rocks of Borneo, and possibly also of Nias and New Guinea.

By the way, it will be noted that there are many other sections showing heterostegine chamberlets; these do not belong to *Spiroclypeus*, being free from lateral layers of chamberlets. The surface of the shell is granulated. See figs. 1, 4, 5, 8, on Pl. I. and figs. 1, 2 on Pl. II. Probably we have here a

1) CARTER in *Ann. Mag. Nat. Hist.*, (2) XI., pl. VII., fig. 26 (cited after DOUVILLÉ). DOUVILLÉ: l.c. 1905.  
 2) DOUVILLÉ: l.c., 1917.  
 3) DOUVILLÉ: l.c., 1905.  
 4) SILVESTRI: l.c.

species of *Cycloclypeus*, though there is another possibility that some of them belong to *Spiroclypeus* and the others to *Heterostegina*.

### Carpenteria, GRAY.

#### *Carpenteria proteiformis* GOES.

Pl. VII. (II.), figs. 9<sub>1</sub>, 10<sub>1</sub>.

1884. *Carpenteria proteiformis* BRADY: Report on Foraminifera, p. 679, pl. XCVII., figs. 8-14.  
 1886. *C. cfr. proteiformis* UHLIG: Ueber eine Mikrofauna aus den Alttertiär der westgalizischen Karpathen. Jahrb. d. K.K. geol. Reichsanstalt Wien, vol. XXXVII., p. 188, pl. V., fig. 3.  
 1886. *C. lithothammica* UHLIG: Ibid., p. 189, pl. V., figs. 1, 2.  
 1901. *Nubecularia elongata* LIEBUS: Ueber die Foraminiferenfauna des Bryozoen-Horizontes bei Priabona. N. Jahrb. f. Min. Geol. u. Pal., I., p. 130, pl. V., fig. 7.  
 1903. *C. proteiformis* MILLETT: Report on the Recent Foraminifera of the Malay Archipelago. Journ. Roy. Micr. Soc., 1903, p. 496, pl. X., figs. 1, 2.  
 1911. *C. proteiformis* SCHUBERT: Die Foraminiferen des Bismarckarchipels und einiger angrenzender Inseln, p. 108, pl. IV., fig. 4.

*Carpenteria* of more or less cylindrical growth, composed of few globular chambers. A chamber at the middle portion of a specimen, here figured (fig. 9<sub>1</sub>) is prolonged to a tube at its extremity. Wall very thick and coarsely perforated; exterior of an adult shell covered with larger into which pores of the inner layer open.

Our specimens are quite similar to those figured by BRADY and SCHUBERT.

This species was first described from the Caribbean Sea by A. GOES under the name *C. balaniformis* var. *proteiformis*; BRADY recorded it from the West Indies, Bermuda, Nares Harbour (Admiralty Islands) and Torres Strait. MILLETT found it common in his material of the recent foraminifera from the Malay Archipelago. It favours water of a moderate depth, the Challenger specimens examined by BRADY being obtained from depth ranging between 17 and 435 fathoms.

As fossil, it was recorded from the Palaeogene of Galicia and Hungary, and from the Miocene of New Mecklenburg. *C. capitata* JONES and CHAPMAN is an allied fossil found in the Miocene of Christmas Island,<sup>1)</sup> and New Guinea<sup>2)</sup>; it shows, CHAPMAN stated, a tendency to connect *Rupertia stabilis* with *Carpenteria proteiformis*.

1) JONES and CHAPMAN: Christmas Island, p. 245, pl. XX., fig. 7.

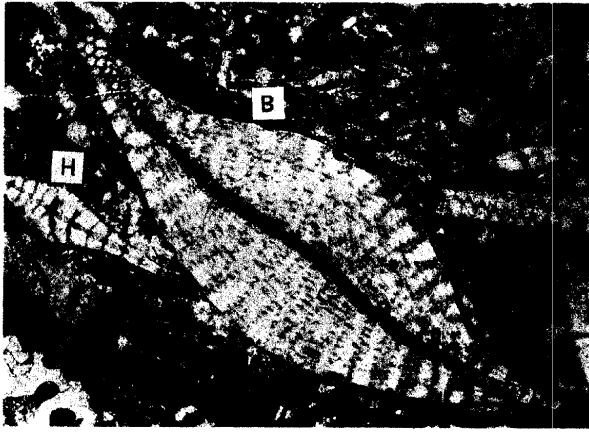
2) CHAPMAN: Limestone of Lower Miocene Age from Bootless Inlet, Papua, p. 289, pl. VII., fig. 1.



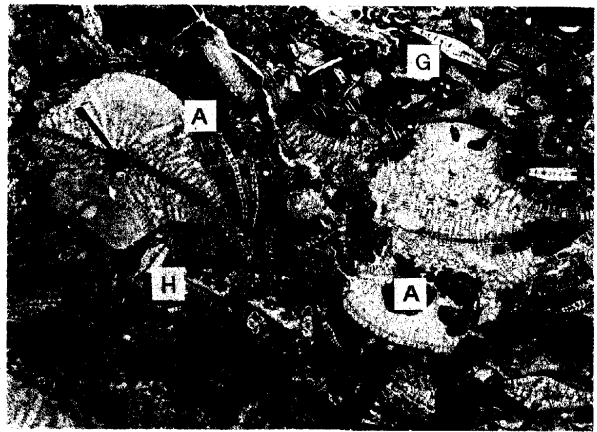
Plate VI. (I.).

Microphotographs of the fossils contained in a *Lepidocyclina* limestone collected by Mr. SH. NISHIHARA from Pauting Botow, Cebu.

- Fig. 1. *Lepidocyclina (Eulepidina) formosa* SCHLUMBERGER (B), and *Cycloclypeus* or *Heterostegina* (H), both in transverse section.  $\times 15$ .
- Fig. 2. *L. (E.) formosa* SCHLUMBERGER, in transverse section.  $\times 15$ .
- Fig. 3. *L. (E.) gibbosa* YABE in transverse section.  $\times 15$ .
- Fig. 4. *L. (E.) formosa* SCHLUMBERGER (B), *L. (E.) gibbosa* YABE (C) and *Cycloclypeus* or *Heterostegina* (H) in transverse section. Also *Spiroclypeus* cfr. *margaritatus* SCHLUMBERGER in oblique section.  $\times 7$ .
- Fig. 5. *L. (E.) monstrosa* YABE (A), *Sp. cfr. margaritatus* SCHLUMBERGER (G) and *Cycloclypeus* or *Heterostegina* (H).
- Fig. 6. *L. (E.) formosa* SCHLUMBERGER in tangential section.  $\times 7$ .
- Fig. 7. *L. (E.) formosa* SCHLUMBERGER (B) in tangential section and showing the structure of the wall of the lateral chamberlets which is composed of solid prisms. Also *L. (E.) gibbosa* YABE? (C) in oblique section.  $\times 15$ .
- Fig. 8. *L. (E.) formosa* SCHLUMBERGER (B) and *Cycloclypeus* or *Heterostegina* (H) in transverse section.  $\times 15$ .



1. x 15



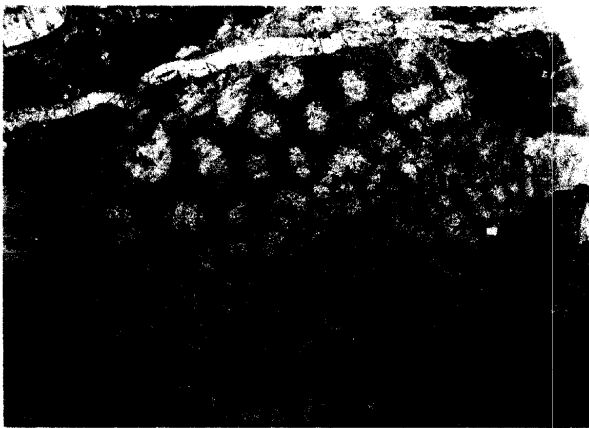
5. x 7



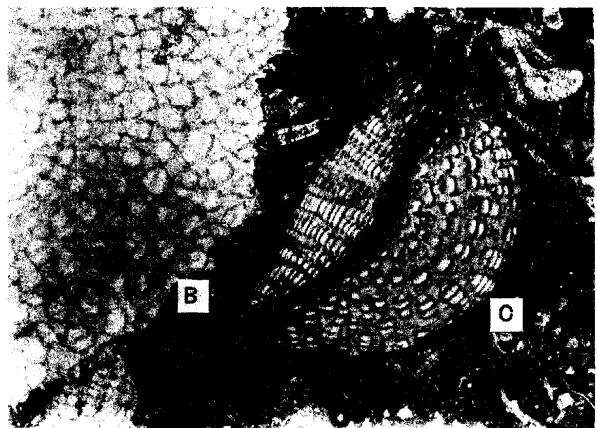
2. x 15



6. x 7



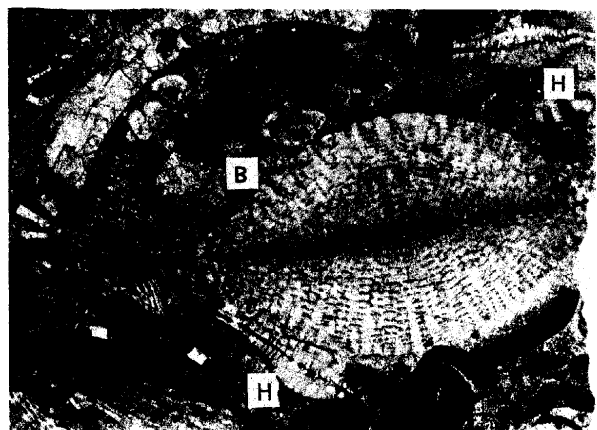
3. x 15



7. x 15



4. x 7

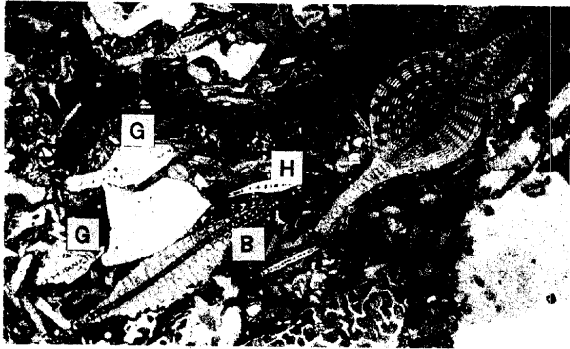


8. x 15

Plate VI. (II.).

Microphotographs of the fossils contained in a *Lepidocyclina* limestone collected by Mr. SH. NISHIHARA from Pauting Botow, Cebu.

- Fig. 1. *Lepidocyclina* (*Eulepidina*) *formosa* SCHLUMBERGER? (B), *L. (E.)* sp. indet. (E) and *Cycloclypeus* or *Heterostegina* (H) in transverse section; *Spiröclypeus* cfr. *margaritatus* SCHLUMBERGER (G) in oblique section. × 7.
- Fig. 2. *L. (E.)* cfr. *inermis* DOUVILLÉ (D) *Cycloclypeus* or *Heterostegina* (H) in transverse section. × 15.
- Fig. 3. *Sp.* cfr. *margaritatus* SCHLUMBERGER, transverse section through the nucleocoach. × 36.
- Fig. 4. *L. (E.) formosa* SCHLUMBERGER, oblique section through the nucleocoach. × 7.
- Fig. 5. *L. (E.) formosa* SCHLUMBERGER, transverse section through the peripheral part of a shell; encrusted by *Lithothamnium ramosissimum* REUSS. × 36.
- Fig. 6. *L. (E.) formosa* SCHLUMBERGER, section through the nucleocoach; two-rayed owing to the wavy peripheral flange of the shell. × 15.
- Fig. 7. *Sp.* cfr. *margaritatus* SCHLUMBERGER, transverse section through the peripheral part of a shell. × 36.
- Fig. 8. *L. (Nephrolepidina) angulosa* PROVALE, in oblique section. × 36.
- Fig. 9. *L. (N.) angulosa* PROVALE? (G), *Carpenteria proteiformis* GOES (I) and *Orbitolites* sp. (J). × 15.
- Fig. 10. *Sp. margaritatus* SCHLUMBERGER? (G) and *Carpenteria proteiformis* GOES (I). × 15.
- Fig. 11. *L. (E.) monstrosa* YABE in tangential section. × 7.
- Fig. 12. *L. (E.) monstrosa* YABE (A) in tangential section. *L. (E.) formosa* SCHLUMBERGER (B), one in transverse section through the nucleocoach and the other in almost median section. × 7.
- Fig. 13. *L. (E.) monstrosa* YABE in oblique section. × 7.
- Fig. 14. *L. (E.) formosa* SCHLUMBERGER (B) in transverse section through the peripheral part of a shell, and *Sp.* cfr. *margaritatus* SCHLUMBERGER (G) in oblique section. × 7.



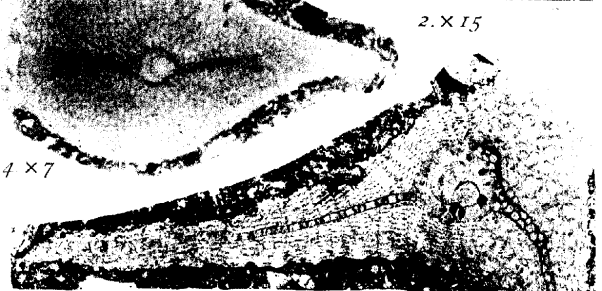
1. x 7



2. x 15



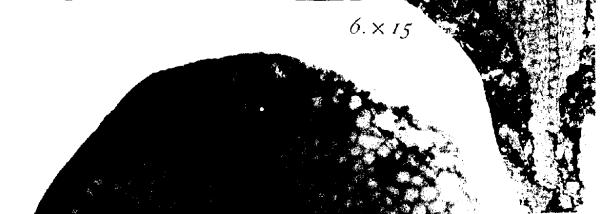
3. x 36



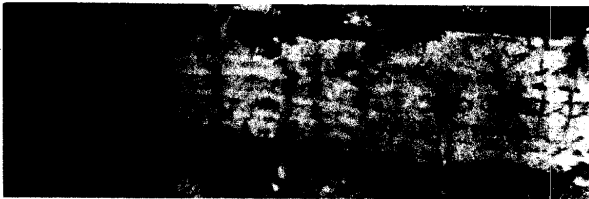
4. x 7



5. x 36



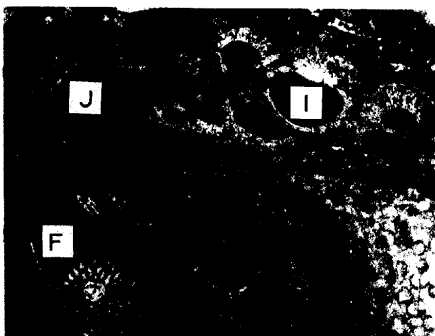
6. x 15



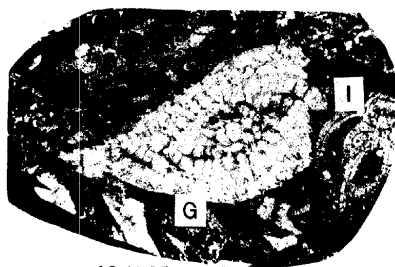
7. x 36



8. x 36



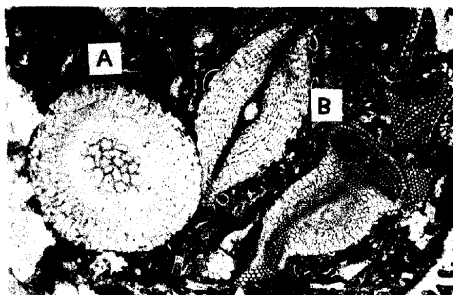
9. x 15



10. x 15



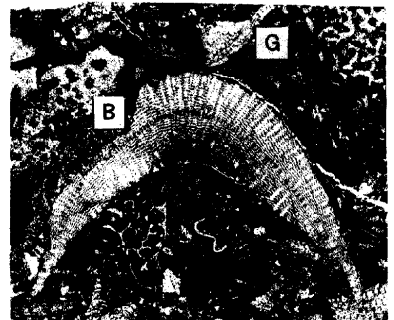
11. x 7



12. x 7



13. x 7



14. x 7