

Larger Foraminifera from the Palau Islands

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By W. STORRS COLE

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GEOLOGICAL SURVEY PROFESSIONAL PAPER 221-B

*Illustrations and descriptions
of Foraminifera from Eocene
and Miocene deposits of the
Indo-Pacific region*



UNITED STATES DEPARTMENT OF THE INTERIOR

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LARGER FORAMINIFERA FROM THE PALAU ISLANDS

By W. STORRS COLE

ABSTRACT

Larger Foraminifera from three localities in the Palau Islands are illustrated and discussed. Eocene deposits have been recorded previously in these islands, but the occurrence of Miocene deposits, belonging to Tertiary *f* of the Indo-Pacific scale, has not been reported before. Certain of the Miocene larger Foraminifera which occur in the Palau Islands appear to be specifically the same as certain specimens from the Lau Group, Fiji Islands.

INTRODUCTION

In a short article entitled "Limestone of the South Sea Islands" Asano¹ discusses the Palau Islands. Unfortunately, most of the text is in Japanese, and therefore not available. However, in a summary table which gives the ages of the limestones of various islands that were under Japanese mandate, it is indicated that the limestones of the Palau Islands should be placed in the Eocene and the Plio-Pleistocene.

Limestone samples collected in the Palau Islands by Harry S. Ladd and Josiah Bridge have been examined by means of random thin sections. In two of these samples there occur interesting faunas, one of which definitely represents the Miocene, Tertiary *f*, and the other is suspected to be in this same stage. Moreover, there is a definite relationship in the Miocene species of the Palau Islands to species described from the Miocene of the Lau Group, Fiji Islands.

In one sample which was examined Foraminifera of Eocene age occur, thus substantiating the previous determination by Asano. No samples of the Plio-Pleistocene were studied.

Samples from the following localities (fig. 1) have been studied in detail:

Station P-Pe-L. Hell's Pocket, Bloody Nose Ridge, Peleliu. Collected by Harry S. Ladd, January 1946.

Station PB-3. Large quarry in agglomerate, north side of road, about one mile east of Ngatkip, southern Babelthuap Island. Collected by Josiah Bridge, April 1947.

¹ Asano, Kiyosi, Limestone of the South Sea Islands under Japanese Mandate; Jubilee Publication Commen. 60th Birthday of Prof. H. Yabe, vol. 1, p. 546, Sendai, Japan, Yabe Kyōju Kanreki Kinen Kai, Tohoku Imperial University, 1939.

Stations PU-1 to PU-7. Along the road from the pier to the lighthouse on Ngaremediu, at the eastern tip of Urukthapel Island at 100-foot intervals vertically

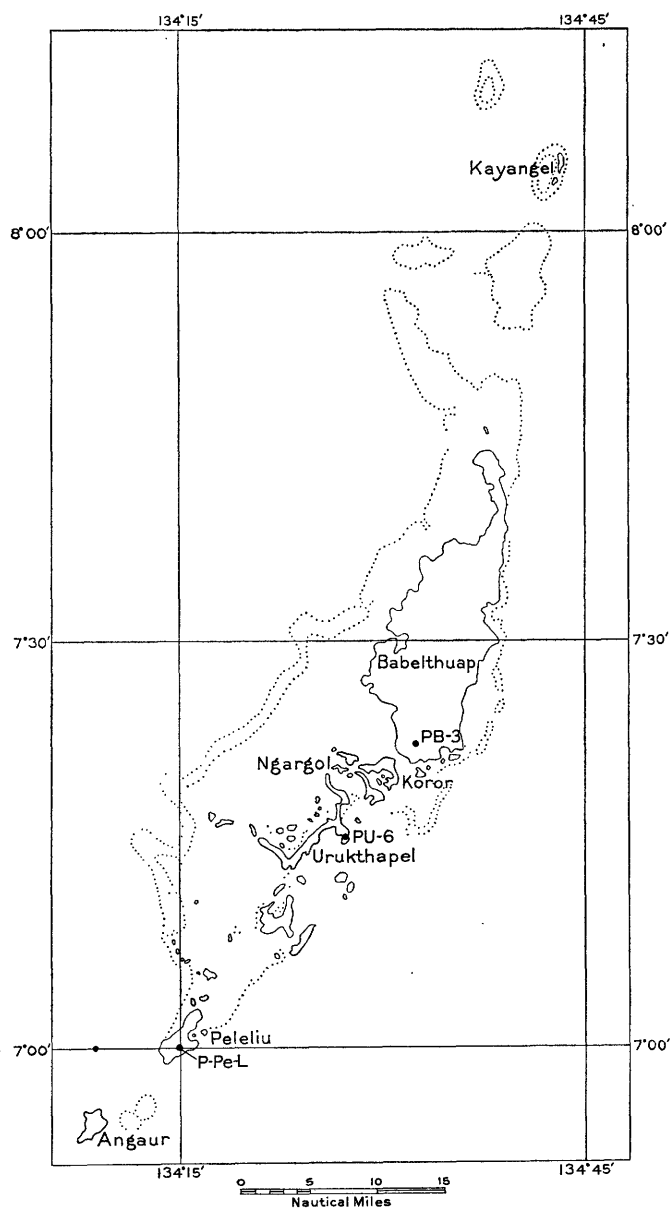


FIGURE 1.—Index map of the Palau Islands, showing localities from which the specimens were collected.

from sea level. Collected by Josiah Bridge and Charles G. Johnson, May 1947.

Station PB-3 represents an agglomerate about 14 feet thick in which limestone is fairly abundant. This limestone is dense, coffee-colored and sparingly fossiliferous. Thin sections show that two species of *Pellatispira* occur, one of which was sufficiently abundant for identification. As the genus *Pellatispira* is known only from the Eocene, the age of this limestone could be established.

Examination of numerous random thin sections from the limestone from station P-Pe-L shows the presence of numerous Foraminifera, mostly of the smaller type. Genera which could be recognized are: *Amphistegina*, *Operculina*, and *Cycloclypeus*. Certain of the vertical sections of *Cycloclypeus* had a single annulus developed on the flange which surrounds the central umbonal area. This structure is developed in the subgenus which Tan² named *Katacycloclypeus*.

The subgenus *Katacycloclypeus* has a short vertical range in the Indo-Pacific. In a summary article on the problems of stratigraphy in the Indo-Pacific, Glaessner³ states that *Katacycloclypeus* is restricted to Tertiary *f* 1-2. On the basis of this fact the writer informally reported the age of the sample from station P-Pe-L as Tertiary *f*. However, the paleontological evidence for this report was not particularly impressive.

The thin sections from the samples from stations PU-1 to PU-7 were disappointing, as the samples from stations 1 to 5 and 7 were devoid of recognizable Foraminifera. In the sections from PU-6 (500 feet above sea level) abundant specimens of *Lepidocyclina* were found. Most of these specimens had the Indo-Pacific modification of the embryonic apparatus that has been termed tryblolopidine. The appearance of these *Lepidocyclina* confirmed the earlier informal report that Miocene limestones do occur in the Palaus.

Moreover, these specimens could be referred to *Lepidocyclina* (*Nephrolepidina*) *rutteni lauensis* Cole,⁴ a stellate variety of *L. rutteni* that is one of the index species to the so-called *f* stage of the Indo-Pacific Tertiary. In addition, several specimens referred to *Operculina bartschi* and *O. ammonoides* occur in association with *L. rutteni lauensis*. One specimen of *Cycloclypeus* and several specimens of an apparently new species of *Lepidocyclina* complete the fauna of larger Foraminifera from the sample.

² Tan, Sin Hok, On the Genus *Cycloclypeus* Carpenter, Wetensch. Meded. No. 19, Dienst. Mijn. Nederland Indie, p. 39, 1932.

³ Glaessner, M. F., Problems of stratigraphic correlation in the Indo-Pacific region: Royal Soc. Victoria Proc., vol. 55, n. ser., table facing p. 80, 1943.

⁴ Cole, W. Storrs, Larger Foraminifera of Lau, Fiji: Bernice P. Bishop Mus. Bull. 181, p. 290, pl. 27, figs. H, I; pl. 28, fig. A, 1945.

DESCRIPTION OF SPECIES

Family CAMERINIDAE

Genus OPERCULINA d'Orbigny, 1826

Operculina ammonoides (Gronovius)⁵

Plate 5, figures 6, 7

Several oblique horizontal sections and transverse sections of evenly lenticular species of *Operculina* occur. A description of the best horizontal and transverse sections follows:

The height of the test is from 2.5 to 2.8 mm. and the thickness through the center is from 1.0 to 1.1 mm.

The test is composed of approximately 4 volutions with more than 19 chambers in the final whorl. The chambers are rectangular in shape in plan view, with the diameter along the volution greater than at right angles to the axis of coiling. The chamber walls are straight and radial, except near their distal ends, where they are slightly recurved.

Station: PU-6.

Age: Miocene, Tertiary *f*.

Although uncertainty of specific identification must exist in dealing with material of this type, these specimens are referred to *O. ammonoides* on the basis of illustrations and descriptions given by other workers.

Operculina bartschi Cushman

Plate 5, figures 3-5

1921. *Operculina bartschi* Cushman, U. S. Nat. Mus. Bull. 100, pp. 376-377, text-fig. 13.

1935. *Operculina bartschi* Cushman. Hanzawa, Tohoku Imp. Univ., Sci. Rep., ser. 2 (geol.), vol. 18, pp. 22-23, pl. 2, figs. 1-12.

1945. *Operculina bartschi* Cushman. Cole, Bernice P. Bishop Mus. Bull. 181, pp. 277-278, pl. 12, figs. H-K; pl. 14, fig. I.

Several oblique median sections and uncentered transverse sections of a thin, compressed *Operculina* were observed. The oblique median sections show that the surface is ornamented with rows of small pustules which have surface diameters of about 40 μ . These pustules radiate from the center and occur in the areas between the sutures.

The diameter of the specimens would be more than 2 mm. as the incomplete portions of the sections available have this measurement. The thickness through the center would be 0.4 mm. at a minimum and the thickness through the flange would be 0.16 mm. at a minimum. The chamber walls are evenly and regu-

⁵ S. Hanzawa has discussed this species in the Japanese Jour. Geology and Geography, vol. 16, pp. 225-232, pls. 15, 16, 1939, and D. D. Bannink has given other facts concerning species of *Operculina* in a doctor's dissertation presented to the Faculty of the University of Leiden, 1948.

larly curved for about three-fourths their length, but toward their distal ends they are very sharply recurved.

In one-half of a final volution there appear 8 chambers; therefore it may be assumed that there are about 16 chambers in the complete final volution.

Station: PU-6.

Age: Miocene, Tertiary *f.*

These fragmentary sections were compared with well-preserved specimens from Lakemba, Lau Group and from the Ryūkyū-rettō. There is agreement between all of these specimens in all features that could be investigated.

Genus **CYCLOCLYPEUS** W. B. Carpenter, 1856

Cycloclypeus sp.

Plate 5, figure 8

A single vertical section assigned to the genus *Cycloclypeus* appears in one of the random thin sections. This section, which is nearly centered, has a diameter of 2.6 mm., of which the umbonate portion occupies 1.4 mm. The thickness through the center is 0.44 mm., and the flange has a thickness of 0.2 mm. Small pillars are present and have a surface diameter of about 40 μ .

Station: PU-6.

Age: Miocene, Tertiary *f.*

Certain features of this transverse section suggest *C. (Cycloclypeus) indopacificus terhaari* Tan, but positive specific identification cannot be made from a single transverse section of *Cycloclypeus*.

Subgenus **KATACYCLOCLYPEUS** Tan, 1932

Cycloclypeus (Katacycloclypeus) transiens Tan

Plate 5, figures 9-11

1945. *Cycloclypeus (Katacycloclypeus) transiens* Tan. Cole, Bernice P. Bishop Mus. Bull. 181, p. 283, pl. 20, figs. D-F.

The following description is of a vertical section that is not exactly centered. The total diameter is 5.6 mm., of which 1.8 mm. occur in the central, inflated portion. The thickness through the center is 0.8 mm. The depressed areas between the central portion and the annulus have a width of 0.5 mm. and a thickness of 0.16 mm. The annulus has a width of 0.6 mm. and a thickness of 0.32 mm. Beyond the annulus is a flange, the width of which is 0.6 mm. and the thickness 0.14 mm. Pillars are not present.

Another vertical section is virtually centered. The total diameter is 5.0 mm. The central portion of the test has a diameter of 2.4 mm. and a thickness of 0.8 mm. The depressed areas between the central portion and the annulus have a thickness of about 0.32 mm. The annulus on one side of the test has a thickness of 0.5 mm. and a width of 0.9 mm. On the other side of the test the

annulus has a thickness of 0.5 mm. and a width of 1.2 mm. Pillars are present as darker, wedge-shaped masses penetrating to the equatorial layer. These pillars have a surface diameter of 80 to 120 μ .

Station: P-Pe-L.

Age: Miocene, Tertiary *f.*

Three specific names have been proposed for species of the subgenus *Katacycloclypeus* that possess one annulus, namely, *K. martini* van der Vlerk, *K. transiens* Tan and *K. posttransiens* Tan. The difference between *K. transiens* and *K. posttransiens* is in the possession or lack of pillars. This is not a valid specific criterion, therefore two fundamental species may be recognized, *K. martini* and *K. transiens*.

Van der Vlerk⁶ illustrated *K. martini*, but Tan⁷ proposed the specific names *K. transiens* and *K. posttransiens* in a table without either description or illustration. Miss Caudri⁸ gave notes and drawings of the equatorial sections of *K. martini* and *K. transiens*. Cole⁹ in the study of larger Foraminifera from Lau Group, Fiji Islands, presented external views and equatorial sections of specimens identified as *K. martini* and *K. transiens*.

As the random thin sections of the material from the Palau Islands were such that oriented equatorial sections could not be obtained it became necessary to investigate the vertical sections of *K. transiens* and *K. martini*.

Equatorial sections demonstrate that the embryonic apparatus of *K. martini* is large, whereas that of *K. transiens* is small. Several of the vertical sections in the random sections of the Palau material pass near the center of the test, but the embryonic apparatus does not show, therefore it was concluded that the species from the Palau Islands possesses a small embryonic apparatus.

A vertical section was made from one of the specimens previously identified as *K. transiens* from Vanua Mbalavu, in the Lau group. A description of this section follows:

The semidiameter is 2.3 mm., and the entire diameter would be about 4.6 mm. The central area has a diameter of 2.6 mm. and a thickness of 1.0 mm. The annulus has a thickness of 0.5 mm., and the depression between the annulus and the central area has a thickness of 0.24 mm. Pillars are apparently not present.

⁶ Van der Vlerk, I. M., Een nieuwe Cycloclypeussoort van Oost-Borneo: Geol. Reichs-Mus. Samml., Leiden, vol. 10, pp. 137, 138, pl. 1, figs. 1-4; pl. 2, figs. 3, 4, 1923.

⁷ Tan, Sin Hok, op cit; Part I: Table I, 1932.

⁸ Caudri, B., De Foraminiferen-Fauna van eenige Cycloclypeus-houdende Geesteenten van Java: Geol.-Mijn. genootschap Nederland en Koloniën, Verh., Geol. Serie vol. 9, no. 3, pp. 192, 193, figs. 4, 5, 6, 14, 1932.

⁹ Cole, W. Storrs, op. cit., p. 283, pl. 20, figs. D-F, I, J, 1945.

It will be observed from this description and the illustrations given that there is very close agreement between the identified specimen from Vanua Mbalavu and the specimens from the Palau Islands. Therefore, these specimens are tentatively referred to this species.

Genus **PELLATISPIRA** Boussac, 1906

Pellatispira rutteni Umbgrove

Plate 5, figures 1, 2

1928. *Pellatispira rutteni* Umbgrove, Wetensch. Meded. No. 10, pp. 20-21, figs. 57-61.
 1932. *Pellatispira rutteni* Umbgrove. Whipple, Bernice P. Bishop Mus. Bull. 96, p. 81, pl. 21, fig. 6.
 1947. *Pellatispira reticularis* Hanzawa, Japanese Jour. Geology and Geography, vol. 20, pp. 59-60, pl. 14, figs. 1-3; pl. 15, fig. 1.

From Nakanai, New Britain, Hanzawa has described recently *Pellatispira reticularis*. He states that this same species occurs in "the Eocene of Babeldaob, the Palao Island," in lenticular masses of limestone in an andesitic agglomerate. Undoubtedly, this is the same form that occurs in the present collection. However, the features observed in the specimens in this collection as well as the illustrations and description given by Hanzawa demonstrate that these specimens should be referred to *P. rutteni*. In every feature there is absolute similarity.

The reticulate mesh, which Hanzawa emphasizes as the most important feature of this species, is to be expected with forms that have the internal structure of this species. The depressions are the result of the coarse vertical canals.

Station: PB-3.

Age: Eocene, Tertiary *a* and *b*.

There are a few very incomplete sections of another species of *Pellatispira* in this material. These sections are most suggestive of *P. crassicolumnata* Umbgrove, but positive identification cannot be made at the present time.

Family **ORBITOIDIDAE**

Genus **LEPIDOCYCLINA** Gumbel, 1868

Subgenus **NEPHROLEPIDINA** H. Douvillé, 1911

Lepidocyclina (Nephrolepidina) rutteni lauensis Cole

Plate 5, figure 13; plate 6, figures 1-13

1945. *Lepidocyclina rutteni lauensis* Cole, Bernice P. Bishop Mus. Bull. 181, p. 290, pl. 27, figs. H, J; pl. 28, fig. A.

The external aspects of the specimens could not be determined, as all the specimens available are in a dense limestone matrix and are known only in thin section. However, the thin sections indicate that individuals would be evenly convex in the umbonal area, which

would be covered by rather large papillae. Some specimens, if not all, would have short arms or rays projecting from the test. The following measurements give the diameter and thickness from accidental, but centered, vertical sections:

Measurements of sections of specimens of *Lepidocyclina (Nephrolepidina) rutteni lauensis* Cole

| Specimen | Diameter (millimeters) | Thickness (millimeters) | Remarks |
|----------|------------------------|-------------------------|---|
| 1---- | 3.34+ | 1.1 | Edges slightly broken; no arms showing. |
| 2---- | 4.7+ | 1.1 | Edges very slightly broken; suggestion of arm development on one side. |
| 3---- | 5.3+ | 1.48 | Edges slightly broken; no arms showing. |
| 4---- | 3.4 | 1.2 | Broken specimen; arm development shown clearly, projecting 1.4 mm. beyond the umbonate portion of the test. |

¹ Semidiameter.

The embryonic chambers appear in plan view in three oblique equatorial sections and are of tryblio-lepidine type. The most clearly exposed embryonic chambers show a larger, thick-walled chamber whose internal diameters are 260 by 320 μ , completely surrounding a smaller, thin-walled inner chamber with internal diameters of 180 by 180 μ . The second oblique equatorial section shows only a portion of the embryonic chambers. The side on which the two embryonic chambers are attached is not exposed so that only the inner edge of the second chamber is exposed. The third section exposes only a portion of the larger chamber.

Of the vertical sections available, six pass through the embryonic chambers. One of these is centered, the other five pass through the embryonic chambers at the side. The centered embryonic chambers have an internal length of 500 μ and a height of 240 μ . The outer wall has a thickness of 30 μ . Two vertical walls representing the inner chamber divide the large chamber into three parts. These vertical walls, with a thickness of about 10 μ , pass completely across the larger chamber. The distance between the walls is 190 μ . A second section shows a portion of the embryonic chambers in vertical view. These chambers have an internal length of 280 μ and an internal height of 180 μ . The thickness of the outer wall is 35 μ . A single thin partition representing one wall of the inner chamber passes across the larger chamber. A third section is similar to the second one in that only one partition of the inner chamber shows. The internal length of the larger chamber is 340 μ and the internal height is 200 μ . The thickness of the bounding wall is 37 μ . A fourth section shows only the larger chamber with an internal length of 220 μ and

an internal height of 140 μ . The thickness of the bounding wall is about 30 μ .

The equatorial chambers near the center are hexagonal in shape with radial and tangential diameters of about 40 μ . Toward the periphery of the test the equatorial chambers become elongate-spatulate in shape, with radial diameters of about 55 μ .

In vertical sections the equatorial chambers have a height near the center of about 60 μ including the thickness of the floors and roofs, and at the periphery a height of about 100 μ . In some vertical sections the height of the equatorial chambers becomes greatly expanded toward the periphery of the test. The specimen that demonstrates this best has an equatorial layer with a height of 120 μ at a distance of 1.6 mm. from the embryonic chambers; at a distance of 2 mm. the height is 200 μ ; and at a distance of 3.2 mm., which is the periphery of the test, the height is 300 μ . The expanded zone of equatorial chambers has a width of 1.4 mm. In the peripheral portion of this zone the equatorial chambers are not covered by lateral chambers. This zone of expanded equatorial chambers is interpreted as occurring in a vertical section which passes through one of the projecting peripheral arms.

The specimen with the centered embryonic chambers has a thickness of 1.48 mm. In this specimen there are 8 lateral chambers to a tier on each side of the embryonic chambers. Small, appressed lateral chambers occur in two or three layers directly over the embryonic apparatus. The succeeding lateral chambers are open with floors and roofs which are slightly curved. The lateral chambers in the central area overlap from one tier to the other, but toward the peripheral zone of the test they occur in rather regular tiers. Normal lateral chambers toward the exterior of the test and over the embryonic apparatus have a length of 180 to 300 μ , a height of 55 μ and floors and roofs with a thickness of about 10 μ .

A second specimen with a thickness of 1.16 mm. has 9 lateral chambers to a tier on each side of the embryonic apparatus, whereas another specimen with a thickness of 1.12 mm. has 10 lateral chambers to a tier.

Pillars with a surface diameter of 100 to 200 μ are well developed in the central portion of the test and occur irregularly in the outer portions of the test. Normal pillars are without taper until they approach the zone of appressed lateral chambers which lie directly over the equatorial layer. At this place the pillars taper sharply to a point resting on the covering wall of the embryonic chambers, or the floors and roofs of the equatorial chambers.

Station: PU-6; abundant.

Age: Miocene, Tertiary *f*.

These specimens are very similar to radiate specimens from Vanua Mbalavu, Lau Group, Fiji Islands. The greatest difference occurs in the thickness of the outer wall of the embryonic chambers. In the specimens from Vanua Mbalavu the embryonic chambers have a very thick outer wall, whereas in the specimens in the present collection they have a much thinner wall. It is extremely doubtful if much importance should be attached to this fact, as slightly different ecological conditions might produce such an effect.

At Vanua Mbalavu, a typical *L. ruttleri* occurs in association with the variety *L. lauensis*. The internal features of *L. ruttleri* and this variety are similar. The same association may occur in the present collection, but as many of the specimens appear to have arms, they are all referred to the variety.

Several of the sections in the present collection are similar to *Lepidocyclina pilifera* Scheffen,¹⁰ which species is placed by Miss Caudri¹¹ in the synonymy of *L. ruttleri* van der Vlerk.

Glaessner¹² gives the range of *L. ruttleri* as Tertiary *f* 3. At Vanua Mbalavu, in the Lau Group this variety occurs with *Katacycloclypeus annulatus* Martin. Glaessner places the beds with *Katacycloclypeus* in Tertiary *f* 1-2.

Lepidocyclina (Nephrolepidina) palauensis Cole, n. sp.

Plate 5, figures 12, 13

This species is known in the present collection from one slightly oblique vertical section and a partial equatorial section that exposes the embryonic chambers and a few of the equatorial chambers.

Externally, there would be a small, central, inflated umbo surrounded by a wide, flat brim. In the available vertical section the umbonate portion has a diameter of 1.6 mm. and the rim has a width of about 1.6 mm. The diameter of the specimen is 5 mm. The thickness through the center is 0.94 mm. The rim has a thickness of about 0.2 mm.

The embryonic chambers exposed in this vertical section have an internal length of 420 μ and a height of 260 μ . The outer wall of the embryonic chambers has a thickness of 40 μ . A single, slightly curved partition across the larger chamber represents the second chamber.

The thickness of the equatorial layer could not be determined exactly because the section is slightly oblique. However, it has an approximate thickness of

¹⁰ Scheffen, W., Ostindische Lepidocyclinen: Wetensch. Meded. No. 21, pp. 29, 30, pl. 4, figs. 2, 3, 1932.

¹¹ Caudri, B., Lepidocyclinen von Java: Geol. Mijnb. genootschap Nederland en Kolenien, Verh. vol. 12, pp. 218-221, figs. 61-65, 1939.

¹² Glaessner, M. F., op. cit.

about 100 μ near the center of the test and expands to a thickness of about 220 μ at the periphery. These measurements include the roof and floor.

For a distance of about 0.8 mm. from the outer edge of the test the equatorial chambers are not covered by lateral chambers. It is in this zone that the equatorial chambers have their greatest thickness.

There are about 8 lateral chambers to a tier on each side of the embryonic chambers. These lateral chambers are arranged in rather regular tiers, but some overlap from one tier into the next. The chamber cavities are open but low. Normal lateral chambers at the center and on the outside have a length of 100 μ , a height of 20 μ , and floors and roofs with a thickness of 20 μ .

The walls between the tiers of lateral chambers are thickened, a condition which produces dark, pillar-like areas, but true pillars were not observed. If such occur, they are very thin.

In the same random thin section a partial equatorial section is thought to represent the same species as the vertical section that has been described. These embryonic chambers are nephrolepidine in type. The larger chamber has a diameter of 520 μ across the chamber along a line parallel to one through the points of juncture of the wall of the inner chamber. At right angles to this line the larger chamber has a diameter of 440 μ . The inner chamber has a diameter of 360 μ along a line connecting the points of juncture of this chamber to the larger chamber and a diameter of 240 μ at right angles to this line. The wall of the larger chamber has a thickness of about 40 μ , whereas the curved wall of the inner chamber has a thickness of about 18 μ .

Equatorial chambers are seen only adjacent to the

embryonic chambers. These chambers are hexagonal and tangentially elongate. The tangential diameter is about 80 μ and the radial diameter is about 40 μ .

Station: PU-6.

Age: Miocene, Tertiary *f*.

Of the species of *Lepidocyclina* which have been described from Tertiary *f*, a number have a small, inflated umbonal area demarked sharply from a wide, flat, thin brim. The important species belonging to this group are: *L. limbata* H. Douvillé,¹³ *L. radiata* Martin (as identified by Whipple¹⁴), *L. gerthi* Caudri,¹⁵ and *L. oneataensis* Cole.¹⁶ Moreover, a specimen figured by Yabe and Hanzawa¹⁷ under the name *L. leytenensis* appears to belong to this group.

Of these species, *L. limbata* and *L. gerthi* are incompletely described, as illustrations and measurements of vertical sections have not been given.

Although it is entirely possible that the specimens in the present collection may represent one of the species already described, it is given a new name for the present because of the low, appressed lateral chambers, the relatively small umbo, and the small thickness through the inflated portion of the test.

¹³ Douvillé, H., Les Foraminifères des couches de Rembang: Geol. Reichs-Mus. Samml., Leiden, vol. 10, pp. 25, 26, pl. 4, figs. 8, 9, 1916.

¹⁴ Whipple, G. L., Larger Foraminifera from Vitilevu, Fiji: Bernice P. Bishop Mus. Bull. 119, pp. 148, 149, pl. 19, figs. 4, 5, 1934.

¹⁵ Caudri, B., Lepidocyclinen von Java: Geol.-Mijnb. genoot. Nederland en Kolenien, Verh. vol. 12, pp. 221-223, figs. 66, 67.

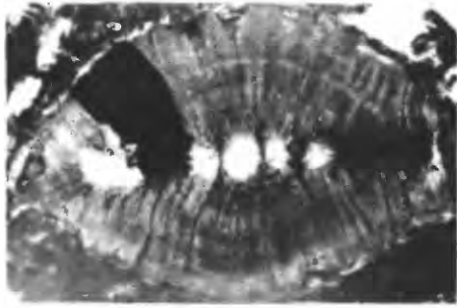
¹⁶ Cole, W. Storrs, Larger Foraminifera of Lau, Fiji: Bernice P. Bishop Mus. Bull. 181, p. 292, pl. 26, figs. A-J; pl. 28, fig. H, 1945.

¹⁷ Yabe, H. and Hanzawa, S., Notes on some Tertiary foraminiferous rocks from the Philippines: Tohoku Imp. Univ., Sci. Repts., ser. 2 (geol.), pp. 107-108, pl. 27, fig. 14 (not pl. 15, figs. 8, 9; pl. 26, figs. 11, 12; pl. 27, figs. 11-13, 15), 1925.

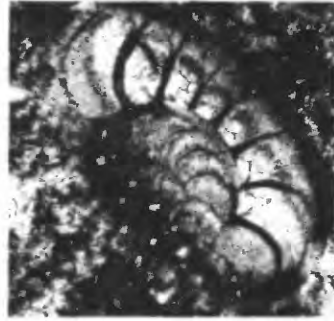
PLATES

PLATE 5

- Figures 1, 2. *Pellatospira ruttleri* Umbgrove.
1. Transverse section, $\times 20$; station PB-3.
2. Median section, $\times 20$; station PB-3.
- 3-5. *Operculina bartschi* Cushman.
3, 4. Portions of oblique median sections which show surface ornamentation and the chambers of the final volution, $\times 20$, station PU-6.
5. Transverse section, not centered, $\times 20$; station PU-6.
- 6, 7. *Operculina ammonoides* (Gronovius).
6. Transverse section, nearly centered, $\times 20$; station PU-6.
7. Oblique median section, $\times 20$; station PU-6.
8. *Cycloclypeus* sp.
8. Transverse section, nearly centered, $\times 20$; station PU-6.
- 9-11. *Cycloclypeus* (*Katacycloclypeus*) *transiens* Tan.
9. Oriented transverse section introduced for comparison, $\times 20$; station 43, Vanua Mbalavu, Lau Group, Fiji Islands.
10. Transverse section, not centered, $\times 12.5$; station PPe-L.
11. Transverse section, nearly centered, $\times 20$; station PPe-L.
- 12-13. *Lepidocyclina* (*Nephrolepidina*) *palauensis* Cole, n. sp.
12. Embryonic chambers and a small portion of the equatorial chambers, $\times 40$; station PU-6.
13. Vertical section (center) to show embryonic chambers and lateral chambers, $\times 20$; station PU-6; holotype.
(NOTE.—The transverse section (left) represents *L. ruttleri lauensis*.)



1



3



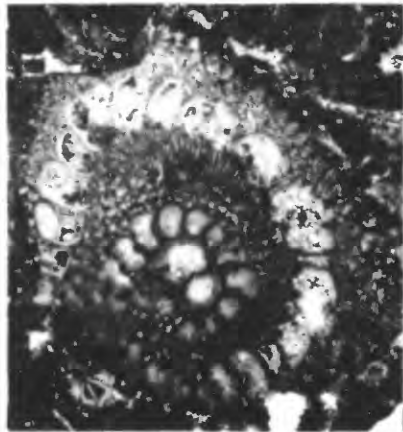
4



10



9



2



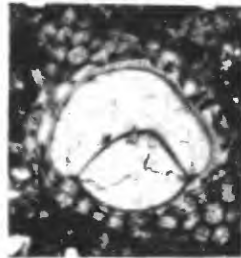
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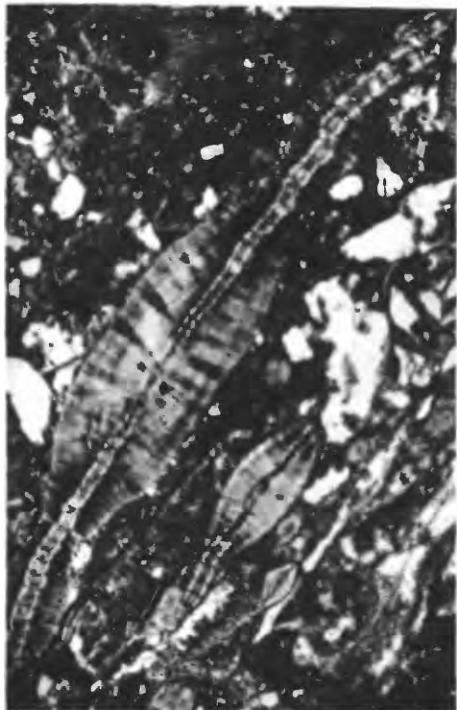
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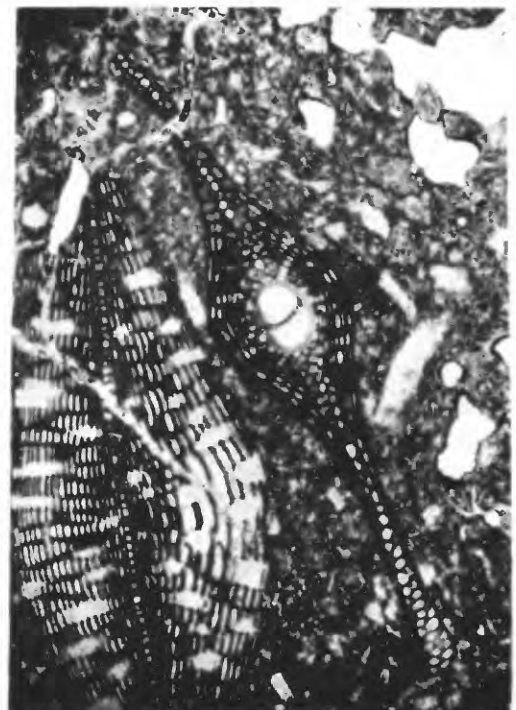
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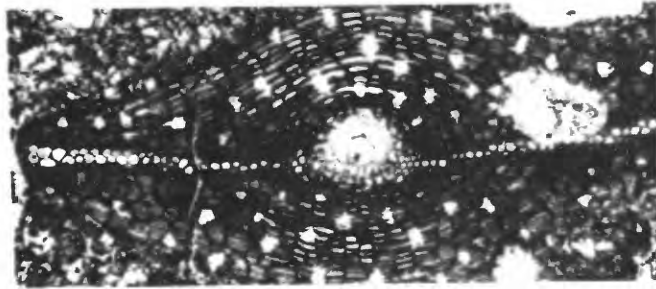


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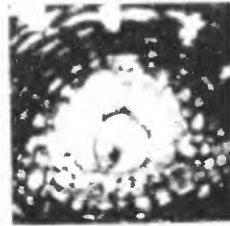


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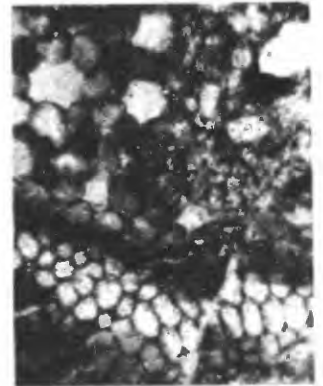
LARGER FORAMINIFERA OF THE PALAU ISLANDS



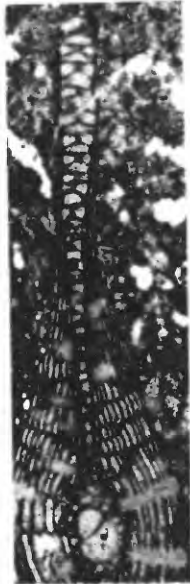
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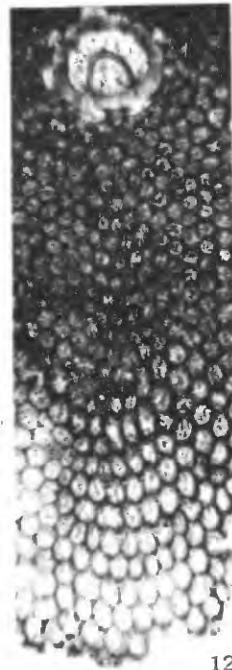
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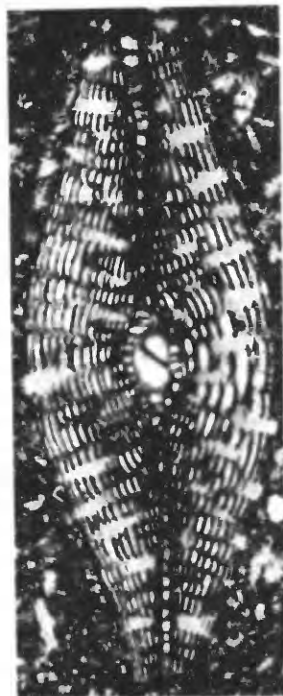
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LARGER FORAMINIFERA OF THE PALAU ISLANDS



PLATE 6

Figures 1-13. *Lepidocyclina (Nephrolepidina) rutteni lauensis* Cole.

1. Strongly oblique median section to illustrate the embryonic chambers, $\times 20$; station PU-6.
2. Embryonic chambers, illustrated in figure 1, enlarged, $\times 40$; station PU-6.
3. Equatorial chambers and a portion of the lateral chambers to illustrate their shape and the distribution of the pillars, $\times 40$; station PU-6.
4. Strongly oblique median section which shows the equatorial chambers, $\times 40$; station PU-6.
5. Vertical section to illustrate the prolongation of the equatorial layer in a ray, $\times 20$; station PU-6.
- 6, 7, 8, 9, 10. Vertical sections of various sizes of individuals, $\times 20$; station PU-6.
11. Portion of a vertical section, not centered, to show the character of a ray, $\times 20$; station PU-6.
12. Portion of an equatorial section of a topotype specimen introduced for comparison, $\times 40$; station 62, Vanua Mbalavu, Lau group, Fiji Islands.
13. Vertical section of a topotype specimen introduced for comparison, $\times 20$; station 62, Vanua Mbalavu, Lau Group, Fiji Islands. (Note.—The transverse section (right), represents *L. (Nephrolepidina) palauensis* Cole, n. sp.)

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