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CONTRIBUTIONS TO THE GEOLOGY AND PALEONTOLOGY OF THE CANAL ZONE, PANAMA, AND GEOLOGICALLY RELATED AREAS IN CENTRAL AMERICA AND THE WEST INDIES

THE LARGER FOSSIL FORAMINIFERA OF
THE PANAMA CANAL ZONE

By JOSEPH AUGUSTINE CUSHMAN
Of the United States Geological Survey

Extract from Bulletin 103, pages 89-102, with Plates 34-45



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THE LARGER FOSSIL FORAMINIFERA OF THE PANAMA CANAL ZONE.

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INTRODUCTION.

The foraminifera, especially the larger forms of the orbitoids, have been little used in America as critical index fossils, except in the Vicksburg group; but in Europe, Asia, and the East Indies they have long been used to distinguish horizons. In many geologic papers one finds *Orbitoides* mentioned, probably *Orbitoides mantelli* Morton, and occasionally *O. dispansus*, *O. forbesi*, etc. From a critical study of the group it soon becomes evident that such identifications as have been made of American orbitoids, except those of Lemoine and Douvillé, have been largely superficial, and are therefore of little value. Since the earlier work of Gümbel the orbitoid foraminifera have with further study been divided largely into the four genera *Orbitoides*, *Orthophragmina*, *Lepidocyclina*, and *Mio-gypsina*, in general respectively characterizing Cretaceous, Eocene, Oligocene, and Miocene formations, but with important exceptions. The American forms, with the exception of the work of Lemoine and Douvillé, have not been properly referred to their respective genera, although our American *Orbitoides mantelli*, described by Morton as *Nummulites mantelli* in 1833, is the type-species of *Lepidocyclina*. In their work on *Lepidocyclina* Lemoine and Douvillé¹ describe two new American species, *L. canellei* and *L. chaperi*, from the Panama Canal Zone, figuring also for the first time the critical chambers of *L. mantelli* (Morton). These are all the American species that are given, although they call attention to the apparently superficial character of the references to *Orbitoides* in American geologic papers. Schlumberger, in his classic works on the genera *Orbitoides* and *Orthophragmina*, did not have American material. The American

¹ Sur le Genre *Lepidocyclina* Gümbel, Mém. Soc. Géol. France, Paléontologie, Mem. 32, 1904.

field is therefore practically unworked, and the description of our species with accurate stratigraphic information is of prime importance, as they have been proved elsewhere to be of great use as index fossils.

The collections now in my hands represent the Canal Zone, the West Indies, and Coastal Plain Province of the eastern and southern United States. Excellent material was collected in the Panama Canal Zone by T. Wayland Vaughan and D. F. MacDonald, and is here presented as a beginning in the determination and figuring of the American species. This will be followed by papers on the West Indian and Coastal Plain species which now, owing to the careful collecting by Doctor Vaughan and his associates, are represented by excellent suites of specimens covering broad ranges, both geographically and stratigraphically. As these are gradually worked up there will be a mass of data which should be of excellent service in the correlation of horizons where these groups are represented, even in the absence of Mollusca and other groups of fossils.

The systematic descriptions of the species of *Lepidocyclina*, *Nummulites*, and *Orbitolites* follow, together with that of a genus and species believed to be new.

LIST OF SPECIES AND THEIR GEOLOGIC OCCURRENCE.

- Lepidocyclina canellei* Lemoine and Douvillé. Oligocene, Culebra formation, stations 6019a, Gaillard Cut; 6023, Rio Frijol; 6027, Bohio (old station); 6891; Bailamons; 6892, 450 feet south of switch at Mamei. Also Oligocene of Trinidad.
- Lepidocyclina chaperi* Lemoine and Douvillé. Oligocene, Culebra formation, stations 6019f, Las Cascadas; 6025, Bohio Ridge switch.
- Lepidocyclina vughani*, new species. Oligocene, Emperador limestone, stations 6021 and 6673, near Caimito Junction; 6255, half mile south of Miraflores Station.
- Lepidocyclina macdonaldi*, new species. Oligocene, station 6523, 2 miles north of David.
- Lepidocyclina panamensis*, new species. Oligocene?, stations 6512, river bed, David; Oligocene, 6586e and 6587, near mouth of Tonosi River; probably at 6010, near Miraflores Locks, and 6012a and 6012e in Gaillard Cut, in the Culebra formation; doubtfully in the Emperador limestone, at station 6015, Empire.
- Lepidocyclina duplicata*, new species. Oligocene, stations 6523, 2 miles north of David; and 6586e, near mouth of Tonosi River.
- Heterosteginoides panamensis*, new species. Oligocene, Culebra formation, stations 6011, Gaillard Cut; 6024a, Rio Agua Salud; 6025, Bohio Ridge switch. Emperador limestone, stations 6015, 6016, quarries at Empire.

Orthophragmina minima, new species. Oligocene ?, station 6512, river bed, David.

Nummulites panamensis, new species. Oligocene, Culebra formation, stations 6024a, Rio Agua Salud; 6025, Bohio Ridge switch; doubtfully at 6026, 2 miles south of Monte Lirio.

Nummulites davidensis, new species. Oligocene?, stations 6512, river bed, David; 6526, Chiriqui.

Orbitolites americana, new species. Oligocene, Culebra formation, Gaillard Cut at stations 6013, 6019b, and 6020a.

DESCRIPTIONS OF SPECIES.

Family NUMMULITIDAE.

Genus LEPIDOCYCLINA.

LEPIDOCYCLINA CANELLEI Lemoine and Douvillé.

Plate 34, figs. 1-6.

Lepidocyclus canellei LEMOINE and DOUVILLÉ, Mém. Soc. Géol. France, Paléontologie. Mém. 32, p. 20, pl. 1, fig. 1; pl. 3, fig. 5, 1904.

Test comparatively small, diameter of largest specimens slightly less than four millimeters, thickness a little more than one-fourth the diameter; circular in outline, central portion somewhat raised and evenly rounded, near the periphery flattened or even slightly concave; surface in well preserved specimens finely granular or even finely papillate, but not strongly so, often appearing smooth to the unaided eye. In worn specimens the surface appears as a series of regular hexagonal, honeycomb-like reticulations due to the edges of the lateral chambers.

In vertical section the lateral chambers are seen to be arranged in vertical columns, one directly above the other, from the equatorial chambers to the surface, about twelve chambers in each vertical column in the central region, the lateral walls hardly thicker than the upper or lower surfaces. Chambers of adjacent columns arranged alternately, no distinct columns present. Equatorial chambers gradually increasing in size toward the periphery, single throughout, extending peripherally beyond the lateral chambers and in surface view in well-preserved specimens appearing as a hexagonal reticulation. Embryonic chambers nearly equal in size, nearly semicircular in section, their common wall straight.

Horizontal section showing the equatorial chambers regularly hexagonal, those toward the periphery largest. Embryonic chambers similar to those shown in the vertical view.

Occurrence.—Lemoine and Douvillé described and figured this species from Panama, from Peñablanca, also noting it from Mar-

tinique and Angola. The species from Panama was recorded by Dall and by Bagg as *Orbitoides forbesi* Carpenter.¹

Cat. No. 135216, U.S.N.M., is *Lepidocyclina canellei* Lemoine and Douvillé. Figures 1, 4-6, on plate 34 are from this material, collected by Hill at Bohio, Panama, where it is very abundant. This is the same locality as station 6027 of Vaughan and MacDonald, orbitoidal marl, a quarter of a mile northwest of Bohio railroad station. In this material *L. canellei* is very abundant and makes up a considerable proportion of the marl. Parts of five specimens, close to one another, are visible in a small part of a section from this station.

Specimens in the collection of the United States National Museum, Catalogue No. 107158, from the Oligocene of Trinidad ("Leda bed," Naparima) collected by Guppy, are also very evidently *Lepidocyclina canellei*.

Specimens of *L. canellei* were also very abundant at station 6891, foraminiferal limestone from Bailamonas, Canal Zone, collected by D. F. MacDonald.

There is a limestone from station 6892, 450 feet south of switch at Mamei, Canal Zone, also collected by MacDonald, which contains numerous specimens of a *Lepidocyclina* in general shape in section resembling *L. canellei*, but the material is very cherty and the finer structure is not well preserved.

A few small weathered specimens from 6019a, Gaillard Cut, opposite Las Cascadas, seem to belong to this species also; and specimens were also obtained at station 6023, along the relocated line of the Panama Railroad, at Rio Frijol. The geologic occurrence is in the Culebra formation.

Cat. Nos. 324733-5, U.S.N.M.

LEPIDOCYCLINA CHAPERI Lemoine and Douvillé.

Plate 35, figs. 1-3; plate 36.

Lepidocyclina chaperi LEMOINE and DOUVILLÉ, Mém. Soc. Géol. France. Paléontologie, Mém. 32, p. 14, pl. 2, fig. 5, 1904.

Test of medium size, diameter from 8 to 20 millimeters, circular in outline, somewhat saddle-shaped, central portion slightly thickened, thence gradually and evenly thinning toward the periphery; surface where well preserved slightly papillate, usually roughened by erosion, toward the periphery often somewhat reticulately depressed above the equatorial chambers.

Vertical section usually curved, lateral chambers numerous, breadth much greater than height, columns separated by distinct pillars, comparatively few except in the central region where there

¹ Hill, Geology of Panama, Bull. Mus. Comp. Zool., vol. 28, pp. 272, 275, 1897.

are a few larger than the others; embryonic chambers of the double type, the two chambers nearly equal in size and separated by a straight common wall.

Horizontal section shows similar conditions of the embryonic chambers and distinctly hexagonal equatorial chambers.

Occurrence.—Lemoine and Douvillé described this species from Panama (Haut-chagres, San Juan). The figured specimens are from United States Geological Survey station 6025, Culebra formation, from marl, south end of Bohio Ridge switch, relocated line, Panama Railroad, collected by Vaughan and MacDonald.

Specimens from station 6019-*f*, Culebra formation, on the west side of Gaillard Cut near Las Cascadas, seem to represent the microspheric form of this species. The sections are shown in plate 35, figure 3, and plate 36.

A specimen from station 6526, Chiriqui, Canal Zone, shows a section which from its general proportions strongly suggests *L. chaperi*.
Cat. Nos. 324736-8, U.S.N.M.

LEPIDOCYCLINA VAUGHANI, new species.

Plate 37. figs. 1-5; plate 38.

Test of medium size, 10 millimeters or more in diameter, flat, surface somewhat umbonate in the central portion, gradually sloping to the peripheral portion, the outer half of which is nearly flat. Wall smooth except for fine papillae.

Horizontal section shows the peculiarity of the chambers, many of which, especially those of the outer peripheral portion are rhomboid, those of the inner portion being more typical and hexagonal. These are shown especially well on the sections of the larger specimens, those of the smaller specimens showing only the regular hexagonal character of the earlier chambers.

No very good vertical sections were obtained in the thin sections but several accidental sections show the characters well. The embryonic chambers are rather large, of the usual American type, of two nearly equal chambers, lateral chambers in vertical columns with a very few, rather well developed pillars.

Occurrence.—Type-specimen from station 6021, from the Emperor Limestone in cuttings of the Panama Railroad near Caimito Junction, Panama, United States National Museum Catalogue No. 324739, collected by T. W. Vaughan and D. F. Mac Donald. Specimens were abundant in this light gray to cream-colored sandy limestone. Specimens were also abundant in the collection from the same locality collected later by MacDonald under station No. 6673. Specimens which are apparently the same species are abundant in a fos-

siliferous limy sandstone collected by MacDonald at station No. 6255 from half a mile south of Miraflores Station on the wagon road to Panama.

LEPIDOCYCLINA MACDONALDI, new species.

Plate 40, figs. 1-6.

Test circular, rather small, about 5 to 7 millimeters in diameter, thickest in the central region, thence gradually sloping to the periphery which for a short distance in from the edge is nearly flat; wall rather smooth except the central portion of the umbonal region, which has a few pustule-like raised spots at the surface end of the vertical pillars.

Vertical section shows the test widest in the middle, gently sloping to near the periphery where the edges are nearly parallel for a short distance to the peripheral edge or even slightly increasing in thickness. Lateral chambers in the central portion in definite vertical columns, occasionally slightly overlapping. Equatorial chambers not increasing very rapidly in height in megalospheric specimens, those at the periphery hardly more than double the height of those near the center of the test; embryonic chambers in the megalospheric form, large, usually of two nearly equal chambers, but in oblique cutting these may appear somewhat unequal, plate 40, figures 2 and 3.

Horizontal sections show chambers somewhat similar to *L. vaughani* but with the inner half of two walls at nearly right angles, the outer wall broadly rounded. The oblique section (pl. 40, fig. 6) shows the pillars.

Occurrence.—Type-specimens from station 6523, from orbitoidal limestone, 2 miles north of David, Panama, collected by D. F. MacDonald, U. S. National Museum Catalogue No. 324740. Specimens were abundant at this station, occurring with *L. panamensis* and *L. duplicata*. The species were also collected by MacDonald at station 6512, in the river bed at David.

LEPIDOCYCLINA PANAMENSIS, new species.

Plate 39, figs. 1-6; plate 42.

Test circular, small, central portion very strongly umbonate, thick, rapidly decreasing in thickness peripherally, the peripheral portion thin and flattened, the raised central portion only one-third to one-fifth the entire diameter, which ranges from three to six millimeters; occasional specimens, perhaps representing the microspheric form, up to 10 or 12 millimeters in diameter; surface smooth except for the umbonal portion which has a few large pustule-like projections marking the ends of the internal pillars.

The vertical section shows very peculiar embryonic chambers in that they do not exhibit the usual characters of American species, but have a broad and much flattened central chamber two to four times as broad as high with a compressed, partially encircling chamber, which in section is usually cut on the opposite sides of the central chamber. In some cases there seems to be an irregular mass of three or four more or less nearly spherical chambers. In the former case these central chambers in section are nearly as wide as the whole umbonal portion of the test. Lateral chambers, usually about twice as wide as high, the outer wall often somewhat arched toward the exterior of the test, arranged in vertical columns. Pillars not distinct except in the central portion where there are a few strong ones increasing rather rapidly in diameter toward the periphery, usually about 9 or 10 chambers in a vertical column in the center of the umbilical region. The peripheral region has only a thin coating of lateral chambers, the last formed layer present only on the outer half of the periphery and often none at all present on the last quarter of the test toward the periphery, the surface being made up by upper and lower walls of the equatorial chambers. Equatorial chambers numerous, comparatively broad, the peripheral wall convex outwardly toward the periphery, the chambers at least as wide as high.

In horizontal section the equatorial chambers are usually somewhat irregularly hexagonal near the center, toward the periphery more or less rhomboid with the outer peripheral wall curved.

As far as described material is concerned this is an unusual form for American species of *Lepidocyclina*, especially in its embryonic chambers.

Occurrence.—Type-specimen, vertical sections, U. S. National Museum Catalogue No. 324741. The species is fairly abundant at stations 6586e and 6587 from near the mouth of Tonosi River, Panama, D. F. MacDonald, collector. It was also collected by MacDonald at station 6512, river bed, David.

At stations 6010, 600 or 700 feet south of the Miraflores Locks, and 6012a and 6012c, south of Empire Bridge, in the Culebra formation, specimens of small orbitoids occur, but they are not sufficiently well preserved for positive identification. Although those from the latter station seem somewhat like *L. panamanensis* in their thin borders and raised center with papillae, they can not be specifically identified with certainty. At other stations poorly preserved orbitoid foraminifera occur, but their specific identity can not be accurately determined. Specimens doubtfully referable to *L. panamensis* were obtained in the Emperador limestone, at station 6015, Empire.

MULTICYCLINA, new subgenus.

Subgenus differing from typical *Lepidocyclina* in the equatorial chambers which instead of being in a single series become complex toward the periphery and may consist of several series.

Type of the subgenus.—*Lepidocyclina duplicata* Cushman.

LEPIDOCYCLINA DUPLICATA, new species.

Plate 41, figs. 2-4.

Test of medium size, 10 to 14 millimeters in diameter, very much thickened in the umbonal region, usually the thickness about one-half the diameter; without the flattened periphery the central portion is subspherical, thinning rapidly toward the periphery, then thickening again at the margin, which is often doubly plicate in the best preserved specimens. Surface of the umbonal portion studded with numerous fine papillae marking the surface terminations of the pillars, peripheral portion nearly smooth.

Vertical section showing the embryonic chambers as very small, apparently microspheric in the specimens sectioned, appearing spiral as is usual in the microspheric form. Lateral chambers numerous, flattened or lenticular, the numerous pillars as wide as or wider than the intermediate columns of chambers, especially in the central portion, rapidly increasing in size toward the surface. Equatorial chambers very small near the center, gradually increasing in size toward the periphery where they become multiple instead of single as is usually the case, and make three or four vertical series, each with numerous fine apertural pores on the outer convex wall.

Horizontal section shows the increase in size of the equatorial chambers which toward the center seem hexagonal and toward the periphery almost rhomboid with the outer half convex.

Of somewhat similar character as far as the duplication of equatorial chambers is the species described by Martin from Java, *L. multipartita* (Martin), and the form described by Jones and Parker from Christmas Island, *L. insulae natalis*, var. *inequalis* (Jones and Parker).

Occurrence.—Type-specimen, U. S. National Museum, Catalogue No. 324742. Specimens were very abundant, weathered out of an orbitoid limestone, at Station 6523, 2 miles north of David, Panama, D. F. MacDonald, collector. They also occur with other species of *Lepidocyclina* at Station 6586e from near the mouth of Tonosi River, D. F. MacDonald, collector.

HETEROSTEGINOIDES, new genus.

Test generally lenticular, somewhat excentric, one side extended peripherally more than the other, chambers rather coarsely perforate, embryonic chambers, often two, of nearly equal size, thick walled, chambers added as in *Heterostegina*, in a revolving series extending from the umbonal region on both sides to the periphery, chambers hemispherical, the outer side strongly convex and all coarsely perforate, the equatorial chambers larger than the lateral ones and nearly spherical.

Type of the genus.—*Heterosteginoides panamensis*, new species.

HETEROSTEGINOIDES PANAMENSIS, new species.

Plate 43, figs. 1-8.

Test biconvex, somewhat more strongly convex on one side than on the other, revolving edge indistinct, surface unevenly rugose, or irregularly pustulate, thickest in the umbonal region. Vertical section showing the embryonic chambers as an equal pair of nearly spherical, thick-walled chambers, equatorial chambers also nearly spherical, lateral chambers hemispherical with the curved side outermost, irregularly piled above the equatorial chambers. Horizontal section showing the central chambers with the equatorial chambers arranged in an irregular semi-spiral manner about them.

Test small, between 1 and 2 millimeters in diameter. Cat. Nos. 324743-4, U.S.N.M.

Occurrence.—This species was abundant in the Culebra formation at station 6025, from marl, south end of Bohio Ridge switch, relocated line, Panama Railroad, collected by Vaughan and MacDonald. There are also numerous specimens at station 6011, Culebra formation, along east side of Gaillard Cut, collected by Vaughan and MacDonald. It was also collected in the Culebra formation at station 6024-a, Rio Agua Salud, and is doubtfully present in the Emperador limestone at stations 6015 and 6016, in Empire.

This species, which in external appearance somewhat resembles a small orbitoid or nummulite, may be distinguished from most species of either group by its comparatively coarse pustulate exterior. In section it can easily be recognized by its peculiar structure.

Genus ORTHOPHRAGMINA.**ORTHOPHRAGMINA MINIMA, new species.**

Plate 41, fig. 1.

Test circular, very small, slightly more than 2 millimeters in diameter, thickness somewhat less than half the diameter, central portion very strongly umbonate, evenly rounded to a point about

two-thirds of the distance from the center to the periphery, from which point to the periphery the surface is nearly flat; surface of the test comparatively smooth.

Horizontal section through the equatorial chambers shows very fine rectangular chambers and the embryonic chambers nearly equal in size.

Vertical section (fig. 1) shows well the contour of the test in this section, the strongly curved central umbonate portion making up two-thirds or more of the width and the peripheral flange with its nearly parallel sides. The chambers are very small, except the embryonic central chambers, which are nearly equal and have a straight division line between them. The lateral chambers are in vertical columns, but the test is without pillars. In the central region there may be more than 20 chambers in a vertical column, and even on the peripheral flange there are usually three or four in a column on each side of the equatorial chambers.

Occurrence.—Type-specimen—the vertical section here figured. Collection of the U. S. National Museum Catalogue No. 324745.

The species is abundant at United States Geological Survey station 6512 in the white limestone, in the river bed above the ice plant near David, Panama, collected by D. F. MacDonald.

This is a very small species yet it has an abundance of very fine chambers. There is an exceptional development of lateral chambers in the region of the periphery.

Genus NUMMULITES.

NUMMULITES PANAMENSIS, new species.

Plate 43, figs. 9, 10.

Test small, about $1\frac{1}{2}$ millimeters in diameter, much compressed, chambers very numerous, about 22 in the last formed coil, each in section two to three times as high as long, test of about four whorls, walls comparatively thick, whole test lenticular, peripheral margin broadly rounded, central portion nearly flat.

Occurrence.—Specimens occur with some frequency in the Culebra formation at station 6025, in marl, south end of Bohio Ridge switch, relocated line, Panama Railroad, collected by Vaughan and MacDonald. Type-specimen, U. S. National Museum Catalogue No. 324746. The species was also collected in the Culebra formation at station 6024-a, Rio Agua Salud, and doubtfully at station 6026, 2 miles south of Monte Lirio, on the relocated line of the Panama Railroad.

NUMMULITES DAVIDENSIS, new species.

Plate 43, fig. 11.

Test comparatively small, about $3\frac{1}{2}$ millimeters in diameter, somewhat compressed, chambers about twice as high as long in median

sections, test of three or four whorls, walls of medium thickness, the upright wall rather strongly recurved backward in the central portion, 15 or 16 chambers in the last formed whorl.

Occurrence.—Specimens were not common at station 6512 from white limestone in river bed above ice plant near David, Panama, collected by D. F. MacDonald.

Type-specimen.—Cat. No. 324751, U.S.N.M.

In material from station 6526 from Chiriqui, Canal Zone, collected by MacDonald, numerous specimens occur which in section seem identical with this species.

Family MILIOLIDAE.

Genus ORBITOLITES.

ORBITOLITES AMERICANA, new species.

Plate 43, figs. 12-14; plate 44, figs. 1, 2; plate 45.

Test flat, of medium size, larger specimens about 10 millimeters in diameter, chambers with the outer wall strongly convex, the inner wall running backward and bluntly pointed, side walls parallel, chambers in two or more tiers; tests mostly microspheric, one (pl. 43, fig. 14) apparently megalospheric, and one (pl. 44, fig. 2) seemingly originating from a fragment of an older test. Numerous specimens, especially plate 45, figure 1, show evidence of breakage and repair. The apertures between the chambers are not evident, as the material largely consists of internal casts of the chambers. Some of the specimens suggest the genus *Presorites* of the Cretaceous described by Douvillé, but this is probably due to the condition of fossilization.

Occurrence.—Specimens which seem referable to this species are from the following stations at Panama, collected by Vaughan and MacDonald: Culebra formation, 6013, east side of Gaillard Cut; 6019b, 6019-e-f, west side of Gaillard Cut near Las Cascadas; and 6020a-c of the same section. Also collected in the Emperador limestone at station 6015, in Empire.

Type-specimen.—Cat. No. 324748, U.S.N.M., from station 6020a.

EXPLANATION OF PLATES.

PLATE 34.

Lepidocyclina canellei Lemoine and Douvillé.

FIG. 1. View of exterior of specimen $\times 10$, a portion of a second specimen showing above the first, from Bohio, Panama. (U.S.N.M. Cat. No. 135216.)

2. Horizontal section $\times 10$, showing embryonic chambers and hexagonal equatorial chambers, from west side of Gaillard Cut near Las Cascadas (U.S.G.S. station 6019a).
3. Horizontal section showing hexagonal equatorial chambers and irregularities in the annuli due to repairs of breakage. $a \times 10$; $b \times 20$. Same locality as No. 2 above.
4. Slightly oblique section $\times 20$, showing narrow zone of equatorial chambers and two broader zones of lateral chambers, the latter with a very evident lack of pillars. Same locality as No. 1 above.
5. Vertical section at one side of embryonic chambers showing general characters of equatorial and lateral chambers $\times 20$. Same locality as No. 1 above.
6. Vertical section through the embryonic chambers showing the two nearly equal chambers with the straight wall dividing the two, $\times 20$. Same locality as No. 1 above.

PLATE 35.

Lepidocyclus chaperi Lemoine and Douvillé.

- FIG. 1. Exterior view of specimen $\times 5$. Specimen broken. From upper part of Culebra formation, from Panama Railroad, southern switch, Bohio Ridge, in light-colored limy sandstone (U.S.G.S. station 6025).
2. Exterior view of small, more complete specimen from same locality as the preceding, $\times 5$.
 3. Horizontal section showing early chambers of the microspheric form of the species, $\times 20$. From west side of Gaillard Cut near Las Cascadas (U.S.G.S. station 6019f).

PLATE 36.

Lepidocyclus chaperi Lemoine and Douvillé.

Horizontal section $\times 10$, showing early central chambers and hexagonal chambers of the equatorial region (U.S.G.S. station 6019f).

PLATE 37.

Lepidocyclus vaughani, new species.

- FIG. 1. View of exterior of specimen $\times 5$, with flat periphery and umbonate center, from limy sandstone half a mile south of Miraflores Station, on wagon road to Panama (station 6255).
2. Horizontal section of young specimen with regularly hexagonal equatorial chambers $\times 20$ (same locality as No. 1).
 3. Oblique section $\times 20$, with narrow zone of regularly hexagonal equatorial chambers and broader zones of lateral chambers and a straight division wall (same locality as No. 1).
 4. Specimen showing zone of equatorial chambers about peripheral portion, lateral chambers covering them in the center $\times 10$. From limestone in cut of relocated line of Panama Railroad opposite San Pablo and about 4 miles north of Gamboa bridge (station 6673).
 5. Portion of vertical section (slightly oblique) through the embryonic chambers, $\times 20$ (same locality as No. 1).

PLATE 38.

Lepidocyclina vaughani, new species.

Specimen $\times 20$, showing peripheral zone cut through the equatorial chambers and central portion covered by lateral chambers. From limestone in cut of re-located line of Panama Railroad opposite San Pablo and about 4 miles north of Gamboa bridge (station 6673).

PLATE 39.

Lepidocyclina panamensis, new species.

- FIG. 1. Very young specimen in vertical section consisting of embryonic chambers and one or two following chambers, $\times 20$.
 2-4. Vertical sections with broad embryonic chambers and showing the relation of equatorial and lateral chambers, vertical columns of lateral chambers with intermediate pillars, $\times 20$.
 5. Oblique section with zone of hexagonal equatorial chambers, $\times 20$.
 6. Section of rock with six specimens lying closely adjacent, four of these cut through the embryonic chambers, $\times 20$.

All specimens from near the mouth of Tonosi River, Panama (station 6586e).

PLATE 40.

Lepidocyclina macdonaldi, new species.

- FIG. 1. Exterior view of specimen, $\times 10$, showing pillars appearing at the surface as raised area.
 2-5. Vertical sections (slightly oblique) through the embryonic chambers, which when cut in plane at right angles to division wall show nearly equal chambers with the division wall straight or very slightly curved. Pillars evident, especially in Nos. 2 and 5. $\times 20$.
 6. Oblique section, $\times 20$, showing zone of "lozenge-shaped" equatorial chambers with lateral chambers on each side. The upper series showing the cut sections of pillars.

All specimens from limestone 2 miles north of David, Panama (station 6523).

PLATE 41.

Orthophragmina minima, new species.

- FIG. 1. Vertical section, $\times 20$, showing general outline and numerous very fine chambers. From white limestone in river bed above ice plant, David, Panama (U.S.G.S. station 6512).

Lepidocyclina duplicata, new species.

2. Exterior view of type, $\times 5$, showing raised center and depressed area inside the raised periphery.
 3. Portions of vertical section showing great increase in width of equatorial zone, multiplication of chambers toward the periphery, heavy pillars and wide lateral chambers. $\times 20$.

4. Portion of oblique section showing narrow zone of "lozenge-shaped" equatorial chambers, perforations of peripheral wall of outer equatorial chambers and perforated pillars among the lateral chambers. $\times 20$.

All specimens of *L. duplicata* from limestone, 2 miles north of David, Panama (station 6523).

PLATE 42.

Section of limestone from station 6523, 2 miles north of David, showing numerous specimens of *Lepidocyclina*, $\times 20$. Left center, *L. panamensis* with broad embryonic chambers; lower middle *L. macdonaldi* with subspherical embryonic chambers; at right a portion of *L. duplicata*.

PLATE 43.

Heterosteginoides panamensis, new genus and new species.

- FIG. 1, 2. External view of specimens, $\times 10$, from limy sandstone, east side of Gaillard Cut (station 6011).
 3-6. Vertical portions, $\times 20$, showing irregular piling of lateral chambers; fig. 6 with two embryonic chambers with thick walls. Specimens from limy sandstone near southern switch, Bohio Ridge (station 6025).
 7, 8. Horizontal sections, $\times 20$, from same locality at Bohio.

Nummulites panamensis, new species.

9. Horizontal section, $\times 20$, from limy sandstone near southern switch, Bohio Ridge (station 6025).
 10. Vertical section from same rock specimen, $\times 10$.

Nummulites davidensis, new species.

11. Horizontal section, $\times 20$, from white limestone in river bed above ice plant, David, Panama (station 6512).

Orbitolites americana, new species.

- 12-14. Horizontal sections, $\times 10$, specimens from west side of Gaillard Cut, near Las Cascadas (station 6020a).

PLATE 44.

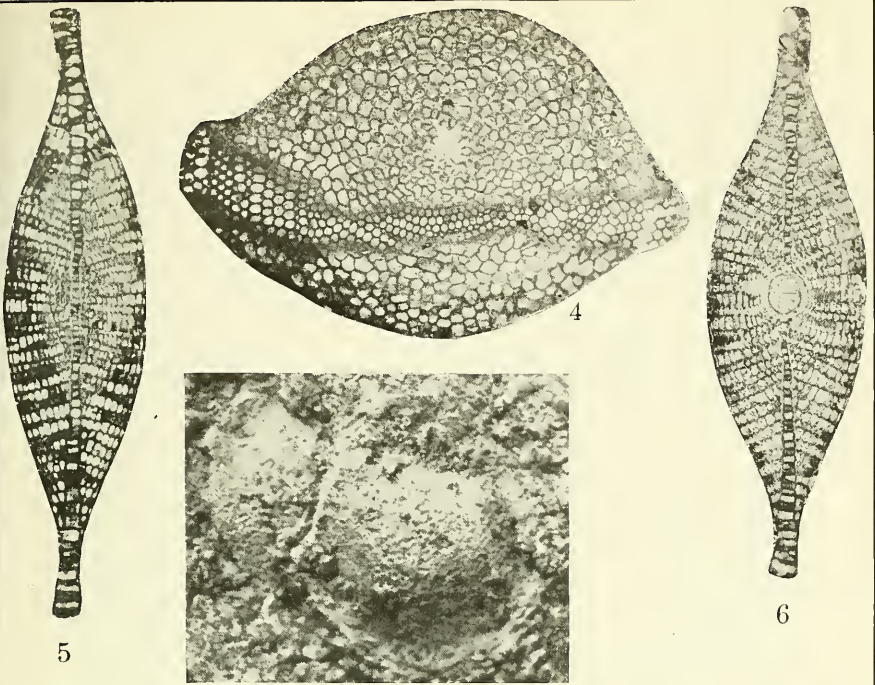
Orbitolites americana, new species.

- FIG. 1. Horizontal section of large specimen, $\times 10$, from Gaillard Cut, near Las Cascadas (station 6019-b).
 2. Horizontal section, broken, showing two layers of chambers and inside cast of outer surface, $\times 20$ (station 6020a).

PLATE 45.

Orbitolites americana, new species.

Specimen in horizontal section, $\times 20$, showing several areas of breakage and subsequent repair, shown by the angular reentrants of the annuli in various places. From Gaillard Cut, near Las Cascadas (station 6020a).

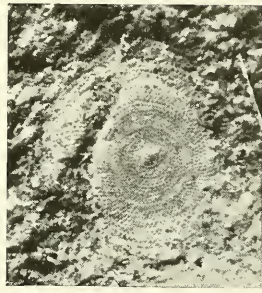


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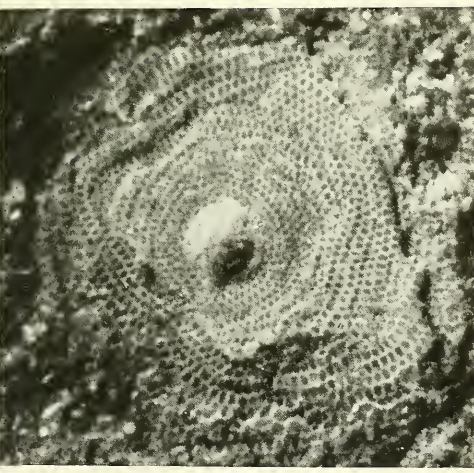
5

4

6



2



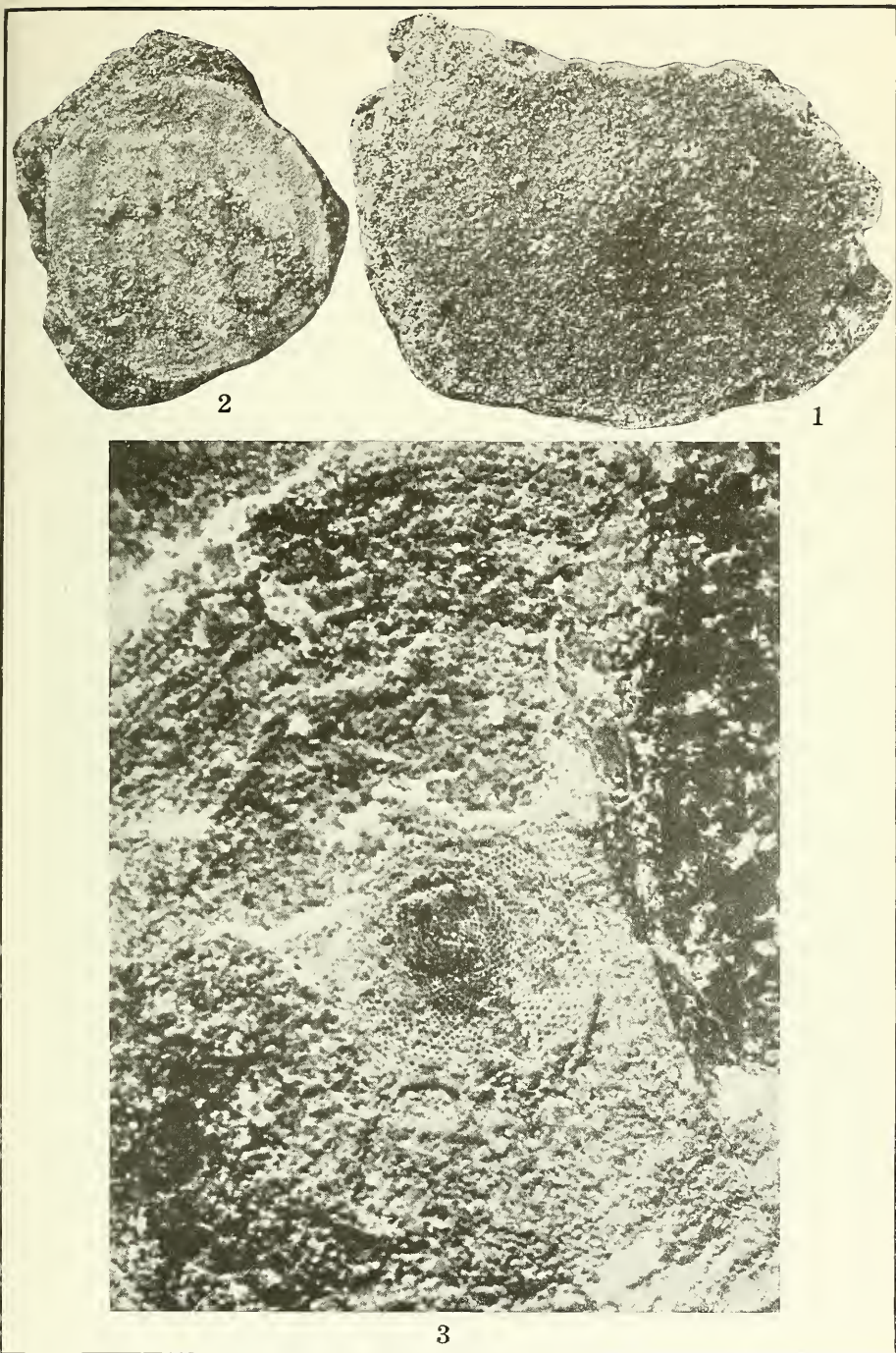
3b



3a

LARGER FOSSIL FORAMINIFERA FROM PANAMA.

FOR EXPLANATION OF PLATE SEE PAGES 99-100



LARGER FOSSIL FORAMINIFERA FROM PANAMA.

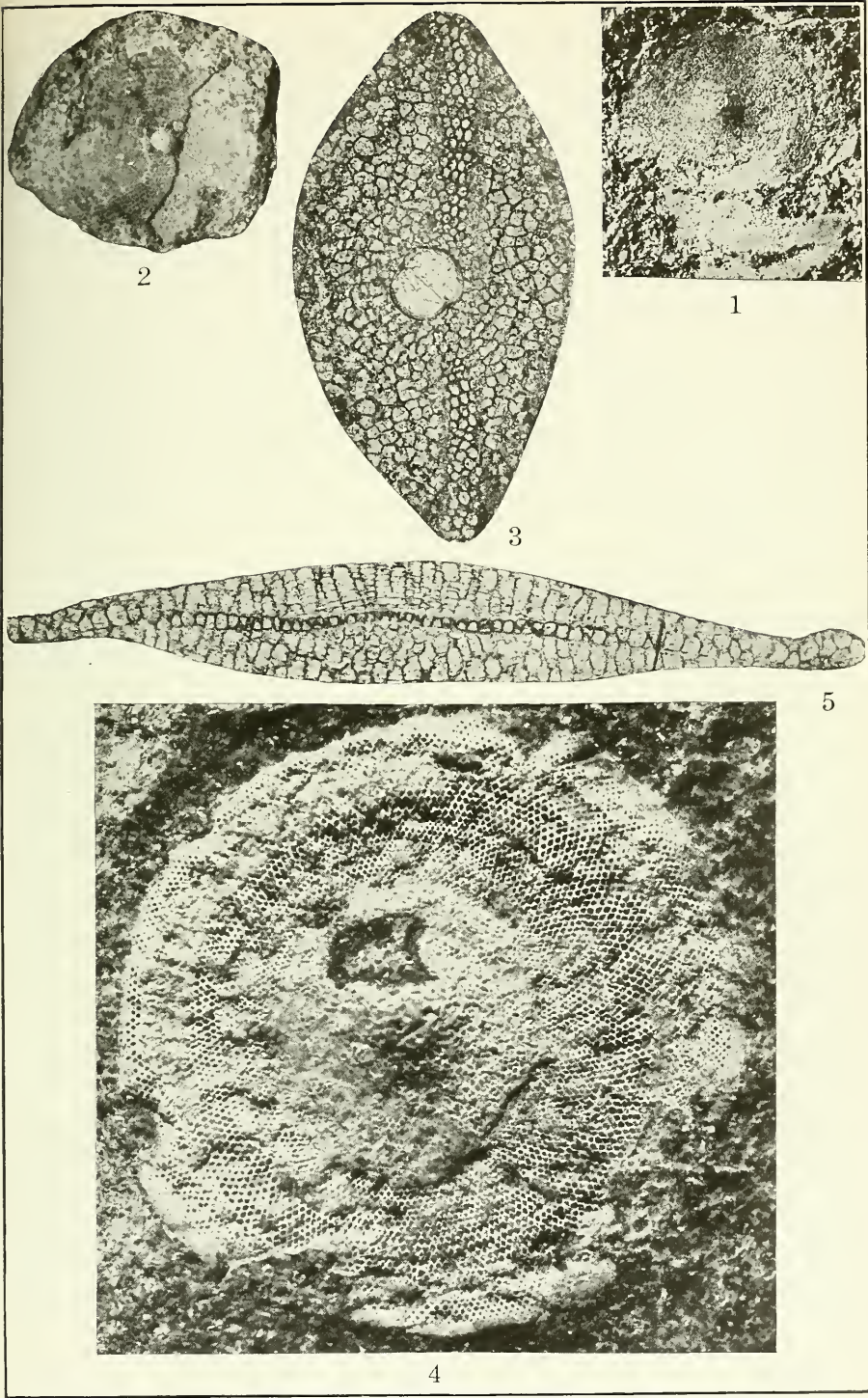
FOR EXPLANATION OF PLATE SEE PAGE 100.



LARGER FOSSIL FORAMINIFERA FROM PANAMA.

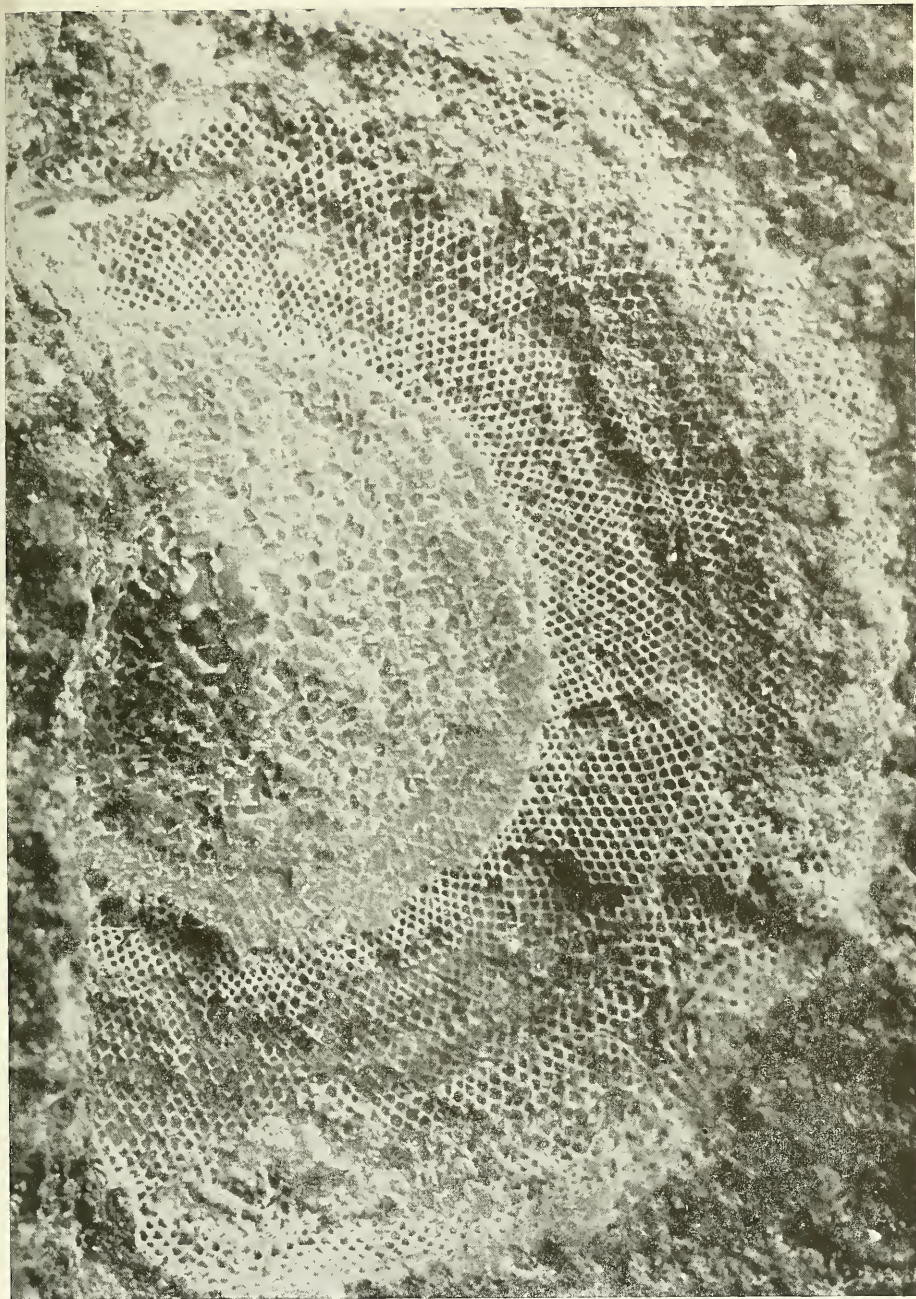
FOR EXPLANATION OF PLATE SEE PAGE 100.





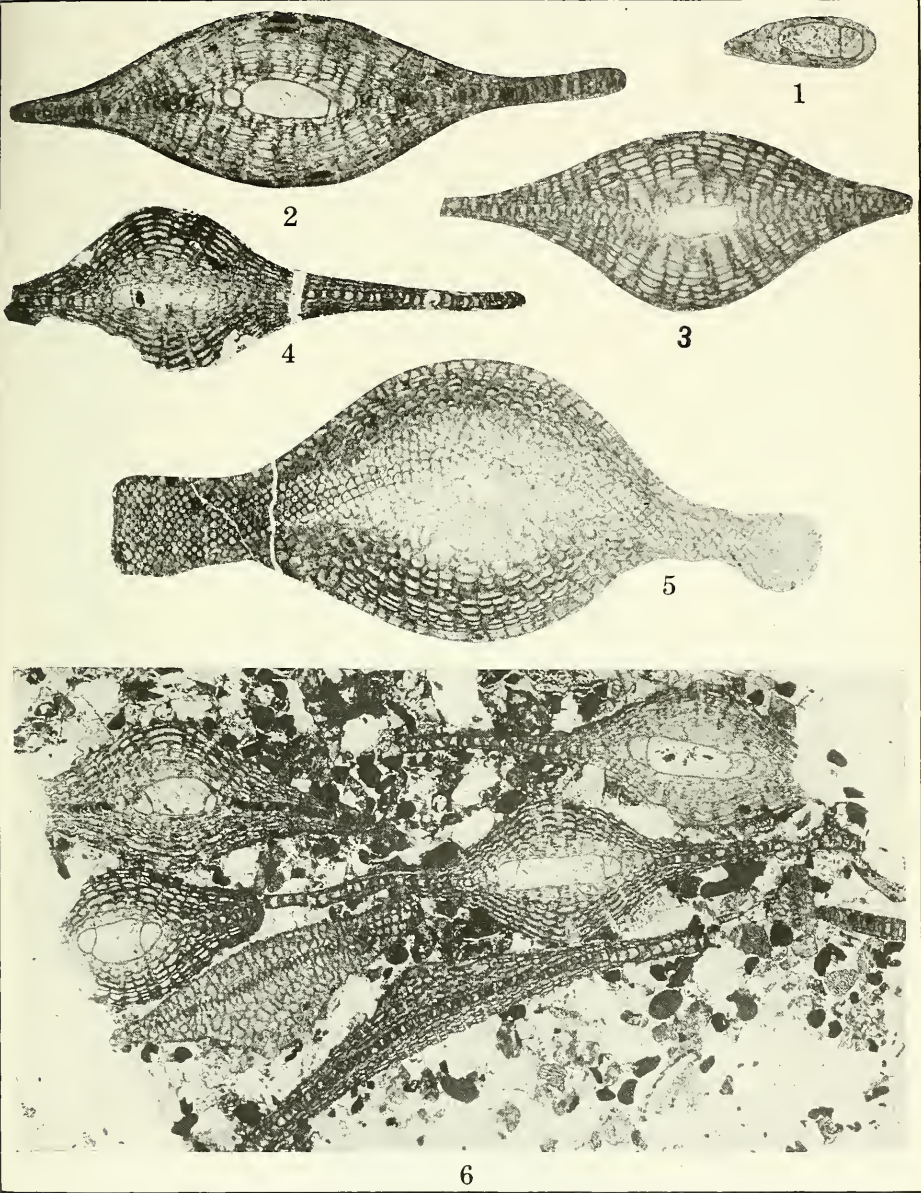
LARGER FOSSIL FORAMINIFERA FROM PANAMA.

FOR EXPLANATION OF PLATE SEE PAGE 100¹



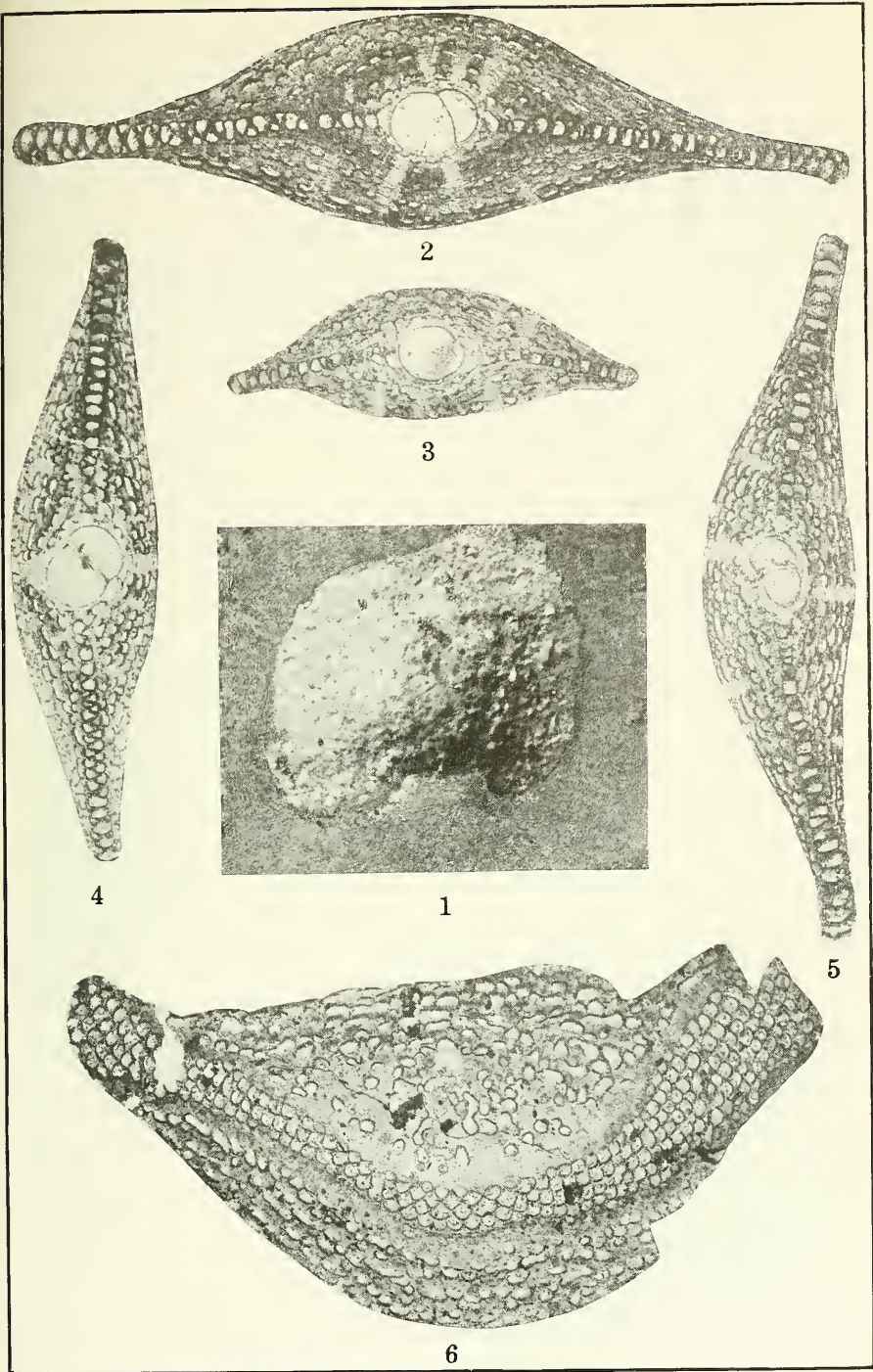
LARGER FOSSIL FORAMINIFERA FROM PANAMA.

FOR EXPLANATION OF PLATE SEE PAGE 101



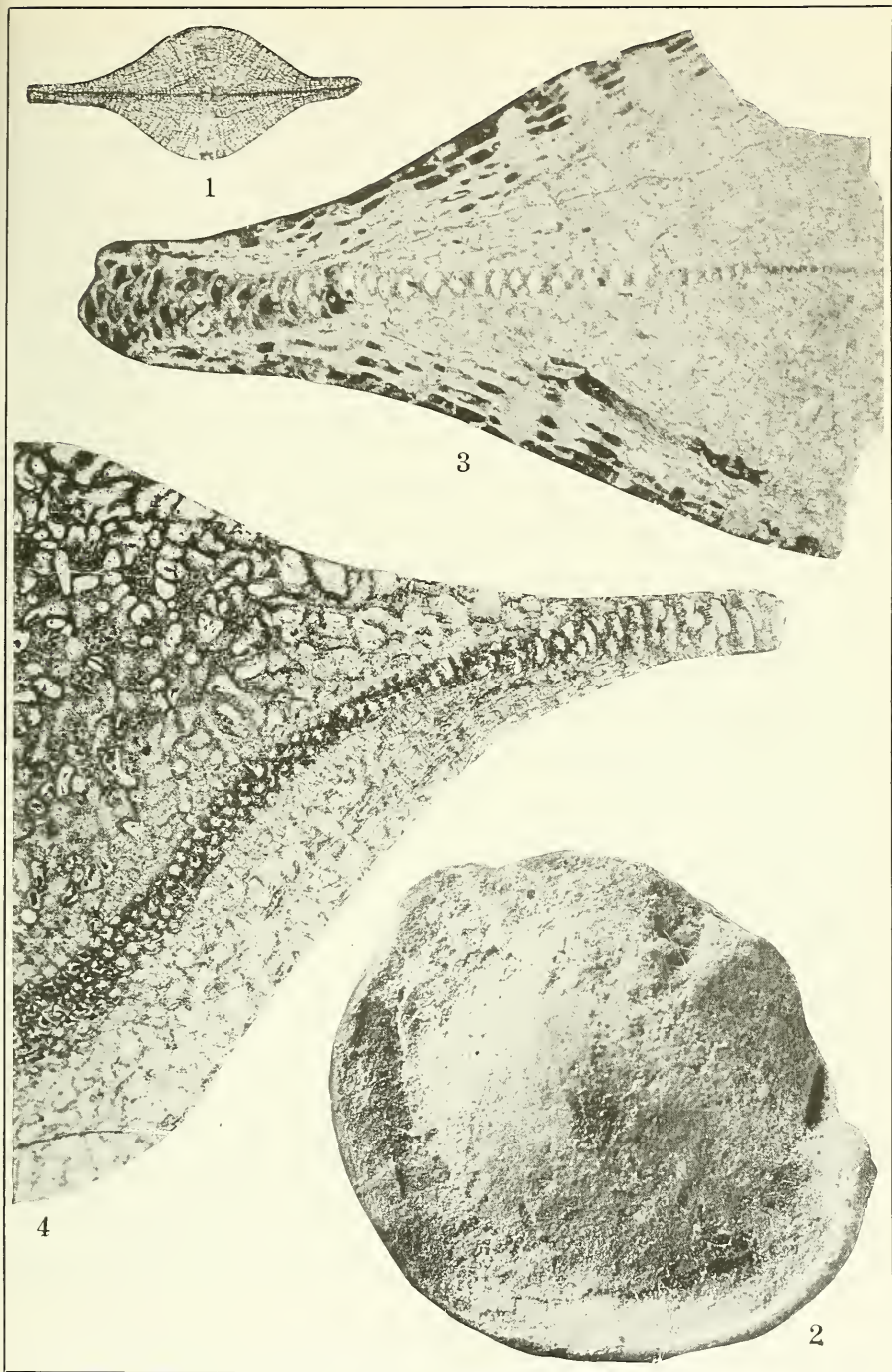
LARGER FOSSIL FORAMINIFERA FROM PANAMA.

FOR EXPLANATION OF PLATE SEE PAGE 101



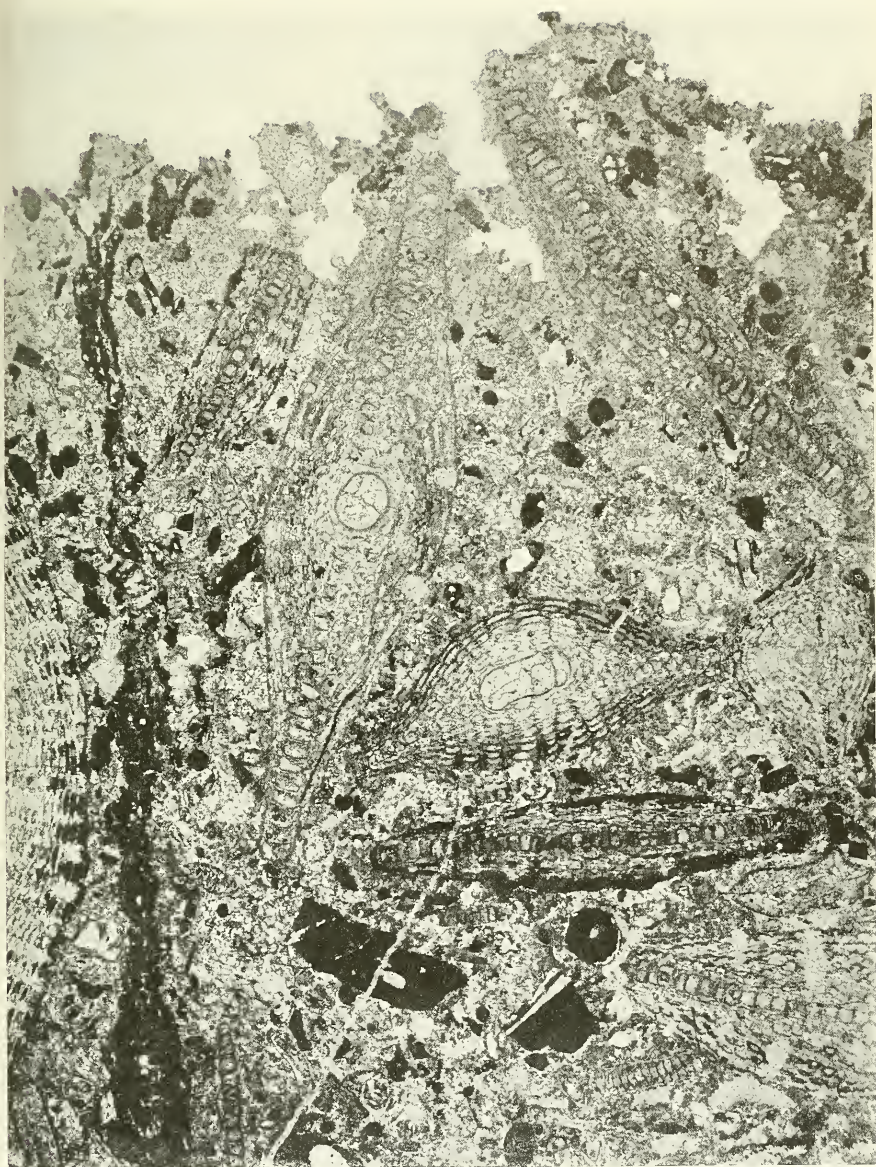
LARGER FOSSIL FORAMINIFERA FROM PANAMA.

FOR EXPLANATION OF PLATE SEE PAGE 101.



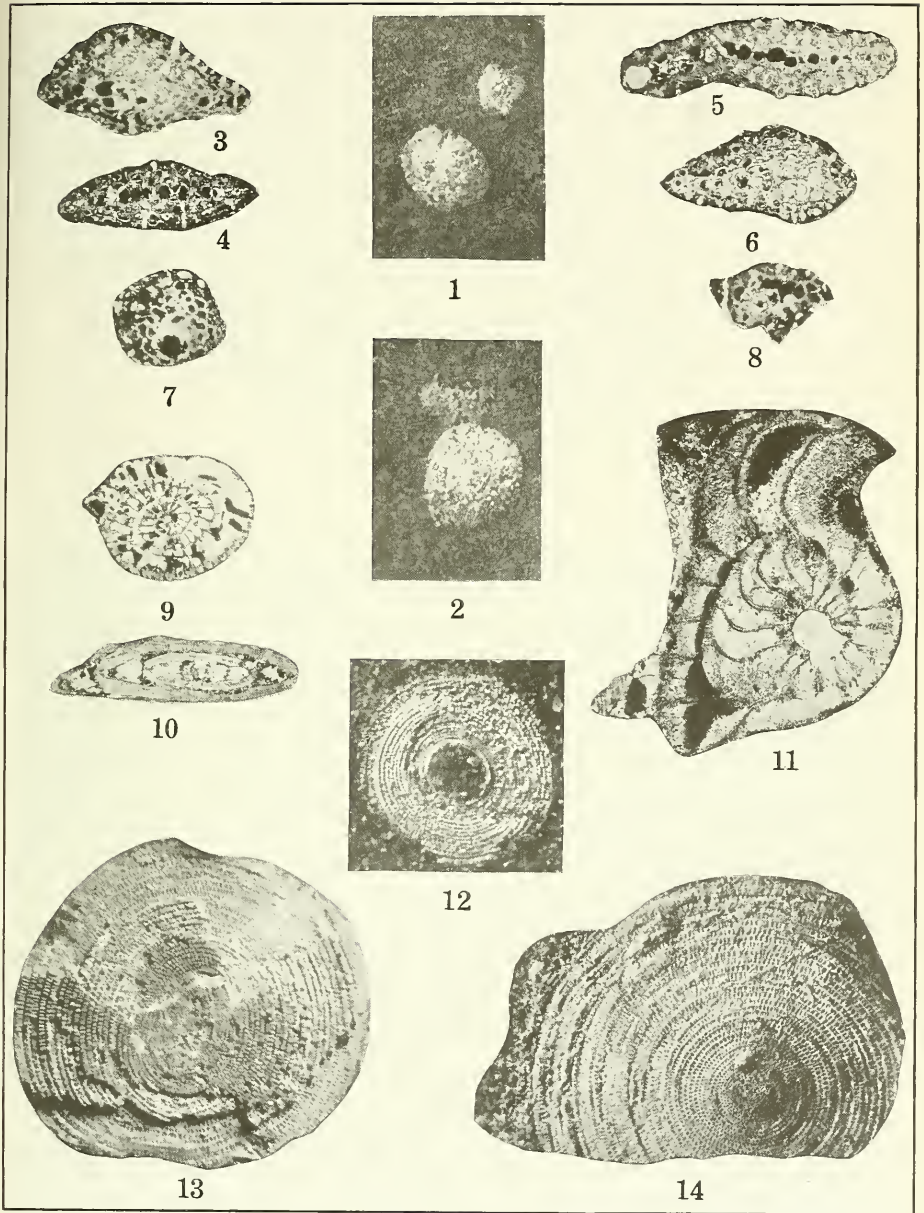
LARGER FOSSIL FORAMINIFERA FROM PANAMA.

FOR EXPLANATION OF PLATE SEE PAGES 101, 102.



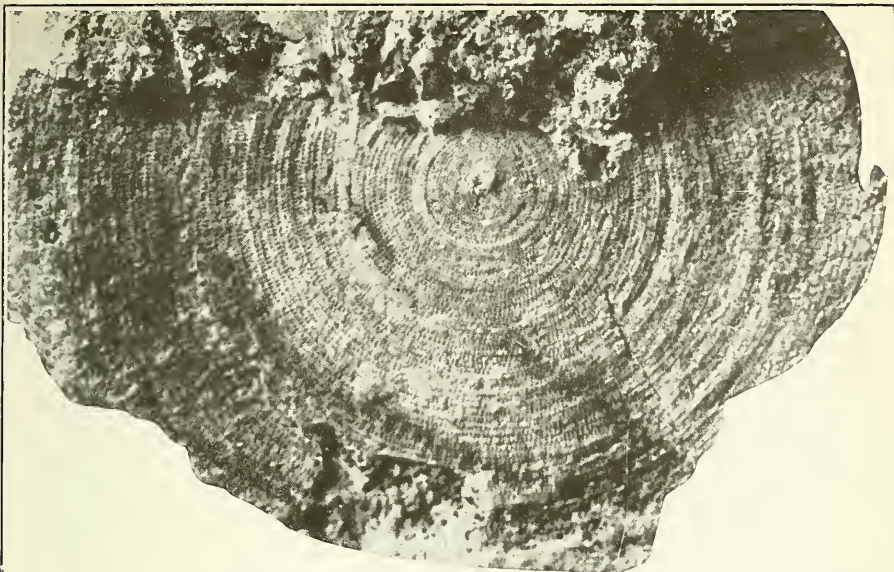
LARGER FOSSIL FORAMINIFERA FROM PANAMA.

FOR EXPLANATION OF PLATE SEE PAGE 100.

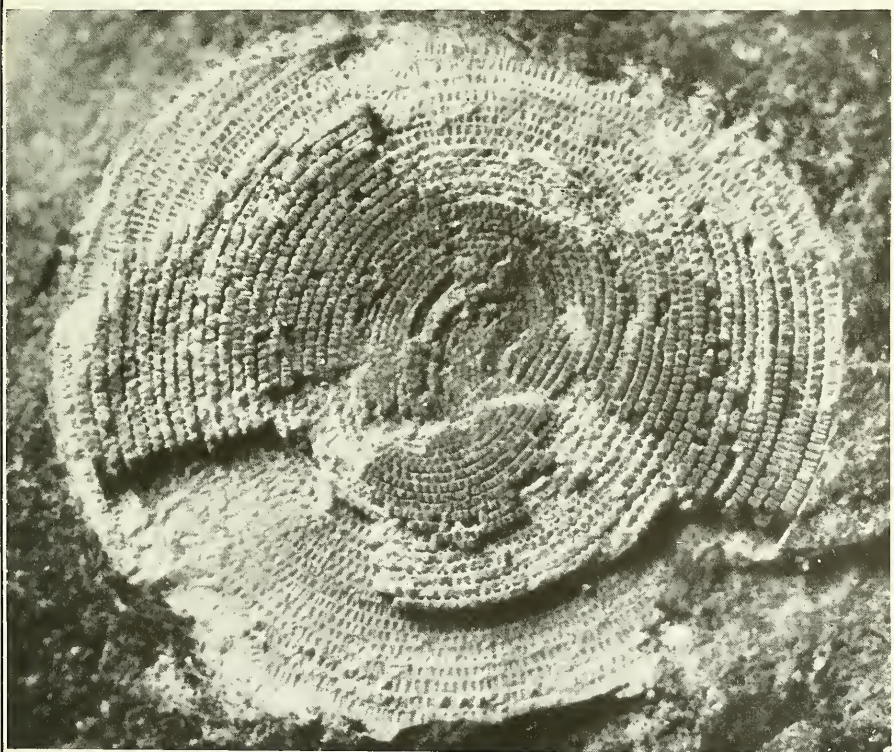


LARGER FOSSIL FORAMINIFERA FROM PANAMA.

FOR EXPLANATION OF PLATE SEE PAGE 102.



1



2

LARGER FOSSIL FORAMINIFERA FROM PANAMA.

FOR EXPLANATION OF PLATE SEE PAGE 102.



LARGER FOSSIL FORAMINIFERA FROM PANAMA.

FOR EXPLANATION OF PLATE SEE PAGE 102.

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