CONTRIBUTIONS
FROM THE
CUSHMAN FOUNDATION
FOR
FORAMINIFERAL RESEARCH

VOLUME XII, Part 4

October, 1961

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FOR FORAMINIFERAL RESEARCH
VOLUME XII, PART 4, OCTOBER, 1961

230. ON SELECTION OF LECTOTYPES AND NEOTYPES[1]

RUTH TODD
U. S. Geological Survey, Washington 25, D. C.

In the course of study of some Recent planktonic Foraminifera, it has come to my attention that two long-abandoned species have been resurrected by means of selection of a lectotype and a neotype respectively. If these selections were accepted, they would result in the elimination from the literature of widely used names for two of the best known and least misinterpreted of the world-wide planktonic species, namely, *Globigerinoides sacculifer* (Brady) and *Globorotalia menardii* (d'Orbigny). Such an eventuality is to be deplored as failing to advance the cause of uniformity of usage of names and, moreover, is in conflict with the spirit of the International Code of Zoological Nomenclature as expressed in the mimeographed preamble to the Code. Therefore I offer the following objections to the acceptance of the proposed lectotype and neotype.

Lectotype of *Globigerina quadrilobata* d'Orbigny (1846, p. 164, pl. 9, figs. 7-10).—After a lapse of an hundred years, during which only one illustrated reference (Costa, 1856, p. 242, pl. 21, fig. 5) to the species seems to have been made, Cushman (1946, p. 19) speculated that this species, recorded as rare at Nussdorf, was probably an irregular specimen. He suggested the name be allowed to lapse. Banner and Blow (1960, p. 17) described in detail a single lot of presumed syntypic specimens of this species still extant in the d'Orbigny collections in Paris. They stated that of the original 11, 3 were lost, 2 belonged in *Globigerina bulloides* d'Orbigny and 1 in *Globigerina bilobata* d'Orbigny. They then added that, although the remaining 5 specimens were conspecific with each other, none agreed well with d'Orbigny's illustrated specimen. With all this we can be in agreement, as the lectotype selected (Banner and Blow, 1960, p. 17, pl. 4, fig. 3) belongs without doubt in the species now widely understood as *Globigerinoides sacculifer* (Brady) and is not in agreement with the species described as *Globigerina quadrilobata* d'Orbigny from the Miocene of Nussdorf. *G. quadrilobata* was described by d'Orbigny as composed of 4 spherical chambers of nearly equal size, the diameter of the whole test being "¼ millim." No mention is made of supplementary dorsal apertures nor are any shown in d'Orbigny's illustration.

In the light of these differences, the lectotype should be rejected on the grounds that it does not reasonably conform with what the author described when he erected the species.

Even if the authenticity of syntypes may be assumed, their inviolability cannot be. This has been best pointed out, perhaps inadvertently, by Banner and Blow themselves when they recognized 2 other species within the presumed syntypic series. After something over 100 years with its accidents of nature, wars, study by subsequent students, and other disturbances, not to mention the possibility of accidental inclusion of more than one species by the original author himself, or even intentional inclusion of what now would be considered more than one species, it is folly to attach inordinate importance to syntypes, without regard to whether they fulfill even the minimum qualifications of what it was obviously the author's intention to describe.

Therefore, the lectotype of *Globigerina quadrilobata* d'Orbigny should be rejected and the name allowed to lapse, as had already been recommended (Cushman, 1946, p. 19).

Neotype of *Rotalina cultrata* d'Orbigny (1839, p. 76, pl. 5, figs. 7-9).—This name, like *Globigerina quadrilobata,* has been virtually ignored since it was originally proposed. Only three instances of its use are known to me: a questionable reference from off the east coast of America (Bailey, 1851, p. 11, pl., figs. 14-16); one where *cultrata* is regarded as a variety of *Pulvinulina menardii* from off the Barbados (vanden Broeck, 1876, p. 141, pl. 3, figs. 13, 15); and one from the Asiatic shelf (Waller and Polski, 1959, p. 125, pl. 10, fig. 3). In the last reference, no description is included, but the specimens placed in *Globorotalia cultrata* (d'Orbigny) are distinguished from those placed in *G. menardii* (d'Orbigny), although the basis of distinction is not stated.

Globorotalia cultrata was described from marine sands of Cuba, Martinique, Guadalupe, and Jamaica. When it was determined (Banner and Blow, 1960, p. 34) that no syntypic material existed, Banner and Blow examined topotypic material—Recent sands from off Cape Cruz, Cuba—and from it selected a neotype which they regarded as "clearly conspecific with d'Orbigny's form."

The selection of a neotype for a long-abandoned species is in conflict with recommendations included in the mimeographed Draft Code adopted in 1958 at the 15th International Zoological Congress in London. There it is stated that a neotype shall be selected only "in connection with revisory work, and then only in exceptional circumstances when a neotype is desirable in the interest of stability." It states further that "A

1 Publication authorized by the Director, U. S. Geological Survey.

neotype shall not be established for its own sake or as a matter of curatorial routine, or for a species whose name neither is in current use nor enters current synonymy." In addition, it is recommended that "To take effect, the neotype selection must be published with . . . (iv) evidence that the selected neotype is consistent with what is known of the original type-material from its description and from other sources."

Although the proposed neotype of *Rotalina cultrata* is stated to be clearly conspecific with d'Orbigny's form, it actually differs in several respects, as follows: (a) d'Orbigny's description and illustration of *Rotalina cultrata* indicate a punctate or hispid wall surface. The text mentions the shell as being "légèrement pointillée" and the illustration shows these features on both surfaces. The drawings are admittedly diagrammatic, yet when one contrasts d'Orbigny's representations of such coarsely punctate forms as *Rosalina candeiana* (d'Orbigny, 1839, p. 97, pl. 4, figs. 2-4) and *Truncatulina advena* (idem, p. 87, pl. 6, figs. 3-5) with his representations of such finely punctate forms as *Rotalina sagra* (idem, p. 77, pl. 5, figs. 13-15) and *Nonionina grateloupi* (idem, p. 46, pl. 6, figs. 6, 7), one is struck by the fact that d'Orbigny intentionally represented *Rotalina cultrata* as having a wall like the former two rather than like the latter two, whereas the neotype is more closely similar to the latter two. (b) The discrepancy in size "⅓ de millim.", which is barely over one-third the size of the neotype selected, throws additional doubt on the validity of the neotype. Although it is generally accepted that size in itself is not a specific character, differences of size extending to severalfold, or large size differences combined with other distinguishing characteristics, do serve as specific characters. Thus the size discrepancy between "⅓ de millim." originally specified for *"Rotalina cultrata,"* and approximately one millimeter specified for the neotype also argues against acceptance of the neotype.

In the light of the above evidence, the neotype of *Rotalina cultrata* should be rejected on the grounds that it does not reasonably conform to what it was obviously the author's intention to describe, and that it is not needed in the interest of stability.

SUMMARY

The underlying reason-for-being of the International Code of Zoological Nomenclature is that one shall understand what another one means by scientific names. Fundamentally, the Rules are set up to serve this purpose, not for the purpose of inhibiting and unreasonably restraining nomenclature. These Rules take their authority and their validity from their reasonableness. They lose both when they become unreasonable or are subject to unreasonable interpretation.

While it is the object of the Rules of Zoological Nomenclature to establish a basis for a stable and universal set of names, the application of any provision of the Code so as to supplant a well-known and important name is to be condemned as contrary to the spirit of the Code. Furthermore, although the Law of Priority is the basic principle to be observed, it is to be moderated by the Principle of Conservation. The two instances discussed above, masked under the guise of priority, are examples of mis-choice in violation of the spirit of the Code and are, therefore, inadmissible into zoological nomenclature.

Therefore, I propose the repudiation of these small obstacles to the continued use of the long-established names for the two well-known planktonic species, *Globigerinoides sacculifer* (Brady) and *Globorotalia menardii* (d'Orbigny).

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XII, PART 4, OCTOBER, 1961

231. GLOBOTRUNCANIDAE BROTZEN, 1942, AS TOOTHPLATE FORAMINIFERA

J. HOFKER
The Hague, Holland

ABSTRACT

Beautifully preserved material from the Lower Campanian has made possible the study of the structure of **Globigerina (Rugoglobigerina?) cretacea** d'Orbigny, **Marginotruncana globigerinoides** (Brotzen), **M. paraventricosa** Hofker, and **Globotruncana linneiformis** Hofker. The "tegula" or "tena" covering the umbilical hollow are the outer parts of toothplates; the aperture itself is a true foramen compositum; the marginal poreless keels of the Globotruncanidae are the remains of marginal parts of the toothplates. It is suggested that a fan-shaped floating apparatus, in living Globotruncanidae and Globorotaliidae, was attached to that poreless rim; the globigerines have a very different floating mechanism, formed by fine spines. Thus, the Cretaceous globigerines, though also having toothplates covering the umbilici, are not closely related to the Globotruncanidae. So-called **Globorotalia** lacking a marginal poreless rim do not appear to be referable to that genus.

In a paper on the Globotruncanidae from northwestern Germany and Holland, I (Hofker, 1956a) gave the opinion that the Globotruncanidae were derived from some group of toothplate Foraminifera, choosing for the ancestral form *Conorboides*. A study of the aperture showed that it was formed by a combination of protoforamen and deuteroforamen (*foramen compositum*), as it is in many groups, and this pointed to "Mundlappen" which in turn suggests a "tenon" in the sense of Brotzen (1948).

Bolli *et al.* (1957, p. 44) described the apertural characteristics of *Globotruncana* as follows: "primary apertures interio-marginal, umbilical, in well preserved specimens covered by tegilla, which are perforated by accessory infraliminal and intraliminal apertures, which are then the only openings to the exterior, the tegilla commonly are partially or wholly broken out in the process of fossilization, or may be preserved only as scalloped fragments."

Banner and Blow (1959, p. 10) describe the apertural conditions as follows: "primary aperture interiomarginal, intraumbilical or umbilical-extraumbilical, characteristically modified by an imperforate complex umbilical coverplate (*tegillum*). Relict part of primary apertures open into umbilicus beneath the tegillum, and thence to exterior through accessory apertures in the tegillum."

The author, with B. J. Romein, collected a complete set of samples from the Lower Campanian arenaceous limestone found in the caves at Folx-les-Caves in central Belgium. Here, a fauna of Lower Campanian age was found in which the Foraminifera had never been recrystallized, adhered to the matrix, or even been filled with matrix. All the fossils are air filled and look like Recent material. Not only the finer structures could be studied, but, in most specimens of globigerines and globotruncanae, the finest parts of the "tena" or "tegilla" were preserved. Each chamber aperture forms at its border a more or less irregular, very thin, poreless plate which covers part of the umbilicus. Each chamber plate covers part of the plate of the former chamber. These plates never fuse at their outer borders with former ones. Each poreless plate is attached to the upper border of its aperture, leaving the proximal and distal curved end of the apertural border free, so that the protoforamenal and deuteroforamenal parts of the foramen compositum remain open. Nearer to the umbilicus, the border of each plate may be nearly flat or may be crumpled up to form a "secondary aperture." When seen from the apertural face (end face of the last-formed chamber), the deuteroforamen always can be seen under the plate.

In the same sample, a very similar structure was found in *Globigerina (Rugoglobigerina) cretacea* and, in addition, it was possible to study these fine structures in *Marginotruncana paraventricosa* Hofker, *M. globigerinoides* (Brotzen), *Globotruncana linneiformis* Hofker, and *G. aspera* Hofker. For this reason it is obvious that the so-called "open umbilicus" of the Globotruncanidae is an artifact resulting from poor preservation; when the test is well-preserved, each chamber has a "tenon" or "tegillum."

In several papers, I have suggested that the poreless plates covering the part of the foramen compositum between the protoforamen and the deuteroforamen must be regarded as real toothplates. Within the chambers of the Protoforaminata, these toothplates run from one aperture towards the next one, since there the next chamber entirely surrounds the former aperture. In protoforaminate *Lamarckina,* part of this toothplate forms a free plate over the umbilical hollow, but each consecutive chamber engulfs it entirely. On the other hand, in the deuteroforaminate Conorbidae, a second aperture is formed, and the free part of the toothplate forms a poreless protruding lip between the protoforamen and the deuteroforamen. This plate is the "tenon" of Brotzen and remains in those forms where the inner part of the toothplate at the protoforamen is reduced (*Discopulvinulina*). In *Valvulineria,* the entire area between protoforamen and deuteroforamen remains as an open slit, so that here we have a case of a foramen compositum; the poreless

plate remains, however, and even covers large parts of the umbilicus. Since the foramen compositum of each successive chamber forms this larger plate, these plates also cover one another successively. The Globotruncanidae likewise have such a foramen compositum and here also the umbilical hollow is more or less covered by the poreless plates.

It is obvious from this analysis that the Globotruncanidae (and also *Rugoglobigerina,* although this form seems to belong to another lineage) are Deuteroforaminata with strongly reduced inner toothplates but with the outer parts of the toothplates greatly developed to form the "tegillae" of Bolli *et al.,* or the "tena" of Brotzen, and the "Mundlappen" of Hofker.

Transverse sections of this beautifully preserved material were made so that only one half of the test was ground down; thus, not only the structure of the toothplates could be studied but also the inner walls of the chambers. Such sections reveal that each chamber is connected with the next one by a large rounded septal foramen which is often bordered by a thickened rim; this is the distal part of the foramen compositum; proximally, in respect to the proloculus, the chamber wall bends upward, not reaching, however, the ventral walls of former coils; at this part of the foramen compositum, the toothplate becomes attached, and it is here that the chamber opens into the umbilical cavity. Still farther proximally, in most cases observed, there is a small indentation where the foramen compositum ends with a small protoforamen. In *Globigerina (Rugoglobigerina?) cretacea,* the entire inner wall around the septal foramen is pierced by pores; in *Marginotruncana globigerinoides,* as well as in all other Globotruncanidae, a clearly bordered poreless band begins at the deuteroforamen (septal foramen) and forms marginally the poreless keel; in the older chambers of *M. globigerinoides,* this keel is slightly thickened at its borders by secondary rims of chalk; these rims are not yet visible in the latest chambers. In *M. paraventricosa,* even in the latest chambers, the outer rims are found; this also is true of *Globotruncana linneiformis* whose pores are finer than those of the other species mentioned. In addition, it was observed that at the place where the toothplate is attached to the bordering rim of the foramen, the bordering part of the chamber wall also is poreless. This condition gives added stress to the view suggested by the author (Hofker, 1951, p. 359; 1956b, p. 190) that the poreless toothplates and poreless keel of the Globotruncanidae both form parts of toothplate structures. The following structures also should be pointed out in this respect: the dorsal poreless "suture" of the toothplate in *Lamarckina,* the poreless keel formed by the toothplate in *Laticarinina,* and the marginal chord of the Nummulitidae. On the other hand, in *Globigerina (Rugoglobigerina?),* the poreless keel is not developed. It was possible to trace that form from the Albian and it is certain that, although also having umbilical toothplates and obviously derived from a similar ancestor to that of the Globotruncanidae, it must belong to quite a different trend unconnected with the Globotruncanidae. Forms such as *G. (R.?) cretacea* seem

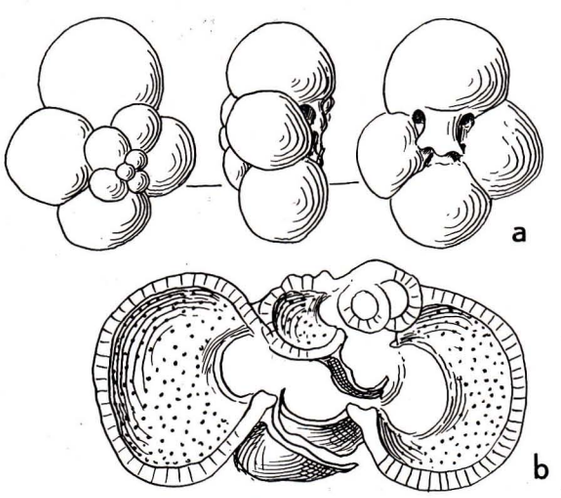

FIGURE 1

Globigerina (Rugoglobigerina?) cretacea d'Orbigny. Sample 1126, Folx-les-Caves, Lower Campanian. a, whole specimen from three sides; showing, on the ventral side, the toothplates covering the umbilical cavity; on the apertural face, the deuteroforamen; × 56. b, transverse section showing the deuteroforamina (septal foramina), entirely porous chamber walls, and the toothplate; × 123.

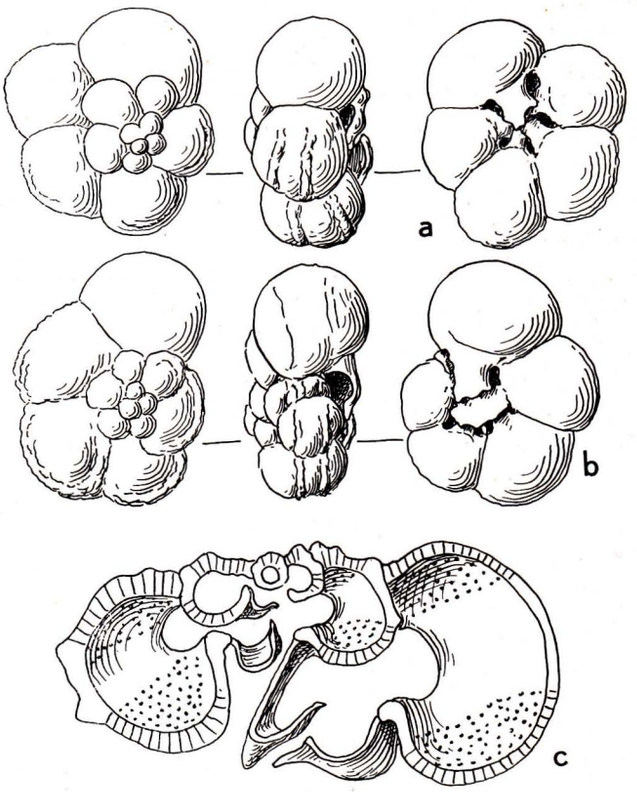

FIGURE 2

Marginotruncana globigerinoides (Brotzen). Sample 1126, Folx-les-Caves, Lower Campanian. a, whole specimen from three sides; showing on the ventral side, the toothplates; on the apertural face, the deuteroforamen; × 56. b, whole specimen from three sides; × 56. c, transverse section showing the septal foramina, the inner side of the chamber walls with the poreless marginal area connected with these apertures, and the toothplates; × 123.

to form a trend which is related closely to *Valvulineria,* another offspring of that same ancestor which also does not develop a marginal part of the toothplate structures. It may be that *Gyroidinoides* also belongs near this group.

The Globotruncanidae are Deuteroforaminata with a foramen compositum; the distal deuteroforamen forms the septal foramen; the proximal protoforamen is inconspicuous; between these foramina, at the border of the foramen compositum, a true toothplate emerges covering the larger part of the umbilical cavity at each chamber; this toothplate is connected with a remnant of the whole toothplate structure (the part of the toothplate attached at the marginal chamber wall) which causes a poreless part of the chamber wall beginning at the border of the septal deuteroforamen, forming in all cases observed a poreless margin which is often secondarily thickened at its border by a rim. It is not certain just what the meaning of this poreless margin in the Globotruncanidae is. It may be that a denser part of the protoplasm emerged from the deuteroforamen which adhered to that marginal poreless "keel," forming a fan-shaped protoplasmic floating apparatus. Since the pores with their sieve plates cannot serve for passing protoplasm (Jahn, 1953, pp. 294-297) but appear to be respiratory organs, the protoplasm when leaving the aperture has to flow over the poreless parts of the test when forming organelles on the outer side of the test. In living globigerines, the "spines" formed by dense protoplasm, often with a chalky inner part, always are found on tubercules on the surface of the test between the pores, which are left free. In Miliolids, on the other hand, which have no pores, the protoplasm flows over the whole outer surface of the test. *Globigerina (Rugoglobigerina?) cretacea* always has large or small pustules on the outer surface which are obviously the places where protoplasmic "spines" adhered to the surface to form a floating apparatus. So it appears that in the Globotruncanidae, the poreless rim or keel at the margin had a distinct function and had something to do with floating. Floating in the Globotruncanidae was performed in a very different way from that in *Globigerina (Rugoglobigerina?).* In Cretaceous *Globigerina,* as in Tertiary and Recent planktonic forms, a totally different gene pool gave rise to the floating mechanism to that in the Globotruncanidae and consequently both groups, though possibly originating from the same stock (*Valvulineria?*), do not belong together. When we seek among Recent species of floating Foraminifera for those forming their floating apparatus with protoplasm, we must find them among the Globorotaliidae. Here also is the poreless rim at the periphery, the poreless toothplate in the foramen compositum between the protoforamen and the deuteroforamen (Hofker, 1959, fig. 2) and the pores without pustules between them on the outer surface. "Spines" have never been found on Recent living *Globorotalia;* the frequently thick-walled test (*G. tumida*) must be kept afloat by means of a fan of

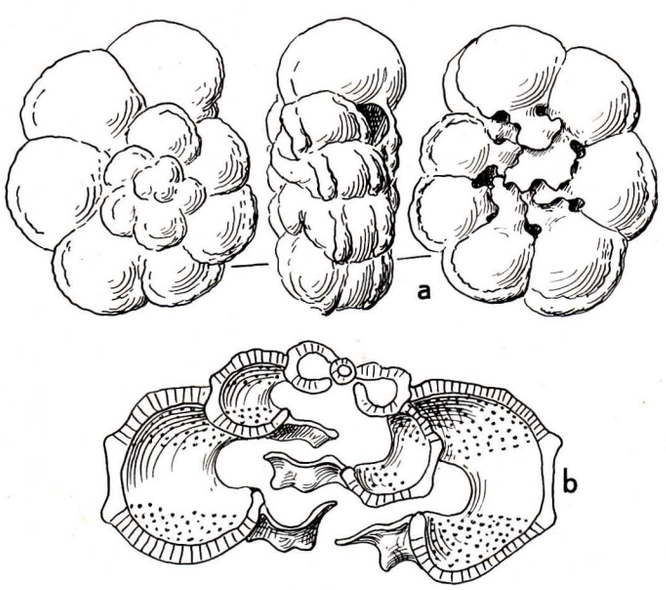

FIGURE 3

Marginotruncana paraventricosa Hofker. Sample 1126, Folx-les-Caves, Lower Campanian. a, whole specimen from three sides; showing on the ventral side, the toothplates covering the umbilical hollow; in apertural view, the deuteroforamen underneath the toothplate; × 56. b, transverse section showing the septal foramina, their connection with the poreless marginal part, and the toothplates; × 123.

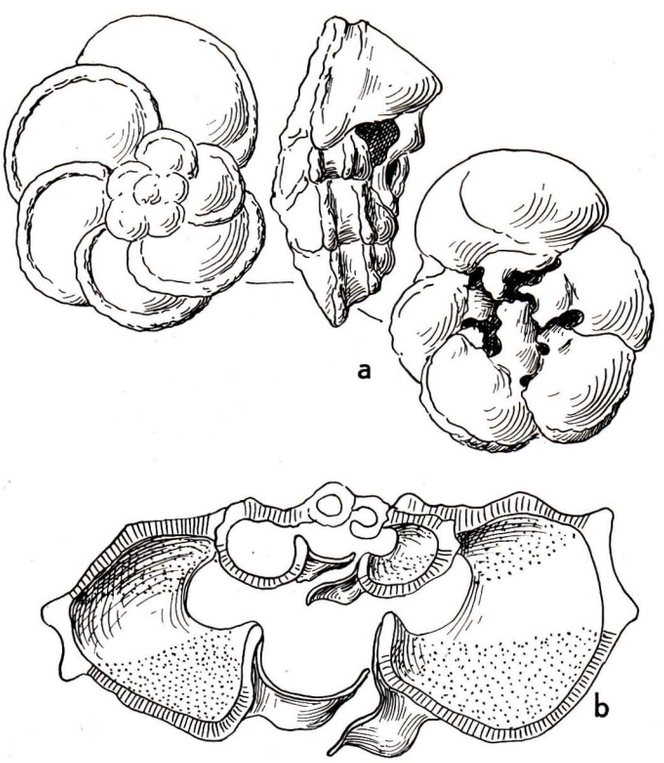

FIGURE 4

Globotruncana linneiformis Hofker. Sample 1126, Folx-les-Caves, Lower Campanian. a, whole specimen from three sides; the ventral side showing the toothplates covering the umbilical hollow, and the apertural face showing the deuteroforamen underneath the toothplate; × 56. b, transverse section with the septal foramina, the poreless rims at the margin at the inner sides of the chamber walls, and the toothplates; × 123.

dense protoplasm attached at the poreless, often roughened, margin. As in the Globotruncanidae, this poreless margin connects with the border of the aperture in *Globorotalia* and the protoplasm streaming from the aperture over the outer surface at the margin, thus, finds at once the poreless surface at the periphery. It is a remarkable fact that so-called *Globorotalia* without a poreless margin (viz: *"Globorotalia" pseudobulloides* in the sense of Bolli *et al.*, *"G." uncinata* Bolli, *"G." opima* Bolli, *"G." obesa* Bolli, etc.) always have test surfaces which have pustules or heavy honeycomb structure between the pores, as do real Tertiary *Globigerina* species. So it is obvious that the gene pattern of such forms must be quite different from that of true *Globorotalia* (viz: *G. pseudomenardii* Bolli, *G. tumida* (Brady), *G. menardii* (d'Orbigny), etc.) having a smooth dorsal surface and a poreless keel at the periphery. Such forms must have a very different floating apparatus. Recent authors seem to lay too much stress on apertural characters; in reality, these apertural characters only show that true Cretaceous *Globigerina* (*Rugoglobigerina*?), true Globotruncanidae, and true *Globorotalia* together with *Valvulineria, Discopulvinulina* and many other groups have similar or identical ancestors. In *Discopulvinulina,* as well as in *Asterigerina,* apertural conditions (distal protoforamen, foramen compositum, proximal protoforamen, external [in *Asterigerina,* later internal] toothplate between them) are identical with those conditions found in the Globotruncanidae and *Globorotalia;* these conditions only prove that all are Foraminifera dentata. We also find these conditions in *"Globorotalia"* without marginal poreless rims but that fact does not mean that these forms are related to true *Globorotalia;* they must belong to quite different genera since rimless *"Globorotalia"* must lead quite a different life to that of true *Globorotalia* with marginal poreless rims or keels. Their whole wall structure is different and is not like that of true *Globorotalia* but like that of Tertiary *Globigerina.*

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FOR FORAMINIFERAL RESEARCH
VOLUME XII, PART 4, OCTOBER, 1961

232. STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION OF LARGER FORAMINIFERA OCCURRING IN A WELL IN COFFEE COUNTY, GEORGIA[1, 2]

W. STORRS COLE
Cornell University, Ithaca, N. Y.
and
ESTHER R. APPLIN
U. S. Geological Survey, Jackson, Mississippi

ABSTRACT

Larger Foraminifera from a well in Coffee County, Georgia, include miogypsinids and other larger Foraminifera characteristic of the American Oligocene **Eulepidina** zone. The geographic, stratigraphic, and faunal associations of miogypsinids in the Gulf Coast of the United States and selected Caribbean localities are reviewed in relation to the faunal sequence in the Georgia well. Species of upper Eocene larger Foraminifera from this well are identical with those found in Florida wells except for **Lepidocyclina pustulosa** which has not been reported from the upper Eocene of Florida.

INTRODUCTION

Although the junior author (Applin, 1960, p. B207) published a preliminary statement on Oligocene sediments in Coffee County, Georgia, it seems desirable to enlarge upon this by expanded discussion of the larger Foraminifera and other fossils.

Major emphasis is given in this article to the geographic and stratigraphic distribution of the miogypsinids, as they are becoming more important in correlation in the Gulf Coastal region and the Caribbean area. Drooger (1952) and Akers and Drooger (1957) have employed a complex species nomenclature for miogypsinids based largely upon statistical analysis. In this article the terminology adopted is that proposed by Cole (1957*a*), as it is believed to be less confusing and seemingly expresses species relationship in a more natural manner.

The Carpenter Oil Co., C. T. Thurman No. 2 well is in Land District 1, Land Lot 189, 450 feet northwest of the center of the SE¼ of Land Lot 189, Coffee County, Georgia. The ground elevation is 299 feet. The total depth of the well is 3550 feet, and the well was completed May 1, 1956.

A detailed log of the Carpenter Oil Co., C. T. Thurman No. 2 well in Coffee County, Georgia, has been published (Applin, 1960, fig. 90.2, p. B208). As this publication is readily available, a graphic log will not be given here.

The specimens studied and illustrated are deposited temporarily in the Cole collection at Cornell University and eventually will be transferred to the U. S. National Museum.

1 Our appreciation and thanks are given to the William F. E. Gurley Foundation for Paleontology of Cornell University for supplying the cost of the printed plates.

2 Publication authorized by the Director, U. S. Geological Survey.

DESCRIPTION OF THURMAN WELL SECTION

Miocene.—The first sample studied, from a depth of 100 feet, is assigned to undifferentiated Miocene. The Miocene sediments contained little fossil material. There were a few badly abraded megafossil fragments and a few specimens of Foraminifera and Ostracoda which may have caved from overlying sediments.

A thin bed of diatomaceous earth in the upper part of this section correlated roughly with similar deposits recognized by the junior author in Miocene sediments in wells in the northern part of Florida.

The basal third of the Miocene section is represented by nonfossiliferous, highly phosphatic sands which characterize the Hawthorne formation of Florida. No evidence of Tampa limestone was found in this well.

Oligocene.—The limestone underlying the Miocene phosphatic sands is light cream colored, finely porous, chalky and irregularly calcitic. Some parts are dolomitic. Fossils are seemingly confined to certain horizons within the limestone. As specimens at well depths lower than the "first statigraphic appearance" may be cavings from fossiliferous horizons above, the only record given for the species will be the depth at which the species was found as the samples were examined in a downward sequence. A listing of these follows:

Depth (feet)	Species
450	*Elphidium leonensis* Applin and Jordan *Miogypsina* (*Miogypsina*) *antillea* (Cushman); *M.* (*M.*) *gunteri* Cole
590	*Streblus mexicanus mecatepecensis* (Nuttall)
660	*Camerina dia* (Cole and Ponton) *Lepidocyclina* (*Eulepidina*) *undosa* Cushman
910	*Dictyoconus floridanus* (Cole) Douglass
940	*Lepidocyclina* (*Eulepidina*) *suwanneensis* Cole; *L.* (*E.*) *yurnagunensis* Cushman

The miogypsinids and the eulepidine lepidocyclinids are significant because they characterize the American Oligocene *Eulepidina* zone. This article is the first to describe in detail the species of this zone in Georgia and to evaluate their stratigraphic significance by comparison with known occurrence and stratigraphic position elsewhere.

Upper Eocene.—Whereas the top of the Eocene in this well is obscured by cavings, the sample at 1050-1060 feet contained abundant worn and fragmentary fossil debris and a small amount of glauconite which may represent that horizon.

At 1070-1080 feet are undoubted upper Eocene larger Foraminifera. They are:

Asterocyclina nassauensis Cole
Camerina floridensis (Heilprin)
Helicostegina polygyralis (Barker)
Lepidocyclina (Pliolepidina) pustulosa H. Douvillé

The first occurrence of *L. (Pliolepidina) ocalana* Cushman was recorded at a depth of 1150-1160 feet.

Below this upper Eocene Ocala limestone section, sands appeared which the junior author correlates by smaller Foraminifera with the Barnwell sand.

STRATIGRAPHIC DISTRIBUTION AND FAUNAL ASSOCIATION OF THE MIOGYPSINIDS

Drooger (1952, p. 21) reported *Miogypsina basraensis* (= *M. (Miogypsina) gunteri*) in a sample from the Kapur Quarry of southern Trinidad and in another sample from this same quarry he found *M. tani* (= *M. (Miogypsina) antillea*). In a sample from the Bohio formation of Barro Colorado Island, Panama Canal Zone, Cole (1957*a*, p. 314) found *M. (M.) antillea and M. (M.) gunteri* in association, and in another sample from the Caimito formation of this island *M. (M.) antillea* and *M. (Miolepidocyclina) panamensis* (Cushman) occurred together. Sachs (1959, p. 401) identified *M. (M.) antillea* and *M. (M.) gunteri* from a sample from the San Sebastián formation of Puerto Rico and in another sample he found *M. (M.) gunteri and M. (Miolepidocyclina) panamensis* in association.

The type locality of *M. (M.) antillea* is the Anguilla formation, Crocus Bay, Anguilla. Woodring (1957, p. 37) correlated the Culebra formation of Panama with the Anguilla formation. The type locality of *M. (Miogypsina) cushmani* Vaughan, a species which Cole (1953, p. 35) considered to be synonymous with *M. (M.) antillea,* is the Culebra formation. Therefore, in Panama *M. (M.) antillea* ranges from the Bohio formation into the Culebra formation.

M. (M.) gunteri was described from a sample at 890-911 feet from the Port St. Joe test well, Gulf County, Florida, from a limestone referred to the Suwannee limestone. In the samples immediately above the one containing *M. (M.) gunteri,* there were specimens which Cole (1938, p. 40) referred to *Heterostegina texana* Gravell and Hanna. Later, he (1953, p. 12) decided that *H. texana* was a synonym of *H. israelskyi* Gravell and Hanna, a species which Sachs (1959, p. 327) combined with *Heterostegina antillea* Cushman.

The part of the Suwannee limestone in which *M. (M.) gunteri* and *H. antillea* occur represents the widespread *Miogypsina-Heterostegina* zone of Gravell and Hanna (1938, p. 989) which extends from southwest Texas into Florida. This zone is included in the subsurface Anahuac formation (Ellisor, 1944, p. 1356) of Texas. Akers and Drooger (1957, p. 658) considered that the Anahuac formation should be assigned to the Aquitanian-Burdigalian stages of the Miocene.

The type locality of *M. (Miolepidocyclina) panamensis,* the other species which is found with *M. (M.) antillea and M. (M.) gunteri,* is in the middle member of the Caimito formation, Gatun Lake Area, Panama Canal Zone (Woodring, 1957, p. 117). Associated species at the type locality are: *Camerina panamensis* (Cushman), *Heterostegina panamensis* Gravell and *Lepidocyclina (Lepidocyclina) pancanalis* Vaughan and Cole (= *L. (L.) canellei* Lemoine and R. Douvillé).

H. M. Bolli at the request of Woodring (1958, p. 27) examined smaller Foraminifera from locality 54*n* on Barro Colorado Island, Panama Canal Zone, and decided that this fauna should be assigned to the planktonic *Globorotalia kugleri* zone of Trinidad (Bolli, 1957, p. 118). Woodring (1957, p. 117) placed this locality in the middle member of the Caimito formation of the Gatun Lake area.

Although larger Foraminifera have not been found at locality 54*n,* they do occur at other localities on Barro Colorado Island in the middle member of the Caimito formation (Cole, 1957*a*, p. 314; Woodring, 1958, p. 24). Thus, *M. (M.) antillea, M. (M.) gunteri and M. (Miolepidocyclina) panamensis* seemingly occur in the *Globorotalia kugleri* zone. Although the evidence is not conclusive, the data available suggest that *M. (Miolepidocyclina) panamensis* is restricted in Panama to the *Globorotalia kugleri* zone of the Caimito formation, whereas *M. (M.) gunteri* occurs in the stratigraphically slightly older beds of the Bohio formation and ranges from the Bohio formation into the Caimito formation.

As *M. (M.) antillea* and *M. (M.) gunteri* occur together in the San Sebastián formation of Puerto Rico and *M. (M.) gunteri* and *M. (Miolepidocyclina) panamensis* were found in association in another, but stratigraphically younger, sample (Sachs, 1959, p. 402), the stratigraphic ranges of *M. (M.) gunteri* and *M. (Miolepidocyclina) panamensis* overlap in Puerto Rico.

Gravell and Hanna (1937, p. 517) reported the following species from the *Heterostegina* zone of the Anahuac formation of Texas: *Operculinoides ellisorae* and *O. howei* [= *Camerina dia* (Cole and Ponton)], *Heterostegina israelskyi* and *H. texana* [= *H. antillea*

Cushman], *Lepidocyclina (Lepidocyclina) colei* [= *L. (L.) giraudi* R. Douvillé] and *L. (L.) texana* [= *L. (L.) asterodisca* Nuttall].

In Panama, *L. (L.) asterodisca* is known to date only from an undifferentiated part of the Caimito formation. *H. antillea* ranges from the Bohio formation into the Caimito formation and *L. (L.) giraudi* extends from the Bohio formation into the La Boca marine member of the Panama formation. *C. dia* has not been reported from Panama.

In Puerto Rico (Sachs, 1959, p. 401), *Camerina dia, Heterostegina antillea, Lepidocyclina asterodisca* and *L. giraudi* occurred in the same sample as did *M. (M.) antillea* and *M. (M.) gunteri.* Moreover, this sample contained *L. (Eulepidina) undosa,* one of the most characteristic species of the *Eulepidina* zone (Cole, 1957*b,* p. 35) of the Oligocene.

The *Eulepidina* zone in Florida extends from the Marianna limestone into the Suwannee limestone (Cole, 1957*b,* p. 40). However, in Florida miogypsinids have not been found in association with *Eulepidina.* They occur in sediments which lie above the top of the *Eulepidina* zone, but below the Tampa limestone, which is not known to contain lepidocyclinids or miogypsinids.

Woodring (1957, p. 37) has written as follows concerning the correlation of the Culebra formation: "According to Vaughan's data, the corals favor correlation with the Anguilla formation of Anguilla, which contains no orbitoids. The mollusks also favor correlation with the Anguilla and other formations of the same age, including the Tampa limestone of Florida, which also contains no orbitoids."

Akers and Drooger (1957, p. 666) suggested that the Tampa limestone should be placed in the "Tortonian or possibly late Helvetian" stages of the middle Miocene. Woodring (1960, p. 31) recently has written "It may be pointed out that the type locality of *Miogypsina cushmani,* shown by Akers and Drooger (1957, fig. 1) as a Helvetian (middle Miocene) species, is in the Culebra formation, which is assigned to the early part of the early Miocene on the basis of its molluscan fauna."

In Panama the major development of the miogypsinids occurred below the Culebra formation, as only two species have been authenticated from the Culebra and the La Boca marine member of the Panama formation. These are *M. (M.) antillea* and *M. (Miolepidocyclina) staufferi* Koch.

Although Drooger (1952) did not mention *M. (Miolepidocyclina) staufferi,* he did identify specimens under other names all of which Cole (1957*a,* p. 323) considered to be synonyms of *M. (M.) staufferi.* This species seemingly is the youngest one of the American miogypsinid series.

M. (Miolepidocyclina) staufferi occurred in the Port St. Joe test well, Gulf County, Florida, (Cole, 1938, p. 19) about 160 feet above the first occurrence of *Heterostegina texana* (= *H. antillea*) and about 190 feet above the first occurrence of *M. (M.) gunteri.* In this well *M. (Miolepidocyclina) staufferi* was associated with *Operculinoides forresti* (= *Camerina dia*).

Later, Cole (1957*b,* p. 32) identified *M. (Miolepidocyclina) staufferi* from a sample from the Morne Diablo quarry in association with *Camerina dia* (Cole and Ponton), *Lepidocyclina (Lepidocyclina) giraudi* R. Douvillé, *L. (L.) mantelli* (Morton) and *L. (L.) waylandvaughani* Cole.

Woodring (1960, p. 29) stated recently "according to a communication from H. G. Kugler, the Morne Diablo limestone, now completely removed for road metal, was a rootless mass of reef limestone immersed in the Lengua and Cruse formations. Marls interbedded with the upper part of the reef limestone, containing a flood of *Lepidocyclina forresti,* yielded Foraminifera of the *Globorotalia fohsi barisanensis* subzone. In central and eastern Trinidad that subzone is found in strata containing late early Miocene and early middle Miocene mollusks. Kugler suggests that the Morne Diablo limestone represented an abbreviated reef facies of considerable time span. The occurrence of *Lepidocyclina forresti* elsewhere in late Oligocene deposits and in the *Globorotalia fohsi barisanensis* subzone indicates that *L. forresti,* a lepidocycline species, has a range of late Oligocene to late early or early middle Miocene and is the youngest species of the genus in the entire Caribbean region."

The specimens for which Woodring used the name *Lepidocyclina forresti* seemingly are the same as those which Cole (1957*b,* p. 38) identified as *L. (L.) mantelli.* The specimens from Morne Diablo quarry studied by Cole were supposedly from the *Globigerinatella insueta* zone (Cole, 1957*b,* p. 32).

Van den Bold (1957, p. 233) wrote concerning the relationship of the Morne Diablo limestone to the Ste. Croix limestone that the ostracodes "suggest that the Ste. Croix limestone is roughly the equivalent of the Tampa/Catahoula or Alum Bluff. The Morne Diablo limestone appears to be slightly older. . ." On a diagram he placed the Ste. Croix and Morne Diablo limestones in the *Globigerinatella insueta* zone.

As the *Globorotalia fohsi barisanensis* subzone immediately overlies the *Globigerinatella insueta* zone, the evidence from planktonic Foraminifera and ostracodes concerning the stratigraphic position of the Morne Diablo limestone is in close agreement.

In Panama the following species are known to occur above the *Globorotalia kugleri* zone: *Miogypsina (Miogypsina) antillea, *M. (Miolepidocyclina) staufferi, Lepidocyclina (Lepidocyclina) canellei, L. (L.) giraudi, *L. (L.) miraflorensis, L. (L.) waylandvaughani* and *L. (Eulepidina) yurnagunensis.* Of the seven species, the two starred are restricted to the Miocene.

The fauna of larger Foraminifera of the Morne Diablo limestone has 6 species, of which 5 occur in Pan-

ama above the *Globorotalia kugleri* zone including the short-ranged species *M. (Miolepidocyclina) staufferi.* The other short-ranged Miocene species of Panama, *L. (L.) miraflorensis,* is not known from the Morne Diablo limestone. However, the Morne Diablo limestone does contain the long-ranged *L. (L.) mantelli,* which to date (1961) has not been reported from Panama.

Table 1 shows the stratigraphic distribution of the larger Foraminifera in the Oligocene and Miocene of the Panama Canal Zone and adjoining areas of Panama, and the stratigraphic distribution of these species in other selected areas.

Of 19 species listed in Table 1, 10 are confined to the Oligocene as defined by Woodring for the Panama Canal Zone and adjacent areas. Two species, *Lepidocyclina (Lepidocyclina) miraflorensis* and *M. (Miolepidocyclina) staufferi,* are restricted to the lower Miocene. The other seven species are abundant in the Oligocene, but occur infrequently in the lower Mio-

TABLE 1. Stratigraphic distribution of some larger Foraminifera in the Oligocene and Miocene

Species	Panama				Florida			Texas	Trinidad
	Bohio formation	Caimito formation	Culebra formation	La Boca member of the Panama formation	Marianna limestone (1, 2)	Suwannee limestone (1)	Suwannee limestone (2)	Anahuac formation of Ellisor, 1944 (2)	Morne Diablo limestone
Oligocene species									
Miogypsina (Miogypsina) gunteri Cole	X								
Heterostegina antillea Cushman	X	X						X	
Lepidocyclina (Eulepidina) undosa Cushman	X	X			X	X	X		
vaughani Cushman	X	X							
Upper Oligocene species									
Camerina panamensis (Cushman)		X							
Heterostegina panamensis Gravell		X							
Lepidocyclina (Lepidocyclina) asterodisca Nuttall		X						X	
(Eulepidina) dartoni Vaughan		X							
tournoueri Lem. and R. Douvillé		X							
Miogypsina (Miolepidocyclina) panamensis Cushman		X							
Oligocene to Miocene species									
Lepidocyclina (Lepidocyclina) canellei Lem. and R. Douvillé	X	X	X						X
giraudi R. Douvillé	X	X		X	X		X	X	X
waylandvaughani Cole	X	X	X						X
(Eulepidina) yurnagunensis Cushman	X	X	X			X			
Miogypsina (Miogypsina) antillea (Cushman)	X	X	X						
Lower Miocene species									
Lepidocyclina (Lepidocyclina) miraflorensis Vaughan			X	X					
Miogypsina (Miolepidocyclina) staufferi Koch			X	X					X
Oligocene and Miocene species not found in Panama									
Camerina dia (Cole and Ponton)					X	X	X	X	X
Lepidocyclina (Lepidocyclina) mantelli (Morton)					X	X			X

(1) Surface; (2) subsurface

cene. The data available suggest that with proper interpretation these larger Foraminifera can be used satisfactorily for correlation and for the recognition of the Oligocene-Miocene boundary in the Americas.

Moreover, this analysis demonstrates that the major development of the miogypsinids occurred in the Oligocene, as four of the five species recognized by Cole (1957*a*) are present in the upper Oligocene. Additionally, *M.* (*Miolepidocyclina*) *staufferi* is a useful species to identify lower Miocene, as Butterlin (1958, p. 595) recently stated. However, *M.* (*M.*) *antillea,* because of its longer stratigraphic range, is most useful where it is associated with other species.

Although Puri and Vernon (1959, p. 93) have correlated the upper part of the Suwannee limestone, which contains the *Miogypsina-Heterostegina* zone in Florida, with the Tampa limestone, the analysis given here indicates that only that part of the subsurface Suwannee limestone which contains *M.* (*Miolepidocyclina*) *staufferi* should be correlated with the basal Tampa limestone (Miocene). The actual *Miogypsina-Heterostegina* zone (= *Miogypsina* subzone of the *Eulepidina* zone), marked in the subsurface of Florida by the occurrence of *Heterostegina antillea* and associated species, must be retained in the Oligocene. If this is done, the Florida subsurface section and that of Panama are in conformity.

Cole (1957*b*, p. 34; 1958*a*, p. 220) outlined a zonation for the American Oligocene and Miocene on the basis of larger Foraminifera as follows:

Lower Miocene - *Lepidocyclina* - *Miogypsina* zone

Oligocene - *Eulepidina* zone
- Upper - *Miogypsina* subzone
- Lower - *Lepidocyclina s. s.* subzone

Data presented in Table 1 support this zonation, except that *L.* (*Eulepidina*) *yurnagunensis,* formerly placed in the subgenus *Lepidocyclina,* is known to occur in the lower Miocene. However, all the other species of *Eulepidina* seemingly are confined to the Oligocene.

It is entirely possible that *L. yurnagunensis* is a zone breaker, or it may be that the occasional specimens encountered in the Miocene of Panama are reworked specimens. However, these infrequent occurrences of this species above the Oligocene do not destroy the essential validity or practical use of the zones and subzones.

MIOGYPSINID ZONES OF THE GULF COASTAL AREA

The miogypsinids in the subsurface sediments of the Gulf Coast area occur in three zones arranged stratigraphically from oldest to youngest as follows: 1. *Miogypsinoides complanatus* zone, 2. *Miogypsina* (*Miogypsina*) *gunteri-M.* (*Miolepidocyclina*) *panamensis-M.* (*M.*) *antillea* zone, and 3. *M.* (*Miolepidocyclina*) *staufferi* zone (Cole, 1957*a*, p. 324). All of these species occur in subsurface samples from Florida except *Miogypsinoides complanatus* which on the Gulf Coast is known only from Louisiana.

M. complanatus occurs in surface samples from Puerto Rico where Galloway and Heminway (1941, p. 288) reported it associated with *Heterostegina antillea, Lepidocyclina* cf. *L. parvula* (= *L.* (*L.*) *giraudi*) and *L.* cf. *L. tournoueri.* In Mexico, *M. complanatus* occurs in surface samples with *Heterostegina antillea* and *L.* (*L.*) *waylandvaughani* (Cole, 1957*a*, p. 319). These associations suggest it belongs in the *Miogypsina* subzone of the *Eulepidina* zone of the Oligocene. In Louisiana, it is reported below the occurrence of the species of *Miogypsina* (*Miogypsina*) (Akers and Drooger, 1957, p. 675).

Although the suggestion has been made (Akers and Drooger, 1957) that the miogypsinid zones of the subsurface of the Gulf Coastal Area extend from Chattian into the Helvetian, the analysis would indicate that these zones are confined to the Chattian and basal Aquitanian. Moreover, the Anahuac formation of the subsurface of Texas which Akers and Drooger (1957, fig. 1) placed in the Aquitanian and Burdigalian should be assigned to the *Miogypsina* subzone of the *Eulepidina* zone of the Oligocene on the basis of larger Foraminifera.

In Florida, the miogypsinids which have been found occur above the occurrence of *Eulepidina* in wells (Cole, 1938, p. 19) and supposedly below the Tampa limestone (Cole, 1938, p. 9; 1941, p. 10; Applin and Applin, 1944, p. 1750). It is apparent, however, that certain of the miogypsinids in the Port St. Joe test well (at 700-721 feet *Miogypsina hawkinsi* and *M. venezuelana* = *M.* (*Miolepidocyclina*) *staufferi*) represent a species which in Trinidad and Panama is restricted to the Miocene. Therefore, this part of the section in the Port St. Joe test well may represent basal Tampa limestone.

However, that part of the section in which *Heterostegina antillea, M.* (*Miogypsina*) *gunteri* and *M.* (*Miolepidocyclina*) *panamensis* occur is definitely Oligocene in the *Miogypsina* subzone of the *Eulepidina* zone as these species are not known elsewhere to extend above the top of the Oligocene.

The faunas of larger Foraminifera from the Gulf Coastal area in the Oligocene contain relatively few species compared with the faunas of the Caribbean region and Panama. Therefore, it is reasonable to ascribe the occurrence of the miogypsinids in the upper Oligocene of Florida without the associated lepidocycline species known to occur with them elsewhere to unfavorable ecological conditions.

COMPARISON OF THE OLIGOCENE SECTION OF THE THURMAN WELL WITH OTHER WELLS

In the Thurman No. 2 well, Coffee County, Georgia, the *M.* (*Miolepidocyclina*) *staufferi* zone is missing.

The first definite Oligocene is indicated at 460-470 feet by the presence of *M. (Miogypsina) gunteri* which is accompanied by the longer-ranging species *M. (M.) antillea. Eulepidina* appears in this well at 660-670 feet or 200 feet below the first appearance of *M. (M.) gunteri.* In the Port St. Joe test well, Gulf County, Florida, *Eulepidina* appeared 127 feet below the first appearance of *M. (M.) gunteri.*

The miogypsinid zone which was encountered at a depth of 450 feet in the Thurman well is correlated with the miogypsinid zone in the Port St. Joe test well (Cole, 1938, p. 19), Gulf County, Florida, which was recognized at a depth of 860 feet with the first appearance of *Heterostegina antillea.* The specimens of *M. (M.) gunteri* first appeared in the Port St. Joe test well at a depth of 890 feet, or 30 feet below the first appearance of *Heterostegina antillea.*

In the Port St. Joe test well, *Lepidocyclina (Eulepidina) undosa* was recovered at a depth of 1017 feet, or approximately 130 feet below the first appearance of *M. (M.) gunteri.*

In two wells in the vicinity of Tallahassee, Leon County, Florida (Cole, 1945), an Oligocene section was penetrated which is similar to the one encountered in the Thurman well below the miogypsinid zone, although that zone was not found in these Florida wells. The depth of first appearance of certain diagnostic species below the miogypsinid zone is shown in Table 2.

TABLE 2. Comparison of the Oligocene section

Species	Depth of first appearance (feet)		
	Thurman well	City of Tallahassee well	Dale Mabry Field well
Streblus mexicanus mecatepecensis (Nuttall)	590	230	139
Camerina dia (Cole and Ponton)	660	280	144
Lepidocyclina (Eulepidina) undosa Cushman	660	280	144
yurnagunensis Cushman	940	.....	212.6
suwanneensis Cole	940	349	218.6
Dictyoconus floridanus (Cole)	910	362	226
Helicostegina polygyralis (Barker)	*1070	*405	*308

* Top of Eocene

The wells in the vicinity of Tallahassee have an Oligocene section approximately 170 feet thick between the first occurrence of *Streblus mexicanus mecatapecensis* and that of *Helicostegina polygyralis* (top of the Eocene). The comparable section in the Thurman well is approximately 480 feet thick.

EOCENE

The first appearance of undoubted Eocene species in the Thurman No. 2 well occurred at 1070-1080 feet. Three species deserve special comment. *Asterocyclina nassauensis* Cole was described from an upper Eocene sample (505-508 feet) from the St. Mary's River Oil Corporation, Hilliard Turpentine Company No. 1 well in Nassau County, Florida (Cole, 1944, p. 33). *Helicostegina polygyralis* was recognized first in the subsurface of Florida in a well drilled in Lafayette Park in Tallahassee, Leon County, Florida (Cole, 1945, p. 19) as *Helicolepidina paucispira.* Recently, it was proven that *Helicolepidina paucispira* is a synonym of *Helicostegina polygyralis* (Cole, 1960*a*, p. 58). The third species is *Lepidocyclina (Pliolepidina) pustulosa,* a characteristic upper Eocene species from Trinidad.

Although the specimens on which the identification of *A. nassauensis* and *H. polygyralis* is based were satisfactory, those used for the identification of *L. (P.) pustulosa* were not. Therefore, this identification might be questioned.

Although *A. nassauensis* has not been authenticated except at its type locality, it is a characteristic and easily recognizable species and readily distinguished from *A. asterisca,* a somewhat similar Ocala species. *H. polygyralis* is widely distributed in the Eocene of the Caribbean region occurring in Trinidad, Mexico and Panama.

The specimens referred to as *L. (Pliolepidina) ocalana* occurred at 1150-1160 feet. Recently, Sachs (written communication) has demonstrated that *L. (Pliolepidina) montgomeriensis* Cole, formerly *L. mortoni* Cushman, is one of the possible thin variants of *L. (P.) ocalana.* The specimens from the Thurman well are of this type.

THE SPECIES

As the species have been described and illustrated adequately in many publications, detailed descriptions are omitted. However, the critical species are illustrated and citations are given to publications which contain illustrations and synonomies.

Family CAMERINIDAE

Genus **Camerina** Bruguière, 1792

For references see: Cole, 1960*b*; 1961.

Camerina dia (Cole and Ponton)

Plate 7, figures 9, 10, 14, 15

1958. *Operculinoides dia* (Cole and Ponton). Cole, Bull. Am. Paleontology, v. 38, no. 173, p. 270, 271, pl. 34, figs. 2-4, 6, 9.

The four specimens illustrated show the variation in individual specimens referred to this species. FIGURES 9, 10, PLATE 7, are the kind formerly referred to *O. antiguensis* Vaughan and Cole or *O. muiri* Barker, whereas those illustrated by FIGURES 14, 15, PLATE 7, would have been identified as *O. vicksburgensis* Vaughan and Cole or *O. bullbrooki* Vaughan and Cole.

Family MIOGYPSINIDAE
Genus **Miogypsina** Sacco, 1893
Subgenus **Miogypsina** Sacco, 1893
Miogypsina (Miogypsina) antillea (Cushman)
Plate 7, figures 1-7

1957. *Miogypsina (Miogypsina) antillea* (Cushman). COLE, Bull. Am. Paleontology, v. 37, no. 163, p. 320, pl. 26, figs. 6, 7; pl. 28, figs. 1-9; pl. 29, figs. 1-9.

FIGURES 1, 2, PLATE 7, should be compared especially with figure 9, plate 28 (Cole, 1957*a*).

Miogypsina (Miogypsina) gunteri Cole
Plate 7, figures 8, 11

1957. *Miogypsina (Miogypsina) gunteri* Cole. COLE, Bull. Am. Paleontology, v. 37, no. 163, p. 321, 322, pl. 26, figs. 1-4, 8, 9; pl. 27, fig. 1.

The embryonic chambers are separated from the apex of the test by the coil of periembryonic chambers, whereas in *M. (M.) antillea* the second embryonic chamber is not separated from the marginal fringe by periembryonic chambers.

Family DISCOCYCLINIDAE
Genus **Asterocyclina** Gümbel, 1870
Asterocyclina nassauensis Cole
Plate 6, figures 1, 10

1944. *Discocyclina (Asterocyclina) nassauensis* COLE, Florida Geol. Survey Bull. 26, p. 79-81, pl. 1, fig. 16; pl. 2, figs. 1, 2, 5, 6; pl. 12, figs. 5, 6; pl. 24, figs. 1-8.

Externally and in equatorial section, this species resembles *Asterocyclina asterisca* (Guppy) of which *A. georgiana* (Cushman) is a synonym. The vertical sections are different as shown by comparison of the vertical sections of the type specimens and of the specimen illustrated with those of specimens referred to *A. asterisca* from Florida (Cole, 1949, fig. 3, pl. 55) and from Trinidad (Cole, 1958*b*, fig. 13, pl. 33).

Family LEPIDOCYCLINIDAE*
Subfamily HELICOLEPIDININAE
Genus **Helicostegina** Barker and Grimsdale, 1936
For references see: Cole, 1960*a*, p. 58.

Helicostegina polygyralis (Barker)
Plate 6, figures 2, 3

1960. *Helicostegina polygyralis* (Barker). COLE, Contr. Cushman Found. Foram. Research, v. 11, pt. 2, p. 59, pl. 10, figs. 2-11; pl. 12, figs. 1-5, 7-10, 12.

* The classification which has been adopted tentatively for the **Treatise of Paleontology** will be used here.

Subfamily LEPIDOCYCLININAE
Genus **Lepidocyclina** Gümbel, 1870
Subgenus **Pliolepidina** H. Douvillé, 1917
Lepidocyclina (Pliolepidina) ocalana Cushman
Plate 6, figures 4, 5

The equatorial section should be compared with the specimen identified as *L. (Lepidocyclina) mortoni* Cushman (Cole, 1944, pl. 16, fig. 10) and the vertical section should be compared with specimens identified as *L. (L.) mortoni* and *L. (L.) ocalana* and its supposed varieties (Cole, 1941).

Cole (1957*b*, p. 31) has stated that ". . . all the variants of *L. ocalana* should be combined under this specific name. To this list should be added *L. georgiana* Cushman which is a synonym of *L. ocalana.*" Sachs (unpublished data) considered *L. (L.) montgomeriensis* Cole (= *L. (L.) mortoni*) to be another synonym, a conclusion with which Cole agrees.

Inasmuch as *L. (P.) ocalana* belongs to the group of *L. (P.) macdonaldi*, a species which Cole (1956, p. 221) placed in the subgenus *Pliolepidina*, it is transferred to this subgenus.

Lepidocyclina (Pliolepidina) pustulosa H. Douvillé
Plate 6, figures 6, 8, 9

1953. *Lepidocyclina (Pliolepidina) pustulosa* H. Douvillé. COLE, U. S. Geol. Survey Prof. Paper 244, p. 17, pl. 13, fig. 21; pl. 14, figs. 12, 13; pl. 15, figs. 17-21.

1960. *Lepidocyclina (Pliolepidina) pustulosa* H. Douvillé. COLE, Micropaleontology, v. 6, no. 2, p. 135, 136, pl. 2, figs. 1-10; pl. 3, figs. 1, 2, 5, 6, 9, 10; pl. 4, figs. 7, 9.

Only three specimens were available for study and more would have been desirable. The vertical section (FIG. 6, PL. 6) should be compared with the specimen from Panama (Cole, 1953, fig. 11, pl. 13).

Subgenus **Eulepidina** H. Douvillé
Lepidocyclina (Eulepidina) suwanneensis Cole
Plate 6, figure 7

1945. *Lepidocyclina (Nephrolepidina) suwanneensis* COLE, Florida Geol. Survey Bull. 28, p. 39-41, pl. 4, figs. 5, 8-10, 12; pl. 7, figs. 1, 14; pl. 11, figs. 6, 7, 11.

This species, known only from two wells in the vicinity of the city of Tallahassee, Leon County, Florida, is characterized by the arched, slit-like lateral chambers which have thick roofs and floors.

Lepidocyclina (Eulepidina) undosa Cushman
Plate 7, figure 12

1945. *Lepidocyclina (Eulepidina) favosa* Cushman. COLE, Florida Geol. Survey Bull. 28, p. 41-43, pl. 4, figs. 3, 4, 7, 11; pl. 8, figs. 1, 2; pl. 9, figs. 1-7; pl. 10, figs. 1-9; pl. 11, fig. 9.

1945. *Lepidocyclina (Eulepidina) undosa* Cushman. COLE, *idem*, p. 43, 44, pl. 1, figs. 14, 15; pl. 2, fig. 8; pl. 8, fig. 7; pl. 11, fig. 8.

The specimen illustrated should be compared with figure 7, plate 8 (Cole, 1945).

Cole (1953, p. 30) has stated concerning *L. (E.) favosa* and *L. (E.) undosa* "It is extremely probable that only one highly variable species is represented, and that *L. gigas* Cushman is the microspheric form of the combined species."

Lepidocyclina (Eulepidina) yurnagunensis Cushman
Plate 7, figure 13

1945. *Lepidocyclina (Lepidocyclina) yurnagunensis* Cushman. Cole, Florida Geol. Survey Bull. 28, p. 31, pl. 6, figs. 5, 6.

1945. *Lepidocyclina (Lepidocyclina) yurnagunensis morganopsis* Vaughan. *idem.*, p. 31, 32, pl. 6, figs. 1-4, 7, 8.

This species assigned previously at various times to the subgenera *Nephrolepidina* and *Lepidocyclina s. s.* has been transferred to the subgenus *Eulepidina* (Cole, 1960*a*, p. 136), and the subgenus *Nephrolepidina* has been suppressed under *Eulepidina* (Cole, 1960*a*, p. 138).

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EXPLANATION OF PLATE 6

Figs. — Page

1, 10. *Asterocyclina nassauensis* Cole 133
1. Vertical section, × 40, at a depth of 1080-1090 feet.
10. Equatorial section, × 40, at a depth of 1080-1090 feet.

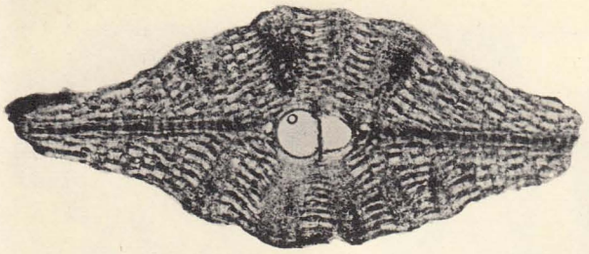
2, 3. *Helicostegina polygyralis* (Barker) 133
2. Equatorial section, × 40, slightly oblique, at a depth of 1070-1080 feet.
3. Vertical section, × 40, at a depth of 1070-1080 feet.

4, 5. *Lepidocyclina (Pliolepidina) ocalana* Cushman 133
4. Vertical section, × 40, at a depth of 1150-1160 feet.
5. Equatorial section, × 20, at a depth of 1150-1160 feet.

6, 8, 9. *Lepidocyclina (Pliolepidina) pustulosa* H. Douvillé 133
6. Vertical section, × 40, at a depth of 1070-1080 feet.
8. Equatorial section, × 40, at a depth of 1070-1080 feet.
9. Equatorial section, × 40, at a depth of 1070-1080 feet.

7. *Lepidocyclina (Eulepidina) suwanneensis* Cole 133
7. Vertical section, × 40, at a depth of 950-960 feet.

All specimens from the Carpenter Oil Company, Thurman well, Coffee County, Georgia



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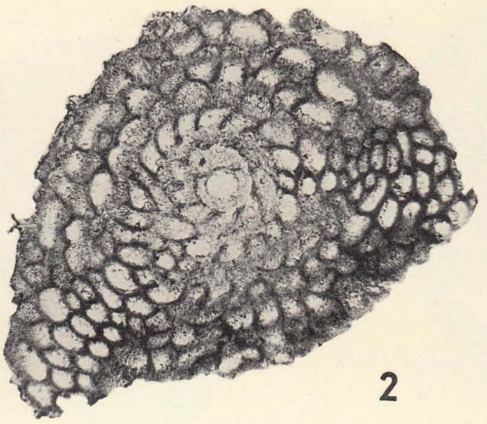

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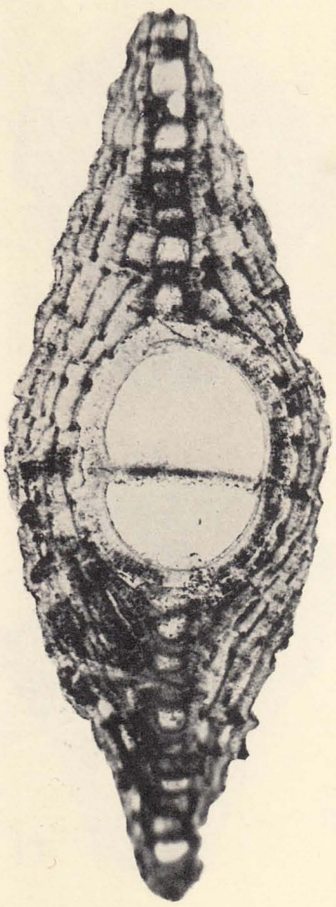

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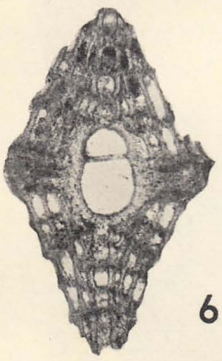

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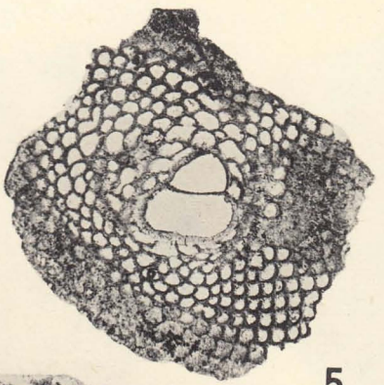

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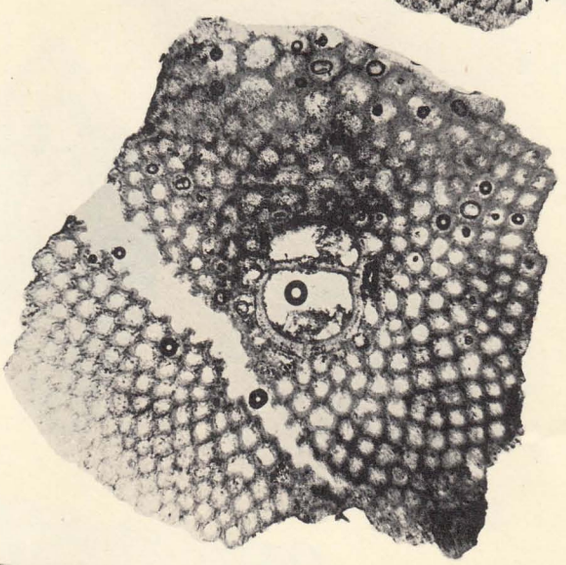

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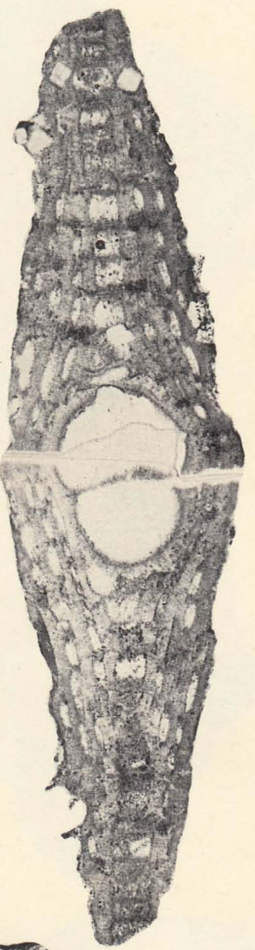

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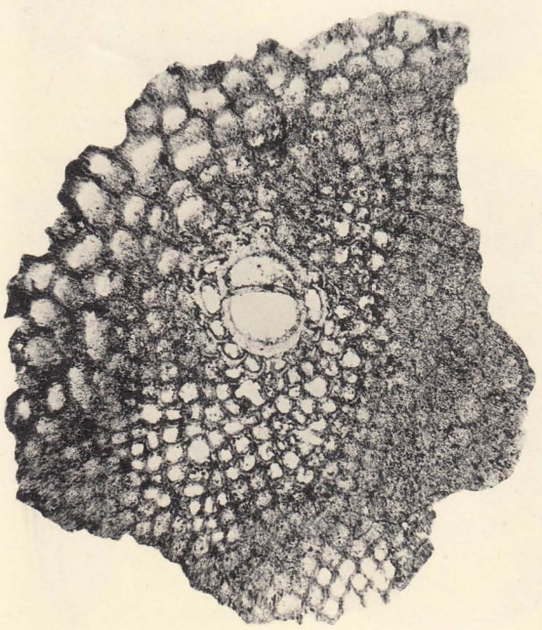

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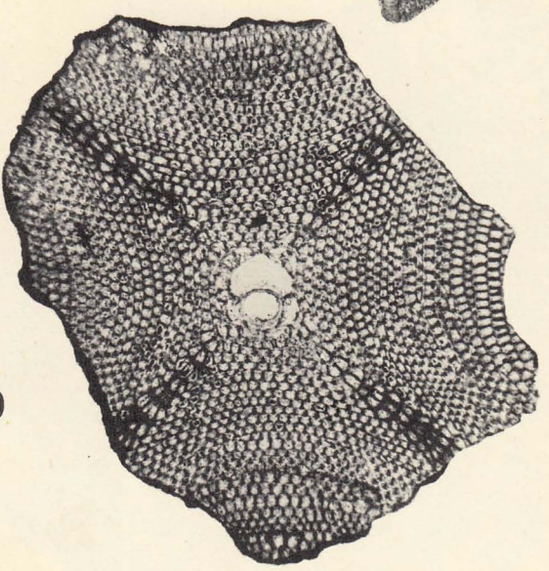

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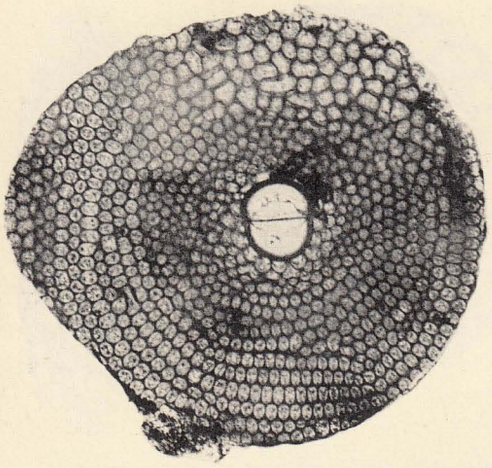
Cole and Applin: Larger Foraminifera, Coffee County, Georgia



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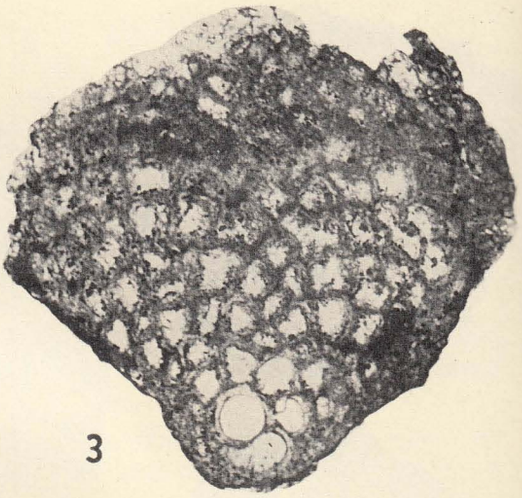

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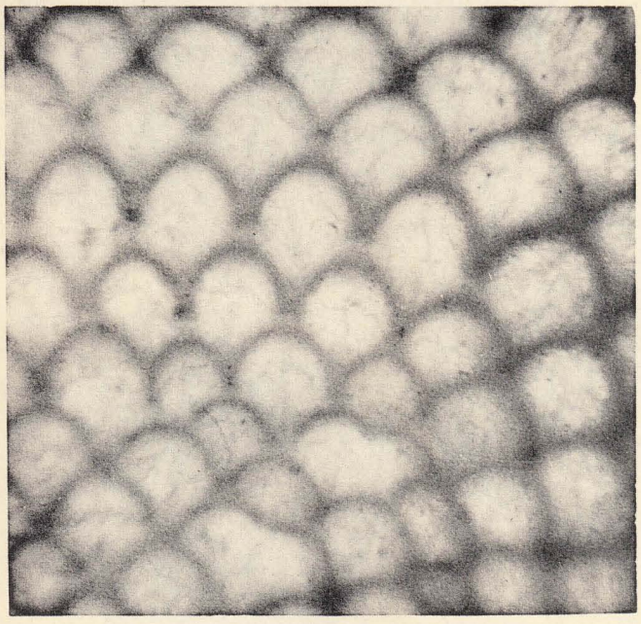

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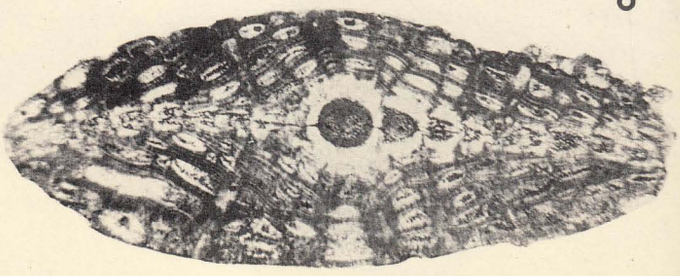

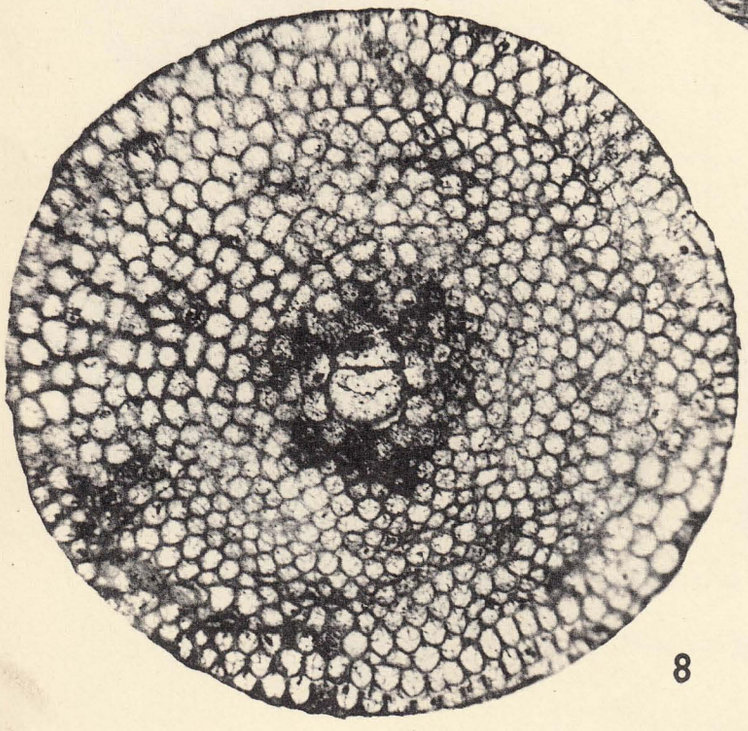

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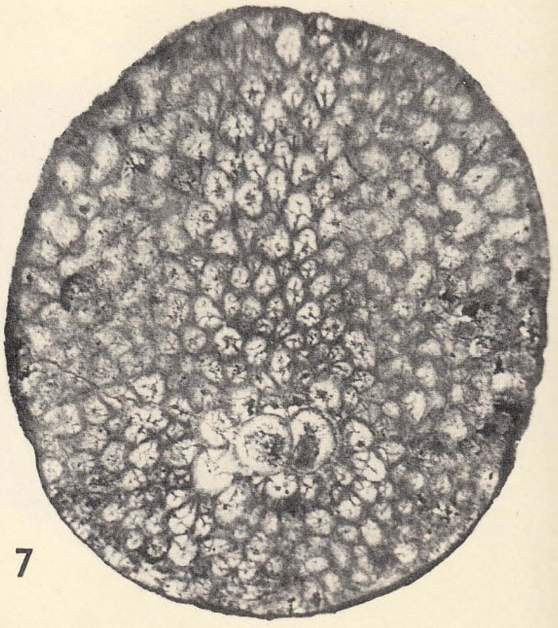

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Cole: Nomenclatural and stratigraphic problems, larger Foraminifera

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EXPLANATION OF PLATE 7

Figs. — Page

1-7. *Miogypsina (Miogypsina) antillea* (Cushman) 133
1, 2, 4-7. Equatorial sections, × 40, at a depth of 460-470 feet.
3. Vertical section, × 40, at a depth of 460-470 feet.

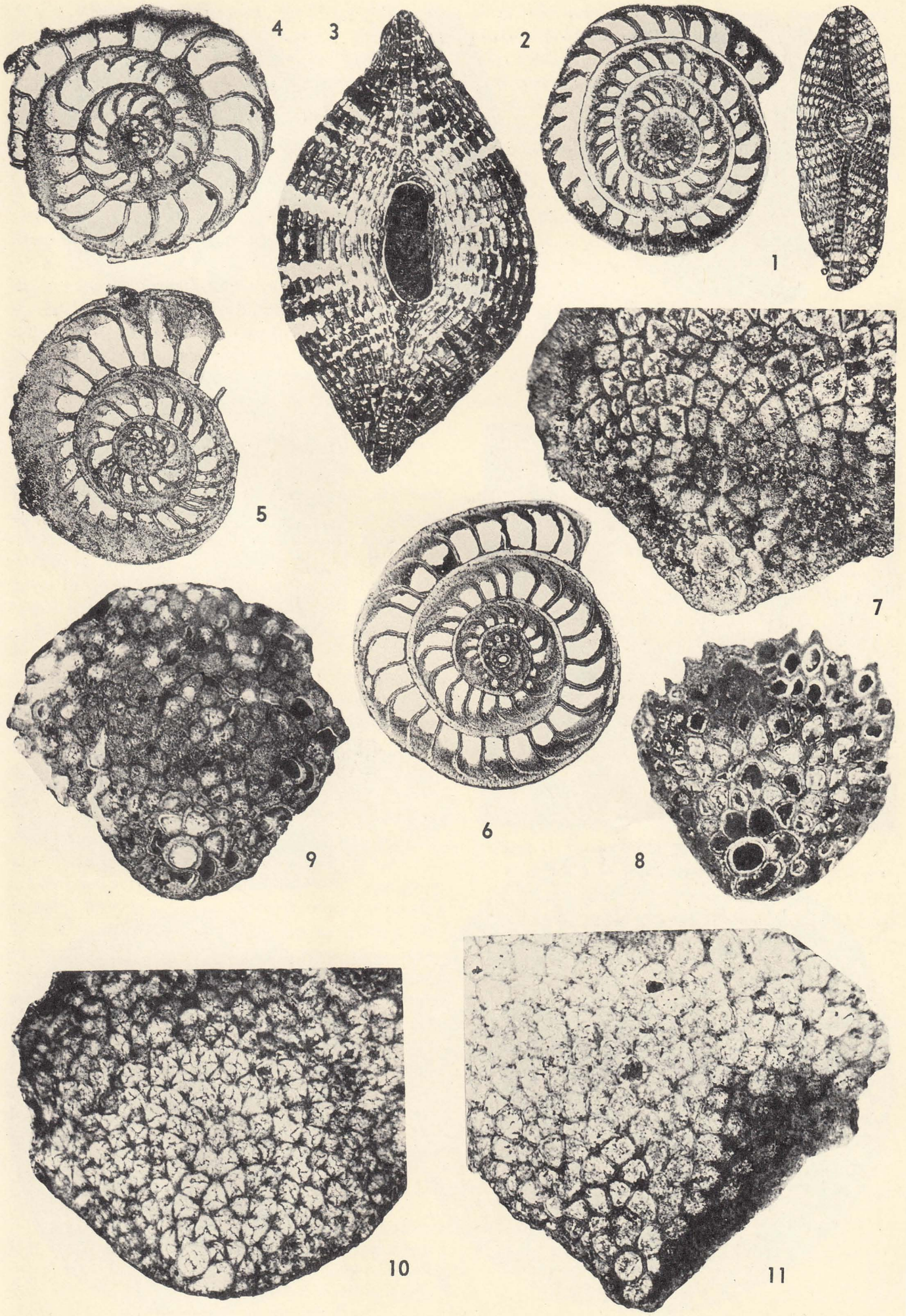
8, 11. *Miogypsina (Miogypsina) gunteri* Cole 133
8, 11. Equatorial sections, × 40, at a depth of 460-470 feet.

9, 10, 14, 15. *Camerina dia* (Cole and Ponton) 132
9. Median section, × 20, at a depth of 660-670 feet.
10. Transverse section, × 20, at a depth of 660-670 feet.
14. Median section, × 20, at a depth of 710-720 feet.
15. Transverse section, × 20, at a depth of 710-720 feet.

12. *Lepidocyclina (Eulepidina) undosa* Cushman) 133
12. Vertical section, × 20, at a depth of 660-670 feet.

13. *Lepidocyclina (Eulepidina) yurnagunensis* Cushman 134
13. Equatorial section, × 40, at a depth of 950-960 feet.

All specimens from the Carpenter Oil Company, Thurman well, Coffee County, Georgia



Cole: Nomenclatural and stratigraphic problems, larger Foraminifera

ranges to genera and subgenera, thereby defeating one of the chief objectives of classification.

Thus, under the scheme proposed by Eames *et al.*, *their Pliolepidina* ranges in the Americas from upper Eocene (*L. pustulosa*) to upper Oligocene (*L. vaughani*), whereas in the Indo-Pacific region *their Pliolepidina* would occur in the Miocene. The names Eocene, Oligocene and Miocene are used here as they are defined in America, and it is not implied that Eames *et al.* (1960) would agree that their *Pliolepidina* occurs either in the American Eocene or Oligocene.

To invoke reworking to explain the associations of larger Foraminifera (Eames *et al.*, 1960, p. 448) over the wide areas of the Caribbean area is obscuring rather than clarifying the associations found. There has been general agreement that all of the associations in which *L. tobleri* (= *L.* (*P.*) *pustulosa*) has been found with one exception are upper Eocene, marked by such distinctive genera as *Asterocyclina, Pseudophragmina,* and *Helicolepidina,* among others.

The only localities in dispute are those near Vamos Vamos, Canal Zone (Woodring, 1957, p. 22) at which all the larger Foraminifera represent an upper Eocene fauna, but the mollusks could be early Oligocene. Woodring (1957, p. 22) has concluded "Pending resolution of the apparently conflicting testimony of the larger Foraminifera and mollusks, a late Eocene or early Oligocene age is assigned to the marine member of the Bohio (?) formation."

If the assumption is correct that ". . . many of the lowest Miocene beds present have been dated as Eocene, purely on the presence of reworked Eocene fossils, but the occurrence of *Pliolepidina* often shows that they are of lowest Neogene age. . . ." (Eames *et al.*, 1960, p. 448), the species with the irregular, multilocular embryonic chambers would be the only indigenous species present at all of the localities from which it is known in the vast Caribbean area.

Localities are known at which only one species is present. Moreover, Cole (1960*b*, p. 134) has stated ". . . if suitable ecological conditions are present, the megalospheric gamonts associate rather than separate." However, at every locality at which specimens with irregular, multilocular embryonic chambers have been found, there are specimens with regular bilocular embryonic chambers. These specimens with the regular bilocular chambers are identical in form and all internal structures, except the embryonic chambers, with those with irregular, multilocular chambers.

If ecological conditions were the only control, and, if all specimens had irregular, multilocular embryonic chambers, it might be possible to make the assumption that these specimens represented one distinct subgenus developed at one stage in the geologic record and that associated specimens were reworked. But, if the thesis is accepted that the specimens with irregular, multilocular embryonic chambers are caused by an association of gamonts, and are but one possible form of a species, the presence or absence of this particular kind of embryonic chamber does not have any stratigraphic significance.

The specimens used in this study are deposited temporarily in the Cole collection at Cornell University and eventually will be transferred to the U. S. National Museum.

LOCALITIES

Trinidad

Loc. 1 - Vista Bella, San Fernando; upper Eocene; H. G. Kugler, collector, May 1932. Kugler (letter dated 19 December 1960) stated: "In May 1932 I collected samples of well preserved orbitoids at Vista Bella, San Fernando. They are typical San Fernando fm. with a rich fauna of upper Eocene echinoids and a few mollusks" (reference: Cole, 1960*b*, p. 133).

2 - K1316 and K1499, Soldado Rock; upper Eocene; H. G. Kugler, collector (reference: Vaughan and Cole, 1941, p. 50).

3 - Steep bank on east (waiting rooms) side of San Fernando Railway Station; upper Eocene; JS 899, John B. Saunders, collector; JS 899 represents the same locality as K R 25684, the type locality of the *Globorotalia cerroazulensis* zone (upper Eocene) in Trinidad (references: Bolli, 1957, p. 160; Cole, 1960*a*, p. 57).

4 - Cipero formation, "Flat Rock tongue," Cipero Coast, type section; Oligocene; Bo 126 - Texaco Cat. No. 221,818, sent by H. Bolli at the request of H. G. Kugler (references: Stainforth, 1948, p. 1298; Bolli, 1957, p. 103).

Panama Canal Zone

Loc. 5 - 123, Río Chilibrillo, 0.6 mile in direct line below bridge on road to Madden Airfield. Medium-grained somewhat calcareous and somewhat tuffa-

EXPLANATION OF PLATE 9

FIGS. PAGE

1, 8. *Lepidocyclina* (*Lepidocyclina*) *canellei* Lem. and R. Douvillé 145
Equatorial sections; 1, × 20; 8, × 40; loc. 6.

2, 5. *Lepidocyclina* (*Eulepidina*) *yurnagunensis* Cushman 145
2. Vertical section, × 20; loc. 6.
5. Equatorial chambers, × 210, from specimen illustrated as FIGURE 3, PLATE 10; loc. 6.

3, 4. *Miogypsina* (*Miogypsina*) *antillea* (Cushman) 145
Equatorial sections, × 40; 3, loc. 7; 4, loc. 6.

6, 7. *Miogypsina* (*Miolepidocyclina*) *staufferi* Koch 145
6. Vertical section, × 40; loc. 6.
7. Equatorial section, × 40; loc. 6.

ceous sandstone, about 1,000 feet above the base of Caimito formation; Oligocene; W. P. Woodring, collector, 1959 (reference: Cole, 1953*b*, p. 7).

6 - USGS no. 6012*c*, west side of Gaillard Cut, south of Empire Bridge; Culebra formation, lower Miocene; T. W. Vaughan and D. F. MacDonald, collectors (reference: Woodring, 1957, p. 122).

7 - USGS no. 6015, old quarry 0.3 mile west-northwest of Empire; Culebra formation, lower Miocene; T. W. Vaughan and D. F. MacDonald, collectors (reference: Woodring, 1957, p. 123).

Costa Rica

Loc. 8 - Below bridge across the Reventazon River between villages of Chitaria and Peralta; fossiliferous conglomerate; Oligocene; Enrique Malvassi V, collector (reference: Drooger, 1952, p. 27).

Cuba

Loc. 9 - Just south of El Jique, about 6 miles above the mouth of Yateras River, altitude about 250 feet, USGS loc. 7552; Oligocene; O. E. Meinzer, collector (reference: Vaughan, 1933, p. 22).

United States

Florida

Loc. 10 - Roof and wall of cave exposed in road-cut on Florida State Road No. 1, about 150 yards east of bridge over Chipola River just east of Marianna; Marianna limestone, Oligocene; W. S. Cole and G. M. Ponton, collectors, 6 July 1929 (reference: Cole and Ponton, 1930, p. 21).

Mississippi

Loc. 11 - Road below National Cemetery, Vicksburg; Byram marl, Oligocene; C. W. Cooke, collector (reference: Vaughan and Cole, 1936, p. 491).

France

Loc. 12 - Le Sauset, Bouches du Rhône; lower Miocene; gift of the late Helen Jeanne Plummer.

Borneo

Loc. 13 - Djaing Langif, Tabalong District, southeast Borneo; gift to T. W. Vaughan by A. Tobler (reference: Douvillé, 1925, p. 111).

14 - Kahajan (report no. 105 - Kah. I, no. 239, 231.4-232.4 m.); specimen is a gift from I. M. van der Vlerk.

Lau, Fiji

Loc. 15 - Basal foraminiferal limestone, near western end of western lake, Oneata; altitude about 15 feet (references: Ladd and Hoffmeister, 1945, p. 189, locality L466; Cole, 1960*b*, p. 134).

LARGER FORAMINIFERA OF THE LOWER MIOCENE, CANAL ZONE

Cushman (1918) identified many species from the Panama Canal Zone, several of which were not correctly identified. *Lepidocyclina panamensis* Cushman (1918, p. 94) was restudied by Vaughan and Cole (1941, p. 66) and placed in the synonomy of *L. (Pliolepidina) tobleri* (= *L. (P.) pustulosa*) (Cole, 1960*b*, p. 135).

This species was reported as occurring at USGS locs. 6586*e*, 6587, and 6512 (Cushman, 1918, p. 95). In addition he reported that ". . . specimens of small orbitoids occur, but they are not sufficiently well preserved for positive identification" at USGS locs. 6010, 6012*a* and 6012*c*. He wrote: "Although those from the latter station seem somewhat like *L. panamensis* in their thin borders and raised center with papillae, they can not be specifically identified with certainty." Finally, he considered that "Specimens doubtfully referable to *L. panamensis* were obtained in the Emperador limestone, at station 6015, Empire."

In the latest review of the paleontology and stratigraphy of the Canal Zone, Woodring (1957) assigned USGS locs. 6012*a* (p. 121), 6012*c* (p. 122) and 6015 (p. 123) to the Culebra formation and USGS loc. 6010 (p. 124) to the La Boca member of the Panama formation.

Through the kindness of W. P. Woodring and R. C. Douglass, a search was made without result of the collections of the U. S. National Museum to ascertain if the specimens doubtfully referred by Cushman to *L. panamensis* at these Culebra localities could be found. However, they sent me parts of the original samples from USGS locs. 6010, 6012*c* and 6015.

Although larger Foraminifera were not found in the samples from USGS loc. 6010, specimens occurred in the other two samples representing the following species:

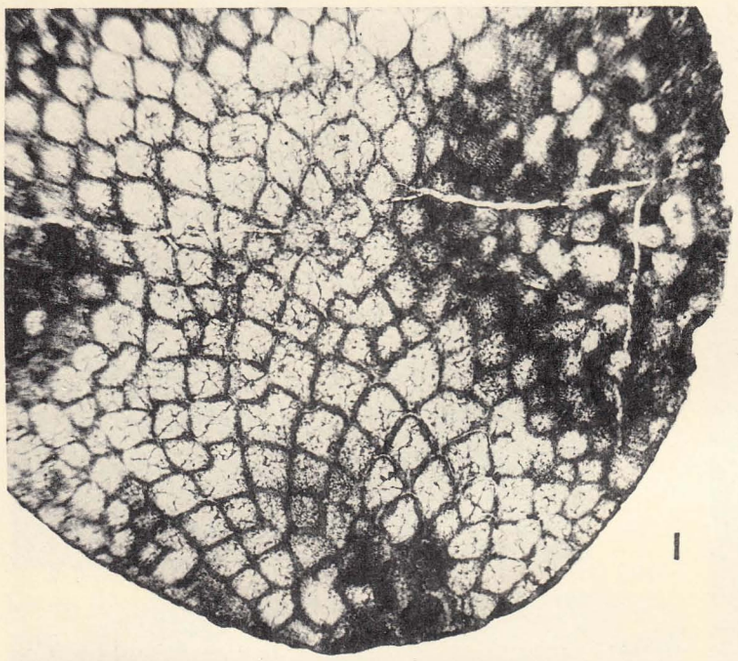
EXPLANATION OF PLATE 10

FIGS. PAGE

1. *Miogypsina (Miogypsina) antillea* (Cushman) 145
   Equatorial section, × 40; loc. 6.
2. *Miogypsina (Miolepidocyclina) staufferi* Koch 145
   Equatorial section, × 40; loc. 7.

3, 4, 6. *Lepidocyclina (Eulepidina) yurnagunensis* Cushman 145
   3, 4. Parts of equatorial sections, × 40; loc. 6.
   6. Equatorial chambers, × 210, from specimen illustrated as FIGURE 4, PLATE 16; loc. 4.

5. *Lepidocyclina (Pliolepidina) pustulosa* H. Douvillé 145
   Equatorial chambers, × 210, from specimen illustrated as FIGURE 3, PLATE 15; loc. 1.



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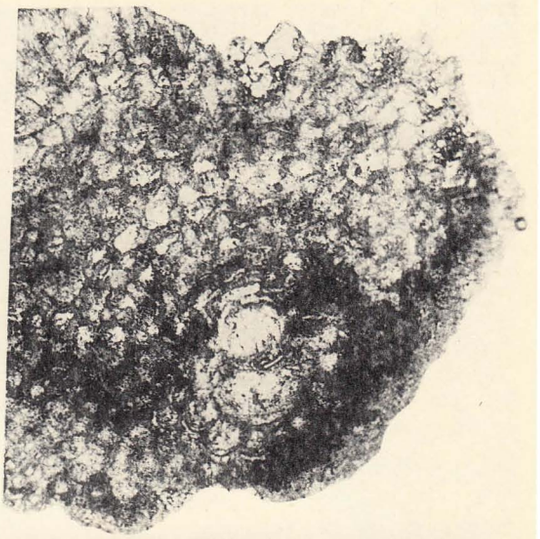

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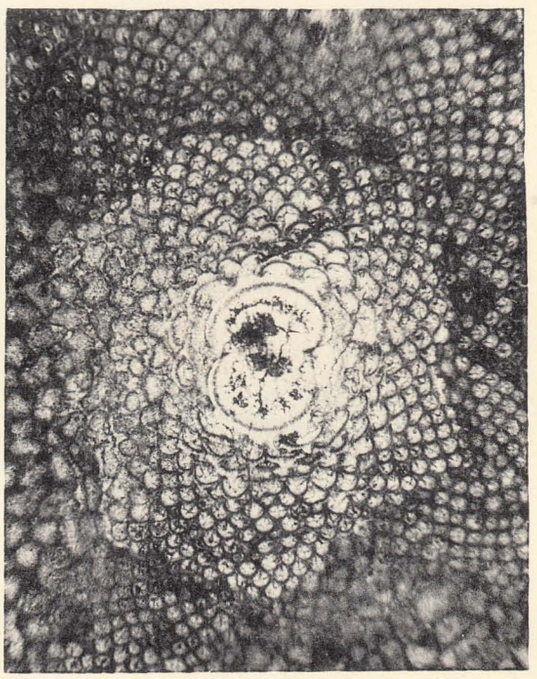

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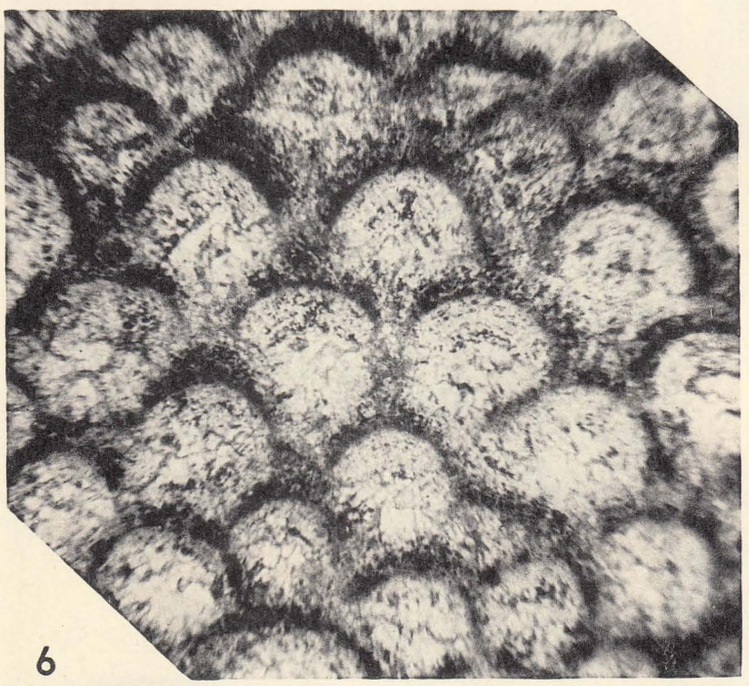

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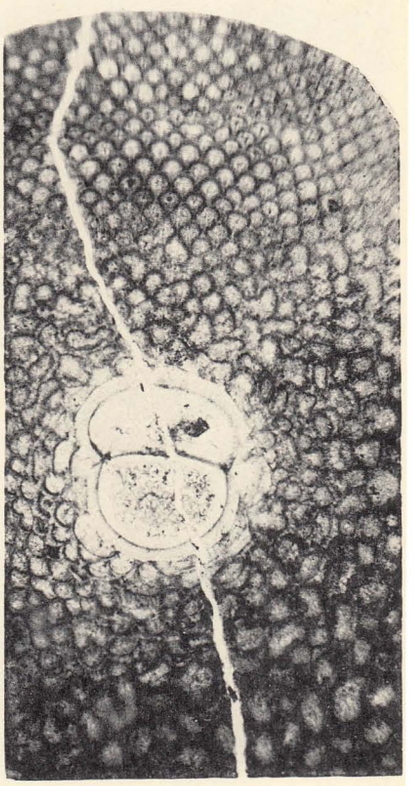

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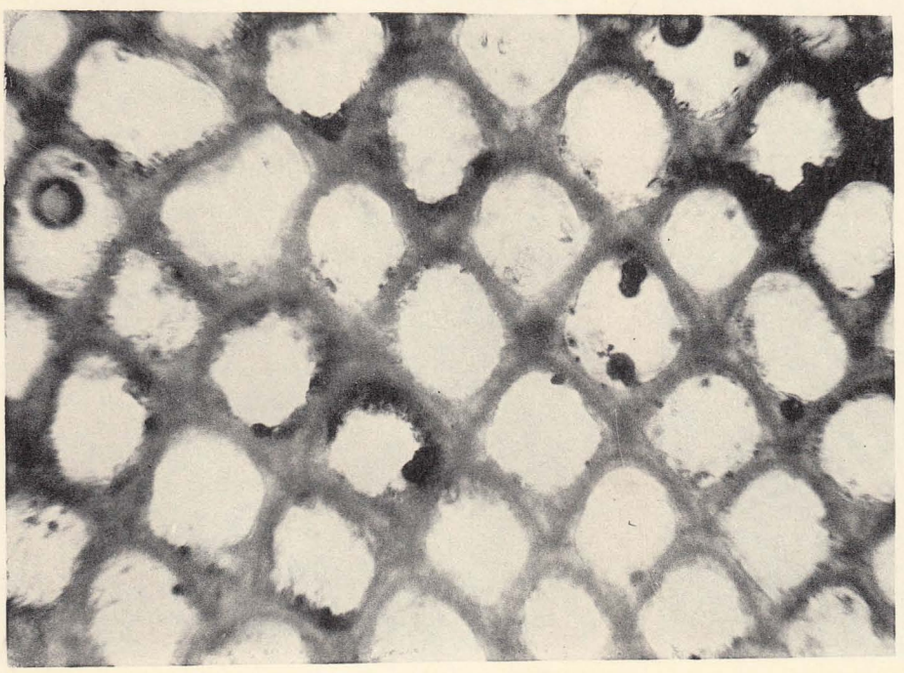
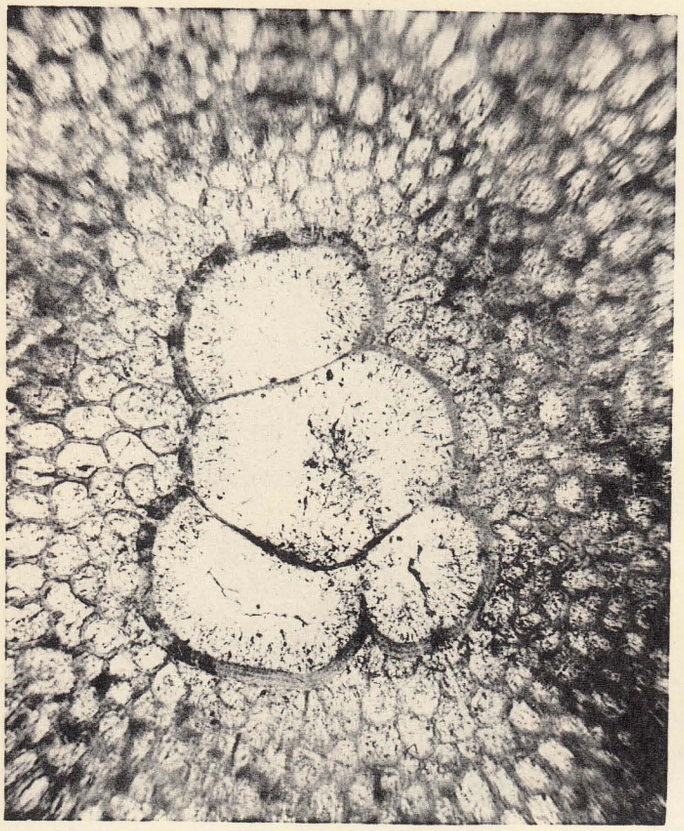


Cole: Nomenclatural and stratigraphic problems, larger Foraminifera



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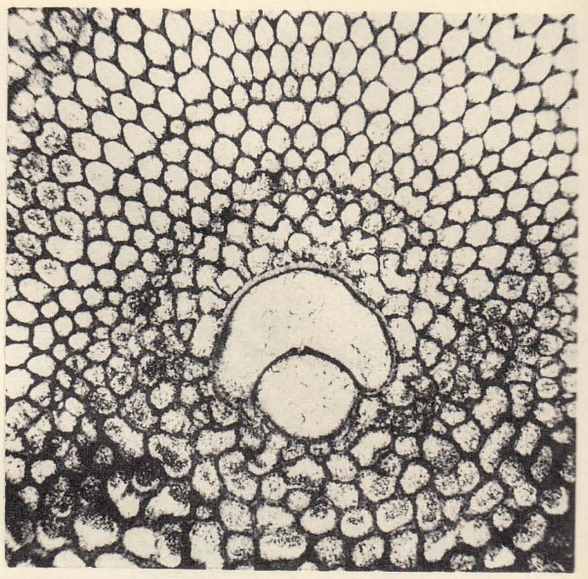

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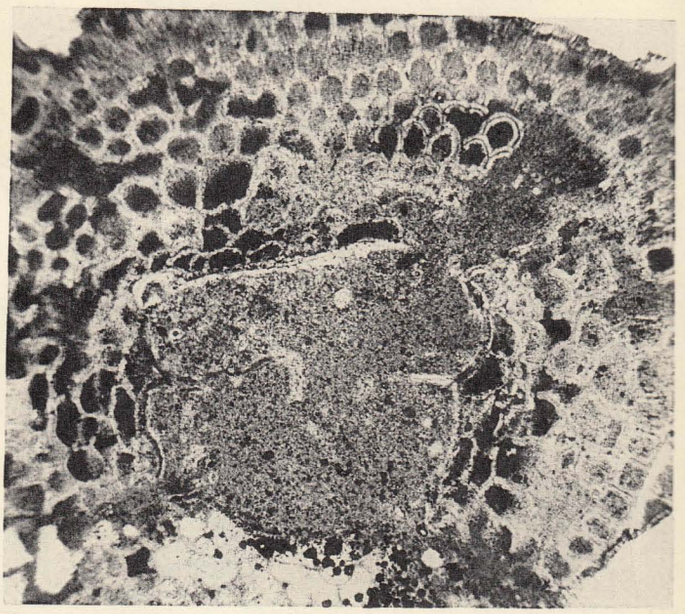

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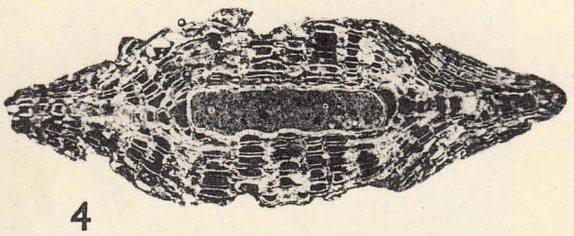
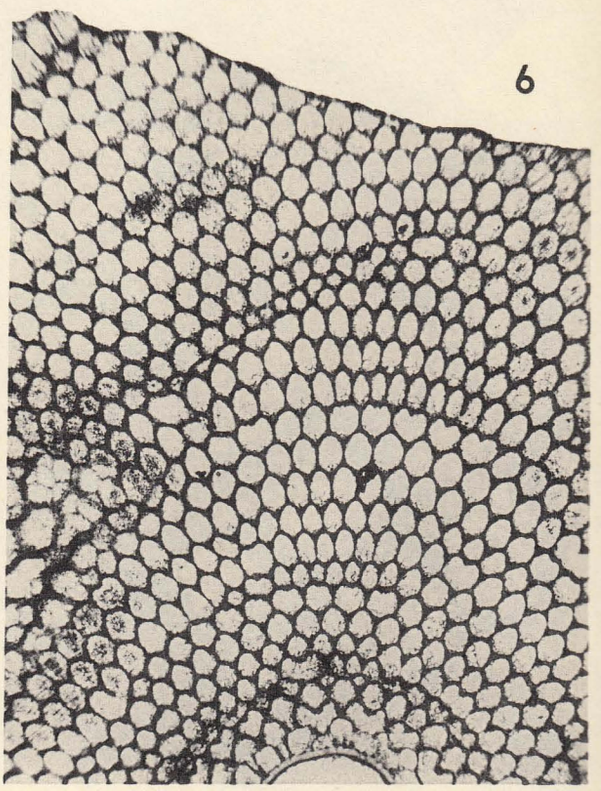


4

5



6

Cole: Nomenclatural and stratigraphic problems, larger Foraminifera

Loc. 6012*c*

Lepidocyclina (*Lepidocyclina*) *canellei* Lem. and R. Douvillé - PL. 8, FIG. 1; PL. 9, FIGS. 1, 8
(*Eulepidina*) *yurnagunensis* Cushman - PL. 9, FIGS. 2, 5; PL. 10, FIGS. 3, 4
Miogypsina (*Miogypsina*) *antillea* (Cushman) - PL. 8, FIG. 10; PL. 9, FIG. 4; PL. 10, FIG. 1
(*Miolepidocyclina*) *staufferi* Koch - PL. 9, FIGS. 6, 7

Loc. 6015

Miogypsina (*Miogypsina*) *antillea* (Cushman) - PL. 8, FIGS. 7, 11; PL. 9, FIG. 3
(*Miolepidocyclina*) *staufferi* Koch - PL. 10, FIG. 2

The type locality of *Miogypsina* (*Miogypsina*) *cushmani* Vaughan (= *M.* (*M.*) *antillea*) is USGS loc. 6012*d*, a locality which is in the Culebra formation (Woodring, 1957, p. 122). At this locality Cole (1957*a*, p. 321) found in addition to *M.* (*M.*) *antillea* a single specimen of *L.* (*E.*) *yurnagunensis*.

Lepidocyclina (*Lepidocyclina*) *miraflorensis* Vaughan was named from specimens obtained from USGS loc. 6255, a locality in the La Boca marine member of the Panama formation (Woodring, 1957, p. 125). In addition, this species (Cole, 1953*a*, p. 332) was found in the Culebra formation at USGS locs. 6019*f* and 6019*g* (Woodring, 1957, p. 121) and in the Emperador limestone at USGS loc. 5866 (Woodring, 1957, p. 123).

Another species found in the Culebra formation is *L.* (*L.*) *waylandvaughani* Cole at USGS loc. 6019*a* (Cole, 1953*a*, p. 336; Woodring, 1957, p. 121). *L.* (*L.*) *parvula* (= *L.* (*L.*) *giraudi* R. Douvillé) was found at USGS loc. 6257 (Cole, 1953*a*, p. 335) in the La Boca member of the Panama formation (Woodring, 1957, p. 124). This specimen from USGS loc. 6257 was associated with specimens which were identified as *M.* (*Miolepidocyclina*) *panamensis* (Cole, 1953*a*, p. 336), but later study has demonstrated they are *M.* (*Miolepidocyclina*) *staufferi*.

The distribution of the species in lower Miocene of the Canal Zone is shown in Table 1.

Although the larger Foraminifera from 13 localities in the lower Miocene of the Canal Zone have been reexamined, it has been impossible to find any specimens of *L.* (*Pliolepidina*) *pustulosa*. Two of the seven species known to occur in the lower Miocene of the Canal Zone, *L.* (*L.*) *miraflorensis* and *M.* (*Miolepidocyclina*) *staufferi*, are not known to occur in stratigraphically older formations either in the Canal Zone or elsewhere. The other five species are ones which have long been recognized as Oligocene species.

Three of the species, *L.* (*L.*) *miraflorensis*, *M.* (*Miogypsina*) *antillea* and *M.* (*Miolepidocyclina*) *staufferi*, occur in some abundance at certain localities, but the other four species are represented by two or three specimens at the best. Moreover, these specimens are often abraided (see: FIG. 1, PL. 8; FIG. 2, PL. 9). Therefore, they may represent, in part, reworked specimens, but this can not be proved with certainty.

MIOGYPSINIDS OF THE LOWER MIOCENE, CANAL ZONE

The genus *Miogypsina* has been known to occur in the Culebra formation of the Canal Zone since Cushman (1918, figs. 1, 2, pl. 43) figured specimens from

TABLE 1

Occurrence of species of larger Foraminifera in the lower Miocene of the Canal Zone

Species	Formations		
	Culebra formation		Panama formation
	Culebra fm.	Emperador ls. mem.	La Boca mem.
L. (*L.*) *canellei* Lem. and R. Douvillé	6012*c*		
waylandvaughani Cole	6019*a*		
(*E.*) *yurnagunensis* Cushman	6012*c*; 6012*d*		
M. (*Miogypsina*) *antillea* (Cushman)	6011; 6012*c*; 6012*d*	6015	
L. (*L.*) *miraflorensis* Vaughan	6019*f*; 6019*g*	5866	6255
M. (*Miolepidocyclina*) *staufferi* Koch	6012*c*	6015	6257
L. (*L.*) *giraudi* R. Douvillé			6257

EXPLANATION OF PLATE 11

FIGS. PAGE

1-6. *Lepidocyclina* (*Eulepidina*) *radiata* (Martin) 145

1. Irregular embryonic chambers, × 40; loc. 15.
2. Regular embryonic chambers, × 40, of a specimen identified by I. M. van der Vlerk as *L.* (*Nephrolepidina*) *borneensis* Provale; loc. 14.
3, 5. Irregular embryonic chambers, × 40, of specimens similar to those identified by H. Douvillé as *Amphilepidina borneensis* Provale; loc. 13.
4. Vertical section, × 20; loc. 13.
6. Equatorial chambers, × 40, of the specimen illustrated as figure 2.

USGS loc. 6011 under the name *Heterosteginoides panamensis*. Later, Vaughan (1924, p. 813) decided that Cushman had combined specimens of two species under the name *Miogypsina panamensis*. He retained the name *M. panamensis* for the species which occurred in the Caimito formation (upper Oligocene) and gave the name *M. cushmani* to the specimens which came from the Culebra formation (lower Miocene).

Although Drooger (1952, p. 38) decided that *M. cushmani* was a valid species, Cole (1957*a*, p. 320) considered that *M. cushmani* was a synonym of *M. antillea*. Moreover, Cole (1953*b*, p. 35) identified *M. antillea* from the Caimito formation. Thus, the stratigraphic range of this species in Panama would be from the Caimito formation (upper Oligocene) into the Culebra formation (lower Miocene).

Drooger (1952, p. 26) named specimens from Costa Rica *M.* (*Miogypsina*) *tani* and identified (Drooger, 1952, p. 36) other specimens from the Canal Zone as *M. intermedia* Drooger. The locality from which Drooger obtained this species (USGS loc. 6505) is assigned to the Culebra formation (Woodring, 1957, p. 122). Cole (1957*a*, p. 320) considered that *M.* (*M.*) *tani* and *M.* (*M.*) *intermedia* were synonyms of *M.* (*M.*) *antillea*.

Through the courtesy of Enrique Malvassi V of the Costa Rican Geological Survey, I received specimens of a *Miogypsina* which seemingly came from the same locality from which Drooger obtained *M.* (*M.*) *tani*. These specimens were associated with *Lepidocyclina* (*Eulepidina*) *undosa* Cushman, and two of these *Miogypsina* are illustrated (FIGS. 8, 9, PL. 8).

If comparisons are made (specifically compare first FIG. 9, PL. 8 with FIG. 3, PL. 9), it will be observed that these specimens, one from Costa Rica and the other from Panama, are identical. If FIGURE 9, PL. 8 is compared with a specimen from the Caimito formation (Cole, 1957*a*, fig. 9, pl. 28), the identity of these specimens will be established.

Other specimens from the Culebra formation identified as *M.* (*Miogypsina*) *antillea* (FIGS. 7, 10, 11, PL. 8; FIGS. 3, 4, PL. 9) are illustrated and should be compared with other illustrations which have been published of *M.* (*M.*) *antillea*.

The other species of *Miogypsina* from the Culebra formation is *M.* (*Miolepidocyclina*) *staufferi* Koch (FIGS. 6, 7, PL. 9; FIG. 2, PL. 10). FIGURE 7, PLATE 9 should be compared with other specimens assigned to this species (Cole, 1957*a*, figs. 1-7, pl. 30).

MULTIPLE EMBRYONIC CHAMBERS IN *LEPIDOCYCLINA*

Illustrations of equatorial sections of *Lepidocyclina* in which multiple or otherwise irregular embryonic chambers occurred were published at least as early as 1909 (Provale, figs. 18, 19, pl. 3). These specimens which Provale named *Lepidocyclina tournoueri borneensis* (= *L.* (*Eulepidina*) *radiata* (Martin)) were associated with other specimens referred by her to this species which had regular nephrolepidine embryonic chambers. These specimens were from the Miocene of Borneo.

Later, Douvillé (1925, p. 109, text fig. 83) figured a specimen from another locality in Borneo which he identified as *Amphilepidina borneensis* which had irregular embryonic chambers. Fortunately, there were specimens from this locality in the collections of the U. S. National Museum sent to T. W. Vaughan by A. Tobler. Thin sections prepared from these specimens are illustrated as FIGURES 3-5, PLATE 11.

The specimen illustrated by FIGURE 5, PLATE 11 is similar to the one figured by Douvillé (1925, p. 109, text fig. 83). The other specimen (FIG. 3, PL. 11) has large, irregular, bilocular embryonic chambers.

Through the courtesy of I. M. van der Vlerk, other specimens which he identified as *L. borneensis* Provale from Borneo were available for comparison. The figured specimen (FIGS. 2, 6, PL. 11) has regular nephrolepidine embryonic chambers. All the specimens, however, have equatorial chambers which are identical and vertical sections which are similar. Therefore, the only difference in internal structure is in the configuration of the embryonic chambers.

Cole (1960*b*) discussed the occurrence of multiple embryonic chambers in *Lepidocyclina* (*Eulepidina*) *radiata* (Martin) from the Miocene of the Indo-Pacific region and in *L.* (*Pliolepidina*) *pustulosa* H. Douvillé from the upper Eocene of the Caribbean area. He explained the development of such embryonic apparati as a normal phenomenon of the reproductive cycle possibly controlled in part by ecological conditions.

In selecting the specimens for that study (Cole, 1960*b*), it was observed that certain localities yielded more specimens of a given species with multiple or otherwise irregular embryonic chambers than did other localities. Moreover, some localities at which the species was found had only specimens with regular embryonic chambers. However, not a single locality was found at which all the specimens had irregular embryonic chambers. When such specimens were found, they were always associated with a considerable number of specimens with regular embryonic chambers.

In 1953(*b*) Cole published a report on the larger Foraminifera of the Panama Canal Zone and vicinity based on extensive collections made by W. P. Woodring. One of the common species in the Caimito formation of upper Oligocene age is *Lepidocyclina vaughani* Cushman. Cole (1953*b*) illustrated a specimen of this species as figure 1, plate 21, describing this equatorial section as "showing an abnormal development of the embryonic chambers." On this same plate he illustrated several other equatorial sections of *L. vaughani* from other localities, all of which show normal nephrolepidine embryonic chambers.

At the time the study was made, 5 specimens from locality 123, the one at which the "abnormal" speci-

men (Cole, 1953*b*, fig. 1, pl. 21) was found, were cut to the equatorial plane. Four of these specimens had normal embryonic chambers and the fifth one with the "abnormal" embryonic chambers was prepared for the illustration cited above.

Inasmuch as one "abnormal" specimen was found at this locality, it seemed reasonable in view of the associations found when the specimens were selected for the discourse on "Variability in embryonic chambers of *Lepidocyclina*" (Cole, 1960*b*) that other specimens with "abnormal" embryonic chambers might be recovered from this same sample. Therefore, 40 additional specimens were ground to the equatorial plane.

Eight of these were of sufficient interest to complete the equatorial section (FIGS. 1-6, PL. 12; FIGS. 1-6, PL. 13). The most interesting specimen (FIG. 4, PL. 12) has nearly normal embryonic chambers (lower right side) adjacent to which are a complex set of embryonic chambers. This illustration should be compared with one of those of *L. (Eulepidina) radiata* (Cole, 1960*b*, fig. 1, pl. 1) and with those of *L. (Pliolepidina) pustulosa* (Cole, 1960*b*, figs. 5, 7, pl. 2). The same phenomenon is shown by all of these specimens.

FIGURE 2, PLATE 12 represents a specimen with normal nephrolepidine embryonic chambers which are well within the range of variation previously recognized in *L. vaughani* (see: Cole, 1953*b*, figs. 2-4, 13, 14, pl. 21). FIGURE 5, PLATE 12 illustrates a specimen with embryonic chambers of the kind variously termed eulepidine or trybliolepidine. FIGURE 1, PLATE 12 shows a specimen in which the second chamber barely embraces the initial chamber. FIGURES 1, 3, 4, PLATE 13 are specimens in which the embryonic chambers are divided into three large chambers.

It should be emphasized that the sample from locality 123 (loc. 5) contained only one species of larger Foraminifera, namely *L. vaughani*, although the sample was large and completely analyzed.

If the sequence of illustrations of *L. vaughani* given here and those published previously are compared with those of *L. (Eulepidina) radiata* (Cole, 1960*b*), it will be observed that the degree of variability of the embryonic chambers is the same in both species. These two species have individual specimens which have nephrolepidine embryonic chambers, other specimens have eulepidine or trybliolepidine and still other specimens have multiple or otherwise irregular embryonic chambers.

A sufficient number of specimens of three distinct species have been analyzed to prove without doubt that the embryonic chambers of these species at certain localities are extremely variable, whereas at other localities the embryonic chambers of these same species are normal. In each of these three species, certain individuals have multiple embryonic chambers which are similar, and, therefore, can not in themselves be used to assign the specimen to a subgenus. However, in every case a sufficient number of specimens with regular embryonic chambers have been found with those with irregular embryonic chambers so that subgeneric assignments can be made.

Moreover, it should be emphasized that this irregularity of development of the embryonic chambers is established so firmly in species of wide geographic and stratigraphic separation that it can be explained only as a circumstance of the reproductive activity of the species. This irregularity may develop in any species regardless of the subgenus to which the species belongs. Thus, multiple or otherwise irregular embryonic chambers do not have any significance in the classification. Cole (1960*b*, p. 138) wrote: "Therefore, once series have been demonstrated, they will be useful in grouping species into subgenera." However, specimens with irregular embryonic chambers can not be assigned to a subgenus until associated specimens with normal embryonic chambers have been found and studied.

Several subgeneric names, such as *Cyclolepidina* and *Multilepidina*, have been proposed for specimens with irregular embryonic chambers, and others (Brönnimann, 1946, p. 373; Grimsdale and Van der Vlerk, 1959, p. 4) have insisted that the emended definition of *Pliolepidina* by Vaughan and Cole (1941, p. 64) to include specimens of a series with normal to irregular embryonic chambers is not correct. It should be clear that to use nomenclatural devices which separate specimens with regular embryonic chambers from those with irregular embryonic chambers obscures rather than clarifies the natural relationship which may occur in a species. Specimens of the same species would be assigned to two or more subgenera depending on the configuration of the embryonic chambers, if the series concept is not recognized and used.

An additional illustration (FIG. 1, PL. 11) of irregular embryonic chambers of *L. (Eulepidina) radiata* (Martin) is given for comparison with similar chambers of *L. (Eulepidina) vaughani* (especially FIG. 1, PL. 13).

Numerous illustrations (Cole, 1960*b*) have been published to show the irregular embryonic chambers of *L. (Pliolepidina) pustulosa*, but to emphasize the irregularities which occur several more illustrations (PL. 14; FIGS. 1-4, PL. 15) are presented. FIGURES 1, 4, PLATE 14 should be compared with figure 5, plate 1 (Cole, 1960*b*). All three of these illustrations show that several gamonts are responsible for the production of the irregular embryonic chambers.

FIGURE 2, PLATE 14 is a section which was not cut completely to the equatorial plane, therefore only the top of the irregular embryonic chamber is shown. If this section had been completed, the embryonic chambers would resemble those shown in such specimens as FIGURE 1, PLATE 15. In the upper left corner (FIG. 2, PL. 14) bilocular chambers show which are similar to those illustrated previously (Cole, 1960*b*, fig. 5, pl. 2). These bilocular chambers are regularly pliolepidine in shape and represent the initial development of one

gamont of the sequence which was responsible for the development of the irregular, multilocular embryonic chamber.

SUBGENERA OF *LEPIDOCYCLINA*

The traditional subdivision of the genus *Lepidocyclina* into subgenera has been based mainly on the shape and arrangement of the embryonic chambers. Various other structures, such as the number and arrangement of the periembryonic chambers or the position of the stolon systems, have been suggested as characteristics which might be used for the determination of subgenera. However, difficulties have been encountered in the use of all of these structures to define subgenera.

Although these difficulties have been recognized for many years, definite stratigraphic ranges have been assigned to the subgenera. Van der Vlerk (1955, p. 73) and Cole (1960*d*, p. 12) used the subgenera *Nephrolepidina* and *Eulepidina* among other genera and subgenera to define certain zones in the Indo-Pacific region. *Eulepidina* was assumed to be present in this area in Tertiary *d* (Oligocene), whereas *Nephrolepidina* was supposed to appear first in Tertiary *e* (Miocene). However, Vaughan (1933, p. 8) had written concerning certain American species: "In *L. undosa*, the chambers may be nephrolepidine or eulepidine." Many other illustrations could be cited to demonstrate that workers were evaluating the subgenera precisely in certain instances, but in other situations were questioning the definitions of the subgenera by implying intergradation.

If subgenera are to be used in classification and if the stratigraphic ranges of these subgenera are to be defined precisely, there must be agreement on the structures by which the subgenera can be recognized. A subgenus based on the shape and arrangement of the embryonic chambers will not have any value if it can be demonstrated that in an interbreeding population certain individuals of a given species have nephrolepidine embryonic chambers whereas other individuals of the same species have eulepidine embryonic chambers, or that some other intergradation occurs.

The subgenera, *Polylepidina* Vaughan 1924, *Pliolepidina* H. Douvillé 1917, *Lepidocyclina s. s.* Gümbel 1870, *Nephrolepidina* H. Douvillé 1911 and *Eulepidina* H. Douvillé 1911, have been the commonly accepted ones although many other subgeneric names have been proposed. Recently, Cole (1960*b*, p. 138) wrote: "Inasmuch as *Nephrolepidina, Eulepidina, Trybliolepidina* and *Multilepidina* have been subgeneric names applied to individuals within one species, and, also constitute one series, they all refer to one distinct type. Tentatively, it is suggested that the subgeneric name *Eulepidina* be applied to this series."

The illustrations of *L. vaughani* show within a species the variation which occurs in the embryonic chambers. The specimens shown as FIGURE 2, PLATE 12, and FIGURE 2, PLATE 13 of this article and those illustrated as figures 2-4, 13, 14, plate 21 (Cole, 1953*b*) have nephrolepidine embryonic chambers. However, the specimens illustrated as FIGURES 5, 6, PLATE 12 have eulepidine embryonic chambers and the specimen shown as FIGURE 4, PLATE 12 has multilepidine embryonic chambers.

The same variations of embryonic chambers shown by the American Oligocene species, *L. vaughani*, which has been classified until now in the subgenus *Nephrolepidina*, have been demonstrated to occur (Cole, 1960*b*, p. 136) in the Indo-Pacific Miocene species *L. radiata*.

Although the irregular embryonic chambers of the multilepidine kind are known to occur so far in only three species, numerous species are known to possess embryonic chambers which vary from nephrolepidine to eulepidine. Therefore, these two subgenera must be combined.

However, the shape and arrangement of the embryonic chambers is a useful characteristic to assist in defining subgenera provided proper interpretations are made. Moreover, it has become increasingly apparent that other structures must be considered in the definitions of the subgenera. If the subgenera can be defined so that they are readily recognizable, it will be possible to use them for stratigraphic purposes with some certainty.

If the subdivision into subgenera is to be maintained, the definition of each subgenus should be based upon structures which can be observed without difficulty and which show even in poorly preserved specimens. The shape and arrangement of the embryonic chambers, the number and arrangement of the periembryonic chambers and the shape and arrangement of the equatorial chambers are normally the best and most easily observed structures of the equatorial plane. Stolons have the disadvantage that they are often not readily observed. Although vertical sections are useful particularly in specific determinations, they are not satisfactory for generic and subgeneric differentiation.

The following key is proposed for the four subgenera which seemingly can be distinguished. The key is based insofar as the embryonic chambers are concerned on the regular embryonic chambers. Specimens with

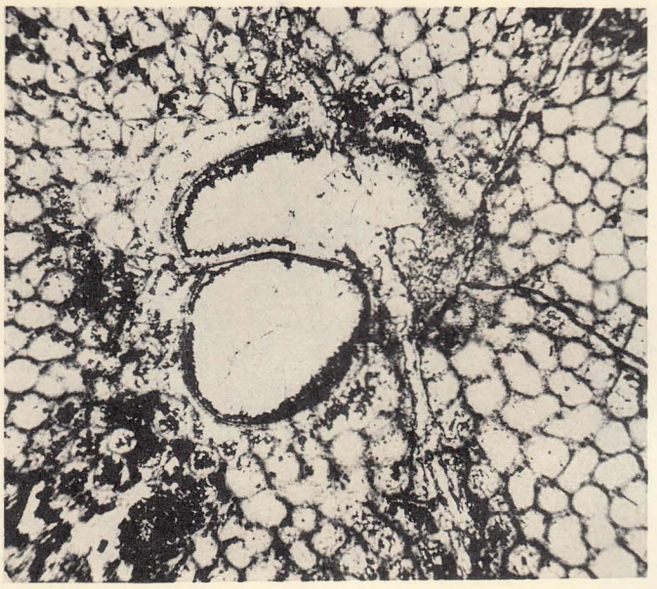
EXPLANATION OF PLATE 12

FIGS. PAGE

1-6. *Lepidocyclina (Eulepidina) vaughani* Cushman 145

1, 2, 4-6. Parts of equatorial sections, × 40, to show the variable shape of the embryonic chambers; loc. 5.

3. Vertical section, × 20; loc. 5.



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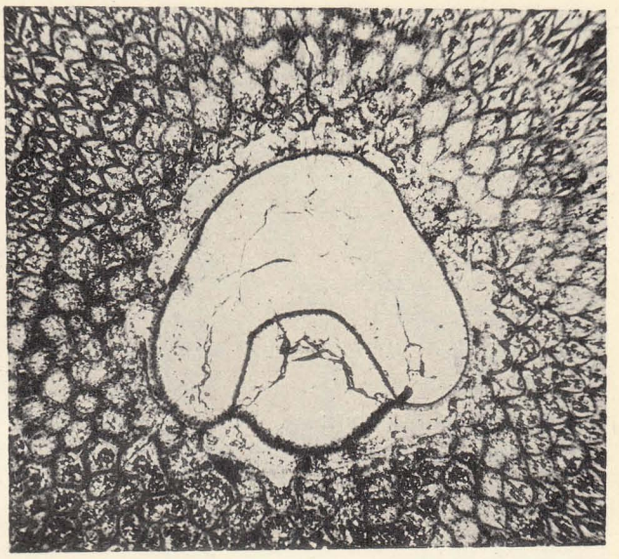

2

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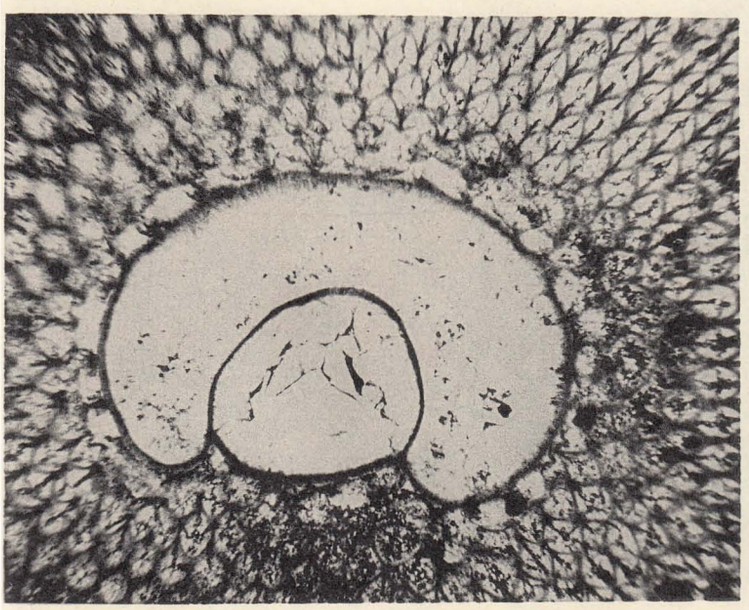

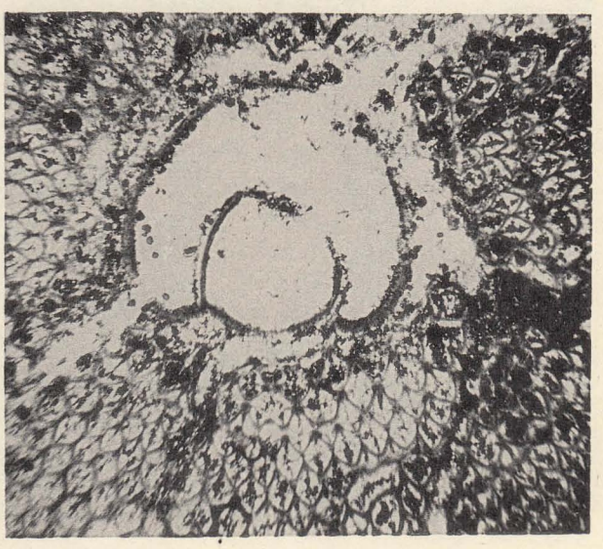

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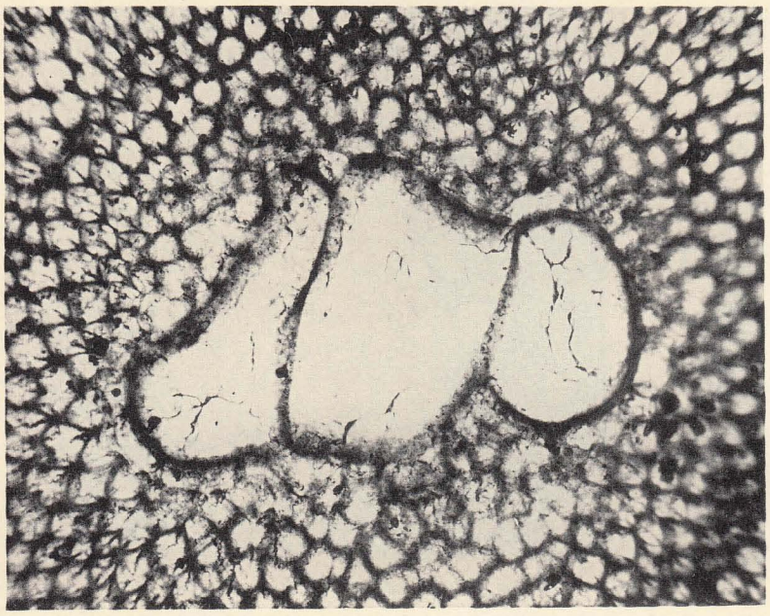

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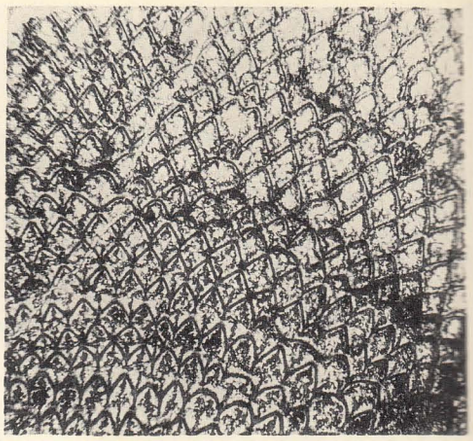
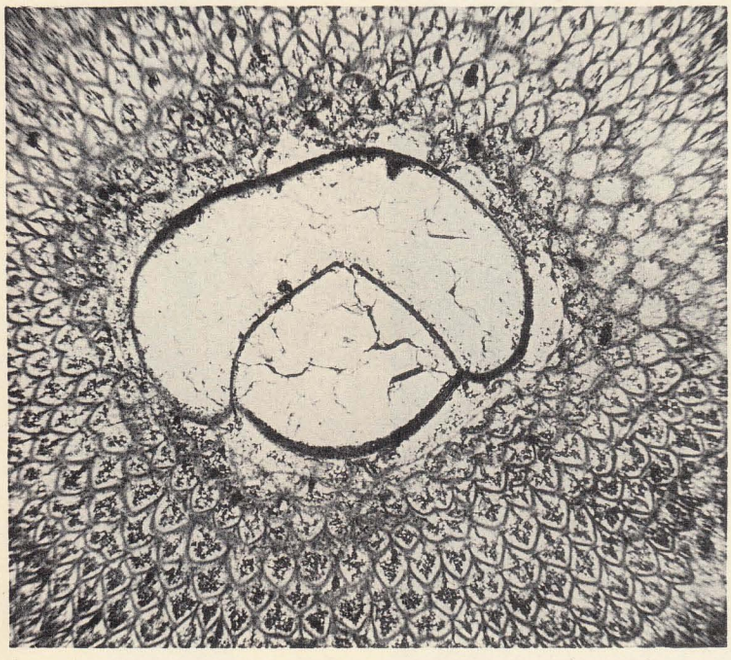
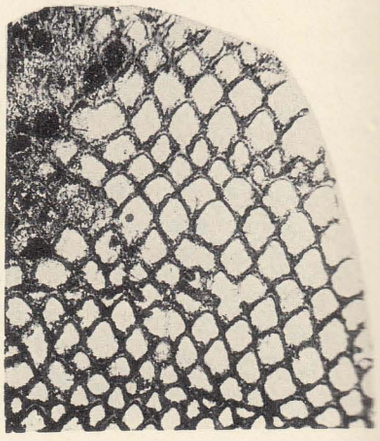


6



2



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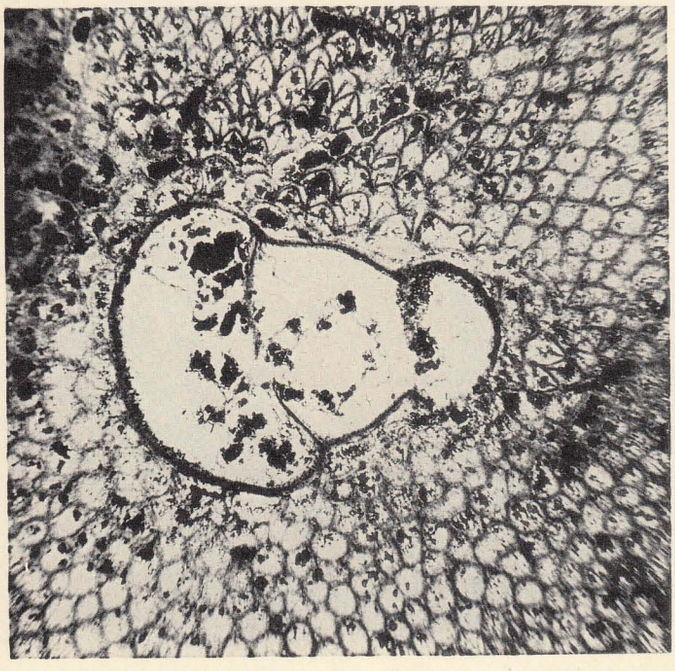

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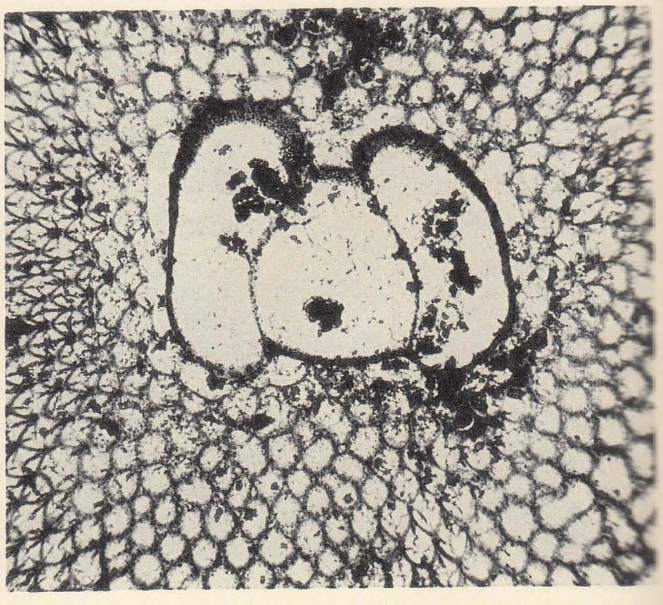

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irregular embryonic chambers must be identified by comparison with associated specimens which have regular embryonic chambers. Moreover, it is desirable to have available several equatorial sections in order to observe the variation which occurs in the species.

Key to the subgenera of *Lepidocyclina*

A. Initial embryonic chamber not embraced, even slightly, by the second embryonic chamber (see: Cole, 1960*a*, figs. 1, 3, pl. 12)

1. Initial embryonic chamber distinctly larger than the second embryonic chamber (see: Cole, 1960*b*, figs. 1, 3, 4, 6, 9, pl. 2)

a. Periembryonic chambers large (see: Cole, 1945, fig. 6, pl. 17)

1′. Periembryonic chambers forming at least one distinct spiral of decreasing size chambers which partially surround the embryonic chambers (see: Cole, 1960*a*, figs. 1, 3, 6, pl. 12)

a′. Equatorial chambers arcuate with the tangential diameters longer than the radial diameters (see: Cole, 1960*a*, figs. 1, 3, 6, pl. 12) — *Polylepidina.*

2′. Periembryonic chambers not forming a distinct spiral (see: Cole, 1960*b*, figs. 1, 3, 4, 6, 9, pl. 2)

a′. Equatorial chambers at the periphery arcuate, ogival or short spatulate (see: Cole, 1960*b*, figs. 3, 4, pl. 3) — *Pliolepidina.*

2. Initial embryonic chamber the same size, larger, or smaller than the second embryonic chamber (see: Cole, 1957*b*, fig. 7, pl. 4; figs. 4, 5, pl. 5)

a. Common wall between the embryonic chambers usually straight, not distinctly curved (see: Cole, 1953*b*, figs. 15-22, pl. 16)

1′. Equatorial chambers at periphery hexagonal (see: Cole, 1953*b*, figs. 15-22, pl. 16) — *Lepidocyclina s. s.*

b. Common wall between the embryonic chambers usually curved (see: FIGS. 1-6, PL. 16)

1′. Equatorial chambers at periphery rhombic or ogival (see: FIGS. 5, 6, PL. 13) — *Eulepidina.*

B. Initial chamber slightly or nearly completely embraced by the second chamber (see: FIGS. 2, 5, 6, PL. 12; FIG. 2, PL. 13; FIGS. 1, 3, 6, PL. 16)

1. Periembryonic chambers large or small, but never in a distinct spiral (see: FIG. 2, PL. 12; FIGS. 1, 4, PL. 16)

a. Common wall between the embryonic chambers curved even if only slightly (see: FIGS. 2-6, PL. 16)

1′. Equatorial chambers at periphery rhombic, ogival, spatulate, short or elongate hexagonal (see: Cole, 1960*b*, figs. 2, 3, pl. 4) — *Eulepidina.*

Although most species can be assigned without difficulty to the proper subgenus by the use of this key, there are a few species which are not so easily placed. Equatorial sections of *L. yurnagunensis* are illustrated by FIGURES 3, 4, PLATE 10 and by FIGURES 2-6, PLATE 16. Vaughan (1933, p. 8) wrote concerning this species: "The type of embryonic chambers is not absolutely fixed. In some species, such as *L. yurnagunensis,* the chambers may be those of *Lepidocyclina s. s.* or they may verge toward *Nephrolepidina.*" He (Vaughan, 1933, p. 21) assigned this species to the subgenus *Lepidocyclina s. s.*

Cole (1934, p. 24; 1953*b*, p. 22) followed this subgeneric assignment of *L. yurnagunensis* until recently (Cole, 1960*b*, p. 136) when he transferred this species to the subgenus *Eulepidina.* Thus, seemingly, at first it might be assumed that *Lepidocyclina s. s.* intergrades with *Eulepidina,* therefore these two subgenera should be combined as has been suggested for *Nephrolepidina* and *Eulepidina.*

FIGURE 1, PLATE 16 is an illustration of a European specimen showing typical eulepidine kind of embryonic chambers. The embryonic apparatus (embryonic and periembryonic chambers) is similar to those of *L. yurnagunensis* (FIGS. 2-6, PL. 16) except that the second embryonic chamber is larger and overlaps the initial chamber to a greater degree.

In three of the specimens of *L. yurnagunensis* (FIGS. 3, 5, 6, PL. 16), the initial chamber is slightly smaller than the second chamber, but in two of the specimens (FIGS. 2, 4, PL. 16) the second chamber is approximately equal to the initial chamber. However, the specimen (FIG. 4, PL. 16) would key to the subgenus *Eulepidina* because of the shape of the equatorial chambers.

All the known, authenticated species of *Lepidocyclina s. s.* are confined to the American Oligocene and lower Miocene and all of them have hexagonal peripheral equatorial chambers. Species assigned to the subgenus *Lepidocyclina s. s.* elsewhere seemingly represent other subgenera or even other genera, an example of which is *L.* (*L.*) *boetonensis* van der Vlerk which is a discocyclinid (Cole, 1960*d*, p. 10).

EXPLANATION OF PLATE 13

FIGS. PAGE

1-6. *Lepidocyclina* (*Eulepidina*) *vaughani* Cushman 145

1-4. Parts of equatorial sections, × 40, to show the variable shape of the embryonic chambers; loc. 5.

5, 6. Equatorial chambers, × 40; 5, from the specimen illustrated as FIGURE 5, PLATE 12; 6, from the specimen illustrated as FIGURE 2, PLATE 12; loc. 5.

The stratigraphic ranges of the four subgenera of *Lepidocyclina* in the Americas have been determined with some certainty. *Polylepidina* originated in and is confined to the middle Eocene; *Pliolepidina* was derived from *Polylepidina* in the upper middle Eocene and continued into the upper Eocene; *Eulepidina* developed from *Pliolepidina* in the uppermost upper Eocene and continued to the end of the Oligocene with its maximum speciation in the upper Oligocene; and *Lepidocyclina s. s.* was derived from *Eulepidina* in the lowermost Oligocene and extended into the lower Miocene.

Eulepidina has been found, represented by the species *L. (E.) yurnagunensis,* in samples from the Culebra formation. However, these may be reworked specimens as they occur rarely and are often abraided. Therefore, the range of *Eulepidina* is not extended here above the top of the American Oligocene. However, in the Indo-Pacific area *Eulepidina,* the only authenticated subgenus of *Lepidocyclina* present in this area, does extend from upper Oligocene (Tertiary *d*) into the Miocene (Tertiary *e* and *f*).

Certain genera, such as *Actinosiphon* Vaughan, 1929, which have been placed in the same family with the lepidocyclines, are not assigned correctly. These genera occur in stratigraphically older sediments and were extinct before the most primitive subgenus, *Polylepidina,* of the genus *Lepidocyclina* originated.

NOTES ON SOME CAMERINIDS

The camerinids with undivided median chambers are difficult to identify. Cole (1958*a*) reviewed the American species and concluded that the number of species should be reduced drastically. He placed the species which he considered valid in four genera: *Camerina, Operculinoides, Operculina* and *Paraspiroclypeus.* Since that time he (1959; 1960*c;* 1961) has stated that *Operculinoides, Operculina* and *Paraspiroclypeus* are synonyms of *Camerina,* therefore the species formerly assigned to these three genera should be placed in the genus *Camerina.*

However, this reassignment of the valid species to the genus *Camerina* neither intensifies nor decreases the difficulty in recognizing certain species. Inasmuch as certain camerinids were found in the samples which were being studied, primarily for specimens of *Lepidocyclina,* three species will be discussed. These species are: *Camerina willcoxi* (Heilprin) (FIGS. 1, 10, PL. 17), *C. trinitatensis* (Nuttall) (FIGS. 3, 5-9, PL. 17), both from the Eocene, and *C. dia* (Cole and Ponton) (FIGS. 2, 4, 11-14, PL. 17; FIGS. 2, 4-6, PL. 8) from the Oligocene.

Topotypes of *C. dia* (FIGS. 4, 5, PL. 8; FIGS. 4, 11, PL. 17) were sectioned for comparison with a specimen formerly identified as *"Operculinoides" vicksburgensis* Vaughan and Cole (FIG. 2, PL. 17) and with specimens from Trinidad formerly named *Operculinoides semmesi ciperensis* Vaughan and Cole (FIGS. 2, 6, PL. 8; FIGS. 12-14, PL. 17).

Although at first inspection it appears impossible to distinguish these species, detailed analysis will show differences which may be used. However, it should be emphasized that the differences are not striking and much attention must be given to minute details. Moreover, it is advisable to have large numbers of specimens available so that a series can be studied.

C. dia can be separated from the two Eocene species best by study of median sections (FIGS. 2, 4-6, PL. 8). These sections typically have the distal ends of the chamber walls sharply recurved. However, a word of caution is necessary as the other two species may have certain chamber walls which are as sharply recurved distally. Such specimens (FIGS. 1, 9, PL. 17), however, do not have the chamber walls as consistently recurved throughout the entire section as does *C. dia.*

Normally, *C. trinitatensis,* a small species with a diameter at the maximum of less than 2.5 mm., can be distinguished readily from *C. willcoxi,* a much larger species, by size. The specimens illustrated are about the same size because small specimens of *C. willcoxi* were selected purposely. If the median sections are studied (FIGS. 1, 7, 8, 9, PL. 17), those representing *C. trinitatensis* (FIGS. 7-9, PL. 17) show the height of the coils expanding more rapidly than do the coils of the specimen (FIG. 1, PL. 17) representing *C. willcoxi.*

At most localities where these species occur, there are other species of larger Foraminifera some of which, at least, can be identified easily. The Eocene species commonly occur in association with discocyclinids, lepidocyclinids and others which definitely give the stratigraphic position of the sample. Likewise, *C. dia* is associated with lepidocyclines, miogypsinids and other forms which characterize Oligocene or lower Miocene strata.

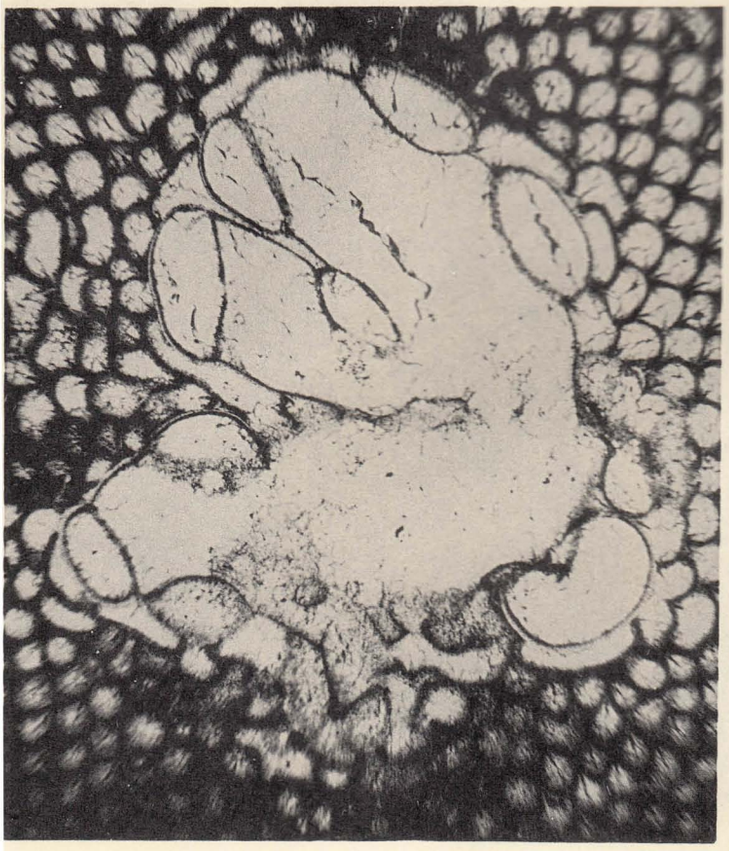
It might be argued that these species of camerinids are not stratigraphically important, or that all three species should be combined into one species. However, there are situations at which these species occur without any associated species. In such cases it is important, no matter how difficult it may be, to identify the species correctly. In many test cases from samples whose stratigraphic position was known to others, but not to the writer, he was able to identify the species

EXPLANATION OF PLATE 14

FIGS. PAGE

1-5. *Lepidocyclina (Pliolepidina) pustulosa* H. Douvillé 145

1-5. Parts of equatorial sections, × 40, to show the variable shape of the embryonic chambers; 2, not centered, to show the appearance of the embryonic chambers as they are approached in sectioning; loc. 1.



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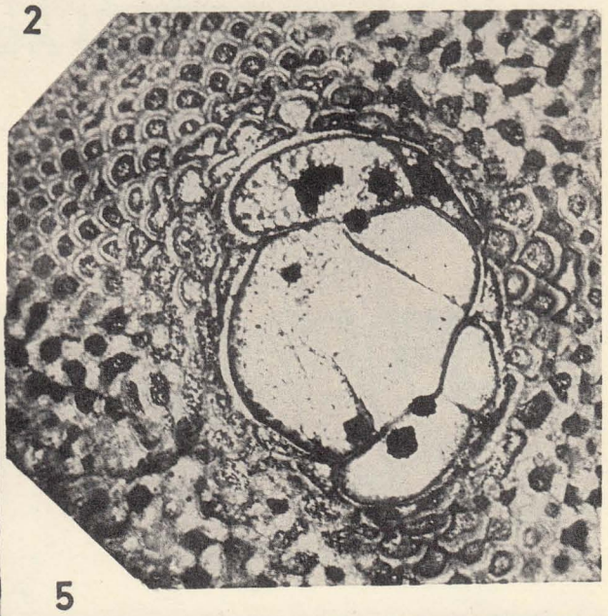
2



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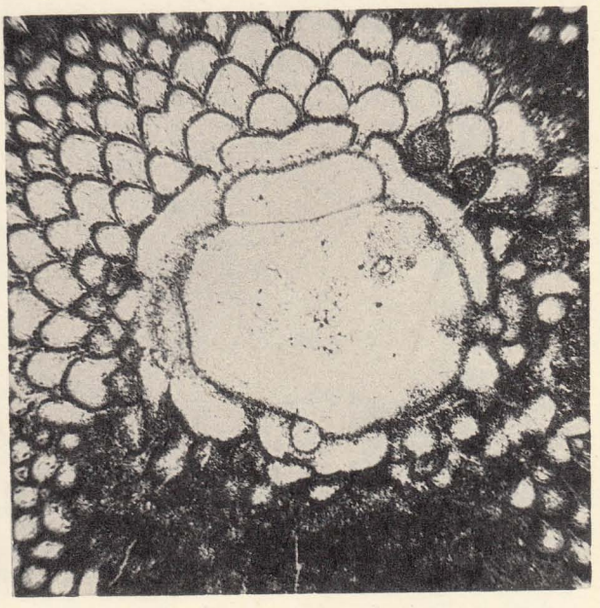

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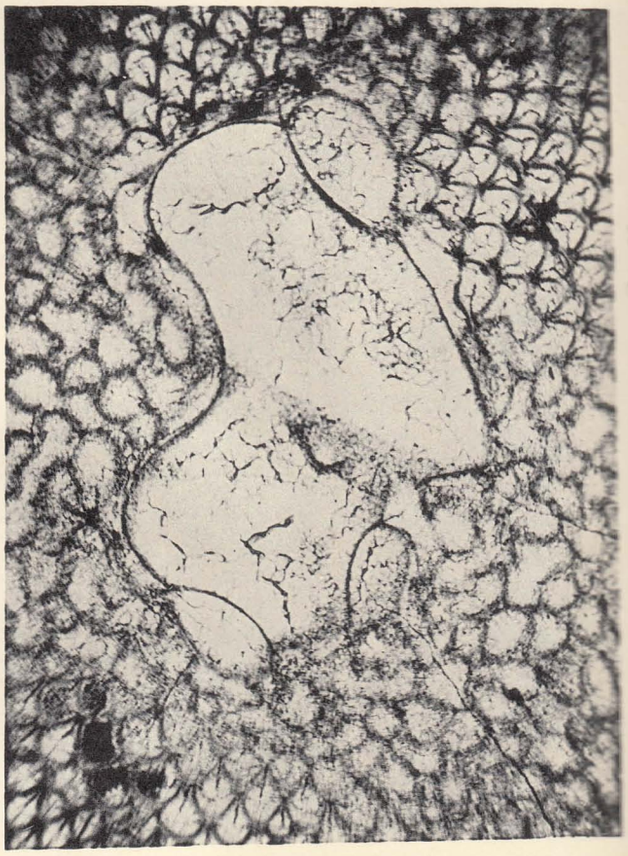

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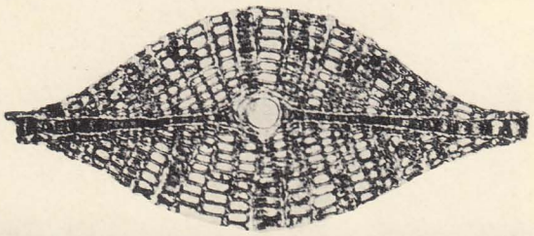
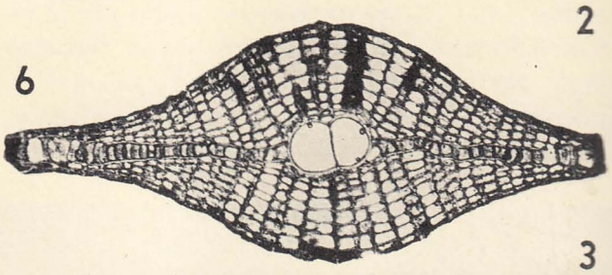


5

2

6



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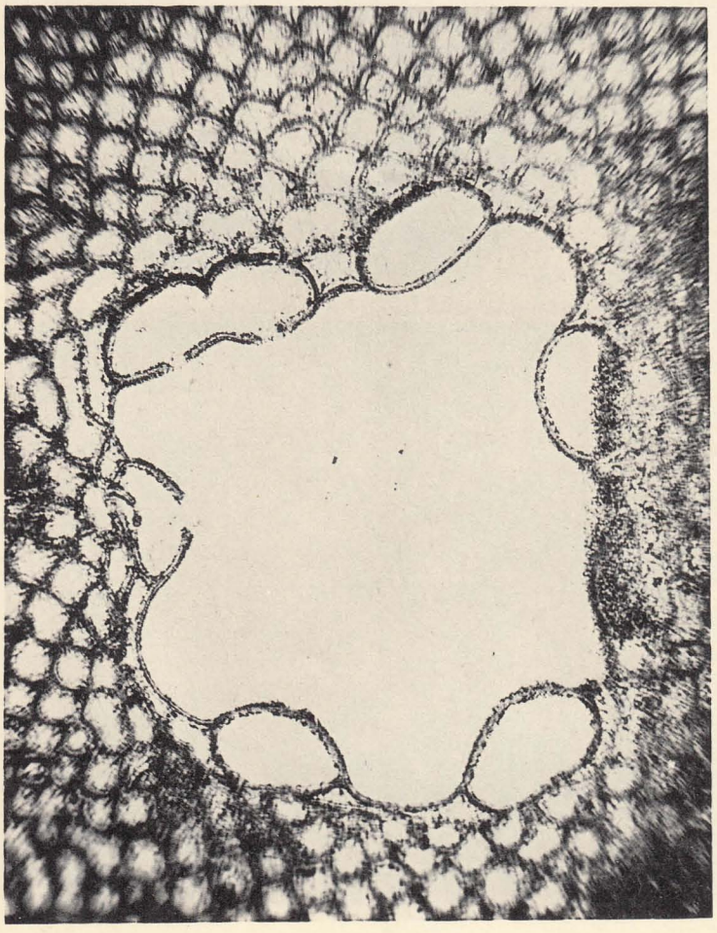

Cole: Nomenclatural and stratigraphic problems, larger Foraminifera

correctly and, thereby, state whether the sample was Eocene or younger.

THE SPECIES ILLUSTRATED

Family CAMERINIDAE
Genus **Camerina** Brugière, 1792
Camerina dia (Cole and Ponton)
Plate 8, figures 2, 4-6; plate 17, figures 2, 4, 11-14

1958. *Operculinoides dia* (Cole and Ponton). COLE, Bull. Amer. Paleontology, v. 38, no. 173, p. 270, 271, pl. 34, figs. 2-4, 6, 9.

Camerina trinitatensis (Nuttall)
Plate 17, figures 3, 5-9

1958. *Operculinoides trinitatensis* (Nuttall). COLE, Bull. Amer. Paleontology, v. 38, no. 173, p. 273.

Camerina willcoxi (Heilprin)
Plate 17, figures 1, 10

1958. *Operculinoides willcoxi* (Heilprin). COLE, Bull. Amer. Paleontology, v. 38, no. 173, p. 273-276, pl. 33, figs. 1, 3-12.

Family MIOGYPSINIDAE
Genus **Miogypsina** Sacco, 1893
Subgenus **Miogypsina** Sacco, 1893
Miogypsina (Miogypsina) antillea (Cushman)
Plate 8, figures 7-11; plate 9, figures 3, 4; plate 10, figure 1

1957. *Miogypsina (Miogypsina) antillea* (Cushman). COLE, Bull. Amer. Paleontology, v. 37, no. 163, p. 320, 321, pl. 26, figs. 6, 7; pl. 28, figs. 1-9; pl. 29, figs. 1-9.

Subgenus **Miolepidocyclina** A. Silvestri, 1907
Miogypsina (Miolepidocyclina) staufferi Koch
Plate 9, figures 6, 7; plate 10, figure 2

1957. *Miogypsina (Miolepidocyclina) staufferi* Koch. COLE, Bull. Amer. Paleontology, v. 37, no. 163, p. 323, 324, pl. 30.

Family LEPIDOCYCLINIDAE
Genus **Lepidocyclina** Gümbel, 1870
Subgenus **Pliolepidina** H. Douvillé, 1917
Lepidocyclina (Pliolepidina) pustulosa H. Douvillé
Plate 8, figure 3; plate 10, figure 5; plate 14; plate 15, figures 1-4

1960. *Lepidocyclina (Pliolepidina) pustulosa* H. Douvillé. COLE, Micropaleontology, v. 6, no. 2, p. 135, 136, pl. 2, figs. 1-10; pl. 3, figs. 1, 2, 5, 6, 9, 10; pl. 4, figs. 7, 9.

One specimen is illustrated to show the characteristics of this species as seen in vertical section (FIG. 3, PL. 8).

Subgenus **Lepidocyclina** Gümbel, 1870
Lepidocyclina (Lepidocyclina) canellei Lem. and R. Douvillé
Plate 8, figure 1; plate 9, figures 1, 8

1953. *Lepidocyclina (Lepidocyclina) canellei* Lem. and R. Douvillé. COLE, U. S. Geol. Survey Prof. Paper 244, p. 18-20, pl. 16, figs. 1-22; pl. 17, figs. 1-3.

Subgenus **Eulepidina** H. Douvillé, 1911
Lepidocyclina (Eulepidina) radiata (Martin)
Plate 11, figures 1-6

1960. *Lepidocyclina (Eulepidina) radiata* (Martin). COLE, Micropaleontology, v. 6, no. 2, p. 136-138, pl. 1, figs. 1-10; pl. 3, figs. 7, 11; pl. 4, figs. 1-3, 6, 8, 10, 11.

Lepidocyclina (Eulepidina) tournoueri Lem. and R. Douvillé
Plate 16, figure 1

1959. *Lepidocyclina (Nephrolepidina) tournoueri* Lem. and R. Douvillé. DROOGER, Micropaleontology, v. 5, no. 4, p. 417-420, pl. 1, figs. 1-4; pl. 2, figs. 1-6.

Lepidocyclina (Eulepidina) vaughani Cushman
Plate 12; plate 13

1953. *Lepidocyclina (Nephrolepidina) vaughani* Cushman. COLE, U. S. Geol. Survey Prof. Paper 244, p. 29, 30, pl. 18, figures 14, 15; pl. 20, figs. 1-6; pl. 21, figs. 1-15.

One specimen is illustrated to show the characteristics of the vertical section (FIG. 3, PL. 12). The equatorial sections are discussed in the text of this article.

Lepidocyclina (Eulepidina) yurnagunensis Cushman
Plate 9, figures 2, 5; plate 10, figures 3, 4, 6; plate 15, figures 5, 6; plate 16, figures 2-6

1953. *Lepidocyclina (Lepidocyclina) yurnagunensis* Cushman. COLE, U. S. Geol. Survey Prof. Paper 244, p. 22, 23, pl. 15, figure 3; pl. 17, figs. 5-18; pl. 20, figs. 11, 12.

1953. *Lepidocyclina (Lepidocyclina) yurnagunensis morganopsis* Vaughan. COLE, *idem*, p. 23, pl. 15, figs. 1, 2, 4, 5; pl. 23, figs. 5-7, 9.

1960. *Lepidocyclina (Eulepidina) yurnagunensis* Cushman. COLE, Micropaleontology, v. 6, no. 2, p. 136, pl. 3, fig. 8.

EXPLANATION OF PLATE 15

FIGS. PAGE

1-4. *Lepidocyclina (Pliolepidina) pustulosa* H. Douvillé 145
1-4. Parts of equatorial sections, × 40, to show the variable shape of the embryonic chambers; 1, loc. 3; 2-4, loc. 1.

5, 6. *Lepidocyclina (Eulepidina) yurnagunensis* Cushman 145
5, 6. Vertical sections, × 20; loc. 4.

The vertical sections (FIGS. 5, 6, PL. 15) of certain specimens assigned to this species resemble those of *L. (L.) canellei* (see: Cole, 1953*b*, fig. 2, pl. 16). However, other specimens (Cole, 1934, fig. 4, pl. 3; Vaughan and Cole, 1941, fig. 1, pl. 38) assigned to *L. yurnagunensis* are similar to those illustrated (FIGS. 5, 6, PL. 15).

Although a number of specimens from the sample from which the specimens which were made into vertical sections were obtained were ground to the equatorial plane, none were found which had embryonic and equatorial chambers of the kind possessed by *L. (L.) canellei.* In addition, the wall of the embryonic chambers is much thicker in *L. (L.) canellei* than that of *L. (E.) yurnagunensis.*

The vertical section (FIG. 2, PL. 9) of a specimen of *L. (E.) yurnagunensis* from the Culebra formation is similar to specimens assigned to this species from the Caimito formation (Cole, 1953*b*, figs. 10-12, pl. 17).

Study of these vertical sections shows how important it is to have a sufficient number of adequate equatorial and vertical sections which have been correlated with each other before identifications are attempted. Otherwise, the species may be identified incorrectly, as has happened unfortunately in many instances.

The sample (loc. 4) from Trinidad contained abundant *L. (E.) yurnagunensis,* a few specimens of *L. (Eulepidina) undosa* Cushman and moderately numerous specimens of *Camerina dia* (Cole and Ponton).

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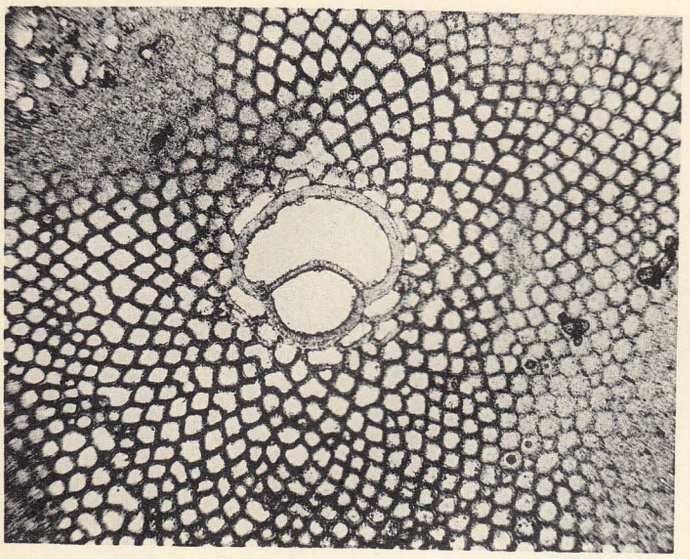
EXPLANATION OF PLATE 16

FIGS. PAGE

1. *Lepidocyclina (Eulepidina) tournoueri* Lem. and R. Douvillé 145
   Equatorial section, × 40, to illustrate the embryonic, periembryonic and equatorial chambers; loc. 12.

2-6. *Lepidocyclina (Eulepidina) yurnagunensis* Cushman 145
   Equatorial sections, × 40, to illustrate the embryonic, periembryonic and equatorial chambers; 2, 4, 5, loc. 4; 3, 6, loc. 9.



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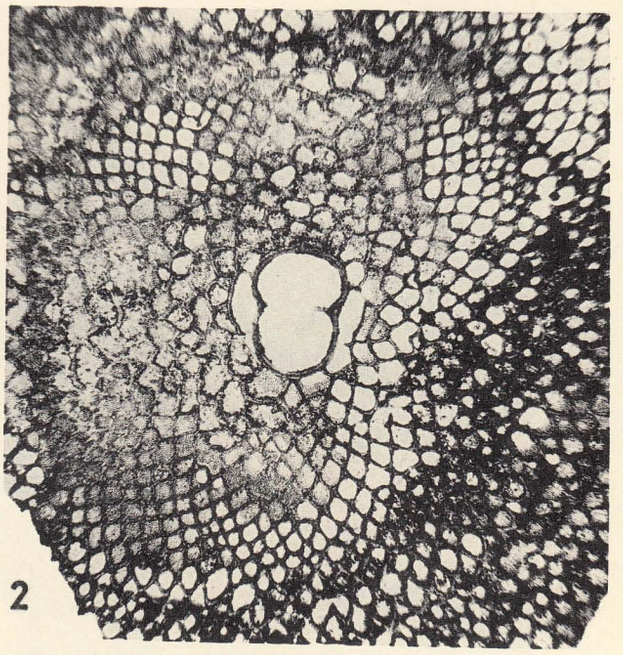

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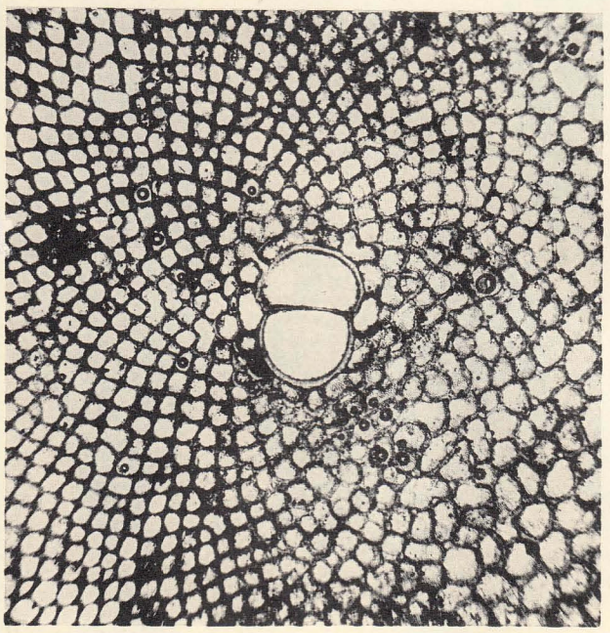

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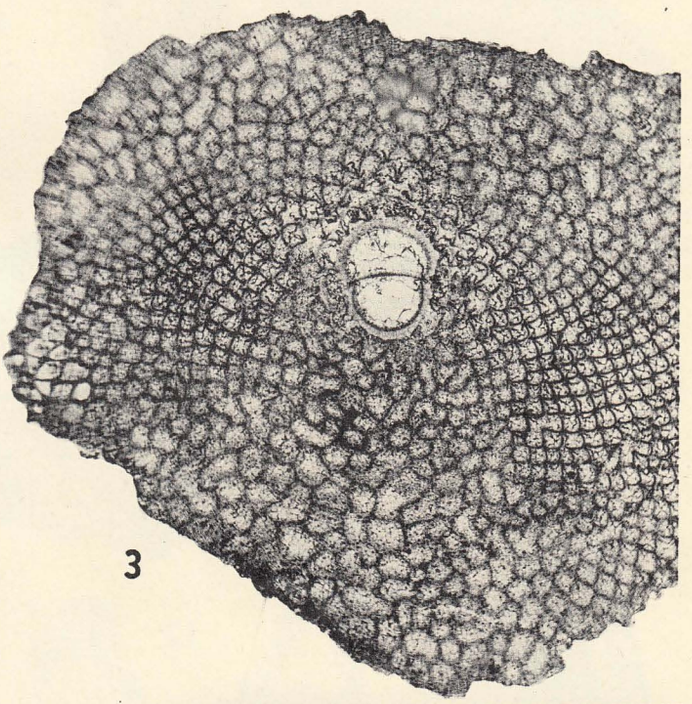

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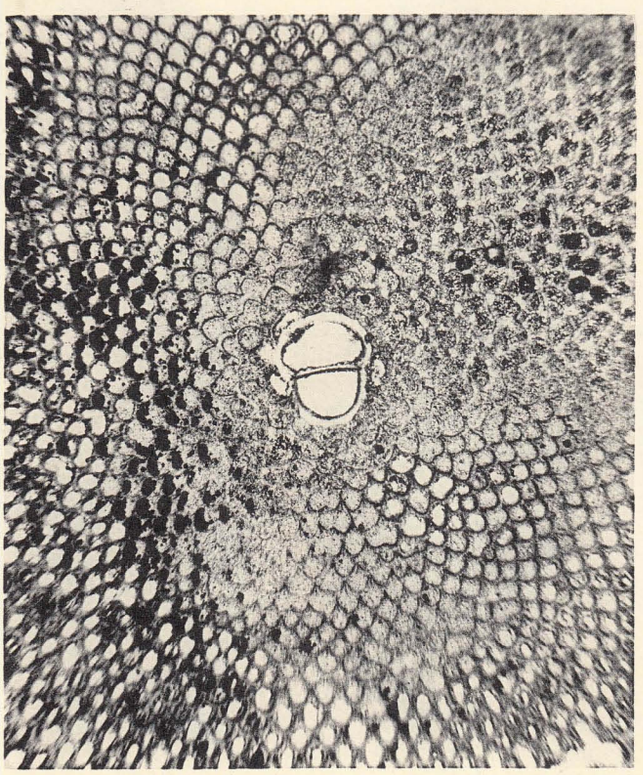

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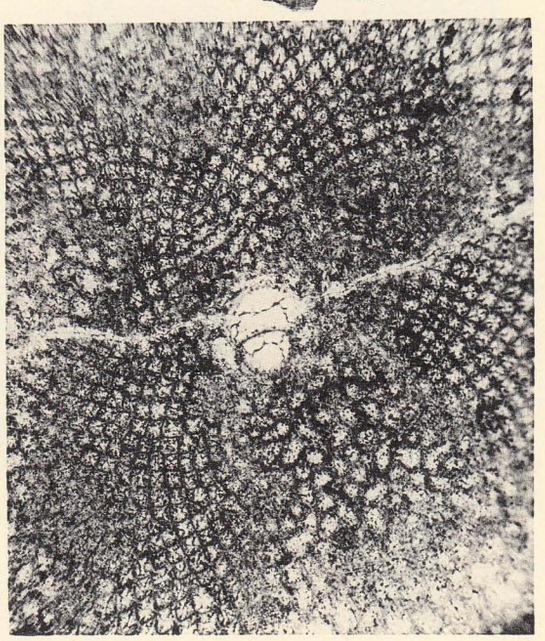

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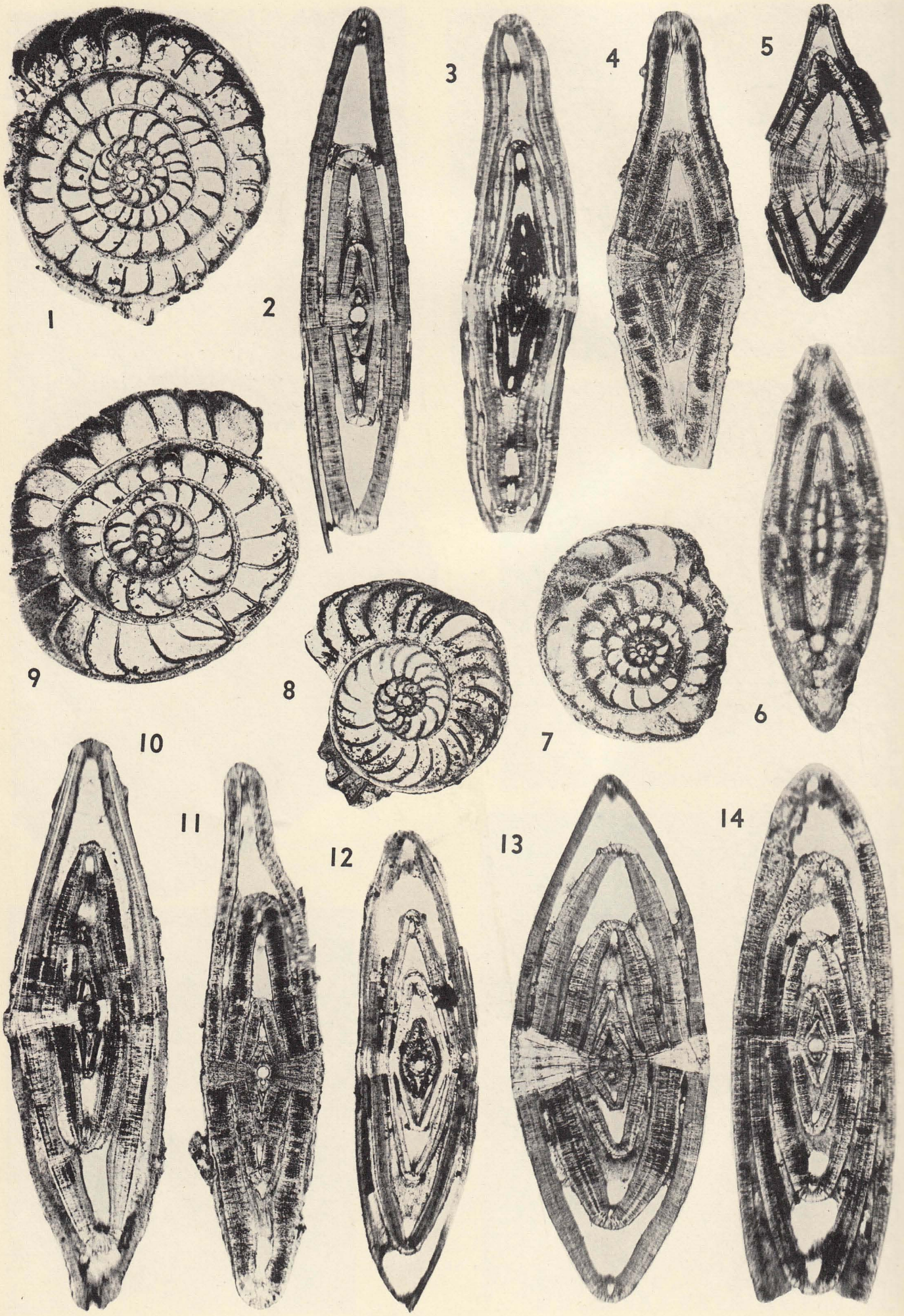
Cole: Nomenclatural and stratigraphic problems, larger Foraminifera



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EXPLANATION OF PLATE 17

FIGS. PAGE

1, 10. *Camerina willcoxi* (Heilprin) 145
1. Median section, × 20; loc. 3.
10. Transverse section, × 40; loc. 3.

2, 4, 11-14. *Camerina dia* (Cole and Ponton) 145
2. Transverse section, × 40, of a topotype of *"Operculinoides" vicksburgensis* Vaughan and Cole; loc. 11.
4, 11. Transverse sections, × 40, of topotypes of *"Operculinella" dia* Cole and Ponton; loc. 10.
12-14. Transverse sections, × 40, of compressed to inflated specimens; loc. 4.

3, 5-9. *Camerina trinitatensis* (Nuttall) 145
3, 5, 6. Transverse sections; 3, compressed specimen, × 40, of the kind previously named *"Operculinoides" kugleri* Vaughan and Cole, loc. 3; 5, inflated specimen, loc. 3; 6, not exactly centered, loc. 2.
7-9. Median sections, × 20; 7, loc. 2; 8, 9, loc. 3.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XII, PART 4, OCTOBER, 1961

NOMENCLATURAL NOTES

234. *VERNEUILINA PHARAONICA,* NEW NAME FOR *V. MINUTA* SAID AND BARAKAT, PREOCCUPIED

RUSHDI SAID
Cairo University, Gizeh, U.A.R.

Dr. Hans E. Thalmann has informed the writer that *Verneuilina minuta* Said and Barakat, 1959, is preoccupied by *V. minuta* Wiesner, 1931. The following new name is therefore proposed: *Verneuilina pharaonica,* new name for *V. minuta* Said and Barakat, 1959, Proc. Egyptian Acad Sci., vol. XIII (1957/58), p. 6, fig. 6; non *V. minuta* Wiesner, 1931, Deutsche Südpolar-Exped., vol. XX (Zool. vol. XII), p. 99, pl. xiii, fig. 155; pl. xxiii, stereo-fig. d.

235. *HELENINA* SAUNDERS, NEW NAME FOR THE FORAMINIFERAL GENUS *HELENIA* SAUNDERS, 1957, *NON HELENIA* WALCOTT, 1889

JOHN B. SAUNDERS
Texaco Trinidad, Inc., Pointe-a-Pierre, Trinidad, West Indies

Helenia Saunders, 1957 (Jour. Washington Acad. Sci., v. 47, no. 11, p. 374) is a homonym of *Helenia* Walcott, 1889. The new name *Helenina* is proposed for *Helenia* Saunders, with *Pseudoeponides anderseni* Warren, 1957 = *Helenina anderseni* (Warren) as type species.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XII, PART 4, OCTOBER, 1961

RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the Foraminifera that have come to hand.

ADAMS, C. G. A note on the age of the Laig Gorge beds, Eigg.—Geol. Mag., v. 97, No. 4, July-Aug. 1960, p. 322-325, text fig. 2 (outline drawings).—Specimens of **Heterohelix** and **Praeglobotruncana?** observed in thin section make necessary a change in age determination from Jurassic to Late Cretaceous.

BELMUSTAKOV, EMIL. Paléogène Grandes Foraminifères (French summary of Bulgarian text).—Acad. Sci. Bulgarie, Les Fossiles de Bulgarie, v. 6, 1959, p. 1-80, pls. 1-20, range chart, distrib. table.—Illustrated systematic catalog includes 72 species, none new, mostly Nummulitidae with a few Discocyclinidae.

BERMUDEZ, PEDRO J. Contribucion al estudio de las Globigerinidea de la region Caribe-Antillana (Paleoceno-Reciente).—Mem. III Congreso Geol. Venez., tomo 3, Bol. Geol., Publ. especial 3, 1960, p. 1119-1393, pls. 1-20.—The superfamily is divided into 3 families of which one (the Globigerinidae) is in turn subdivided into 5 subfamilies, one new, Globigerinitinae (type genus **Globigerinita** Bronnimann 1952). Forty-four genera are discussed, with many of the ones having post-Cretaceous occurrences in the Antillean-Caribbean region being illustrated with stereo-photographs. Systematic catalog includes 216 species (26 new and 1 given a new name) and 18 varieties (1 new).

BIOT, J. Note sur quelques Foraminifères de la Plage de Luc-sur-Mer (Calvados) (Note préliminaire).—Bull. Soc. Géol. Normandie, tome 50, Ann. 1960, p. 43-44.—Species listed from 2 tidal samples.

BLUMENSTENGEL, HORST. Foraminiferen aus dem Thüringer Oberdevon.—Geologie, Berlin, Jahrgang 10, heft 3, April 1961, p. 316-335, pls. 1-3, 1 text fig., 1 table.—Twenty-three species (6 new and 10 indeterminate) of silicified agglutinated Foraminifera.

CASSAN, GINETTE, and SIGAL, JACQUES. Un cas de schizogonie intrathalame chez un orbitoide.—Bull. Soc. Hist. Nat. Toulouse, v. 96, 1961, p. 153-156, pl. 1.—Embryonic megalospheric individuals enclosed in brood chambers within the wall of a microspheric individual of **Orbitoides media.**

CHANG, LI-SHO. A biostratigraphic study of the Miocene in western Taiwan based on smaller Foraminifera (Part II: Benthonics).—Bull. Geol. Survey Taiwan, No. 12, Dec. 1960, p. 67-91, pls. 1-16, text figs. 1-3 (maps), tables 1-8.—About 180 species and varieties are illustrated and their occurrence and abundance in several formations tabulated. Five species and one variety are new.

CHEVALIER, JEAN. Quelques nouvelles espèces de Foraminifères dans le Crétacé inférieur méditerranéen.—Revue de Micropaléontologie, v. 4, No. 1, June 1961, p. 30-36, pl. 1, range chart.—Six new species (4 of them planktonics) from southeastern France.

CITA, M. B., and PALMIERI, V. Prima segnalazione in Italia dei generi di Foraminiferi **Aragonia** Finlay e **Clavigerinella** Bolli, Loeblich, e Tappan.—Boll. Soc. Pal. Ital., v. 1, No. 1, 1960, p. 74-83, text figs. 1-7.—**Aragonia anauna** n. sp. and **Clavigerinella eocanica** (Nuttall) from middle Eocene, probably **Hantkenina aragonensis** zone, with their associated species listed.

CRESPIN, IRENE. Catalogue of type and figured specimens in the Commonwealth Palaeontological Collection, Canberra.—Australia Bureau Min. Res., Geol. and Geophys., Rept. No. 54, 1960, p. 1-92.—Foraminifera listed on p. 7-43.

DOUGLASS, RAYMOND C. Orbitolinas from Caribbean Islands.—Jour. Paleontology, v. 35, No. 3, May 1961, p. 475-479, pls. 65, 66, text figs. 1-5 (maps).—The 3 species recognized indicate Albian age.

DROOGER, C. W., and FELIX, R. Some variations in foraminiferal assemblages from the Miocene of the North Sea basin.—Proc. Kon. Nederl. Akad. Wetenschappen, ser. B, Phys. Sci., v. 64, No. 2, 1961, p. 316-324, text figs. 1-4 (map, graphs), table 1.—Attempting to determine whether differences in microfaunal composition are a result of ecologic differences existing at one time or are dependent on geologic time, the authors compare qualitative and quantitative compositions of several Miocene formations with Recent and subrecent deposits off the Orinoco mouth having approximately equivalent (though not identical) species.

DuBAR, JULES R., and BEARDSLEY, DONALD W. Paleoecology of the Choctawhatchee deposits (late Miocene) at Alum Bluff, Florida.—Southeastern Geology [Duke Univ.], v. 2, No. 3, March 1961, p. 155-189 [including appendix], text figs. 1, 2 (map, section), tables 1, 2, faunal check lists 1, 2.—Comparison of the assemblage in Bed 3 with nearby extant communities indicates deposition in the inner neritic zone (less than 8 fathoms).

DZODZO-TOMIC, RADOJKA. Middle Miocene (Tortonian) Foraminifera of the wider surroundings of Negotin—East Serbia (Sarenkamen, Stubik, Bracevac) (English summary of Serbian text).—Instit. Geol. Montenegro, Bull. Geol., livre 3, 1959, p. 87-97, pls. 14-17.—Many smaller Foraminifera listed and illustrated.

EMILIANI, C., MAYEDA, T., and SELLI, R. Paleotemperature analysis of the Plio-Pleistocene section at Le Castella, Calabria, southern Italy.—Bull. Geol. Soc. America, v. 72, No. 5, May 1961, p. 679-688, text figs. 1, 2 (map, graph), tables 1, 2.—An undisturbed section covering 167.8 meters stratigraphically and crossing the Plio-Pleistocene boundary as defined by the lowest occurrence of **Anomalina baltica** was logged and closely sampled. Isotopic analyses made of 22 Pliocene samples and 25 Pleistocene samples, using 2 planktonic species individually for summer surface-water temperatures, 2 more for temperatures at some depth or at a different season, and mixed benthonics for bottom-water temperatures, reveal numerous oscillations and a general cooling trend from late Pliocene to late Pleistocene, but no abrupt change at the Pleistocene boundary. Species restricted to or more abundant in the Pliocene and in the Pleistocene respectively are listed.

ESPITALIÉ, J., and SIGAL, J. Microstratigraphie des "marnes bleues" des bassins tertiaires des Alpes méridionales. Le genre **Caucasina** (Foraminifère).—Revue de Micropaléontologie, v. 3, No. 4, March 1961,

p. 201-206, pl. 1, text fig. 1 (map).—**Caucasina oligocaenica** from the upper part (probably lower Oligocene) of the "marnes bleues" and **C. alpina** n. sp. from the lower part (upper Priabonian).

GIRELLI, MAURIZIO. Microfauna Langhiana nella Pietra da Cantoni di Moleto (Monferrato Orientale).—Boll. Soc. Geol. Ital., v. 79, fasc. 1, 1960, p. 89-95, pls. 1, 2.—The assemblage is illustrated and the species listed.

GONZALES, B. A. Planktonic Foraminifera from the Miocene Lubuagan, Callao, and Cabagan formations exposed along the Cabagan River, eastern Isabela.—The Philippine Geologist, v. 14, No. 4, Dec. 1960, p. 106-130, text fig. 1 (map), tables 1-3.—Records a total of 35 species, subspecies, and varieties from 3 formations of early, middle, and late Miocene age.

GORDON, W. A. Distribution of Foraminifera in the middle Tertiary San Sebastián-Isabela section, Puerto Rico.—Univ. Puerto Rico, Caribbean Jour. Sci., v. 1, No. 2, May 1961, p. 48-58, tables 1-3.—Includes paleoecologic analysis of 5 formations.

Miocene Foraminifera from the Lajas Valley, southwest Puerto Rico.—Jour. Paleontology, v. 35, No. 3, May 1961, p. 610-619, text figs. 1, 2 (plates of fossils).—Twenty-three species and subspecies, 2 species new; a shallow-water fauna.

GRAHAM, JOSEPH J. An annotated bibliography of California Cretaceous microfossils, including a brief history of the literature.—Calif. Div. of Mines, Spec. Rept. 66, 1961, p. 1-43.

GUYADER, J. Les zones a Foraminifères du Jurassique Supérieur de l'estuaire de la Seine (Argiles de Villerville).—Bull. Soc. Géol. Normandie, tome 50, Ann. 1960, p. 27-32, 4 graphs.—Quantitative analysis of 4 samples shown graphically.

HAGN, HERBERT. Die Gliederung der bayerischen Miozän-Molasse mit Hilfe von Kleinforaminiferen.—Mitteil. Geol. Gesell. Wien, Band 52, 1959 (1960), p. 133-141.

HANZAWA, SHOSHIRO. Facies and micro-organisms of the Paleozoic, Mesozoic and Cenozoic sediments of Japan and her adjacent islands.—Internat. Sedimentary Petrographical Ser., Leiden, E. J. Brill, v. 5, 1961, p. 1-420, pls. 1-148, text figs. 1-6 (maps), 4 plates of stratigraphic columns.—Book includes nearly 300 thin section photographs illustrating fossil-bearing sediments from Silurian to Holocene, many containing identified larger and smaller Foraminifera.

HILTERMANN, H. Bibliographie stratigraphisch wichtiger mikropaläontologischer Publikationen von etwa 1830 bis 1958 mit Kurzreferaten.—E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, 1961, 403 p.—Annotated bibliography separated into 4 sections (text- and handbooks, general, and ecology; techniques; stratigraphy subdivided into periods; and bibliographies) and indexed under author, subject and locality.

HOFKER, J. Les Foraminifères planctoniques du Montien de la localité-type.—Revue de Micropaléontologie, v. 4, No. 1, June 1961, p. 53-57, text figs. 1, 2 (columnar sections), table 1.—The type Montian can be correlated with the **Globorotalia pseudomenardii** zone (upper part of lower Paleocene), and the lower part of lower Paleocene is present between the Montian and the Danian.

HORNADAY, GORDON R. Foraminifera from the Sacate formation south of Refugio Pass, Santa Barbara County, California.—Univ. Calif. Publ. Geol. Sci., v. 37, No. 3, May 11, 1961, p. 165-203, pls. 1-13, text figs. 1-6 (maps, columnar section, distrib. and abund. chart, check list).—Includes illustrated systematic catalog of 71 species (1 new and 20 indeterminate) and 9 varieties (3 new) obtained from 35 samples from the Upper member belonging in the Narizian stage of the upper Eocene.

HUANG, TUN-YOW. Smaller Foraminifera from the beach sands at Tanmenkang, Pachao-Tao, Penghu.—Proc. Geol. Soc. China, No. 4, April 1961, p. 83-90, pls. 1-5.—Seventy-two species (none new) recorded and illustrated with good photographs.

IGÔ, HISAYOSHI. Some Permian fusulinids from the Hirayu District, southeastern part of the Hida Massif, Central Japan.—Sci. Repts. Tokyo Kyoiku Daigaku, sec. C, v. 6, No. 56, March 31, 1959, p. 231-254, pls. 1-4, map.—Twelve species (2 new and 3 indeterminate), 2 new subspecies, and 2 varieties.

IORGULESCU, T. Contributions à l'étude micropaléontologique de Miocène supérieur de la Munténie Orientale (Prahova et Buzau).—Rép. Pop. Roumaine, Ann. Com. Geol., Tomes 26-28, 1959, p. 5-36, pls. 1-9 (fossils), pls. 1-3 (geol. section, distrib. and abund. table, columnar sections and stratig. range chart).—Twelve zones recognized on the basis of occurrence and abundance of fossils (chiefly smaller Foraminifera), coincide with lithologic complexes in general but not in all instances.

ISHII, ATSUSHI, and TAKAHASHI, HAJIME. Fusulinids from the Upper Permian Ogamata formation, central part of the Kwanto Massif, Japan.—Sci. Repts. Tokyo Kyoiku Daigaku, sec. C, v. 7, No. 66, Oct. 25, 1960, p. 205-216, pls. 4, 5, text figs. 1, 2 (maps).—Eight species, 4 new and 1 indeterminate.

JULIUS, CHARLES. Sur une nouvelle variété de **Nonion** du Miocène supérieur d'Aquitaine.—C. R. S. Soc. Géol. France, May 8, 1961, fasc. 5, p. 139-140, text figs. 1, 2.—**Nonion sol** Lys et Bourdon var. **magnum.**

DE KLASZ, IVAN. Présence de **Globotruncana concavata** (Brotzen) et **Gl. concavata carinata** Dalbiez (Foraminifères) dans le Coniacien du Gabon (Afrique équatoriale).—C. R. S. Soc. Géol. France, May 8, 1961, fasc. 5, p. 123-124.

KURC, GEORGES. Foraminifères et Ostracodes de l'étang de Thau.—Rev. Trav. Inst. Pêches marit., v. 25, No. 2, 1961, p. 131-247, pls. 1-5, text figs. 1-34 (maps, photographs, graphs, drawings), tables 1-15, 2 appendices (data tables, core descriptions).—A quantitative study based on about 75 bottom samples and 27 cores taken throughout a large lagoonal area in which numerous physical and chemical factors are also recorded. Sixty-five species and varieties (1 species new), principally in the families Rotaliidae, Miliolidae, Nonionidae, and Buliminidae, are recorded and the distribution and abundance of several species plotted on maps.

LOEBLICH, ALFRED R., JR., and TAPPAN, HELEN. The status of the foraminiferal genera **Ammodiscus** Reuss, and **Involutina** Terquem.—Micropaleontology, v. 7, No. 2, April 1961, p. 189-192.—Both genera are retained.

The genera **Microaulopora** Kuntz, 1895, and the status of **Guembelina** Egger, 1899.—Jour. Paleontology, v. 35, No. 3, May 1961, p. 625-627, text fig. 1.—**Guembelina** Egger, 1899, is a junior homonym of **Guembelina** Kuntz, 1895, a microscopic chitinous genus of Paleozoic corals.

Cretaceous planktonic Foraminifera: Part 1—Cenomanian.—Micropaleontology, v. 7, No. 3, July 1961, p.

257-304, pls. 1-8.—Systematic catalog of 27 species (4 new) included in 8 genera classified in 3 families (Planomalinidae, Schackoinidae and Rotaliporidae; the latter subdivided into subfamilies Hedbergellinae and Rotaliporinae). Alphabetical list of all Cenomanian species including synonyms is given. Changes of age for three formations are based on their planktonic assemblages.

LUDBROOK, N. H. Subsurface stratigraphy of the Maralinga area, South Australia.—Trans. Royal Soc. So. Australia, v. 84, March 1961, p. 51-59, figs. 1-3 (map, columnar sections, geol. section).—Eocene sediments recognized by their smaller Foraminifera.

Outline of the biostratigraphy of Andamooka opalfield. —Trans. Royal Soc. So. Australia, v. 84, March 1961, p. 129-137, map, table 1.—Opal in conglomerates interbedded with sandy clays containing Aptian Foraminifera and overlain by Quaternary sediments containing Foraminifera and mollusks typical of warm, shallow water, confirming existence of an extensive northward estuary.

MAGNÉ, A., and ESPITALIÉ, J. Mise au point d'un dispositif pratique pour la stéréo-microphotographie. —Revue de Micropaléontologie, v. 3, No. 4, March 1961, p. 217-226, pls. 1-3, text figs. 1-5.—Results obtained commend the equipment.

MALAVASSI V., ENRIQUE. Some Costa Rican larger foraminiferal localities.—Jour. Paleontology, v. 35, No. 3, May 1961, p. 498-501, text fig. 1 (map), table 1.—Nineteen species of larger Foraminifera are listed from localities ranging in age from Late Cretaceous to late Oligocene.

MARIE, PIERRE. Présence de **Globotruncana elevata** (Brotzen) dans le Santonien des Corbières.—C. R. S. Soc. Géol. France, May 8, 1961, fasc. 5, p. 124-125.

MARKOVSKIJ, B. P., ed. Novyie vidy drevnikh rastenij i bespozvonochnykh SSSR.—Russia Vses. nauchnoissl. geol. instit., Moscow, 1960, 612 p., 93 pls., 39 text figs.—Includes a section on Foraminifera (p. 137-169, pls. 25-29) in which are described as new 2 genera, 1 subgenus, 28 species and 1 variety from various localities, the work of seven different authors. New are **Eoendothyra** M.-Maclay (type species **Endothyra communis** Rauser, 1948), **Quasiarchaediscus** M.-Maclay (type species **Q. pamirensis** sp. nov.), and **Pseudotristix** M.-Maclay, subgenus of **Tristix** (type species **Tristix (Pseudotristix) tcherdynzevi** sp. nov.).

MAYNC, WOLF. Note sur le genre **Orbitammina** (Foraminifère) et sa répartition stratigraphique.—Revue de Micropaléontologie, v. 4, No. 1, June 1961, p. 7-16. pls. 1, 2, text fig. 1 (map).—**Orbitammina elliptica** and **Meyendorffina bathonica** are associated in subreefal limestones of late Bathonian age in the Paris Basin.

MONCHARMONT ZEI, MARIA. Contributo alla conoscenza del Pleistocene della Sicilia.—Boll. Soc. Nat. Napoli, v. 69, 1960, p. 141-185, pls. 1-14 [pls. 1-6, Foraminifera; pls. 7-14, Mollusca], occurrence chart. —Many Foraminifera are illustrated and their occurrences in several Sicilian localities recorded. Two new species of **Rectuvigerina** are described.

MOULLADE, M. Quelques Foraminifères et Ostracodes nouveaux du Crétacé inférieur vocontien.—Revue de Micropaléontologie, v. 3, No. 4, March 1961, p. 213-216, pl. 1.—Three new Foraminifera and a new name for another.

NEUMANN, M. Sur la présence du genre **Preverina** (Foraminifère) dans l'Oligocène de Grèce.—Bull. Soc. Géol. France, ser. 7, tome 2, No. 4, 1960 (May 1961), p. 450-451, text fig. 1.

NOCCHI, MARISA. Osservazioni sulla stratigrafia e cenni sulla tettonica della parte meridionale dei Monti del Chianti.—Boll. Soc. Geol. Ital., v. 79, fasc. 2, 1960, p. 217-256, pls. 1-7, text figs. 1, 2 (columnar sections, photomicrographs), geol. sections, map.—Includes photomicrographs of rocks bearing planktonics and larger Foraminifera.

NOGAMI, YASUO. Permische Fusuliniden aus dem Atetsu-Plateau Südwestjapans. Teil 1. Fusulinidae und Schwagerininae.—Mem. College Sci., Univ. Kyoto, ser. B, v. 27, No. 3, Feb. 1961, p.159-248, pls. 1-11, text fig. 1 (range chart), table 1.—Descriptions and illustrations of 36 species (9 new and 11 indeterminate) and 7 subspecies (2 new). Five zones and 8 subzones are recognized.

NYIRÖ, M. R. Auswertung der Foraminiferen aus den transdanubischen tortonischen Beckenablagerungen.— Ann. Hist.-Nat. Mus. Nat. Hungarici, tom. 52, 1960, p. 33-50, pls. 1, 2, distrib. table.—Occurrence and abundance is recorded for 174 species, with a few described and illustrated, 1 new.

PAPP, A. Die Fauna der Michelstettener Schichten in der Waschberg-Zone (Niederösterreich).—Mitteil. Geol. Gesellschaft Wien, Band 53, 1960, April 1961, p. 209-247, text figs. 1-10 (maps, plates of drawings).—A rich Foraminifera fauna interpreted as of Aquitanian age.

PESSAGNO, EMILE A., JR. The micropaleontology and biostratigraphy of the middle Eocene Jacaguas group, Puerto Rico.—Micropaleontology, v. 7, No. 3, July 1961, p. 351-358, pls. 1, 2, text figs. 1-3 (maps, correl. chart), chart 1 (distrib. and abund. table).—Illustrations of the planktonic part of an early middle Eocene assemblage correlated with the **Hantkenina aragonensis** and **Globigerapsis kugleri** zones of Trinidad.

PETRUCCI, FRANCO. Osservazioni sulla zona collinare tra il T. Taro e il T. Recchio (Parma) con particolare riguardo al limite Mio-Pliocene.—Atti Soc. Ital. Sci. Nat. Mus. Civico Milano, v. 99, fasc. 4, Dec. 1960, p. 314-334, pls. 18-22, text fig. 1 (geol. section).—Smaller Foraminifera listed and assemblages illustrated from Pliocene and Miocene.

POIGNANT, ARMELLE. Quelques précisions sur les Lituonelles de l'Éocène du Médoc.—Revue de Micropaléontologie, v. 4, No. 1, June 1961, p. 66, 67.—**Lituonella cuvillieri** Poignant = **L. depressa** Azzaroli, and a species referred to as a trochoid form of **L. roberti** Schlumberger should be re-identified as **L. kerfornei** Allix. The age assignment is changed from upper to middle Eocene (upper Lutetian).

POKORNY, VLADIMIR. Microstratigraphie et biofaciès du Flysch Carpatique de la Moravie Méridionale (Tchécoslovaquie).—Rev. Instit. Français Pétrole et Ann. Combust. Liquides, v. 15, Nos. 7-8, July-Aug. 1960, p. 1099-1141, pls. 1-18, text figs. 1, 2 (map, range chart). —Photographs of a succession of 12 assemblages from Upper Senonian? to Aquitanian of the Magura flysch in the internal zone and the Zdanice flysch in the external zone. Distinctive species are illustrated.

ROVEDA, V. Contributo allo studio di alcuni macroforaminiferi di Priabona.—Riv. Ital. Pal. Stratig., v. 67, No. 2, 1961, p. 153-224, pls. 14-19, text figs. 1-19 (columnar section, map, range and abund. chart, graphs, outline drawings).—Six species of **Nummulites** (1 new) and one each of **Operculina, Spiroclypeus, Pellatispira,** and **Heterostegina** from the type locality of the Priabonian stage are diagnostic of that part of

the section and some have short stratigraphic ranges within it.

SAID, RUSHDI, and BARAKAT, MOHAMED G. Foraminifera from subsurface Jurassic rocks of Wadi El-Natroun, Egypt.—Proc. Egyptian Acad. Sci., v. 13, 1957/58, 1959, p. 44-49, text figs. 1-9.—Ten species, 2 new.

SAID, RUSHDI, and KERDANY, MOUSTAFA T. The geology and micropaleontology of the Farafra Oasis, Egypt.—Micropaleontology, v. 7, No. 3, July 1961, p. 317-336, pls. 1, 2, text figs. 1-13 (maps, columnar sections, distrib. and abund. table, outline drawings, thin section photographs).—Study of planktonics from a section including Maestrichtian Chalk and Esna shale of Landenian age reveals an unconformity between the two formations. Intercalation of reefal assemblages with planktonic assemblages establishes the late Paleocene age of primitive nummulites and alveolines found in the upper part of the Esna shale. Ypresian nummulites and alveolines occur in the capping Farafra limestone. Thirty-two species of planktonic genera are described and illustrated, none new.

SCOTT, G. H. Contribution to the knowledge of **Rzehakina** Cushman (Foraminifera) in New Zealand (with an appendix on statistical method applied to bi-variate analysis of **Rzehakina** Cushman by Miss M. T. K. CHUNG and R. M. WILLIAMS).—New Zealand Jour. Geol. Geophys., v. 4, No. 1, Feb. 1961, p. 3-43, text figs. 1-32 (graphs, drawings).—Statistical analysis of variability in prolocular size, gross dimensions, and coiling indicate the existence of 3 generational forms. Range in New Zealand is from lower Senonian to Paleocene and is correlatable with other known occurrences.

Foraminifera from an alternating sequence, Eketahuna, New Zealand.—New Zealand Jour. Geol. Geophys., v. 4, No. 1, Feb. 1961, p. 73-88, text figs. 1-7 (columnar section, graphs), tables 1-8.—The fact that size-frequency distribution of **Uvigerina miozea** from alternating sandstone and siltstone is similar to that of an inferred original distribution points toward a stable microfaunal assemblage not much affected by mechanical sorting after death.

STANTON, R. L. Explanatory notes to acompany a first geological map of Santa Ysabel, British Solomon Islands Protectorate.—Overseas Geol. Min. Resources, v. 8, No. 2, 1961, p. 127-149, geol. map, text figs. 1, 2 (map, sections).—Smaller Foraminifera used by F. M. KICINSKY to determine age as upper Miocene (Tertiary **g**).

THALMANN, HANS E. An index to the genera and species of the Foraminifera 1890-1950.—George Vanderbilt Foundation, Stanford Univ., Calif., 1960, 393 p.

TRIFONOVA, EK. On the presence of the Paleocene deposit of the Eastern Bulgarian.—Ann. Direct. Gen. Recherches Geol., ser. A, v. 10, 1959 (1960), p. 155-164, pls. 1, 2, range charts.—Occurrence and abundance of 71 species in Maestrichtian, Danian, Paleocene, and middle Eocene.

VALLENILLA LÉON, P. Estratigrafia de las formaciones Caujarao, La Vela y Coro en sus localidades tipos, Estado Falcon.—Asoc. Venez. Geol., Min. Petr., Bol. Informativo, v. 4, No. 2, Feb. 1961, p. 29-78, text figs. 1-10 (maps, columnar sections, graphs, distrib. and abund. table, geol. sections).—Four biostratigraphic zonules based on smaller Foraminifera extend from upper Helvetian to Sarmatian.

VOICU, GH., and PATRUT, I. Cretaceous microfossils in the Paleogene and Miocene of the Roumanian Carpathians.—Jour. Pal. Soc. India, v. 3, 1958, p. 224-227, pl. 42.—A minority report on the significance of **Globotruncana** and **Gümbelina** in the Tertiary; i.e., that they persisted locally until their extinction resulting from freshening of the Sarmatian sea.

WALL, J. H. Upper Cretaceous Foraminifera from the Smoky River area, Alberta.—Research Council of Alberta, Bull. 6, 1960, p. 1-43, pls. 1-5, text fig. 1 (map), table 1, chart 1 (range and abund. chart).—Eighteen species (1 new and 8 indeterminate) and 1 subspecies comprise a predominantly arenaceous assemblage from the upper part of the Kaskapau shale and lower part of the Puskwaskau shale, the microfauna dated by association with ammonites as Coniacian-Santonian.

WATKINS, JAMES G. Foraminiferal ecology around the Orange County, California, ocean sewer outfall.—Micropaleontology, v. 7, No. 2, April 1961, p. 199-206, text figs. 1-17.—The increased nutrient salts in the sea near the outfall, and consequent thriving phytoplankton, result in a 2- or 3-fold increase in numbers of living and dead specimens per gram of sediment. Arenaceous species inhabit shallower water near the outfall than elsewhere along the continental shelf, and abnormality of specimens shows a marked increase in certain species. About 50 species and varieties were identified and most of them found living. Two depth zones were determined: intertidal (0-20 feet), dominated by **Elphidium translucens,** and upper sublittoral (20-78 feet), dominated by **Buliminella elegantissima.**

WEGMANN, RUDOLF. Zur Geologie der Flyschgebiete südlich Elm (Kanton Glarus).—Mitteil. Geol. Instit. Univ. Zurich, ser. C, No. 76, 1961, 256 p. (offset), pls. 1-3 (maps, sections), text figs. 1-32, tables.—Microscopic sections, mostly of **Globotruncana** and **Nummulites,** are illustrated.

WETZEL, OTTO. New microfossils from Baltic Cretaceous flintstones.—Micropaleontology, v. 7, No. 3, July 1961, p. 337-350, pls. 1-3.—Includes photographs of 3 kinds of primitive or doubtful Foraminifera.

WOODRING, W. P., and MALAVASSI V., ENRIQUE. Miocene Foraminifera, mollusks, and a barnacle from the Valle Central, Costa Rica.—Jour. Paleontology, v. 35, No. 3, May 1961, p. 489-497, pls. 69, 70, text fig. 1 (map).—Foraminifera, suggesting middle Miocene age, are listed.

ZEDLER, BRUNHILDE. Stratigraphische Verbreitung und Phylogenie von Foraminiferen des nordwestdeutschen Oberhauterive.—Paläont. Zeitschr., Band 35, Nr. 1/2, April 1961, p. 28-61, pls. 7, 8, text figs. 1-8 (graphs, drawings, range chart).—Includes descriptions and illustrations of 14 species (6 new), and discussions of 3 phylogenetic groups.

ZERNETH'KIJ, B. F. Pro znakhidku **Nummulites orbignyi** (Galeotti) na Volgo-Dons'komu Mezhirichchi.—Geol. Zhurnal, Akad. Nauk Ukraine. RSR, Vid. Khim, Geol. Nauk, tom 20, vyp. 5, 1960, p. 93-96, 1 pl.

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