

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
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287. LIVING PLANKTONIC FORAMINIFERA COLLECTED
ALONG AN EAST-WEST TRAVERSE IN THE NORTH PACIFIC¹

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ABSTRACT

Samples of living planktonic Foraminifera collected from the Northeastern Pacific suggest that a redefinition of previously described faunal boundaries may be of value. Cold-water populations of Foraminifera in this region are considerably larger than their southerly counterparts. However, variations in the composition of the faunas along an East-West traverse do not appear to be directly correlated with the available physical data.

INTRODUCTION

Bradshaw (1959) outlined the distribution of living planktonic Foraminifera in the North Pacific, in a comprehensive study. He divided the distribution of the species present into three general groups: a northern cold-water fauna, a southern warm-water fauna, and a transition fauna composed of species from the two other groups. In a previous paper, (Smith, 1963), the author described the distribution and ecology of Foraminifera collected in an area bounded by 39° and 51° N Lat. and by 141° W Long. and the west coast of North America. This fauna was similar, in relation to the species present, to Bradshaw's transitional fauna. However, fewer organisms and an extreme patchiness in distribution were noted. Concentrations of Foraminifera ranged from nil to 96.8 specimens per cubic meter of water filtered.

The present study is the result of an intention to sample both the cold-water and transitional faunas in areas not previously studied, and to describe more thoroughly the boundaries of existing faunas. The seven samples studied were collected in the summer of 1960 during an east-west traverse made by the *M. V. Brown Bear*, the University of Washington's research vessel.

All hauls were taken vertically from a depth of 200 meters to the surface, using one-half meter, number 12 mesh, nylon nets with apertures of 0.119 mm. The organisms were stored in glass jars containing formalin neutralized with borax. Prior to study, the samples were quartered with a mechanical splitter and small quantities from a single quarter were examined in a petri dish until all Foraminifera in that split had been identified and counted. Because few organisms were captured at stations one and two, the entire samples from those stations were sorted. Only one quarter of each of the five other samples was examined.

AREAL DISTRIBUTION

Text figure 1 locates the seven stations sampled and shows the percentages of each species present. Table 1 lists the number of specimens of each species collected at each station as well as the total population. Juveniles and poorly preserved specimens were counted, but were not identified specifically.

Station 1 showed the smallest population of Foraminifera; only 91 specimens, representing 4 species, plus the morphologic intergrade "*Globigerina pachyderma-eggeri*" were collected here. This form was discussed in the previous study (Smith, 1963). The faunal composition at station 1 agrees closely with that found during the earlier study. The chief difference lies in the greater abundance of *Globigerina quinqueloba* and *Globorotalia scitula*. The small number of species present was not unusual and can be explained as a result of the patchy distribution mentioned above.

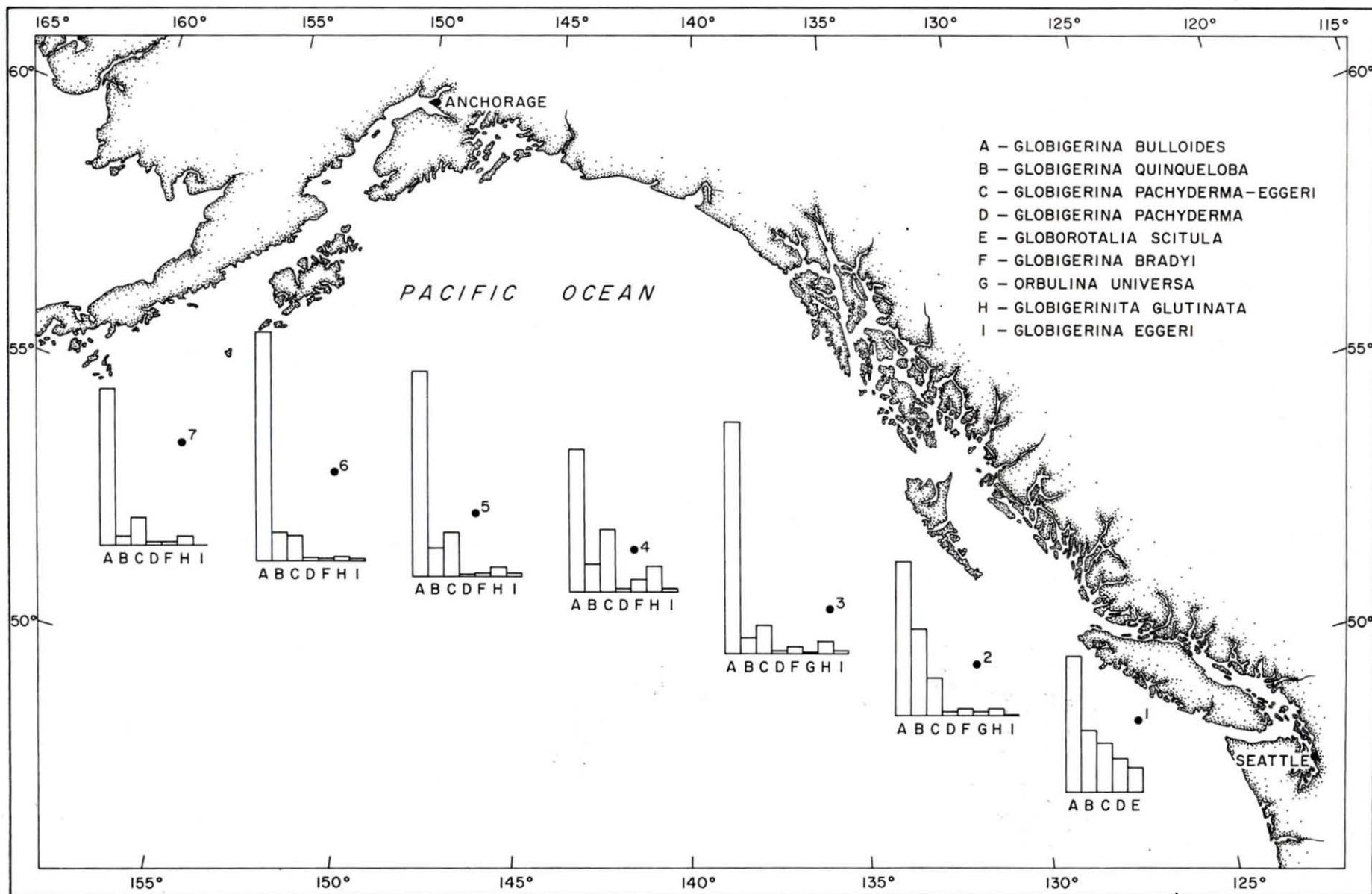
Station 2 exhibited a marked increase in the total number of Foraminifera. Here, 2384 organisms were collected. The only species recorded in the previous work that was not identified here is *G. scitula*, which appeared only at station 1. As at station 1, *Globigerina bulloides*, *G. quinqueloba* and "*Globigerina pachyderma-eggeri*" are the dominant forms.

The total number at station 3 (4246 in one quarter of the sample) was the highest recorded for the traverse. The composition of the fauna here was essentially the same as at station 2, except for the increased dominance of *G. bulloides*, which made up 75.3 percent of the population, and the lower abundance of *G. quinqueloba* relative to that of "*Globigerina pachyderma-eggeri*."

Stations 4 through 7 showed similar faunal compositions. *Orbulina universa*, the species used by Bradshaw to mark the northern limit of the transitional fauna, was not found. *Globigerina bulloides* was by far the dominant species, with "*Globigerina pachyderma-eggeri*" and *G. quinqueloba* ranking second and third except at station 6 where the latter comprised 9.0 percent of the population, and "*Globigerina pachyderma-eggeri*" 7.6 percent. Of the five seaward stations, number 4 showed the smallest total number of Foraminifera.

From these data, it would appear that the boundary of the transitional fauna lies farther northwest than was previously believed. Using the most northerly occurrence of *Orbulina universa* as our criterion

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TEXT FIGURE 1

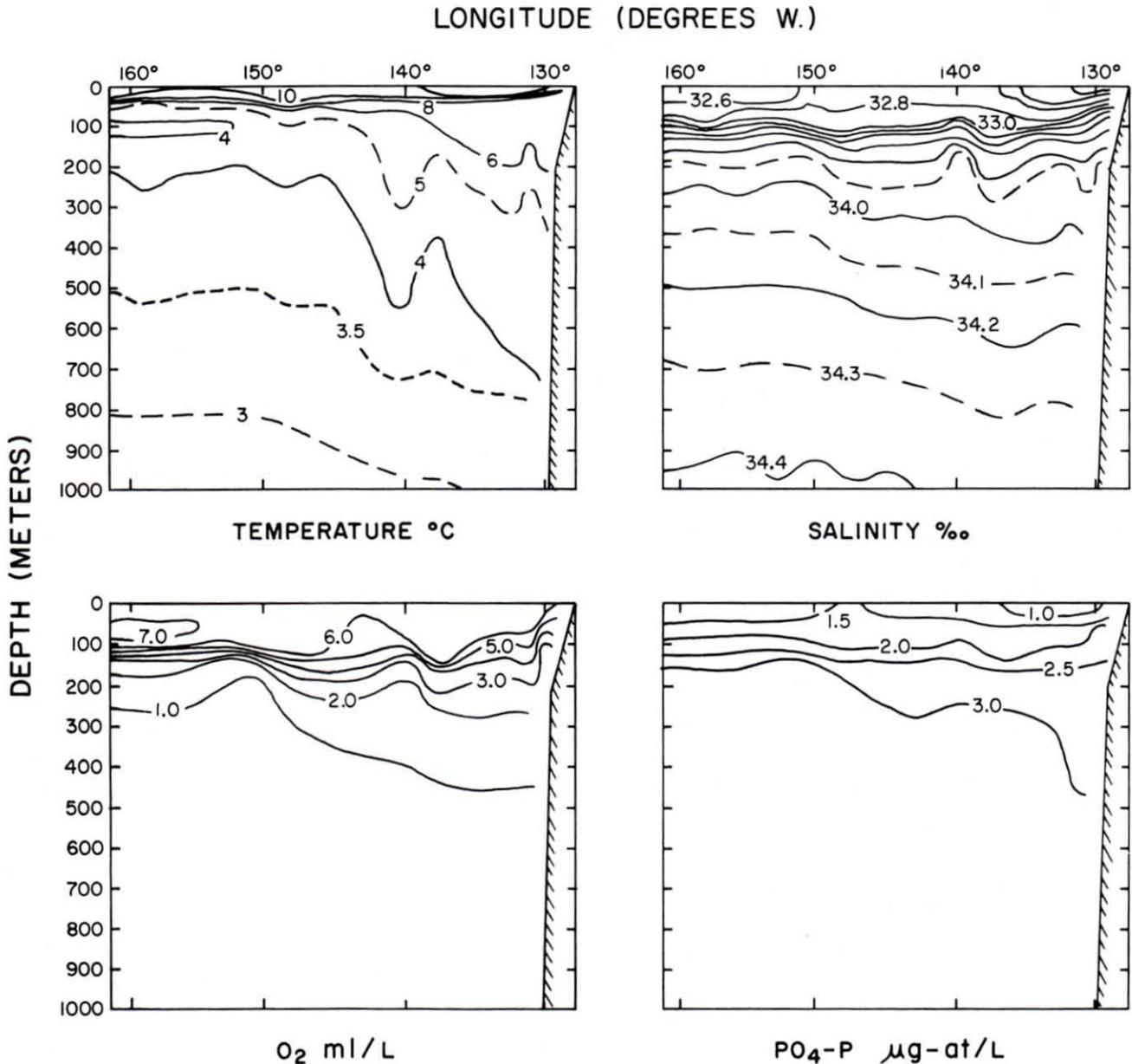
Locations of stations and the percentages of individual species collected at each station

ion, the boundary of the two faunas lies between stations 3 and 4. In addition to this criterion, Bradshaw (1959) also based his boundary on the northern limit of larger *Globigerina eggeri*. In the present study, only smaller forms were collected and their abundance was consistent throughout the traverse.

The definition of faunal boundaries from samples taken over a short period of time is extremely tenuous. Variations in the time of the reproductive cycles of the species may give erroneous impressions of their dominance. Adverse environmental conditions or extremely favorable conditions at the time of sampling can strongly bias our conclusions. The patchy distribution of the Foraminifera may add to our confusion. In the previous study (Smith, 1963), most species of planktonic Foraminifera ex-

hibited erratic distribution patterns; for example, *Orbulina universa* was found to be dominant at one of the stations and absent at the bordering stations. Therefore, any definition of faunal boundaries based upon one or two forms must be regarded with caution.

Perhaps the most striking feature of the cold-water fauna considered in the present study is its large increase in total numbers of Foraminifera compared to that of the transitional fauna off the coast of Washington and Oregon. This increase is gradual but is most striking at station 3 where the population is approximately seven times that observed at station 2. Even the smallest population, that found at station 4, is considerably larger than any of those found to the southeast.



Temperature, salinity, dissolved oxygen and inorganic phosphate concentrations in vertical sections at 52° N Lat. and extending from 130° to 160° W Long.

TABLE 1.—Number of Specimens Collected at Each Station

Species	Station						
	1	2	3	4	5	6	7
<i>Globigerina bulloides</i>	40	1203	3198	375	2068	1882	837
<i>Globigerina quinqueloba</i>	18	658	198	76	273	229	44
" <i>Globigerina pachyderma-eggeri</i> "	15	298	401	162	427	195	151
<i>Globigerina pachyderma</i>	10	30	19	7	26	16	19
<i>Globigerina bradyi</i>	0	47	106	36	37	15	24
<i>Globigerina eggeri</i>	0	7	18	7	22	11	3
<i>Globigerinita glutinata</i>	0	44	156	64	93	30	48
<i>Orbulina universa</i>	0	36	2	0	0	0	0
<i>Globorotalia scitula</i>	7	0	0	0	0	0	0
Totals include Juveniles and broken specimens not listed above	91	2384	4246	805	3108	2536	1651
			x	x	x	x	x
			4	4	4	4	4

TABLE 2.—Percentage of Left Coiling in *Globigerina pachyderma*

Station	Percent
1	100
2	67
3	95
4	86
5	96
6	81
7	89

There has been considerable recent interest in the use of coiling ratios in *Globigerina pachyderma* as a guide to paleotemperatures (Bandy, 1960). Because little has been published concerning these ratios for living specimens, they are included here, in Table 2. It must be remembered that this species is rare along the traverse and that the figures were derived on the basis of 7 to 30 specimens per sample.

PHYSICAL ENVIRONMENT

Because the planktonic Foraminifera appear to be uniformly distributed throughout the upper 150 to 200 meters of water, it is difficult to correlate their occurrence with physical variables in stratified water. Generally, these organisms will be living in two or three layers of water. Text figures 2, 3, 4, and 5, taken from the NORPAC Atlas (1960), rep-

resent temperature, salinity, dissolved oxygen and inorganic phosphate concentrations in vertical sections at 52° N Lat. and extending from 130° to 160° W Long. It can be seen that the horizontal composition of the water is quite uniform, as is the composition of the Foraminifera population. No explanation for the northern limits of the distribution of *Orbulina universa* and *Globorotalia scitula* can be offered on the basis of these data.

ACKNOWLEDGMENTS

Thanks are extended to Dr. James A. Gast who took charge of collecting the plankton samples.

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288. *NORMANIA CONFERTUM* FROM THE OSLO FIORD
IN NORWAY

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ABSTRACT

In 1952, in Oslo Fiord in Norway, an organism was found which certainly was identical with *Halyphysema confertum* described by A. M. Norman in 1878, and later renamed *Normania confertum* by Cushman in 1928. Some notes on the building of the test of this organism are presented here.

In 1878 A. M. Norman described an organism which he, with some reservations, assigned to the genus *Haliphysema* (Norman 1878, p. 279, pl. 16, fig. 1, 2). In the same paper he traced the history of this genus and referred to the different opinions which later on established that the genotype *Haliphysema tumanowiczi* and some other species were Foraminifera and not Spongia. *H. tumanowiczi* was described as a sponge in 1862 by Bowerbank, and Norman was, in 1878, of the same opinion as Bowerbank. Norman's description is:

"Animal consisting of a bunch of 'persons' attached together by their base, and forming nearly a complete ball. Body of persons nearly spherical, attached by a long slender pedicel. Pedicel 3-4 times as long, and not more than one fourth as broad, as the body. Mouth opening very large. Extraneous bodies, which incrust the animal, consisting, on the pedicel, of sand-grains and other very minute bodies, on the body, of sand-grains and Foraminifera."

In the text he also states that — "the extraneous material is not apparently completely built into the substance of the body-wall, but appears rather as though clinging to a viscid substance which holds it." It was found at the "Valorous" Expedition 1875, Station 9, 59° 10' N, 50° 25' W, depth 1750 fathoms. The position is in the southern part of the Davis Strait. Two specimens were found.

H. confertum was not mentioned again before J. Cushman in 1928 made it the genotype of the new genus *Normania* (Cushman, 1928, p. 7). Cushman's slightly altered description is:

"Test consisting of, a globular proloculum and small elongate tubular second chamber, individuals gathered together in masses, the tubular portions toward the center of the mass; wall chitinous with agglutinated material on the exterior, of sand grains or other foraminiferal tests; aperture at the end of the tubular chamber."

After 1928 it has, as far as I can see, not been mentioned again. Norman's two specimens, the only ones found, are seemingly lost. I have not been able to trace them.

During a study of the Foraminifera fauna in Oslo

Fiord one sample was taken July 9, 1952 outside Filtvet on mud bottom at 202 m. depth. 59° 33' N, 10° 08' E. This is outside the area treated in the investigation of the Foraminifera fauna of the Dröbak Sound (Christiansen, 1958). The sample from Filtvet contained a large number of Foraminifera and among them was a peculiar organism which was placed, together with a number of Foraminifera, in a microaquarium. The next day it had risen from the mud surface, and a drawing was made of it. This drawing is reproduced in Text figure 1. From the same mud sample also a similar organism, containing only one single animal, had risen from the mud surface. Nothing more happened for a few days, and the largest animal was fixed in alcohol. The smallest was lost. Later when the animal was more closely examined its likeness to Norman's figure was recognized. It has been searched for at the same locality many times, but in vain.

The organism found in Oslo Fiord agrees with Norman's description; the only difference is that it is a bit larger. Norman gives the following dimensions: "Diameter of cluster, containing forty or fifty 'persons' about one millim., length of a 'person' about one third of a millim." The animal from Oslo Fiord was: Diameter of the whole cluster about 1.5 mm., length of the longest animal (person) 1.08 mm., diameter of the largest globular chamber 0.25 mm.

Closer examination revealed the following facts (see Text figure 2): The tubular parts of the tests are hollow, built of small sand grains and apparently without any inner lining. These tubes contained, in the fixed animal, no protoplasm, only 1-6 very thin threads which run from the protoplasm in the globular parts of the tests through the tubes and down into the mud. The threads from the different tests were twisted around each other and this is the reason for the tests being gathered in a cluster. The tubes were seemingly not connected with each other. The threads are certainly a means of anchoring the animal in the mud. The same is seen in *Marsipella arenaria* (Christiansen, 1958, p. 32, fig. 13). In Norman's figure it seems that the tubes are actually connected, or built together at the base. There is another detail in Norman's figure not mentioned in the text. This is that it seems that in some of the specimens one tubular part extends from

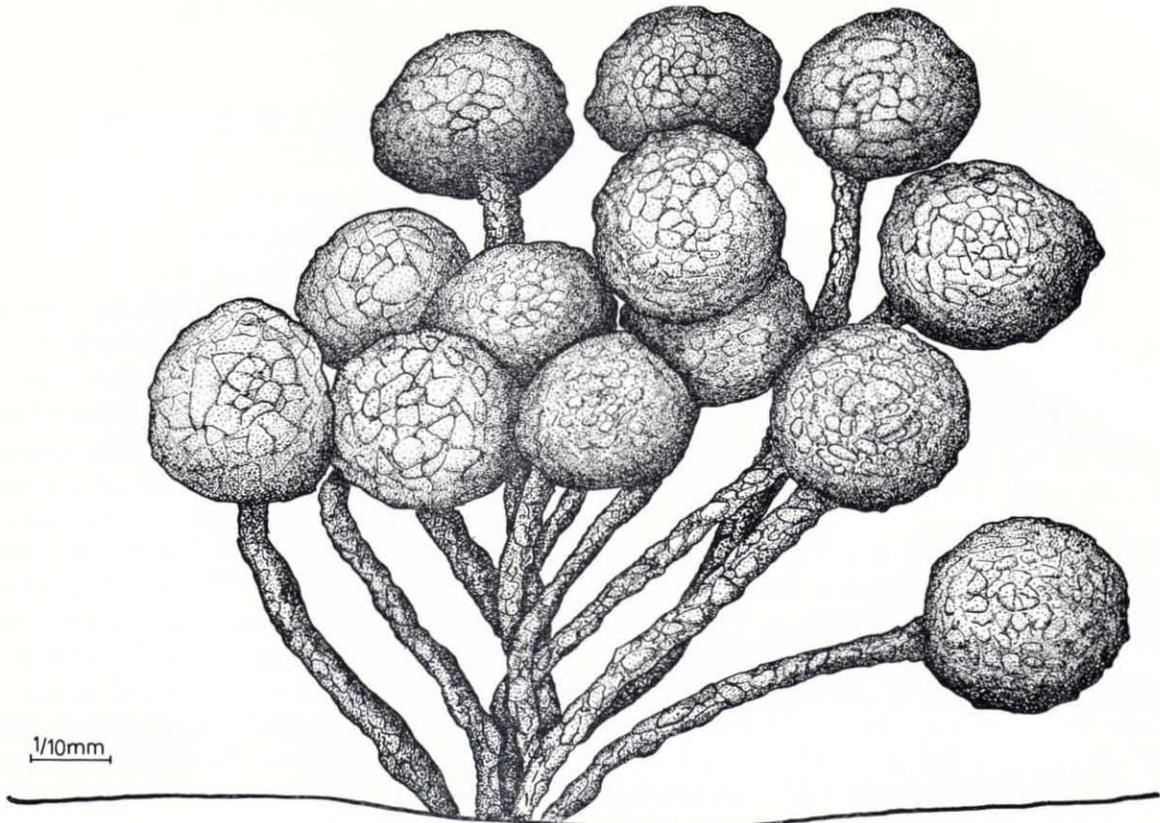


FIGURE 1

Normania confertum Norman. The living animal standing upright from the mud surface

each end of the globular part of the test, or the globular part is only an expansion on a long tubular part. This was not observed in the animals from Oslo Fiord.

The tubular parts of the tests were more loosely built than the globular parts, and during the handling of the tests most of the tubular parts disintegrated, leaving the globular tests hanging together in the thin threads.

The globular parts of the tests had apparently a strong inner lining and were built of one single layer of small mineral grains with very little "cement." No apertures were recognized on the globular chambers, but there were possibly some small openings between the mineral grains in the test wall (indicated by an arrow in Text figure 2). Cushman stated that the open end of the tubular parts of the tests were the apertures, but as these ends are stuck in the mud, it is perhaps less probable that these openings are the main openings for the extending pseudopodia. It depends, in fact, on where the animals take their food, from the free water or from the mud. They seem to be sessile animals anchored in the mud, and therefore most probably take their food from the free water.

The globular parts of the tests contained spherical masses of protoplasm with no visible structure. In the fixed animals the protoplasm occupied only a part of the inner volume of the globular parts of the tests. In 1963 some attempts were made to ex-

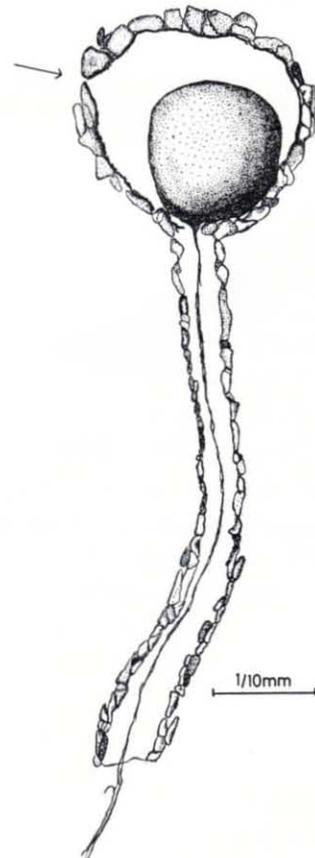


FIGURE 2

Section through one individual of *Normania confertum* Norman

amine the cytology of the protoplasm but in vain. No nuclei nor any other structure were recognized.

The single animal observed may be loosened from the larger one proving that each of the tests is an independent organism, or it may be a young individual which by a dividing process gives rise to the cluster of tests seen in the larger animal. The reason for this aggregate of tests seems to be the twisting of the fine threads, and the aggregation of the tests is therefore chance and no real colony.

It is an open question if this organism is a foraminifer. Norman clearly indicated that he was in doubt about its systematic position, and at last he assigned it to the genus *Haliphysema*, which at that time was recognized as a sponge. The present investigation has not proved anything, but it seems most probable that it is a foraminifer. The protoplasm clearly is unicellular, it may be a protozoan, or perhaps a cluster of eggs. The building of the test-walls and the anchoring by thin threads is very similar to what is found in some Foraminifera. Certainly this organism will be found again and

then it will be possible to state with certainty its real status.

The pronounced difference between the two places where *Normania* is found, seems curious, but is not exceptional. Some other deep-sea Foraminifera have been found in Oslo Fiord. Among others *Psammosphera testacea* Flint and *Sorosphaera confusa* Brady. Some notes regarding the distribution of these forms have been given in an earlier paper (Christiansen, 1958, p. 78).

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289. AMERICAN MID-TERTIARY MIOGYPSINID FORAMINIFERA:
CLASSIFICATION AND ZONATION¹

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ABSTRACT

Classifications of miogypsinids (larger Foraminifera) proposed by Drooger (1952, 1963), Cole (1957a) and Hanzawa (1962) are reviewed, and another classification based on the development of the embryonic apparatus is proposed. Two genera are recognized as occurring in America, *Miogypsinoides* with one species, and *Miogypsina* with two species. Additional data are given concerning variation in species of camerinids. The associations of miogypsinids, camerinids, and lepidocyclinids from selected geographic areas in the Americas are analyzed and an attempt is made to correlate zones of larger Foraminifera with those established on the basis of planktonic Foraminifera.

INTRODUCTION

Systemic study to develop a suitable classification of American species of the miogypsinid kind of larger Foraminifera was initiated by Drooger. In 1952 he published a statistical method of classification, and stratigraphically arranged the 14 species he recognized from different geographic areas on a phylogenetic chart (Drooger, 1952, p. 72).

Akers and Drooger (1957) published extensive information on the miogypsinids from samples from wells drilled on the Gulf Coast of the United States from Louisiana to Florida. In the text and by charts (Akers and Drooger, 1957, text figs. 1, 2) the stratigraphic and geographic distribution of the American species of miogypsinids and associated species of other benthonic and planktonic Foraminifera were shown.

Cole (1957a) in a study based on miogypsinids from Barro Colorado Island, Canal Zone, collected by W. P. Woodring of the U. S. Geological Survey, and supplemented by specimens from wells in Florida, and by specimens from outcrop samples in Mexico, Trinidad and Anguilla, proposed an alternate classification in which only five species of miogypsinids were recognized. He (Cole, 1957a, p. 318) stated that ". . . Drooger's statistical approach was sound, but he allowed himself to be over-influenced by minor variations which occur in all the larger Foraminifera . . . Therefore, the number of specific separations will be increased, as the division is artificial rather than natural."

Hanzawa (1962) reviewed and revised the classification of many species of larger Foraminifera and included a detailed discussion of a system for the identification of species of miogypsinids, par-

ticularly species of the genus *Miogypsinoides*. He (Hanzawa, 1962, p. 155) emphasized in his opinion that ". . . all miogypsinid species are considered as being characterized by their distinctive juvenaria, and there is no individual variation in their nepionic stages, as referred to by Cole (1957)."

Drooger (1963, p. 314) wrote concerning Hanzawa's system of classification: "Hanzawa's (1957) pronounced splitting of *Miogypsinoids* into species, based on the ordinal number of the nepionic chamber at the apex of the test (a feature correlated with our γ), completely disregards the existing variation in every sample."

Recently, Drooger (1963, p. 315-349) gave a restatement of his classification in which he considered most of the species of miogypsinids of the world. The evolutionary development of the miogypsinids presented by Drooger is similar to the concept advanced by Barker and Grimsdale (1937, p. 168) and seemingly is correct.

However, the statistical scheme by which Drooger recognized species is inflexible, as the species are recognized by mathematic averages which do not reflect the variation which may occur in the basic growth pattern between individuals of a single population, and the influence of ecological conditions has been ignored. Moreover, Drooger's classification (1963, p. 346) implied that the species can be arranged rather precisely on a chronostratigraphic scale in which the species follow each other in regular order and exist for only a limited span of geologic time.

Akers and Drooger (1957, p. 658, 659, 669) gave the stratigraphic order from older to younger of certain species of *Miogypsina* as *M. thalmani*, *M. panamensis*, *M. gunteri* and *M. tani* on the Gulf Coast of the United States. Drooger (1963, p. 346) repeated this order for these species.

Figures 7, 10, Plate 10 from locality 7 (Caimito formation) seemingly represent *M. tani*. These specimens have a uniserial coil of not more than 7 chambers partially surrounding the embryonic chambers. Other specimens (Pl. 9, fig. 4; Pl. 11, fig. 4) from this same locality, if I interpret Drooger's classification correctly, should be referred to *M. gunteri-tani* as there are 10 chambers which encircle the embryonic chambers.

Specimens (Pl. 9, fig. 3; Pl. 11, figs. 2, 3, 11) from locality 4 (Bohio formation) are *M. gunteri*.

¹ The cost incidental to this study including the printed plates was supplied by the William F. E. Gurley Foundation for paleontology of Cornell University.

As locality 4 is known to be stratigraphically older than locality 7, it would appear that Drooger's classification and stratigraphic order of the species was correct, at least, in the case of *M. gunteri* and *M. tani*.

However, the topotypes of *M. panamensis* (Pl. 9, fig. 5; Pl. 10, figs. 4, 5, 9) are from the Caimito formation at approximately the same stratigraphic level as locality 7. Therefore, in Panama, *M. panamensis* occurs above, not below, *M. gunteri*.

Woodring (1960, p. 31) recently stated "It may be pointed out that the type locality of *Miogyopsina 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."

Although Drooger (1963, p. 346) retained *M. cushmani* and *M. antillea* as distinct species, topotypes (Cole, 1957a, pl. 29, figs. 1, 8, 9) of these two species are identical. Moreover, they occur at approximately the same stratigraphic level, as Woodring (1957, p. 37) recently stated that the mollusks favored correlation of the Culebra, including the Emperador member, with the Anguilla formation.

These illustrations show that the evolutionary development of American *Miogyopsina* and their stratigraphic position are not in accord with the sequences postulated by Drooger's scheme.

As Drooger's statistical approach resulted in the recognition of some 15 species, each of which is postulated to have a more or less restricted stratigraphic range, his interpretation of the evolutionary history and speciation of the miogyopsinids is at variance with interpretations of Cole (1957a; 1957b; 1958b; 1958c; 1961b) of the development of American camerinids, discocyclinids, and lepidocyclinids. Although the miogyopsinids are a distinct group, it would be remarkable if they developed so many species in a much shorter geologic time span than the other groups of larger Foraminifera did. Therefore, a restudy was made of the American miogyopsinids which resulted in the classification to be presented later in this article.

An attempt will be made not only to present the probable development of the miogyopsinid test as the basis of the classification, but also to consider the associated species of larger Foraminifera occurring at each of the selected localities.

The nomenclature of the associated species of larger Foraminifera which will be used is from the recent publications of Cole. However, proof will be offered that *Camerina dia* is a synonym of *Camerina panamensis* and that only a single species of *Heterostegina* occurs in the stratigraphic interval discussed in this article.

LOCALITIES OF THE FIGURED SPECIMENS

GEORGIA

Loc. 1—Carpenter Oil Co., C. T. Thurman No. 2 well, Land District 1, Land Lot 189, 450 feet northwest of the center of the SE $\frac{1}{4}$ of Land Lot 189, Coffee County, at a depth of 460-470 feet. (Reference: Cole and Applin, 1961, p. 127). Oligocene.

FLORIDA

Loc. 2—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; collected by W. S. Cole and G. M. Ponton, 6 July 1929 (Reference: Cole and Ponton, 1930, p. 21). Marianna limestone.

Loc. 3—Port St. Joe Test well no. 3, Port St. Joe, Gulf County, at a depth of 996-1017 feet (Reference: Cole, 1938, pl. 8, fig. 4). Suwanee limestone.

PANAMA CANAL ZONE

Loc. 4—Stream east of Shannon Trail, about 335 meters southeast of Shannon 1, Barro Colorado Island; 42h, collected by W. P. Woodring, 1954 (References: Cole, 1957a, p. 313; Woodring, 1957, p. 116; 1958, p. 34). Bohio formation.

Loc. 5a—"Foraminiferal marl and coarse sandstone about 200 yards (200 meters) south of southern end of switch at Bohio Ridge station, relocated Panama Railroad. D. F. MacDonald and T. W. Vaughan, 1911 (MacDonald, 1919, p. 540, pl. 154)." (Reference: Woodring, 1957, p. 117). U.S.G.S. no. 6025: Type locality of *Camerina panamensis*, *Miogyopsina panamensis* and *Lepidocyclina pancanalisis* (References: Cushman, 1918, p. 97, 98; Vaughan and Cole, 1932, p. 510). Middle member of Caimito formation.

Loc. 5b—"Panama Railroad, east side of second cut southeast of Bohio Peninsula. Soft calcareous tuffaceous sandstone. S. M. Jones and W. P. Woodring." (Reference: Woodring, 1957, p. 117). Same locality as 5a (Reference: Cole, 1952, p. 6, 7).

Loc. 6—Low garden islet 0.25 mile northeast of landing, Barro Colorado Island; 53, collected by S. M. Jones and W. P. Woodring, 1947 (References: Cole, 1952, p. 6; Woodring, 1957, p. 116; 1958, p. 34). Middle member of Caimito formation.

Loc. 7—Stream crossing Standley Trail at Standley 11 plus 60 meters, about 30 meters downstream from trail, Barro Colorado Island; 54f, collected by W. P. Woodring, 1954. (References: Cole, 1957a, p. 316; Woodring, 1957, p. 117; 1958, p. 35). Middle member of Caimito formation.

- Loc. 8—Second stream northwest of end of Armour Trail, about 60 meters above mouth, Barro Colorado Island; 54l, collected by W. P. Woodring, 1954 (References: Cole, 1957a, p. 316; Woodring, 1957, p. 117; 1958, p. 35). Middle member of Caimito formation.
- Loc. 9—"Near Canal station 1910, northwest of Pedro Miguel Locks. [About 600 meters northwest of north end of Pedro Miguel Locks]. Mudstone. D. F. MacDonald and T. W. Vaughan, 1911 (MacDonald, 1919, p. 534, pl. 154)." (Reference: Woodring, 1957, p. 124). U.S.G.S. no. 6010: Type locality of *Siphogenerina transversa* Cushman (Reference: Cushman, 1918, p. 64). La Boca marine member of Panama formation.

MEXICO

- Loc. 10—500 meters east of Rancho Abajo which is near kilometer 9 on the Huasteca Petroleum Company's narrow gauge railroad between San Geronimo and Cerro Azul, Tampico Embayment Area (Reference: Cole, 1957a, p. 319). Meson formation.
- Loc. 11—Papantla—Tajin Road, bend in road northeast of Finca de los Tremari, Veracruz (References: Nuttall, 1933, p. 176; Cole, 1952, p. 36). Tuxpan formation.

JAMAICA

- Loc. 12—Between Dumfries and Content, St. James; collected by H. R. Versey (Reference: Cole, 1956, p. 212). Montpelier formation.

TRINIDAD

- Loc. 13—Kugler loc. K11399, Morne Diablo quarry; collected by Hans G. Kugler (References: Cole, 1957a, p. 324; 1957b, p. 32), Morne Diablo limestone.

ANGUILLA

- Loc. 14—U.S.G.S. no. 6965, Crocus Bay; sample supplied through the courtesy of W. P. Woodring (Reference: Cushman, 1919, p. 50). Anguilla formation.

ABUNDANCE OF
MID-TERTIARY AMERICAN SPECIES
OF LARGER FORAMINIFERA

In this discourse 12 species of camerinids, miogypsinids, and lepidocyclinids, occurring in the Caribbean region in sediments classified by many American stratigraphers as Oligocene and lower Miocene are recognized as valid species on the data available. However, if the extensive literature on American larger Foraminifera is examined, one discovers that more than 68 specific names have been proposed for species in these three groups of larger Foraminifera in this stratigraphic interval.

Camerina panamensis has had, at least, 10 specific names applied to it (*antiguensis*, *bullbrookii*, *dia*, *ellisoriae*, *forresti*, *howei*, *muiri*, *palmarealensis*, *semmesi*, and *vicksburgensis*). *Heterostegina antillea* has been called *H. israelskyi*, *H. panamensis* and *H. texana*. *Spiroclypeus bullbrookii* is the only American camerinid to which other names have not been applied.

Six species of lepidocyclinids are recognized in this discourse, but some 40 names have been used for these six species. For *Lepidocyclina canellei* alone Cole (1961b, p. 383-386) recorded eight synonyms, and that listing was not complete.

Two species of *Miogypsinoides* have been recognized in the Caribbean region, but only *Miogypsinoides complanatus* is recognized. Some 16 species of *Miogypsina* have been named, but of these only two are considered to be valid.

Table 1 presents the stratigraphic distribution by zone and subzone of the 12 American species of larger Foraminifera which occur between the top of the Eocene and the final extinction of these species in the Caribbean region. The zone names were defined by Cole (1957b, p. 37) for the American Oligocene and lower Miocene based on larger Foraminifera, and later he (Cole, 1958a, p. 220), Sachs (1959, p. 403) and Cole and Applin (1961, p. 131) found this zonation useful in correlating the general stratigraphic position of faunas of larger Foraminifera from different geographic areas.

Brönnimann and Rigassi (1963, p. 444) modified the zonation based upon larger Foraminifera. They recognized an Oligocene *Lepidocyclina* (*Lepidocyclina*)-*Lepidocyclina* (*Eulepidina*) zone, followed by Miocene *Heterostegina antillea*, and *Operculinoides* zones. They divided the *Heterostegina* zone into a lower *Lepidocyclina* (*Lepidocyclina*)-*Miogypsina* subzone succeeded by a *Miogypsina* subzone.

If Brönnimann and Rigassi's modifications were accepted, the faunas of larger Foraminifera from the Caimito formation (Cole, 1957a; Woodring, 1958, p. 24) which Woodring (1960, p. 27) correlated with the planktonic *Globorotalia kugleri* zone would fall in their *Lepidocyclina* (*Lepidocyclina*)-*Miogypsina* subzone of their *Heterostegina antillea* zone. However, *Miogypsinoides complanatus* occurs with *Heterostegina antillea* and *Lepidocyclina* (*Eulepidina*) *undosa* in Mexico (loc. 10); *Lepidocyclina* (*Eulepidina*) *vaughani* occurs with *Heterostegina antillea* and *Miogypsina* in Carriacou (Cole, 1958a, p. 221); *L. (E.) undosa* and *L. (E.) tournoueri* occur with *Heterostegina antillea* and *Miogypsina* at several localities in Trinidad (Vaughan and Cole, 1941) and the types of *L. (E.) undosa* and *Heterostegina antillea* were obtained from the same locality (U.S.G.S. no. 6869, Antigua).

Moreover, in Trinidad (Cole, 1957a, p. 34), Panama (Cole, 1961c, p. 136), and in Jamaica

TABLE 1.—Distribution of Mid-Tertiary American Species of Larger Foraminifera by Zones

Species	Zone		<i>Eulepidina</i>		<i>Lepidocyclina s. s.- Miogypsina</i>
	Sub-zone		<i>Lepidocyclina s. s.</i>	<i>Miogypsina</i>	
<i>Camerina panamensis</i> (Cushman)			X	X	X
<i>Lepidocyclina</i> (<i>Lepidocyclina</i>) <i>canellei</i> Lem. & R. Douvillé			X	X	X
<i>mantelli</i> (Morton)			X	X	X
(<i>Eulepidina</i>) <i>urnagunensis</i> Cushman			X	X	X
<i>undosa</i> Cushman			X	X	
<i>Heterostegina antillea</i> Cushman				X*	?
<i>Spiroclypeus bullbrooki</i> Vaughan & Cole				X	
<i>Lepidocyclina (Eulepidina)</i> <i>ournoueri</i> Lem. & R. Douvillé				X	
<i>vaughani</i> Cushman				X	
<i>Miogypsinoidea complanatus</i> (Schlumberger)				X†	
<i>Miogypsina panamensis</i> (Cushman)				X	X
<i>antillea</i> (Cushman)					X

* Seemingly ranges in Cuba into the *Lepidocyclina-Miogypsina* zone.

† Lower part only.

(loc. 12; Cole, 1956, p. 213, loc. V170) *Lepidocyclina (Lepidocyclina)* and *Miogypsina* occur in association in sediments which represent the final occurrence of these kinds of larger Foraminifera. *Heterostegina antillea* to date has not been found in this zone, except possibly in Cuba.

As *Heterostegina* occurs with various species of the subgenus *Eulepidina* in Panama, Antigua, Trinidad, Mexico and elsewhere, *Heterostegina antillea* is one of the diagnostic species of the *Eulepidina* zone as defined and used by Cole. Therefore, that part of Brönnimann and Rigassi's *Heterostegina antillea* zone which they correlated with the *Globorotalia kugleri* planktonic zone would be referred by Cole to the *Miogypsina* subzone of the *Eulepidina* zone. The remainder of the *Heterostegina antillea* zone (the parts which Brönnimann and Rigassi correlated with the *Catapsydrax dissimilis* and *Globigerinatella insueta* planktonic zone) would correspond to the *Lepidocyclina (Lepidocyclina)-Miogypsina* zone of Cole.

From the data available the *Lepidocyclina s. s.* subzone of the *Eulepidina* zone of Table 1 correlates with the *Globigerina ampliapertura*, *Globorotalia opima* and *Globigerina ciproensis* planktonic zones. The lower part of the *Miogypsina* subzone seemingly occurs in the upper part of the *Globiger-*

ina ciproensis planktonic zone, but the major part of the *Miogypsina* subzone correlates with *Globorotalia kugleri* planktonic zone. The *Lepidocyclina s. s.-Miogypsina* zone of Table 1 spans the interval included in the *Catapsydrax dissimilis*, *Catapsydrax stainforthi*, and *Globigerinatella insueta* planktonic zones. Similar zonal correlations were suggested by Woodring (1960, p. 27) and are in conformity with the data obtained in this study.

VARIATION IN SOME AMERICAN SPECIES OF CAMERINIDS

Camerina panamensis was described by Cushman (1918, p. 98) as *Nummulites panamensis* from the Panama Canal Zone. Vaughan and Cole (1941, p. 46) restudied and illustrated (pl. 10, figs. 13, 14; pl. 11, figs. 1-4) topotypes. In Trinidad they referred specimens from locality K2907, Morne Diablo, to *Camerina panamensis*. Other specimens from this same locality (K2907) were made the types of a new species, "*Operculinoides*" *bullbrooki* Vaughan and Cole (1941, p. 44).

Cole (1958b) reviewed the American species of camerinids. He (p. 272) maintained *Camerina panamensis* as a valid species, but placed "*Operculinoides*" *bullbrooki* in the synonymy of "*Operculinoides*" *dia*. *Camerina panamensis* was separated

by Cole (1958*b*, p. 263) from *Camerina dia* on the supposed differences in recurvature of the chambers as viewed in median section and upon the degree of roundness of the marginal cord as viewed in transverse section.

Although Cole (1958*b*) originally maintained such generic names as *Operculinoides*, he later revised this opinion and assigned the camerinids with undivided chambers, formerly placed in such genera as *Operculina*, *Operculinoides* and *Ranikothalia*, to *Camerina* (Cole, 1960, p. 189-198; 1961*a*, p. 111-123; 1961*b*, p. 377-383; see Cole, 1953, p. 31, footnote 3).

Five new thin sections (Pl. 14, figs. 2, 6, 9, 10, 14) of topotypes of "*Nummulites*" *panamensis* Cushman are illustrated. Figures 1, 5, 11, Plate 14 are topotypes of "*Operculinella*" *dia* Cole and Ponton. Three thin sections (Pl. 14, figs. 3, 8, 13) represent specimens previously (Cole, 1957*b*, pl. 5, figs. 6, 7) identified as "*Amphistegina*" *bullbrookii* (Vaughan and Cole). Three specimens (Pl. 14, figs. 4, 7, 12) were identified originally (Cole, 1957*a*, p. 314) as "*Operculinoides*" *panamensis*.

Comparison of these new thin sections demonstrates that there are not any significant differences between these specimens from four different localities. Therefore, "*Operculinella*" *dia* is assigned to the synonymy of *Camerina panamensis*.

Several thin sections (Pl. 13, figs. 1-3, 6, 8, 11, 12) of *Heterostegina* are illustrated. Previously, Cole (1957*a*, p. 319) identified the specimens (Pl. 13, figs. 1, 3, 6, 11, 12) from locality 10 (Mexico) as *H. israelskyi*. Vaughan and Cole (1932, p. 511) identified the specimens (Pl. 13, figs. 2, 8) from the Canal Zone (loc. 5*a*) as *H. panamensis*. Recently, Sachs (1959, p. 405) combined *H. israelskyi* with *H. antillea*, a revision which is accepted.

Although Sachs (1959, p. 406) maintained *Heterostegina panamensis* as a valid species, it is another synonym of *H. antillea*. *Heterostegina panamensis* has been characterized as biconvex, involute with one to four operculine chambers and pronounced axial plugs, whereas *H. antillea* was in-

volute, more or less compressed with one operculine chamber. As certain specimens formerly referred to *H. panamensis* have all the characteristics of *H. antillea*, *H. panamensis* is considered to be another synonym of *Heterostegina antillea*.

THE MIOGYPSINIDS

BASIS OF CLASSIFICATION OF THE MIOGYPSINIDS

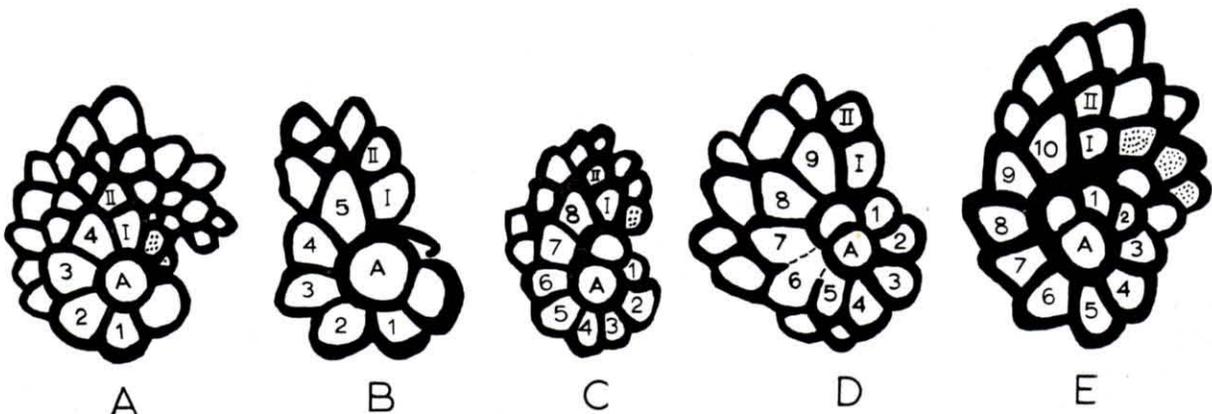
Kinds of Test.—There are two basic kinds of miogypsinid tests: 1) those in which lateral chambers are not developed (Pl. 11, fig. 10) (*Miogypsinoides*), and 2) those in which lateral chambers are present (Pl. 10, fig. 2) (*Miogypsina*). The bilocular embryonic chambers in *Miogypsinoides* are followed by a uniserial coil of periembrionic chambers of approximately 1½ whorls (Pl. 11, fig. 7). The bilocular embryonic chambers in *Miogypsina* are followed either by a uniserial coil of periembrionic chambers (Pl. 9, figs. 1-6) or by biserial coils of periembrionic chambers (Pl. 12, figs. 2-6, 8, 9).

Uniserial Miogypsina.—Text figure 1 is a series of sketches made from specimens of *Miogypsina* each of which has a uniserial coil of periembrionic chambers. The specimens from which these sketches were made are illustrated by photomicrographs as follows:

Text-figure	Illustrated on:	Locality
1A	Pl. 9, fig. 6; Pl. 10, fig. 7	7
1B	Pl. 9, fig. 2; Pl. 10, fig. 8	7
1C	Pl. 9, fig. 4; Pl. 11, fig. 9	7
1D	Pl. 9, fig. 1	3
1E	Pl. 9, fig. 5; Pl. 10, fig. 9	5 <i>b</i>

In these sketches the initial embryonic chamber is designated by A, the periembrionic chambers are numbered, and the equatorial chambers immediately following the last periembrionic chamber are designated by Roman numerals.

The specimen represented by text figure 1D is one of the types of *Miogypsina gunteri* Cole (1938, pl. 8, fig. 4). Text figure E is a topotype of *Heterosteginoides panamensis* Cushman (1918, p. 97).



TEXT FIGURE 1

Diagrams of the embryonic apparatus of the uniserial kind of *Miogypsina*

Text figure 1C represents a specimen similar to ones previously identified as *M. panamensis* (see: Cole, 1957a, pl. 27, fig. 2), and text figures 1A, B are similar to specimens previously named *M. antillea* (see: Cole, 1957a, pl. 28, figs. 7-9).

In classifications previously used the embryonic apparatus of specimens similar to that of text figure 1E (Pl. 9, fig. 5) has been defined as consisting of three parts: 1) the bilocular embryonic chambers, 2) the coil of large, distinct perieembryonic chambers, designated 1 to 10 on text figure 1E, and continuing through I as the row of stippled chambers and 3) the intercalary chambers (Drooger, 1952, p. 5) which occur between the row of stippled chambers and the numbered perieembryonic chambers on text figure 1E.

However, the basic pattern of the embryonic apparatus of large suites of *Miogypsina* with the uniserial kind of embryonic chambers of which text figures 1A-E are representative consists only of two parts: 1) the bilocular embryonic chambers, and 2) the large, distinct perieembryonic chambers which are designated by Arabic numerals on the sketches.

These perieembryonic chambers are followed by two smaller chambers designated by Roman numerals I and II on the sketches. These chambers represent the first equatorial chambers developed at the distal end of the perieembryonic coil, and are in every respect similar to equatorial chambers developed elsewhere in the equatorial plane. Therefore, such chambers should not be included in the perieembryonic sequence.

Text figure 1E and the photomicrograph (Pl. 9, fig. 5) from which this sketch was made demonstrate the method of formation of the chambers. The initial chamber (A) formed from which the protoplasm flowed through a single stolon to develop the second embryonic chamber. From a single stolon in the wall of the second embryonic chamber just above the dividing wall between the embryonic chambers a mass of protoplasm protruded to form the first perieembryonic chamber (1).

Perieembryonic chambers (text figure 1E) 2 to 10 were developed by protoplasm extruded through stolons at the base of the perieembryonic chamber wall just above the wall of the embryonic chambers. However, beyond perieembryonic chamber (1) each perieembryonic chamber has two major stolons, the basal stolon adjacent to the embryonic chamber wall and another stolon at the base of the chamber wall which joins the preceding perieembryonic chamber.

Thus, from perieembryonic chamber (2) two chambers were generated, perieembryonic chamber (3) and the unmarked chamber directly above perieembryonic chamber (2). In a similar manner development continued through the formation of perieembryonic chambers to (10). Two revolving

coils were developed in sequence around the embryonic chambers, the inner one (1 to 10) consisting of the large perieembryonic chambers and the outer one composed of the initial row of equatorial chambers.

After the development of the final perieembryonic chamber (10) (text fig. 1E) a normal equatorial chamber (I) developed. From the basal stolon of this chamber the adjacent stippled chamber developed, and from the other stolon of I another normal equatorial chamber (II) was formed. The adjacent unmarked chamber and succeeding chambers then developed.

Thus, all chambers above and beyond the distinct perieembryonic chambers are considered to be normal equatorial chambers, and not a part of the embryonic apparatus.

In other specimens (text fig. 1D; Pl. 9, fig. 1) the first equatorial chamber from the perieembryonic row is generated from perieembryonic chamber (4) rather than from perieembryonic chamber (2) (text fig. 1E). In such cases the initial part of the perieembryonic coil (2 to 3) is in contact with the marginal fringe of the test (Pl. 9, fig. 1).

Moreover, after the development of equatorial chambers I and II, following perieembryonic chamber (9) in text figure 1D, only one or two equatorial chambers developed. However, the basic pattern of the development of the embryonic apparatus of this specimen (*M. gunteri* — text fig. 1D; Pl. 9, fig. 1) is entirely analogous to that of *M. panamensis* — (text fig. 1E; Pl. 9, fig. 5) although in *M. panamensis* more initial equatorial chambers developed, and the perieembryonic chambers are separated by equatorial chambers from the marginal fringe.

The development of the embryonic apparatus in text figure 1C (Pl. 9, fig. 4) is identical with that shown in text figure 1D (Pl. 9, fig. 1) except there are 8 perieembryonic chambers rather than 9.

Text figures 1A (Pl. 9, fig. 6) and 1B (Pl. 9, fig. 2) have short perieembryonic coils with 4 and 5 perieembryonic chambers, and the second embryonic chamber is in contact with the marginal fringe. Otherwise the development of the embryonic apparatus is similar to those described in text figures 1C-E.

The specimen (Pl. 9, fig. 3) has 10 perieembryonic chambers beyond which only chambers I and II appear before the marginal fringe developed. However, at this same locality 4 other specimens (Pl. 11, fig. 8) have three rows of equatorial chambers beyond chambers I and II. (In this specimen, figure 8, Plate 11, there are 7 perieembryonic chambers followed by a large chamber I and a small chamber II).

In many equatorial and vertical sections two distinct kinds of structure occur, the chamber walls, and the marginal fringe (Pl. 9, figs. 2, 6, lower

part). The chamber walls represent deposits accumulated around the periphery of masses of protoplasm extruded from stolons. However, the marginal fringe probably developed as deposits between elongated filaments of protoplasm. Thus, the marginal fringe is composed of more or less radial rods between which occur elongated porous spaces.

In certain specimens (Pl. 9, figs. 2, 6) the outer wall of the second embryonic chamber appears to be pierced by minute pores. Such specimens have a strongly developed marginal fringe. Moreover, in this kind of specimen the second embryonic chamber is apical with only the marginal fringe separating it from the periphery of the test.

In specimens, such as figure 5, Plate 9, a small development of radial, porous structure develops on the outer wall of the initial periembrionic chamber producing a thickened area between the periembrionic chamber (1) and the overlying equatorial chamber I (text fig. 1E).

The position of the stolons governs the basic arrangement of the chambers. The number of periembrionic chambers in individuals from a single population (loc. 7) varies from 4 (Pl. 9, fig. 6), (5 Pl. 9, fig. 2; 6 Pl. 10, fig. 1) to 8 (Pl. 9, fig. 4). Specimens in which a well developed marginal fringe occurs in contact with the second embryonic chamber have a smaller number of periembrionic chambers, and the second embryonic chamber is situated apically.

Therefore, the conclusion has been reached that certain individuals (Pl. 9, fig. 4) rapidly develop a longer coil of periembrionic chambers as most of the protoplasmic mass is utilized for the construction of these chambers. Other individuals, however, have only a part of the protoplasmic mass available for the development of periembrionic chambers as the other part is extruded as the filaments from which the marginal fringe develops.

The basic pattern of the embryonic apparatus is determined by the distribution of the protoplasm as well as the position of the stolons. Certain specimens of a species may develop a long coil of periembrionic chambers (8 or more) whereas other specimens of this species may construct a short coil of periembrionic chambers (3 to 5). Specimens (Pl. 9, figs. 1, 3, 4, 5) which rapidly develop the long coil of periembrionic chambers have these chambers between the embryonic chambers and the margin of the test. Specimens (Pl. 9, figs. 2, 6) in which the periembrionic coil is short have the second embryonic chamber in contact with the marginal fringe which is highly developed because of numerous filaments of protoplasm.

Topotypes of *Miogypsina panamensis* (Pl. 9, fig. 5) consistently have the chamber walls thicker than specimens of *Miogypsina* from other localities have. Moreover, these specimens have longer periembrionic

coils and a more rapid development of equatorial chambers. Superficially, therefore, the embryonic development appears to be different (compare Pl. 9, fig. 5 with Pl. 9, fig. 4).

Since the basic pattern of development is similar, such differences may be assigned to ecological rather than genetic control. The type specimens of *M. panamensis* (Pl. 9, fig. 5) occupied an ecological niche in which conditions, such as food supply or temperature, were more favorable for rapid growth than did specimens such as the ones illustrated by figures 1, 4, Plate 9.

If these conclusions are accepted, specimens previously classified into several species, such as *Miogypsina tani* Drooger, *M. gunteri* Cole and *M. panamensis* (Cushman), must represent only one species. For this sequence of *Miogypsina* with a uniserial periembrionic coil the name *M. panamensis* (Cushman) is applied.

Biserial Miogypsina.—The specimens (Pl. 12, figs. 2-6, 8, 9) have biserial periembrionic development in which the periembrionic coils develop from two initial periembrionic chambers, one on each side of the embryonic chambers. In this kind of *Miogypsina* the second embryonic chamber developed two stolons, whereas in the uniserial kind of *Miogypsina* only one stolon developed.

In the biserial *Miogypsina* each of the two initial periembrionic chambers developed four coils of periembrionic chambers so that these coils completely surround the embryonic chambers. Seemingly, the two coils which surround the initial embryonic chamber (larger embryonic chamber, Pl. 12) are composed of slightly larger periembrionic chambers than the periembrionic chambers around the second embryonic chamber.

Equatorial chambers may develop from all of the periembrionic chambers. Because of the availability of protoplasm, the most rapid development of equatorial chambers occurs from the two partial rings of periembrionic chambers which encircle the initial equatorial chamber. This focus of protoplasm outward from the initial periembrionic chambers determines the direction of expansion of the test through the more rapid addition of equatorial chambers in this direction.

Tests so produced have the embryonic apparatus situated in a subapical position, and such embryonic apparatus are surrounded completely by normal embryonic chambers. Specimens exhibiting this pattern have been assigned to the subgenus *Miolepidocyclina*, and American species which have been named *Miogypsina staufferi* Koch and *M. bronni-manni* Drooger are representative of this kind.

Certain specimens (Pl. 13, figs. 7, 9, 10; Cole, 1957a, pl. 29, figs. 1, 8, 9) with biserial embryonic apparatus have the rings of periembrionic chambers surrounding the second embryonic incomplete. In

such specimens the distal part of the wall of the second embryonic chamber is in contact with the marginal fringe.

However, following the interpretation developed for specimens with uniserial perieembryonic chambers, these biserial specimens are thought to represent individuals in which a marginal fringe developed from filaments of protoplasm from the second embryonic chamber, thus the development of perieembryonic chambers around the second embryonic chamber was inhibited. In such specimens the focus of development of the equatorial chambers would be from the rings of perieembryonic chambers surrounding the initial embryonic chamber. Therefore, the embryonic apparatus in this kind of development would be situated apically.

The following illustrations should be studied in the order in which they are cited to appreciate the variation in development of the position of the embryonic apparatus between specimens of the same species: Plate 12, all figures; plate 30, figure 2 (Cole, 1957a); plate 25, figure 9 (Cole, 1952); plate 30, figure 3 (Cole, 1957a); plate 29, figure 4 (Cole, 1957a); plate 29, figure 5 (Cole, 1957a), and plate 29, figure 8 (Cole, 1957a). These specimens have been classified under various specific names, such as *Miogypsina antillea*, *M. cushmani*, *M. mexicana* and *M. staufferi*. Yet, they have the same basic development, and seemingly represent only one species. All of these specimens with biserial embryonic apparatus, situated either apically or subapically, are considered to be *Miogypsina antillea*.

Tan (1937, pl. 3) identified specimens from a single locality as *Miogypsina (Miogypsina) thecideaformis* L. Rutten (figs. 11a, b) and other specimens as *Miogypsina (Miolepidocyclina) excentrica*, new species. The specimens identified as *M. thecideaformis* have the second embryonic chamber in contact with the marginal fringe and are entirely similar in development to the specimen illustrated as figure 9, Plate 13. The specimens identified as *M. (Miolepidocyclina) excentrica* have embryonic apparatus which developed in the same manner as those of the specimens illustrated on Plate 12.

Under the classification presented in this article these specimens would represent superficially different development of the embryonic apparatus within individuals of the same species. Thus, *M. (Miolepidocyclina) excentrica* would become a synonym of *M. (Miogypsina) thecideaformis*, and the subgenus *Miolepidocyclina* would be a synonym of *Miogypsina*.

SPECIES OF AMERICAN MIOGYPSINIDS

If the interpretation of the development of miogypsinids is accepted, only three species of American miogypsinids can be recognized. These are *Miogypsinoides complanatus* (Schlumberger), *Mio-*

gypsina panamensis (Cushman) and *Miogypsina antillea* (Cushman).

Miogypsinoides complanatus is characterized by a coil of perieembryonic chambers of approximately 1½ volutions (Pl. 11, fig. 7) and the absence of lateral chambers (Pl. 11, fig. 10). *Miogypsina panamensis* and *Miogypsina antillea* have well developed lateral chambers. *M. panamensis* has a uniserial embryonic apparatus, whereas *M. antillea* has a biserial embryonic apparatus.

Illustrations of typical representatives of these are given on the Plates as follows: *Miogypsinoides complanatus* (Schlumberger) on Plate 11, figures 7, 10; *Miogypsina antillea* (Cushman) on Plate 12, all figures; Plate 13, figures 7, 9, 10; and *Miogypsina panamensis* (Cushman) on Plate 9, all figures; Plate 10, all figures; Plate 11, figures 1-6, 8, 9, 11; Plate 13, figures 4, 5.

References and synonyms of American specimens referred to *Miogypsinoides complanatus* are given by Cole (1957a, p. 318, 319) and will not be repeated here. In this same publication the references and synonyms of *Miogypsina panamensis* (p. 322) are given. To these should be joined the references and synonyms of *Miogypsina gunteri* (p. 321, 322).

Many of the references and synonyms given by Cole (1957a, p. 320) to *Miogypsina antillea* are correct, but not all of them. Specimens assigned to *M. antillea* by Cole (1952, pl. 24, fig. 17; pl. 25, figs. 13-14) have uniserial embryonic apparatus and must be assigned to *M. panamensis*. To the list of references and synonyms of *M. antillea* should be added the references and synonyms of *Miogypsina staufferi* (Cole, 1957a, p. 323) as all of these specimens have biserial embryonic apparatus which characterize *Miogypsina antillea*.

The reduction of the number of species of American miogypsinids by an interpretation of the mechanism involved in the development of the test demonstrates that speciation was not any more rapid in this group than in other groups of larger Foraminifera within the same stratigraphic interval. As all of these organisms occupied the same ecological situations, and as the tests are composed of the same elements (embryonic chambers, perieembryonic chambers, equatorial chambers and the like) in most cases, one might postulate that there would be some degree of parallelism in the evolutionary histories.

SPECIES OF LARGER FORAMINIFERA ASSOCIATED WITH MIOGYPSINIDS

Mexico.—*Miogypsinoides complanatus* (Pl. 11, figs. 7, 10) at locality 10 occurs with *Camerina panamensis* (Cushman), *Heterostegina antillea* Cushman (Pl. 13, figs. 1-3, 8, 11, 12), *Lepidocyclina (Eulepidina) undosa* Cushman and *Lepidocyclina (Lepidocyclina) canellei* Lemoine and R. Douvillé

(see: Cole, 1957b, pl. 2, fig. 5; pl. 5, fig. 4) in the Meson formation.

Nuttall (1933, p. 176) illustrated specimens identified as *Miogypsinoides complanatus* from "1100 metres NNE. of Meson, State of Veracruz," Mexico and stated "In Mexico this species is found in typical Meson formation associated with *Lepidocyclina gigas* Cushman and *Lepidocyclina undosa* Cushman"

Recently, Brönnimann and Rigassi (1963, p. 411) stated that the planktonic Foraminifera in a sample from the type locality of the Meson formation suggest ". . . that this fauna falls in the younger part of the *Globigerina ciperoensis-Globorotalia opima* zone."

The larger Foraminifera at locality 10 indicate that this locality falls in the lower part of the *Miogypsina* subzone of the *Eulepidina* zone (Cole, 1958a, p. 220; Cole and Applin, 1961, p. 131).

Panama Canal Zone.—Specimens (Pl. 11, figs. 2, 3, 5, 8, 11) previously identified as *Miogypsina gunteri* (= *M. panamensis*) occur abundantly at locality 4 in the Bohio formation in association with *Heterostegina antillea* Cushman and *Lepidocyclina canellei* Lemoine and R. Douvillé.

In the Caimito formation of the Panama Canal Zone at locality 5a, b the type locality of *Miogypsina panamensis* (Pl. 9, fig. 5; Pl. 10, figs. 4, 5, 9), this species occurs with *Camerina panamensis* (Cushman), *Heterostegina antillea* Cushman, *Lepidocyclina (Lepidocyclina) canellei* Lemoine and R. Douvillé and *L. (Eulepidina) yurnagunensis* Cushman. At locality 6 *M. panamensis* is associated with *L. (L.) canellei*, *L. (E.) yurnagunensis*, and *L. (E.) vaughani* Cushman. At locality 7 *M. panamensis* is associated with *Heterostegina antillea* and *L. (L.) canellei*. Finally, at locality 8 *M. panamensis* occurs with abundant specimens of *Camerina panamensis*, rare specimens of *Heterostegina antillea*, and moderately abundant specimens of *L. (L.) canellei*.

The part of the Caimito formation represented by localities 5-8 has been referred by Woodring (1960, p. 27, 29) to the *Globorotalia kugleri* zone of the planktonic foraminiferal sequence developed by Bolli (1957, p. 100) for Trinidad.

This part of the Caimito formation with reference to the larger Foraminifera zonation is assigned to the upper part of the *Miogypsina* subzone of the *Eulepidina* zone (Cole, 1958a, p. 220; Cole and Applin, 1961, p. 131). Larger Foraminifera which characterize this subzone in addition to *Miogypsina panamensis* are *Lepidocyclina (Eulepidina) tournoueri*, and *L. (E.) vaughani*.

Species which range throughout the *Miogypsina* subzone are: *Camerina panamensis*, *Heterostegina antillea*, *Lepidocyclina (Lepidocyclina) canellei* and *L. (Eulepidina) undosa*.

In formations above the Caimito up to and in-

cluding the La Boca marine member of the Panama formation miogypsinids occur. Cole (1961c) has summarized the occurrence of larger Foraminifera in this part of the section in Panama which has been assigned by Woodring (1960, p. 27) to the early part of the lower Miocene. Two species of *Lepidocyclina* occur. They are *Lepidocyclina (Lepidocyclina) canellei* and *L. (Eulepidina) yurnagunensis*. *Miogypsina antillea* (including specimens previously identified as *Miogypsina staufferi*) occur both in the Culebra and Panama formations.

One specimen has been illustrated (Cole, 1961c, pl. 9, fig. 3) from the Culebra formation and identified as *M. antillea* which undoubtedly represents *Miogypsina panamensis* as it has a uniserial embryonic apparatus.

The zone above the *Eulepidina* zone has been designated the *Lepidocyclina-Miogypsina* zone. The only species of larger Foraminifera which seemingly is restricted to this zone is *Miogypsina antillea*. Species with longer stratigraphic ranges which occur in the *Lepidocyclina-Miogypsina* zone are: *Camerina panamensis* (Trinidad), *Lepidocyclina (Lepidocyclina) mantelli* (Trinidad), *L. (L.) canellei* (Trinidad, Jamaica, and Panama) and *L. (Eulepidina) yurnagunensis* (Panama).

United States, Gulf Coast and Georgia.—In Florida Cole (1938, p. 19) found abundant specimens of *Miogypsina antillea* (identified as *M. hawkinsi* and *M. venezuelana*) in the Port St. Joe Test well no. 3 stratigraphically above a zone with *Heterostegina antillea* (identified as *H. texana*). In a still lower zone there were numerous specimens of *Miogypsina panamensis* (identified as *M. gunteri*), below which in the last sample of the well occurred *Lepidocyclina canellei* (identified as *L. parvula*), *L. (Eulepidina) undosa* and *Heterostegina antillea*.

Drooger (1952, p. 22) referred the specimens in the Port St. Joe Test well no. 3 identified in this article as *Miogypsina antillea* to *Miogypsina ex. interc. cushmani-mexicana*. In southern Florida Drooger (1952; summary in Akers and Drooger, 1957, p. 676, 677) identified among other species *M. cushmani-mexicana*, *M. cushmani*, and *M. mexicana*. Cole (1957a, pl. 27, figs. 1, 4, 8) previously identified specimens from a well in southern Florida as *M. gunteri* and *M. panamensis*.

Thus, in the Port St. Joe Test well no. 3 and in southern Florida there are two zones, at least, in which *Miogypsina* occurs, an upper one with *Miogypsina antillea* and a lower one with *M. panamensis*.

In Georgia Cole and Applin (1961, p. 127) reported *M. antillea* (= *M. panamensis*) and *M. gunteri* (= *M. panamensis*) in the C. T. Thurman no. 2 well in Coffee County. Drooger (1962, p. 39) stated "In my opinion, there is no reason to recognize more than one species, probably *M. tani*, for these figured individuals."

Several specimens (Cole and Applin, 1961, pl. 7, figs. 1, 2, 4) show the embryonic apparatus excellently. These specimens have 3 to 4 perie embryonic chambers before the development of equatorial chambers I and II and are entirely comparable to specimens illustrated as figures 3, 6-8, 10, Plate 10 which are referred now to *M. panamensis*.

Figure 1, Plate 11 is the same specimen illustrated by Cole and Applin (1961, pl. 7, fig. 8), but photographed by reflected light. The embryonic chambers are separated from the periphery of the test by the perie embryonic coil and there are 7 perie embryonic chambers before the equatorial chambers I and II develop.

This specimen according to Drooger's notation of the perie embryonic chambers would have 10 perie embryonic embryonic chambers, whereas the other specimens would have a maximum of 6. Therefore, the specimen (Cole and Applin, 1961, pl. 7, fig. 8; Pl. 11, fig. 1) would identify as *M. gunteri* (Drooger, 1952, p. 51) whereas the other specimens (Cole and Applin, 1961, pl. 7, figs. 1, 2, 3) would be assigned to *M. tani* (Drooger, 1952, p. 51). Under the classification here proposed all of these specimens identify as *Miogyopsina panamensis*.

From wells in Louisiana and Mississippi Akers and Drooger (1957, p. 668, fig. 2) reported a number of species of *Miogyopsinoides* and *Miogyopsina*. They (p. 660) stated ". . . since *Heterostegina* probably had the same environmental restrictions as the *Miogyopsinidae*, it is at once comprehensible that all the records of the *Miogyopsina* species (*M. gunteri*, *M. tani*, *M. irregularis*, *M. bronnimanni*) seem to cluster around the *Heterostegina* zone."

Analysis of the distribution of the species of *miogyopsinids* in Louisiana and Mississippi show that *Miogyopsinoides complanatus* (synonym: *Miogyopsinoides bermudezi*) is stratigraphically the lowest species found, and that either *Miogyopsina bronnimanni* or *M. mexicana* (both of which are synonyms in our present classification of *M. antillea*) are stratigraphically the highest species.

Gravell and Hanna (1937, p. 517) described six new species of larger Foraminifera from the *Heterostegina* zone of Texas and Louisiana. They were *Operculinoides ellisorae*, *O. howei*, *Heterostegina israelskyi*, *H. texana*, *Lepidocyclina colei* and *L. texana*. In the nomenclature used in this article these species would be identified as *Camerina panamensis*, *Heterostegina antillea* and *Lepidocyclina canellei*.

Akers and Drooger (1957, p. 664) stated "*Miogyopsina tani* commonly occurs in the Gulf Coast subsurface in association with *Heterostegina israelskyi* and *H. texana*." They (p. 664) stated concerning the stratigraphic position of *Miogyopsina gunteri* that it most probably occurred in ". . . the lower part of the *Heterostegina* zone and possibly the

upper portion of the *Marginulina* zone of the Anahuac formation."

If the data available from Louisiana east to Florida and Georgia are combined, three zones characterized by *miogyopsinids* can be recognized. These would be the *Miogyopsinoides complanatus* zone, the *Miogyopsina panamensis* zone and the *Miogyopsina antillea* zone. In terms of the large-Foraminifera zonation previously used (Cole, 1957a, p. 34; Cole and Applin, 1961, p. 131) *Miogyopsinoides complanatus* would fall in the lower part of the *Miogyopsina* subzone of the *Eulepidina* zone and *M. panamensis* would characterize the upper part of the *Miogyopsina* subzone. *Miogyopsina antillea* would mark the overlying *Lepidocyclina-Miogyopsina* zone. Thus, the large-foraminiferal zonation of the Gulf Coast of the United States would be the same as that postulated for the combined Mexican-Panama Canal Zone zonation.

The occurrence of such species as *Miogyopsinoides complanatus*, *Miogyopsina panamensis* and *Heterostegina antillea* in the Anahuac formation places it in the *Miogyopsina* subzone of the *Eulepidina* zone. If our correlation of the larger foraminiferal zones with those established by planktonic Foraminifera is correct, the Anahuac formation should correlate with the *Globorotalia kugleri* planktonic zone.

Puerto Rico.—Sachs (1959, p. 401) recorded the presence of *Miogyopsina antillea* (= *M. panamensis*) and *M. gunteri* (= *M. panamensis*) in one sample and *M. gunteri* (= *M. panamensis*) and *M. panamensis* in another sample. The associated species of larger Foraminifera from these two samples are: *Camerina dia* (= *C. panamensis*), *Heterostegina antillea*, *Lepidocyclina canellei* (as *L. asterodisca*, *L. canellei* and *L. giraudi*) and *L. (Eulepidina) undosa*.

Sachs and Gordon (1962, p. 10) from two additional Puerto Rican localities recorded the species listed above and gave in addition to the associated species mentioned *Lepidocyclina yurnagunensis*.

These localities were assigned correctly to the *Miogyopsina* subzone of the *Eulepidina* zone by Sachs, and by Sachs and Gordon.

Previously Drooger (1952, p. 25) reported *Miogyopsina ecuadorensis* (= *M. panamensis*) and *M. gunteri-tani* (= *M. panamensis*) from a single Puerto Rican sample.

Trinidad.—A revised list of the species of larger Foraminifera occurring in the Morne Diablo limestone follows: *Camerina panamensis*, *Lepidocyclina (Lepidocyclina) canellei*, *L. (L.) mantelli* and *Miogyopsina antillea* (from: Vaughan and Cole, 1941; Stainforth, 1948, p. 1311; Cole, 1957b, p. 34). This association is characteristic of the *Lepidocyclina-Miogyopsina* zone.

The stratigraphically lower Mejias and Kapur limestones (Stainforth, 1948, p. 1312) contain such

species as *Heterostegina antillea*, *Lepidocyclina* (*Eulepidina*) *undosa* and *L. (E.) tournoueri*. *Miogypsina panamensis* (identified as *M. gunteri*, *M. hawkinsi*, *M. tani*, *M. basraensis* or *M. tani-bronni-manni*) occurs in these limestones. The association demonstrates that the Mejias and Kapur limestones should be assigned to the upper part of the *Miogypsina* subzone of the *Eulepidina* zone.

Cuba.—Brönnimann and Rigassi (1963) presented data from Cuba on the occurrence of certain larger Foraminifera with planktonic Foraminifera. They recorded from the *Globigerina ciperoensis-Globorotalia opima* zone *Operculinoides dius* (= *Camerina panamensis*) (p. 436), *Heterostegina israelkyi* (= *H. antillea*) (p. 397), *Lepidocyclina* (*Lepidocyclina*) *giraudi* (= *L. canellei*) (p. 413), *L. (L.) wayland-vaughani* (= *L. canellei*) (p. 436), *L. (Eulepidina) undosa* (p. 436), *L. (E.) yurnagunensis* (p. 436), and the rotalid *Pararotalia mexicana mecatepecensis* (p. 441).

From the *Catapsydrax dissimilis* zone (p. 441) they reported *Operculinoides dius* (= *Camerina panamensis*), *Heterostegina antillea*, *Lepidocyclina* (*Lepidocyclina*) sp., and *Miogypsina bracuensis*. In the *Globigerinatella insueta* zone (p. 441, 442) they found *Operculinoides* sp., *Heterostegina antillea*, and species of *Miogypsina* identified as *M. hawkinsi*, *M. hawkinsi*, or *bramletti* and *M. antillea*. All of these probably are *M. antillea*.

In Panama and Trinidad *Heterostegina antillea* does not range above the *Globorotalia kugleri* planktonic zone. The occurrence of this species in Cuba in higher zones seemingly represents the major anomaly in these associations found so far.

Carriacou and Costa Rica.—*Miogypsina panamensis* has been reported (Cole, 1958a, p. 221) from Carriacou in association with *Camerina panamensis*, *Heterostegina antillea*, *Lepidocyclina* (*Lepidocyclina*) *canellei*, *L. (Eulepidina) vaughani* and *L. (E.) tournoueri*. This association is typical of the upper part of the *Miogypsina* subzone of the *Eulepidina* zone.

In Costa Rica *Miogypsina tani* (= *M. panamensis*) occurs with *Camerina panamensis*, *Heterostegina antillea*, *Lepidocyclina* (*Eulepidina*) *vaughani* and *L. (E.) undosa* (Malavassi, 1961, p. 500) in the same subzone as that represented by the Carriacou specimens.

Ecuador.—Barker (1932, p. 277) reported larger Foraminifera from sandstones near the village of San Pedro, about forty miles north of Santa Elena Point. He identified these as *Lepidocyclina* (*Nephrolepidina*) *verbeeki* Newton and Holland, *Miogypsina* aff. *panamensis* (Cushman) and *M. sp. indet. cf. staufferi* Koch.

Cole (1952, p. 30) stated the *Lepidocyclina* “. . . is without question *L. vaughani*.” The *Miogypsina* has been identified as *M. ecuadorensis*, but in the classification used here, it would be *M. panamensis*.

Thus, this Ecuadorean assemblage, although composed of only two species, can be assigned to the *Miogypsina* subzone of the *Eulepidina* zone.

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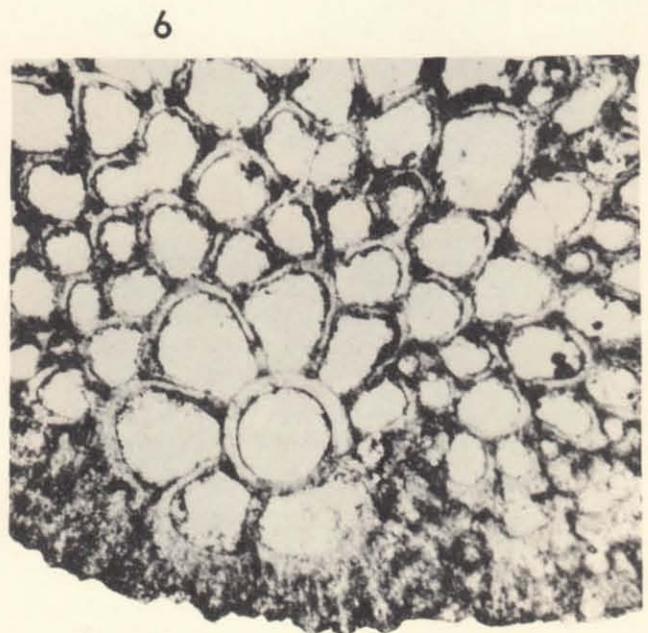
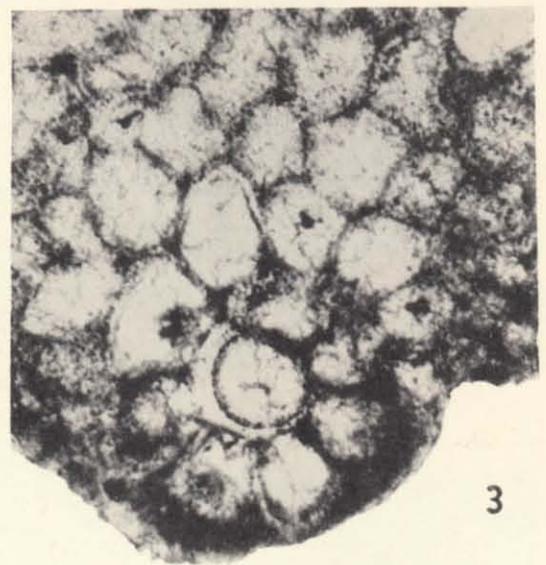
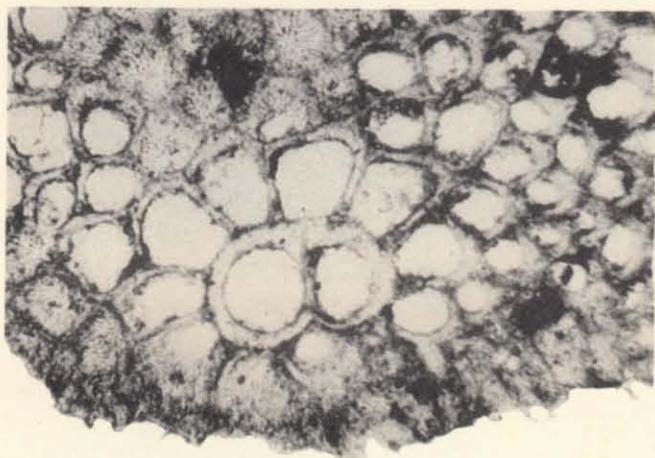
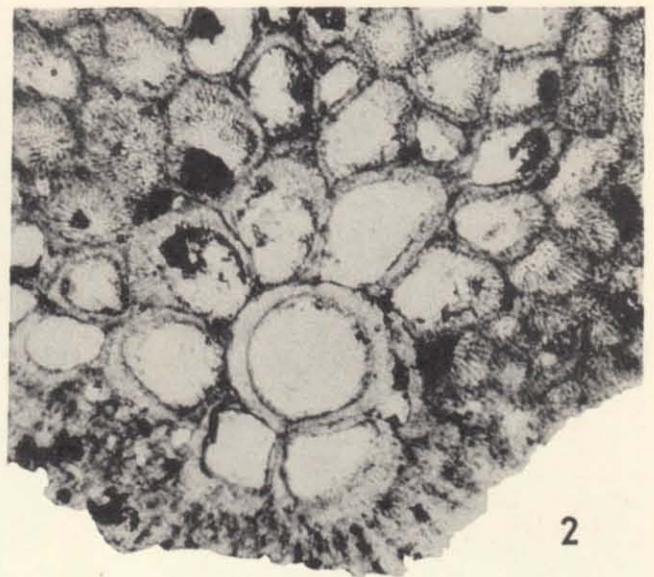
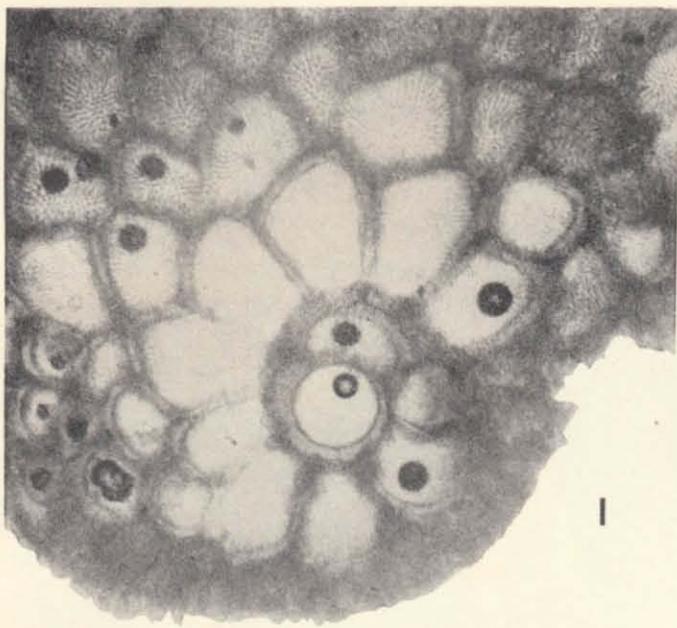
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EXPLANATION OF PLATE 9

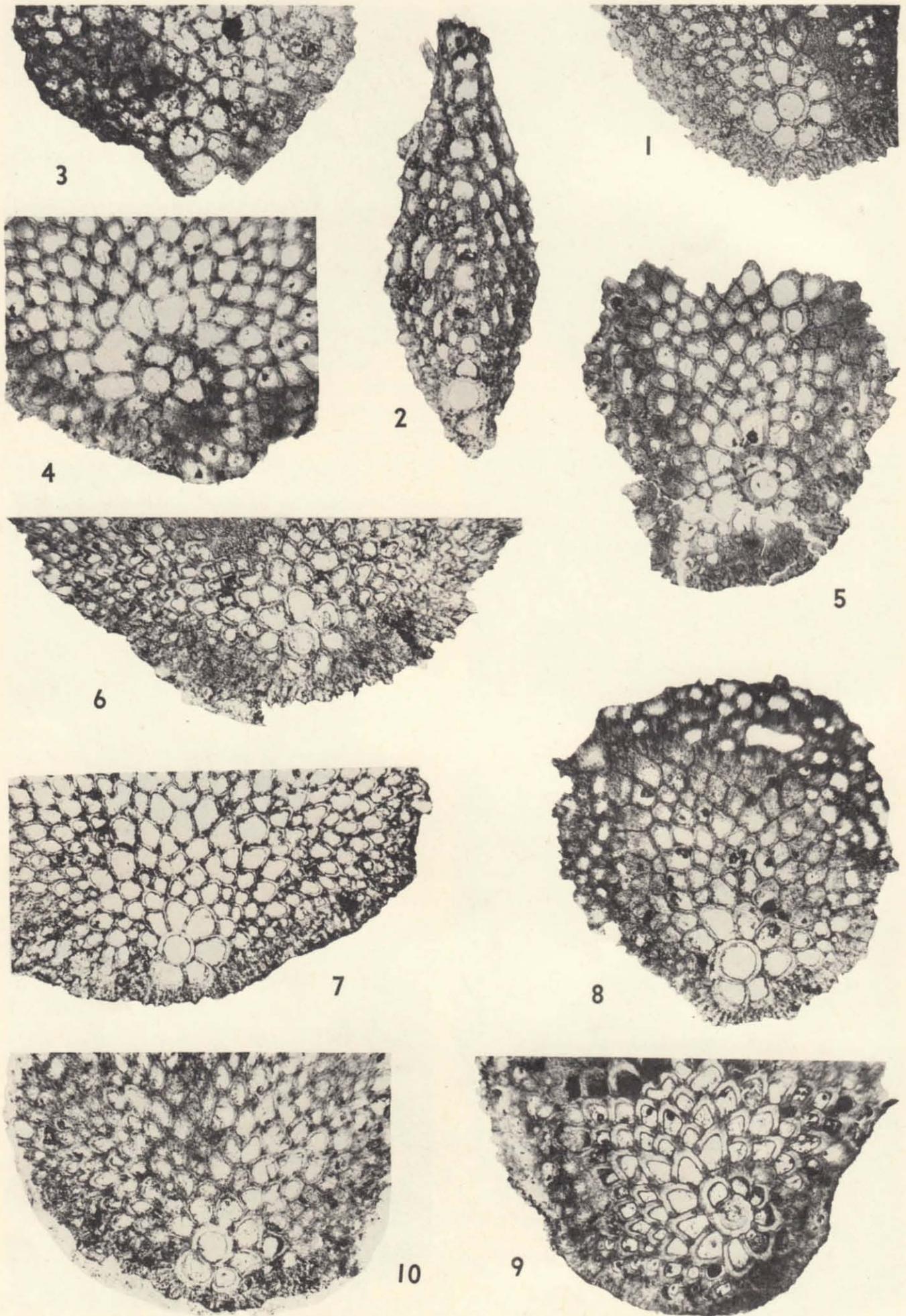
FIGS.

PAGE

- 1-6. *Miogypsina panamensis* (Cushman) 138, 139, 142, 143, 144, 145, 146
1. Embryonic, periembryonic, and initial equatorial chambers of one of the types of *M. gunteri* Cole (1938, pl. 8, fig. 4), $\times 73$; see text fig. 1 D; loc. 3.
 2. Enlargement, $\times 80$, of the initial part of the specimen illustrated as fig. 8, Pl. 10; 5 periembryonic chambers; see text fig. 1 B; loc. 7.
 3. Enlargement, $\times 80$, of the initial part of the specimen illustrated as fig. 2, Pl. 11; 7 periembryonic chambers; loc. 4.
 4. Enlargement, $\times 80$, of the initial part of the specimen illustrated as fig. 9, Pl. 11; 8 periembryonic chambers; see text fig. 1 C; loc. 7.
 5. Enlargement, $\times 80$, of the initial part of the specimen illustrated as fig. 9, Pl. 10; 10 periembryonic chambers; see text fig. 1 E; loc. 5b.
 6. Enlargement, $\times 80$, of the initial part of the specimen illustrated as fig. 7, Pl. 10; 4 periembryonic chambers; see text fig. 1 A; loc. 7.



Cole: American Mid-Tertiary Miogypsinids



Cole: American Mid-Tertiary Miogypsinids

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EXPLANATION OF PLATE 10

All figures, $\times 40$

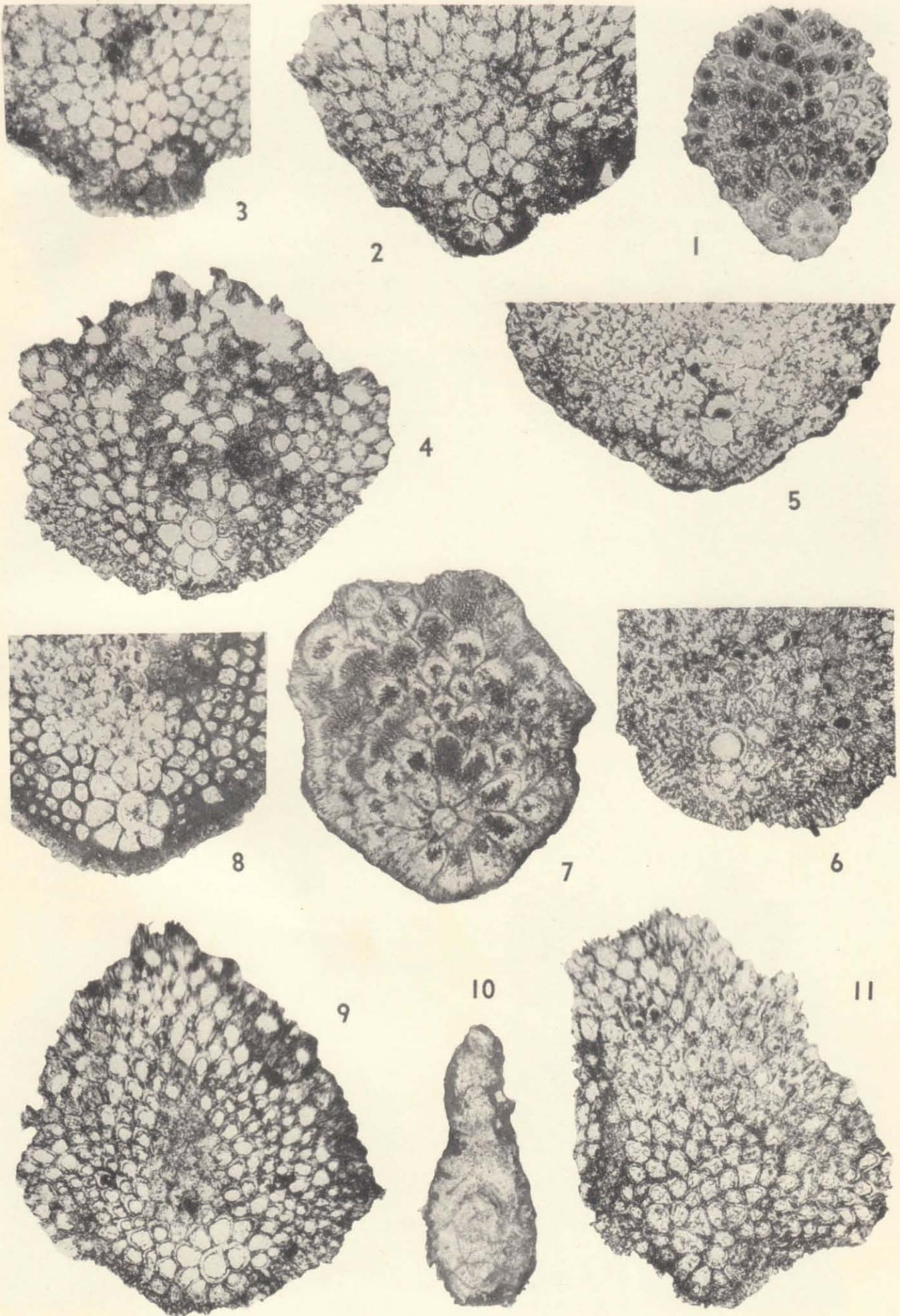
FIGS.	PAGE
1-10. <i>Miogypsinina panamensis</i> (Cushman)	138, 139, 144, 145, 146, 147
1, 3-10. Parts of equatorial sections to illustrate the embryonic, periembryonic and initial equatorial chambers; 4, 5, 9, topotypes of <i>M. panamensis</i> ; for enlargements of figs. 7-9 see figs. 2, 5, 6, Pl. 9; 1, 6-8, 10, loc. 7; 3, loc. 6; 4, 5, 9, loc. 5b.	
2. Vertical section; loc. 7.	

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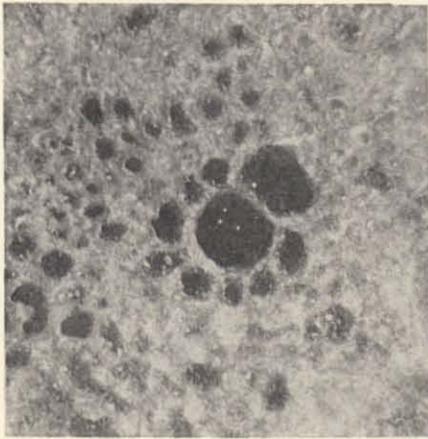
EXPLANATION OF PLATE 11

All figures, $\times 40$

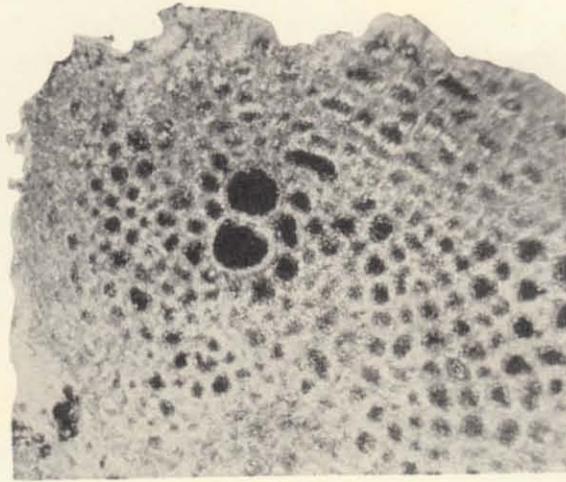
FIGS.	PAGE
1-6, 8, 9, 11. <i>Miogypsina antillea</i> (Cushman)	142, 143, 145, 146, 147
Equatorial and parts of equatorial sections to illustrate the embryonic, periem-bryonic, and equatorial chambers; 1, loc. 1 (Oligocene); 2, 3, 5, 8, 11, loc. 4 (Bohio formation); 4, 9, loc. 7 (Caimito formation); 6, loc. 6 (Caimito formation); 1, reflected light, the same specimen illustrated as fig. 8, pl. 7, Cole and Applin, 1961.	
7, 10. <i>Miogypsinoides complanatus</i> (Schlumberger)	142, 145
7. Equatorial section; 10, vertical section; loc. 10 (Meson formation).	



Cole: American Mid-Tertiary Miogypsinids



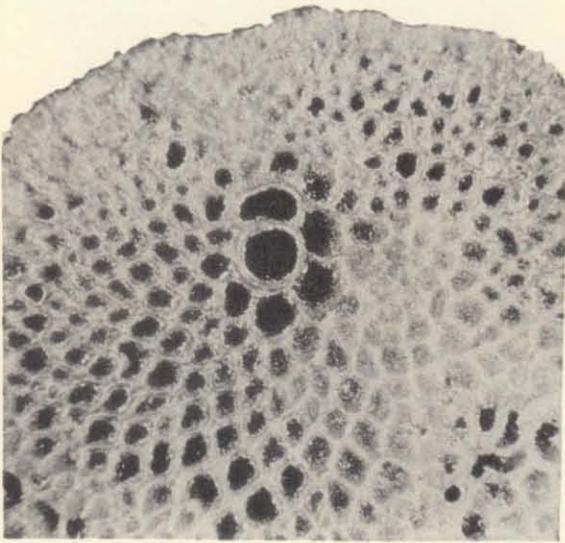
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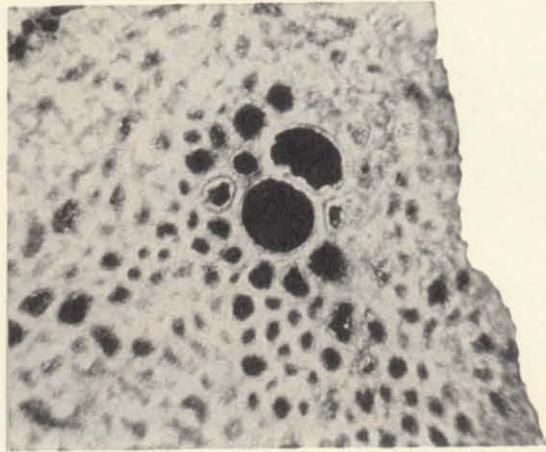
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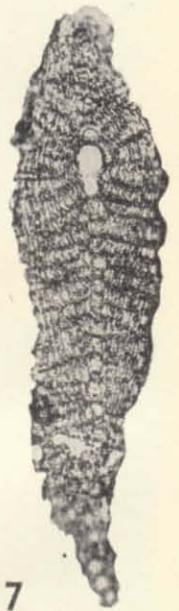
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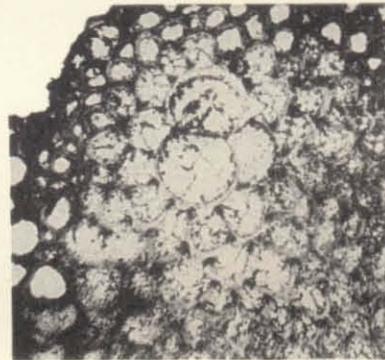
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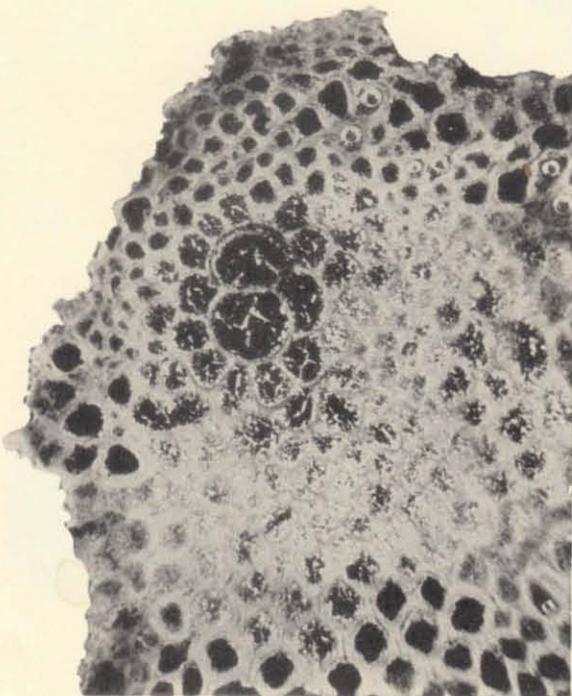
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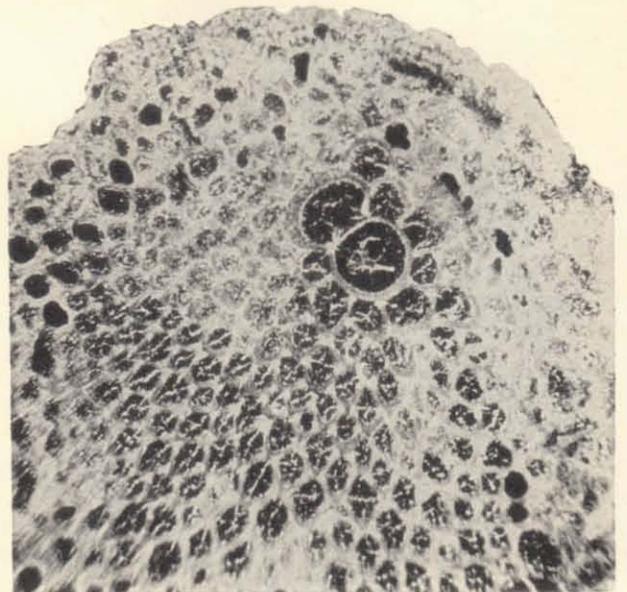
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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XV, PART 4, OCTOBER, 1964
RECENT LITERATURE ON THE FORAMINIFERA

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

- ALEXANDROWICZ, STEFAN WITOLD. Stratigraphy of the Miocene deposits in the Upper Silesian Basin (in Polish with English and Russian summaries).—Poland Instyt. Geol., Prace, tom 39, 1963, p. 1-145, pls. 1-11, text figs. 1-23 (maps, columnar sections, range and abund. charts), tables 1-50.—Fifteen microfaunal assemblages are recognized and illustrated by Foraminifera assemblage photomicrographs.
- ALIMARINA, V. P. Nekotorye Osobennosti Razvitiya Planktonnykh Foraminifer v Svjazi s Zonal'nym Raschleneniem Nizhnego Paleogena Severnogo Kavkaza.—Akad. Nauk SSSR, Otdel. geol.-geogr. nauk, geol. inst., Voprosy Mikropaleont., vyp. 7, 1963, p. 158-195, text figs. 1-4 (correlated columnar sections), tables 1, 2.—Zonation by planktonics in the interval Danian to lower Eocene.
- ARNOLD, ZACH M. Biological observations on the foraminifer *Spiroloculina hyalina* Schulze.—Univ. Calif. Publ. Zoöl., v. 72, March 17, 1964, p. 1-78, pls. 1-7, text figs. 1-14 (drawings, graphs, map), tables 1-3.—A detailed and abundantly illustrated study of life history, variations, and morphological aberrancies based on laboratory specimens (mass cultures and isolation cultures) originating from two different populations of this minute miliolid (one from Florida and the other from California) provides bases for speculations regarding phylogenetic relationships within the Foraminifera. Observations are made on isomorphism between *S. hyalina* and numerous species within various genera. Its variation potential is retained throughout its present wide geographic distribution, the species being known under various names. Its presence in the salt wells of the Kara-Kum desert is evidence that its lineage was differentiated from that of other miliolids at least as far back as the separation of the Sarmatian Sea from the Mediterranean.
- BANDY, ORVILLE L. Miocene-Pliocene boundary in the Philippines as related to Late Tertiary stratigraphy of deep-sea sediments.—Science, v. 142, No. 3597, Dec. 6, 1963, p. 1290-1292, text fig. 1 (range chart).—Within a Pliocene section in the Philippines are foraminiferal trends that indicate that the proposed Pliocene-Pleistocene boundary reported in deep-sea cores from the Atlantic is actually a Miocene-Pleistocene contact.
- BANDY, ORVILLE L., and ECHOLS, RONALD J. Antarctic foraminiferal zonation.—Biology of the Antarctic Seas, Milton O. Lee, Editor, Antarctic Research Series, v. 1, Am. Geophysical Union, Publ. No. 1190, 1964, p. 73-91, text figs. 1-14 (map, graphs, range chart), tables 1, 2.—A synthesis of data (chiefly from McKnight, 1962) reveals depth zonations, based upon upper depth limits of selected isobathyal species, at 200 ± 150 meters, 500 ± 150 meters, 1000 ± 200 meters, 2000 ± 200 meters, and 2400 ± 600 meters.
- BANDY, ORVILLE L., INGLE, JAMES C., JR., and RESIG, JOHANNA M. Foraminiferal trends, Laguna Beach outfall area, California.—Limnology and Oceanography, v. 9, No. 1, Jan. 1964, p. 112-123, text figs. 1-8 (map, distrib. maps, fence diagrams).—In this area of chlorinated effluent, live populations are doubled over normal amounts, total populations increased 5-fold, and abundance of planktonic specimens in the sediments about 50-fold. Species diversity declines markedly at the outfall. Among the dominant living species of the area there is, within 500 meters of the outfall, an abundance aureole of *Buliminella elegantis*.

EXPLANATION OF PLATE 12

FIGS.

PAGE

- 1-9. *Miogypsina antillea* (Cushman) 142, 144, 145
 1, 7. Vertical sections, $\times 20$; loc. 12 (Montpelier formation).
 2-6, 8, 9. Parts of equatorial sections, $\times 40$; 2, 3, 5, loc. 12 (Montpelier formation); 4, loc. 13 (Morne Diablo limestone); 6, 8, 9, topotypes of *M. mexicana* Nuttall, loc. 11 (Túxpan formation); 6, same specimen as fig. 9 by transmitted light; 3, specimen previously illustrated by transmitted light in Cole, 1956, pl. 30, fig. 6; 4, specimen previously illustrated by transmitted light in Cole, 1957a, pl. 30, fig. 6.

sima and *Bolivina vaughani* and a depression aureole of *Buccella frigida*.

Foraminifera, Los Angeles County outfall area, California.—*Limnology and Oceanography*, v. 9, No. 1, Jan. 1964, p. 124-137, text figs. 1-7 (map, distrib. maps).—In this area of untreated effluent, there is a zone without live specimens beneath part of the sewage field. *Trochammina pacifica* and associated arenaceous species are most abundant in the dead population. Elsewhere living specimens of hyaline species are more than 8 times as abundant as living arenaceous and porcelaneous ones, and segments of an abundance aureole are found peripheral to the field (1 or 2 km from the outfall). Number of planktonic specimens in the sediments increases at the outfall. *Bulimina marginata denudata* and *Buliminella elegantissima* appear to thrive within the outfall area, and *Discorbis columbiansis* extends its area of abundance from its normal habitat of shallower water and different substrate out to the outfall. Species of *Nonionella* appear not to tolerate the pollution environment.

Facies trends, San Pedro Bay, California.—*Bull. Geol. Soc. America*, v. 75, No. 5, May 1964, p. 403-423, text figs. 1-10 (maps), table 1.—Quantitative analysis of Foraminifera in 44 bottom samples on the shelf and to a depth of 176 meters in the upper bathyal zone reveal 3 main bathymetric groupings. Abundance and diversity increase toward the outer shelf and upper bathyal zone. Calcareous perforate species predominate in both dead and live assemblages. Live/dead ratios are highest in central and inner shelf areas, but live specimens are 3 times as abundant in the upper bathyal zone as on the shelf. Planktonic/benthic ratios are highest in the upper bathyal region. *Hopkinsina pacifica* is diagnostic of the harbor area.

BARKHATOVA, N. H., and NEMKOV, G. I. Paleotheno-
vye Nummulity Mangyshlaka.—*Izvest. Vyssh.*

Ucheb. Zaved., Geol. i Razved., No. 4, 1964,
p. 48-50, 1 pl.—*Nummulites fraasi* de la Harpe.

BASHKIROV, L. V. K Voprosu o Klassifikatsii Tre-
tichnykh Orbitoidov.—*Izvest. Vyssh. Ucheb.*
Zaved., Geol. i Razved., No. 4, 1964, p. 51-55.

BAULINA, M. N. K Voprosu o Sistematscheskom
Polozhenii *Staffella sphaerica* (Abich).—*Akad.*
Nauk SSSR, Otdel. geol.-geogr. nauk, geol.
inst., Voprosy Mikropaleont., vyp. 7, 1963, p.
85-104, pls. 1, 2, text figs. 1-9 (graphs).

BELJAEVA, N. V. Raspredelenie Planktonnykh
Foraminifer na dne Indijskogo Okeana.—*Akad.*
Nauk SSSR, Otdel. geol.-geogr. nauk,
geol. inst., Voprosy Mikropaleont., vyp. 7,
1963, p. 209-222, text figs. 1-9 (maps, graphs).
—Quantitative analysis of numerous samples
in Indian Ocean and along Antarctic coast,
based on total number of specimens, ecologic
affinities of genera, and counts of planktonic
species.

BERMUDEZ, PEDRO J., and SEIGLIE, GEORGE A.
Estudio sistematico de los Foraminiferos del
Golfo de Cariaco.—*Bol. Instit. Oceanografico*
Univ. de Oriente Cumana, Venezuela, v. II,
No. 2, Dec. 31, 1963, p. 1-267, pls. 1-29, text
figs. 1-9 (drawings), graphs 1-9.—Illustrated
catalog containing 205 species, 16 new, includ-
ing *Neopateoris cumanaensis* gen. nov., sp.
nov., a new miliolid.

BIEDA, FRANCISZEK. Foraminiferen des Klippen-
nahen Flysch in der Ostslowakei (German
summary of Czech text).—*Geol. Prace, Brat-*
islava, zpravy 18, 1960, p. 131-139, pls. 5, 6.—
Larger Foraminifera.

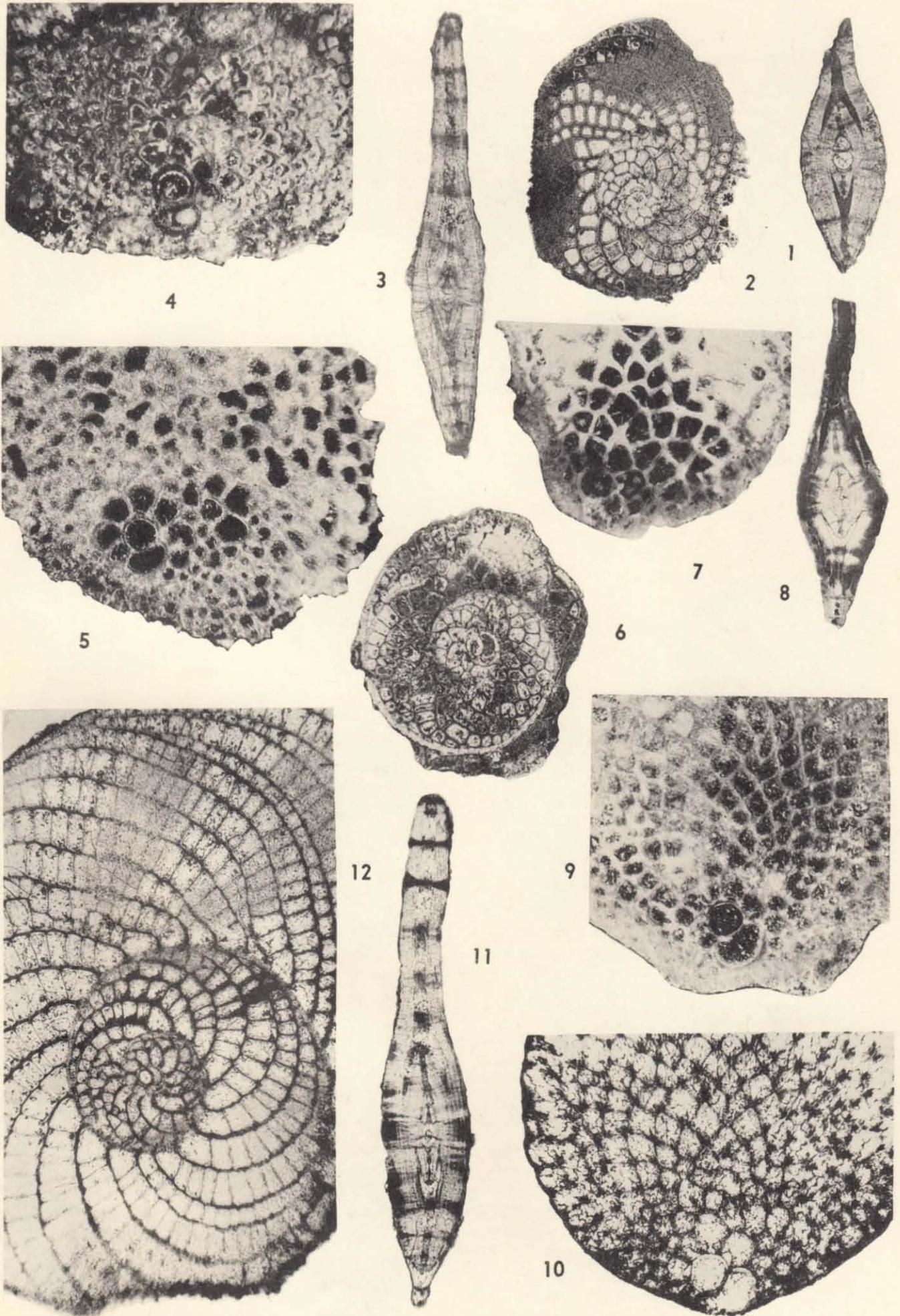
Larger Foraminifers of the Tatra Eocene.—
Poland Instyt. Geol., Prace, tom 37, 1963, p.
1-215, pls. 1-26, text figs. 1-11, tables 1-3.—
Monographic treatment of 51 species (none
new), all but 6 in the families Nummulitidae
and Discocyclinidae. Notes on ecology, para-
sitism, and abnormalities of structure. Strati-
graphic ranges and occurrence in the 4 local
hemeras are indicated.

EXPLANATION OF PLATE 13

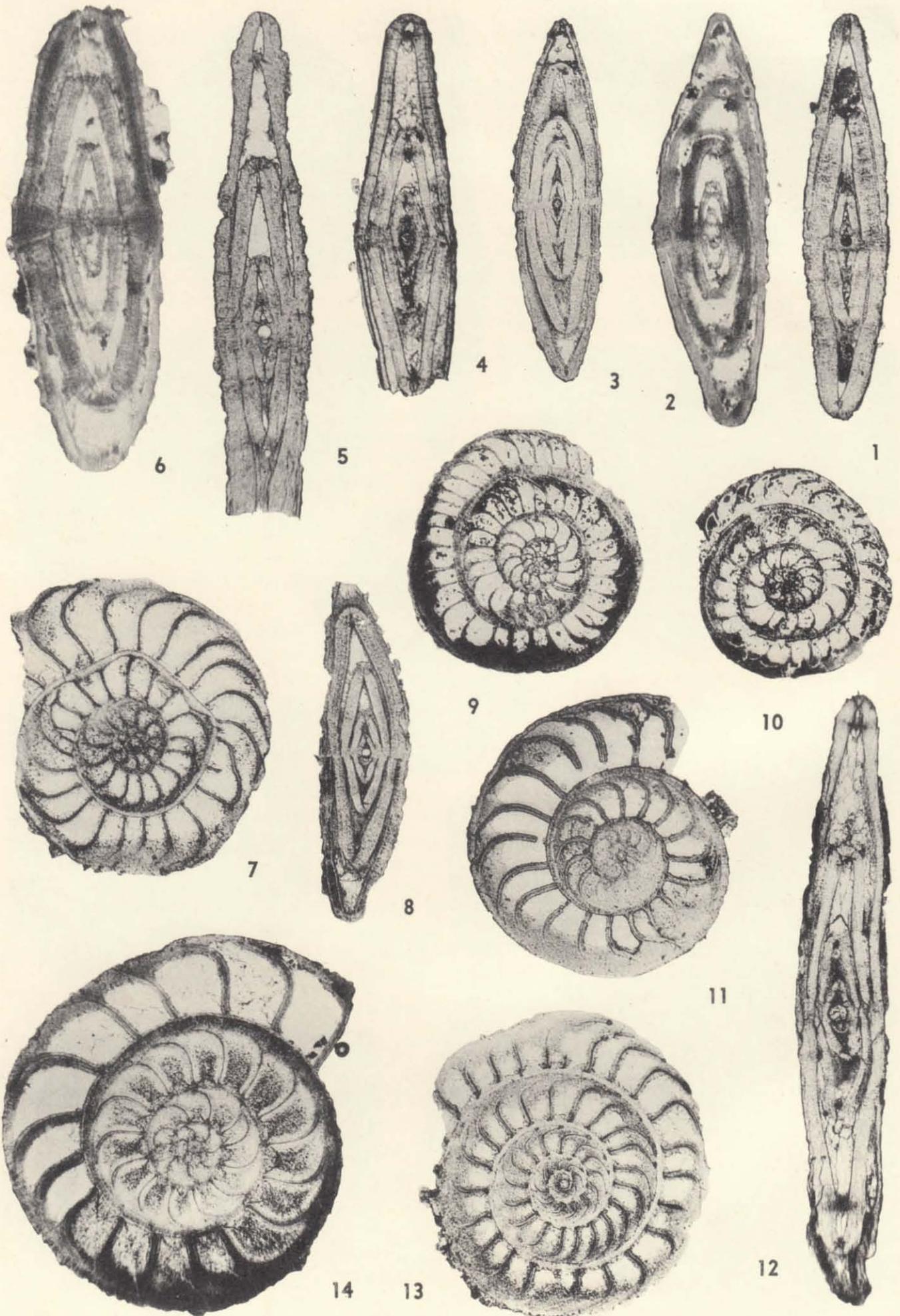
FIGS.

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|--------------------|--|----------|
| 1-3, 6, 8, 11, 12. | <i>Heterostegina antillea</i> Cushman | 142, 145 |
| 1, 3, 8, 11. | Transverse sections, $\times 20$; 8, specimen identified as <i>H. panamensis</i> Gravell (Vaughan and Cole, 1932, p. 511), loc. 5a; 1, 3, 11, loc. 10. | |
| 2, 6, 12. | Median sections, $\times 20$; 2, specimen identified as <i>H. panamensis</i> Gravell (Vaughan and Cole, 1932, p. 511), loc. 5a; 6, 12, loc. 10. | |
| 4, 5, 7, 9, 10. | <i>Miogypsina antillea</i> (Cushman) | 144, 145 |
| | Parts of equatorial sections, $\times 40$, to illustrate the embryonic, periembryonic and equatorial chambers; 4, loc. 6 (Caimito formation); 7, 10, loc. 9 (La Boca member); 9, loc. 14 (Anguilla formation), topotype of <i>M. antillea</i> . | |



Cole: American Mid-Tertiary Miogypsinids



Cole: American Mid-Tertiary Miogypsinids

- BILLIARD, JACQUELINE, and MOULLADE, MICHEL. Étude de quelques représentants du genre *Iraqia* (Orbitolinidae) dans l'Aptien des contreforts Pyrénéens Français et Espagnols.—*Revue de Micropaléontologie*, v. 6, No. 4, March 1964, p. 237-242, pl. 1.—Five species, 3 new.
- BIRKENMAJER, KRZYSZTOF, and PAZDRO, OLGA. On the age and geological position of the so-called "Sub-Flysch Beds" of the Pieniny Klippen Belt of Poland (English summary of Polish text).—*Ann. Soc. Geol. Pologne*, v. 33, fasc. 4, 1963, p. 415-456, pls. 19, 20, text figs. 1-5 (geol. sections), table 1.—Includes illustrations and descriptions of 30 species of Foraminifera (none new) from ?Barremian-Albian? beds.
- BLONDEAU, ALPHONSE, and CURRY, DENNIS. Sur la présence de *Nummulites variolarius* (Lmk) dans les diverses zones du Lutétien des bassins de Paris, de Bruxelles et du Hampshire.—*Bull. Soc. Géol. France*, ser. 7, tome 5, No. 3, 1963 (April 1964), p. 275-277, pls. 13, 14.
- BOGDANOVICH, A. K. Novye Predstaviteli Foraminifer s Khalthedonovoj Stenokoj iz Tretichnykh Otlozhenij Severnogo Kavkaza i Kryma.—*Akad. Nauk SSSR, Otdel. geol.-geogr. nauk, geol. inst., Voprosy Mikropaleont.*, vyp. 7, 1963, p. 150-157, pl. 1.—Four species (3 new and 1 indeterminate) in *Hippocrepinella* and *Saccamina*, from the Oligocene and lower Miocene.
- BOLTOVSKOY, ESTEBAN. Foraminiferos y sus relaciones con el medio.—*Rev. Mus. Argentino Ciencias Nat. "Bernardino Rivadavia," Instit. Nac. Invest. Ciencias Nat., Hidrobiol.*, Tomo 1, No. 2, 1963, p. 21-107, 2 diagrams.—A synthesis of ecologic information on benthonic and planktonic Foraminifera.
- Sobre las relaciones entre Foraminiferos y Turbellarios.—*Neotropica*, v. 9, No. 29, Aug. 1, 1963, p. 55-60, 1 pl.—Stalked cocoons of *Turbellaria* attached to walls of *Quinqueloculina seminulum*, an example of epibiosis.
- BOURROUILH, ROBERT, and MOULLADE, MICHEL. Étude stratigraphique et micropaléontologique d'une série jurassique de l'île de Minorque, Baléares (Espagne).—*Bull. Soc. Géol. France*, ser. 7, tome 5, No. 3, 1963 (April 1964), p. 375-382, pl. 16, text figs. 1, 2 (columnar section, thin section photographs).—Three species of *Coskinolina* (*Meyendorffina*), 2 new and 1 indeterminate.
- BRAZHNIKOVA, N. E., et al. Reshenija Vtorogo Kolokviuma po Sistematike Endotiroidnykh Foraminifer, Organizovannogo Koordinatsionnoj Komissiej po Mikropaleontologii v Moskve v Aprele 1962 g.—*Akad. Nauk SSSR, Otdel. geol.-geogr. nauk, geol. inst., Voprosy Mikropaleont.*, vyp. 7, 1963, p. 223-227, pl. 1.—Colloquium concerned family relationships in the endothyrids and resulted in several new subgenera. Two species of *Rectoseptatourneyella* (1 new) are described.
- BRESTENSKA, EDITA, and LEHOTAYOVA, RUZENA. Unteroligozäne brackische Ablagerungen mit *Rotalia beccarii* (L.) aus dem Gebiete von Sturovo (Südslowakei) (German summary of Czech text).—*Geol. Prace, Bratislava, zpravy* 19, 1960, p. 109-115, pls. 15, 16.—Includes illustrations of assemblages dominated by *Miliammina*, by *Rotalia*, and by *Ammobaculites* and *Ammomarginulina*.
- DE CASTRO, PIERO. Sulla presenza del Lias negli "Scisti Silicei" di Giffoni Vallepiiana nel Salernitano.—*Boll. Serv. Geol. Ital.*, v. 83, 1962 (1963), p. 3-14, pls. 1-9, text figs. 1-3 (map, geol. section, drawings).—Liassic, dated by Foraminifera, underlying Triassic.
- CHANG, LI-SHO. A biostratigraphic study of the Tertiary in the Hengchun peninsula, Taiwan, based on smaller Foraminifera (I: northern part).—*Proc. Geol. Soc. China*, No. 7, April 1964, p. 48-62, pls. 1-3, text figs. 1-4 (maps), tables 1-7.—Distribution and abundance of 149 species and subspecies of smaller Foraminifera are recorded in several sections, and a

EXPLANATION OF PLATE 14

FIGS.		PAGE
1-14.	<i>Camerina panamensis</i> (Cushman)	142
1, 5, 11.	Topotypes of <i>Operculinella dia</i> Cole and Ponton; 1, 5, $\times 40$; 11, $\times 20$; 1, 5, transverse sections; 11, median section; loc. 2.	
2, 6, 9, 10, 14.	Topotypes of <i>Nummulites panamensis</i> Cushman; 2, 6, 14, $\times 40$; 9, 10, $\times 20$; 2, 6, transverse sections; 9, 10, 14, median sections; loc. 5a.	
3, 8, 13.	Sections of specimens similar to <i>Operculinoides bullbrooki</i> Vaughan and Cole; $\times 20$; 3, 8, transverse sections; 13, median section; loc. 13.	
4, 7, 12.	Specimens identified as <i>Operculinoides panamensis</i> by Cole, 1957a, p. 314; 4, 12, $\times 40$; 7, $\times 20$; 4, 12, transverse sections; 7, median section; loc. 8.	

- few of the species illustrated. One subspecies is new. Three of the West Indian planktonic zones and 2 subzones are recognized.
- CHANG, YI-MAW. Biostratigraphic study of smaller Foraminifera from the Wu-chi Section, Kuohsing Nantou, Taiwan.—Petr. Geol. Taiwan, No. 2, Jubilee Volume in commemoration of the seventieth birthday of Mr. Hung-Hsun Ling, Dec. 1963, p. 183-206, text fig. 1 (map), tables 1-6.—Quantitative analysis of species in 4 zonules. One hundred and five species are identified.
- CHEN' THZIN'-SHI. K Morfologii i Sistematike Rodov *Protriticites*, *Quasifusulinoides* i *Obsoletes* iz Pogranichnykh Otlozhenij Srednego i Verkhnego Karbona.—Akad. Nauk SSSR, Otdel. geol.-geogr. nauk, geol. inst., Voprosy Mikropaleont., vyp. 7, 1963, p. 71-84, pls. 1-6, figs. 1-5 (charts, columnar section).
- CHRISTODOULOU, G. Geologische und mikropaläontologische Untersuchungen im Neogen der Insel Kreta.—Athens, 1963, 157 pp., 15 pls., 8 figs. (map, columnar sections, distrib. tables).—A Miocene cycle of sedimentation (upper Helvetian, Tortonian, and ending with Sarmatian lacustrine beds) overlain by a Pliocene cycle (Piacenzian, Astian, and ending with Levantine lacustrine beds). Illustrated catalog of 344 species and subspecies, 1 new (*Gyroidinoides graecus* n. sp.).
- CIRY, RAYMOND. A propos de *Meandropsina larrazeti* Mun.-Ch., géotype d'un genre nouveau: *Larrazetia* Ciry.—Revue de Micropaléontologie, v. 6, No. 4, March 1964, p. 185-195, pls. 1-3, text figs. 1, 2.
- COLALONGO, MARIA LUISA. *Sellialveolina viallii* n. gen. n. sp. di alveolinide Cenomaniano dell'Appennino Meridionale.—Giornale Geol., Ann. Mus. Geol. Bologna, ser. 2, v. 30, 1962 (1963), p. 1-10, pl. 1, text figs. 1, 2 (map, schematic reconstruction).
- DANILOVA, ALEKSANDRA. *Neoiraqia convexa*—a new Foraminifer from the Cenomanian-Turonian of Kosovo polje.—Yugoslavia Instit. Geol. Geophys. Res., Bull. (Geol.), ser. A, No. 20, 1962 (1963), p. 225-237, pls. 1-4.
- DECIMA, A. Il Pleistocene in facies levantina di Montallegro (Sicilia Sud-Occidentale).—Geologica Romana, v. II, 1963, p. 59-106, pls. 1-5, figs. 1-15 (maps, photographs, geol. sections, columnar sections, histograms, range chart), distrib. chart.—Includes illustrated systematic catalog of 31 species of Foraminifera, none new.
- DIVINO-SANTIAGO, PAZ. Planktonic foraminiferal species from west side of Tarlac province, Luzon Central Valley.—The Philippine Geologist, v. 17, No. 3, Sept. 1963, p. 69-99, text figs. 1, 2 (maps), tables 1-3.—Systematic recording of 43 species, subspecies, and varieties from 3 Miocene formations, including indication of distribution and abundance in various stratigraphic sections.
- DOLITSKAYA, I. V. Evoluthija v Predelakh Vida *Cibicides montanus* sp. nov. iz Kampanskikh Otlozhenij Juzhnogo Priaral'ja.—Akad. Nauk SSSR, Otdel. geol.-geogr. nauk, geol. inst., Voprosy Mikropaleont., vyp. 7, 1963, p. 127-137, pls. 1, 2, text figs. 1-3 (graph, drawings, columnar section).—A new *Cibicides* with 2 subspecies, both new, from upper Santonian and lower Campanian respectively.
- ECKERT, HANS Ruedi. Die obereozänen Globigerinen-Schiefer (Stad- und Schimbergschiefer) zwischen Pilatus und Schratzenfluh.—Eclogae Geol. Helvetiae, v. 56, No. 2, Dec. 31, 1963, p. 1001-1072, pls. 1-7, text figs. 1-35 (maps, geol. sections, columnar section, photograph, drawings, photomicrograph, correl. chart).—Includes illustrated systematic catalog of 98 species and subspecies. The fauna belongs in the *Globigerapsis semi-involuta* zone.
- ERICSON, DAVID B., EWING, MAURICE, and WOLLIN, GOESTA. Sediment cores from the Arctic and Subarctic seas.—Science, v. 144, No. 3623, June 5, 1964, p. 1183-1192, text figs. 1-7 (maps, photographs of cores, graphic logs, climatic curves), table 1.—Indications of a northward shift of the 7.2°C isotherm at the end of the last glacial stage, of direction of ice movements, and of continuity of ice cover are derived from study of fluctuating percentages of warm- and cold-water planktonics, dominant coiling direction in *Globigerina pachyderma*, and presence of reworked Cretaceous Foraminifera.
- FEYLING-HANSEN, ROLF W. Foraminifera in Late Quaternary deposits from the Oslofjord area.—Norges Geol. Unders., Nr. 225, April 1964, p. 1-383, pls. 1-21, text figs. 1-44 (maps, graphs, range charts, profiles, columnar sections, correl. chart, outline drawings), table of occurrence and abundance.—Quantitative analysis of about 2500 core samples from 130 borings between 4 and 40 meters long. An ecological zonation of 7 zones and 10 subzones is recognized and correlated with an amelioration from Arctic to Boreal conditions and shallowing of water resulting from isostatic land rise. Included is an illustrated catalog of 180 species, subspecies, and forms (2 species of *Dentalina* new).

- GROSDIDIER, EMMANUEL, and SAINT-MARC, PIERRE. Sur la présence de *Thomasinella* (Foraminifère) en Aquitaine.—C. R. S. séances Soc. Géol. France, fasc. 2, Feb. 3, 1964, p. 68-70, drawing, photomicrograph.—In the Cenomanian.
- HANZAWA, SHOSHIRO. The phylomorphogeneses of the Tertiary foraminiferal families, Lepidocyclinidae and Miogypsinidae.—Sci. Repts. Tohoku Univ., Sendai, 2nd Ser. (Geol.), v. 35, No. 3, March 20, 1964, p. 295-313, correl. table, range chart, phylogenetic diagrams.—Consideration of evidences for correlation between zonation by larger Foraminifera and zonation by planktonics, and for placement of Oligocene-Miocene boundary below or above Aquitanian. Charts show phylogenetic connections between genera of the Lepidocyclinidae and between species of the Miogypsinidae.
- HANZAWA, SHOSHIRO, and URATA, HIDEO. Supplementary note to the Nummulitic rocks of Amakusa, Kyushu, Japan.—Repts. on Earth Sci., Dept. General Educ., Kyushu Univ., No. 11, March 1964, p. 1-12, pls. 1-6.—Descriptions of 3 species of *Nummulites* (2 new) and 2 of *Discoyclina* (1 new) from rocks probably Ypresian in age.
- HERB, RENÉ. Über Vorkommen von Amdenerschichten im mittleren Säntisgebirge.—Eclogae Geol. Helvetiae, v. 56, No. 2, Dec. 31, 1963, p. 904-906, pls. 1, 2.—Illustrations of 10 species of Upper Cretaceous Foraminifera from 2 wells.
- HERB, RENÉ, and SCHAUB, HANS. Zur Nummulitenfauna des Mitteleozäns von Sordel'Abbaye (Landes, Frankreich).—Eclogae Geol. Helvetiae, v. 56, No. 2, Dec. 31, 1963, p. 973-999, pls. 1-12, text figs. 1-12 (map, geol. section, drawings, graphs, range chart).—Twelve species, 2 new.
- HERMAN, YVONNE. Temperate water planktonic Foraminifera in Quaternary sediments of the Arctic Ocean.—Nature, v. 201, No. 4917, Jan. 25, 1963, p. 386, 387, text figs. 1, 2 (graph, correl. diagram), table 1.—In 5 deep-sea cores from the Alpha Rise occur alternations of brown Foraminifera-rich layers (interpreted as slow deposition during cold periods) and silty Foraminifera-poor layers (interpreted as rapid deposition during warm periods). Specimens of several temperate water species occur in the silty layers.
- HERMES, J. J. Planktonic Foraminifera from Tertiary of the region of Vélez Rubio, appendix to Further notes on the geology of the Betic of Málaga, the Subbetic, and the zone between these two units, in the region of Vélez Rubio (southern Spain), by H. J. MACGILLAVRY, et al.—Geol. Rundschau, Stuttgart, v. 53, No. 1, May 1964, p. 256-259.—Species listed from several formations and correlations made with the West Indian zones.
- HILTERMANN, HEINRICH. Erkennung fossiler Brackwassersedimente unter besonderer Berücksichtigung der Foraminiferen.—Fortschritte in der Geologie von Rheinland und Westfalen, Krefeld, Band 10, Oct. 1963, p. 49-52.
- HOFKER, J. Foraminifera of the Cretaceous of South-Limburg, Netherlands. LXVIII. *Planorbullinella cretae* (Marsson).—Natuurhist. Maandblad, 52° Jrg., No. 9, Sept. 26, 1963, p. 129-131, text figs. 1-6.—In the Paleocene, a double-walled species possibly related to the orbitoid group.
- LXIX. The Miliolidae of the Maestricht Tuff Chalk.—Natuurhist. Maandblad, 52° Jrg., No. 10, Oct. 30, 1963, p. 143-144, text figs. 1-3.—Four species, none new, in the lowermost Paleocene.
- LXX. The finer structure of the test of *Mississippina binkhorsti* (Reuss, 1862) and its bearing on the taxonomic position of *Mississippina*.—Natuurhist. Maandblad, 52° Jrg., No. 11, Nov. 27, 1963, p. 157-160, text figs. 1-6.—Transverse sections of well-preserved material reveal the original wall is agglutinated of fine chalky material that is covered, except in the sunken parts, by a pore-less hyaline layer of fine chalk prisms perpendicular to the wall surface. The structure suggests an affinity with the Tetrataxidae.
- LXXI. The increase of the pore-diameters in *Gavelinopsis involuta* (Reuss, 1862) during the later Cr 4 and the Maestricht Tuff Chalk in the Canal Albert region.—Natuurhist. Maandblad, 52° Jrg., No. 12, Dec. 30, 1963, p. 173-176, text figs. 1-3, table.—Pore-diameters show jumps in continuity corresponding to discontinuities in sedimentation.
- LXXII. On the wall-structure of some Upper Cretaceous and Paleocene agglutinated Foraminifera.—Natuurhist. Maandblad, 53° Jrg., No. 1, Jan. 29, 1964, p. 8-11, 1 pl.—Nine species—from Cretaceous, Eocene, and Recent—having agglutinated walls perforated by pores, some with an inner crystal layer.
- LXXIII. The genus *Cymbalopora*.—Natuurhist. Maandblad, 53° Jrg., No. 3, March 25, 1964, p. 40-43, text figs. 1-6.—Study of the 3 known species by thin sections shows a 3-layered wall: a single row of coarser sand grains between inner and outer layers of finer agglutinated material. *Cymbaloporetta* is probably unrelated, differing in wall structure and in possess-

- ing connections between rows of chambers, not found in *Cymbalopora*.
- La position taxonomique de *Gabonella*.—Revue de Micropaléontologie, v. 6, No. 4, March 1964, p. 259-261, pl. 1.—Because wall is non-perforate the genus should not be classified in Heterohelicidae. It is related to *Siphogaudryina* (*Bolivinitella*) and *Valvobifarina*.
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- HUANG, TUNYOW. Planktonic Foraminifera from the Peikang PK-3 Well in the Peikang Shelf Area, Yunlin, Taiwan.—Petr. Geol. Taiwan, No. 2, Jubilee Volume in commemoration of the seventieth birthday of Mr. Hung-Hsun Ling, Dec. 1963, p. 153-181, pls. 1-6, text figs. 1-4 (map, range chart, distrib. table, subsurface correl. chart), tables 1, 2.—About 50 species are illustrated from 4 formations (1 Pleistocene, 1 Pliocene, 2 Miocene) in a section of about 2000 feet. Restricted stratigraphic ranges are indicated for the more important species—25 planktonic and 20 benthonic.
- Smaller Foraminifera from the Sanhsien-Chi, Taitung, eastern Taiwan.—Proc. Geol. Soc. China, No. 7, April 1964, p. 63-72, pls. 1-4, text figs. 1-4 (map, graphs, frequency diagrams), table 1—Illustrations and tables showing distribution and abundance of about 150 species, subspecies, and varieties in 15 samples of a section. The beds, deposited in warm and moderately deep water of a gradually shallowing sea, are Pliocene or younger. *Bolivina wui* n. sp. is described.
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- ISHIWADA, YASUFUMI. Benthonic Foraminifera off the Pacific coast of Japan referred to biostratigraphy of the Kazusa group.—Geol. Survey Japan, Rept. No. 205, 1964, p. 1-44, pls. 1-8, text figs. 1-14 (map, graphs, composition diagrams, frequency diagrams, distrib. diagram, structure map, correl. diagram), tables 1-6.—Quantitative analyses of samples from 37 stations provide a picture of faunal composition at depths ranging from 22 to 1180 meters and within 3 different water masses: Oyashio, Kuroshio, and mixed Kuroshio. Coexistence of past Oyashio and past Kuroshio waters is recognized in the Pliocene assemblages.
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- LAFRENTZ, H. R., and WOSZIDLO, H. Wichtige Foraminiferen aus dem Holstein- und dem Eem-Interglazial Schleswig-Holsteins und ihre ökologische Auswertung.—Schrift. Naturwiss. Vereins Schleswig-Holstein, Band 34, Dec. 1963, p. 106-115, text fig. 1 (map), table 1.—Certain species appear to be restricted to one or the other interglacial stage.
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