

# Smaller Foraminifera From Midway Drill Holes

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GEOLOGICAL SURVEY PROFESSIONAL PAPER 680-E



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By RUTH TODD and DORIS LOW

GEOLOGY OF THE MIDWAY AREA, HAWAIIAN ISLANDS

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*Smaller Foraminifera from two cored holes,  
about 4 miles apart, drilled to the basaltic  
foundation underlying Midway atoll*



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## GEOLOGY OF THE MIDWAY AREA, HAWAIIAN ISLANDS

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By RUTH TODD and DORIS LOW

### ABSTRACT

Two cored drill holes yielded abundant free specimens of smaller Foraminifera. All beds are interpreted as of shallow deposition, probably near or within a reef. Both holes reached the basaltic foundation, one at 516 feet and the other at 1,261 feet. Miocene (Tertiary *g*) was reached at 445 feet in the shallower hole, at 500 feet in the deeper. The deeper hole is Tertiary *c* (lower Miocene) in its lower part. *Austrotrillina striata*, a miliolid which became extinct in Tertiary *e* and is known only in Europe, Asia, and the western Pacific, is present in abundance in the lower part of the deeper hole. More than 400 core samples were examined. Checklists give the occurrence and abundance of about 172 species. Three species are described as new—*Angulogerina midwayensis*, *Eponides formosulus*, and *Neconorbina rustica*.

### INTRODUCTION

In 1965, two cored holes were drilled about 4 miles apart on Midway atoll seeking evidence on the environment, age, and history of the Hawaiian Island chain. As shown in figure 1, the Sand Island hole was drilled on the northern edge of the island of that name, which is within the southern sector of the atoll, and the Reef hole was drilled on the northern edge of the lagoon from a barge resting in 8 feet of water. Both holes reached the basaltic foundation of the seamount upon which Midway atoll grew; in Sand Island hole at 516 feet and in Reef hole at 1,261 feet (Ladd and others, 1967, p. 1088). The age of the oldest sedimentary rocks, those immediately above the basaltic foundation, is early Miocene (Tertiary *e*), and the overlying stratigraphic section is Miocene up to within 445 feet and 500 feet of the surface (in Sand Island hole and in Reef hole, respectively). Age of the post-Miocene section of rocks and unconsolidated debris is not determinable by Foraminifera. The Foraminifera fauna recovered from the cored rocks is meager compared with that associated with coral reefs in lower latitudes. However, 172 species were identified from the Miocene and post-Miocene rocks in the two holes together.

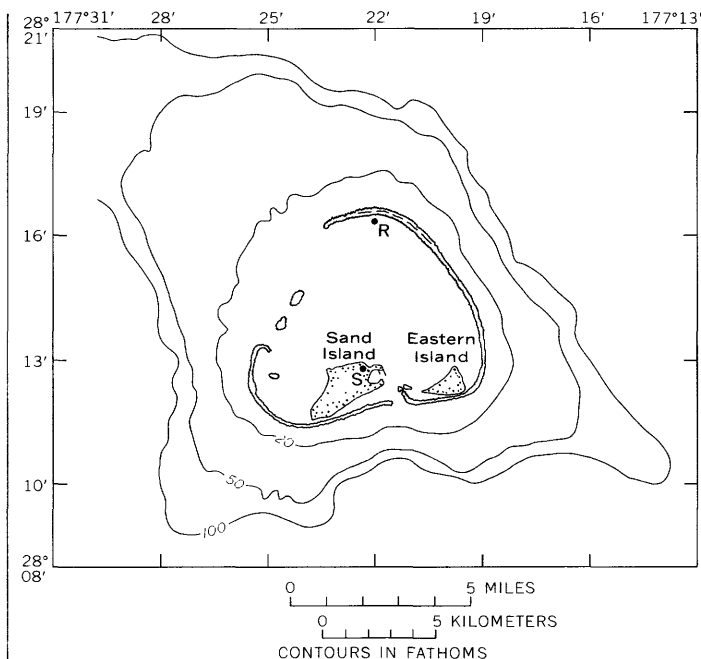


FIGURE 1.—Map of Midway atoll, showing location of drill holes. S, Sand Island hole; R, Reef hole. From Ladd, Tracey, and Gross (1970).

At the top of the holes, the Sand Island assemblages are richer than those from Reef hole, possibly because they were laid down nearer to land. Although Sand Island hole was drilled to a depth less than one-half that of Reef hole, 120 species were recorded from Sand Island hole, nearly 83 percent of the total number of species (145) taken from Reef hole. At the corresponding depth of 500 feet in each hole, which is the deepest point from which specimens were obtained from Sand Island hole, 50 percent more species were recorded from Sand Island than Reef hole. The two holes have 89 species in common; 31 species occur only in Sand Island hole and 55 only in Reef hole. Thus, there is a total fauna of smaller Foraminifera of approximately 175

species, including three identified only as to general group.

*Acknowledgments.*—The study benefited from our having the opportunity to examine and take samples from the well cores, and we are grateful to H. S. Ladd for arranging the National Science Foundation supporting funds for our visit to the Hawaii Institute of Geophysics for this purpose. For suggestions and helpful discussions of our work, we are indebted to many colleagues, chiefly C. G. Adams, W. Storrs Cole, J. E. Hazel, H. S. Ladd, Frances L. Parker, Johanna M. Resig, and J. I. Tracey, Jr. Our appreciation goes to Ted Murphy of the Hawaii Institute of Geophysics for his assistance in handling the core boxes and in other ways during our stay at the University of Hawaii.

The figures on plates 1–9 are drawings by Mrs. Naida Page; those on plates 10 and 11 are photographs retouched by the junior author; and those on plate 12 are photographs of rock sections cut by Richard Margerum and photographed by Robert H. McKinney.

### PREPARATION OF MATERIAL

Better consolidated sediments and improved drilling methods resulted in a far better core recovery at Midway (Ladd and others, 1967, p. 1088–1089, table 1, fig. 4) than that obtained at Eniwetok (Ladd and others, 1953, p. 2259–2268, fig. 2). Of the approximately 421 samples reported on in this paper (tables 1 and 2), all but one are from cores; whereas of the 406 samples tabulated from the Eniwetok drill holes E–1 and F–1 (Todd and Low, 1960, tables 2 and 3), only 23 were taken from cores.

The 3-inch-diameter cores, retrieved in a rubber sleeve, were cut in 5-foot lengths at Midway and packed in numbered wooden boxes for storage at Honolulu. During our 4-week visit at the Hawaii Institute of Geophysics at the University of Hawaii in early 1966, parts of these cores were given spot checks for Foraminifera and other microfossils. Series of samples were then selected for detailed study, and our collection information was marked on the inside of the box covers for future reference.

Sections indicating the most promising results were sampled at intervals of 6 inches or less. A good example of this is the interval of 1,101.5–1,115.5 feet in the Reef hole (table 1)—a series of 16 samples within 15 feet of core (core boxes 303–305). Boxes containing poorly consolidated material could not be marked as to more precise depths. Some covered 5 feet of drilling depth but less than 5 feet of core recovery. For this situation the tables show the inclusive depth figures for an individual box and indicate the part of the box that was sampled. For example, from the depth 866 to 871 feet in the Reef

hole (table 1), box 255 yielded three samples listed as 866–871 top, 866–871 middle, and 866–871 bottom.

In examining the cores we noted a fluctuation in richness of assemblage that was unreflected by any obvious change in lithology of the sediments. Some of the poorer samples examined were eliminated from the tables. However, very few of the samples examined were wholly barren of smaller Foraminifera.

For final study, the samples were routinely prepared by gently boiling and then washing on a 200-mesh screen. Some were treated with hydrogen peroxide, but this was ineffective on the harder, more recrystallized sediment.

Unlike the Eniwetok study in which each of us concentrated on one drill hole (Todd and Low, 1960, p. 800), we combined our examination of the Midway material by each picking and mounting alternate samples throughout both holes.

### SUMMARY OF FAUNAS

Tables 1 and 2 show the distribution and abundance of species in Reef hole and Sand Island hole, respectively. In each table, the species are arranged in order of their first appearances and are numbered consecutively. In the text the species are arranged in systematic order and the consecutive numbers are included there in order to facilitate finding the species on the tables.

#### REEF HOLE

Coring started at about 70 feet. From this level down to the sample at 103.5 feet the hole penetrated a fairly rich miliolid-*Amphistegina* facies similar to but slightly less rich than the miliolid-*Amphistegina* facies at the top of Sand Island hole. The major constituent, *Amphistegina madagascariensis* d'Orbigny, is accompanied by *Marginopora vertebralis* Quoy and Gaimard and a large variety of miliolids as well as various other species, mostly roataliids and bolivinids.

Below the sample at 103.5 feet with its rich and well-preserved fauna, the material is quite meager and badly obscured by recrystallization down to 500 feet, although *A. madagascariensis* maintains its abundance more or less throughout, except where it is replaced by *Heterostegina* (Cole, 1969, p. C8) between 376.5 and 400 feet. *Marginopora vertebralis* and *Reussella simplex* (Cushman) are discontinuously present. At 206 feet *Rosalina turgida* (Dorreen) makes its appearance. Between 362.5 and 381 feet, the only recognizable fossils are miliolid fragments.

The sample at about 426 feet is a good one and includes several planktonic species in addition to the roataliids and bolivinids already found at higher levels. Between 426 and 500 feet, the recrystallized zone con-

tinues with virtually undeterminable specimens, probably of the genus *Amphistegina*.

At 500 feet there is a sudden and nearly complete change at the top of the Miocene. The material is less crystallized and the following species make their first appearance:

*Amphistegina bikiniensis* Todd and Post  
*Asterigerina tentoria* Todd and Post  
*Baggina parva* Todd  
*Bolivina folium* (Parker and Jones)  
*Cribrogoesella parvula* Todd and Low  
*Globigerina trilocularis* d'Orbigny  
*Neoconorbina patelliformis* (Brady)  
*Valvulamina marshallana* Todd and Post  
*Valvulina martii* Cushman and Bermudez

This level is equivalent to that at 445 feet in Sand Island hole where the top of the Miocene is marked by a conglomerate of basalt boulders and cobbles, and the faunal change is nearly as striking with first appearances of *Amphistegina bikiniensis*, *Asterigerina tentoria*, *Valvulamina marshallana*, and *Valvulina martii*.

We interpret the age of the top of the Miocene at Midway as Tertiary *g*. This interpretation is based on the combined presence of *Valvulamina marshallana* and *Asterigerina tentoria*. The top occurrence of *A. tentoria* is in Tertiary *g* at Bikini and in Tertiary *f* at Eniwetok, whereas the top occurrence of *Valvulamina marshallana* is in Tertiary *g* at both Bikini and Eniwetok. Although the top occurrence of *Amphistegina bikiniensis* is in the middle part of Tertiary *e* at Eniwetok and Bikini, and either close above or close below the top of *Austrotrillina striata*, it is found relatively much higher here at Midway, where its top occurrence is with that of *Valvulamina marshallana* and *Asterigerina tentoria*.

At about 510 feet and also 514–516 feet, the core consists of limestone pieces on the surface of which can be seen densely packed specimens of miliolids, some as sections and some as whole individuals. (See pl. 12, fig. 3.) The interval containing *Asterigerina tentoria* ends at about 560 feet and that containing *Valvulamina* ends at about 570 feet. Both species reappear at deeper levels. The sediment, though much recrystallized, still contains usually abundant *Amphistegina*, now the species *A. bikiniensis*.

The top of Tertiary *e* at about 590 feet, as interpreted by Cole (1969, p. C2) on the basis of larger Foraminifera, is not evident in the fauna of smaller Foraminifera which continues with little change down to about 910 feet where the first specimens of *Austrotrillina* appear.

In the interval of more than 300 feet between the top of Tertiary *e* (about 590 ft) and the first significant change shown by smaller Foraminifera, specimens of

*Amphistegina bikiniensis* are more or less consistently present, accompanied in some samples by large spherical specimens of *Gypsina globula* (Reuss). The sediments are mostly coarsely recrystallized so that the larger specimens of Foraminifera are poorly preserved, often nearly obscured by crystal coatings and accompanying shell and algal debris, and the smaller specimens—bolivids, nonionids, and rotaliids—are usually missing. (See pl. 12, fig. 5.)

At around 875 feet the assemblage of smaller species, although still meager, becomes more clearly discernable, and at 876.5 feet the first specimens of *Baggatella* sp. appear.

At about 910 feet, limestone fragments show the first rare specimens of *Austrotrillina striata* Todd and Post, the distinctive Tertiary *e* miliolid that occurs in floods at deeper levels.

Beginning at 930 feet, most of the samples contain fairly rich assemblages of smaller Foraminifera consisting chiefly of species of the following genera: *Clavulina*, *Quinqueloculina*, *Pyrgo*, *Bolivina*, *Reussella*, *Rosalina*, *Rotorbinella*, *Nonion*, and *Cibicides*. First occurrences at about this level include the following species:

*Astacolus* sp.  
*Bolivina fastigia* Cushman  
*Cancris pauciloculatus* Cushman and McGlamery  
*Eponides formosulus* Todd and Low, n. sp.  
*Gaudryina triangularis angulata* Cushman  
*Planorbulinella larvata* (Parker and Jones)  
*Spiroloculina oclusa* (Cushman)  
*Virgulina complanata* Egger

At 979.5–981 feet a thin oyster bed was penetrated. All the associated Foraminifera are small kinds—species of *Bolivina*, *Buliminella*, *Virgulina*, *Angulogerina*, *Pseudononion*, and *Caucasina* (its first occurrence). *Ammonia beccarii tepida* (Cushman), indicating near-brackish conditions, is also associated with the oyster bed. A second oyster bed occurs about 61½ feet lower, again with the same associated species.

The assemblages continue to be rich, and gradually more first occurrences are added. Between 930 and 1,027 feet an almost complete lack of *Amphistegina bikiniensis* is noted, with such species as *Rotorbinella mira* (Cushman), *Nonion pacificum* (Cushman), *Rosalina globularis* d'Orbigny, and *Cibicides lobatulus* (Walker and Jacob) occupying the dominant position. Between 1,027 and 1,043 feet the following species have their first occurrence:

*Glabratella* sp.  
*Nonion akitaense* Asano  
*Pseudononion* aff. *P. tredecum* Asano  
*Quinqueloculina akneriana* d'Orbigny  
*Q. costata* d'Orbigny  
*Spiroloculina communis* Cushman and Todd

At about 1,027 feet *Amphistegina bikiniensis* resumes its position of dominance in the assemblages. Many of the samples contain beautifully preserved specimens, but some show effects of recrystallization. The sample at 1,008.5 feet shows perfect preservation. The chambers are empty with pores visible, and the walls are lustrous. In some samples the individual specimens show abrasion, possibly from reworking, and in some there appear to be beach-polished grains.

A diverse fauna at 1,042 feet seems to indicate relatively shallower water deposition, although none of the Midway faunas indicate deposition at depths greater than several hundred feet. In this sample were observed grains of polished beach sand, and the Foraminifera assemblage—*Amphistegina*, large miliolids, peneroplids, and species of *Cornuspira*, *Bolivina*, *Buliminella*, *Virgulina*, *Bolivina*, *Rosalina*, *Elphidium*, *Pseudononion*, and *Cibicides*—is suggestive of near-shore and shallow deposition.

At 1,044–1,046 feet, a soft black clay contains mostly *Amphistegina*, with little else in the medium-size fraction. The fine fraction is rich in species of *Bolivina*, *Virgulina*, *Buliminella*, *Bolivina*, *Caucasina*, *Rosalina*, *Nonion*, *Pseudononion*, *Elphidium*, and *Cibicides*.

Between 1,046 and 1,101.5 feet, many samples are either barren of Foraminifera or very poor, and those that do contain identifiable species consist in large part of semiconsolidated organic debris, recrystallized and cavernous. *Amphistegina bikiniensis* and unidentifiable miliolids make up most of the fauna. (See pl. 12, fig. 2.)

Between 1,101.5 and 1,108 feet the following species have their first occurrences:

*Bolivina alazanensis* Cushman  
*Cycloloculina* sp.  
*Gyroidina orbicularis* d'Orbigny  
*Heronallenia* sp.  
*Marginulina procera* (Stache)  
*Siphonodosaria*? sp.

Below the change at 1,101.5 feet, the assemblages are rich in most of the samples and by 1,106.75 feet, *Austrotrillina striata* is abundant. At this level, *Valvulammia marshallana* recurs. In addition, *Valvulina martii*, that accompanies *Valvulammia marshallana* at the top of the Miocene, accompanies it here also.

From this level down to 1,120 feet, the sediment is dominated by *Austrotrillina striata*, and in places consists of an *Austrotrillina* sand. (See pl. 12, fig. 4.) *A. striata*, a species having an upper age limit of Tertiary *e*, confirms the Tertiary *e* age of this part of the section. The associated fauna of smaller Foraminifera is rich and moderately well preserved, and *Rotorbinella mira* approaches *Amphistegina bikiniensis* in abundance in some samples.

Between 1,113 and 1,120.5 feet, *Gypsina discus* Goës occurs in association with *Austrotrillina striata*. Although *Austrotrillina* is absent or very rare below 1,120 feet, the assemblage associated with it continues down to about 1,129 feet.

Below a virtually barren interval of 36 feet, a totally different fauna occurs at 1,165 feet. In a dark-brown clay (pl. 12, fig. 6), the assemblage is dominated by *Bolivina striatula* Cushman, *Buliminella elegantissima* (d'Orbigny), *Virgulina complanata* Egger, *Rotorbinella mira* (Cushman), and *Amphistegina bikiniensis* Todd and Post. The specimens appear fresh and unchanged by recrystallization.

Beneath an additional 21 feet of barren sediment is found the lowest fauna at Midway—at 1,186 feet are abundant miliolids (*Quinqueloculina laevigata* d'Orbigny) and common peneroplids (*Peneroplis proteus* d'Orbigny) plus a few rare individuals of species known from higher levels, all represented by glauconite molds. This miliolid-peneroplid fauna appears to be a reef or near-reef deposit.

There are no faunal elements suggesting an age any older than Miocene for either of these two lowest Midway faunas.

#### SAND ISLAND HOLE

Coring in the shallower drilling, Sand Island hole, started about 40 feet higher than in Reef hole. This may account, in part, for the slightly richer fauna obtained from the top of this hole. The facies in the uppermost section is similar to that of the Reef hole with *Amphistegina madagascariensis* d'Orbigny and *Marginopora vertebralis* Quoy and Gaimard dominating numerous miliolids, buliminids, and rotaliids.

Samples from 137 to 148 feet, including the only sample of cuttings (145 feet), contain abundant well-preserved specimens especially rich in miliolids. Although *Cibicides lobatulus* (Walker and Jacob) continues fairly regularly to the bottom, it is most common in this section. More than 58 percent of the Sand Island species (70 taxa) make their first appearance in the top 148 feet of the hole.

From this level downward the material is mostly hard, porous, and recrystallized and yields generally meager faunas. At 152.5 feet, *Marginopora vertebralis* becomes rare and continues only sporadically downward. *Amphistegina madagascariensis* is also rare and worn here but is again abundant, although still poorly preserved, from 218 to 241 feet and from 296.5 to 443 feet. (See pl. 12, fig. 1.)

Miliolids are virtually absent below 241 feet except for rare unidentifiable fragments. Two additional exceptions are *Quinqueloculina polygona* (d'Orbigny)

and *Spiroloculina manifesta* Cushman and Todd occurring commonly at 259.8 feet.

At 242.5 feet a small shallow-water fauna of Foraminifera is accompanied by many specimens of the ostracode *Cyprideis beaenensis* LeRoy. This ostracode indicates brackish water conditions (J. E. Hazel, written commun., 1969). Specimens of *Elphidium* and *Discorbis vesicularis dimidiata* (Parker and Jones) are present here within a 1-foot interval but do not recur further down.

Nothing much of significance appears in the small residues obtained from the hard, recrystallized cores in this interval down to 445 feet. *Reussella simplex* (Cushman) and *Cymbaloporella bradyi* (Cushman) occur together in sporadic common to abundant numbers from 258.8 to 321 feet. From 296.5 to 443 feet, *Amphistegina madagascariensis* is once again common to abundant but ends abruptly at the latter depth.

Between 427 and 443 feet, a coarse conglomerate of basaltic cobbles occurs. The only Foraminifera found in it are *Amphistegina madagascariensis* and undetermined miliolid fragments.

The following significant species make their first appearance at 445 feet, interpreted as the top of the Miocene in the Sand Island hole: *Amphistegina bikiniensis* Todd and Post (abundant), *Valvulamina marshallana* Todd and Post, and *Valvulina martii* Cushman and Bermudez. At 446 feet, the Miocene evidence is strengthened by *Asterigerina tentoria* Todd and Post and fragments of *Austrotrillina*, presumably *A. striata* Todd and Post. These are unmistakable remnants of *Austrotrillina* and are the only representatives of the genus in the Sand Island cores, presumably reworked from Tertiary *e*.

The existence of reworked material at this level so close beneath the basaltic conglomerate between 427 and 443 feet is to be expected. We assume that the ancestral Midway basaltic foundation was receiving sediments as it sank and that locally these sediments were eroded and redeposited due to intermittent rising and sinking of the local area with respect to sea level. The presence of the basaltic cobbles suggests that the site of Sand Island hole was near land receiving sedimentation from some adjacent higher area. Hence some of the earlier deposited Tertiary *e* specimens from the abundant *Austrotrillina* sand probably became mixed with the Tertiary *g* specimens that lived in the area at the time preceding the deposition of the basaltic conglomerate.

The material from about 460 feet to the bottom is mostly hard and recrystallized with some core pieces being porous agglomerates of reef debris. It yields rare,

mostly very tiny, poorly preserved Foraminifera down to 500 feet. Additional first occurrences which may be of significance are the following between 460 and 485 feet:

*Angulogerina tenuistriata* (Reuss)  
*Baggina parva* Todd  
*Buccella perforata* Todd and Low  
*Clavulina multicamerata* Chapman  
*Globigerina trilobularis* d'Orbigny  
*Globigerinoides trilobus altiapertura* Bolli

Of these, *Globigerinoides trilobus altiapertura* and *Angulogerina tenuistriata* are not found in our Reef hole cores.

Some bolivinids such as *Bolivina striatula* Cushman, *B. compacta* Sidebottom, and *Reussella simplex* (Cushman) recur from about 460 feet to the bottom. *Bolivina striatula* is strikingly abundant from 483.5 to 489 feet. At 488–496 feet *Gypsina globula* (Reuss) increases in number of specimens and from there persists rarely to the bottom.

Between 483.5 and 501.5 feet, specimens of the agglutinated species *Clavulina angularis* d'Orbigny and *C. multicamerata* Chapman have incorporated black grains into their otherwise white tests. These black grains indicate that the sediment on which these species lived included black grains, presumably of volcanic rock.

Organic fragments from 500.6 to 529.5 feet seem to be of little significance, and the cores are omitted from table 2.

## PALEOECOLOGY

The kinds of smaller Foraminifera present in the rocks of the Midway drill holes indicate a marine environment throughout except for two narrow zones: one at about 242 feet in Sand Island hole characterized by species of *Elphidium* and *Discorbis* together with associated brackish water ostracodes, and the other, oyster beds at about 980 and 986 feet in Reef hole where *Ammonia beccarii tepida* and several other species suggest a brackish environment.

Depth of deposition was shallow, no deeper than around 300 feet and probably much shallower, such as 60–150 feet. Grains of polished beach sand and abraded specimens of Foraminifera at 1,042 feet in Reef hole suggest near-short and shallow deposition. The assemblage at 1,186 feet in Reef hole suggests it lived on a reef. No significant difference in depth of deposition was observed between the two holes except that in Sand Island hole the top of the Miocene is marked by a conglomerate of basaltic boulders whereas in the Reef hole, no conglomerate marks the top of the Miocene.

Turbulence was probably not severe over most of the area of deposition. In some parts of the section, such as at 1,045 feet and 1,165 feet in Reef hole, the faunal assemblage suggests that it may have lived behind a fringing reef. However, the presence of rare globigerinids, mostly in the post-Miocene parts of the section, is evidence of the circulation of oceanic water over the area of deposition.

Around 1,105–1,120 feet, where *Austrotrillina striata* Todd and Post is abundant enough to constitute an *Austrotrillina* sand, we interpret the conditions to have been shallow and possibly moderately turbulent.

Temperature, as is to be expected for this latitude, was undoubtedly cooler than that of the Marshall and Mariana Islands in lower latitudes. Lowered temperature is accompanied by decrease in number of species, and the Midway assemblages have significantly fewer species than do assemblages in the Marshalls and Marianas. Moreover, the presence of such a species as *Fissurina cucurbitasema* Loeblich and Tappan, that was described from the Arctic, implies cooler water.

Remoteness of new volcanic islands from a source of colonization may also contribute to the sparseness of the population at Midway. Shallow-water benthonic species can be "filtered" by adverse conditions as they move, presumably by some sort of rafting as discussed by Cole (1960a, p. 15–17), for long distances across areas such as oceanic regions where they do not live.

## CORRELATION

Correlation between the two Midway holes is fairly clear at 445 feet in Sand Island hole and 500 feet in Reef hole where the following species first appear: *Amphistegina bikiniensis* Todd and Post, *Asterigerina tentoria* Todd and Post, *Valvulamina marshallana* Todd and Post, and *Valvulina martii* Cushman and Bermudez; and this level is interpreted as the top of the Miocene (Tertiary g). Many other species occur in common between the two holes, both above and below the top of the Miocene, but no others besides those mentioned seem to be useful for precise correlation. There seems no evidence that the bottom of Sand Island hole extends below Tertiary g.

Several points of probable correlation between the Miocene section at Midway and sections studied at Bikini (Todd and Post, 1954) and Eniwetok (Todd and Low, 1960) are recognizable, although the Midway section appears to be only about half the thickness of the Marshall Islands ones, and there is a striking lack at Midway of the genera *Calcarina* and *Pararotalia* and the heavy-walled species of *Ammonia* that make up dominating parts of the assemblages in the Marshalls.

The top of the Miocene at Midway at 445 and 500 feet in the two holes is marked by the first appearances of *Amphistegina bikiniensis* Todd and Post, *Asterigerina tentoria* Todd and Post, *Cribrogoesella parvula* Todd and Low, *Valvulamina marshallana* Todd and Post,

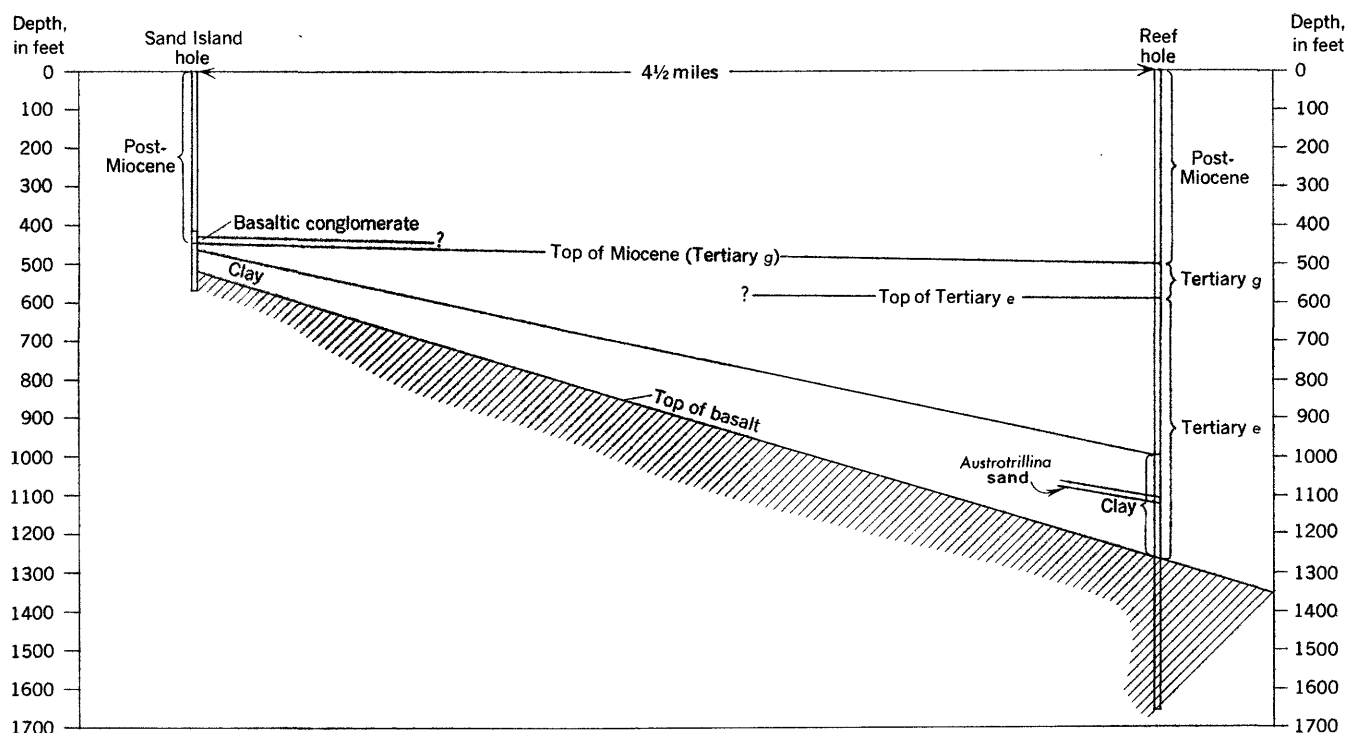


FIGURE 2.—Correlation between Reef hole and Sand Island hole, Midway atoll. Core depths are in feet below drilling platform, which was 16.5 feet above mean lower low water for Sand Island hole and 10.5 feet for Reef hole.

and *Valvulina martii* Cushman and Bermudez. Tops of these species in the two sections in the Marshalls are tabulated below.

	Bikini hole 2B (in ft)	Eniwetok hole E-1 (in ft)
<i>Amphistegina bikiniensis</i> Todd and Post.....	1, 891	≈ 1, 500
<i>Asterigerina tentoria</i> Todd and Post.....	852	960
<i>Cribrogoesella parvula</i> Todd and Low.....	1, 293	1, 020
<i>Valvulamina marshallana</i> Todd and Post....	852	800
<i>Valvulina martii</i> Cushman and Bermudez....	1, 209	1, 030

We favor placing more weight on *Valvulamina marshallana* and *Asterigerina tentoria* to correlate the level at 445 feet in Sand Island hole and 500 feet in Reef hole with levels of approximately 800 feet at Eniwetok and 850 feet at Bikini.

An alternative interpretation is that the unconformity at the basaltic conglomerate above 445 feet in Sand Island hole has removed some of the upper part of the Miocene represented at 800 and 850 feet at Eniwetok and Bikini and that the correlation should be made with a deeper level in those two sections. This alternative

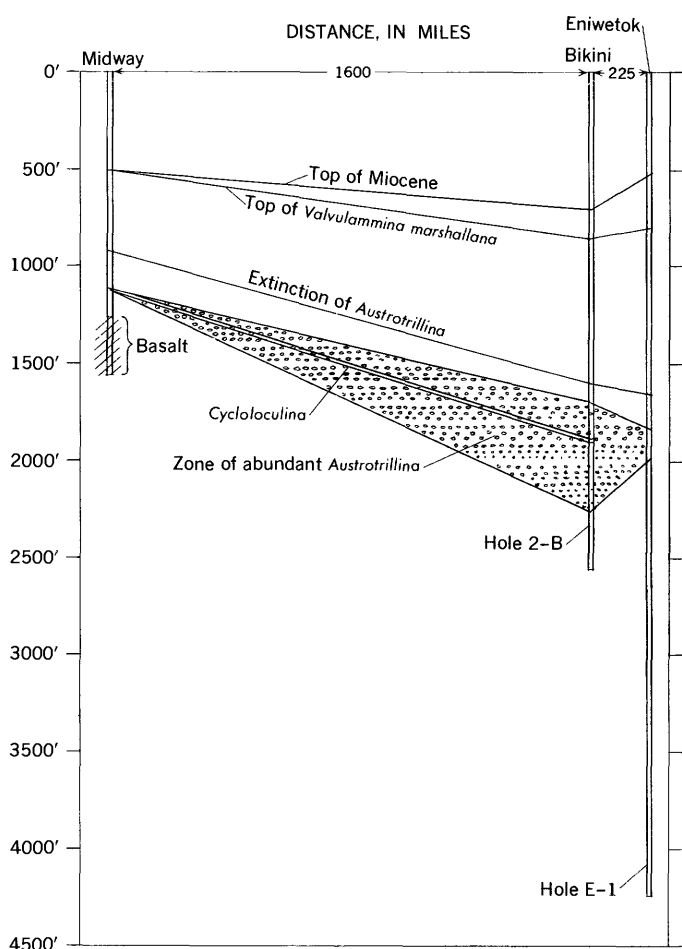


FIGURE 3.—Correlation between Midway, Bikini, and Eniwetok drill holes.

interpretation is supported by that of Cole (1969, p. C3) in which the Reef hole section between 590 and 960 feet is correlated with the part of the Tertiary *e* section that lies between 1,190 and 1,452 feet at Eniwetok and between 1,387 and 1,597 feet at Bikini.

Miocene age seems fairly well established for the section in Reef hole above 590 feet, the uppermost occurrence of Tertiary *e* larger Foraminifera, and below 500 feet, the uppermost occurrence of Miocene smaller Foraminifera. What is in question is what part of the Miocene this should be assigned to. No larger Foraminifera were found in this questionable 90 feet of section that is correlated, by smaller Foraminifera, with about 55 feet of section underlying a basaltic conglomerate in Sand Island hole. This questionable Miocene section could conceivably be placed in Tertiary *e*, Tertiary *f*, or Tertiary *g*.

Lacking evidence for placing this questionable section in Tertiary *e* or Tertiary *f*, we favor placing it in Tertiary *g* on the basis of the occurrence of *Valvulamina marshallana* and *Asterigerina tentoria*. The former ranges downward from beds determined by larger Foraminifera to be Tertiary *g* at both Bikini and Eniwetok. The latter ranges downward from beds determined by larger Foraminifera to be Tertiary *g* at Bikini and Tertiary *f* at Eniwetok.

*Austrotrillina striata* Todd and Post provides another good correlation between Midway and the Marshall Islands. This genus, having become extinct with the end of Tertiary *e*, is found at its highest point at 911 feet in Reef hole but is not abundant until between 1,110 and 1,120 feet. In the Marshalls it is first observed at a depth of 1,658 feet in hole E-1 at Eniwetok and about 1,600 feet in holes 2A and 2B at Bikini, and the zones of its abundance are at 1,835–2,003 feet at Eniwetok and about 1,700–2,250 feet at Bikini. Thus we assume the extinction of *Austrotrillina striata* makes a reliable point of correlation, namely about 911 feet at Midway, about 1,658 feet at Eniwetok, and about 1,600 feet at Bikini. Moreover, the narrow zone of abundant *Austrotrillina* between 1,110 and 1,120 feet at Midway probably falls somewhere within the thicker zones of common to abundant *Austrotrillina* between 1,835 and 2,003 feet at Eniwetok and about 1,700–2,250 feet at Bikini.

Another species showing possible correlation between Midway and the Marshalls is *Cycloloculina* sp. At Midway it occurs between 1,106.75 and 1,126 feet, approximately within the zone of abundant *Austrotrillina*. At Bikini it occurs between 1,891.5 and 1,902 feet in hole 2B which is also within this zone of abundance.

Outside the Marshalls, there are other possible correlations. The finding of the planktonic subspecies *Globigerinoides trilobus altiapertura* Bolli in Sand

Island hole at 460 feet, about 15 feet below the top of the Miocene, provides a correlation with Bodjonegoro-1 well in Java where the same form is reported as occurring in the lower and middle Miocene (Bolli, 1966, range chart). The benthonic assemblage of the Bodjonegoro-1 well, however, being of deep-water facies (Boomgaart, 1949), has virtually nothing in common with the Midway section.

*Bolivina chinenensis* LeRoy described from the Pliocene of Okinawa, and also known (under another name) from the Miocene (Tertiary *f*) part of the Eniwetok section, occurs in both the Miocene and the post-Miocene parts of Sand Island hole and the Miocene part of Reef hole. It seems to have a rather long range and is probably not useful for close correlation.

### SYSTEMATIC CATALOG

In the systematic catalog that follows we have added symbols to facilitate locating each species in the Reef hole (table 1) and the Sand Island hole (table 2). On each table the species are numbered consecutively and in the text these numbers are included after each species. For example, S49, R22 means that *Textularia foliacea* is No. 49 in the Sand Island hole and No. 22 in the Reef hole. Extra categories are tabulated in each hole to include unidentifiable specimens in the Miliolidae and Peneroplidae. They are No. 55 for miliolid fragments, No. 87 for miliolid molds, and No. 63 for peneropliids in the Reef hole and No. 71 for miliolid fragments and No. 101 for miliolid molds in the Sand Island hole.

#### Family HYPERAMMINIDAE Genus SAGENINA Chapman, 1900

##### *Sagenina frondescens* (Brady)

*Sagenina frondescens* (Brady). Todd, 1966, p. 31, pl. 17, fig. 1.

A piece of shell having slender tubes attached to its inner surface was found in the 35.5–40-foot sample from Sand Island hole.

*Species No.*—S29.

#### Family TEXTULARIIDAE Genus TEXTULARIA Defrance, 1824

##### *Textularia agglutinans* d'Orbigny

*Textularia agglutinans* d'Orbigny. Cushman, Todd, and Post, 1954, p. 328, pl. 83, fig. 2.

Typical specimens were found in the post-Miocene section of Sand Island hole only, where they are of good size and fairly common and persistent between 284 and 300 feet.

*Species No.*—S60.

##### *Textularia foliacea* Heron-Allen and Earland

*Textularia foliacea* Heron-Allen and Earland. Cushman, Todd, and Post, 1954, p. 329, pl. 83, fig. 7.

Two typical specimens were found at 137 feet in Sand Island hole. A juvenile specimen at 73 feet in Reef hole is questionably included.

*Species Nos.*—S49, R22.

#### Family VERNEUILINIDAE Genus GAUDRYINA d'Orbigny, 1839

##### *Gaudryina triangularis angulata* Cushman

*Gaudryina triangularis* var. *angulata* Cushman. Cushman, Todd, and Post, 1954, p. 331, pl. 83, fig. 14.

Several well-preserved specimens of this angular subspecies occur at about 930 feet in the Reef hole. Additional less well preserved specimens are found between 1,074 and 1,118 feet. The species was found in an Eniwetok core sample from 2,000 feet considered Miocene in age, as well as from cuttings from 700 to 1,300 feet in that drill hole.

*Species No.*—R103.

##### Subgenus SIPHOGAUDRYINA Cushman, 1935

##### *Gaudryina* (*Siphogaudryina*) *rugulosa* Cushman

*Gaudryina* (*Siphogaudryina*) *rugulosa* Cushman. Cushman, Todd, and Post, 1954, p. 331, pl. 82, fig. 1.

Todd and Low, 1960, p. 818, pl. 255, fig. 2; pl. 263, fig. 3.

The rugged surface features of this species are very apparent through the sugary recrystallization of the rare specimens from near the top of the Reef hole. The species has been found in the Holocene sediments of the Pacific and in Tertiary sediments of both the Marshall and Mariana Islands.

*Species No.*—R56.

##### *Gaudryina* (*Siphogaudryina*) *siphonifera* (Brady)

*Gaudryina* (*Siphogaudryina*) *siphonifera* (H. B. Brady). Cushman, Todd, and Post, 1954, p. 331, pl. 83, fig. 17.

Todd and Low, 1960, p. 818.

Fresh specimens of this tubulose species occur in the uppermost cores of both holes, to 137 feet in Sand Island hole and to 88 feet in Reef hole. It is well known in Holocene sediments of the Pacific. LeRoy (1964, p. 18, pl. 1, fig. 21) noted it from beds of Miocene age in southern Okinawa, the oldest recorded occurrence we have found.

*Species Nos.*—S36, R4.

#### Family VALVULINIDAE Genus VALVULINA d'Orbigny, 1826

##### *Valvulina davidiana* Chapman

*Valvulina davidiana* Chapman. Cushman, Todd, and Post, 1954, p. 331, pl. 82, fig. 2.

Todd and Low, 1960, p. 819.

*Valvulina davidiana*, the more triangular of the two species of this genus occurring in the Midway drill holes, is scattered to a depth of 1,125 feet in the Reef hole. It occurs more rarely in the Sand Island hole to a depth of about 491 feet.

In some samples, namely at 568.5 feet in Reef hole, *V. davidiana* and *V. martii* occur together. They appear to grade into one another, but the specific distinctions may be somewhat obscured by recrystallization and breakage.

*Valvulina davidiana* is short and angular, capped by the widely expanded final chambers and more open apertural area. *V. martii* is more elongate with rounded chambers and deeper sutures; the final chambers are gently rounded and the aperture is only slightly depressed and not as commonly broken out.

*Species Nos.*—S68, R64.

***Valvulina martii* Cushman and Bermudez**

*Valvulina martii* Cushman and Bermudez. Todd and Post, 1954, p. 553, pl. 198, fig. 1.

In both holes at Midway this species is associated with *Valvulamina marshallana* as it was at Bikini and Eniwetok. Specimens are less abundant than those of *V. marshallana* and are quite variable. All are of moderately large size and are irregularly angular. They are slenderer than *Valvulina davidiana*.

*Species Nos.*—S104, R81.

**Genus VALVULAMMINA Cushman, 1933**

***Valvulamina marshallana* Todd and Post**

Plate 10, figures 1-8

*Valvulamina marshallana* Todd and Post, 1954, p. 554, pl. 198, fig. 3.

Todd and Low, 1960, p. 820, pl. 255, fig. 4.

This large and striking species was described from Miocene beds in the deep drill hole at Bikini and was subsequently found in both Miocene and Eocene beds of the deep drill holes on Eniwetok. It is well represented in both Midway holes beginning at the top of the Miocene, 445 feet in Sand Island hole and 500 feet in Reef hole. In Reef hole, there are two zones of *Valvulamina marshallana*—one between 500 and 568.5 feet and another between 1,106.75 and 1,120 feet.

*Species Nos.*—S103, R80.

**Genus CLAVULINA d'Orbigny, 1826**

***Clavulina angularis* d'Orbigny**

Plate 1, figure 2; plate 11, figure 4

*Clavulina angularis* d'Orbigny. Todd and Low, 1960, p. 819.

*Clavulina pacifica* Cushman. Cushman, Todd, and Post, 1954, p. 332, pl. 83, fig. 19.

This neatly built triangular species is found nearly throughout both holes, most commonly and persistently in the lower parts of Reef hole, namely between 527 and 585 feet, 928 and 970.5 feet, 1,049.75 and 1,066.5 feet, and 1,091 and 1,129 feet. Between 1,118 and 1,122 feet, typical forms are accompanied by rare specimens of a form in which the final few chambers are flattened instead of triangular in section.

This species, under the name of *Clavulina pacifica*, is widely reported from the Pacific.

*Species Nos.*—S34, R41.

***Clavulina multicamerata* Chapman**

Plate 1, figure 1

*Clavulina parisiensis* d'Orbigny var. *multicamerata* Chapman, 1907, p. 127, pl. 9, fig. 5.

*Clavulina multicamerata* Chapman. Todd, 1957, p. 277 (table 3), pl. 81, figs. 6, 7.

This species is circular in section following a small triangular initial stage. It was described from off Port Phillip, Victoria, Australia, and has been reported from the Miocene of Saipan and the Miocene of the deep drilling at Eniwetok. At Midway it is found in both holes in the Miocene part, from 512 to 1,126.3 feet in Reef hole and 485-497.5 feet in Sand Island hole.

*Species Nos.*—S119, R84.

**Genus TRITAXILINA Cushman, 1911**

***Tritaxilina* aff. *T. hantkeni* Cushman**

*Tritaxilina hantkeni* Cushman (1936, p. 41, pl. 6, fig. 13) was described from beds of early Oligocene age in Hungary, and we found no records of any later origin. The specimens from 928 feet in the Reef hole are poorly preserved, which makes a more precise identification impossible.

*Species No.*—R99.

**Genus CRIBROGOESELLA Cushman, 1935**

***Cribrogoesella parvula* Todd and Low**

Plate 1, figure 3

*Cribrogoesella parvula* Todd and Low, 1960, p. 820, pl. 261, figs. 1, 2.

This species was described from the Miocene section, both in the parts referred to Tertiary f and to Tertiary e, of Eniwetok drill hole E-1. It has also been reported from drill hole 2B at Bikini.

At Midway, typical specimens are fairly common at the top of the Miocene at 500 feet in Reef hole, and two rare fragments were found below at 545 and 568.5 feet.

*Species No.*—R75.

**Family MILIOLIDAE**

**Genus QUINQUELOCULINA d'Orbigny, 1826**

***Quinqueloculina akneriana* d'Orbigny**

Plate 11, figure 2

*Quinqueloculina akneriana* d'Orbigny, 1846, p. 290, pl. 18, figs. 16-21.

This widely recorded species, originally described from the Miocene of the Vienna Basin, is found in some numbers at 1041.25 feet in Reef hole. Specimens are thick, rounded in section, and rounded at top and bottom of the test.

*Species No.*—R127.

[A, abundant; C, common; X, present]

[illegible]

67. *Globigerinoides conglobatus*.....  
 68. *Globorotalia inflata*.....  
 69. *Globorotalia* aff. *G. margaritae*.....  
 70. *Trifarina* aff. *T. bradyi*.....  
 71. *Amphistegina bitinensis*.....  
 72. *Asterigerina tentoria*.....  
 73. *Bulminella folium*.....  
 74. *Bulminella madagascariensis*.....  
 75. *Cyrtoscella parvula*.....  
 76. *Globigerina trilobulata*.....  
 77. *Neonorbina patelliformis*.....  
 78. *Quinqueloculina polygona*.....  
 79. *Triloculina trilocula*.....  
 80. *Volutammina marshallana*.....  
 81. *Volutina maritii*.....  
 82. *Bagina parva*.....  
 83. *Eponides duprei ciervoensis*.....  
 84. *Clavulina multicamerata*.....  
 85. *Quinqueloculina* aff. *Q. bradyana*.....  
 86. *Quinqueloculina* cf. *Q. seminulum*.....  
 87. milioid molds.....  
 88. *Globatella?* sp.....  
 89. *Nonion pacificum*.....  
 90. *Lenticulina* sp.....  
 91. *Buccella perforata*.....  
 92. *Chicidella cicatricosa*.....  
 93. *Bulmina chinensis*.....  
 94. *Bulminella elegantissima*.....  
 95. *Chicidella variabilis*.....  
 96. *Elphidium advena*.....  
 97. *Epistella* sp.....  
 98. *Avicula striata*.....  
 99. *Trifarina* aff. *T. lantkeni*.....  
 100. *Antechinus* sp.....  
 101. *Bulmina fastigia*.....  
 102. *Bulmina* (*Leontium*) *majori*.....  
 103. *Gaudryina triangularis angulata*.....  
 104. *Neonorbina costata*.....  
 105. *Pleurobuccella larada*.....  
 106. *Volutina complanata*.....  
 107. *Chicidella* sp.....  
 108. *Spiraloculina octava*.....  
 109. *Quinqueloculina* *subangensis* n. sp.....  
 110. *Tracina milledti*.....  
 111. *Eponides formosus* n. sp.....  
 112. *Neonorbina floridensis*.....  
 113. *Onchidella pseudonigerianus*.....  
 114. *Chicidella pseudonigerianus*.....  
 115. *Cucullina* sp.....  
 116. *Pseudonion atlanticum*.....  
 117. *Ammonia beccarii* sp.....  
 118. *Ammonia beccarii* sp.....  
 119. *Ammonia beccarii* sp.....  
 120. *Ammonia beccarii* sp.....  
 121. *Ammonia beccarii* sp.....  
 122. *Ammonia beccarii* sp.....  
 123. *Ammonia beccarii* sp.....  
 124. *Ammonia beccarii* sp.....  
 125. *Ammonia beccarii* sp.....  
 126. *Ammonia beccarii* sp.....  
 127. *Ammonia beccarii* sp.....  
 128. *Ammonia beccarii* sp.....  
 129. *Ammonia beccarii* sp.....  
 130. *Ammonia beccarii* sp.....  
 131. *Ammonia beccarii* sp.....  
 132. *Ammonia beccarii* sp.....  
 133. *Ammonia beccarii* sp.....  
 134. *Ammonia beccarii* sp.....  
 135. *Ammonia beccarii* sp.....  
 136. *Ammonia beccarii* sp.....  
 137. *Ammonia beccarii* sp.....  
 138. *Ammonia beccarii* sp.....  
 139. *Ammonia beccarii* sp.....  
 140. *Ammonia beccarii* sp.....  
 141. *Ammonia beccarii* sp.....  
 142. *Ammonia beccarii* sp.....  
 143. *Ammonia beccarii* sp.....  
 144. *Ammonia beccarii* sp.....  
 145. *Ammonia beccarii* sp.....  
 146. *Ammonia beccarii* sp.....

TABLE 1.—Distribution of smaller Foraminifera in selected core samples of Reef drill hole, Midway atoll—Continued

	Depth, in feet.	
336	X	Amphisetina madagascariensis
337	X	Gnathoporella bradyi
338	X	Eponides repandus
339	X	Gaudryina (Siphogaudryina) siphonifera
340	X	Homotrema rubrum
341	X	Marginozoua vertebalis
342	X	Peneroplus planatus
343	X	Quinqueloculina sulcata
344	X	Rosalina orientalis
345	X	Rosalina mitra
346	X	Spirallina decorata
347	X	Spirallina tuberculatolimbat
348	X	Spirallina orietina
349	X	Spiraloculina angulata
350	X	Spiraloculina involuta
351	X	Astericaster indistincta
352	X	Cypsinella lobatulus
353	X	Gypsina globula
354	X	Pyrgo denticulata
355	X	Quinqueloculina parkeri
356	X	Rosalina nitens
357	X	Trochammina foliacea
358	X	Triloculina bicarinata
359	X	Triloculina irregularis
360	X	Triloculina kerimbatica
361	X	Triloculina oblonga
362	X	Anomalina glabrata
363	X	Planorbolina acervilis
364	X	Acervulina tuberosa
365	X	Bolivina compacta
366	X	Fissurina lagenoides
367	X	Globigerinoides ruber
368	X	Hauerina involuta
369	X	Mitrolina labiosa
370	X	Quinqueloculina tubus
371	X	Renssella simplex
372	X	Siphonogenerina raphana
373	X	Alutina translucens
374	X	Bolivina rhomboidalis
375	X	Bolivina striatula
376	X	Cionulina angularis
377	X	Globigerinita glutinata
378	X	Planorbulinoides reticulatus
379	X	Siphonina tubulosa
380	X	Spirillina viitpara
381	X	Spiraloculina samoensis
382	X	Tretomphalus concinnus
383	X	Triloculina terquemiana
384	X	Vertebratina striata
385	X	Bolivina tortuosa
386	X	Spiraloculina dara
387	X	Chicidites mayori
388	X	Rosalina turgida
389	X	Globigerinoides sacculifer
390	X	Globigerinoides mulloti fragments
391	X	Gaudryina (Siphogaudryina) rugulosa
392	X	Bolivina (Lateralostoma) gumbeliniformis
393	X	Bolivina (Lateralostoma) rustica n. sp
394	X	Neonorbina trilobus
395	X	Globigerinoides trilobus
396	X	Globorotalia crassirostris
397	X	Rosalina globularis
398	X	peneroplus
399	X	Volutina daniana
400	X	Chicidites refulgens
401	X	Globigerina conglomerala

375-049 O-70-3

[illegible][illegible]

[illegible]

Depth, in feet.

[illegible]

[illegible]

Depth, in feet--

[illegible]

[illegible]

TABLE 1.—*Distribution of smaller Foraminifera in selected core samples of Reef drill hole, Midway atoll—Continued*

[illegible]

375-049 O-70-4

TABLE 2.—*Distribution of smaller Foraminifera in selected*

[A, abundant; C, common; X, present.

	30-35.5	35.5-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100	100-105	105-110	110-115	115-120	120-125	125-130	130-135	135-140	140-145	145 (cuttings)	150-155	155-160	160-165	165-170	170-175	175-180	180-185	185-190	190-195	195-200	200-205	205-210	210-215	215-220	220-225	225-230	230-235	235-240	240-245	245-250	250-255	255-260	260-265	265-270	270-275	275-280	280-285	285-290	290-295	295-300	300-305	305-310	310-315	315-320	320-325	325-330	330-335	335-340	340-345	345-350	350-355	355-360	360-365	365-370	370-375	375-380	380-385	385-390	390-395	395-400	400-405	405-410	410-415	415-420	420-425	425-430	430-435	435-440	440-445	445-450	450-455	455-460	460-465	465-470	470-475	475-480	480-485	485-490	490-495	495-500	500-505	505-510	510-515	515-520	520-525	525-530	530-535	535-540	540-545	545-550	550-555	555-560	560-565	565-570	570-575	575-580	580-585	585-590	590-595	595-600	600-605	605-610	610-615	615-620	620-625	625-630	630-635	635-640	640-645	645-650	650-655	655-660	660-665	665-670	670-675	675-680	680-685	685-690	690-695	695-700	700-705	705-710	710-715	715-720	720-725	725-730	730-735	735-740	740-745	745-750	750-755	755-760	760-765	765-770	770-775	775-780	780-785	785-790	790-795	795-800	800-805	805-810	810-815	815-820	820-825	825-830	830-835	835-840	840-845	845-850	850-855	855-860	860-865	865-870	870-875	875-880	880-885	885-890	890-895	895-900	900-905	905-910	910-915	915-920	920-925	925-930	930-935	935-940	940-945	945-950	950-955	955-960	960-965	965-970	970-975	975-980	980-985	985-990	990-995	995-1000																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
1. <i>Amphistegina madagascariensis</i>	A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Only sample 145 consists of cuttings]

[illegible]

TABLE 2.—Distribution of smaller Foraminifera in selected core

		Depth, in feet.....														
		30-35.5	35.5-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100	100-105
		137	140	145 (cuttings)	148	152.5	215-223	241	242.5	243.5	257.5	268.8	269.8	270.5	282.5	283.5
		284	285	286.2	286.5	287	287.5	289.5	292.75	294	296.5	299				
89.	<i>Epistominella tubulifera</i> .....															
90.	<i>Globorotalia crassaformis</i> .....															
91.	<i>Bolivina tortuosa</i> .....															
92.	<i>Lenticulina</i> sp.....															
93.	<i>Rosalina turgida</i> .....															
94.	<i>Bolivina (Loxostomum) mayori</i> .....															
95.	<i>Asterigerina indistincta</i> .....															
96.	<i>Cibicides</i> cf. <i>C. robertsonianus</i> .....															
97.	<i>Neonorbina crustata</i> .....															
98.	<i>Bulminella elegantissima</i> .....															
99.	<i>Orbulina universa</i> .....															
100.	<i>Globigerinoides trilobus</i> .....															
101.	mililid molds.....															
102.	<i>Amphistegina bikiensis</i> .....															
103.	<i>Valvulamina marshallana</i> .....															
104.	<i>Valvulina martii</i> .....															
105.	<i>Austrotrullina</i> cf. <i>A. striata</i> .....															
106.	<i>Neonorbina patelliformis</i> .....															
107.	<i>Asterigerina tentoria</i> .....															
108.	<i>Bulminella madagascariensis</i> .....															
109.	<i>Anomalina glabrata</i> .....															
110.	<i>Epistominella pulchra</i> .....															
111.	<i>Globigerina trilobularis</i> .....															
112.	<i>Globigerinoides trilobus altiperturus</i> .....															
113.	<i>Lagena hispida</i> .....															
114.	<i>Cibicides variabilis</i> .....															
115.	<i>Buccella perforata</i> .....															
116.	<i>Angulogerina tenuistriata</i> .....															
117.	<i>Baggina parva</i> .....															
118.	<i>Glabratella</i> ? sp.....															
119.	<i>Clavulina multicamerata</i> .....															
120.	<i>Glabratella</i> sp.....															

**Quinqueloculina bradyana Cushman**

*Quinqueloculina bradyana* Cushman. Cushman, Todd, and Post, 1954, p. 332, pl. 83, fig. 26.

*Quinqueloculina bradyana* is represented by a few good specimens in the Sand Island hole and by molds having characteristics of the species in the Reef hole. In the Marshall Islands it was found only in the Holocene.

*Species Nos.*—S86, R85.

**Quinqueloculina costata d'Orbigny**

Plate 1, figure 5

*Quinqueloculina costata* d'Orbigny. Schlumberger, 1893, p. 211, pl. 3, figs. 75, 76; text fig. 20.

Fornasini, 1905, p. 62, pl. 2, fig. 6.

Specimens at 1,041.25 and 1,043 feet in the Reef hole appear to belong in this costate species, described from the Holocene of the Mediterranean and widely recorded both as a fossil (as early as Eocene) and from the Holocene.

*Species No.*—R128.

**Quinqueloculina distorta Cushman**

*Quinqueloculina distorta* Cushman, in Cushman, Todd, and Post, 1954, p. 333, pl. 83, fig. 27.

A few typical specimens occur in Sand Island hole at 145 and 148 feet. They have the slender tubular neck that is characteristic of this species.

*Species No.*—S65.

**Quinqueloculina laevigata d'Orbigny**

Plate 1, figure 8

*Quinqueloculina laevigata* d'Orbigny. Fornasini, 1905, p. 63, pl. 2, fig. 8.

Described from the Eocene of the Paris Basin, this species has been reported from many localities both fossil and recent.

This elongate species is represented only by glauconitic molds, that commonly occur in a narrow zone between 1,185 and 1,186.5 feet in Reef hole. Specimens are as much as 1.2 mm long, about as thick as broad, and some tend to be triloculine rather than quinqueloculine. As they occur only as internal molds, the surface and the aperture were not observed.

*Species No.*—R145.

**Quinqueloculina neostriatula Thalmann**

*Quinqueloculina neostriatula* Thalmann. Cushman, Todd, and Post, 1954, p. 333, pl. 83, fig. 28.

Typical specimens occur near the top of Sand Island

			X	X	300
					321
					374
					375
					386
					389
					442.5
					443
					445
		XXA			446 (box 72 bottom)
		XX GA		X	446 (box 73 top)
		XX			453.5
		X X		X	454
		X		X	458.5
		XXX			460
		XXXXX	X	X	461.5
		X			465
					466.5
		XX	X		468
		X	X		470
		XX			470.5
					471.5
					473.5
			X	X	480
		X		X	483.5
		X			485
					486.5
					488
			X	X	489
			X	X	490
			X	X	491-496 (box 82 top)
			X	X	491-496 (box 82 middle)
		XX	X	X	491-496 (box 82 bottom)
			X		496 (box 83 top)
			X	X	496.6
					497
			X	X	497.5
				C	498
		X	X		499
			X	X	499.5 (above contact)
				X	500 (below contact)
				XX	
89.					<i>Epistominella tubulifera</i> .
90.					<i>Globovalvula crassaformis</i> .
91.					<i>Bolivina tortuosa</i> .
92.					<i>Lenticulina</i> sp.
93.					<i>Rosalina turgida</i> .
94.					<i>Bolivina (Lorostomum) mayori</i> .
95.					<i>Asterigerina indistincta</i> .
96.					<i>Cibicides</i> cf. <i>C. robertsonianus</i> .
97.					<i>Neconorbina crustata</i> .
98.					<i>Bulinella elegantissima</i> .
99.					<i>Orbulina universa</i> .
100.					<i>Globigerinoides trilobus</i> .
101.					milliolid molds.
102.					<i>Amphistegina bikiniensis</i> .
103.					<i>Valvulaminna marshallana</i> .
104.					<i>Valvulina martii</i> .
105.					<i>Austrotrillina</i> cf. <i>A. striata</i> .
106.					<i>Neconorbina patelliformis</i> .
107.					<i>Asterigerina tentoria</i> .
108.					<i>Bulinella madagascariensis</i> .
109.					<i>Anomalina glabrata</i> .
110.					<i>Epistominella pulchra</i> .
111.					<i>Globigerina trilocularis</i> .
112.					<i>Globigerinoides trilobus altiaperturus</i> .
113.					<i>Lagena hispidia</i> .
114.					<i>Cibicidella variabilis</i> .
115.					<i>Buccella perforata</i> .
116.					<i>Angulogerina tenuistriata</i> .
117.					<i>Baggina parva</i> .
118.					<i>Glabratella?</i> sp.
119.					<i>Clavulina multicamerata</i> .
120.					<i>Glabratella</i> sp.

*Species No.*—S27.

*Quinqueloculina parkeri* (Brady). Cushman, Todd, and Post, 1954, p. 333, pl. 83, fig. 23.

*Species Nos.*—S66, R20.

## Plate 1, figure 4

*Quinqueloculina polygona* d'Orbigny. Todd, 1962 [1961 imprint],  
p. 187, pl. 22, fig. 5.

*Species Nos.*—S87, R78.

Several casts scattered in the top of the Miocene sec-

*Species No.*—R86.

*Quinqueloculina sulcata* d'Orbigny. Cushman, Todd, and Post, 1954, p. 334, pl. 84, figs. 1, 2.

*Quinqueloculina sulcata*-*Q. ferussaci* gradational series. Todd, 1957, p. 286 (table), pl. 86, figs. 3-6.

*Species Nos.*—S28, R8.

*Quinqueloculina tubus* Todd, 1957, p. 306, pl. 85, fig. 18.

*Species No.*—R35.

Genus **TRILOCULINA** d'Orbigny, 1826**Triloculina bicarinata** d'Orbigny

*Triloculina bicarinata* d'Orbigny, 1839, p. 180, pl. 10, figs. 18-20.  
Cushman, 1932, p. 60, pl. 13, fig. 6.

*Triloculina* cf. *T. bicarinata* d'Orbigny. Cushman, Todd, and Post, 1954, p. 338, pl. 85, fig. 2.

This distinctive waffle-surfaced Holocene species, described from off Cuba and widely known in the Pacific, occurs in a few of the Midway samples from both holes. All are near the top in the post-Miocene section, where it is represented by excellent specimens, especially in Sand Island hole.

*Species Nos.*—S42, R23.

**Triloculina bikiniensis** Todd

*Triloculina bikiniensis* Todd, in Cushman, Todd, and Post, 1954, p. 338, pl. 85, fig. 19.

Todd, 1957, p. 286 (table), pl. 86, fig. 14.

Typical specimens of this species, described from the Marshall Islands and also found at Saipan, occur rarely in the post-Miocene section of Sand Island hole.

*Species No.*—S51.

**Triloculina incisura** Todd

*Triloculina incisura* Todd, 1957, p. 308, pl. 86, fig. 18.

This species, described from Guam, is distinctive in its apertural tooth that completely fills the apertural opening. Single specimens were found at 63-65 feet and 152.5 feet in Sand Island hole.

*Species No.*—S43.

**Triloculina involuta** Todd

*Triloculina involuta* Todd, in Cushman, Todd, and Post, 1954, p. 338, pl. 85, fig. 4.

This robust and faintly costate species, described from the Marshalls and also reported from Saipan and Guam, occurs at Midway near the top of both holes.

*Species Nos.*—S17, R15.

**Triloculina irregularis** (d'Orbigny)

*Triloculina irregularis* (d'Orbigny). Cushman, Todd, and Post, 1954, p. 338, pl. 85, fig. 12.

Typical specimens of this Holocene species are well represented in Sand Island hole near the top. A few are also present in Reef hole but are poorly preserved.

*Species Nos.*—S18, R24.

**Triloculina kerimbatica** (Heron-Allen and Earland)

*Triloculina kerimbatica* (Heron-Allen and Earland). Cushman, Todd, and Post, 1954, p. 339, pl. 85, figs. 10, 11.

This transversely crinkled species well known and widely distributed in the Holocene, occurs in both holes near the top.

*Species Nos.*—S19, R25.

**Triloculina linneiana** d'Orbigny

*Triloculina linneiana* d'Orbigny. Graham and Militante, 1959, p. 55, pl. 8, fig. 7.

A single specimen from 137 feet in Sand Island hole is typical of this costate species, originally described from Cuba and widely known from both the Atlantic and Pacific.

*Species No.*—S52.

**Triloculina oblonga** (Montagu)

*Triloculina oblonga* (Montagu). Graham and Militante, 1959, p. 56, pl. 8, figs. 8, 9.

This smooth elongate species is probably cosmopolitan in warm shallow waters. It is not common but occurs in both holes in scattered samples. Its deepest occurrence is at 947 feet in Reef hole.

*Species Nos.*—S32, R26.

**Triloculina terquemiana** (Brady)

*Triloculina terquemiana* (Brady). Cushman, Todd and Post, 1954, p. 340, pl. 85, fig. 9.

A single specimen was found at 103.5 feet in Reef hole.

*Species No.*—R48.

**Triloculina trigonula** (Lamarck)

*Triloculina trigonula* (Lamarck). Todd, 1957, p. 288 (table 4), pl. 86, fig. 16.

This well-known miliolid, triangular with rounded angles, is present in both holes. It occurs very rarely and near the top in Sand Island hole. In Reef hole it occurs only in the Miocene section beginning at 500 feet and continuing in scattered samples down to 1,106.75 feet. The Sand Island specimens are original shell material, but those from Reef hole are only internal molds.

*Species Nos.*—S33, R79.

Genus **MILIOLINELLA** Wiesner, 1931**Miliolinella labiosa** (d'Orbigny)

*Miliolina labiosa* d'Orbigny, sp. Brady, 1884, p. 170, pl. 6, figs. 3-5.

*Miliolinella labiosa* (d'Orbigny). Todd and Low, 1960, p. 822, pl. 261, fig. 10.

Although fossil specimens were recorded from the Eniwetok drill hole E-1, this primarily Holocene species occurs only in the tops of the two Midway drill holes. Brady found it in a coral sand at 40 fathoms depth off Honolulu, Hawaiian Islands.

*Species Nos.*—S26, R34.

Genus **SPIROLOCULINA** d'Orbigny, 1826**Spiroloculina angulata** Cushman

*Spiroloculina angulata* Cushman. Cushman, Todd, and Post, 1954, p. 334, pl. 84, figs. 11, 12.

Todd and Low, 1960, p. 822.

No attempt has been made to distinguish between the species *Spiroloculina angulata* Cushman and *S. corrugata* Cushman and Todd (1944, p. 61, pl. 8, figs. 22-25), because the angularity or roundness of the peripheries and length of tests are extremely variable features. The similarity of their recorded occurrences and ranges negates the value of a more detailed study of the specimens in this material. The attempt to separate them in the Eniwetok drill hole samples (Todd and Low, 1960, p. 822, 823) emphasized this problem.

The specimens are found in the tops of both drill holes at Midway and are scattered as deep as 1,054.5 feet in the Reef hole.

*Species Nos.*—S16, R14.

***Spiroloculina caduca* Cushman**

*Spiroloculina caduca* Cushman. Todd, 1957, p. 286 (table 4), pl. 87, fig. 10.

A few specimens of this species described from the Holocene of Florida occur near the top of the Sand Island hole. It has not been recorded from Marshall Island sediments but was found at both Saipan and Guam in the Mariana Islands.

*Species No.*—S40.

***Spiroloculina clara* Cushman**

*Spiroloculina clara* Cushman. Cushman, Todd, and Post, 1954, p. 335, pl. 84, fig. 9.

*Spiroloculina clara* var. *virata* Cushman, in Cushman, Todd, and Post, 1954, p. 335, pl. 84, fig. 10.

Single specimens near the top of each hole can be included in this species described from the Marshall Islands.

Examination of the type material for the species and its variety *virata* indicates the varietal features are not sufficient grounds for separation.

*Species Nos.*—S41, R51.

***Spiroloculina communis* Cushman and Todd**

*Spiroloculina communis* Cushman and Todd. Cushman, Todd, and Post, 1954, p. 335, pl. 84, fig. 13.  
Todd and Low, 1960, p. 822.

Four specimens, comparing well with this species, were obtained in the Miocene from 1,042 feet in the Reef hole. The central area is not as clean as in the types, but this is probably due to preservation and adhering matrix.

*S. communis* occurred in Holocene sediments of the Marshall Islands as well as in the Miocene section of the Eniwetok drill hole.

*Species No.*—R129.

***Spiroloculina manifesta* Cushman and Todd**

*Spiroloculina manifesta* Cushman and Todd, 1944, p. 62, pl. 8, figs. 26-28.

This species compares closely with *S. marshallana* Todd (in Cushman and others, 1954, p. 335, pl. 84, fig. 8) described from Holocene sediments of Bikini Atoll and later (Todd and Low, 1960, p. 823) recorded from beds considered as old as Miocene penetrated by drill holes on Eniwetok Atoll of the Marshall Islands. However, *S. manifesta* is a larger, more rugged looking species with acutely angled edges. In some specimens the peripheral angle is sharp enough to make the last-formed chambers somewhat concave. The umbilical area is more deeply depressed and the general outline of the test is more elongate. The species has a dull, rough surface as compared to the smooth, more polished wall of *S. marshallana*.

In Sand Island hole it is common in one core sample, 259.8 feet, and one broken specimen was found at 279.5 feet.

It was described from the Philippines and was recorded from off Samoa at that time also. Asano (1951, p. 15, figs. 101, 102) attributed it to beds as old as Pliocene in Japan as well as to Holocene sediments. It was not found in the Marshall Islands.

*Species No.*—S88.

***Spiroloculina mayori* Cushman**

*Spiroloculina mayori* Cushman. Cushman, Todd, and Post, 1954, p. 336, pl. 84, fig. 15.

Todd and Low, 1960, p. 823.

Several distinctive specimens easily attributable to this species occur in the next to highest sample of the Sand Island hole. It was recorded from Holocene sediments of the Marshall Islands as well as the top of hole F-1 at Eniwetok.

*Species No.*—S31.

***Spiroloculina oclusa* (Cushman)**

Plate 11, figure 3

*Massilina oclusa* Cushman, 1922, p. 104, pl. 28, fig. 2.

*Spiroloculina oclusa* (Cushman). Cushman and Todd, 1944, p. 15, pl. 3, fig. 12.

The distinctively squarish test and apertural neck of this species make this identification quite secure, the only difference appearing to be a slightly larger size of some of the Midway specimens. The central area is only a little depressed, being obscured by the overlapping final two chambers which form the complete outer part of the test.

Length of figured specimen 0.90 mm; breadth 0.50 mm; thickness 0.27 mm.

*Spiroloculina oclusa* has been recorded from beds of Oligocene age only in Mississippi and Alabama. At Midway it occurs rarely, scattered in a restricted sec-

tion of the Reef hole between 933.3 and 947 feet.

*Species No.*—R108.

***Spiroloculina samoensis* Cushman**

*Spiroloculina planissima* (Lamarck) var. *samoensis* Cushman, 1924, p. 58, pl. 21, figs. 9, 10.

*Spiroloculina samoensis* Cushman. Cushman and Todd, 1944, p. 56, pl. 8, figs. 8–10.

*Spiroloculina samoensis* differs markedly from other costate species in the genus by having oblique ridges that extend nearly to the periphery, giving the more strongly ornamented specimens a cusped edge.

It has been recorded only from Holocene sediments of the tropical part of the Indo-Pacific region. Good specimens occur in the Midway Sand Island hole between 140 and 148 feet, with only one broken specimen coming from 103.5 feet in the Reef hole.

*Species Nos.*—S59, R46.

**Genus *HAUERINA* d'Orbigny, 1839**

***Hauerina involuta* Cushman**

*Hauerina involuta* Cushman. Cushman, Todd, and Post, 1954, p. 337, pl. 84, figs. 28, 29.

There are single occurrences of this species in the tops of both Midway drill holes. It was described from the Marshall Islands and was recorded from the cuttings of the Eniwetok drill holes.

*Species Nos.*—S4, R33.

***Hauerina milletti* Cushman**

*Hauerina milletti* Cushman, in Cushman, Todd, and Post, 1954, p. 337, pl. 84, fig. 23.

One specimen from 936.5 feet in the Reef hole compares favorably with the small paratypes of this species described from Rongerik Lagoon, Marshall Islands. It is recorded from other shallow water areas in the Pacific but has not been found as a fossil.

*Species No.*—R110.

***Hauerina pacifica* Cushman**

*Hauerina pacifica* Cushman. Cushman, 1932, p. 44, pl. 10, figs. 10, 11.

Todd, 1957, p. 286 (table 4), pl. 88, fig. 3.

*Hauerina pacifica* was described from a depth of 24 fathoms off the Hawaiian Islands, and all subsequent records are from warm, shallow waters of the Pacific. It occurs rarely in the top of the Sand Island hole.

*Species No.*—S25.

**Genus *PYRGO* Defrance, 1824**

***Pyrgo denticulata* (Brady)**

*Pyrgo denticulata* (Brady). Cushman, Todd, and Post, 1954, p. 340, pl. 85, fig. 22.

This typical Holocene species is found at the top of both holes and also in the Miocene part of Reef hole down to 1,044.5 feet.

*Species Nos.*—S8, R19.

**Genus *AUSTROTRILLINA* Parr, 1942**

***Austrotrillina striata* Todd and Post**

Plate 11, figure 5

*Austrotrillina striata* Todd and Post, 1954, p. 555, pl. 198, fig. 9.

Todd and Low, 1960, p. 825, pl. 261, fig. 22.

Adams, 1968, p. 92, pl. 4, figs. 1–13; pl. 6, fig. 9.

This striking miliolid is an important index fossil in the middle Tertiary of the Pacific. It was described from Bikini drill hole 2B and also found in hole E-1 at Eniwetok. Adams (1968, fig. 1) shows its range to be from upper Tertiary *d* throughout Tertiary *e* or from upper Rupelian through the Chattian to the top of the Aquitanian.

Its highest occurrence in Reef hole is at 911 feet, and it occurs discontinuously to near the bottom of the hole at 1,186 feet, often in the form of molds. At 1,110–1,120 feet it is very abundant and makes up an *Austrotrillina* sand in that section. Two fragmentary pieces of *Austrotrillina* were found in Sand Island hole at 446 feet, at the top of the Miocene. If they were in place at this level, they would be more than 400 feet above their comparable position relative to the top of the Miocene in Reef hole. Therefore, we believe these fragments may have had their origin in reworked material.

*Species Nos.*—S105, R98.

**Family OPTHALMIDIIDAE**

**Genus *CORNUSPIRA* Schultze, 1854**

***Cornuspira planorbis* Schultze**

*Cornuspira planorbis* Schultze. Cushman, Todd, and Post, 1954, p. 341, pl. 85, fig. 27.

Typical specimens occur rarely in both holes at Midway; in the post-Miocene section of Sand Island hole from 35.5 to 152.5 feet and in the Miocene section of Reef hole from 943 to 1,054 feet. This small translucent porcellaneous coil is characteristically found with miliolids.

*Species Nos.*—S23, R112.

**Genus *VERTEBRALINA* d'Orbigny, 1826**

***Vertebralina striata* d'Orbigny**

*Vertebralina striata* d'Orbigny. Graham and Militante, 1959, p. 60, pl. 9, figs. 11, 12.

Good representatives of this shallow-water miliolid occur near the top of both holes. One specimen from 137 feet in Sand Island hole shows reticulate ornamentation.

*Species Nos.*—S53, R49.

Genus **PARRINA** Cushman, 1921**Parrina bradyi** (Millett)

*Parrina bradyi* (Millett). Cushman, Todd, and Post, 1954, p. 342, pl. 85, figs. 31-34.

This wild-growing miliolid is represented by a few specimens at 140 and 145 feet in Sand Island hole.

*Species No.*—S57.

Family **FISCHERINIDAE**Genus **FISCHERINA** Terquem, 1878**Fischerina helix** Heron-Allen and Earland

*Fischerina helix* Heron-Allen and Earland. Cushman, 1932, p. 76, pl. 17, fig. 5.

A single specimen was found between 35.5 and 40 feet in Sand Island hole. The specimen is involute on one side and evolute on the other, but the generic separation of such forms as *Fischerinella* seems unjustified.

*Species No.*—S24.

Family **PENEROPLIDAE**Genus **PENEROPLIS** Montfort, 1808**Peneroplis planatus** (Fichtel and Moll)

*Peneroplis planatus* (Fichtel and Moll). Todd and Low, 1960, p. 829, pl. 261, fig. 13.

Only rare specimens are present, being found at the top of both holes and in a few samples near 1,040 feet in Reef hole.

*Species Nos.* S48, R7.

**Peneroplis proteus** d'Orbigny

Plate 11, figure 1

*Peneroplis protea* d'Orbigny, 1839, p. 60, pl. 7, figs. 7-11.

Associated with specimens of *Quinqueloculina laevigata* and, like them, only in the form of glauconitic molds. This species occurs also in the narrow zone between 1,185 and 1,186.25 feet. There was also a single specimen found higher at 1,170 feet in Reef hole.

The nearly circular specimens are flattened, have about 16 long curved chambers per whorl, and none show the later flaring stage that is typical of this species.

*P. proteus* was described from Holocene sands of Cuba and is known in the West Indian region, both living and fossil, as early as Miocene.

*Species No.*—R144.

Genus **SPIROLINA** Lamarck, 1804**Spirolina arietina** (Batsch)

*Spirolina arietina* (Batsch). Cushman, Todd, and Post, 1954, p. 348, pl. 87, figs. 4, 5.

Todd and Low, 1960, p. 830.

Typical specimens are found in the tops of both holes. In addition, the species is scattered rarely as deep as 1,043 feet in the Reef hole and 497.5 feet in the Sand Island hole. It was recorded from a Miocene core at Eniwetok.

*Species Nos.*—S15, R13.

Genus **MARGINOPORA** Quoy and Gaimard, 1830**Marginopora vertebralis** Quoy and Gaimard

*Marginopora vertebralis* Blainville. Cushman, Todd, and Post, 1954, p. 348, pl. 82, figs. 5, 6.

*Marginopora vertebralis* occurs in some abundance at the top of both holes and continues rather persistently down to 389 feet in Sand Island hole and 334 feet in Reef hole. Only scattered occurrences, mostly of small specimens, are found to the bottom of Sand Island hole and to 1,127.3 feet in Reef hole.

*Species Nos.*—S6, R6.

Family **NODOSARIIDAE**Genus **LENTICULINA** Lamarck, 1804**Lenticulina** sp.

Plate 2, figure 1

Rare specimens from between 282.5 and 292.75 feet in Sand Island hole and between 529 and 1,129 feet in Reef hole, represent a small smooth species of *Lenticulina*. The test is close coiled, unornamented, lacks a keel, and has six chambers per whorl. Size ranges between 0.23 and 0.27 mm.

*Species Nos.*—S92, R90.

Genus **ASTACOLUS** Montfort, 1808**Astaculus** sp.

Plate 1, figure 7

The rich fauna at about 930 feet in the Reef hole yielded two small specimens belonging to this nodosariid genus. They consist of seven or eight rather tightly coiled chambers; slightly depressed sutures; a non-lobulated, rounded periphery, smooth wall; radiate aperture at tip of elongate final chamber. Length about 0.55 mm.

*Species No.*—R100.

Genus **MARGINULINA** d'Orbigny, 1826**Marginulina procera** (Stache)

Plate 1, figure 6

*Hemicristellaria procera* Stache, 1864, p. 222, pl. 23, fig. 1.

This species was described from New Zealand in rocks probably of early Oligocene or late Eocene age. It is an

arcuate cylindrical species, with an incipient coil at the initial end, and a slightly produced apertural end. Sutures are oblique and chambers not inflated. Specimens are found in Reef hole between 1,101.5 and 1,118 feet.

*Species No.*—R133.

Genus *VAGINULINA* d'Orbigny, 1826

*Vaginulina obtusicosta* ten Dam and Reinhold

Plate 11, figure 8

*Vaginulina striatula* ten Dam and Reinhold [not Roemer, 1842], 1942, p. 65, pl. 4, fig. 10; pl. 9, fig. 12.

*Vaginulina obtusicosta* ten Dam and Reinhold, 1947, p. 186.

Rare and fragmentary specimens of a flattened and costate species of *Vaginulina* occur in Reef hole between 1,120.5 and 1,126 feet. They have an angular periphery and otherwise seem similar to this species that is known from the middle Miocene of the Netherlands.

*Species No.*—R142.

Genus *LAGENA* Walker and Jacob, 1798

*Lagena hispida* Reuss

*Lagena hispida* Reuss. Graham and Militante, 1959, p. 67, pl. 10, fig. 14.

A single specimen from the Miocene beds of Sand Island hole, at a depth of 460 feet, seems identical with this widely reported species.

*Species No.*—S113.

Family *POLYMORPHINIDAE*

Genus *SIGMOMORPHINA* Cushman and Ozawa, 1928

*Sigmomorphina* aff. *S. terquemiana* (Fornasini)

Rare polymorphinids in Reef hole between 982.5 and 1,008.5 feet are questionably assigned to this widely reported and long ranging species. Specimens are flattened, pointed at the apical end, and the sutures are obscure.

*Species No.*—R119.

Family *PLECTOFRONDICULARIIDAE*

Genus *BOLIVINELLA* Cushman, 1927

*Bolivinella folium* (Parker and Jones)

Plate 3, figure 1

*Bolivinella folium* (Parker and Jones). Todd and Low, 1960, p. 831, pl. 262, fig. 2.

*Bolivinella folium* is found only in Reef hole where it first appears at the top of the Miocene at 500 feet. It continues to 565 feet then breaks off until 982.5 feet. From there it occurs in scattered samples to 1,120 feet. It is a variable species. Some specimens are narrow and *Bolivina*-like; others are broad and flaring with slender,

backward-curving chambers. Some specimens are flat; others thickened in the middle. In some chambers the sutures are raised and limbate; in others they are faintly beaded.

*Species No.*—R73.

Family *BULIMINIDAE*

Genus *BAGGATELLA* Howe, 1939

*Baggatella* sp.

Plate 3, figure 7

Two specimens at 930 feet in Reef hole, plus several very small individuals at 876 and 876.5 feet, are referred to this genus that has thus far been regarded as occurring only from middle Eocene to late Oligocene. This Midway record thus extends the range upward into the early Miocene.

The specimens are high spired, have four inflated chambers per whorl, and a high-arched aperture.

*Species No.*—R97.

Genus *CAUCASINA* Khalilov, 1951

*Caucasina* sp.

Plate 2, figure 4

Deep in the Miocene section of the Reef hole (979.5–1,165 ft) are scattered fragile buliminidlike specimens belonging in the genus *Caucasina*. Lack of comparative material and rarity of specimens in the present material prohibits specific identification. The Midway forms most closely resemble *C. khalilovi* Loeblich and Tappan (1964, p. 78, pl. 2, figs. 7–9) described from the Oligocene of California in being small for the genus, elongate, and having a very low trochoid coil in the initial stage. Measurements of the figured specimen are length 0.17 mm, width 0.11 mm.

*Species No.*—R116.

Genus *BULIMINELLA* Cushman, 1911

*Buliminella elegantissima* (d'Orbigny)

*Buliminella elegantissima* (d'Orbigny). Cushman and Parker, 1947, p. 67, pl. 17, figs. 10–12.

This long-ranging Eocene to Holocene species is small and slender with numerous chambers. It occurs in both holes but is common only at 1,165 feet in Reef hole.

*Species Nos.*—S98, R94.

*Buliminella madagascariensis* (d'Orbigny)

Plate 2, figure 5

*Buliminella madagascariensis* (d'Orbigny). Cushman and Parker, 1947, p. 68, pl. 17, figs. 15–17.

This Oligocene to Holocene species is proportionally short and thick with a blunt initial end and a little-indented periphery. The Midway specimens show considerable variation from typical ones to some in the

lower part of Reef hole that approach the slender test of *B. elegantissima* (d'Orbigny). Specimens occur in scattered samples in the Miocene part of both holes but are always rare.

*Species Nos.*—S108, R74.

**Genus BULIMINA d'Orbigny, 1826**

***Bulimina marginata* d'Orbigny**

*Bulimina marginata* d'Orbigny. Cushman and Parker, 1947, p. 119, pl. 28, figs. 5, 6.

Two typical but small specimens of this widely reported species were found at 258.8 feet in Sand Island hole. They have the characteristic fringelike ornamentation overhanging the undercut edges of the chambers.

*Species No.*—S81.

**Genus BOLIVINA d'Orbigny, 1839**

***Bolivina alazanensis* Cushman**

Plate 2, figure 3

*Bolivina alazanensis* Cushman, 1937, p. 63, pl. 8, figs. 6, 7.

Three specimens of this Oligocene and Eocene species were found at 1,104.25 feet in Reef hole. They are characterized by the inner parts of each chamber being inflated so that the surface of the test appears lumpy. Specimens are slightly twisted and have a narrow peripheral keel.

*Species No.*—R134.

***Bolivina chinenensis* LeRoy**

Plate 2, figure 6

*Bolivina chinenensis* LeRoy, 1964, p. 31, pl. 2, figs. 10, 11.

*Loxostomum?* sp. A Todd and Low, 1960, p. 834, pl. 262, fig. 4.

This species was described from the Pliocene of southern Okinawa, and a single specimen had been reported earlier in the Tertiary *f* section at Eniwetok. It is a flat, slightly twisted, highly ornamented species with beadlike spinose projections extending out from the periphery, especially in the early part of the test.

*Bolivina chinenensis* is rare at Midway. The best representatives of it are in Sand Island hole. It occurs in both the Miocene and post-Miocene sections.

*Species Nos.*—S61, R93.

***Bolivina compacta* Sidebottom**

Plate 2, figure 2

*Bolivina compacta* Sidebottom. Cushman, Todd, and Post, 1954, p. 352, pl. 87, fig. 37.

This species is characterized by its crinkled surface and relatively coarse pores. It occurs throughout both holes, like *B. striatula*, most consistently below 930 feet. Among the Bolivinas it seems to rank next to *B. striatula* in numbers and persistence.

It has not before been reported in rocks as old as Miocene, at least not under this name.

*Species Nos.*—S21, R30.

***Bolivina fastigia* Cushman**

Plate 2, figure 8

*Bolivina fastigia* Cushman, 1937, p. 76, pl. 9, figs. 12–14.

This species, described from the Oligocene of Germany, is widely recorded in the Oligocene and Miocene of central Europe. It has also been recorded from the Oligocene of Guam. It is characterized by dark limbate sutures with a prominent upward curve toward the median line and by irregular costate ornamentation that tends to obscure the early sutures.

At Midway it is found only in Reef hole, from 930 to 1,046 feet and from 1,101.5 to 1,120.5 feet.

*Species No.*—R101.

***Bolivina rhomboidalis* (Millett)**

Plate 2, figures 11, 12

*Bolivina rhomboidalis* (Millett). Cushman, Todd, and Post, 1954, p. 353, pl. 87, figs. 41, 42.

This Holocene species is easily recognizable by its rhomboid shape in section. It is scarce at Midway but is present nearly throughout both holes. It is best represented in Reef hole between 1,096.5 and 1,111.5 feet.

*Species Nos.*—S44, R39.

***Bolivina striatula* Cushman**

Plate 2, figure 7

*Bolivina striatula* Cushman. Cushman, Todd, and Post, 1954, p. 353, pl. 87, fig. 43.

This small slender species is the commonest and most persistent of the Bolivinas at Midway. The wall striations over the initial part are rarely visible. It occurs nearly throughout both holes in scattered samples and becomes most consistently present below 930 feet in Reef hole.

*Bolivina striatula* was described from Holocene material but has also been reported from sediment as old as Miocene.

*Species Nos.*—S62, R40.

***Bolivina tortuosa* Brady**

Plate 2, figure 9

*Bolivina tortuosa* Brady. Cushman, Todd, and Post, 1954, p. 353, pl. 87, figs. 45–47.

This Eocene to Holocene species is easily distinguished by its short and usually strongly twisted test and relatively coarse pores set far apart.

The species occurs in both holes, being best developed below about 1,100 feet in Reef hole.

*Species Nos.*—S91, R50.

**Subgenus LATEROSTOMELLA de Klsz and Rérat**

**Bolivina (Laterostomella) gumbeliniformis (de Klsz and Rérat)**

Plate 2, figure 10

*Laterostomella gumbeliniformis* de Klsz and Rérat, 1962, p. 177, pl. 1, figs. 1, 2.

This species was described from the lower Miocene of Gabon. The aperture appears hooded and opens at right angles to the normal plane of apertural openings in *Bolivina* so that it is more visible from one flat side than from the opposite flat side. Examination of metatypes leads us to reconsider this generic character and to regard it as of subgeneric rather than generic value. Besides its unique sideways-opening aperture, *B. gumbeliniformis* is characterized by a slender test with slightly inflated chambers, a slightly lobulated periphery, and a rugose wall, somewhat like that of *B. compacta*.

At Midway the species is well developed, especially in Sand Island hole where it occurs only in the post-Miocene section between 241 and 300 feet. In Reef hole it is present through a longer section occurring in scattered samples between 213.5 and 934 feet.

*Species Nos.*—S72, R57.

**Subgenus LOXOSTOMUM Ehrenberg, 1854**

**Bolivina (Loxostomum) limbata Brady**

Plate 3, figures 4, 5

*Loxostomum limbatum* (Brady). Cushman, Todd, and Post, 1954, p. 353, pl. 88, fig. 8.

This Miocene to Holocene species is rather scarce. It is characterized by a slightly twisted test and heavy, discontinuous costae mostly over the initial end of the test.

*Species No.*—R58.

**Bolivina (Loxostomum) mayori Cushman**

*Loxostomum mayori* (Cushman). Cushman, Todd, and Post, 1954, p. 354, pl. 88, fig. 6.

Described from off the Dry Tortugas, Florida, and recorded from both the Atlantic and the Pacific, this species is present in both Midway holes. It is similar to *Bolivina elongata* described from the Eocene of Hungary and is possibly the younger equivalent of that species. Both are smooth compressed species with rather coarse perforations in the wall when well preserved. They tend to become uniserial.

*Species Nos.*—S94, R102.

**Genus VIRGULINA d'Orbigny, 1826**

**Virgulina complanata Egger**

Plate 3, figure 11

*Virgulina complanata* Egger. Cushman, 1942, p. 13, pl. 4, figs. 2-5.

This species is widely known in the Holocene and has been reported as far back as the Miocene. It is present in both holes at Midway. In Reef hole it is found only in the Miocene section, from 930 to 1,165 feet, being common and of good size around 982 and 1,044 feet. In Sand Island hole it occurs both above and below the top of the Miocene, from 258.8 to 483.5 feet.

*Species Nos.*—S84, R106.

**Genus FISSURINA Reuss, 1850**

**Fissurina circularis Todd**

*Fissurina circularis* Todd, in Cushman, Todd, and Post, 1954, p. 351, pl. 87, fig. 27.

Todd and Low, 1960, p. 831.

*Fissurina circularis* was described from the Holocene sediments of Eniwetok lagoon and was recorded from the Miocene section of the Eniwetok drill hole. One specimen occurs in the Sand Island hole of Midway atoll at 241 feet. It is distinctively smaller and more compressed than *F. circulum* Seguenza found in beds of Miocene age at Guam (Todd, 1966, p. 27, pl. 12, fig. 9).

*Species No.*—S74.

**Fissurina cucurbitasema Loeblich and Tappan**

*Fissurina cucurbitasema* Loeblich and Tappan, 1953, p. 76, pl. 14, figs. 10, 11.

Two specimens from 258.8 feet in Sand Island hole compare very well with this melon-seed-shaped species described from the Arctic. This is the first recorded occurrence of *Fissurina cucurbitasema* from tropical regions.

*Species No.*—S83.

**Fissurina lagenoides (Williamson)**

*Entosolenia marginata* var. *lagenoides* Williamson, 1858, p. 11, pl. 1, figs. 25, 26.

Todd, 1957, p. 290 (table 4), pl. 89, fig. 10.

A single specimen of this species was found at 88 feet in Reef hole. None was recorded from the Marshall Islands, but it did occur in the Holocene of Saipan and the Oligocene of Guam in the Mariana Islands and the Holocene of Onotoa Atoll, Gilbert Islands.

*Species No.*—R31.

**Genus OOLINA d'Orbigny, 1839**

**Oolina globosa (Montagu)**

*Lagena globosa* Montagu, sp. Brady, 1884, p. 452, pl. 56, figs. 1-3.

A few specimens of this globose species were found in Reef hole between 1,002 and 1,010 feet. They are small (about 0.17 mm in diameter) and lack an apertural collar.

*Species No.*—R121.

Genus **ANGULOGERINA** Cushman, 1927

*Angulogerina midwayensis* Todd and Low, n. sp.

Plate 3, figure 2

Test elongate, somewhat fusiform, early part circular in section, later part subtriangular in section, initial end subacute, covered by irregular fine costae, roughened by recrystallization, periphery distinctly lobulated, more so toward apertural end; early chambers gently rounded, compact, later ones unornamented, becoming more separated with slightly concave undersides contributing to lobulated periphery; sutures distinct although somewhat obscured by ornamentation in early stage; wall opaque, crystalline overall, irregularly costate in early part, unornamented toward apertural end; apertural neck short, thick, with distinct lip. Length 0.23–0.32 mm; maximum diameter 0.16 mm.

Holotype, USNM 688120, from core at a depth of 942 feet in the Miocene section of Reef hole, Midway atoll, Hawaiian Islands.

In the general outline of the test, *Angulogerina midwayensis*, n. sp. most resembles *A. hughesi* (Galloway and Wissler, 1927, p. 76, pl. 12, fig. 5), but *A. hughesi* is larger and lacks costae. There is some similarity in size and costae to *A. occidentalis* (Cushman, 1923, p. 169), but that species is more sharply triangular in section with a less lobulated periphery. *A. fijiensis* Cushman (1931, p. 31, pl. 4, fig. 11) is also more triangular than *A. midwayensis*, n. sp. In addition, the sharp distinct costae of *A. fijiensis* are quite prominent on the final chambers and extend onto the slender neck whereas the final chambers of the present species are smooth and the neck is short and thick.

*Angulogerina midwayensis*, n. sp. is found only in the Reef hole, 936.5 feet being its highest level. It is scattered, with bolivinids, down to 1,165 feet and almost always has a very granulated aspect resulting from recrystallization. Several specimens at 1,008.5 feet have a fresher, glassy surface hinting that the striations may occur very lightly on the last-formed chambers. However, the present description is based on the appearance of the majority of the specimens examined.

Toward the bottom of the hole, some isolated individuals appear to be shorter, more compact variants which are probably ancestral forms.

*Species No.*—R109.

Genus **Angulogerina tenuistriata** (Reuss)

Plate 3, figure 3

*Angulogerina tenuistriata* (Reuss). Cushman and Edwards, 1938, p. 84, pl. 15, figs. 1–7.

This species occurs rarely at about 470 feet in Sand Island hole. The specimens are smaller than typical but compare favorably with topotypes in the U.S. National Museum collections from beds of Oligocene age in Pietzpuhl, Germany.

The Midway specimens tend to be triangular in cross section through the last-formed chambers and the test terminates with a very short neck.

*Species No.*—S116.

Genus **TRIFARINA** Cushman, 1923

*Trifarina* aff. *T. bradyi* Cushman

Plate 3, figure 8

Several specimens from 421–426.2 feet in the Reef hole plus a few from near the top of the Sand Island hole are very similar to *Trifarina bradyi* Cushman. Poor preservation and recrystallization obscure much of the detail, but the uniserial arrangement of the last formed chambers is distinct. The three distinguishing keels or carinae, are clearly present in the later part of the test but do not show over the initial chambers. The Midway specimens compare more closely with Cushman's material from Samoa (Cushman, 1924, p. 27, pl. 7, fig. 5) than with the types from the Caribbean (Cushman, 1923, p. 99, pl. 22, figs. 5–7).

*Species Nos.*—S50, R70.

Genus **REUSSELLA** Galloway, 1933

*Reussella simplex* (Cushman)

*Reussella simplex* (Cushman). Cushman, Todd, and Post, 1954, p. 354, pl. 88, figs. 1, 2.

Todd and Low, 1960, p. 835.

*Reussella simplex* is present throughout the material from Midway, in a pattern similar to that in the Eniwetok drill holes. Although some specimens from the deepest parts of the holes tend to be smaller than typical and more opaque due mainly to recrystallization, it has seemed reasonable to include them all in this species.

*Species Nos.*—S9, R36.

Genus **SIPHOGENERINA** Schlumberger, 1883

*Siphogenerina raphana* (Parker and Jones)

*Siphogenerina raphana* (Parker and Jones). Cushman, Todd, and Post, 1954, p. 356, pl. 88, figs. 23, 24.

Todd and Low, 1960, p. 834.

*Siphogenerina raphana* has been widely recorded in warm shallow waters. Specimens from drill holes in the Marshall Islands appeared to have originated in the Holocene as do the present ones from the tops of both Midway drill holes. Its deepest occurrence at Midway is at 385.5 feet in the Reef hole.

*Species Nos.*—S38, R37.

**Genus SIPHONODOSARIA A. Silvestri, 1924**

*Siphonodosaria?* sp.

Plate 3, figure 10

Between 1,105.5 and 1,112 feet in Reef hole are a few fragmentary specimens of an unornamented slender arcuate uniserial species. None shows an unbroken apertural end, so the generic assignment remains in doubt.

*Species No.*—R136.

**Family SPIRILLINIDAE**

**Genus SPIRILLINA Ehrenberg, 1843**

*Spirillina decorata* Brady

*Spirillina decorata* H. B. Brady. Cushman, Todd, and Post, 1954, p. 356, pl. 88, figs. 32, 33.

*Spirillina decorata* occurs in the upper parts of both holes, a pattern similar to that found at Eniwetok.

*Species Nos.*—S39, R11.

*Spirillina tuberculatolimbata* Chapman

*Spirillina tuberculato-limbata* Chapman. Cushman, Todd, and Post, 1954, p. 357, pl. 88, fig. 34.

This is found in the tops of both holes, in many samples together with *S. decorata*. All records checked for this species in the Pacific or elsewhere are from the Holocene.

*Species Nos.*—S14, R12.

*Spirillina vivipara* Ehrenberg

*Spirillina vivipara* Ehrenberg. Todd and Low, 1960, p. 836, pl. 260, fig. 4.

Todd, 1965, p. 6.

*Spirillina vivipara* occurs in the tops of both holes and in random levels to a depth of 1,165 feet in the Reef hole. It is more common in cores from 1,051 to 1,061 feet. Todd (1965, p. 6) included the variety *densepunctata*, recorded from Holocene sediments in the Marshall Islands, in the synonymy of the species *S. vivipara*. Thus the present record agrees with that previously noted for this area.

*Species Nos.*—S30, R45.

**Family PATELLINIDAE**

**Genus PATELLINA Williamson, 1858**

*Patellina advena* Cushman

Plate 3, figure 6

*Patellina advena* Cushman. Todd, 1965, p. 7, pl. 1, fig. 2.

Very rare specimens from four Miocene samples between 1,053.5 and 1,125 feet in Reef hole belong in this low scalelike species that was described from the Oligocene of Mississippi and has been reported widely in Holocene sediments in the Pacific. Specimens are also found in both the post-Miocene and Miocene sections of Sand Island hole.

*Species Nos.*—S64, R131.

**Family DISCORBIDAE**

**Genus ROSALINA d'Orbigny, 1826**

*Rosalina globularis* d'Orbigny

*Rosalina globularis* d'Orbigny. Todd, 1965, p. 11, pl. 3, fig. 4.

This species of *Rosalina* is distinguished by a lobulate and rounded periphery, slightly inflated chambers, and a moderately high spire. It is found in scattered samples in both holes, both above and below the Miocene.

It may be a matter of degree between *R. globularis* and *R. micens*, but they are here regarded as separate species for convenience in designating the two forms—*R. micens* a low nearly circular, caplike, four-chambered form, and *R. globularis* a higher more lobulated form having six or more chambers. They occur together in many samples.

*Species Nos.*—S58, R62.

*Rosalina micens* (Cushman)

Plate 4, figure 1

*Rosalina micens* (Cushman). Todd, 1965, p. 12, pl. 4, fig. 2.

This low caplike species is found in both holes, in scattered samples both above and below the top of the Miocene.

*Species Nos.*—S10, R21.

*Rosalina orientalis* (Cushman)

*Discorbis orientalis* Cushman. Todd, 1957, p. 278, 290 (tables 3, 4), pl. 82, fig. 10; pl. 90, fig. 13.

This high-spired species was originally described from Kure and Midway Islands. It is well represented in the post-Miocene part of both holes, more continuously in Sand Island hole than in Reef hole.

It appears to be morphologically related to *R. turgida* which may be its ancestor, but the two species are occasionally found together. It has been reported from both Holocene and Miocene of Saipan.

*Species Nos.*—S11, R9.

*Rosalina rugosa* d'Orbigny

*Rosalina rugosa* d'Orbigny. Todd, 1965, p. 12, pl. 4, fig. 1.

A single specimen from the top sample of Sand Island hole seems typical in its dense coarse pores.

*Species No.*—S12.

***Rosalina turgida* (Dorreen)**

Plate 4, figure 3

*Lamareckina turgida* Dorreen, 1948, p. 297, pl. 39, fig. 6.*Rosalina turgida* (Dorreen). Todd and Low, 1960, p. 837.*Discorbis "globularis" (d'Orbigny)*. Todd and Post, 1954, p. 560, pl. 199, fig. 13.

This robust species, described from the upper Eocene of New Zealand and reported in the Eocene and Miocene of the Eniwetok drill holes, occurs in both Midway holes. In Reef hole it begins at 206 feet and is found fairly consistently through the post-Miocene section but not below it, except for one questionable specimen. In Sand Island hole it is found in scattered samples between 282.5 and 321 feet and again between 483.5 and the bottom of the hole.

The hemispherical shape of the test, the coarsely perforate upper surface, and the radial ridges on the flat lower surface serve to distinguish this species.

*Species Nos.*—S93, R53.**Genus TRETOMPHALUS Moebius, 1880*****Tretomphalus concinnus* (Brady)***Tretomphalus concinnus* (Brady). Todd, 1965, p. 39.*Rosalina concinna* (Brady). Todd, 1965, p. 10, pl. 4, fig. 3.

Rare but typical specimens, some showing the balloon chamber, occur near the top of both holes, and also at 931 feet in Reef hole.

*Species Nos.*—S67, R47.**Genus NEOCONORBINA Hofker, 1951*****Neoconorbina crustata* (Cushman)***Neoconorbina crustata* (Cushman). Todd, 1965, p. 15, pl. 2, figs. 2, 3.

This low, scalelike species having nearly concentric dorsal sutures, and typically with a less conspicuously punctate wall on the dorsal than on the ventral side, is present in both holes but is very rare.

*Species Nos.*—S97, R104.***Neoconorbina floridensis* (Cushman)**

Plate 4, figure 5

*Neoconorbina floridensis* (Cushman). Todd, 1965, p. 15, pl. 2, fig. 4.

Rare specimens at 241 and 243.5 feet in Sand Island hole and at 945 feet in Reef hole belong in this species reported from Fiji. They show dense punctation of the dorsal wall in between the curved limbate sutures, and the ventral surface is without visible punctation.

*Species Nos.*—S75, R113.***Neoconorbina frustata* (Cushman)***Neoconorbina frustata* (Cushman). Todd, 1965, p. 16, pl. 1, fig. 7.

Four single specimens in the lower part of Reef hole, between 1,121 and 1,126 feet, and a single specimen from 148 feet in Sand Island hole are the only representatives of this Holocene species described from off Fiji. The species is distinctive in the rufflelike upturned edges of the chambers on the dorsal surface and in the translucent appearance of the test.

*Species Nos.*—S69, R143.***Neoconorbina patelliformis* (Brady)***Neoconorbina patelliformis* (Brady). Todd, 1965, p. 16, pl. 2, fig. 1.

Rare specimens, mostly small and poorly preserved, occur in both holes in scattered samples both above and below the top of the Miocene. They are characterized by having a pointed conical test and a deep ventral umbilicus.

*Species Nos.*—S106, R77.***Neoconorbina rustica* Todd and Low, n. sp.**

Plate 4, figures 4, 6

Test planoconvex or with ventral side slightly concave with open umbilicus, periphery entire, rounded, chambers indistinct, not inflated, four making up the final whorl, lunate on the dorsal side, much overlapping on the ventral side so that the final one occupies about half the ventral surface; sutures indistinct, in some specimens marked by curved raised ridges on the dorsal side, slightly depressed at their inner ends on the ventral side, wall smooth except for raised limbate sutural ridges on the dorsal side and irregular thickened ridges radiating out from the depressed umbilicus; aperture under the edge of the final overlapping chamber, opening into the umbilicus. Diameter 0.35–0.58 mm, height 0.20–0.30 mm.

Holotype, USNM 688104, from core at a depth of about 426 feet in the post-Miocene section of Reef hole, Midway atoll, Hawaiian Islands. The species is common at this depth. Rare specimens, mostly smaller and less well developed, occur in scattered other samples in both Reef and Sand Island holes between 222 and 529.5 feet in Reef hole and between 137 and 296.5 feet in Sand Island hole.

This species differs from *Neoconorbina patelliformis* in lacking a high pointed apex and the radial markings of the ventral surface. In shape of test it more closely resembles *N. floridensis* but does not show the dense punctation of the dorsal wall that is characteristic of that species. Moreover *N. rustica* n. sp. has the irregular thickened ridges and knob around the umbilicus that are not present in other species of *Neoconorbina*.

*Species Nos.*—S47, R59.

**Neoconorbina terquemi (Rzehak)**

*Neoconorbina terquemi* (Rzehak). Todd, 1965, p. 16, pl. 5, fig. 6.

This species is thicker than *N. crustata* but less thick than *N. patelliformis*. It lacks the ventral knobs that characterize *N. rustica* n. sp. It occurs rarely and in scattered samples in the lower section of the Reef hole.

*Species No.*—R124.

**Genus DISCORBIS Lamarck, 1804*****Discorbis vesicularis dimidiata* (Parker and Jones)**

Plate 4, figure 2

*Discorbis vesicularis* (Lamarck) var. *dimidiata* (Jones and Parker). Parr, 1932, p. 227, pl. 21, figs. 27–29.

Test small for the genus, composed of 2½–3 whorls, convex on the evolute dorsal side, flat or slightly concave on the involute ventral side, periphery rounded and slightly lobulated; chambers distinct, slightly inflated, gradually increasing in size as added, seven or eight composing the final whorl; sutures distinct, straight, and tangential on the dorsal side, straight and nearly radial on the ventral side which has prominent astral flaps extending about half way out to the periphery from the umbilicus; wall smooth, densely punctate, unornamented; apertures consisting of long slits extending outward along the rear edge of each astral flap. Diameter 0.32–0.45 mm, thickness 0.17–0.22 mm.

Outside of their smaller size, more delicate construction, and rounded not angled periphery, the present specimens seem closely related to topotypes of this species from the Eocene of the Paris Basin. They seem identical with a variable form (see above synonymy) that was reported from shallow-water habitats of Australia and New Zealand, particularly with the specimen (Parr, 1932, pl. 21, fig. 29) illustrated from Glenelg, South Australia.

This form is likely indicative of shallow or possibly even brackish environments. At Midway it was found only at 242.5 and 243.5 feet in Sand Island hole. At 242.5 feet it is the major faunal element.

*Species No.*—S77.

**Genus DISCORBINELLA Cushman and Martin, 1935*****Discorbinella?* sp.**

Plate 3, figure 9

Test complanate, much compressed, consisting of about 2½ whorls, dorsal evolute side slightly convex, ventral involute side flat and concave in the umbilicus, periphery rounded, entire; chambers seven per adult whorl, distinct, not inflated, increasing only slightly in size as added; sutures distinct, strongly curved on the

dorsal side, straight and tangential on the ventral side; wall densely and coarsely perforate on the dorsal side, smooth on the ventral side; aperture a low slit at the base of the final chamber on the ventral side with supplementary openings at the rear of each umbilical flap that marks the inner end of each chamber. Diameter 0.32–0.48 mm; thickness about 0.17 mm.

This species is probably new, but material is insufficient to base a new species on. This species differs from *D. montereyensis* Cushman and Martin in being more evolute on the dorsal side and in showing the strong contrast in punctuation between dorsal and ventral surfaces. Also, the present specimens do not have the peripheral aperture that is characteristic of this genus. For these reasons the generic assignment is questionable.

Specimens are found only in Sand Island hole where they occur in the Miocene section between 490 and 499.5 feet, with a juvenile specimen at 258.8 feet in the post-Miocene section.

*Species No.*—S82.

**Genus ROTORBINELLA Bandy, 1944*****Rotorbinella mira* (Cushman)**

Plate 5, figures 2, 3

*Rotorbinella mira* (Cushman). Todd 1965, p. 18, pl. 8, fig. 2.

*Discorbis balcombensis* Chapman, Parr, and Collins. Todd and Low, 1960, p. 838, pl. 262, fig. 7.

*Rotorbinella* sp. Todd and Post, 1954, p. 562, pl. 200, fig. 2.

This species has been known under several specific names including *Discorbis turbo* of authors (not d'Orbigny) and possibly others besides those included in the partial synonymy above.

Originally described from the Holocene of the West Indies, the species appears to have a wide distribution in shallow water in the equatorial regions, and to go back at least into the lower Miocene.

Specimens are scarce in the post-Miocene section of both holes, but in the Miocene part they are consistently present and compose a significant part of the population in many samples.

*Species Nos.*—S13, R10.

**Genus GYROIDINA d'Orbigny, 1826*****Gyroidina orbicularis* d'Orbigny**

*Gyroidina orbicularis* d'Orbigny. Parker 1954, p. 528, pl. 9, figs. 13, 18.

Rare specimens of a small smooth species having about nine chambers per whorl, and lacking an umbilical depression, occur in the lower part of Reef hole between 1,105.5 and 1,126 feet. *G. orbicularis* appears to range from Eocene to Holocene.

*Species No.*—R135.

Genus *EPONIDES* Montfort, 1808*Eponides duprei ciervoensis* Cushman and Simonson

*Eponides duprei ciervoensis* Cushman and Simonson. Todd and Low, 1960, p. 838, pl. 260, fig. 7.

A single specimen was found at 512 feet in Reef hole. This subspecies was described from the Oligocene of California and has been reported from hole E-1 at Eniwetok.

*Species No.*—R83.

*Eponides formosulus* Todd and Low, n. sp.

Plate 5, figure 1

Test small for the genus, close coiled but flattened on both the dorsal and ventral surfaces, consisting of about two whorls, periphery entire, not lobulated, rounded; chambers few, seven in the last whorl, not inflated; sutures straight and radial on the ventral side, slightly thickened toward the umbilicus, slightly curved on the dorsal side; wall smooth; aperture not observed. Diameter 0.17 mm; thickness 0.11 mm.

Holotype, USNM 688121, from core at 944 feet in the Miocene section of Reef hole, Midway atoll, Hawaiian Islands.

This minute species differs from *Eponides pusillus* Parr from the Holocene of Tasmania by having seven instead of five chambers per whorl, by the ventral sutures being thickened toward the umbilicus, by the dorsal sutures not being oblique, and by the test being flattened instead of biconvex.

*Species No.*—R111.

*Eponides repandus* (Fichtel and Moll)

*Eponides repandus* (Fichtel and Moll). Todd, 1965, p. 20, pl. 7, figs. 3, 4.

Rare specimens of this Holocene species are found in scattered samples of both holes, throughout Sand Island hole and down to 510.3 feet in Reef hole.

*Species Nos.*—S35, R3.

*Eponides subornatus* (Cushman)

Plate 5, figure 5

*Eponides subornatus* (Cushman). LeRoy, 1964, p. 38, pl. 7, figs. 27-29.

Rare specimens from between 1,075 and 1,084 feet in Reef hole belong to this robust conical species that is recorded from Miocene, Pliocene, and Holocene in the Pacific. The coiled side is high conical, the umbilical side is nearly flat, and the sutures are limbate.

*Species No.*—R132.

Genus *CANCERIS* Montfort, 1808*Canceris pauciloculatus* Cushman and McGlamery

Plate 5, figure 4

*Canceris pauciloculatus* Cushman and McGlamery. Cushman and Todd, 1942, p. 85, pl. 22, fig. 4.

This species is characterized by fewer chambers per whorl than other species in the genus. It occurs in a narrow interval in Reef hole, between 967.5 and 970.5 feet. It was described from the Oligocene of Alabama and reported from several other Oligocene localities of the Gulf Coast of the United States. Its presence in the lower Miocene here is an upward extension of its range.

*Species No.*—R114.

Genus *BAGGINA* Cushman, 1926*Baggina parva* Todd

*Baggina parva* Todd, 1957, p. 297, pl. 83, fig. 8.

This species was described from the Miocene Tagpochau Limestone of Saipan. Typical and well-preserved specimens occur rarely in the Miocene section of both holes.

*Species Nos.*—S117, R82.

Genus *BUCCELLA* Andersen, 1952*Buccella perforata* Todd and Low

Plate 6, figure 1

*Buccella? perforata* Todd and Low, 1960, p. 840, pl. 262, figs. 9, 10.

*Eponides* sp. A LeRoy. Todd and Post [not LeRoy], 1954, p. 560, pl. 200, fig. 1.

This species was described from the Miocene of Eniwetok and was also recorded from the Miocene of Bikini. Rare specimens are present in the Miocene sections of both Midway holes, between 466.5 and 498 feet in Sand Island hole and between 535 and 1,165 feet in Reef hole. Most of the specimens are small for the species and have the characteristics described for juveniles.

*Species Nos.*—S115, R91.

Genus *SIPHONINA* Reuss, 1850*Siphonina tubulosa* Cushman

*Siphonina tubulosa* Cushman. Cushman, Todd, and Post, 1954, p. 361, pl. 89, figs. 29, 30.

This Holocene to Miocene species is found in both holes more consistently below the top of the Miocene than above it. Some of the better preserved specimens show the tubules through the wall. The apertural neck

is very short so that the aperture barely extends out beyond the periphery.

*Species Nos.*—S70, R44.

**Genus NUTTALLIDES Finlay, 1939**

*Nuttallides umboniferus* (Cushman)

Plate 6, figure 3

*Nuttallides umbonifera* (Cushman). Parker, 1964, p. 626, pl. 99, figs. 36, 40.

Todd, 1965, p. 29, pl. 11, fig. 1.

A single typical specimen was found in the lower part of the Reef hole, at 1,110.5 feet. It clearly shows the re-entrant along the apertural face and the wall is rather coarsely perforate.

The species was described from deep water of the tropical Pacific and has also been recorded from the Miocene and Pliocene of the experimental Mohole drilling near Guadalupe Island, Mexico.

*Species No.*—R140.

**Genus PAUMOTUA Loeblich, 1952**

*Paumotua terebra* (Cushman)

*Paumotua terebra* (Cushman). Todd, 1965, p. 25, pl. 16, figs. 3, 4.

This species occurs rarely in the post-Miocene section of Sand Island hole.

*Species No.*—S7.

**Genus HERONALLENIA Chapman and Parr, 1931**

*Heronallenia* sp.

Plate 6, figure 5

Three single specimens belonging in this genus were found at 1,108, 1,109.75, and 1,120.5 feet in Reef hole. They are small for the genus, 0.23 mm in length, depressed, and unornamented.

*Species No.*—R139.

**Genus GLABRATELLA Dorreen, 1948**

*Glabratella* sp.

Plate 6, figure 4

Rare specimens of a small species having four to five chambers per final whorl, a lobulated periphery, and a large deep umbilical opening surrounded by radial grooves, are found in Sand Island hole near the bottom and in Reef hole between 1,027 and 1,126 feet. Most specimens are rugose or crinkled on the dorsal surface.

*Species Nos.*—S120, R125.

*Glabratella?* sp.

Plate 6, figure 2

Rare specimens in eight samples from near the top of the Miocene section in Reef hole—from between 522 and

620.5 feet—appear to be undescribed. A single specimen from Sand Island hole at 483.5 feet also seems the same. They are small, about 0.23 mm in diameter, compact, planoconvex with a deep cavernous umbilical depression. About six chambers make up the final whorl. The periphery is rounded and entire. The convex dorsal surface is more coarsely perforate than the ventral side and is slightly rugose.

There is a question as to whether these would be better assigned to *Rosalina* than to *Glabratella* because no radial lines are visible around the umbilical opening. However, they are tentatively assigned to *Glabratella* because the umbilical opening is larger and deeper than that typical of *Rosalina*.

*Species Nos.*—S118, R88.

**Genus EPISTOMINELLA Husezima and Maruhasi, 1944**

*Epistominella pulchra* (Cushman)

*Epistominella pulchra* (Cushman). Todd, 1965, p. 31, pl. 10, figs. 3, 4.

Typical specimens of this Holocene species occur in the Miocene sections of both holes on Midway, best developed between 1,120.5 and 1,126 feet in Reef hole. It has previously been recorded in Miocene beds, from between 600 and 1,955 feet in hole E-1 on Eniwetok.

*Species Nos.*—S110, R123.

***Epistominella tubulifera* (Heron-Allen and Earland)**

*Epistominella tubulifera* (Heron-Allen and Earland). Todd, 1965, p. 31, pl. 10, fig. 2.

Rare specimens of this Holocene species are found in the post-Miocene section of Sand Island hole, between 279.5 and 287.5 feet. The specimens are distinctive in the relatively large irregular openings around the periphery.

*Species No.*—S89.

**Family ROTALIIDAE**

**Genus AMMONIA Brunnich, 1772**

***Ammonia beccarii* (Linné) and subspecies *tepida* (Cushman)**

This species and its subspecies, both well known and widely reported from the Holocene and as far back as Miocene, are present at Midway. Both are significant of shallow deposition, the subspecies being characteristic of more subdued and protected environments than the typical form.

The typical form is found rarely in Reef hole between 1,105.5 and 1,127.3 feet, whereas the subspecies is found more commonly and in both holes—between 981 and 1,109.3 feet in Reef hole and between 140 and 499 feet in Sand Island hole.

*Species Nos.*—S54, R118, R120.

Family **AMPHISTEGINIDAE**  
Genus **ASTERIGERINA** d'Orbigny, 1839

**Asterigerina indistincta** Todd and Post

*Asterigerina indistincta* Todd and Post, 1954, p. 562, pl. 201, fig. 1.

This species, described from the post-Miocene section in the Bikini holes and reported in the Eniwetok holes, occurs commonly at 73 feet in Reef hole. It is not known from Holocene sediments. Scattered rare occurrences to 293.5 feet in Reef hole and at 286.2 feet and 473.5 feet in Sand Island hole extend its range downward.

*Asterigerina indistincta* is superficially similar to *Amphistegina madagascariensis*, but its fewer chambers are usually visible around the circumference on the dorsal side and do not extend inward to the central area, although no spiral suture limits them.

*Species Nos.*—S95, R16.

**Asterigerina tentoria** Todd and Post

Plate 7, figure 1

*Asterigerina tentoria* Todd and Post, 1954, p. 562, pl. 201, fig. 2.

This planoconvex species was described from Tertiary *g* to *e* beds at Bikini and has also been reported in Tertiary *e* and *f* and Eocene beds at Eniwetok.

In both the Midway holes, *A. tentoria* occurs at the top of the Miocene and in scattered samples to 560 feet in Reef hole and to 460 feet in Sand Island hole. In addition, it reappears in a lower section of Reef hole, from 1,041.25 to 1,107.25 feet.

*Species Nos.*—S107, R72.

Genus **AMPHISTEGINA** d'Orbigny, 1826

**Amphistegina bikiniensis** Todd and Post

Plate 7, figures 2, 3; plate 8, figure 1

*Amphistegina bikiniensis* Todd and Post, 1954, p. 563, pl. 201, fig. 4.

This species begins at the top of the Miocene in both holes and continues in scattered samples more or less abundantly to the bottom of both holes. It is the predominant species in most of the Miocene section as *Amphistegina madagascariensis* is in the post-Miocene section, and *A. bikiniensis* is gradational with and ancestral to *A. madagascariensis*.

Although *A. bikiniensis* was originally described as differing from *A. madagascariensis* by its flatter test this distinction does not seem to hold true for all specimens. Instead, most specimens seem to differ by lacking the irregular limbate lines that typically appear between the sutures of *A. madagascariensis*. Also the sup-

plementary chambers are short and triangular and not long and curved as they are in *A. madagascariensis*.

*Species Nos.*—S102, R71.

**Amphistegina madagascariensis** d'Orbigny

*Amphistegina madagascariensis* d'Orbigny. Cushman, Todd, and Post, 1954, p. 362, pl. 90, figs. 1, 2.

This species occupies the predominant position in the upper part of both holes; abundantly to 443 feet in Sand Island hole and to about 467 feet but with scattered breaks in Reef hole. In both holes there are scattered and less abundant occurrences below these depths. At 445 feet in Sand Island hole and 500 feet in Reef hole, *A. madagascariensis* is replaced by its ancestral species *A. bikiniensis*, that occurs abundantly up to the top of the Miocene.

Farther down in the holes, the specimens appear to become perceptibly flatter than they are at the tops of the holes, but still seem specifically indistinguishable. Johanna Resig (written commun., July 28, 1969) reports that around Oahu the specimens of *A. madagascariensis* are generally flatter in deep waters than in shallow waters.

The transition between *A. madagascariensis* and *A. bikiniensis* seems to have occurred sometime in the late Miocene because by the top of the Midway Miocene, which is interpreted as Tertiary *g*, the specimens seem to belong in the latter species.

*Species Nos.*—S1, R1.

Family **ELPHIDIIDAE**

Genus **ELPHIDIUM** Montfort, 1808

**Elphidium advena** (Cushman)

*Elphidium advenum* (Cushman). Cushman, Todd, and Post, 1954, p. 345, pl. 86, fig. 30.

Rare, mostly small, specimens were found in Sand Island hole between 243.5 and 498 feet and in Reef hole between 807 and 1,165 feet. They have an acute periphery, narrow chambers, and a small umbilical knob.

*Species Nos.*—S79, R96.

**Elphidium aff. E. formosum** Todd

Rare specimens were found at 242.5 and 243.5 feet in Sand Island hole. This species was described (Todd, 1957, p. 299, pl. 88, fig. 22) from Holocene beach sediments of Saipan and is characterized by its sutures having a beaded appearance. The Midway specimens seem similar but not identical.

*Species No.*—S78.

**Elphidium hyalocostatum Todd**

*Elphidium hyalocostatum* Todd, 1957, p. 300, pl. 88, fig. 19.

A single specimen of this species described from Holocene Saipan sediments was found at 241 feet in Sand Island hole.

*Species No.*—S73.

**Family CYMBALOPORIDAE**

**Genus CYMBALOPORETTA Cushman, 1928**

**Cymbaloporetta bradyi (Cushman)**

Plate 8, figure 3

*Cymbaloporetta bradyi* (Cushman). Cushman, Todd, and Post, 1954, p. 364, pl. 90, figs. 13, 14.

This well-known Holocene species occurs in typical form in both holes from the top down to 300 feet in Sand Island hole and to 341 feet in Reef hole. A few specimens in Reef hole are unusually flat (see pl. 8, fig. 3) but are otherwise identical.

In Sand Island hole there is a zone of common to abundant *Cymbaloporetta bradyi* between 279.5 and 292.75 feet. It is associated here with common to abundant specimens of *Reussella simplex*.

*Species Nos.*—S3, R2.

**Family ANOMALINIDAE**

**Genus ANOMALINA d'Orbigny, 1826**

**Anomalina glabrata Cushman**

Plate 8, figure 5

*Anomalina glabrata* Cushman. Graham and Militante, 1959, p. 115, pl. 19, fig. 8.

This Miocene to Holocene species widely reported around the Pacific, is distinguished from *Nonion pacificum* by being evolute on one side. It is found in both holes in scattered samples nearly throughout Reef hole but only in the lower part of Sand Island hole.

*Species Nos.*—S109, R27.

**Anomalina? maculosa Todd**

*Anomalina? maculosa* Todd, 1957, p. 296, pl. 92, fig. 12.

Typical and well-preserved specimens occur rarely near the top of Sand Island hole.

*Species No.*—S2.

**Genus CIBICIDES Montfort, 1808****Cibicides cicatricosus (Schwager)**

Plate 11, figure 7

*Cibicides cicatricosus* (Schwager). Cushman, Todd, and Post, 1954, p. 371, pl. 91, figs. 25, 26.

Todd, 1957, p. 279 (table 3), pl. 80, fig. 8.

Todd, 1965, p. 52, pl. 22, fig. 3.

Todd, 1966, p. 26.

This robust, coarsely porous species occurs most commonly in the Sand Island hole at 490–500 feet with scattered specimens just above that section. It occurs first at the 560-foot level in the Reef hole and is scattered to a depth of 1,127 feet.

It was found in only the Holocene sediment of the Marshall Islands and in Miocene to Holocene of the Mariana Islands.

*Species Nos.*—S45, R92.

**Cibicides lobatulus (Walker and Jacob)**

*Cibicides lobatulus* (Walker and Jacob). Cushman, Todd, and Post, 1954, p. 371, pl. 91, figs. 27, 28.

Todd and Low, 1960, p. 852.

Todd, 1965, p. 52, pl. 22, fig. 1.

This cosmopolitan and variable species is scattered throughout both drill holes in varying degrees of abundance. In the Reef hole it is found as deep as 1,165 feet and occurs most commonly between 529 and 535 feet.

Some specimens approach the genus *Cibicidina* in form, but the coarsely perforate wall indicates their correct placement is in *Cibicides*.

*Species Nos.*—S22, R17.

**Cibicides mayori (Cushman)**

*Cibicides mayori* (Cushman). Cushman, Todd, and Post, 1954, p. 371, pl. 91, figs. 29, 30.

Todd and Low, 1960, p. 852.

Todd, 1965, p. 53, pl. 22, fig. 7.

The occurrence of this species in the Midway core samples as deep as 1,108 feet in Reef hole tends to confirm our supposition that it occurred in place in the cuttings of Miocene age in the Eniwetok drill hole E-1. The rare specimens scattered in the tops of both Midway drill holes are beautifully preserved, the distinctive keel on several individuals retaining a frilled edge.

*Species Nos.*—S63, R52.

**Cibicides pseudoungerianus (Cushman)**

*Cibicides pseudoungerianus* (Cushman). LeRoy, 1964, p. 45, pl. 8, figs. 13–15.

Rare specimens of this close-coiled species are found between 968.5 and 974.5 feet in the Reef hole. The species has a long recorded range from Eocene to Holocene and is widely reported.

*Species No.*—R115.

**Cibicides refulgens Montfort**

*Cibicides refulgens* Montfort. Todd and Low, 1960, p. 852, pl. 262, fig. 14.

Todd, 1965, p. 53.

Several specimens at 421–426.2 feet in the Reef hole are clearly identifiable as this planoconvex species. It

was scattered in the upper parts of the Eniwetok drill holes.

*Species No.*—R65.

**Cibicides cf. C. robertsonianus (Brady)**

One specimen in the Sand Island hole closely resembles the biconvex species *Cibicides robertsonianus*. Recrystallization tends to obscure the porosity of the surface although the backward-curving sutures are visible.

The species is not common in the Pacific and was not recorded from the Marshall or Mariana Islands.

*Species No.*—S96.

**Genus CIBICIDINA Bandy, 1949**

**Cibicidina sp.**

Plate 6, figure 6

A few specimens from between 931 and 985.5 feet in Reef hole appear to belong in this genus. They are planoconvex or concavoconvex with limbate sutures on the flat side. Preservation is too imperfect to permit more accurate identification.

*Species No.*—R107.

**Genus CYCLOLOCULINA Heron-Allen and Earland, 1908**

**Cycloloculina sp.**

Plate 8, figure 2

*Cycloloculina* sp. Todd and Post, 1954, p. 564, pl. 200, fig. 6.

Todd, 1957, p. 268 (table 1), pl. 71, fig. 5.

Todd and Low, 1960, p. 850, pl. 257, fig. 5.

A few rare but well-preserved specimens are present in Reef hole between 1,106.75 and 1,126 feet. The genus is not known from rocks younger than Miocene. It has a worldwide distribution and has been reported from several Pacific localities: Bikini, Eniwetok, and Saipan. (See synonymy above.)

*Species No.*—R137.

**Genus CIBICIDELLA Cushman, 1927**

**Cibicidella variabilis (d'Orbigny)**

*Cibicidella variabilis* (d'Orbigny). Cushman, Todd, and Post, 1954, p. 372, pl. 82, fig. 13.

This widely recorded Holocene species occurs rarely in both holes at Midway. Most of the specimens are small for the species, or represent initial stages of the species.

*Species Nos.*—S114, R95.

**Family PLANORBULINIDAE**

**Genus PLANORBULINA d'Orbigny, 1826**

**Planorbulina acervalis Brady**

*Planorbulina acervalis* Brady. Cushman, Todd, and Post, 1954, p. 372, pl. 82, fig. 14; pl. 91, figs. 34–36.

This species, together with *Acervulina inhaerens* with which it may be confused, is present in scattered samples throughout both holes. It is characterized by an irregular test with individually inflated chambers.

*Species Nos.*—S37, R28.

**Genus PLANORBULINOIDES Cushman, 1928**

**Planorbulinoides retinaculatus (Parker and Jones)**

*Planorbulinoides retinaculata* (Parker and Jones). Todd and Low, 1960, p. 853, pl. 262, fig. 5; pl. 263, fig. 10.

A few scattered specimens of this rough-surfaced attached form are found in both holes, some in the Miocene part of Reef hole.

*Species Nos.*—S80, R43.

**Genus PLANORBULINELLA Cushman, 1927**

**Planorbulinella larvata (Parker and Jones)**

*Planorbulinella larvata* (Parker and Jones). Todd and Low, 1960, p. 853, pl. 258, fig. 6; pl. 263, fig. 5.

Although this species was recorded as rare in Holocene sediments of the Marshall Islands, it was somewhat abundant in the cuttings from the upper sections of the Eniwetok drill hole E-1. In addition, it was found in the Eocene core of Eniwetok hole F-1.

It is restricted to three Miocene samples in the Midway Reef hole at about 931 feet, a section having a rich fauna of fairly well preserved material.

*Species No.*—R105.

**Genus ACERVULINA Schultze, 1854**

**Acervulina inhaerens Schultze**

*Acervulina inhaerens* Schultze. Cushman, Todd, and Post, 1954, p. 372, pl. 91, figs. 37, 38.

This species is less well represented than *Planorbulina acervalis* but it is present in both holes. The test is a low scalelike mass of chambers that grow out over each other with a sinuous pattern of sutures, and the wall is usually less coarsely perforate than in *Planorbulina acervalis*.

*Species Nos.*—S20, R29.

**Genus GYPSINA Carter, 1877**

**Gypsina discus Goës**

Plate 11, figure 6

*Gypsina vesicularis* var. *discus* Goës, 1896, p. 74, pl. 7, figs. 4–6. Chapman, 1900, p. 199, pl. 19, fig. 13.

*Gypsina discus* Goës, (Cole, 1961 [1960 imprint], p. A5, pl. 3, figs. 3, 4, 7.

Rare specimens of *Gypsina discus* occur in the short section between 1,113 and 1,129 feet as well as at 1,165 feet in Reef hole.

The species was described from dredgings from a depth of 400 fathoms in the Caribbean. It has been recorded more extensively from Holocene sediments in the Pacific, but it was not found in the Marshall Islands. It is recorded from beds of Oligocene and Miocene age in the Mariana Islands, Fiji, and the Caribbean area.

*Species No.*—R141.

**Gypsina globula (Reuss)**

*Gypsina globula* (Reuss). Todd and Low, 1960, p. 853. Todd, 1965, p. 55, pl. 22, fig. 5.

*Gypsina vesicularis* (Parker and Jones). Todd and Low, 1960, p. 853.

This species is found in scattered occurrences from near the top of each hole to a depth of 1,128 feet in the Reef hole and 500 feet in the Sand Island hole. In the Reef hole it dominates the fauna, with *Amphistegina bikiniensis*, at 1,070 to 1,071 feet; in the Sand Island hole it dominates, with *Cibicides mayori*, at 488 to 496 feet.

*Gypsina globula* was found in cores of Eocene age as well as cuttings throughout the Eniwetok drill holes.

*Species Nos.*—S46, R18.

**Family HOMOTREMATIDAE**

**Genus HOMOTREMA Hickson, 1911**

**Homotrema rubrum (Lamarck)**

*Homotrema rubrum* (Lamarck). Todd and Low, 1960, p. 854.

Rare fragmentary specimens, some of the "*Homotrema*-type" and some of the more fragile "*Miniacina*-type," are found in both holes. Those in Sand Island hole are found only to 145 feet; those in Reef hole are in scattered samples to 620.5 feet.

*Species Nos.*—S5, R5.

**Family NONIONIDAE**

**Genus NONION Montfort, 1808**

**Nonion akitaense Asano**

Plate 8, figure 4

*Nonion akitaense* Asano, 1950, p. 1, figs. 1, 2.

This species is depressed with a rounded periphery and has eight or nine chambers in the whorl. Rare specimens occur in Reef hole between 1,043 and 1,045 feet, between 1,121 and 1,125 feet, and at 1,186 feet. Comparison with Japanese specimens indicates they are the same.

This species was described from the Pliocene of Japan and recorded from the Pliocene of Okinawa and the Quaternary of China.

*Species No.*—R130.

**Nonion pacificum (Cushman)**

Plate 8, figure 6

*Nonion pacificum* (Cushman). Cushman, Todd, and Post, 1954, p. 345, pl. 86, fig. 25.

This Miocene to Holocene species is superficially similar to *Anomalina glabrata* but is equally involute on both sides.

It is found in both holes, both above and below the top of the Miocene.

*Species Nos.*—S76, R89.

**Genus FLORILUS Montfort, 1808**

**Florilus communis (d'Orbigny)**

Plate 9, figure 2

*Nonion commune* (d'Orbigny). Cushman, 1939, p. 10, pl. 3, fig. 2.

Two single specimens of this Miocene species were found at 1,108 and 1,121.5 feet in Reef hole. They are thick and flaring at the apertural face, and there are nine chambers visible.

*Species No.*—R138.

**Genus PSEUDONONION Asano, 1936**

**Pseudononion atlanticum (Cushman)**

Plate 9, figure 1

*Nonionella atlanticum* Cushman, 1947, p. 90, pl. 20, figs. 4, 5.

This species occurs in the Miocene section in Reef hole between 979.5 and 1,046 feet and again between 1,101.5 and 1,165 feet. There is considerable variation in size and shape (thickness and length), but all specimens are thin walled and appear to belong to this species described from off the coast of Florida.

*P. atlanticum* resembles and may prove to be indistinguishable from *P. grateloupi* (d'Orbigny) (Cushman, 1939, p. 21, pl. 6, figs. 1–7) whose reported records go back to the Miocene. However, *P. atlanticum* is usually thicker and proportionally shorter and broader than *P. grateloupi*.

*Species No.*—R117.

**Pseudononion aff. P. tredecum Asano**

Plate 9, figure 3

Three specimens at 1,041.25 feet and one at 1,111.5 feet in Reef hole are similar to this species (Asano, 1950, p. 5, figs. 22–24) and are reported to range from upper Pliocene to Holocene in Japan. The specimens are nearly circular and flattened with about 12 long curved chambers in the last whorl.

*Species No.*—R126.

Genus **ASTRONONION** Cushman and Edwards, 1937

*Astrononion* sp.

Plate 9, figure 6

A small species of *Astrononion*, having eight to 10 chambers per whorl and rather narrow and inconspicuous supplementary chambers, occurs in the lower part of Reef hole, from 1,005 to 1,129 feet. Specimens are persistent but rare. They are insufficient for identification.

*Species No.*—R122.

Family **CASSIDULINIDAE**

Genus **CASSIDULINA** d'Orbigny, 1826

*Cassidulina minuta* Cushman

*Cassidulina minuta* Cushman. Cushman, Todd, and Post, 1954, p. 366, pl. 90, fig. 35.

A single typical specimen of this Holocene species was found at 259.8 feet in Sand Island hole. *Cassidulina minuta* is widely reported in shallow water around the Pacific Islands.

*Species No.*—S85.

Family **ROBERTINIDAE**

Genus **ALLIATINA** Troelsen, 1954

*Alliatina translucens* (Cushman)

*Nonionella translucens* Cushman, 1933, p. 45, pl. 11, fig. 2.

*Alliatina translucens* (Cushman). Todd, 1962 [1961 imprint], p. 179 (table 1), pl. 23, fig. 2.

This distinctively mottled and translucent aragonitic species is represented by one broken specimen at 103.5 feet in Reef hole. Recorded occurrences appear to be restricted to Holocene sediments of the tropical Pacific.

*Species No.*—R38.

Family **GLOBIGERINIDAE**

Genus **GLOBIGERINA** d'Orbigny, 1826

*Globigerina conglomerata* Schwager

*Globigerina conglomerata* Schwager. Bradshaw, 1959, p. 33, pl. 6, figs. 6, 7.

Three specimens, two immature, from Reef hole at 426.2 feet are the only representatives found of this Holocene species.

*Species No.*—R66.

*Globigerina trilocularis* d'Orbigny

Plate 9, figure 4

*Globigerina trilocularis* d'Orbigny. Bermúdez, 1960, p. 1202, pl. 5, figs. 10, 11.

Some specimens, in which the final whorl consists of three chambers, the periphery is lobulate, and the single umbilical aperture is relatively small, are referred to this long-ranging species that was described from the

Miocene of France. At Midway they are found only in the Miocene sections of both holes.

*Species Nos.*—S111, R76.

Genus **GLOBIGERINITA** Bronnimann, 1951

*Globigerinita glutinata* (Egger)

*Globigerinita glutinata* (Egger). Parker, 1967, p. 146, pl. 17, figs. 3-5.

Only single specimens were found at 103.5 and at 500 feet in Reef hole.

*Species No.*—R42.

Genus **GLOBIGERINOIDES** Cushman, 1927

*Globigerinoides conglobatus* (Brady)

*Globigerinoides conglobatus* (Brady). Parker, 1967, p. 154, pl. 20, figs. 3, 4.

This species is found very rarely in the post-Miocene section of both holes.

*Species Nos.*—S55, R67.

*Globigerinoides ruber* (d'Orbigny)

*Globigerinoides ruber* (d'Orbigny). Parker, 1967, p. 156, pl. 22, figs. 1-4.

Specimens were found only in the post-Miocene section of Reef hole. It occurs fairly commonly with other planktonics at about 426 feet (421-426.2 feet bottom).

*Species No.*—R32.

*Globigerinoides sacculifer* (Brady)

*Globigerinoides sacculifer* (Brady). Parker, 1967, p. 156, pl. 21, figs. 1, 2, 4; text fig. 5.

Very rare but typical specimens are found in both holes. All but one at 986.2 feet in Reef hole are in the post-Miocene section.

*Species Nos.*—S56, R54.

*Globigerinoides trilobus* (Reuss)

*Globigerinoides triloba* (Reuss). Hamilton and Rex, 1959, p. 792, pl. 253, figs. 17-19.

Though poorly preserved and not abundant, specimens are found between 257 and 970.5 feet in Reef hole and at 292.75 and 460 feet in Sand Island hole. The species is typical of Miocene and younger deposits.

*Species Nos.*—S100, R60.

*Globigerinoides trilobus altiapertura* Bolli

Plate 9, figure 5

*Globigerinoides triloba altiapertura* Bolli, 1957, p. 113, pl. 25, figs. 7, 8; text fig. 21 (3).

A few specimens were found in Sand Island hole at 460 and 483.5 feet. They have a relatively large high-

arched aperture. The subspecies was described from the Miocene of Trinidad and has been reported from many localities in America, Europe, Australia, and New Zealand. Bolli (1966, range chart) reports its range to extend from lower Miocene into middle Miocene (zones *Globorotalia fohsi barisanensis* to *Globorotalia mayeri*) in the Bodjonegoro-1 well in Java.

*Species No.*—S112.

**Genus ORBULINA d'Orbigny, 1839**

***Orbulina universa* d'Orbigny**

*Orbulina universa* d'Orbigny. Bradshaw, 1959, p. 49, pl. 8, figs. 17, 18.

A single specimen was found in Sand Island hole at 289.5 feet.

*Species No.*—S99.

**Family GLOBOROTALIIDAE**

**Genus GLOBOROTALIA Cushman, 1927**

***Globorotalia crassaformis* (Galloway and Wissler)**

Plate 9, figure 7

*Globorotalia crassaformis* (Galloway and Wissler). Parker, 1962, p. 235, pl. 4, figs. 17, 18, 20, 21.

Parker, 1967, p. 176, pl. 30, figs. 1-3.

This well known and widely distributed species is reported to range from lower Pliocene to Holocene. Single specimens were found at 317.5 and 344 feet in Reef hole and 279.5 feet in Sand Island hole.

*Species Nos.*—S90, R61.

***Globorotalia inflata* (d'Orbigny)**

*Globorotalia inflata* (d'Orbigny). Parker, 1962, p. 236, pl. 5, figs. 6-9.

Parker, 1967, p. 179, pl. 29, figs. 1, 3.

This well known and widely distributed species is reported to range only from upper Pliocene to Holocene. Typical specimens occur at about 426 feet in Reef hole.

*Species No.*—R68.

***Globorotalia aff. G. margaritae* Bolli and Bermudez**

Two specimens in Reef hole at about 426 feet appear to be related to this species whose range is reported to be from upper Miocene to middle Pliocene. *G. margaritae* (Bolli and Bermudez, 1965, p. 139, pl. 1, figs. 16-18) was described from Venezuela and reported also from Java. It differs from *G. menardii* chiefly by its more convex dorsal surface and by the shape of its chambers that are broader than high. Our specimens are larger and have higher chambers than topotypes lent by Frances Parker, but otherwise seem similar.

*Species No.*—R69.

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<i>vesicularis, Gypsina</i> .....	42
<i>dimidiata, Discorbis</i> .....	5, 22, 23, 36; pl. 4
<i>discus, Gypsina</i> .....	41
<i>Virgulina</i> .....	3, 4
<i>complanata</i> .....	3,
4, 11, 13, 15, 17, 19, 21, 22, 23, 32; pl. 3	
<i>vivipara densepunctata, Spirillina</i> .....	34
<i>Spirillina</i> .....	10, 12, 14, 16, 18, 20, 22, 23, 34



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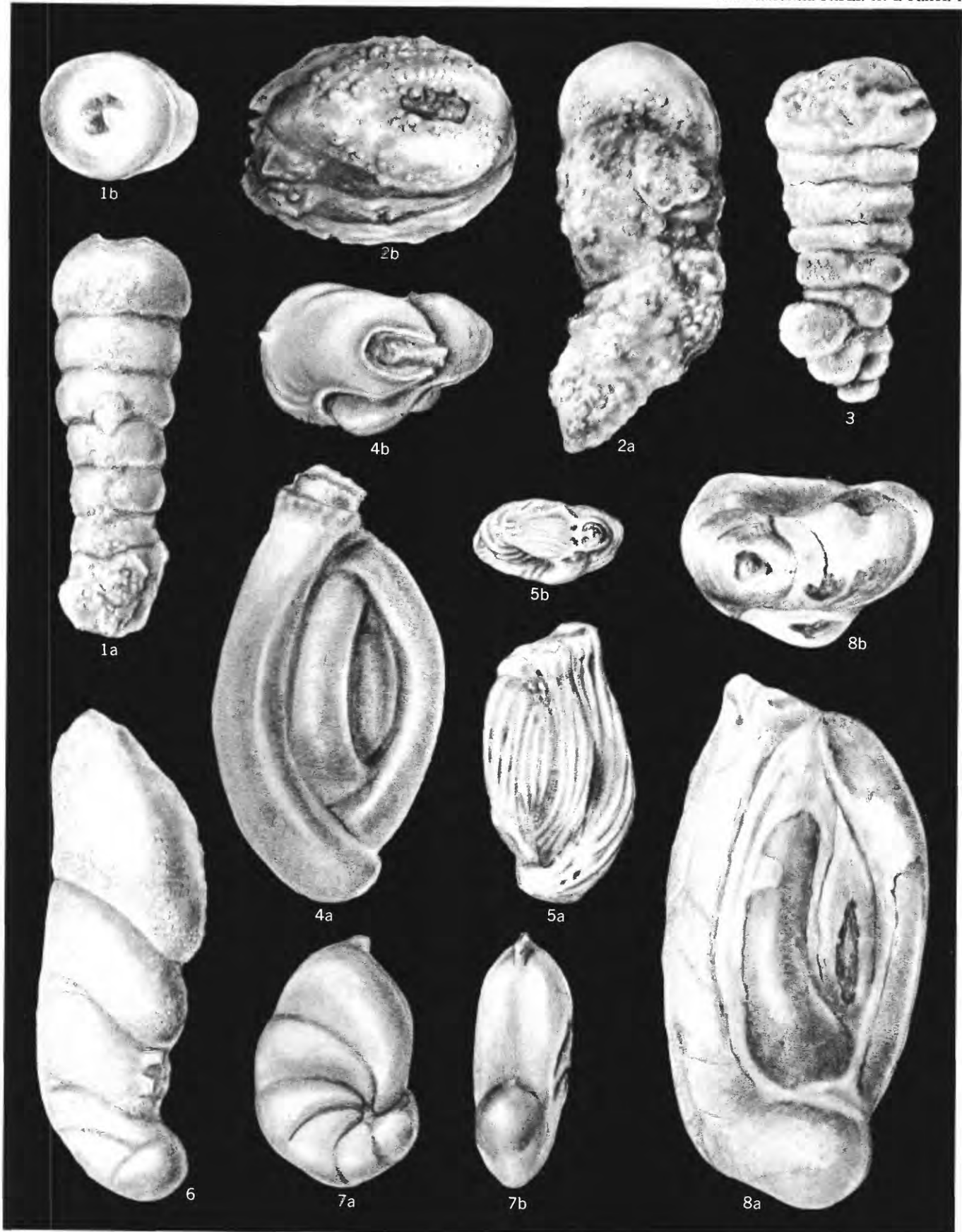
PLATES 1–12

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## PLATE 1

- FIGURE 1. *Clavulina multicamerata* Chapman (p. E9).  
USNM 688096,  $\times 90$ ; Miocene, Sand Island hole, 491–496 feet, top; *a*, side view; *b*, top view.
2. *Clavulina angularis* d'Orbigny (p. E9).  
Specimen showing flattened apertural end, USNM 688160,  $\times 60$ ; Miocene, Reef hole, 1,121.5 feet; *a*, side view; *b*, oblique top view.
3. *Cribrogoesella parvula* Todd and Low (p. E9).  
USNM 688105,  $\times 90$ ; Miocene, Reef hole, 495–500 feet bottom.
4. *Quinqueloculina polygona* d'Orbigny (p. E25).  
Mold, USNM 688109,  $\times 90$ ; Miocene, Reef hole, 512 feet; *a*, side view; *b*, top view.
5. *Quinqueloculina costata* d'Orbigny (p. E24).  
USNM 688132,  $\times 90$ ; Miocene, Reef hole, 1,041.25 feet; *a*, side view; *b*, top view.
6. *Marginulina procera* (Stache) (p. E29).  
USNM 688145,  $\times 160$ ; Miocene, Reef hole, 1,103.25 feet.
7. *Astacolus* sp. (p. E29).  
USNM 688116,  $\times 90$ ; Miocene, Reef hole, 930 feet; *a*, side view; *b*, edge view.
8. *Quinqueloculina laevigata* d'Orbigny (p. E24).  
Glauconitic mold, USNM 688165,  $\times 90$ ; Miocene, Reef hole, 1,186 feet; *a*, side view; *b*, top view.



SMALLER FORAMINIFERA FROM MIDWAY

## PLATE 2

FIGURE 1. *Lenticulina* sp. (p. E29).

USNM 688133,  $\times 160$ ; Miocene, Reef hole, 1,041.25 feet.

2. *Bolivina compacta* Sidebottom (p. E31).

USNM 688137,  $\times 160$ ; Miocene, Reef hole, 1,045 feet; *a*, front view; *b*, top view.

3. *Bolivina alazanensis* Cushman (p. E31).

USNM 688146,  $\times 160$ ; Miocene, Reef hole, 1,104.25 feet; *a*, front view; *b*, top view.

4. *Caucasina* sp. (p. E30).

USNM 688136,  $\times 200$ ; Miocene, Reef hole, 1,044.5 feet; *a*, side view; *b*, basal view.

5. *Buliminella madagascariensis* (d'Orbigny) (p. E30).

USNM 688127,  $\times 160$ ; Miocene, Reef hole, 1,005 feet.

6. *Bolivina chinenensis* LeRoy (p. E31).

USNM 688089,  $\times 160$ ; post-Miocene, Sand Island hole, 258.8 feet; *a*, front view; *b*, top view.

7. *Bolivina striatula* Cushman (p. E31).

USNM 688139,  $\times 160$ ; Miocene, Reef hole, 1,045 feet.

8. *Bolivina fastigia* Cushman (p. E31).

USNM 688138,  $\times 160$ ; Miocene, Reef hole, 1,045 feet.

9. *Bolivina tortuosa* Brady (p. E31).

USNM 688164,  $\times 160$ ; Miocene, Reef hole, 1,165 feet; *a*, front view; *b*, top view.

10. *Bolivina (Laterostomella) gumbeliniformis* (de Klasz and Rérat) (p. E32).

USNM 688090,  $\times 160$ ; post-Miocene. Sand Island hole, 258.8 feet; *a*, front view; *b*, top view.

11, 12. *Bolivina rhomboidalis* (Millett) (p. E31).

11. USNM 688162,  $\times 160$ ; Miocene, Reef hole, 1,125 feet; *a*, front view; *b*, top view.

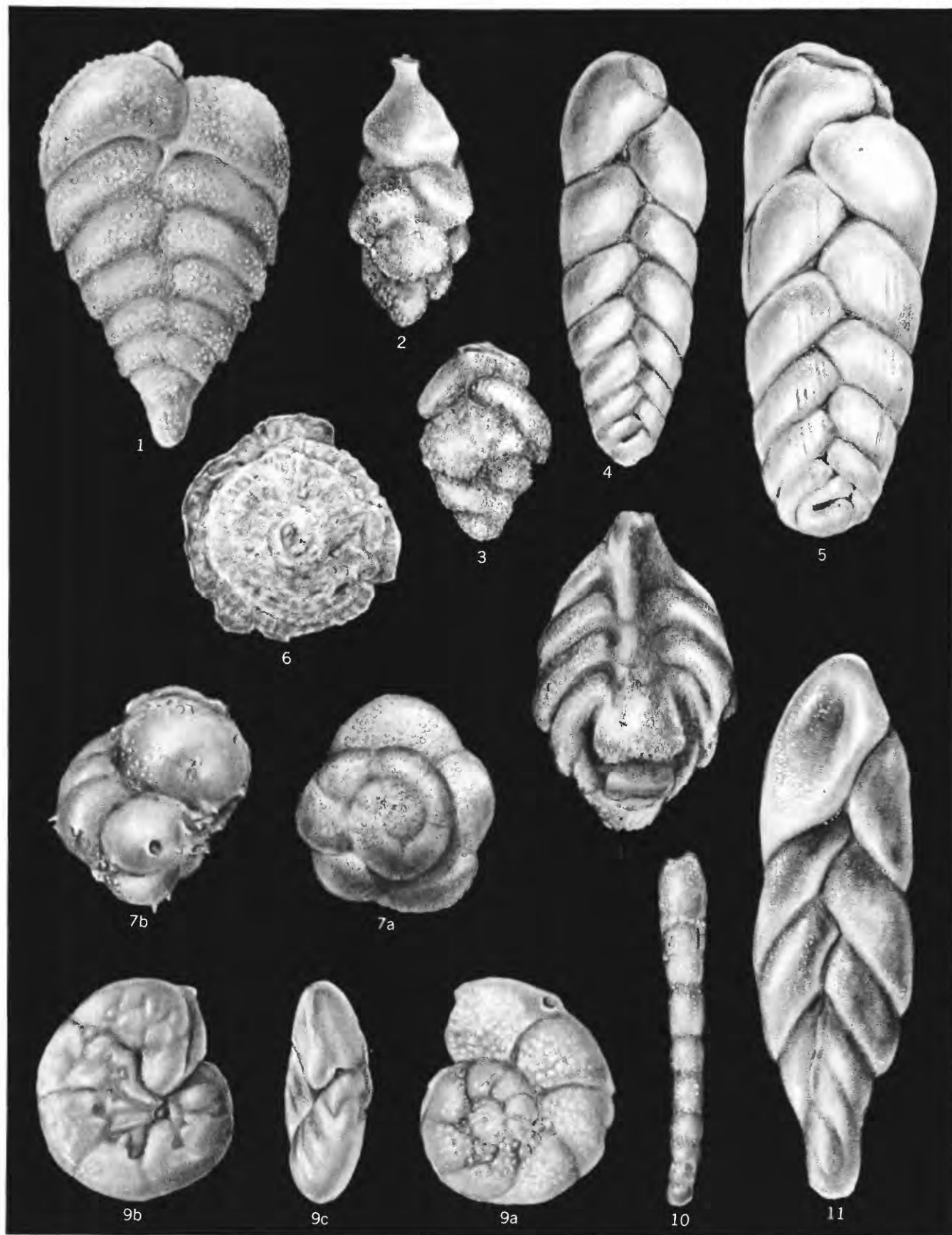
12. USNM 688147,  $\times 160$ ; Miocene, Reef hole, 1,104.25 feet; *a*, front view; *b*, top view.



SMALLER FORAMINIFERA FROM MIDWAY

### PLATE 3

- FIGURE 1. *Bolivina folium* (Parker and Jones) (p. E30).  
 USNM 688106,  $\times 160$ ; Miocene, Reef hole, 500 feet.
2. *Angulogerina midwayensis* Todd and Low, n. sp. (p. E33).  
 Holotype, USNM 688120,  $\times 160$ ; Miocene, Reef hole, 942 feet.
3. *Angulogerina tenuistriata* (Reuss) (p. E33).  
 USNM 688093,  $\times 160$ ; Miocene, Sand Island hole, 470 feet.
- 4, 5. *Bolivina (Loxostomum) limbata* Brady (p. E32).  
 4. USNM 688115,  $\times 160$ ; Miocene, Reef hole, 796–801 feet, middle.  
 5. USNM 688128,  $\times 160$ ; Miocene, Reef hole, 1,005 feet.
6. *Patellina advena* Cushman (p. E34).  
 USNM 688142,  $\times 160$ ; Miocene, Reef hole, 1,053.5 feet.
7. *Baggatella* sp. (p. E30).  
 USNM 688117,  $\times 90$ ; Miocene, Reef hole, 930 feet; *a*, top view; *b*, side view.
8. *Trifarina* aff. *T. bradyi* Cushman (p. E33).  
 USNM 688087,  $\times 160$ ; post-Miocene, Sand Island hole, 137 feet.
9. *Discorbinella?* sp. (p. E36).  
 USNM 688097,  $\times 90$ ; Miocene, Sand Island hole, 491–496 feet middle; *a*, dorsal view; *b*, ventral view; *c*, edge view.
10. *Siphonodosaria?* sp. (p. E34).  
 USNM 688153,  $\times 90$ ; Miocene, Reef hole, 1,112 feet.
11. *Virgulina complanata* Egger (p. E32).  
 USNM 688126,  $\times 160$ ; Miocene, Reef hole, 982.5 feet.



SMALLER FORAMINIFERA FROM MIDWAY

## PLATE 4

[a, Dorsal view; b, ventral view; c, edge view]

- FIGURE 1. *Rosalina micens* (Cushman) (p. E34).  
USNM 688094,  $\times 160$ ; Miocene, Sand Island hole, 480 feet.
2. *Disorbis vesicularis dimidiata* (Parker and Jones) (p. E36).  
USNM 688088,  $\times 90$ ; post-Miocene, Sand Island hole, 242.5 feet.
3. *Rosalina turgida* (Dorreen) (p. E35).  
USNM 688099,  $\times 90$ ; Miocene, Sand Island hole, 498 feet.
- 4, 6. *Neoconorbina rustica* Todd and Low, n. sp. (p. E35).  
4. Paratype, USNM 688102,  $\times 90$ ; post-Miocene. Reef hole, 222 feet.  
6. Holotype, USNM 688104,  $\times 90$ ; post-Miocene, Reef hole, 421–426.2 feet  
bottom.
5. *Neoconorbina floridensis* (Cushman) (p. E35).  
USNM 688122,  $\times 90$ ; Miocene, Reef hole, 945 feet.

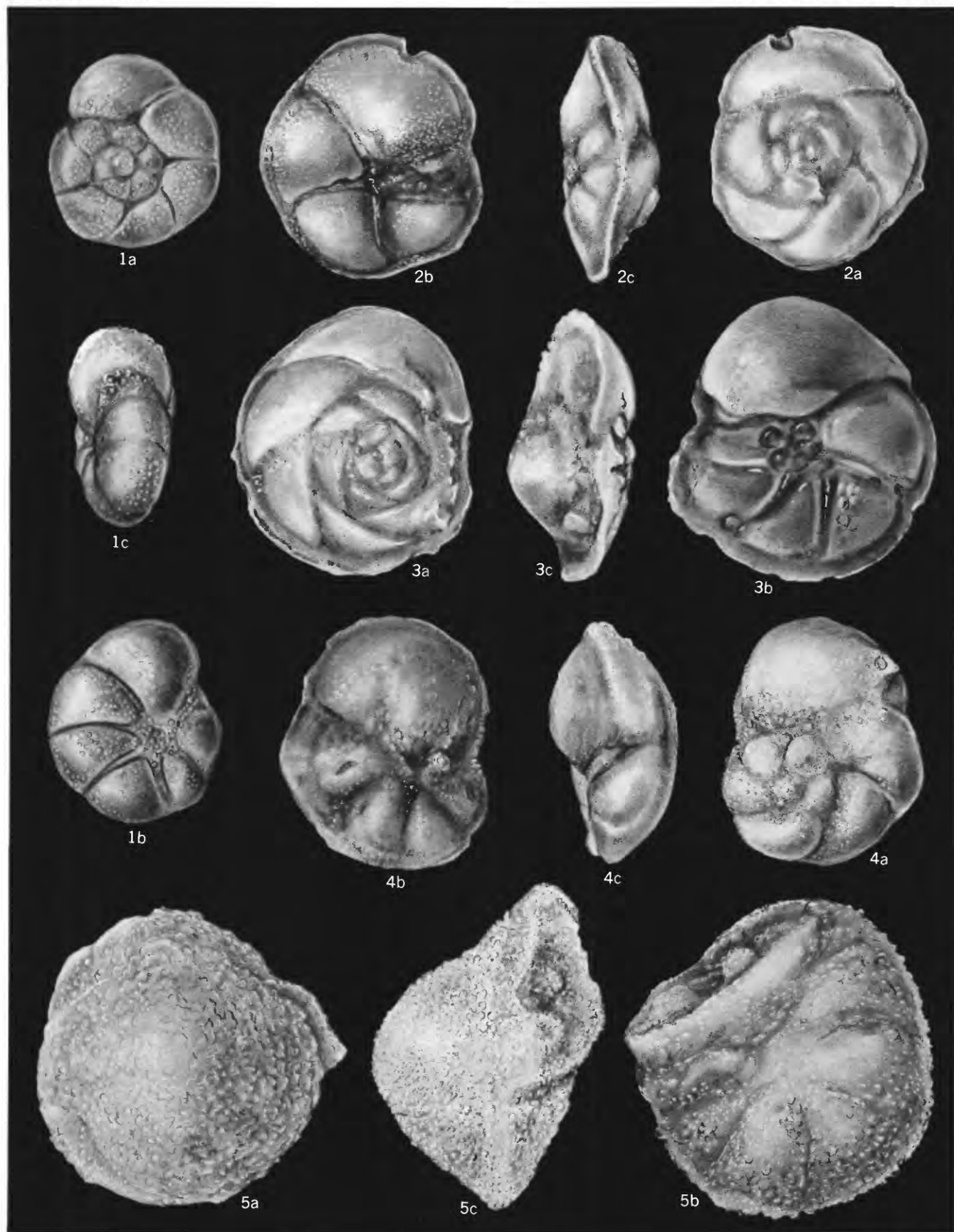


SMALLER FORAMINIFERA FROM MIDWAY

## PLATE 5

[a, Dorsal view; b, ventral view; c, edge view]

- FIGURE 1. *Eponides formosulus* Todd and Low, n. sp. (p. E37).  
Holotype, USNM 688121,  $\times 200$ ; Miocene, Reef hole, 944 feet.
- 2, 3. *Rotorbinella mira* (Cushman) (p. E36).  
2. USNM 688156,  $\times 90$ ; Miocene, Reef hole, 1,118 feet.  
3. USNM 688100,  $\times 90$ ; post-Miocene, Reef hole, 103.5 feet.
4. *Cancris pauciloculatus* Cushman and McGlamery (p. E37).  
USNM 688125,  $\times 90$ ; Miocene, Reef hole, 970.5 feet.
5. *Eponides subornatus* (Cushman) (p. E37).  
USNM 688143,  $\times 90$ ; Miocene, Reef hole, 1,075 feet.

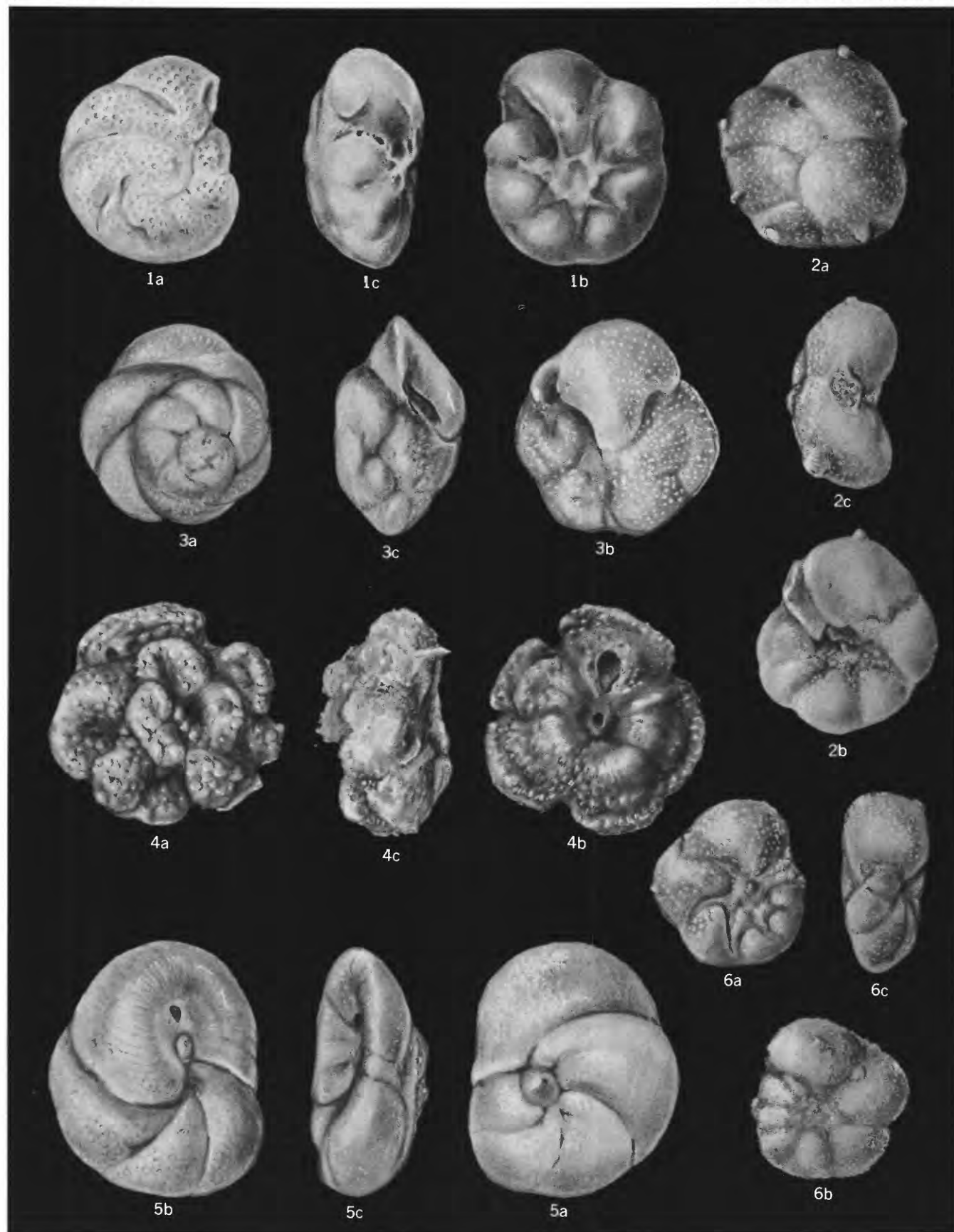


SMALLER FORAMINIFERA FROM MIDWAY

## PLATE 6

[a, Dorsal view; b, ventral view; c, edge view]

- FIGURE 1. *Buccella perforata* Todd and Low (p. E37).  
USNM 688095,  $\times 90$ ; Miocene, Sand Island hole, 483.5 feet.
2. *Glabratella?* sp. (p. E38).  
USNM 688114,  $\times 90$ ; Miocene, Reef hole, 568.5 feet.
3. *Nuttallides umboniferus* (Cushman) (p. E38).  
USNM 688152,  $\times 90$ ; Miocene, Reef hole, 1,110.5 feet.
4. *Glabratella* sp. (p. E38).  
USNM 688163,  $\times 160$ ; Miocene, Reef hole, 1,125 feet.
5. *Heronallenia* sp. (p. E38).  
USNM 688159,  $\times 160$ ; Miocene, Reef hole, 1,120.5 feet.
6. *Cibicidina* sp. (p. E41).  
USNM 688118,  $\times 90$ ; Miocene, Reef hole, 931 feet.



SMALLER FORAMINIFERA FROM MIDWAY

## PLATE 7

[a, Dorsal view; b, ventral view; c, edge view]

FIGURE 1. *Asterigerina tentoria* Todd and Post (p. E39).

USNM 688141,  $\times 90$ ; Miocene, Reef hole, 1,051.5 feet.

2, 3. *Amphistegina bikiniensis* Todd and Post (p. E39).

2. USNM 688129,  $\times 90$ ; Miocene, Reef hole, 1,005 feet.

3. USNM 688144,  $\times 90$ ; Miocene, Reef hole, 1,087.75 feet.



SMALLER FORAMINIFERA FROM MIDWAY

## PLATE 8

FIGURE 1. *Amphistegina bikiniensis* Todd and Post (p. E39).

USNM 688157,  $\times 90$ ; Miocene, Reef hole, 1,118 feet; *a*, dorsal view; *b*, ventral view.

2. *Cycloloculina* sp. (p. E41).

USNM 688149,  $\times 90$ ; Miocene, Reef hole, 1,108 feet.

3. *Cymbaloporella bradyi* (Cushman) (p. E40).

USNM 688101,  $\times 60$ ; post-Miocene, Reef hole, 213.5 feet; *a*, dorsal view; *b*, ventral view; *c*, edge view.

4. *Nonion akitaense* Asano (p. E42).

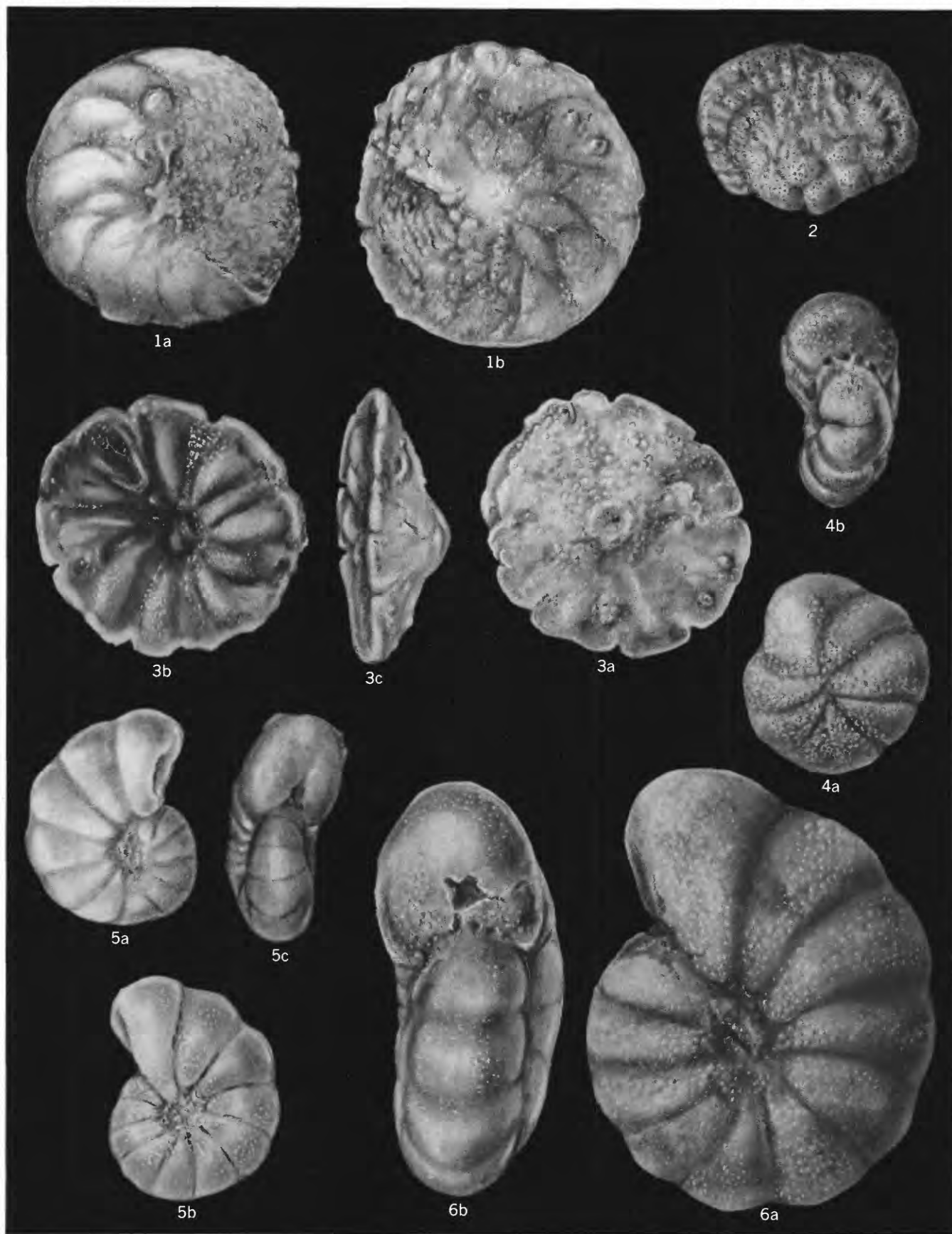
USNM 688135,  $\times 160$ ; Miocene, Reef hole, 1,044 feet; *a*, side view; *b*, edge view.

5. *Anomalina glabrata* Cushman (p. E40).

USNM 688124,  $\times 90$ ; Miocene, Reef hole, 968 feet; *a*, dorsal view; *b*, ventral view; *c*, edge view.

6. *Nonion pacificum* (Cushman) (p. E42).

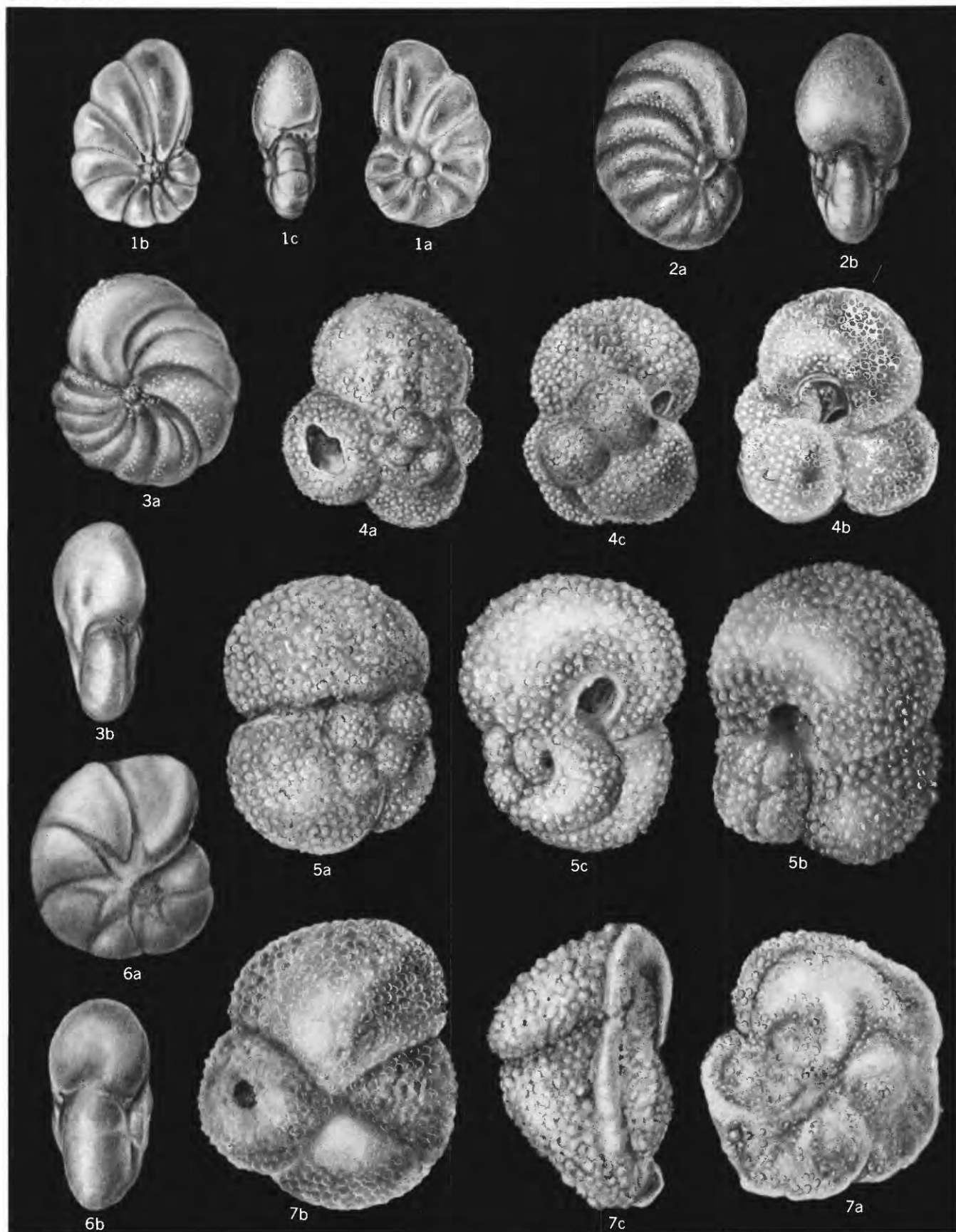
USNM 688123,  $\times 90$ ; Miocene, Reef hole, 968 feet; *a*, side view; *b*, edge view.



SMALLER FORAMINIFERA FROM MIDWAY

## PLATE 9

- FIGURE 1. *Pseudononion atlanticum* (Cushman) (p. E42).  
USNM 688140,  $\times 90$ ; Miocene, Reef hole 1,045 feet; *a*, dorsal view; *b*, ventral view; *c*, edge view.
2. *Florilus communis* (d'Orbigny) (p. E42).  
USNM 688148,  $\times 90$ , Miocene, Reef hole, 1,108 feet; *a*, side view; *b*, edge view.
3. *Pseudononion* aff. *P. tredecum* Asano (p. E42).  
USNM 688134,  $\times 90$ ; Miocene, Reef hole, 1,041.25 feet; *a*, side view; *b*, edge view.
4. *Globigerina trilocularis* d'Orbigny (p. E43).  
USNM 688091,  $\times 160$ ; Miocene, Sand Island hole, 460 feet; *a*, dorsal view; *b*, ventral view; *c*, edge view.
5. *Globigerinoides trilobus altiapertura* Bolli (p. E43).  
USNM 688092,  $\times 160$ ; Miocene, Sand Island hole, 460 feet; *a*, dorsal view; *b*, ventral view; *c*, edge view.
6. *Astrononion* sp. (p. E43).  
USNM 688130,  $\times 160$ ; Miocene, Reef hole, 1,005 feet; *a*, side view; *b*, edge view.
7. *Globorotalia crassaformis* (Galloway and Wissler) (p. E44).  
USNM 688103,  $\times 160$ ; post-Miocene, Reef hole, 317.5 feet; *a*, dorsal view; *b*, ventral view; *c*, edge view.



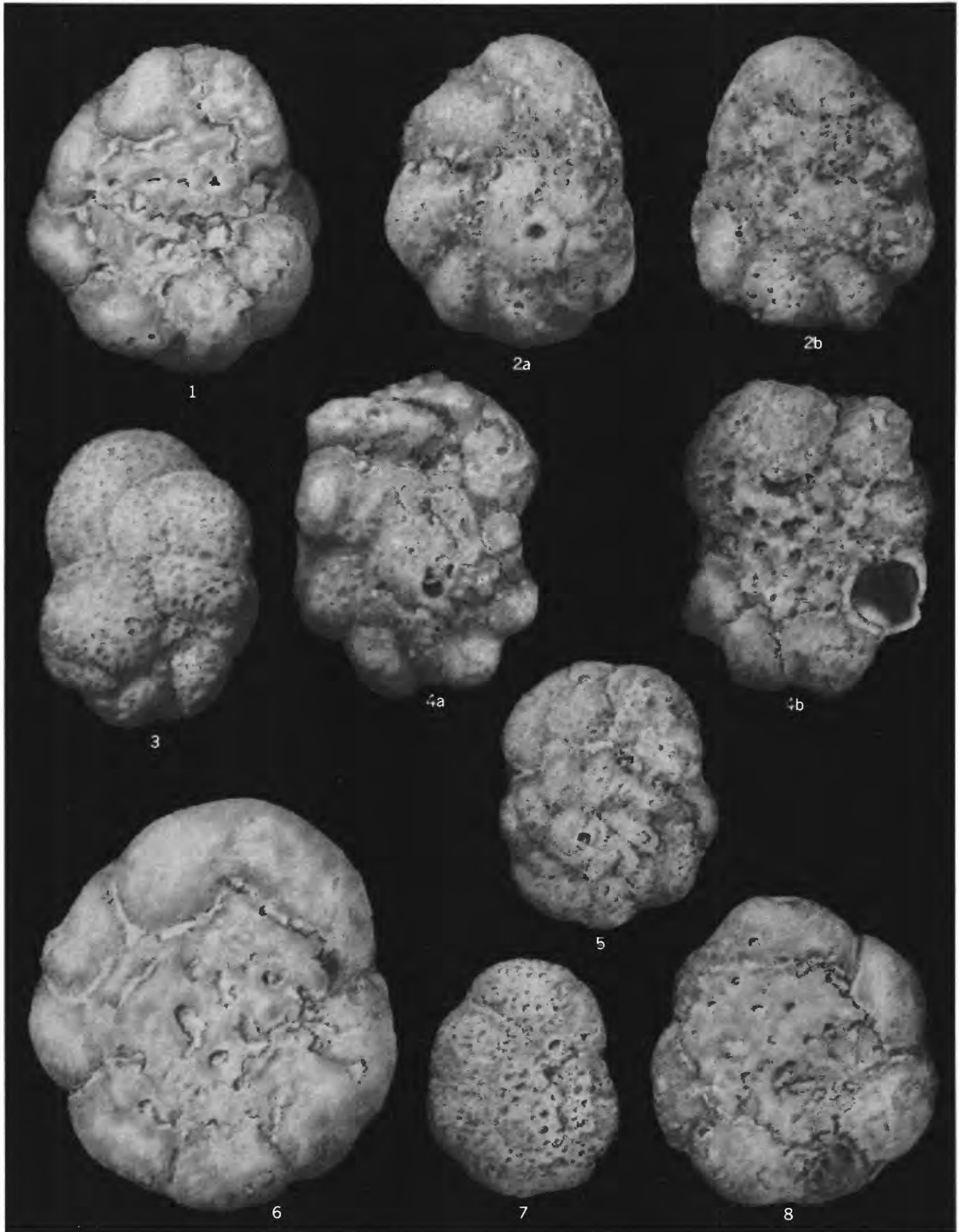
SMALLER FORAMINIFERA FROM MIDWAY

## PLATE 10

[All figures  $\times 45$ ]

FIGURES 1–8. *Valvulamina marshallana* Todd and Post (p. E9).

1. USNM 688111; Miocene, Reef hole, 568.5 feet; ventral view.
2. USNM 688151; Miocene, Reef hole, 1,109.3 feet; *a*, dorsal view; *b*, ventral view.
3. USNM 688112; Miocene, Reef hole, 568.5 feet; dorsal view.
4. USNM 688150; Miocene, Reef hole, 1,109.3 feet; *a*, dorsal view; *b*, ventral view showing empty chamber cavities.
5. USNM 688113; Miocene, Reef hole, 568.5 feet; dorsal view.
6. USNM 688110; Miocene, Reef hole, 568.5 feet; ventral view.
7. USNM 688107; Miocene, Reef hole, 500 feet; dorsal view.
8. USNM 688108; Miocene, Reef hole, 500 feet; ventral view with broken chamber showing calcite filling.



SMALLER FORAMINIFERA FROM MIDWAY

## PLATE 11

[All figures  $\times 45$ ]

- FIGURE 1. *Peneroplis proteus* d'Orbigny (p. E29).  
Glaucinitic mold, USNM 688166; Miocene, Reef hole, 1,186 feet; *a*, side view;  
*b*, edge view.
2. *Quinqueloculina akneriana* d'Orbigny (p. E29).  
USNM 688131; Miocene, Reef hole, 1,041.25 feet; *a*, side view; *b*, top view.
3. *Spiroloculina occlusa* (Cushman) (p. E27).  
USNM 688119; Miocene, Reef hole, 939 feet; *a*, front view; *b*, edge view.
4. *Clavulina angularis* d'Orbigny (p. E9).  
USNM 688155; Miocene, Reef hole, 1,118 feet; *a*, side view; *b*, top view.
5. *Austrotrillina striata* Todd and Post (p. E28).  
USNM 688154; Miocene, Reef hole, 1,116 feet.
6. *Gypsina discus* Goës (p. E41).  
USNM 688158; Miocene, Reef hole, 1,118 feet; *a*, side view; *b*, edge view.
7. *Cibicides cicatricosus* (Schwager) (p. E40).  
USNM 688098; Miocene, Sand Island hole, 491–496 feet (middle); *a*, dorsal  
view; *b*, ventral view; *c*, edge view.
8. *Vaginulina obtusica* ten Dam and Reinhold (p. E30).  
USNM 688161; Miocene, Reef hole, 1,121.5 feet.

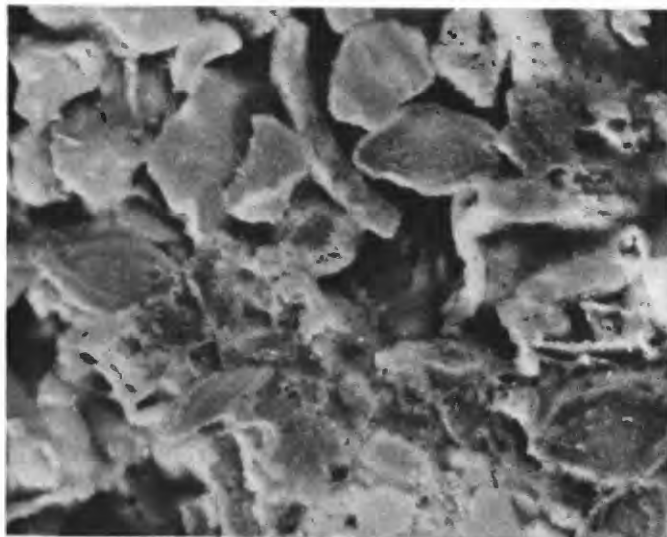


SMALLER FORAMINIFERA FROM MIDWAY

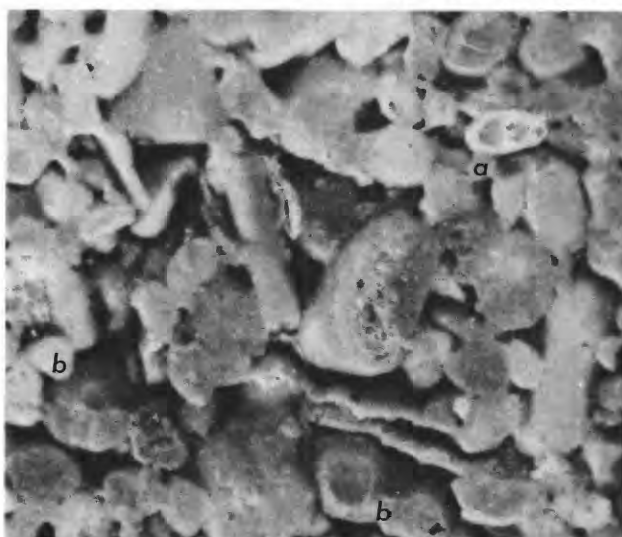
## PLATE 12

[All figures  $\times 20$ ]

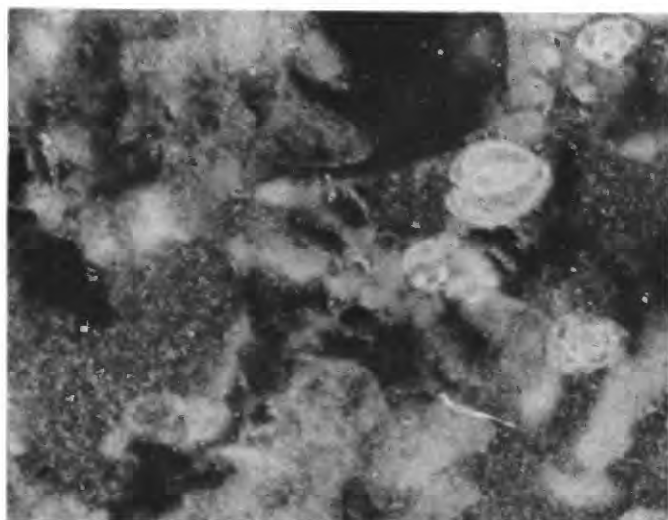
- FIGURE 1. Cut surface of post-Miocene rock at 375 feet in Sand Island hole, showing porous cemented agglomerate of organic debris consisting of *Amphistegina*, algae, and unidentified shell fragments. (See vertical sections of *Amphistegina* at *a*, *a*, and *a*.) (p. E4)
2. Cut surface of Miocene rock at 1,074 feet in Reef hole, showing porous agglomerate of organic debris consisting of algae, echinoid fragments, unidentified shell fragments, and rare Foraminifera. (See miliolid at *a* and rotaliform Foraminifera at *b* and *b*.) (p. E4)
  3. Cut surface of Miocene rock at 516 feet in Reef hole, showing limestone containing abundant miliolids. Occasional cavities in the limestone result from the solution of shells or incomplete cementation of the rock. (p. E3)
  4. Cut surface of Miocene rock at 1,114 feet in Reef hole, showing porous cemented *Austrotrillina* sand. (p. E4)
  5. Cut surface of Miocene rock at 627 feet in Reef hole, showing limestone containing indeterminate organic debris, mostly algal. (p. E3)
  6. Broken surface of soft brown Miocene rock at 1,165 feet in Reef hole, showing light-colored specimens of *Bolivina*. (p. E4)



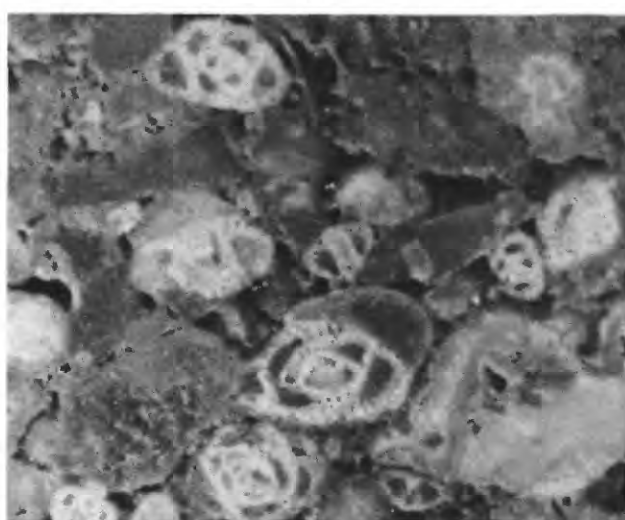
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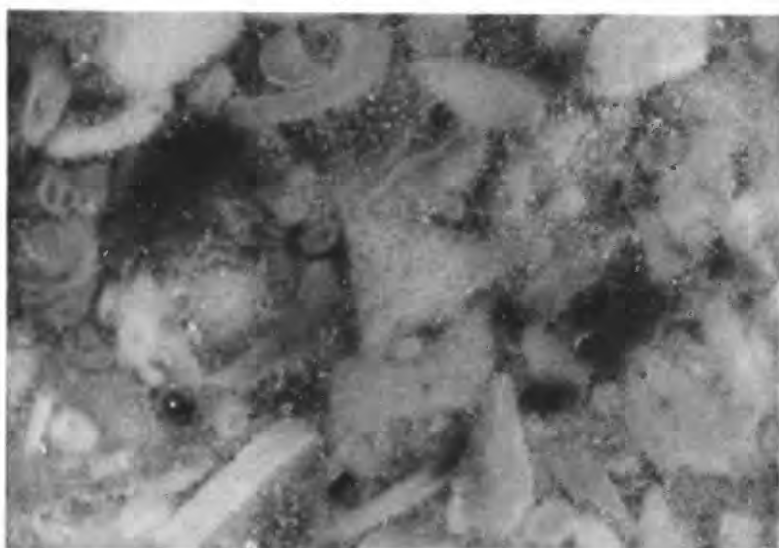
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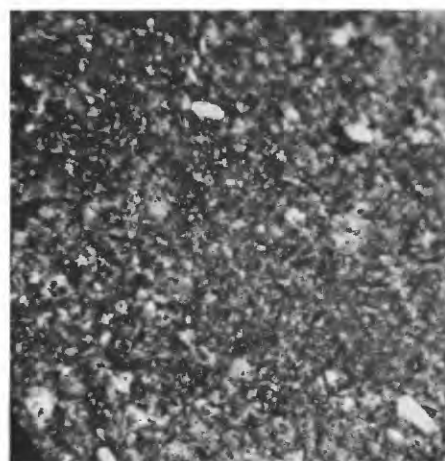
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6

ROCKS FROM MIDWAY DRILL HOLES





