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PLANKTONIC FORAMINIFERA AND BIOSTRATIGRAPHY OF SOME NEOGENE FORMATIONS, NORTHERN FLORIDA AND ATLANTIC COASTAL PLAIN

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ILLUSTRATIONS

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I. ABSTRACT

Planktonic foraminifera are identified and illustrated (by scanning electron photomicrographs) from the Chipola, Yellow River, Red Bay, and Jackson Bluff formations of northwestern Florida. Similar studies of material from Yorktown and Waccamaw localities on the coastal plains of the eastern United States, the Moín Formation of Costa Rica, and the Encanto and Agueguexquite formations of Mexico indicate stratigraphic relationships, which are different from the ages and correlations previously proposed for some of these strata based on other criteria. The calcareous nannofossil genera *Discoaster, Catinaster,* and *Sphenolithus,* were also included in the present studies.

Comparative ranges of these microfossils indicate a Burdigalian age for the Chipola Formation, a late Langhian age for the Encanto and Yellow River formations, a Tortonian to Messinian age for the Red Bay Formation, and an early to middle Pliocene age for the Jackson Bluff, Yorktown, and Agueguexquite formations. Material from several localities assigned to the Waccamaw Formation are correlated with the Moín Formation of Costa Rica for which an early Pleistocene age is indicated.

A total of 52 species and subspecies of planktonic foraminifera were identified from these Neogene formations. One of these species, *Globorotalia (Globorotalia) praeoscitans* is new. This report is intended primarily as documentation of planktonic foraminifera from some American formations which long have been neglected by specialists on this group of fossils.

II. INTRODUCTION

Neogene formations of northern Florida hold interest for the biostratigrapher, who must look to these sediments as the nearest accessible marine strata that are equivalent to the subsurface oil-bearing beds of the northern Gulf of Mexico, which attain thicknesses in the subsurface of 20,000 feet and more.

Malacologists, who have correlated the macrofaunas from classic localities in northern Florida with assemblages from outcrops in the Atlantic Coastal Plain and the West Indies, long have been aware, however, that morphologic similarities are related to similarities of depositional environment as well as time. It was with such problems in mind that Cooke, Gardner, and Woodring (1943, p. 1713) cautioned that "there is little basis for an exact correlation between the Cenozoic formations of the Atlantic and Gulf Coastal Plain and the Caribbean region on the one hand and the European standard section on the other."

The development of stratigraphic nomenclature for the Florida Neogene began with Conrad (1846, pp. 36-48; pp. 399-400) who considered some of these rocks to be of late Eocene age. Tuomey (1851, pp. 390-4) agreed with Conrad, but Heilprin (1884, pp. 115-154; 1887) proposed an Oligocene age for these same beds.

Map 1. Choctawhatchee and Chipola localities of northern Florida from which planktonic microfossils have been identified.

Many of the localities were made famous by the molluscan studies of Julia Gardner (1926-1950) and W. C. Mansfield (1930-1937), and of Joseph A. Cushman and G. M. Ponton (1932) on the foraminifera. These authors were largely responsible for the standard middle Miocene section of North America. Puri (1953, p. 15) reviewed the stratigraphic terminology applied to Neogene rocks in northern Florida and pointed out that early age determinations were based on erroneously identified fossils and that little was known in regard to stratigraphy. Encouraged by Vernon (1942), Puri (1953) recognized the Tampa Stage of early Miocene age, the Alum Bluff Stage of early and middle Miocene age, and the Choctawhatchee Stage of middle and late Miocene age. Certain formations were reinterpreted as lithofacies, and zones were redefined as faunal facies. Subdivisions of each stage were considered contemporaneous (see Figure 1). This treatment seemed, indeed, the logical and most conservative interpretation of beds for which there are few and scattered outcrops.

The exact relationships of the discontinuous Neogene beds exposed in the Florida panhandle can be established by three types of data, (1) absolute dating methods, (2) refined knowledge of the evolution of taxa (*e.g.*, Vokes, 1965), and (3) the sequence of planktonic microfossils. This study employs the last of these methods. The ideal solution would be based upon all three methods with aid from paleomagnetic data.

Work on fossil planktonic assemblages during the last fifteen years has resulted in recognition of over 50 distinct faunal zones in Cretaceous and Tertiary strata. "These zones appear in the same sequence around the world" (Tappan and Loeblich, 1968, p. 1348). Several classic localities have long been known to have a moderate frequency of planktonic foraminifera, but this group was omitted or treated in a cursory manner by the early workers (Cushman, 1918; 1920; 1930; Cushman and Ponton, 1932; Cushman and Cahill, 1933) because of the imperfect knowledge at that time concerning the systematics and evolution of these foraminifers. The planktonic component of foraminiferal assemblages in the Choctawhatchee Formation, for example, was dismissed by Cushman (1930, p. 59) with his remarks on the genus *Globigerina*: "The various species of the genus *Globigerina* used in a restricted sense are in such a chaotic state that it is difficult to treat most of them intelligently. A study of the types with large series of topotype specimens is necessary to straighten out the confusion now existing. There is a very considerable difference in the early and adult stages in most of the species, and unless good series can be obtained,

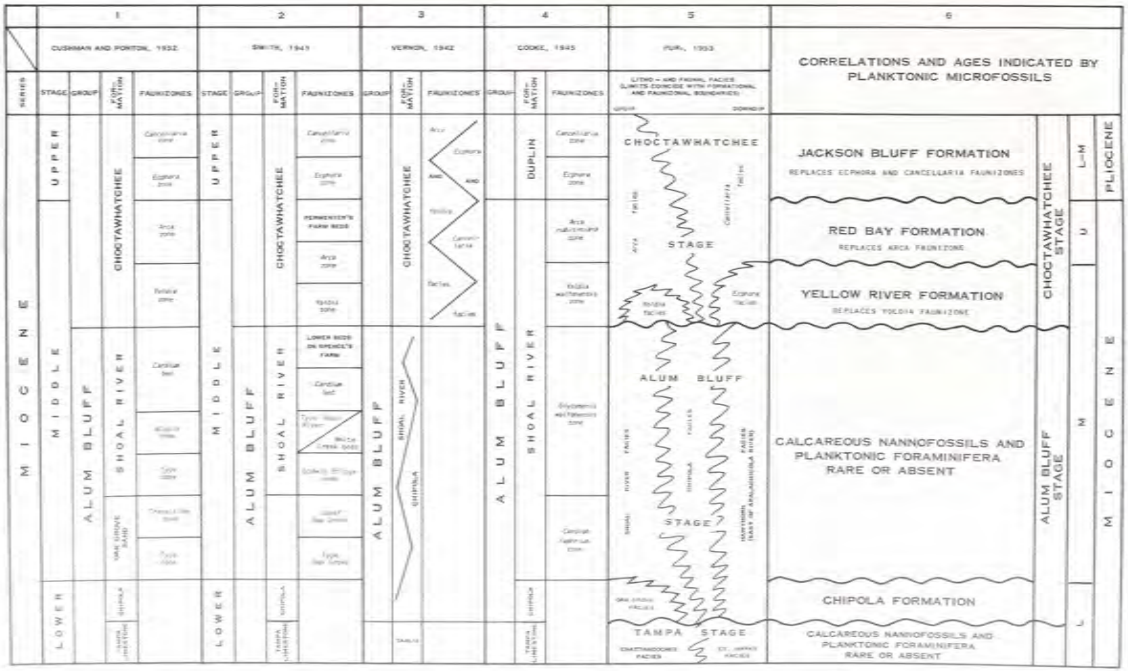

Figure 1. Correlations of formations in northern Florida. Correlation of columns 1-5 after Puri (1953). Subdivisions of Choctawhatchee Stage in column 6 are by Puri and Vernon (1964).

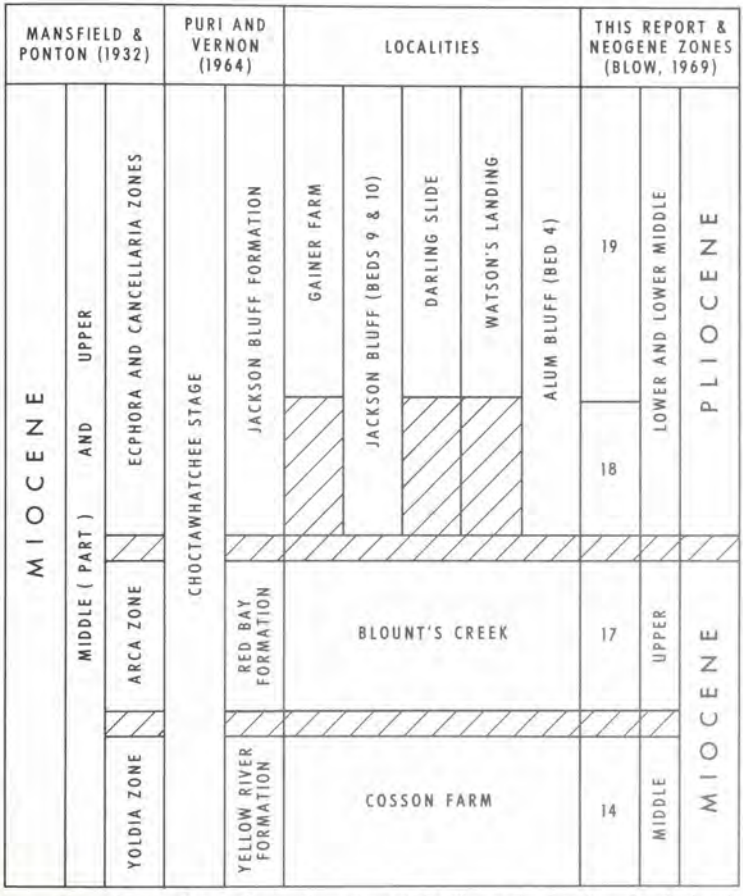

Figure 2. Correlation of some formations of the Choctawhatchee Stage by planktonic microfossils.

descriptions based on a few specimens are worth little. A number of the forms were figured in my earlier work (Bull. 676, U. S. Geol. Survey, 1918, pls. 12, 13), and while some of these were not named or only with a question, they must remain in this unsatisfactory condition until some one available to the types can make a species study of this genus." These early reports, incomplete for the planktonic species, have remained the standard references to the Middle Tertiary foraminifera of Florida.

Planktonic microfossils are rare in much of the Florida Cenozoic, but it was hoped that prolonged examination of sieved, disaggregated material would reveal sufficient planktonic foraminifera or calcareous nannoplankton for identification of at least portions of the section with the sequence established by Blow (1969), Bolli (1966), Bramlette and Wilcoxon (1967), and Gartner (1969). Beds which can be dated by planktonic microfossils are indicated on Figures 2, 3. They are, as pointed out by Puri (1953) and Puri and Vernon (1964), of different litho- and faunal facies. There is strong evidence, however, that the subdivisions of the Choctawhatchee Stage are not contemporaneous, as suggested by these authors, but of different ages. It is interesting that our data indicate the same relative positions as proposed earlier by Mansfield and Ponton (1932, pp. 84-88), although a slightly different correlation with the European time scale is now indicated.

The main purpose of this report is to establish the biostratigraphic interrelationship of Neogene beds in northern Florida which contain planktonic microfossils and to document the occurrence there of planktonic foraminifera which are now known to be useful for the circumglobal correlation of marine sediments (Figures 3 and 4). Several formations of the Atlantic and Gulf of Mexico coastal plains are included because of long interest among stratigraphers in their relationship to the Florida section. The calcareous nannofossil content of these beds also was investigated, and, although this was sparse by comparison with the content of deep-sea cores, nannoplankton corroborate ages indicated by planktonic foraminifera for some of the formations.

Varying quantities of sampled material were prepared for concentration of free foraminiferal specimens. Boiling of original material in a solution of "Quaternary 0" for approximately four hours was found effective for cleaning clay and marly deposits out of the pores and apertures (see Zingula, 1968, p. 1092). This procedure was followed for all samples and produced specimens so clean as to resemble tests of well preserved modern foraminifera.

A U. S. Standard Sieve number 200 was then used for screening out "fines" below the size of identifiable species. The openings in this screen are smaller than the diameter of *Cassigerinella chipolensis* (Cushman and Ponton), which is one of the smallest planktonic foraminifers identified in the Neogene of Florida. No pressure greater than a fine spray of water from the tap was applied to this material because of the fragile nature of the tests, many of which were left hollow from boiling in the "Quaternary 0" solution.

Several samples, such as those from the Waccamaw Formation, were more than 90% quartz sand by volume, and tetrachloroethylene was found useful for separating the calcareous microfossil material from the quartz. The usual procedure for separation by heavy liquid was followed, and the examination time for each sample so treated was reduced from several weeks to a few days.

No set rule was followed for the quantity of residue examined. The search for specimens of planktonic foraminifera was continued for each sample until the writer was convinced that every species representative of the biofacies had been found. For some studies it was necessary to prepare several lots of material. Thus, examination by stereoscopic microscope varied from 20 to 30 hours in the case of fairly fossiliferous residues to more than a hundred hours for those in which planktonic foraminifers were scarce.

Preparation of samples for study of calcareous nannoplankton was essentially the same as described by Bramlette and Sullivan (1961). As with the search for planktonic foraminifera, the examination of material was extended until the writer was convinced that every species representative of the biofacies had been found.

The holotype and paratypes of *Globorotalia (Globorotalia) praeoscitans*, n. sp., are deposited at the U. S. National Museum. All other figured specimens are deposited in the Chevron Collections, New Orleans, Louisiana.

III. ACKNOWLEDGMENTS

Sample material was collected in northern Florida on several field trips, which were organized and led by Robert O. Vernon and Harbans S. Puri. The writer's participation in these trips and several independent visits to collecting localities in the Florida panhandle were supported by the Chevron Oil Company. Most of the Yorktown, Waccamaw, and Chipola material was supplied by Harold E. and Emily H. Vokes, whose great interest in and knowledge of biostratigraphy of the Gulf of Mexico and Atlantic coastal plains were a constant source of encouragement and guidance. They also furnished abundant other material from Mexico, Central America, and Europe for comparison with Neogene microfaunas of Florida and the Atlantic Coast of the United States.

Hubert C. Skinner gave particular assistance with taxonomic and illustrative aspects of this report, and the writer is indebted to him for both editorial and technical review of all data presented herein.

Paul E. Koeppel and Louisa O. MacLaren of Chevron assisted with the preparation and illustration of planktonic foraminifera. All illustrations are Stereoscan photographs made with a Cambridge scanning electron microscope in the New Orleans laboratory of Chevron Oil Company. The use of the instrument is greatly appreciated.

C. Wylie Poag, formerly of Chevron, now of Texas A. & M. University, examined most of the planktonic foraminifera on which correlations in this report are based, and the writer has benefited from numerous discussions with him concerning taxonomic determinations. Frances L. Parker of Scripps Oceanographic Institute has also seen portions of the material, and the writer has benefitd from her suggestions.

IV. SUMMARY

Planktonic foraminifera are documented (by scanning electron photomicrographs) from some Neogene formations of the coastal plains of the eastern United States, northwestern Florida, the Isthmus of Tehuantepec, Mexico, and Costa Rica. Both planktonic foraminifera and calcareous nannoplankton are employed in the correlation of these strata with Neogene stages of Italy by means of concurrent-range zones, which have been established by various investigators for many regions of the low and middle latitudes.

Comparative ranges of these planktonic microfossils indicate that the Chipola Formation is of Burdigalian age (late early Miocene). The Encanto Formation of Mexico is correlative with the Yellow River Formation of northwestern Florida, and these are of late Langhian age (middle Miocene). The Red Bay Formation of northwestern Florida is Tortonian to Messinian (late Miocene). Some localities of northwestern Florida, which have long been classic sites for molluscan and benthonic foraminiferal studies represent synchronous deposition and are of early to middle Pliocene age. These localities are referable to the Jackson Bluff Formation and include Alum Bluff (Bed 4), Watson's Landing, Darling Slide, Jackson Bluff (Bed 9 and Bed 10), and Gainer Farm. Several localities referred to the Yorktown Formation have planktonic microfossils which suggest correlation with the Jackson Bluff Formation, and therefore, an early to middle Pliocene age, rather than late Miocene, as long proposed for these beds. The Agueguexquite Formation of Mexico is approximately correlative with the Jackson Bluff and the Yorktown. Two localities assigned to the Waccamaw Formation contain assemblages of planktonic foraminifera that indicate a Calabrian age, and the Moín Formation of Costa Rica must be correlated with the Waccamaw and also referred to the lower Pleistocene.

Samples from the Caloosahatchee, Hawthorn, Shoal River, Trent Marl, and Tampa Limestone formations were examined. Planktonic foraminifera and calcareous nannofossils were rare or absent in all of these. Thus, stratigraphic relationships of the complete Florida and Atlantic Coastal Neogene sequence cannot be established by planktonic microfossils alone.

V. BIOSTRATIGRAPHY

Blow (1969) has evaluated and summarized much of the Neogene biostratigraphy that is based upon planktonic foraminifera. By supplementing our knowledge of the geologic ranges and evolution of these organisms with data on the ranges of calcareous nannofossils, credible correlations can now be established between widely separated Cenozoic sections, including some of the type sections in Europe. The writer is fortunate in having considerable Neogene topotypic material from the Gulf of Mexico, Caribbean, Mediterranean, and west European regions for comparison with those taxa upon which the age-dating and correlation of various authors are based. Actual specimens are particularly valuable to such comparative studies in view of the varying taxonomic opinions of those who investigate these problems.

Although the primary purpose of this report is to document planktonic foraminifera in some of the Neogene formations of Florida and the Atlantic Coastal Plain and to review the biostratigraphic interrelationships of these beds, the inevitable question arises as to the relationship between the subject formations and the European stages. In recent years world-wide studies by numerous specialists on planktonic foraminifera have been extended into the type European sections, and it is now possible to establish zonations and correlations that appear to be synchronous over long distances validating, for the first time, the use of European stratigraphic terminology in areas remote from the type localities. The recognition of planktonic microfossils for these purposes is a "break-through," particularly for those who have long found the Lyellian percentage method inadequate or spurious as a precise means of determining the age of a Cenozoic formation (see Dall, 1892, p. 215).

A sequence of zones based on evolutionary appearances of circum-equatorial planktonic foraminifera was introduced by Banner and Blow (1965), and boundary positions were related to type localities in Europe. Parker (1967) recognized these successions in Indo-Pacific deep-sea cores and adopted the zones as defined. Further clarification of these zonations and documentation of the European Neogene succession were accomplished in a comprehensive report by Blow (1969), and Berggren (1969) related the sequence (Upper Cretaceous to Pleistocene) to the radiometric time scale, geomagnetic polarity history, and North American mammalian stages. Smith (1969) and Gartner (1969) have related calcareous nanofossil successions in the type Calabrian of Italy and other regions to the foraminiferal zones.

A major limitation to planktonology as the "Rosetta Stone" for Cenozoic biostratigraphy is encountered near the landward margins of depositional basins. As a rule, only the more seaward facies yield sufficient planktonic foraminifera and calcareous nannofossils for age determination. Certain species, as *Sphaeroidinella dehiscens* (Parker and Jones), show an affinity for the deeper layers of oceanic water. This species is typically developed in modern seas only below 300 meters (Bé, 1965, p. 84). *Globigerinatella insueta* Cushman and Stainforth, an excellent guide fossil of short stratigraphic range in the Miocene of the Caribbean and Gulf of Mexico regions, is absent or rare except in deep water facies in the subsurface of both Trinidad and coastal Louisiana. Low-latitude species, such as *Globigerinoides ruber* and *Globigerinoides "sacculifer,"* which abound in the upper-water layers (Berger, 1969, p. 19), are the most likely forms to be found in the littoral zones of modern seas, and by analogy with ancient environments, these or phylogenetically related species, would be expected to dominate the planktonic component of fossil assemblages found in rocks of nearshore origin. This is precisely the case with the formations investigated in this study. The Waccamaw and Chipola Formations contain a predominance of the near-surface planktonic foraminifera over other planktonics, and the planktonic to benthonic ratio is low in both formations. Calcareous nannoplankton are rare in the Chipola and absent in Waccamaw material.

Offshore facies, such as those represented at the Cosson Farm, Blount's Creek, and Jackson Bluff localities of the Choctawhatchee Stage in northern Florida, yield planktonic assemblages which are qualitatively

similar to those in deep-sea cores from oceanic basins. The ratio of planktonic to benthonic total individuals is far less, however, than in deep-sea cores recovered from bathyal or greater depths.

The Caloosahatchee, Hawthorn, Shoal River, Trent Marl and Tampa Limestone formations were found to be almost completely devoid of both planktonic foraminifera and calcareous nannoplankton. Although the writer was tempted to propose interpretations of the stratigraphic relationships of these formations, this report is confined to those beds from which adequate planktonics were derived for correlation with age-dated sections (Berggren, 1969) and sections which have been related to the sequence of planktonic foraminifera as now understood (Blow, 1969; Bolli, 1966).

Temperature is an important controlling factor in the distribution of planktonic organisms. Thus, if the Waccamaw is early Pleistocene, decreasing paleotemperatures of the Atlantic nearshore waters could, along with shallow paleobathymetry, account for the scarcity in this formation of warm water species, such as *Globorotalia cultrata* (d'Orbigny). The Moín, also of early Pleistocene age, is a deposit of greater paleobathymetry and lower latitude, and consequently it has a greater diversity of planktonic species.

Paleotemperatures complicate the correlation of synchronous sediments on an interregional scale. Much has been written in recent years on the world-wide distribution of planktonic foraminiferal species as related to the temperature of water masses (*e.g.*, Bandy, 1964; Bé and Hamlin, 1967; Boltovskoy, 1964 and 1965; Bradshaw, 1959; Parker, 1960). Distributions of the 30 modern species are succinctly summarized by Bé (1966), who recognizes four provinces, each of which is characterized by a group of planktonic species. These are the Equatorial or Tropical species, the Central-water or Subtropical species, the Subpolar species, and a single Polar species. Upwellings and displacement by warm currents result in cross-latitudinal incursions. Thus, it happens that synchronous paleonenvironments may have dissimilar fossil assemblages. We see the same species in middle Tertiary beds of Saipan, for example, as those in the middle Tertiary of the Caribbean and Gulf of Mexico regions, but the middle Tertiary assemblages of California are different. Fortunately, the deposits considered in this study are of tropical and subtropical origin, so that the principal difficulties in correlation are related to paleobathymetry rather than to paleotemperature.

Those formations of the Atlantic and Gulf Coastal Plains of the United States and the formations of Mexico and Costa Rica reviewed for stratigraphic relationships, as indicated by planktonic microfossils, are discussed below.

CHIPOLA FORMATION
Plates 1-5

Material from 25 localities of the Chipola Formation, Calhoun County, Florida, was examined for planktonic microfossils (Map 1 and Locality data). All of these are in the general vicinity of the type locality (Dall, 1892, p. 122; Dall and Stanley-Brown, 1894, pp. 140-170; Matson and Clapp, 1909, p. 91; Gardner, 1926, p. 1), where about 28 feet of a blue-gray to yellowish brown, highly fossiliferous marl are exposed. Cushman and Ponton (1932) described the benthonic foraminiferal fauna, and Puri (1953) recorded the ostracodes of the Chipola Formation.

Recently Emily H. Vokes (1965) has commented on the age of the Chipola as indicated by the Muricinae (Mollusca: Gastropoda) suggesting that this formation may be equivalent to the Helvetian of western Europe rather than Burdigalian as indicated and perpetuated in the Geological Society of America correlation chart (Cooke *et al.*, 1943). Gibson (1967, p. 643) looked at several samples from the Chipola and thought that planktonic foraminifera indicated correlation with the *Globigerinatella insueta* Zone of Trinidad, the same zone to which he refers the upper part of the Calvert Formation of Maryland and the Pungo River Formation of North Carolina.

All of the Chipola localities investigated yielded essentially the same planktonic species, although the planktonic to benthonic ratio was higher at some of the sites than at

others. One of the highest ratios was found at TU 951 in Section 12, T1N, R10W, Calhoun County, Florida, and most of the specimens illustrated and discussed in this report are from that locality.

The Chipola Formation contains the following planktonic foraminifera:

Cassigerinella chipolensis (Cushman and Ponton), pl. 1, fig. 1; pl. 2, fig. 1
Globigerinita glutinata (Egger)
Globigerinita uvula (Ehrenberg), pl. 1, fig. 2
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny), pl. 3, fig. 4
Globigerinoides subquadratus Bronnimann, pl. 4, fig. 3
Globoquadrina baroemoenensis (LeRoy), pl. 3, fig. 3; pl. 5, figs. 2-3
Globoratalia (Turborotalia) obesa Bolli, pl. 3, fig. 1
Globorotalia (Turborotalia) siakensis (LeRoy), pl. 5, fig. 1

In addition to the above species, rare specimens occur resembling *Globigerinoides quadrilobatus altiaperturus* Bolli (pl. 3, fig. 2). These have apertures which are wider than in the typical form. Other small specimens are found which show a superficial similarity to *Globigerinoides sicanus* de Stefani, but none of these have the slit-like apertures characteristic of that species, and most are probably juveniles and aberrants of G. *quadrilobatus quadrilobatus* (pl. 2, fig. 2). A few larger specimens (pl. 4, figs. 1, 2, 4) may be aberrant or gerontic forms.

Globigerinoides quadrilobatus quadrilobatus occurs more frequently than any other planktonic foraminifer at all of the Chipola localities investigated. It also attains the largest size of all the forms seen from this formation. *Globigerinita uvula* and *Globigerinita glutinata* (Egger) are rare. A single broken specimen of the latter was found at TU 951. *Cassigerinella chipolensis* occurs at most of the 25 sites, but it is never abundant in even the finest fractions of the residues. *Globorotalia (T.) siakensis, Globorotalia (T.) obesa, Globoquadrina baroemoenensis,* and *Globigerinoides subquadratus* also occur at most of the localities but always in low frequencies.

Discoaster deflandrei Bramlette and Riedel, *Braarudosphaera bigelowi* (Gran and Braarud) Deflandre, and small, unidentified coccoliths are found in low frequencies (one specimen per 20 mm of traverse at X500) in preparations of calcareous nannofossil material.

All of the Chipola planktonics, both in foraminiferal and calcareous nannofossil categories, have relatively long stratigraphic ranges. This seems to be a phenomenon common to microplanktonic assemblages of restricted marine occurrence. A position for the Chipola above the *Globigerinoides* datum (base of Zone N. 4) is dictated by the presence of this genus, and a maximum age reconcilable with Zone N. 5 is indicated by *G. subquadratus* and *Globigerinita glutinata,* both of which are unknown in sediments below this zone. A position below the *Orbulina* datum (top of Zone N. 8) is suggested by the absence of *Orbulina* spp. and other forms which are found in association with members of this long-ranging genus. Although it is a corollary of positive data, the absence of taxa is an unsatisfactory basis for biostratigraphic conclusions. In view of the number of Chipola samples examined, however, and confronted with the lack of more reliable criteria, a position below the evolutionary first occurrence of *Orbulina* must be accepted for the present. Thus, as Gibson (1967, p. 643) concluded, the Chipola appears to be correlative with the *Globigerinatella insueta* Zone of Trinidad (Zones N. 7 and N. 8), for which a Burdigalian age is assigned (Blow, 1969, fig. 19). Of these two zones, N. 7 is tentatively preferred for the Chipola Formation. This interpretation requires a greater age for the Chipola Formation and the *Globigerinatella insueta* Zone on the European time scale than earlier proposed by Akers and Drooger (1957, p. 658).

The Chipola has been correlated with beds in the valley of the Saucats, southwestern France, which contain *Miogypsina.* It is believed that this genus became extinct in the Gulf of Mexico region just prior to Chipola

time, since no specimens of *Miogypsina* have been found here in strata as young as either the Chipola Formation or the *Globigerinatella insueta* Zone of the Louisiana subsurface (Akers and Drooger, 1957, fig. 1). The Saucats also lies below the ***Orbulina*** datum, and an interesting analogy (but of dubious significance) is the dominance and large size attained by *Globigerinoides quadrilobatus quadrilobatus* in the writer's material from this European area. *Orbulina* first appears in Europe in beds considered to be Helvetian in age.

ENCANTO FORMATION
Plates 6-9

Unnamed beds at TU 635 are referred provisionally here to the Encanto Formation (Harold E. and Emily H. Vokes, personal communication). The locality is a roadcut on the Trans-Isthmian Highway (Mexico Highway 185), 1.4 miles south of the bridge over Rio Jaltepec, Oaxaca, Mexico. Ages assigned to molluscan collections from this area have varied from lower Miocene to Pliocene (Durham, *et al.*, 1955, p. 985).

The foraminiferal fauna is interesting in that most of the benthonic components have been recorded from localities in northern Florida or the Louisiana subsurface Miocene. Among these are the following:

Amphistegina lessonii d'Orbigny
Bolivina floridana Cushman
Bolivina marginata Cushman
Gyroidinoides scalata (Garrett)
Reussella miocenica Cushman
Siphogenerina lamellata Cushman
Uvigerina altacostata Cushman and Ellisor
Uvigerina peregrina Cushman

The following planktonic foraminifera were identified from this locality:

Biorbulina bilobata (d'Orbigny)
Globigerina sp., pl. 6, fig. 1
Globigerinoides obliquus obliquus Bolli, pl. 7, fig. 1
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny), pl. 6, fig. 2
Globoquadrina altispira globosa Bolli, pl. 8, fig. 2
Globoquadrina dehiscens (Chapman, Parr, and Collins), pl. 8, fig. 1
Globorotalia (Globorotalia) cultrata menardii (Parker, Jones and Brady), pl. 9, fig. 2
Globorotalia sp., pl. 9, fig. 3
Hastigerina (Hastigerina) siphonifera siphonifera (d'Orbigny), pl. 9, fig. 1
Orbulina suturalis Bronnimann
Orbulina universa d'Orbigny
Sphaeroidinellopsis subdehiscens subdehiscens Blow, pl. 7, fig. 2

A single specimen was found (pl. 6, fig. 1) which bears a striking resemblance in rugose, mammillated wall structure to *Globigerapsis index* (Finlay), as illustrated by Blow (1969, pl. 27, figs. 1, 2). Rare, small specimens occur which seem to be referable to *Globorotalia (Globorotalia) paralenguaensis* Blow (pl. 9, fig. 3) for which a range is recorded from Zone N. 15 to Zone N. 16. A definite identification cannot be made because of a scarcity of specimens and the lack of topotypes for comparison. The species has been recorded only from the type locality, Muruan Formation, Papua.

Calcareous nannofossils are scarce in the Encanto Formation. Rare *Discoaster* cf. *D. deflandrei* Bramlette and Riedel and a single *Discoaster* cf. *D. hamatus* Martini and Bramlette were found.

The planktonic foraminiferal assemblage is dominated by *Globigerinoides obliquus obliquus, G. quadrilobatus quadrilobatus, Globoquadrina altispira globosa,* and *Globorotalia (G.) cultrata menardii. Globoquadrina dehiscens* and *Sphaeroidinellopsis subdehiscens subdehiscens* were rare but typical. All specimens of *Globorotalia (G.) cultrata menardii* are sinistrally coiled. Coiling in *Globoquadrina altispira globosa* is predominantly sinistral.

The oldest zone to which this planktonic assemblage can be assigned is Zone N. 13 on the basis of *Sphaeroidinellopsis subdehiscens subdehiscens*, which is not known to occur below this zone, and *Globorotalia (G.) cultrata menardii*, which is found as low as Zone N. 14 and questionably Zone N. 13 (Blow, 1969, p. 359). Zone N. 15 is the

highest *possible* position for the assemblage because of the absence of *Globigerinoides obliquus extremus* Bolli and Bermúdez, which appears in association with *G. obliquus obliquus* above Zone N. 15. The high frequency of the latter to the complete exclusion of the former is at least indicative of this interpretation though not conclusive because of the negative character of the data.

It is interesting, though again not a valid basis for exact age dtermination, that the benthonic fauna is identical with an association of species in the northern Gulf Coast which is invariably restricted to Zone N. 14 and the upper part of Zone N. 13.

YELLOW RIVER FORMATION
Plates 10-13

The type locality for the *Yoldia* Zone of the Choctawhatchee Formation (Mansfield and Ponton, 1932) is on the Albert H. Cosson Farm (formerly Frazier's Farm), SE 1/4, Section 18, T2N, R19W, Walton County, Florida (Cushman and Ponton Sample No. 9, USGS locality No. 12060, 1932, pp. 13-14, 26-27). The Cosson Farm also is the type locality for the Yellow River Formation of Puri and Vernon (1964, pp. 200-202), who show a total of 7.5 feet exposed here representing the *Yoldia* Faunizone (Yellow River Formation), as follows:

Bed	Description	Thickness (feet)
2	Greenish gray, sandy, plastic clay, casts of molluscs and scattered *Yoldia waltonensis*	5.0
1	Greenish gray shell marl with abundant *Yoldia waltonensis*	2.5

Foraminifera are scarce in Bed 2, but at least 17 benthonic species and 12 planktonic forms occur in Bed 1. Cushman and Ponton (1932, table 1) list only two species of planktonic foraminifera from this locality, *Globorotalia menardii* (d'Orbigny) and *Orbulina universa* d'Orbigny, yet one of the richest planktonic assemblages to be found in the Middle Tertiary of northern Florida occurs here, both in terms of total specimens and in number of species per unit volume of formation material.

Planktonic foraminifera from the Yellow River Formation at the type locality, Bed 1, include:

Biorbulina bilobata (d'Orbigny)
Globigerina juvenilis Bolli, pl. 12, fig. 1
Globigerinoides obliquus obliquus Bolli, pl. 10, fig. 1
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny), pl. 11, figs. 2, 3
Globoquadrina altispira globosa Bolli, pl. 11, fig. 1
Globorotalia (Globorotalia) cultrata menardii (Parker, Jones and Brady), pl. 13, fig. 1
Globorotalia (Turborotalia) minima Akers, pl. 13, fig. 2
Globorotalia (Turborotalia) siakensis (LeRoy), pl. 13, fig. 3
Hastigerina (Hastigerina) siphonifera siphonifera (d'Orbigny), pl. 12, fig. 2
Orbulina suturalis Bronnimann
Orbulina universa d'Orbigny, pl. 10, fig. 2
Sphaeroidinellopsis seminulina kochi (Caudri), pl. 12, fig. 3

All of the species and subspecies listed here are abundant at the Cosson Farm site except *Globorotalia minima*, which, though not abundant, is typical (see Systematic Paleontology section for discussion of the morphology and range of this species). All specimens observed of *Globorotalia* and *Globoquadrina* were sinistrally coiled.

The following species of calcareous nannoplankton were identified from Bed 1 at the type locality. The first two species listed are the most abundant. Numerous coccoliths of *Cyclococcolithus* sp., probably *C. leptoporous* (Murray and Blackman), were also seen.

Catinaster coalitus Martini and Bramlette
Discoaster brouweri Tan Sin Hok
Discoaster challengeri Bramlette and Riedel
Discoaster exilis Martini and Bramlette
Discoaster hamatus Martini and Bramlette
Discoaster variabilis Martini and Bramlette
Sphenolithus moriformis (Bronnimann and Stradner)

The precise zone to which the Yellow River Formation (at the type locality) is referable is established by *Catinaster coalitus*. This nannofossil species is confined to a short interval within the middle Miocene of the Louisiana subsurface, some Lamont deep-sea cores, the experimental Mohole (Martini and Bramlette, 1963), and the *Globorotalia mayeri* Zone (as defined by Bolli, 1957; 1966) of the Cipero Formation, Trinidad (Bramlette and Wilcoxon, 1967, p. 108). The *Globorotalia mayeri* Zone of Bolli is Zone N. 14 of Blow (1969, fig. 15). It is also the highest zone in which *Globorotalia (T.) minima* and *Globorotalia (T.) siakensis* are found.

RED BAY FORMATION ?
Plates 14-17

The type locality of the *Arca* Faunizone (Mansfield *in* Cooke and Mossom, 1929, pp. 140-142) is represented by 19 feet of gray, sandy and clayey, shell marl in the vicinity of Red Bay, Walton County, Florida. Puri and Vernon (1964, p. 197) designated the site here, now known as the W. D. McDaniel farm (Section 19, T2N, R17W), as the type locality for their Red Bay Formation. Cushman and Ponton (1932, table 1) list 40 species and varieties of benthonic foraminifera and one planktonic species (*Orbulina universa*) from these beds. Investigations by the writer, however, have failed to reveal the foraminiferal fauna reported here by Cushman and Ponton and as attirbuted to these authors by Puri and Vernon (1964, pp. 198-199). Only rare specimens of *Amphistegina lessonii* can be found at this locality. It is the writer's opinion that the locality records of Cushman and Ponton are in error, and that the benthonic foraminifera attributed to the McDaniel farm were in actuality derived from the Blount's Creek site (Section 27, T2N, R19W). Benthonic species obtained by the writer from the Blount's Creek locality match the list for the McDaniel farm site.

USGS locality No. 12046, Sample No. 8 of Cushman and Ponton (1932, pp. 13, 26-27), is from 100 feet below a small falls near head of Vaughan Creek (locally known as Blount's Creek), Section 27, T2N, R19W, Walton County, Florida. Cushman and Ponton (1932, p. 13) place six feet of marl at this locality in the lower part of the *Arca* Zone of the Choctawhatchee Formation and refer to the molluscan fauna as "especially well preserved and numerous as to species." They list 48 species and varieties of benthonic foraminifera but only a single planktonic species, *Orbulina universa* d'Orbigny.

Beds at the Blount's Creek locality are assigned provisionally to the Red Bay Formation on the assumption that they have been placed correctly in the *Arca* Faunizone. There is no microfaunal basis for correlating the section at Red Bay with beds at the Blount's Creek locality.

The following plantonic foraminifera have been identified at the Blount's Creek site:

Biorbulina bilobata (d'Orbigny)
Globigerina bulloides bulloides d'Orbigny, pl. 14, fig. 4
Globigerina cf. *G. druryi decoraperta* Takayanagi and Saito, pl. 14, fig. 3
Globigerina juvenilis Bolli
Globigerina nepenthes Todd, pl. 14, fig. 1
Globigerinita uvula (Ehrenberg), pl. 15, fig. 2
Globigerinoides bollii Blow
Globigerinoides obliquus extremus Bolli and Bermúdez
Globigerinoides obliquus obliquus Bolli, pl. 16, fig. 1
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny), pl. 16, fig. 4
Globigerinoides ruber (d'Orbigny), pl. 16, fig. 3
Globigerinoides sp., pl. 16, fig. 2
Globoquadrina altispira globosa Bolli, pl. 15, fig. 1
Globoquadrina dehiscens (Chapman, Parr, and Collins), pl. 15, fig. 3
Globorotalia (Turborotalia) acostaensis acostaensis Blow, pl. 17, fig. 1
Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito, pl. 17, fig. 4
Globorotalia (Globorotalia) cultrata menardii (Parker, Jones and Brady), pl. 17, fig. 2

Hastigerina (Hastigerina) siphonifera siphonifera (d'Orbigny), pl. 17, fig. 3
Orbulina suturalis Bronnimann
Orbulina universa d'Orbigny
Sphaeroidinellopsis seminulina seminulina (Schwager), pl. 14, fig. 2
Sphaeroidinellopsis subdehiscens subdehiscens Blow

The predominant planktonic forms at Blount's Creek are *Globigerinoides quadrilobatus quadrilobatus* and *Globigerinoides obliquus obliquus*. *Globorotalia (T.) acostaensis acostaensis* and *Globorotalia (G.) cultrata menardii* are scarce but typical. Only four specimens of each were found at this locality. All four specimens of the latter are sinistrally coiled. *Globigerina nepenthes* is rare, and none of the specimens have the final thumb-like chamber seen in adult forms when they occur in high frequency.

Typical *Globigerinoides ruber* is rare, and specimens occur in this assemblage that appear transitional between this species and *Globigerinoides bollii*. Blow (1969) has reported that the development of *G. ruber* from *G. bollii* occurs in Zone N. 16. All of the specimens of *Globigerina bulloides bulloides* bear a resemblance to *Globigerina praebulloides praebulloides* Blow, suggesting that the beds at Blount's Creek represent a time close to the divergence of these taxa, which may have taken place within the later half of Zone N. 16 (Blow, 1969). Specimens of *Globorotalia (T.) acostaensis humerosa* appear to be rather primitive forms, all having fewer chambers than observed in higher zones.

Several specimens of *Globigerinoides* (pl. 16, fig. 2) were found which may be aberrant forms of *G. quadrilobatus quadrilobatus*, although there seems to be a difference in wall structure. A few specimens are referred provisionally to *Globigerina druryi decoraperta*. Forms from the Blount's Creek locality have a larger and more weakly lipped aperture than usually seen in that taxon. The Blount's Creek specimens are also larger than typical in that subspecies.

The following species of calcareous nannoplankton were identified at the Blount's Creek locality:

Discoaster exilis Martini and Bramlette
Discoaster hamatus Martini and Bramlette
Discoaster pentaradiatus Tan Sin Hok
Discoaster variabilis Martini and Bramlette
Braarudosphaera bigelowi (Gran and Braarud) Deflandre
Lithostromation perdurum Deflandre

All of the above data and in particular the occurrence of early phylogenetic forms of *Globigerina bulloides bulloides, Globigerinoides ruber,* and *Globorotalia (T.) acostaensis humerosa* suggest a position in Zone N. 17 for the beds at Blount's Creek.

JACKSON BLUFF FORMATION
ECPHORA FAUNIZONE
Alum Bluff, Bed 4
Plates 18-20

This locality is on the east side of the Apalachicola River, about four miles north of Bristol, Liberty County, Florida, in the SW 1/4, SE 1/4, NE 1/4, Section 24, T1N, R8W. Sample No. 12, USGS locality numbers 1/670 and 1/956 of Cushman and Ponton (1932, p. 14) is from this site.

Bed 4 of the section at this locality (Puri and Vernon, 1964, pp. 202-204) is the *Ecphora* "bed" of Dall (1892) and represents the *Ecphora* Zone of Mansfield (*in* Cooke and Mossom, 1929). This is the type locality for the *Ecphora* Faunizone, and both Bed 4 and Bed 5 of the section at this locality are assigned by Puri and Vernon (1964, p. 202) to their Jackson Bluff Formation. Puri and Vernon (1964, p. 204) describe the lithology of Bed 4 as a very sandy, blue and bluish gray shell marl, practically a coquina. The upper six inches is glauconitic and indurated, and the lower foot contains pebbles of gray, phosphoritic, sandy limestone, gray sandstone, and blue clay. They give 13.5 feet for the thickness of this bed. Mollusk shells are abundant, although *Ecphora quadricostata* var. *umbilicata,* for which the faunizone was named, is rare. Cushman and Ponton (1932) recorded 43 species and varieties of benthonic foraminifera from Bed 4 but only *Orbulina universa* and *Globorotalia menardii* among the planktonics.

The following planktonic foraminifera were found in Bed 4 at the Alum Bluff site:

Globigerina bulloides apertura Cushman, pl. 19, fig. 1
Globigerina bulloides bulloides d'Orbigny
Globigerina druryi decoraperta Takayanagi and Saito
Globigerina juvenilis Bolli, pl. 19, fig. 5
Globigerinoides bollii Blow
Globigerinoides obliquus obliquus Bolli, pl. 18, fig. 2
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny), pl. 18, fig. 1
Globigerinoides ruber (d'Orbigny), pl. 18, fig. 3
Globoquadrina altispira globosa Bolli, pl. 20, fig. 1
Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito, pl. 19, fig. 3
Globorotalia (Globorotalia) cultrata menardii (Parker, Jones, and Brady)
Globorotalia (Globorotalia) margaritae Bolli and Bermúdez, pl. 19, fig. 4
Globorotalia (Globorotalia) multicamerata Cushman and Jarvis, pl. 19, fig. 2
Globorotaloides hexagona hexagona (Natland)
Orbulina universa d'Orbigny
Sphaeroidinellopsis subdehiscens subdehiscens Blow, pl. 20, figs. 2-4

Some of the most significant species are of low frequency in this assemblage. Only five specimens of *Globorotaloides hexagona hexagona* were found. These are typical, however, and fix the maximum possible age of Bed 4 within Zone N. 18. *Globorotalia (G.) margaritae,* of which only three juvenile specimens (all sinistrally coiled) were observed, ranges from the middle to later parts of Zone N. 16 to within Zone N. 19 (Blow, 1969). *Globorotalia (G.) cultrata menardii* is rare and dextrally coiled. In the Atlantic regions, including the Gulf of Mexico and Caribbean, predominantly dextral specimens of this taxon indicate an age of Pliocene or latest Miocene. *Globorotalia (G.) multicamerata,* also rare and typically dextral, ranges from the middle of Zone N. 17 to Zone N. 21.

Among the calcareous nannoplankton, the following species occur in Bed 4:

Discoaster pentaradiatus Tan Sin Hok
Discoaster perplexus Bramlette and Riedel
Discoaster surculus Martini and Bramlette
Discoaster variabilis Martini and Bramlette
Lithostromation perdurum Deflandre

Biostratigraphically, *Discoaster surculus* is the most significant member of this nannofossil assemblage, since it has the most restricted range in time. All of the other species are known from strata of Miocene, as well as Pliocene age. It is noteworthy that this form does not occur in the youngest Miocene (Zone N. 15) of Trinidad (Bramlette and Wilcoxon, 1967). It does occur in the subsurface Pliocene of the Gulf of Mexico region, however, making its first appearance near the Miocene-Pliocene boundary. Martini and Bramlette (1963) logged the species in the experimental Mohole only in the section attributed by them to the Pliocene. Hay and Schmidt (1968) report *Discoaster surculus* from the Plaisancian section at Castell-'Arquato and from the Trubi Marl of Cattolica Eraclea, Sicily, which is considered to be early Pliocene (from the middle of Zone N. 18 to the top of Zone N. 19 of Blow, 1969). Hay and Boudreaux (1968, p. 145) report the species in the 200 cm core of the Submarex boring, Nicaragua Rise, Caribbean Sea, and term it "a typical Pliocene form."

Both the nannofossil and the foraminiferal data, therefore, point to an age for Bed 4 at Alum Bluff of early Pliocene (middle of Zone N. 18 to within Zone N. 19). Hazel (1971, p. 8) suggested that the *Ecphora* Zone should be assigned to N. 18 or N. 19 on the basis of the planktonic foraminifera identified by Ruth Todd from bed 4 of Puri and Vernon (1964, p. 204) at Alum Bluff.

JACKSON BLUFF FORMATION ?
ECPHORA FAUNIZONE
Watson's Landing
Plates 21-25

This site is a cut in the road leading to Watson's Landing, about two miles north of Alum Bluff and about two miles from the

Apalachicola River, 2000 feet north and 100 feet west of the southeast corner of Section 7, T1N, R7W, Liberty County, Florida. The locality is represented by outcrop sample no. 46 of Puri (1953, p. 60), who termed the section here "*Ecphora* Facies of the Choctawhatchee Stage."

Beds about 40 feet above the river terrace were identified with the *Ecphora* Zone of the Chocatwhatchee Formation by Cushman and Ponton (1932, p. 18), who recorded 13 species and varieties of benthonic foraminifera but no planktonics. The writer collected material from a tan to brown colored shell bed above a white to buff marl in 1957. Well preserved mollusks were abundant.

The following planktonic foraminifera are present at this locality:

Globigerina bulloides apertura Cushman, pl. 21, fig. 3
Globigerina bulloides bulloides d'Orbigny
Globigerina druryi decoraperta Takayanagi and Saito
Globigerina juvenilis Bolli
Globigerina sp., pl. 21, fig. 1
Globigerinita glutinata (Egger), pl. 21, fig. 2
Globigerinoides bollii Blow, pl. 22, fig. 2
Globigerinoides conglobatus conglobatus (Brady), pl. 24, figs. 1, 2
Globigerinoides obliquus extremus Bolli and Bermúdez, pl. 23, fig. 2
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny), pl. 22, fig. 1
Globigerinoides ruber (d'Orbigny), pl. 22, fig. 3; pl. 23, fig. 1
Globoquadrina altispira globosa Bolli, pl. 25, fig. 1
Globoquadrina conglomerata (Schwager)
Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito, pl. 25, fig. 2
Globorotalia (Globorotalia) miocenica Palmer
Globorotalia (Turborotalia) scitula scitula (Brady)
Globorotaloides hexagona hexagona (Natland)
Hastigerina (Hastigerina) siphonifera siphonifera (d'Orbigny), pl. 24, fig. 3
Orbulina universa d'Orbigny
Sphaeroidinella dehiscens dehiscens forma *immatura* (Cushman)
Sphaeroidinellopsis subdehiscens subdehiscens Blow
Turborotalita quinqueloba (Natland)

Most of the foraminifera listed above can be found at Watson's Landing with diligent searching. Only four specimens of *Globigerinoides conglobatus conglobatus* and *Orbulina universa* were seen. Two specimens each of *Sphaeroidinella dehiscens dehiscens* forma *immatura* and *Globorotalia (T.) scitula scitula* and six specimens of *Globorotaloides hexagona hexagona* were found.

The following species of calcareous nannoplankton were identified at Watson's Landing:

Discoaster brouweri Tan Sin Hok (both five and six rayed forms)
Discoaster pentaradiatus Tan Sin Hok
Discoaster surculus Martini and Bramlette
Lithostromation perdurum Deflandre
Sphenolithus abies Deflandre

Planktonic microfossil assemblages at Alum Bluff, Bed 4, and Watson's Landing are similar in constituents. It is possible that the beds at Watson's Landing are slightly younger, since *Globoquadrina conglomerata* occurs there and has not been found in Bed 4, Alum Bluff. This species has not been documented below the later parts of Zone N. 19. *Sphaeroidinella dehiscens dehiscens* forma *immatura* was also found at Watson's Landing but not at Alum Bluff, Bed 4. It is confined to Zone N. 19, according to Blow (1969).

JACKSON BLUFF FORMATION ?
ECPHORA FAUNIZONE ?
Darling Slide
Plates 26-33

This site (TU 712) is an old log slide at a bluff on the east bank of the Chipola River, about 2.5 miles southeast of Clarksville, Calhoun County, Florida. It is USGS locality no. 1/960 of Cushman (1930, p. 13) and Cushman and Ponton (1932, p. 17). Collec-

tions were made here by the writer in November, 1957, from two horizons, one near the base of the exposure, and one, seven feet higher.

According to Cushman and Ponton (1932, p. 17), the molluscan fauna is poorly preserved and small as to species. *Mulinia congesta* is abundant. They recorded 36 species and varieties of benthonic foraminifera but only three planktonic species, *Hastigerina pelagica (Hastigerina (H.) siphonifera siphonifera), Orbulina universa,* and *Globorotalia menardii* (*Globorotalia cultrata* subspecies). These authors relate this locality to the *Ecphora* Zone, Choctawhatchee Formation.

The following planktonic foraminifera were identified at Darling Slide:

Globigerina bulloides apertura Cushman, pl. 30, fig. 1; pl. 31, fig. 1
Globigerina bulloides bulloides d'Orbigny, pl. 30, fig. 2; pl. 31, fig. 2
Globigerina druryi decoraperta Takayanagi and Saito, pl. 29, fig. 1; pl. 31, fig. 3
Globigerina juvenilis Bolli
Globigerina sp., pl. 29, fig. 2
Globigerinita glutinata (Egger), pl. 33, fig. 3
Globigerinita uvula (Ehrenberg), pl. 29, fig. 3
Globigerinoides obliquus obliquus Bolli, pl. 26, fig. 2; pl. 27, fig. 3
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny), pl. 27, fig. 2; pl. 30, fig. 3
Globigerinoides ruber (d'Orbigny), pl. 26, fig. 4; pl. 27, fig. 1
Globoquadrina conglomerata (Schwager)
Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito, pl. 26, fig. 3; pl. 28, fig. 2
Globorotalia (Globorotalia) cultrata limbata (Fornasini), pl. 33, fig. 2
Globorotalia (Globorotalia) cultrata subspecies, pl. 32, fig. 2
Globorotalia (Globorotalia) margaritae Bolli and Bermúdez, pl. 32, fig. 1; pl. 33, fig. 1
Globorotalia (Turborotalia) praeoscitans, new species, pl. 32, fig. 3
Globorotaloides hexagona hexagona (Natland), pl. 28, fig. 1
Hastigerina (Hastigerina) siphonifera siphonifera (d'Orbigny), pl. 26, fig. 1; pl. 31, fig. 4
Turborotalita quinqueloba (Natland)

A species of *Globigerina* (pl. 29, fig. 2) resembles the form from Watson's Landing (pl. 21, fig. 1). These may be related to *Globigerina juvenilis*. The specimens of *Globorotalia (G.) margaritae* are not as large as most specimens from deep-sea cores, nor do they have the extremely arched spiral side characteristic of specimens from predominantly planktonic assemblages. The Florida form may be a subspecies of this group. The predominantly dextral coiling of the *Globorotalia (G.) cultrata* complex and the predominantly sinistral coiling of associated *Globorotalia (G.) margaritae* in the *Ecphora* Faunizone present an interesting analogy with the occurrence of these taxa in Java and the Caribbean area. "In all samples studied from these areas, the new species *(G. margaritae)* coils sinistrally, whereas *Globorotalia menardii* strongly prefers dextral coiling in the same samples" (Bolli and Bermúdez, 1965, p. 140). The samples described by Bolli and Bermudez are now considered lower Pliocene by Blow (1969), that is, the later part of Zone N. 18 and at least the early part of Zone N. 19.

Microfossil assemblages from the two horizons sampled at Darling Slide were examined separately and are illustrated separately here. There are no significant differences, however, either quantitatively or qualitatively, between the planktonic assemblages of the two beds.

The following species of calcareous nannofossils are present in both of the samples taken at Darling Slide:

Discoaster brouweri Tan Sin Hok
Discoaster pentaradiatus Tan Sin Hok
Braarudosphaera bigelowi (Gran and Braarud) Deflandre
Lithostromation perdurum Deflandre

A single specimen of *Discoaster variabilis* Martini and Bramlette was observed from the upper horizon.

Coccoliths are abundant in the material from Darling Slide, and it is a paradox that *Sphenolithus abies* Deflandre was not seen, since it almost invariably occurs in lower Pliocene sediments of the Gulf of Mexico region in which coccoliths are so highly concentrated as at this locality. The absence of this species in such sediments usually indicates an age younger than early Pliocene (Gartner, 1969, fig. 7). There is nothing in either the foraminiferal assemblages or the calcareous nannoplankton concentrations, however, which would confirm an age for these beds younger than those at Watson's Landing. *Globoquadrina conglomerata*, though rare, indicates that the Darling Slide beds are no older than Zone N. 19. It must be concluded, on the basis of planktonic microfossils, that the early investigators were correct in referring these sediments to the same faunizone as the strata at Watson's Landing and Bed 4 of Alum Bluff.

JACKSON BLUFF FORMATION
ECPHORA FAUNIZONE
Jackson Bluff, Bed 9
Plates 34-46

This locality is on the left bank of the Ocklocknee River, just above the bridge, Leon County, Florida. It is the horizon for Sample no. 37, USGS locality no. 1/967 of Cushman (1930, p. 13) and Cushman and Ponton (1932, p. 17). It is also Stop 55, Bed 9, of Puri and Vernon (1964, p. 208).

The assemblage here represents the latest fauna of the *Ecphora* Zone of the Choctawhatchee Formation according to Cushman and Ponton (1932, p. 17). Puri and Vernon (1964, p. 208) consider Bed 9 as the upper bed of the *Ecphora* Faunizone of their Jackson Bluff Formation, Choctawhatchee Stage. They describe it as 2 feet of "shell marls, with abundant *Pecten* in a bluish gray clay matrix."

The writer sampled this bed in May, 1956, and found it to be slightly glauconitic. Cushman and Ponton (1932, Table 1) listed 17 species and varieties of benthonic foraminifera from the zone. They made no mention of planktonic forms.

The following planktonic foraminifera occur in Bed 9, Jackson Bluff:

Globigerina bulloides bulloides d'Orbigny, pl. 34, fig. 1
Globigerina druryi decoraperta Takayanagi and Saito, pl. 34, fig. 3
Globigerina juvenilis Bolli
Globigerinoides bollii Blow
Globigerinoides obliquus extremus Bolli and Bermúdez
Globigerinoides obliquus obliquus Bolli, pl. 35, fig. 1
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny), pl. 34, fig. 4

PLATE 1
CHIPOLA FORMATION
TU 951

Figures Page

1. *Cassigerinella chipolensis* (Cushman and Ponton). 130
Maximum diameter, 0.23 mm
   a. Side view, showing aperture, X 280
   b. Opposite side, X 280
   c. Portion of penultimate chamber in fig. 1a, X 560
   d. Portion of penultimate chamber in fig. 1a, X 1120

2. *Globigerinita uvula* (Ehrenberg). 72
Maximum diameter, 0.23 mm
   a. Apertural view, X 280
   b. Opposite side, X 280

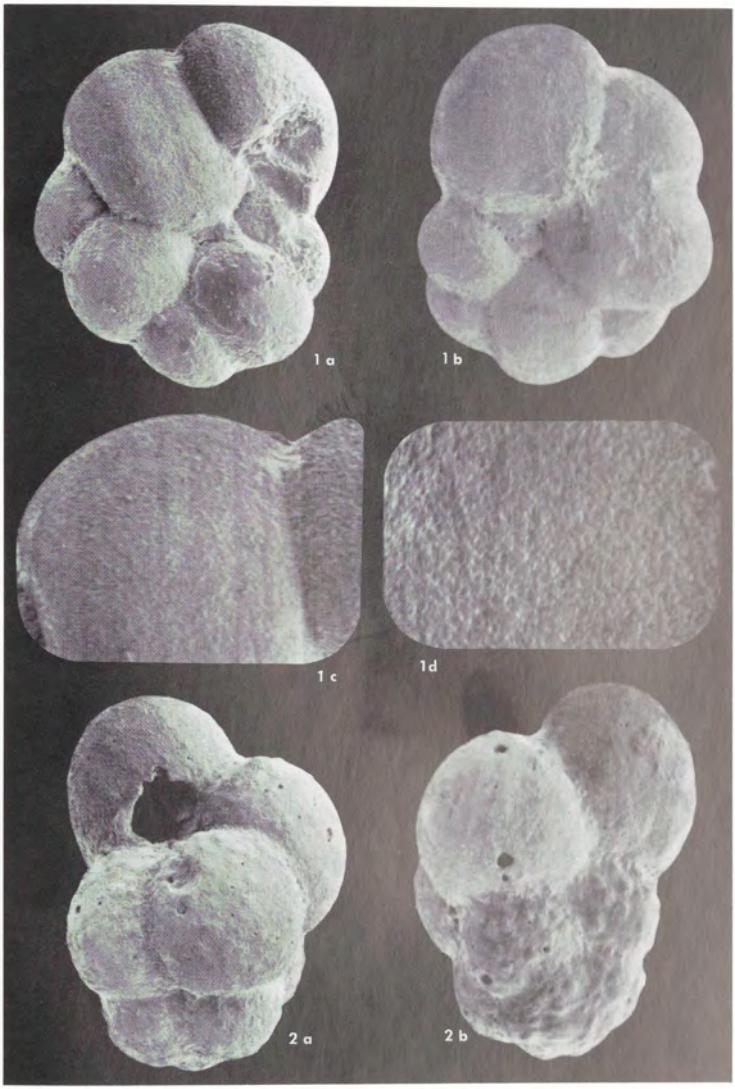

Plate 1

Globigerinoides ruber (d'Orbigny), pl. 35, fig. 2
Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito, pl. 36, fig. 2
Globorotalia (Globorotalia) cultrata subspecies, pl. 36, fig. 1
Globorotalia (Turborotalia) praeoscitans, new species, pl. 36, fig. 3
Orbulina universa d'Orbigny
Sphaeroidinellopsis subdehiscens subdehiscens Blow, pl. 34, fig. 2; pl. 35, figs. 3, 4

Except that planktonic specimens are scarcer, this is a similar assemblage to those at Darling Slide, Watson's Landing, and Alum Bluff, Bed 4. A dextrally coiled subspecies of *Globorotalia (G.) cultrata* (pl. 36, fig. 1) occurs here, which is close in appearance to that at Darling Slide (pl. 32, fig. 2). A single specimen of *Globorotalia (T.) praeoscitans*, n. sp., was found which appears to be the same form seen at Darling Slide (pl. 32, fig. 3), where it is also rare. Planktonic foraminifera are rare in Bed 9, Jackson Bluff. *Globigerinoides ruber* and *Globigerinoides obliquus obliquus* are the most frequent taxa in the assemblage.

Calcareous nannofossils are rare, there being only an average of 10 specimens per 20 mm at X600. No discoasters were observed, nor were *Sphenolithus* or *Lithostromation*.

This bed is tentatively assigned to the upper part of Zone N. 18 to the upper part of Zone N. 19 on the similarity of the planktonic foraminiferal assemblage here and at Darling Slide, Watson's Landing, and Alum Bluff, Bed 4. A precise assignment within the Pliocene is not as apparent for Jackson Bluff, Bed 9, as for the strata at these other sites.

JACKSON BLUFF FORMATION
CANCELLARIA FAUNIZONE
Jackson Bluff, Bed 10
Plates 37-40

This locality is on the left bank of the Ocklocknee River, just above the bridge, Leon County, Florida. It is the horizon for Sample no. 14, USGS locality no. 11732 of Cushman and Ponton (1932, p. 14), who described the locality as a borrow-pit just east of the power dam at Jackson Bluff, Florida. It is also Stop 55, Bed 10, of Puri and Vernon (1964, p. 208).

This bed is four feet thick and is a "cream to white, sandy shell marl, and sand with abundant mollusks" according to Puri and Vernon (1964, p. 208), who designated it as the *Cancellaria* Faunizone of their Jackson Bluff Formation, Choctawhatchee Stage.

PLATE 2
CHIPOLA FORMATION
TU 820

Figures Page

1. *Cassigerinella chipolensis* (Cushman and Ponton). 130
Maximum diameter, 0.17 mm

a. Side view (showing aperture), X 406
b. View of wall of penultimate chamber shown in fig. 1a, X 7350
c. View of penultimate chamber shown in fig. 1a, X 700
d. View of wall of penultimate chamber shown in fig. 1a, X 3500

TU 951

2. *Globigerinoides* sp., a rare form which resembles *Globigerinoides sicanus* de Stefani. This is probably an aberrant *Globigerinoides quadrilobatus quadrilobatus*. . . . 10
Maximum diameter, 0.48 mm

a. Side view, X 98
b. Opposite view, X 100

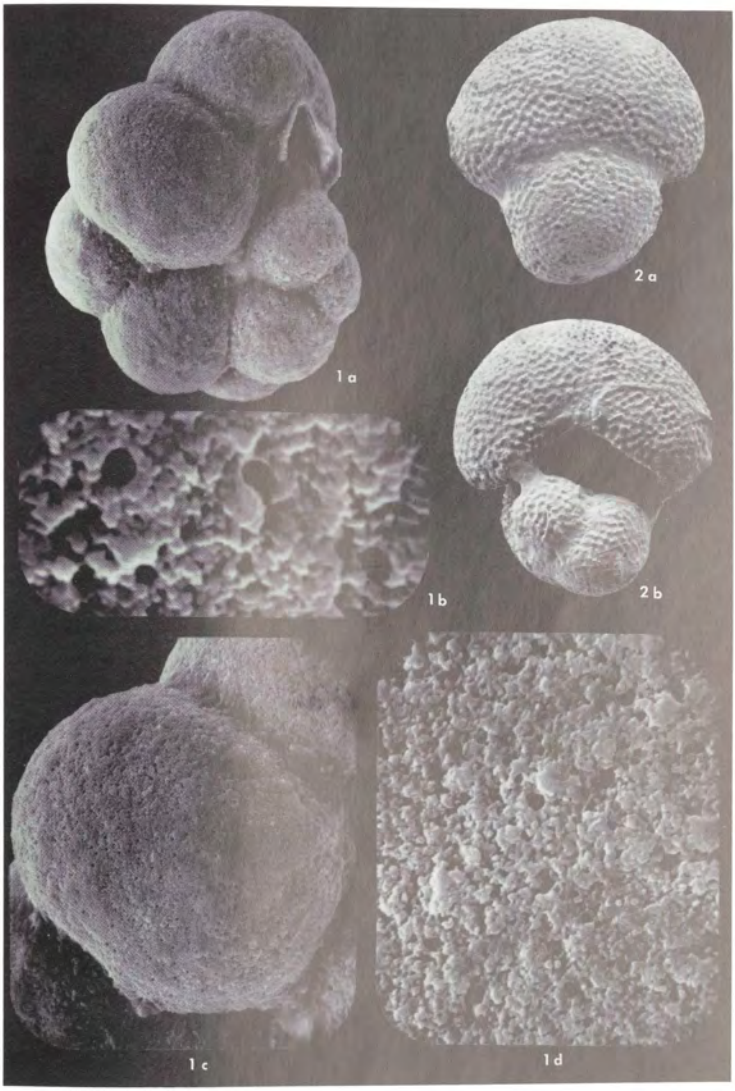

Plate 2

Cushman and Ponton (1932, p. 14) considered the bed representative of the *Cancellaria* Zone of the Choctawhatchee Formation. They reported (Table 1) 49 species and varieties of benthonic foraminifera and a single planktonic form, *Orbulina universa* d'Orbigny.

The writer has identified the following planktonic foraminifera from this bed:

Globigerina bulloides apertura Cushman, pl. 37, fig. 1
Globigerina bulloides bulloides d'Orbigny, pl. 37, fig. 3
Globigerina druryi decoraperta Takayanagi and Saito, pl. 37, fig. 2
Globigerina juvenilis Bolli
Globigerinita glutinata (Egger), pl. 38, fig. 2
Globigerinoides bollii Blow
Globigerinoides obliquus extremus Bolli and Bermúdez, pl. 38, fig. 1
Globigerinoides obliquus obliquus Bolli
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny), pl. 39, fig. 2
Globigerinoides ruber (d'Orbigny), pl. 38, fig. 3
Globoquadrina altispira globosa Bolli, pl. 40, fig. 1
Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito, pl. 40, fig. 2
Globorotalia (Globorotalia) cultrata subspecies, pl. 40, fig. 3
Hastigerina (Hastigerina) siphonifera siphonifera (d'Orbigny)
Orbulina suturalis Bronnimann
Orbulina universa d'Orbigny
Sphaeroidinellopsis subdehiscens subdehiscens Blow, pl. 39, fig. 1, 3

Planktonic foraminifera are more abundant in this upper bed than in the lower Bed 9. *Globigerinoides ruber* is the most

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PLATE 3
CHIPOLA FORMATION
TU 951

Figures Page

1. *Globorotalia (Turborotalia) obesa* Bolli. 116
Maximum diameter, 0.69 mm
   a. Umbilical view, X 140
   b. Spiral view, X 99
   c. Edge view, X 140

2. *Globigerinoides* sp., a form resembling *Globigerinoides quadrilobatus altiaperturus* Bolli, but having apertures wider than in that subspecies. 10
Maximum diameter, 0.44 mm
   a. Spiral view, X 132
   b. Umbilical view, X 131

3. *Globoquadrina baroemoenensis* (LeRoy). 90
Maximum diameter, 0.47 mm
   a. Spiral view, X 100
   b. Umbilical view, X 100

4. *Globigerinoides quadrilobatus quadrilobatus* (d'Orbigny). 62
Maximum diameter, 0.63 mm
   a. Umbilical view, X 99
   b. Spiral view, X 91

Plate 3

frequently encountered species. Of the above taxa, only members of *Globoquadrina*, *Globorotalia*, and *Hastigerina* are rare in samples from this horizon. All of the few *Globorotalia cultrata* forms seen were dextrally coiled.

Calcareous nannofossils are also far more abundant in Bed 10 than in Bed 9, but discoasters are slightly calcified. No bifurcating forms were seen, and *Discoaster brouweri* was the only species of this genus positively identified. Two to five specimens per 20 mm were observed at X600. Other species identified were *Lithostromation perdurum*, *Braarudosphaera bigelowi*, and *Coccolithus pelagicus*.

No basis was seen among the microfossils at Jackson Bluff for an assignment of Bed 10 to a younger zone than that of the *Ecphora* beds (Zone N. 19).

JACKSON BLUFF FORMATION ?
CANCELLARIA FAUNIZONE ?
R. L. Gainer Farm
Plates 41-46

This site on the Econfina River in Section 4, T1S, R13W, Bay County, Florida, is Sample no. 36, USGS locality no. 1/953 of Cushman (1930, p. 13) and Cushman and Ponton (1932, p. 17). The locality was sampled by the writer in November, 1957, when it appeared, as described by Cushman and Ponton (1932, p. 17), to be "loose shells representing the *Cancellaria* Zone of the Choctawhatchee Formation . . . lying on the hard indurated Chipola Formation . . . " Although they reported that "no exposure of the marl was seen in place," the writer's material is believed to be in place, representing the near horizontal surface of the exposure. It is uncontaminated by Chipola microfossils.

PLATE 4
CHIPOLA FORMATION
TU 951

Figures Page

1. *Globigerinoides* sp. 10
Maximum diameter, 0.59 mm
   a. Umbilical view, X 99
   b. Spiral view, X 98

2. *Globigerinoides* sp. 10
Maximum diameter, 0.53 mm
   a. Spiral view, X 99
   b. Umbilical view, X 98

3. *Globigerinoides subquadratus* Bronnimann. 68
Maximum diameter, 0.59 mm
   a. Spiral view, X 101
   b. Umbilical view, X 101

4. *Globigerinoides* sp. 10
Maximum diameter, 0.68 mm
   a. Spiral view, X 99
   b. Umbilical view, X 99

1, 2, and 4 are possible variants of *Globigerinoides quadrilobatus quadrilobatus* (d'Orbigny). These seem to be transitional forms between the typical and rare specimens (fig. 2, 4). The latter may be gerontic.

Plate 4

The above authors identified only 11 species and varieties of benthonic foraminifera from this locality, and they made no mention of planktonic forms.

The present investigation has disclosed the following planktonic foraminifera at the Gainer locality:

Globigerina bulloides apertura Cushman, pl. 42, fig. 1
Globigerina bulloides bulloides d'Orbigny, pl. 41, fig. 1
Globigerina druryi decoraperta Takayanagi and Saito
Globigerina juvenilis Bolli
Globigerinoides obliquus extremus Bolli and Bermúdez, pl. 43, fig. 1
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny), pl. 42, fig. 2
Globigerinoides ruber (d'Orbigny), pl. 43, fig. 2
Globoquadrina altispira altispira (Cushman and Jarvis), pl. 44, fig. 1
Globoquadrina altispira globosa Bolli
Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito, pl. 44, fig. 2
Globorotalia (Globorotalia) cultrata subspecies, pl. 46, fig. 2
Globorotalia (Globorotalia) multicamerata Cushman and Jarvis, pl. 46, fig. 1
Globorotaloides hexagona hexagona (Natland)
Hastigerina (Hastigerina) siphonifera siphonifera (d'Orbigny), pl. 46, fig. 3
Orbulina universa d'Orbigny
Sphaeroidinella dehiscens dehiscens (Parker and Jones), pl. 45, fig. 2
Turborotalita quinqueloba (Natland), pl. 41, fig. 2; pl. 45, fig. 1

The predominant planktonic forms in the Gainer beds are *Globigerinoides ruber* and *Globigerinoides quadrilobatus quadrilobatus*. *Orbulina universa* and *Sphaeroidinella dehiscens dehiscens* are rare. The other forms listed above can be found in sufficient numbers with diligent searching to illustrate the range of variation for the various taxa.

Coiling in the complex of *Globorotalia cultrata* subspecies and *Globorotalia multicamerata* is predominantly dextral. The most significant foraminifera at this locality are *Sphaeroidinella dehiscens dehiscens*, which is known from the base of Zone N. 19 (Blow,

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PLATE 5
CHIPOLA FORMATION
TU 951

Figures

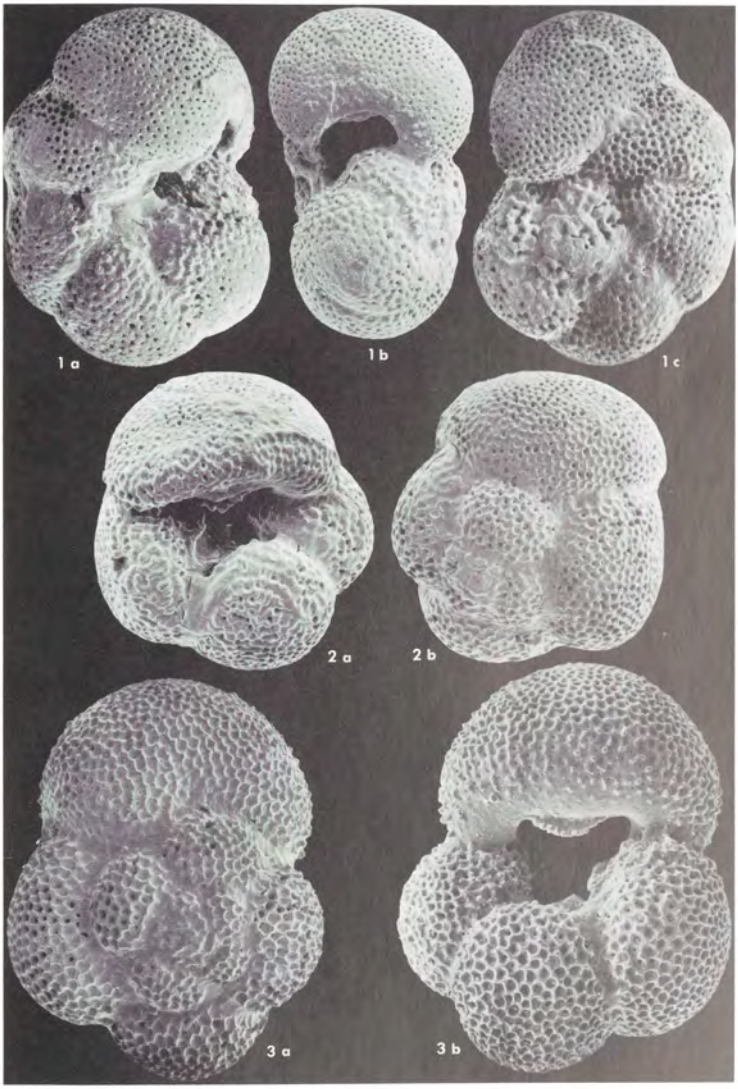

Plate 5

1969), and *Globigerina bulloides apertura*, which has not been recorded above Zone N. 19. Thus, it would appear that beds at the Gainer site, as well as those at the other localities assigned to the *Cancellaria* Faunizone, are of approximately the same age as beds referred to the *Ecphora* Faunizone (Zone N. 19), and in turn, to the Bowden Formation of Woodring (1925; 1928) and Palmer (1945).

The calcareous nannofossil assemblage in the Gainer beds is restricted to a few coccoliths and rare *Discoaster brouweri*, *Lithostromation perdurum*, and *Braarudosphaera bigelowi*, which fail to amplify or contradict the foraminiferal evidence for an early Pliocene age for these sediments.

AGUEGUEXQUITE FORMATION

Beds which crop out on the north coast of the Isthmus of Tehuantepec, Mexico, are included in this study, because of faunal similarity to foraminiferal assemblages of the northern Gulf Coast and Atlantic Coastal Plain. Samples were collected by Harold E. and Emily H. Vokes from the lower part of the exposure, a dark gray clay, in a roadcut and quarry on Mexico Highway 180, 14 miles east of the junction with the road into Coatzacoalcos, Vera Cruz (TU 638). Perrilliat Montoya (1963) has described the mollusks from this area, and the beds have been variously considered as middle and upper Miocene in age (see also Contreras Velazquez, 1956, p. 52).

The predominant planktonic foraminifer at this locality is *Globigerinoides quadrilobatus quadrilobatus*. Additional forms were identified as listed below but are not illustrated.

Globigerina bulloides apertura Cushman
Globigerina bulloides bulloides d'Orbigny
Globigerina juvenilis Bolli
Globigerinoides obliquus extremus Bolli and Bermúdez
Globigerinoides obliquus obliquus Bolli
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny)
Globigerinoides ruber (d'Orbigny)
Globorotalia (Turborotalia) acostaensis acostaensis Blow
Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito
Globorotalia (Globorotalia) cultrata subspecies (dextral)
Hastigerina (Hastigerina) siphonifera siphonifera (d'Orbigny)
Orbulina universa d'Orbigny
Sphaeroidinella dehiscens dehiscens forma *immatura* (Cushman)

Benthonic foraminifera include forms reminiscent of late Pliocene and early Pleistocene species of the northern Gulf Coast (Akers and Dorman, 1964), especially *Angulogerina*

PLATE 6
ENCANTO FORMATION
TU 635

Figures Page

1. *Globigerina* sp. 11
Maximum diameter, 0.36 mm
a. Spiral view, X 129
b. Edge view, X 128
c. Umbilical view, X 128

2. *Globigerinoides quadrilobatus quadrilobatus* (d'Orbigny). 62
Maximum diameter, 0.56 mm
a. Spiral view, X 112
b. Edge view, X 112
c. Umbilical view, X 112

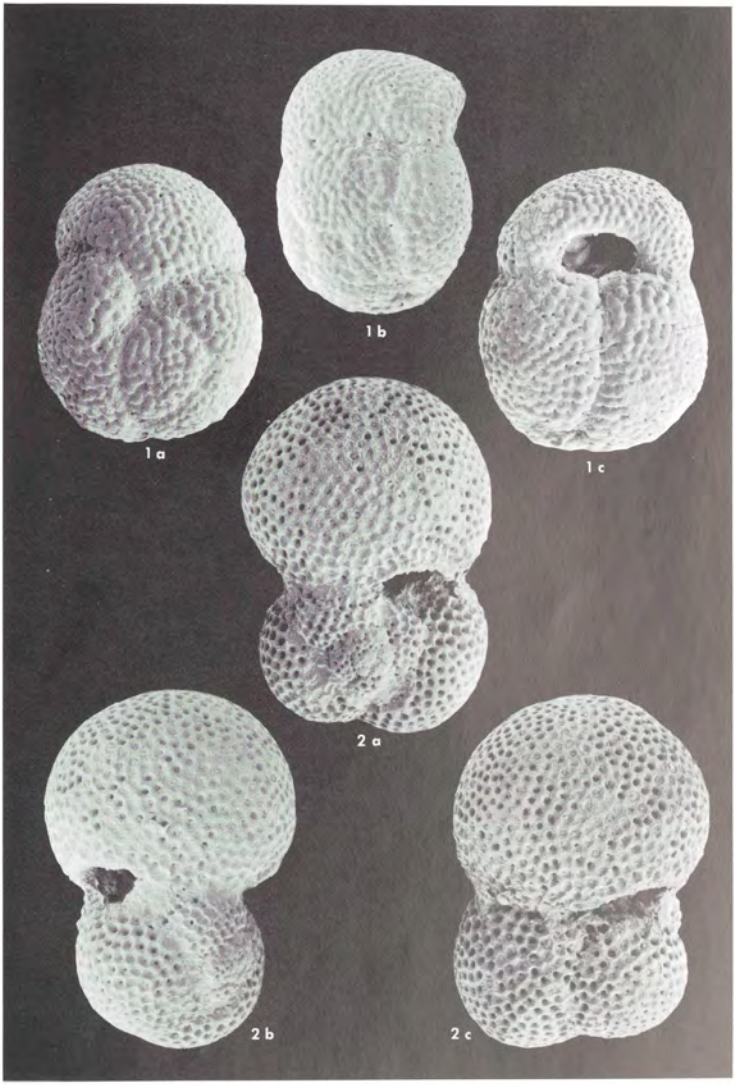

Plate 6

holcki Akers and Dorman, which, until this writing, has been identified only in the subsurface upper Pliocene-lower Pleistocene of Louisiana. The benthonic component is exceeded by the planktonic component of the assemblage, an anomaly (by northern Gulf of Mexico standards) in view of the large quantity of gravels and coarse sands in and interbedded with the clay.

Approximately 200 coccoliths occur per 20 mm of traverse (at X600) on calcareous nannoplankton slides. *Sphenolithus abies,* ubiquitous in upper Miocene to middle Pliocene sediments of pelagic origin, was not seen. *Discoaster brouweri, Discoaster pentaradiatus, Discoaster* cf. *Discoaster surculus, Discoaster variabilis,* and *Lithostromation perdurum* were identified. Rare, reworked Eocene species of *Discoaster* were observed.

The total assemblage of planktonic microfossils is suggestive of a middle to upper Pliocene age, and the presence of *Sphaeroidinella dehiscens dehiscens* forma *immatura* would seem to fix the exact position of the beds in Zone N. 19. *Globigerina bulloides apertura* has not been identified above Zone N. 19. The beds in at least this part of the Agueguexquite Formation are approximately correlative with the *Cancellaria* and *Ecphora* Faunizones of the Jackson Bluff Formation.

YORKTOWN FORMATION
Rice's Pit
Plates 47-51

This is TU 613 on Harris Creek Road, near junction with Fox Hill Road (State Highway 167), just off U. S. Highway 258, Hampton, Virginia.

Several Yorktown sites are included in this study of which the above contained the highest ratio of planktonic to benthonic foraminifera. Additional localities investigated for planktonic microfossils are listed in the Locality data at the end of this report.

The Yorktown Formation was defined by Clark and Miller (1906, pp. 19-20) and is composed of sands, clays, shell marl, and coquinas. It has been considered to be of late Miocene age by most workers. Thickness at the outcrop is as much as 145 feet. McLean (1956) has reviewed most of the paleontologic research on the formation and has recorded the benthonic foraminiferal species in the York-James Peninsula of Virginia. His account of the planktonic species is incomplete due to their scarcity at most localities and the sketchy taxonomy of this group before the present decade.

This investigation disclosed the following planktonic foraminifera at Rice's Pit:

Globigerina bulloides apertura Cushman, pl. 47, fig. 3
Globigerina bulloides bulloides d'Orbigny, pl. 47, fig. 1, 2

PLATE 7
ENCANTO FORMATION
TU 635

Figures

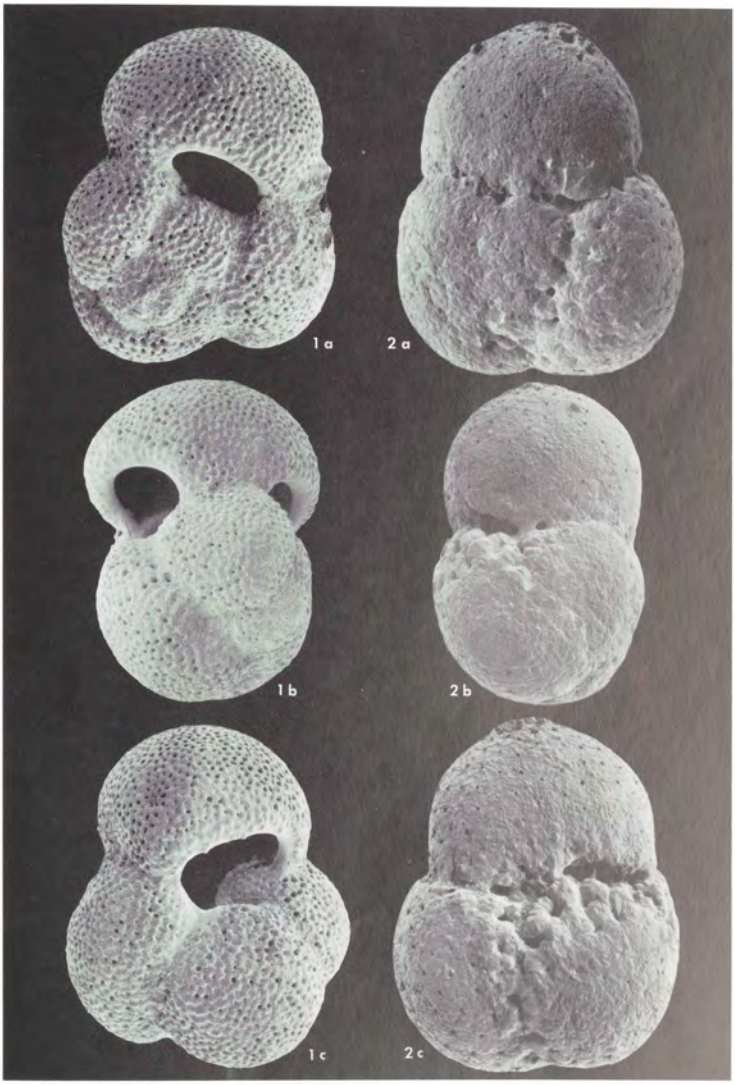

Plate 7

Globigerina juvenilis Bolli
Globigerinita glutinata (Egger)
Globigerinoides bollii Blow, pl. 48, fig. 2
Globigerinoides conglobatus conglobatus (Brady)
Globigerinoides obliquus extremus Bolli and Bermúdez, pl. 48, fig. 3
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny), pl. 49, fig. 1
Globigerinoides ruber (d'Orbigny), pl. 49, fig. 2
Globoquadrina conglomerata (Schwager)
Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito, pl. 48, fig. 1
Globorotalia (Globorotalia) cultrata subspecies, pl. 51, fig. 2
Globorotalia (Turborotalia) praeoscitans, new species, pl. 50, fig. 2; pl. 51, fig. 3
Globorotalia (Globorotalia) species, pl. 51, fig. 1
Hastigerina (Hastigerina) siphonifera siphonifera (d'Orbigny), pl. 50, fig. 1
Orbulina universa d'Orbigny
Sphaeroidinellopsis subdehiscens subdehiscens Blow, pl. 49, fig. 3

The predominant planktonic foraminifera at this locality, in order of highest frequency, are *Globigerina bulloides bulloides*, *Globorotalia (T.) acostaensis humerosa*, *Globigerinoides quadrilobatus quadrilobatus*, *Globigerinoides ruber*, and *Globigerina bulloides apertura*. Others are rare, one specimen to six specimens of each of the taxa having been found after 15 hours of searching through residues.

The calcareous nannoplankton here are small coccoliths (approximately 50 per 20 mm at X600) and occasional *Braarudosphaera bigelowi*. Discoasters are absent.

This type of calcareous nannofossil assemblage suggests not only a shallow environment of deposition but also temperatures lower than those so far seen in this investigation. Foraminiferal criteria support this conclusion in the predominance of *Globigerina bulloides bulloides* and the dearth of keeled *Globorotalia* specimens and species. Nevertheless, the planktonic foraminiferal assemblage is essentially a Jackson Bluff (late Choctawhatchee) one. The presence of *Globigerina bulloides apertura* precludes a zone later than Zone N. 19, and *Globoquadrina conglomerata* indicates a position later than at least the middle of Zone N. 18. *Globorotalia (Turborotalia) praeoscitans*, n. sp., has been seen only in Yorktown beds and in the Jackson Bluff Formation. The planktonic microfossil evidence argues strongly (1) for a correlation of the Yorktown Formation, at least that part exposed at Rice's Pit, with the Jackson Bluff Formation of north Florida and (2) that the circumglobal distributions of these taxa indicate an early to early middle Pliocene age for the Jackson Bluff and Yorktown Formations. Hazel (1971, p. 8) has

PLATE 8
ENCANTO FORMATION
TU 635

Figures Page

1. *Globoquadrina dehiscens* (Chapman, Parr, and Collins). 92
Maximum diameter, 0.36 mm
   a. Spiral view, X 179
   b. Edge view, X 167
   c. Umbilical view, X 180

2. *Globoquadrina altispira globosa* Bolli. 88
Maximum diameter, 0.52 mm
   a. Spiral view, X 125
   b. Edge view, X 120
   c. Umbilical view, X 125

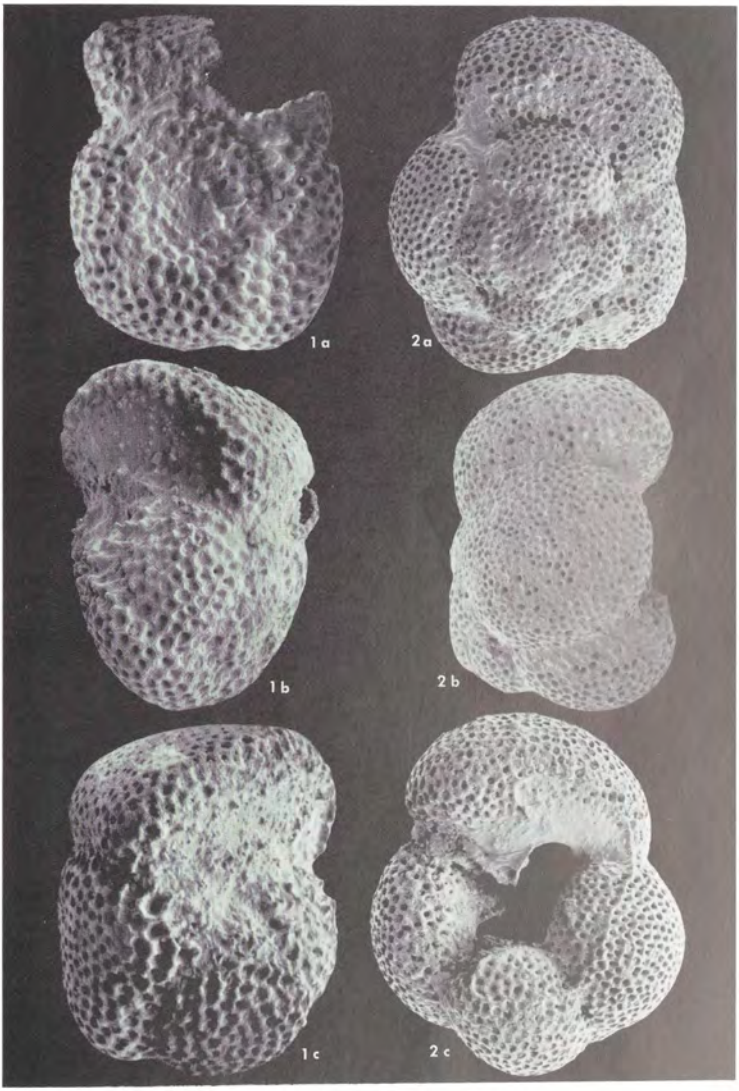

Plate 8

assigned portions of the Yorktown Formation to the early Pliocene and suggested that "the upper Miocene–lower Pliocene boundary in the Atlantic and Gulf Coastal Plain eventually will be revised further downward to include in the Pliocene more of the deposits that have been traditionally assigned to the upper Miocene."

Yorktown beds in the Lee Creek Mine at Aurora, North Carolina (see Locality data), have a planktonic assemblage of abundant individuals but relatively few species. The predominant species here is *Globigerina bulloides bulloides*. The second most frequently observed species is *Globorotalia (Turborotalia) praescitans*, n. sp. A few specimens of *Globorotalia (Turborotalia) acostaensis humerosa* were seen, and the following forms were rare:

Globigerinita glutinata (Egger)
Globigerinoides obliquus obliquus Bolli
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny)
Globigerinoides ruber (d'Orbigny)

The calcareous nannofossil assemblage is poor, as it is at Rice's Pit.

The planktonic microfossil assemblages are too impoverished here for a basis of exact correlation. The same may be said of TU 843 and the Lone Star Cement Pit, Chuckatuck, Virginia (see Locality data), where planktonic microfossils are rare.

WACCAMAW FORMATION
Plates 52-57

Planktonic foraminifera were obtained from the Waccamaw Formation at three localities, TU 558, TU 870, and TU 875, by examining 25 ml of material floated by means of tetrachloroethylene from each site. TU 558 is a pit locality at the north end of the runway at Crescent Beach Airport and south of the intracoastal waterway, South Carolina. TU 870 is also a pit site on the east side of North Carolina Highway 130, 2.8 miles north of "Old Dock School" and 0.6 miles north of intersection of road to Hallsboro, Columbus County, North Carolina. TU 875 is at Walker's Bluff on the west bank of the Cape Fear River, 9.5 miles south of Elizabethtown, North Carolina, via North Carolina Highway 87 and 1.5 miles through field of Mr. Monroe.

PLATE 9
ENCANTO FORMATION
TU 635

Figures

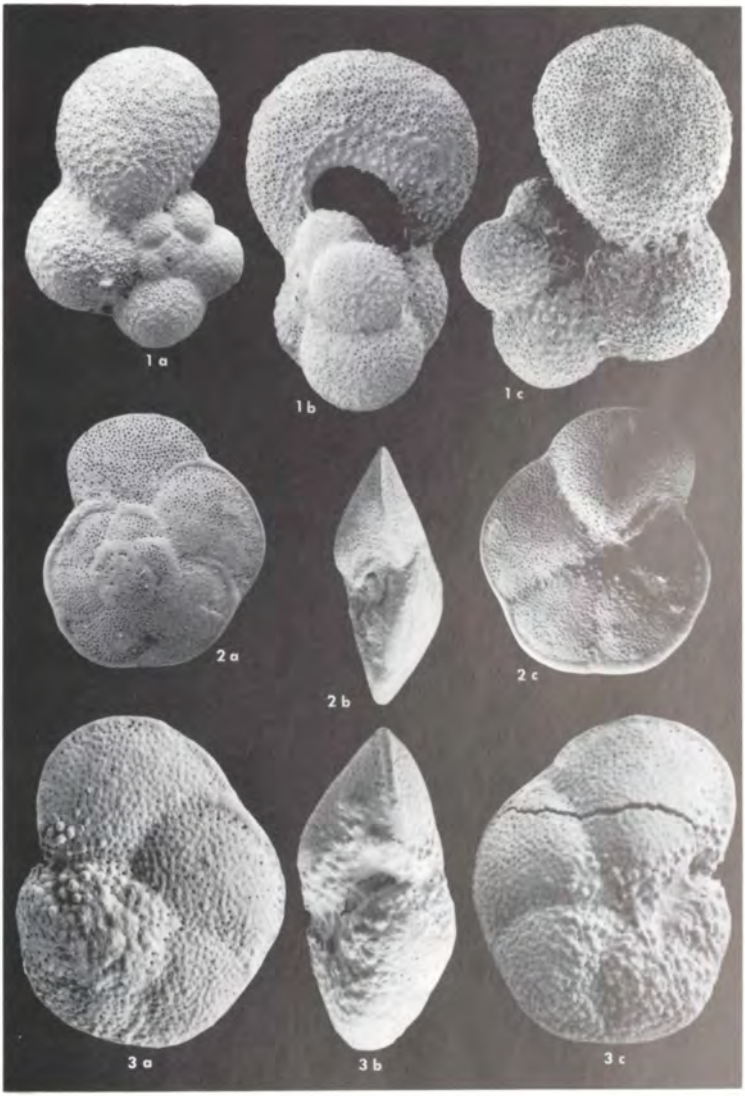

Plate 9

The Waccamaw Formation was named by Dall (1892, p. 209) for deposits approximately 25 feet in thickness, along the Waccamaw River in South Carolina. In southern North Carolina this formation consists mainly of medium to coarse quartz sands with pebbles, shell beds, and some clayey sand units. It overlies Cretaceous and Eocene sediments unconformably and is unconformably overlain by Pleistocene sands, gravels, and clays.

DuBar (1959) has regarded the Waccamaw and Croatan beds of the Carolinas as pre-Pamlico Pleistocene, although they had long been considered to be of Pliocene age (Cooke, Gardner, and Woodring, 1943). Richards (1969, p. 607) recently has expressed the opinion that the upper part of the Waccamaw and Croatan formations of the Carolinas and the upper part of the Caloosahatchee Formation of Florida "could be Pliocene or early Pleistocene." He believes that the lower part of these formations is definitely Pliocene, particularly the Caloosahatchee, on the basis of a high percentage of extinct molluscan species. The benthonic foraminifera at several Waccamaw localities indicated a late Miocene age to Gibson (1962, p. 22), who believed that this formation is contemporaneous with the Yorktown and Duplin formations.

DuBar (1959, p. 6) reviewed the Lyellian percentage method and assessed it as a spurious means of determining the precise age of a Cenozoic formation. He considered the Caloosahatchee, as well as the Waccamaw, to be Pleistocene, and Puri and Vernon (1964, p. 231) agreed with him in this conclusion.

The following planktonic foraminifera were found in the Waccamaw Formation at TU 875:

Globigerina borealis Brady
Globigerina bulloides bulloides d'Orbigny, pl. 52, fig. 4
Globigerina juvenilis Bolli, pl. 52, fig. 2
Globigerinita uvula (Ehrenberg), pl. 52, fig. 1
Globigerinoides obliquus obliquus Bolli, pl. 53, fig. 2
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny), pl. 53, fig. 3
Globigerinoides ruber (d'Orbigny), pl. 53, fig. 1
Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito, pl. 54, fig. 2
Globorotalia (Turborotalia) acostaensis pseudopima Blow
Globorotalia (Globorotalia) cultrata menardii (Parker, Jones and Brady), pl. 55, fig. 3
Globorotalia (Turborotalia) inflata (d'Orbigny), pl. 52, fig. 3
Globorotalia (Globorotalia) truncatulinoides (d'Orbigny), pl. 55, fig. 1
Globorotalia (Globorotalia) species, pl. 55, fig. 2
Globorotaloides hexagona hexagona (Natland)

PLATE 10
YELLOW RIVER FORMATION
COSSON FARM

Figures Page

1. *Globigerinoides obliquus obliquus* Bolli. 60
Maximum diameter (a-c), 0.50 mm

a. Spiral view, X 126
b. Umbilical view, X 126
c. Edge view, X 125
d. Umbilical view of another specimen, X 140. Maximum diameter, 0.34 mm

2. *Orbulina universa* d'Orbigny. 74
Maximum diameter, 0.48 mm

Part of test removed to show early *Globigerina* stage, X 126

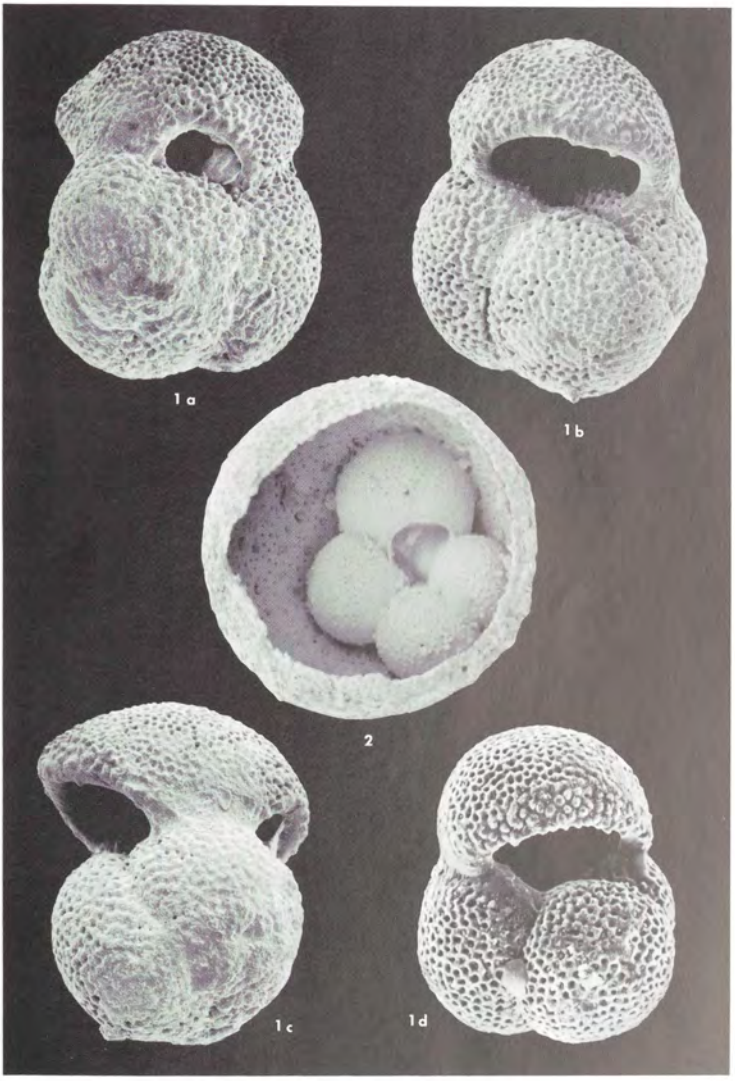

Plate 10

Hastigerina (Hastigerina) siphonifera siphonifera (d'Orbigny), pl. 54, fig. 1
Orbulina universa d'Orbigny

Planktonic foraminifera are rare in the Waccamaw Formation at TU 875. After approximately 100 hours of examination (by binocular microscope) of material floated by tetrachloroethylene from residues, however, 234 specimens of *Globigerinoides ruber* and 90 specimens of *Globigerinoides quadrilobatus quadrilobatus* were counted. Thirty-seven specimens of *Globorotalia (T.) acostaensis humerosa* were seen. A single *Globorotalia (G.) cultrata menardii* (sinistral) and two specimens of *Globorotalia truncatulinoides* were found. Low counts (1-5) were made of the remaining forms listed above.

Use of rare index fossils in the recognition of boundaries on an intercontinental scale is not an ideal approach in biostratigraphy, and yet several small pieces may be all that are needed to complete our understanding of the picture-puzzle. The environment of deposition of the Waccamaw Formation did not leave us any abundance of data, but several planktonic keys relate a version that is consistent with the total data.

Ericson, Ewing, and Wollin (1963), Akers (1965), and Poag and Akers (1967) proposed that *Globorotalia (G.) truncatulinoides* occurs in abundance only above the Pliocene-Pleistocene boundary. This conclusion seemed appropriate for at least the Gulf of Mexico and the Atlantic Ocean. Additional work on deepsea cores from the Pacific (Parker, 1967) and the Gulf of Mexico (Lamb, 1969) suggests strongly that the evolutionary first-occurrence of this species is above the boundary. This interpretation is tenable if we conclude that sporadic and rare occurrences of *Globorotalia (G.) truncatulinoides* below the boundary are not valid and represent contamination in the coring process. Both Bayliss (1969) and Lamb (1969) report that this species appears for the first time above the base of the Calabrian in the type area of the Calabrian at Santa Maria di Catanzaro in southern Italy.

The single sinistrally coiled *Globorotalia (G.) cultrata menardii* found here (pl. 55, fig. 3) corresponds morphologically with the "single fairly uniform race above the boundary" (Ericson, *et al.*, 1963). The specimen also resembles those found above the boundary in the northern Gulf of Mexico

PLATE 11
YELLOW RIVER FORMATION
COSSON FARM

Figures Page

1. *Globoquadrina altispira globosa* Bolli. 88
Maximum diameter, 0.57 mm
   a. Spiral view, X 98
   b. Umbilical view, X 99
   c. Edge view, X 99

2. *Globigerinoides quadrilobatus quadrilobatus* (d'Orbigny). 62
Maximum diameter, 0.51 mm
   a. Spiral view, X 105
   b. Umbilical view, X 105

3. *Globigerinoides quadrilobatus quadrilobatus* (d'Orbigny). 62
Maximum diameter, 0.69 mm
   a. Spiral view, X 92
   b. Edge view, X 91
   c. Umbilical view, X 93

Plate 11

both in coiling direction and test morphology (Akers, 1965). *Globorotalia (T.) acostaensis pseudopima* and *Globigerina borealis* point to a Quaternary or late Pliocene age.

Since *Globigerinoides obliquus obliquus* becomes extinct within Zone N. 22 (Blow, 1969), the presence of this form precludes a middle Pleistocene to Holocene age. The species discussed above, then, especially *Globorotalia (G.) truncatulinoides*, which precludes a pre-Quaternary age, indicate that the Waccamaw at this locality is early Pleistocene in age (the later part of Zone N. 21 to the early part of Zone N. 22).

The material from TU 875 is a composite sample from an interval of ten feet. The association of *Globorotalia (G.) cultrata menardii* with *Globorotalia (T.) inflata* suggests that both a warm and a cool stage are represented in this interval. It must be pointed out that the beds at TU 875 are not necessarily the same age as sediments at other localities which have been assigned to the Waccamaw. It is possible, too, that the Caloosahatchee Formation is older than this material.

TU 870 is similar faunally to TU 875. Calcareous nannoplankton are rare at both sites, and the frequency of planktonic foraminifera is about the same, although *Globorotalia (G.) cultrata menardii* and *Globorotalia (G.) truncatulinoides* were not identified at TU 870. It is, therefore, not possible to be so specific as to the age of the beds at TU 870. They may be the same age as at 875, but this cannot be confirmed as yet.

The following planktonic foraminifera occur in the Waccamaw Formation at TU 870:

Globigerina borealis Brady
Globigerina bulloides bulloides d'Orbigny, pl. 57, fig. 3
Globigerina juvenilis Bolli
Globigerinita glutinata (Egger)
Globigerinita uvula (Ehrenberg)
Globigerinoides conglobatus conglobatus (Brady)
Globigerinoides obliquus obliquus Bolli, pl. 56, fig. 1
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny), pl. 56, fig. 2
Globigerinoides ruber (d'Orbigny), pl. 56, fig. 3
Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito, pl. 57, fig. 1

PLATE 12
YELLOW RIVER FORMATION
COSSON FARM

Figures

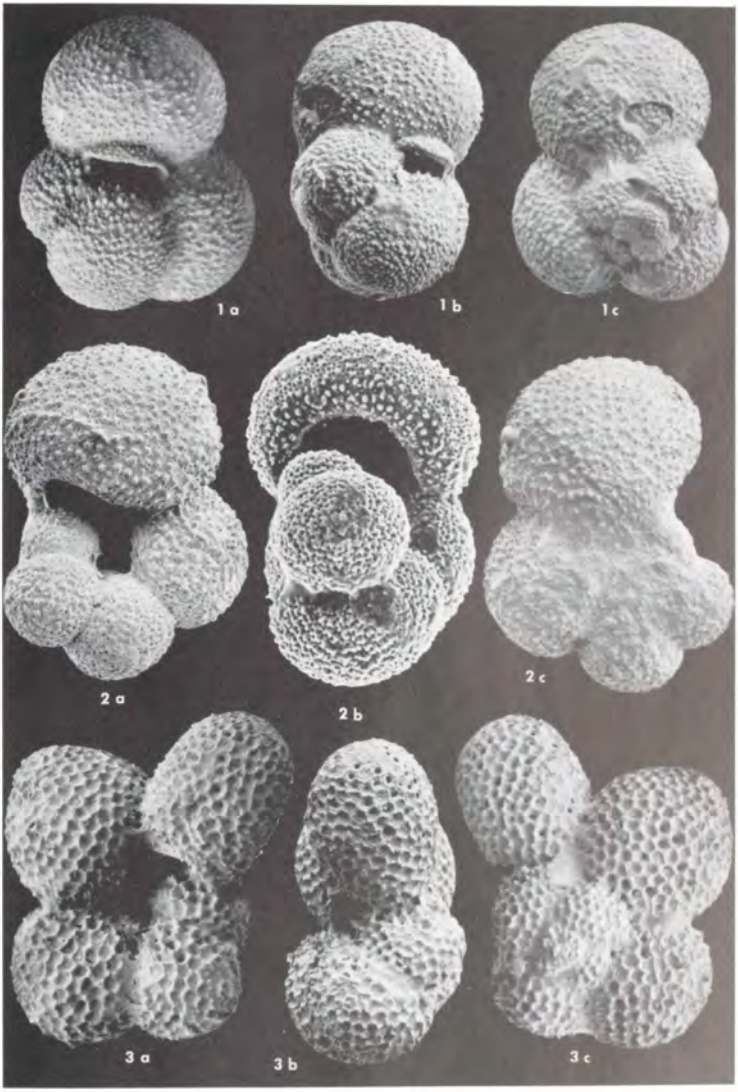

Plate 12

Globorotalia (Turborotalia) inflata (d'Orbigny), pl. 57, fig. 2
Orbulina universa d'Orbigny

Planktonic foraminifera are rare at TU 558, only four specimens having been found. Three of these represent *Globigerinoides ruber* (d'Orbigny), and the fourth is *Globigerinita glutinata* (Egger).

MOÍN FORMATION
Plates 58-60

Harold E. and Emily H. Vokes provided the writer with material from their locality, TU 954, a hill-cut behind the Standard Fruit Company box factory, just west of Cemetery Pueblo Neuvo, about two km west of Limon, Costa Rica. Sands and clays of unknown thickness here contain abundant mollusks. Gabb (1895, p. 80) named the formation and considered it post-Pliocene. It is interesting that subsequent workers interpreted the molluscan fauna as Pliocene in age and suggested that Gabb had mistranslated into Spanish the term "post-Pliocene" for "later Pliocene." Harold E. and Emily H. Vokes (personal communication) consider the molluscan assemblage to be of Pleistocene age.

The following planktonic foraminifera were identified in the Moín Formation at TU 954:

Globigerinoides conglobatus conglobatus (Brady), pl. 58, fig. 1, 2
Globigerinoides obliquus obliquus Bolli, pl. 58, fig. 3
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny), pl. 59, fig. 1
Globigerinoides quadrilobatus sacculifer (Brady), pl. 59, fig. 2
Globigerinoides ruber (d'Orbigny), pl. 58, fig. 4
Globoquadrina dutertrei (d'Orbigny), pl. 60, fig. 2
Hastigerina (Hastigerina) siphonifera siphonifera (d'Orbigny), pl. 60, fig. 1
Orbulina universa d'Orbigny
Pulleniatina obliquiloculata obliquiloculata (Parker and Jones), pl. 60, fig. 3
Sphaeroidinella dehiscens dehiscens (Parker and Jones), pl. 59, fig. 3

Globigerinoides quadrilobatus quadrilobatus is the predominant planktonic foraminifer here. At least three specimens of the other

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PLATE 13
YELLOW RIVER FORMATION
COSSON FARM

Figures Page

1. *Globorotalia (Globorotalia) cultrata menardii* (Parker, Jones and Brady). 98
Maximum diameter, 0.43 mm
   a. Spiral view, X 127
   b. Edge view, X 127
   c. Umbilical view, X 126

2. *Globorotalia (Turborotalia) minima* Akers. 114
Maximum diameter, 0.26 mm
   a. Spiral view, X 195
   b. Edge view, X 193
   c. Umbilical view, X 196

3. *Globorotalia (Turborotalia) siakensis* (LeRoy). 122
Maximum diameter, 0.39 mm
   a. Spiral view, X 147
   b. Edge view, X 147
   c. Umbilical view, X 147

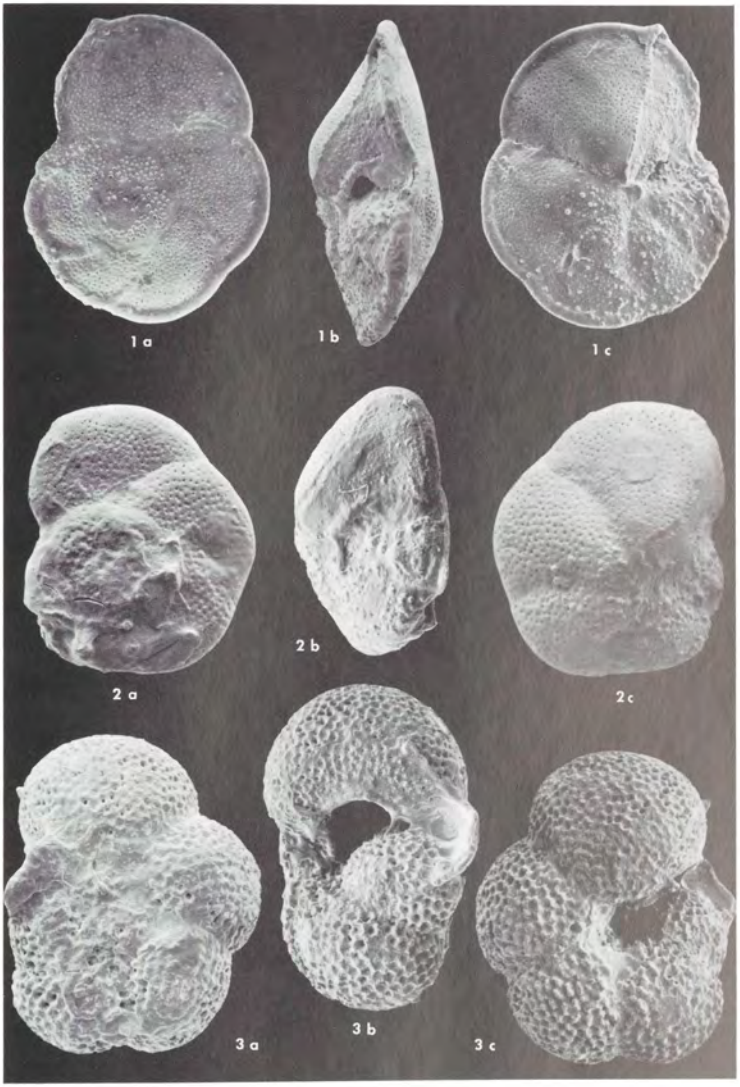

Plate 13

taxa listed above were found. It is curious that no representatives of *Globorotalia* were seen, although the assemblage is otherwise a tropical one.

Several of the forms listed above appear for the first time in Pliocene sediments, but they are not found in higher frequencies below the Pleistocene. *Globoquadrina dutertrei* is one of these, and it is not typically developed until the lower Quaternary (Parker, 1967, p. 168). The high frequency of *Pulleniatina obliquiloculata obliquiloculata* and *Sphaeroidinella dehiscens dehiscens* (with the exclusion of *Sphaeroidinellopsis*) are indicative of the Quaternary, although these taxa are reported to have an origin in the Pliocene (Zone N. 19). The benthonic foraminifera are of modern aspect, all of the species occuring in the late Quaternary assemblages of the Mississippi River Mudlumps (Andersen, 1961).

Calcareous nannofossils are in low frequency. Discoasters are absent, and even small coccoliths are rare. The absence of discoasters suggests a post-Pliocene age, but their absence might also be due to unfavorable environmental factors.

The writer believes that the Moín Formation at TU 954 is of early Pleistocene age. This interpretation is reconcilable with all faunal data available and best fits the planktonic microfossil data as herein reviewed.

VI. SYSTEMATIC PALEONTOLOGY

Order FORAMINIFERIDA Eichwald, 1830

Superfamily GLOBIGERINACEA Carpenter, Parker and Jones, 1862

Family GLOBIGERINIDAE Carpenter, 1862

Genus GLOBIGERINA d'Orbigny, 1826

GLOBIGERINA BOREALIS Brady

Globigerina bulloides d'Orbigny, "arctic variety," BRADY, 1878, Ann. Mag. Nat. Hist. (ser. 5), vol. 1, p. 435, pl. 21, figs. 10a-c.

Globigerina bulloides d'Orbigny variety *borealis* BRADY, 1881, Ann. Mag. Nat. Hist. (ser. 5), vol. 8, no. 48, p. 412, (no figure).

Globigerina bulloides d'Orbigny var. *borealis* Brady. BRADY, 1882, Roy. Soc. Edinburgh, Proc., vol. 11, (1880-1882), no. 111, p. 716, (no figure).

PLATE 14
RED BAY FORMATION ?
BLOUNT'S CREEK

Figures Page

1. *Globigerina nepenthes* Todd. 52
Maximum diameter, 0.33 mm
   a. Umbilical view, X 146
   b. Spiral view, X 145

2. *Sphaeroidinellopsis seminulina seminulina* (Schwager). 84
Maximum diameter, 0.64 mm
   a. Umbilical view, X 91
   b. Spiral view, X 90

3. *Globigerina* cf. *G. druryi decoraperta* Takayanagi and Saito. 50
Maximum diameter, 0.33 mm
   a. Umbilical view, X 170
   b. Spiral view, X 168

4. *Globigerina bulloides bulloides* d'Orbigny. 48
Maximum diameter, 0.46 mm
   a. Spiral view, X 126
   b. Umbilical view, X 127

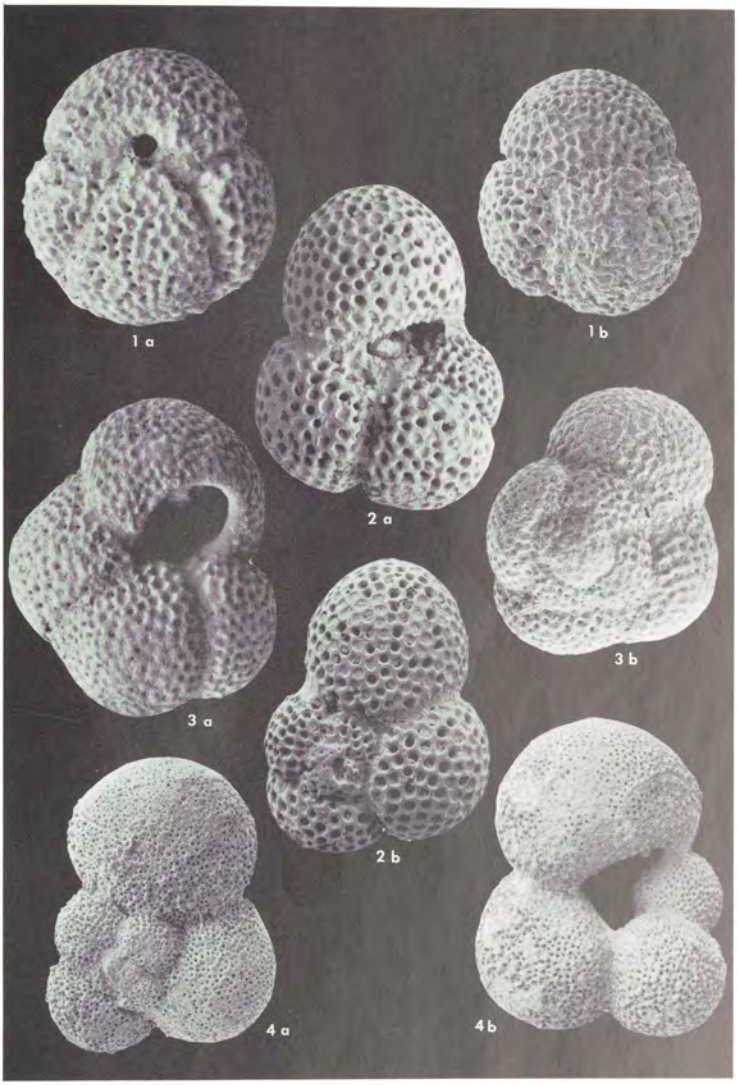

Plate 14

Globigerina pachyderma (Ehrenberg). BRADY, 1884, Rept. Voy. *Challenger*, Zool., vol. 9, p. 600, pl. 114, figs. 19, 20. (?non *Aristerospira pachyderma* Ehrenberg 1861).

Globigerina bulloides d'Orbigny var. *borealis* Brady. BANNER and BLOW, 1960, Cushman Found. Foram. Res., Contr., vol. 11, pp. 4-5, pl. 3, figs. 4a-c (lectotype designated).

Globigerina borealis Brady. BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 316 (no figure).

"The small tumid trochoid test consists of a fairly rapidly enlarging series of about 14 chambers arranged in about 3 whorls. The trochospire is low and consequently the dorsal surface is only slightly convex. The chambers are uniformly inflated but partially embracing and considerably appressed. About 4 chambers are present in the last whorl with the earlier whorls having about 5 chambers. The equatorial profile is subcircular to ovate and the equatorial periphery is weakly lobulate. The axial profile is suboval and the axial periphery smoothly rounded. The umbilicus is very small, almost closed, but depressed. The dorsal sutures are initially obscure but in the last whorl both the spiral and intercameral sutures are slightly depressed and fairly distinct. The later dorsal intercameral sutures are radial, meeting the spiral suture almost at right angles. The ventral sutures are distinct, slightly depressed and nearly radial. The aperture is a long low arch, interiomarginal, umbilical in position, not totally restircted to the deepest part of the umbilical depression. The aperture is bordered by a greatly thickened and broad rim. The test wall is uniformly and finely perforate and is characteristically thick. The test surface is practically smooth with only traces of an original fine hispidity. Maximum diameter of lectotype: 0.31 mm." (Banner and Blow, 1960)

Lectotype: British Museum (Natural History) 1959.7.1.1; collected by the North Polar Expedition of 1875-76, from the most northern sounding, 83° 19' N., depth 72 fathoms, and identified by Brady.

Discussion: Few specimens were identified in this investigation that are referable to this species. A single specimen from the Waccamaw (TU 875, Walker's Bluff, Bladen County, North Carolina) is typical.

The writer follows Blow in the choice of this taxon over "*Globigerina pachyderma* (Ehrenberg)" of some workers. Forms identical to the lectotype are said to range from within Zone N. 20 to Zone N. 23.

GLOBIGERINA BULLOIDES APERTURA
Cushman

Pl. 19, fig. 1; Pl. 21, fig. 3;
Pl. 30, fig. 1; Pl. 31, fig. 1;
Pl. 37, fig. 1; Pl. 42, fig. 1;
Pl. 47, fig. 3

Globigerina apertura CUSHMAN, 1918, U. S. Geol. Surv., Bull. 676, p. 57, pl. 12, figs. 8a-c.

PLATE 15
RED BAY FORMATION ?
BLOUNT'S CREEK

Figures Page

1. *Globoquadrina altispira globosa* Bolli. 88
Maximum diameter, 0.45 mm
   a. Spiral view, X 136
   b. Umbilical view, X 140

2. *Globigerinita uvula* (Ehrenberg). 72
Maximum diameter, 0.30 mm
   a. Apertural view, X 172
   b. Opposite view, X 168

3. *Globoquadrina dehiscens* (Chapman, Parr, and Collins). 92
Maximum diameter, 0.45 mm
   a. Umbilical view, X 126
   b. Spiral view, X 122
   c. View of wall (spiral side), X 630

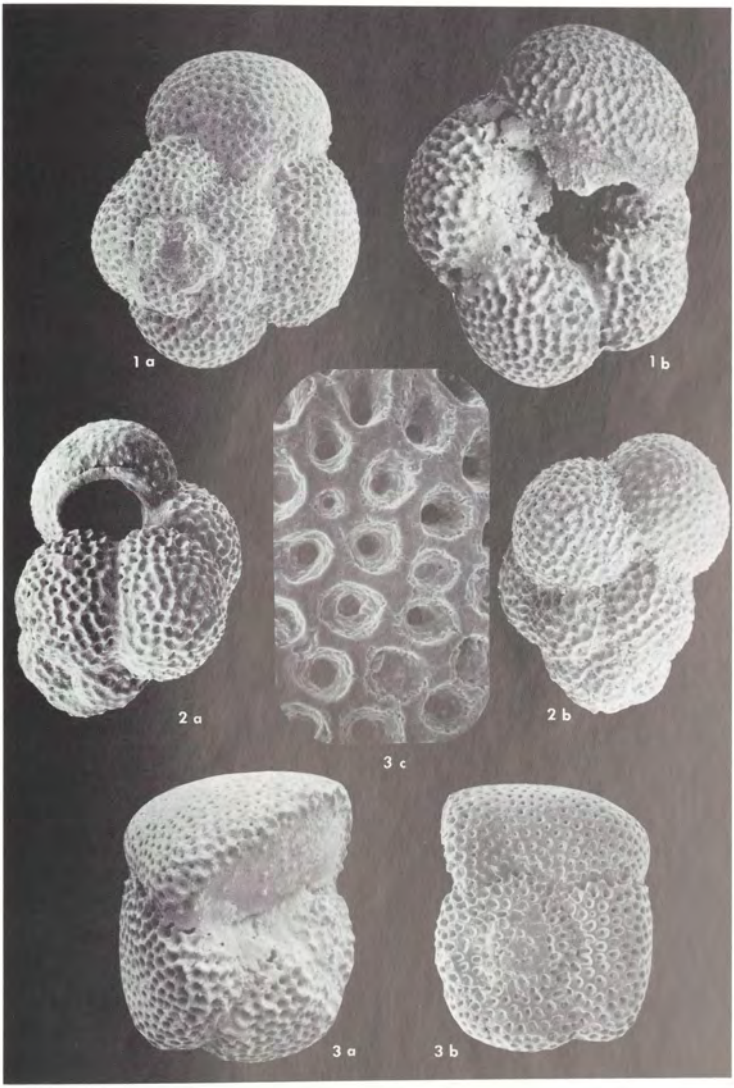

Plate 15

Globigerina apertura Cushman. BLOW, 1959, Bull. Amer. Paleontology, vol. 39, no. 178, pp. 172, 173, pl. 8, figs. 55a-b.

Globigerina riveroae BOLLI and BERMÚDEZ, 1965, Boletin Informativo, Asociacion Venezolana de Geologia, Min. y Pet., vol. 8, no. 5, pp. 137, 138, pl. 1, figs. 1-6.

Globigerina bulloides apertura Cushman. BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 317, pl. 12, fig. 8.

"Test spiral, depressed, all the chambers visible from the dorsal side, the four chambers making the last-formed coil visible from the ventral side chambers rapidly increasing in size; aperture very large, semicircular, opening into the central umbilical cavity. Diameter, 0.50 mm. This species may be distinguished by its extremely large semicircular aperture, compressed test, and few chambers." (Cushman, 1918)

Holotype: USNM 325323; Yorktown Formation, Suffolk, Virginia.

Discussion: Range is from Zone N. 16 to Zone N. 19 and questionably the early part only of Zone N. 20, according to Blow.

GLOBIGERINA BULLOIDES BULLOIDES d'Orbigny

Pl. 14, fig. 4; Pl. 30, fig. 2; Pl. 31, fig. 2, Pl. 34, fig. 1; Pl. 37, fig. 3; Pl. 41, fig. 1; Pl. 47, figs. 1, 2; Pl. 52, fig. 4; Pl. 57, fig. 3

"Polymorphium tuberosum et globiferum" SOLDANI, 1791 (part), Testaceogr. ac Zoophytogr., vol. 1, pt. 2, p. 117, pl. 123, fig. 0 (not figs. H, I, and P, according to Banner and Blow, 1960, p. 3).

Globigerina bulloides D'ORBIGNY, 1826, Ann. Sci. Nat. (ser. 1), vol. 7, p. 277, list No. 1.

Globigerina bulloides d'Orbigny. BANNER and BLOW, 1960, Cushman Found. Foram. Res., Contr., vol. 11, pp. 3-4, pl. 1, figs. 1a-c (lectotype), 4.

Globigerina bulloides d'Orbigny. PARKER, 1962, Micropaleontology, vol. 8, no. 2, p. 221, pl. 1, figs. 1-8.

Globigerina bulloides bulloides d'Orbigny. BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, pp. 316-317, pl. 14, figs. 1, 2.

PLATE 16
RED BAY FORMATION ?
BLOUNT'S CREEK

Figures

Page

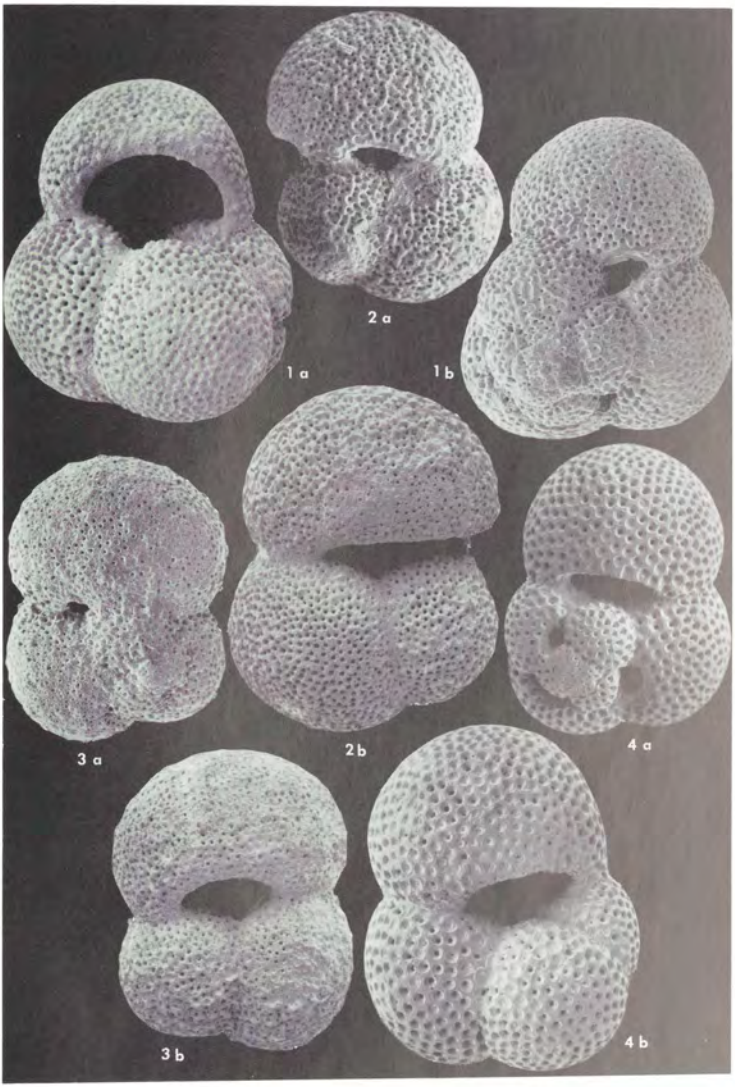

Plate 16

"The small tumid trochoid test consists of a fairly rapidly enlarging series of about 14 chambers arranged in about 3 whorls. The trochospire is low and consequently the dorsal surface is only slightly convex. The chambers are uniformly inflated but partially embracing and considerably appressed. About 4 chambers are present in the last whorl with the earlier whorls having about 5 chambers. The equatorial profile is sub-circular to ovate and the equatorial periphery is weakly lobulate. The axial profile is sub-oval and the axial periphery smoothly rounded. The umbilicus is very small, almost closed, but depressed. The dorsal sutures are initially obscure but in the last whorl both the spiral and intercameral sutures are slightly depressed and fairly distinct. The later dorsal intercameral sutures are radial, meeting the spiral suture almost at right angles. The ventral sutures are distinct, slightly depressed and nearly radial. The aperture is a long low arch, interiomarginal, umbilical in position, not totally restricted to the deepest part of the umbilical depression. The aperture is bordered by a greatly thickened and broad rim. The test wall is uniformly and finely perforate and is characteristically thick. The test surface is practically smooth with only traces of an original fine hispidity. Maximum diameter of lectotype: 0.31 mm." (Banner and Blow, 1960)

Lectotype: Muséum National de l'Historie Naturelle, Paris, 12309; collection of Alcide d'Orbigny, labelled "Subappenin, Rimini."

Discussion: Blow believes that "*Globigerina praebulloides praebulloides* Blow gives rise to *Globigerina bulloides bulloides* within Zone N. 16."

GLOBIGERINA DRURYI DECORAPERTA Takayanagi and Saito

Pl. 14, fig. 3; Pl. 29, fig. 1;
Pl. 31, fig. 3; Pl. 34, fig. 3;
Pl. 37, fig. 2

Globigerina druryi Akers *decoraperta* TAKAYANAGI and SAITO, 1962, Sci. Repts. Tohoku Univ., ser. 2 (Geology), Spec. vol. no. 5, p. 85, pl. 28, fig. 10.

Globigerina decoraperta Takayanagi and Saito. PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, p. 149, pl. 19, figs. 1a-c, not fig. 2.

"Test small, trochospiral, equatorial periphery lobulate, axial periphery broadly rounded; chambers spherical, about 12, arranged in about three whorls, increasing rather rapidly in size, last chamber somewhat protruded in radial direction; sutures rather distinct, depressed, nearly radial on both sides; wall calcareous, perforate, surface pitted; aperture a medium-sized, fairly high, symmetrical arch with a slightly thickened rim, interiomarginal and umbilical in position, placed rightly on opposite sides of

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PLATE 17
RED BAY FORMATION ?
BLOUNT'S CREEK

Figures — Page

1. *Globorotalia (Turborotalia) acostaensis acostaensis* Blow. 106
Maximum diameter, 0.29 mm
   a. Umbilical view, X 166
   b. Spiral view, X 165

2. *Globorotalia (Globorotalia) cultrata menardii* (Parker, Jones and Brady). 98
Maximum diameter, 0.40 mm
   a. Umbilical view, X 137
   b. Spiral view, X 137

3. *Hastigerina (Hastigerina) siphonifera siphonifera* (d'Orbigny). 124
Maximum diameter, 0.52 mm
   a. Spiral view, X 126
   b. Peripheral view, X 125

4. *Globorotalia (Turborotalia) acostaensis humerosa* Takayanagi and Saito. 108
Maximum diameter, 0.36 mm
   a. Umbilical view, X 158
   b. Spiral view, X 158

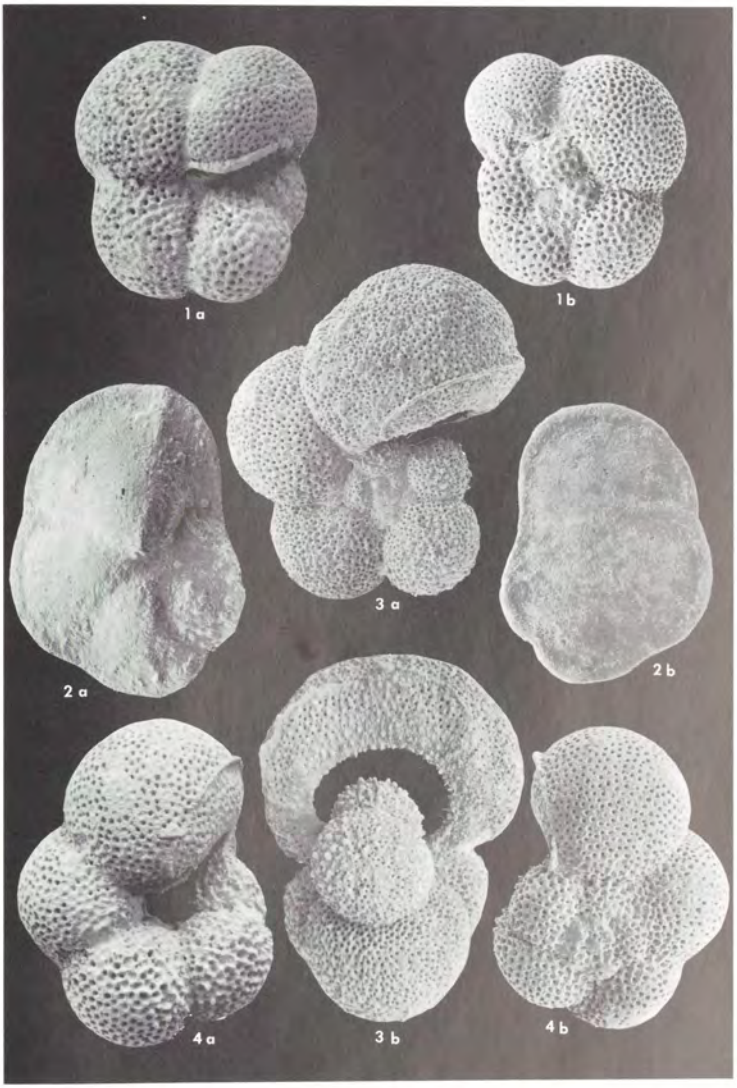

Plate 17

antepenultimate chamber. Coiling of the tests is nearly random, but with slight preference to left in direction. Maximum diameter of holotype 0.26 mm, thickness 0.19 mm. Other specimens range from 0.17 to 0.27 mm in maximum diameter." (Takayanagi and Saito, 1962)

Holotype: IGPS 75070; Nobori Formation, Shikoku, Japan.

Discussion: Blow (1969, p. 318) gives Zone N. 14 (? later part Zone N. 13) to Zone N. 21 as the range of this form.

GLOBIGERINA JUVENILIS Bolli

Pl. 12, fig. 1; Pl. 19, fig. 5; Pl. 52, fig. 2

Globigerina juvenilis BOLLI, 1957, U. S. Natl. Mus., Bull. 215, p. 110, pl. 24, figs. 5a-6.

Globigerina juvenilis Bolli. BLOW, 1959, Bull. Amer. Paleontology, vol. 39, no. 178, p. 178, pl. 10, figs. 43a-b.

Globigerina juvenilis Bolli. BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 320, pl. 17, figs. 5, 6 (metatype).

"Shape of test moderately to distinctly trochospiral; equatorial periphery distinctly lobate. Wall calcareous, perforate, surface smooth to very finely pitted. Chambers spherical to ovate; about 12, arranged in about 3 whorls; the 3-4 chambers of the last whorl increase rapidly in size. Sutures on spiral side curved to radial in the early stage, radial in the last whorl, depressed; on umbilical side radial, depressed. Umbilicus very small. Aperture a low elongate slit, often with a thin lip; interiomarginal, umbilical. Coiling random. Largest diameter of holotype: 0.29 mm." (Bolli, 1957)

Holotype: USNM P5617; from the type section of the *Globorotalia fohsi robusta* Zone, Trinidad.

Discussion: Specimens from Florida compare closely with Blow's specimens from eastern Falcon. Compare his Stereoscan illustrations (Blow, 1969, pl. 17, figs. 5, 6) with those in this report. Relationship is yet to be resolved with *Globigerinita glutinata* (Egger) and *Globigerinita naparimaensis* Bronnimann. The range of *Globigerina juvenilis* is from the base of Zone N. 4 to Zone N. 23 (Blow, 1969).

GLOBIGERINA NEPENTHES Todd

Pl. 14, fig. 1

Globigerina nepenthes TODD, 1957, U. S. Geol. Survey, Prof. Paper 280-H, p. 301, pl. 78, figs. 7a-b.

Sphaeroidinellopsis nepenthes (Todd) var. *constricta* BERMÚDEZ, 1961, Mem. III Congr. Geol. Venezolano, vol. 3, Bol. Geol. Publ. esp. 3 (1960), p. 1278, pl. 10, figs. 2a-b.

Globigerina nepenthes Todd. POAG and AKERS, 1967, Cushman Found. Foram. Res., Contr. vol. 18, pt. 4, p. 170, pl. 16, figs. 1-12.

Globigerina nepenthes Todd. BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 320, pl. 14, fig. 5.

PLATE 18
JACKSON BLUFF FORMATION
ALUM BLUFF, BED 4

Figures Page

1. *Globigerinoides quadrilobatus quadrilobatus* (d'Orbigny). 62
Maximum diameter, 0.44 mm
   a. Spiral view, X 134
   b. Umbilical view, X 133

2. *Globigerinoides obliquus obliquus* Bolli. 60
Maximum diameter, 0.37 mm
   a. Spiral view, X 162
   b. Umbilical view, X 162

3. *Globigerinoides ruber* (d'Orbigny). 66
Maximum diameter, 0.41 mm
   a. Spiral view, X 155
   b. Umbilical view, X 152

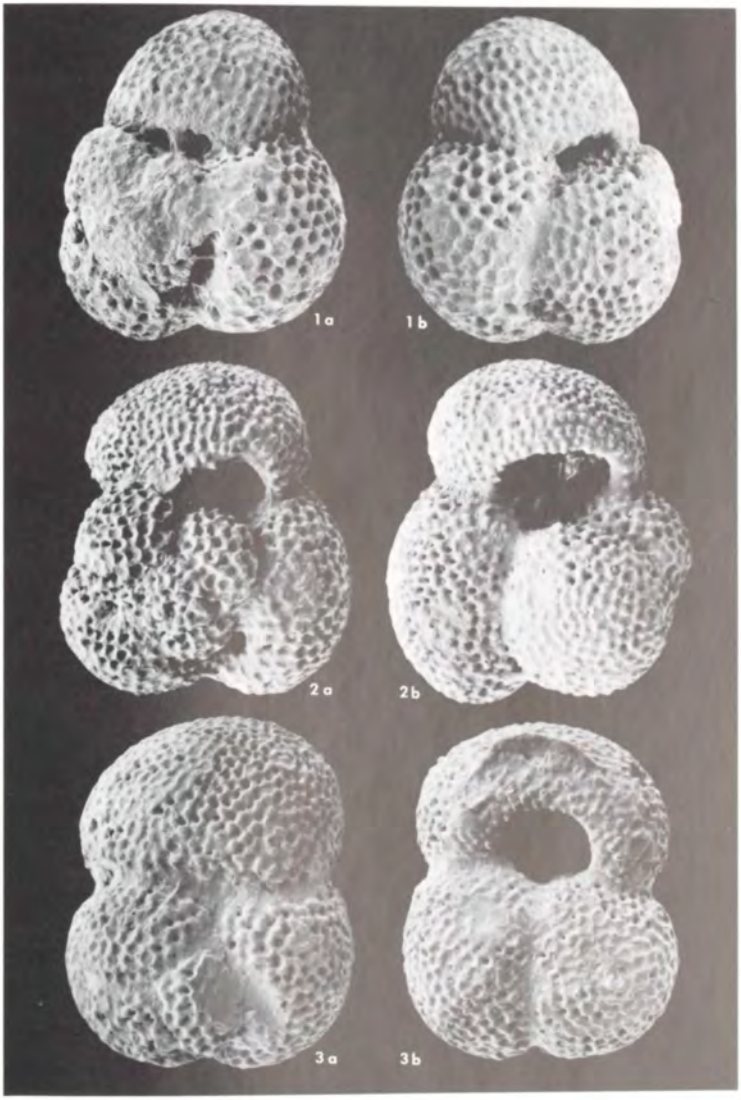

Plate 18

"Test small, compactly coiled except for the last-formed protruding chamber; height of spire ranges between three-quarters of and equal to diameter of spire. Chambers indistinct, slightly inflated; four chambers constituting the last whorl, with a fifth elongate chamber extending downward and at an angle to the axis of coiling. Sutures indistinct, except the last few which are indented. Wall thin, calcareous, perforate, ornamented by a rather coarse cancellation. Aperture large and semicircular or broad and arched at the umbilical edge of the protruding chamber, bordered by a thickened and slightly upturned lip of clear shell material. Diameter exclusive of protruding chamber 0.30-0.37 mm; greatest dimension of test 0.42-0.58 mm." (Todd, 1957)

Holotype: USNM 624037; Tagpochau Limestone, Donni Sandstone Member, east-central Saipan, Mariana Islands.

Discussion: Blow regards the range of this species to be from the base of Zone N. 14 to approximately the boundary between Zones N. 19 and N. 20.

Genus GLOBIGERINOIDES Cushman, 1927

GLOBIGERINOIDES BOLLII Blow

Pl. 22, fig. 2; Pl. 48, fig. 2

Globigerinoides bollii BLOW, 1959, Bull. Amer. Paleontology, vol. 39 no. 178, pp. 189-191, pl. 10, figs. 65a-c.

Globigerinoides bollii Blow. PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, pp. 153-154, pl. 20, figs. 1, 2.

Globigerinoides bollii Blow. BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 324, pl. 20, figs. 2, 3.

"Test trochospiral with four chambers in the last whorl; equatorial periphery lobate; axial periphery rounded; chambers subspherical or ovate, much embracing; sutures of the spiral and umbilical sides depressed but often indistinct, radial to slightly curved; umbilicus small, often almost completely closed; primary aperture interiomarginal, umbilical, the opening almost completely circular but generally rather small; supplementary apertures on the spiral

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PLATE 19
JACKSON BLUFF FORMATION
ALUM BLUFF, BED 4

Figures

Plate 19

side, sutural, small; usually only one present, situated in the suture between the last chamber and its predecessor, although an additional supplementary aperture may be present in the suture between the penultimate and the antepenultimate chambers; wall calcareous, perforate, often rather thick; maximum diameter of holotype, 0.34 mm." (Blow, 1959)

Holotype: USNM 625717; Pozón Formation, eastern Falcón, Venezuela.

Discussion: Specimens from the Blount's Creek site are typical. The range is from "early to middle parts of Zone N. 11 to within Zone N. 21" (Blow, 1969).

GLOBIGERINOIDES CONGLOBATUS CONGLOBATUS (Brady)

Pl. 24, figs. 1, 2; Pl. 58; figs. 1, 2

Globigerina conglobata BRADY, 1879, Quart. Jour. Micr. Science, (new ser.), vol. 19, p. 286.

Globigerina conglobata Brady. BRADY, 1884, Rept. Voy. *Challenger*, Zoology, vol. 9, p. 603, pl. 80, figs. 1-5; pl. 82, fig. 5.

Globigerina conglobata Brady. BANNER and BLOW, 1960, Cushman Found. Foram. Res., Contr., vol. 11, p. 6, pl. 4, fig. 4 (lectotype).

"The shape of the large test is subglobular to subquadrate. In axial profile the dorsal surface is convex and the axial periphery is broadly rounded. The equatorial periphery is weakly lobate. The chambers are coiled in a fairly low but tight trochospire consisting of approximately three whorls. The chambers are initially reniform but later becoming narrowly lunate in dorsal aspect. The later chambers are characteristically strongly depressed, slightly embracing but moderately inflated. There are about 4 1/2 chambers in the earlier whorls reducing to 3 1/2 chambers in the last whorl. The dorsal spiral and intercameral sutures are initially obscure but become distinctly narrowly depressed during ontogeny, so much so that the later formed sutures appear deeply incised and the chambers "bevelled." Four chambers are visible ventrally and the sutures between them are distinct, narrowly depressed, slightly sinuous to radial. The umbilicus is small almost closed, but deep. The apertures are multiple; the distinct primary interiomarginal-umbilical aperture is a fairly long, comparatively low, slightly asymmetric arch broadest posteriorly with respect to the direction of coiling. The dorsal supplementary apertures are sutural in position and are visible in the basal sutures of the chambers of the last whorl and the later part of the penultimate whorl. In the last chamber there are three such supplementary apertures. Both the primary and supplementary apertures of the last chamber are

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PLATE 20
JACKSON BLUFF FORMATION
ALUM BLUFF, BED 4

Figures Page

1. *Globoquadrina altispira globosa* Bolli. 88
   Maximum diameter, 0.39 mm
   a. Spiral view, X 135
   b. Umbilical view, X 137

2. *Sphaeroidinellopsis subdehiscens subdehiscens* Blow, a decorticated specimen. 86
   Maximum diameter, 0.39 mm
   a. Spiral view, X 133
   b. Umbilical view, X 133

3. *Sphaeroidinellopsis subdehiscens subdehiscens* Blow. 86
   Maximum diameter, 0.45 mm
   a. Spiral view, X 126
   b. Umbilical view, X 125

4. *Sphaeroidinellopsis subdehiscens subdehiscens* Blow, a decorticated specimen. 86
   Maximum diameter, 0.52 mm
   a. Spiral view, X 134
   b. Umbilical view, X 133

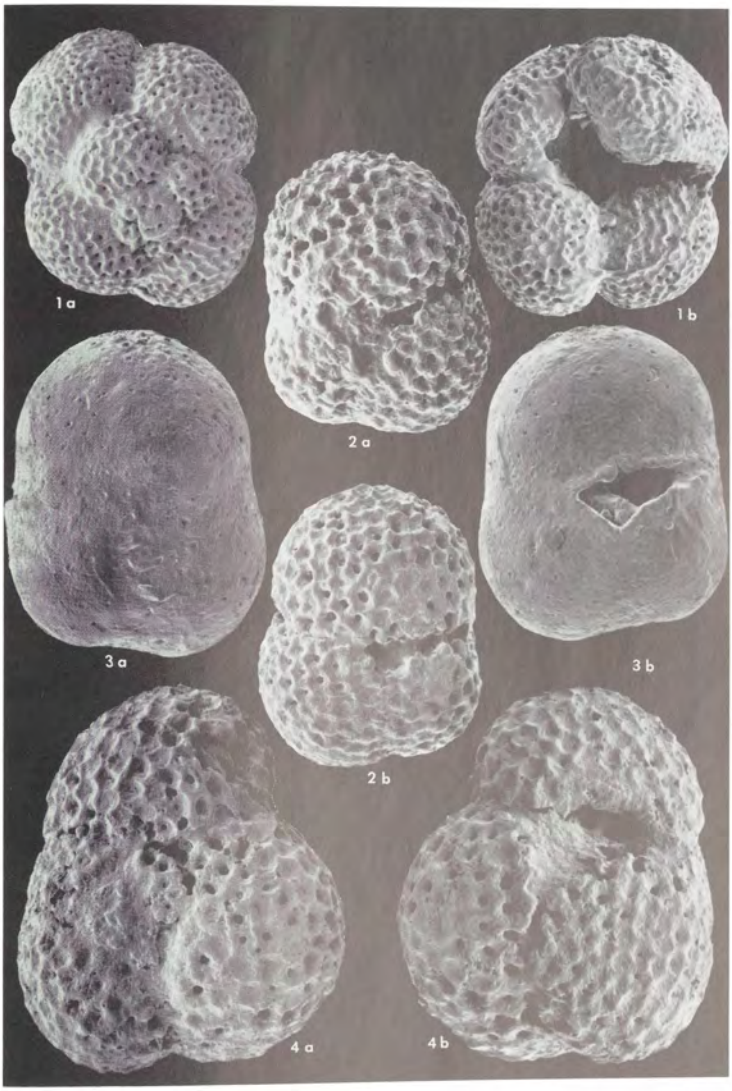

Plate 20

bordered by thickened rim-like lips. The wall is characteristically very thick, especially in the early whorls, and it is uniformly and fairly coarsely perforate. The surface of the test is cancellate and syntypes taken *in vivo* show it to have been originally finely, uniformly and densely spinose. Maximum diameter of lectotype: 0.85 mm." (Banner and Blow, 1960)

Lectotype: British Museum (Natural History) 1959.4.13.7; obtained by Brady from *Challenger* station 338, S. Atlantic, at 1990 fathoms.

Discussion: Forms from Watson's Landing are identical with specimens from the Bowden beds of Jamaica (Palmer, 1945, p. 6, Station 2). *G. conglobatus conglobatus* is rare in the writer's material from both Bowden and Watson's Landing. It is characteristic of the specimens from these two localities that the later chambers are not so depressed as in specimens from modern seas. In these fossil forms the primary aperture is usually infilled causing it to appear smaller and sutural in position. This results in a superficial resemblance to *Globigerinoides gomitulus* (Seguenza) for which *Globigerinoides cyclostomata* (Galloway and Wissler) appears to be a junior synonym. *G. gomitulus* is a smaller form, and it has a larger, higher aperture than *G. conglobatus conglobatus*. Mamelones and a confluence of pore ridges seen on the specimens from Watson's Landing (pl. 24, figs. 1, 2) are also characteristic of some specimens from Recent sediments, and the development of these wall structures appears to be an ecological function (bathymetry?). The compact, closely coiled test of the Florida and Bowden forms is typical of *G. conglobatus conglobatus*.

The range of this subspecies is from within Zone N. 17 to Zone N. 23, according to Blow.

GLOBIGERINOIDES OBLIQUUS EXTREMUS Bolli and Bermúdez

Pl. 23, fig. 2; Pl. 38, fig. 1;
Pl. 43, fig. 1; Pl. 48, fig. 3

Globigerinoides obliquus extremus BOLLI and BERMÚDEZ, 1965, Bol. Informativo, Assoc. Venezolana de Geol., Min. y Pet., vol. 8 no. 5, p. 139, pl. 1, figs. 10-12.

Globigerinoides obliquus extremus Bolli and Bermúdez. BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 324, pl. 21, figs. 2, 3.

"Shape of test high trochospiral; equatorial periphery distinctly lobate; axial periphery rounded. Wall calcareous, perforate, surface finely pitted.

PLATE 21
JACKSON BLUFF FORMATION ?
WATSON'S LANDING

Figures

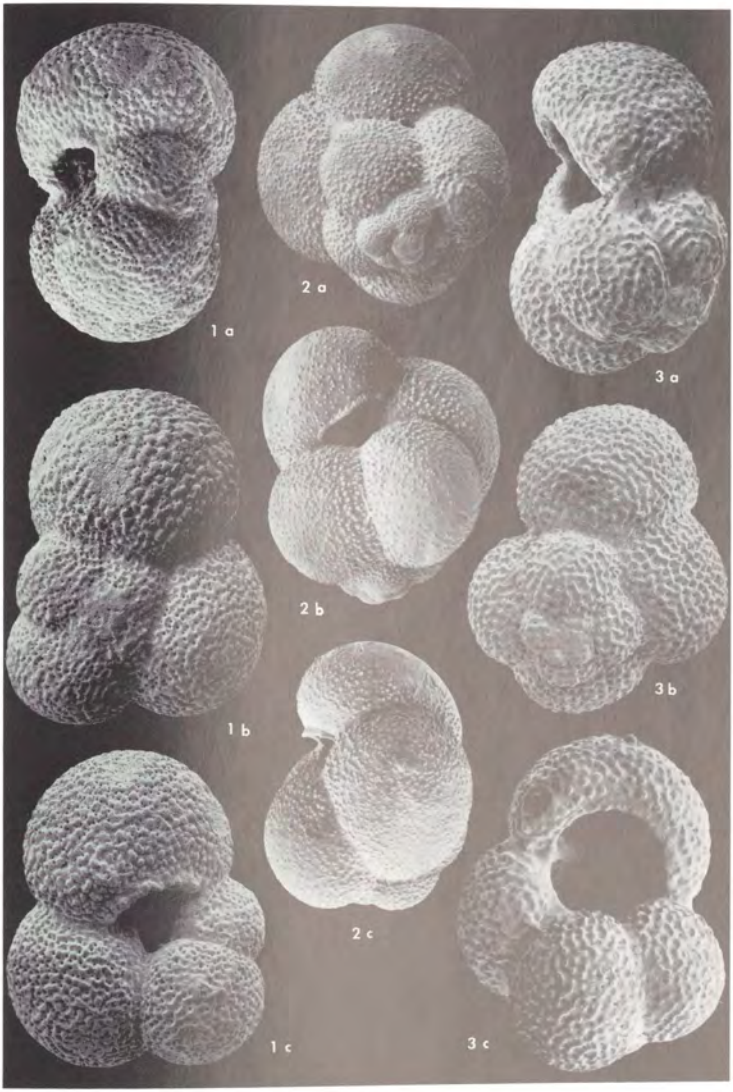

Plate 21

Chambers of the last whorl progressively more compressed in a lateral, oblique manner; 10-12, arranged in 2 to 3 whorls; the last 4 chambers of the last whorl increase fairly rapidly in size, though the last chamber may be slightly reduced in some specimens. Sutures somewhat oblique on spiral and umbilical side, incised. Umbilicus rather narrow. Primary aperture a distinct arch of medium height, interiomarginal, umbilical. One supplementary aperture on last chamber often also visible on earlier ones. Largest diameter of holotype: 0.36 mm." (Bolli and Bermúdez, 1965)

Holotype: USNM; from core 1029-1034 feet, Cubagua-1, Estado Nueva Esparta, Venezuela.

Discussion: This form ranges from the earlier part of Zone N. 16 to within Zone N. 21, according to Blow.

GLOBIGERINOIDES OBLIQUUS OBLIQUUS Bolli

Pl. 7, fig. 1; Pl. 10, fig. 1;
Pl. 16, fig. 1; Pl. 18, fig. 2;
Pl. 26, fig. 2; Pl. 27, fig. 3;
Pl. 35, fig. 1; Pl. 53, fig. 2;
Pl. 56, fig. 1; Pl. 58, fig. 3

Globigerinoides obliqua BOLLI, 1957, U. S. Natl. Mus., Bull. 215, p. 113, pl. 25, figs. 9, 10; text-fig. 21, no. 5.

Globigerinoides obliquus obliquus Bolli. BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 324.

"Shape of test trochospiral; equatorial periphery distinctly lobate; axial periphery rounded. Wall calcareous, perforate, surface finely pitted. Chambers spherical, except the ultimate ones, which are compressed in a lateral oblique manner; chambers twelve to fifteen, arranged in about three whorls; the three, in large specimens four, chambers of the last whorl increase rapidly in size; in large specimens the last chamber may be reduced again in size. Sutures on spiral side radial to oblique, depressed; on umbilical side radial, depressed. Umbilicus small. Primary aperture a distinct, often fairly high arch, interiomarginal, umbilical; one or occasionally two supplementary sutural apertures are visible in the last few chambers. Largest diameter of holotype, 0.5 mm." (Bolli, 1957)

Holotype: USNM P5634; Lengua Formation, 2½ miles south-southeast of Lengua Settlement, southern Trinidad.

Discussion: The range, according to Blow is from the latest part of Zone N. 5 into Zone N. 22.

GLOBIGERINOIDES QUADRILOBATUS ALTIAPERTURUS Bolli

Globigerinoides triloba altiapertura BOLLI, 1957, U. S. Natl. Mus., Bull. 215, p. 113, pl. 25, figs. 7a-8.

PLATE 22
JACKSON BLUFF FORMATION ?
WATSON'S LANDING

Figures

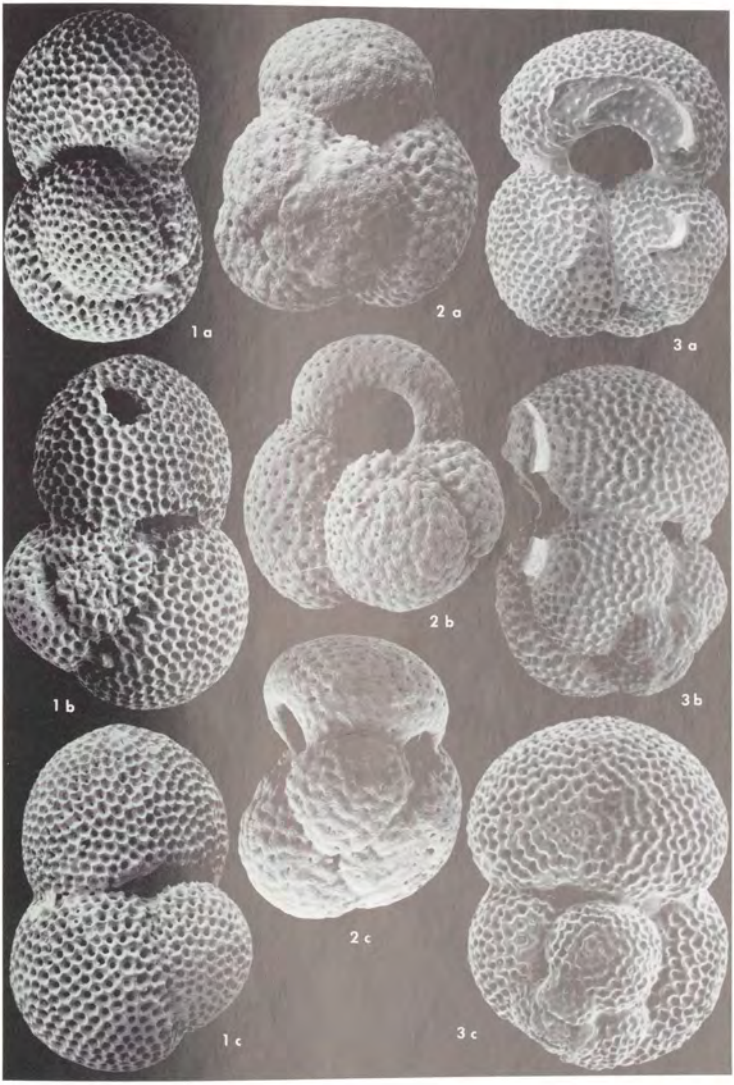

Plate 22

Globigerinoides triloba altiapertura Bolli. BLOW, 1959, Bull. Amer. Paleontology, vol. 39, no. 178, pp. 187-188, pl. 10, figs. 61 a-b.

Globigerinoides quadrilobatus altiaperturus Bolli. BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 325.

"Shape of test trochospiral; equatorial periphery distinctly lobate (trilobate); axial periphery rounded. Wall calcareous, perforate, surface finely pitted. Chambers spherical; about twelve, arranged in about two and one-half whorls; the three chambers of the last whorl increase rapidly in size. Sutures on spiral side between early chambers radial, later slightly curved and oblique, depressed; on the umbilical side radial, depressed. Umbilicus fairly narrow, deep. Primary aperture a high, distinct arch, interiomarginal, umbilical; the last few chambers show one supplementary sutural aperture about opposite the primary aperture. Coiling random. Largest diameter of holotype, 0.55 mm." (Bolli, 1957)

Holotype: USNM P5632; Cipero Formation, western Trinidad.

Discussion: This form ranges from near the base of Zone N. 5 to within the earlier parts of Zone N. 7, according to Blow. Specimens from the Chipola Formation have a wider primary aperture than do specimens from the Cipero Formation.

GLOBIGERINOIDES QUADRILOBATUS QUADRILOBATUS (d'Orbigny)

Pl. 3, fig. 4; Pl. 6, fig. 2;
Pl. 11, figs. 2, 3; Pl. 16, fig. 4;
Pl. 18, fig. 1; Pl. 22, fig. 1;
Pl. 27, fig. 2; Pl. 30, fig. 3;
Pl. 34, fig. 4; Pl. 39, fig. 2;
Pl. 42, fig. 3; Pl. 49, fig. 1;
Pl. 53, fig. 3; Pl. 56, fig. 2;
Pl. 59, fig. 1

Globigerina quadrilobata D'ORBIGNY, 1846, Foraminifères fossiles du bassin tertiaire de Vienne, p. 164, pl. 9, figs. 7-10.

Globigerina quadrilobatus d'Orbigny. BANNER and BLOW, 1960, Cushman Found. Foram. Res., Contr., vol. 11, pp. 17-19, pl. 4, figs. 3a-b (lectotype).

Globigerinoides quadrilobatus quadrilobatus d'Orbigny. BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 35.

"The fairly large test consists of about nine chambers arranged in a low, loose trochospire of about two whorls, each whorl, following the proloculum, consisting of about four chambers. The chambers are rapidly and uniformly enlarging, much inflated and little embracing. The equatorial profile is ovoid and the test has a strongly lobulate equatorial periphery. The axial profile is ovate and the axial periphery is smoothly rounded. The chambers are sub-globular and the intercameral sutures become increasingly deeply depressed during ontogeny. The spiral suture is initially slightly depressed becoming deeply depressed and incised in the last whorl. The umbilicus is small, almost closed, and is shallow. The apertures are multiple; the primary aperture is interiomarginal, umbilical, a low, symmetrical, sub-rectangular arch-like opening with no lip or rim. The dorsal supplementary apertures open in the spiral suture; each is an elongate, rather slit-like opening present at the base of each chamber in the last whorl at least and they may be present in the earlier whorls. The supplementary apertures do not possess lips or well marked rims. The wall is

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PLATE 23
JACKSON BLUFF FORMATION ?
WATSON'S LANDING

Figures Page

1. *Globigerinoides ruber* (d'Orbigny). 66
Maximum diameter, 0.47 mm
   a. Side view, X 126
   b. Umbilical view, X 126
   c. Spiral view, X 127

2. *Globigerinoides obliquus extremus* Bolli and Bermúdez. 58
Maximum diameter, 0.39 mm
   a. Edge view, X 143
   b. Spiral view, X 143
   c. Umbilical view, X 145

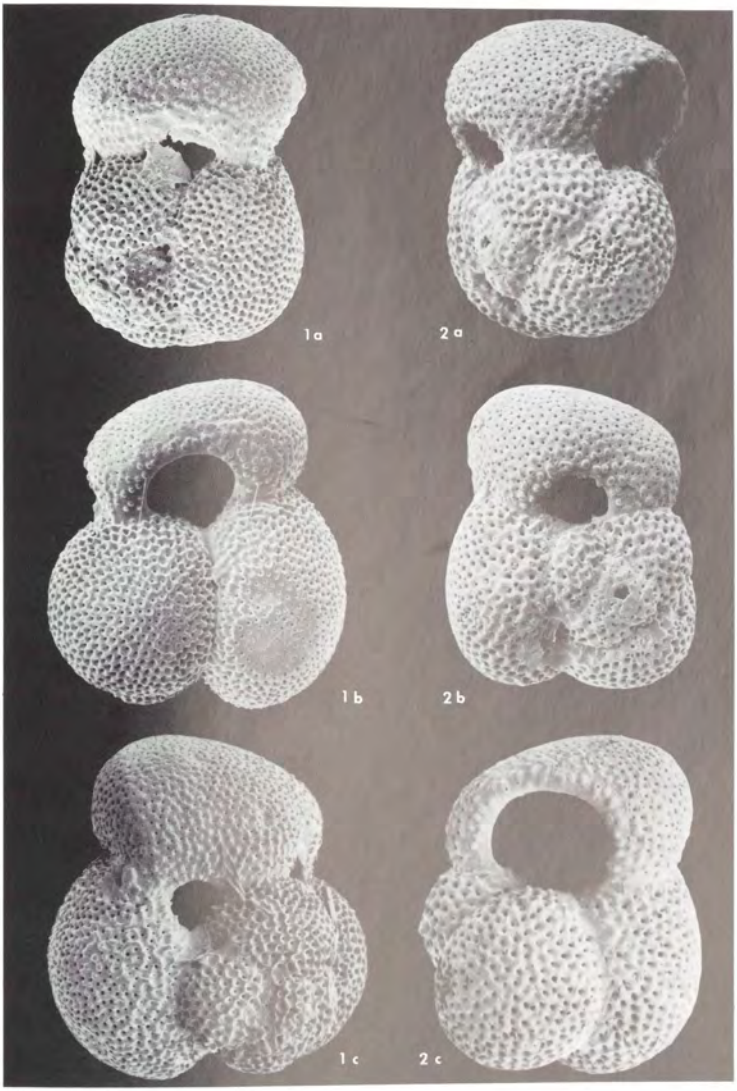

Plate 23

thick, and is coarsely uniformly perforate. The surface of the test is markedly cancellate and punctate. Maximum diameter of lectotype: 0.57 mm." (Banner and Blow, 1960)

Lectotype: Muséum National de l'Histoire Naturelle, Paris; selected from specimens which bore the label "*Globigerina quadrilobata* d'Orbigny, Tortonien, Nussdorf (Autriche)."

Discussion: Banner and Blow (1960) and Parker (1967) thoroughly discuss the taxonomic problem relating to this form and those forms described as *Globigerina triloba* Reuss 1850, *Globigerina sacculifera* Brady 1879, *Globigerinoides sacculiferus* (Brady) var. *immatura* LeRoy 1939, and *Sphaeroidinella cellata* Subbotina 1958. This problem is further complicated by the shallow paleobathymetry indicated for the sediments studied for the present report, since there is a possible ecotypic relationship between bathyal to abyssal depths and the elongate sac-like final chamber observed on specimens of this plexus, particularly those of late Miocene and younger age. Specimens close in appearance to the lectotype (without a sac-like final chamber and with a high primary aperture) are the predominant planktonic foraminifers at all of the Chipola localities included in this study. Blow (1969, p. 325) considers the range of *Globigerinoides quadrilobatus quadrilobatus* (d'Orbigny) to be from near the top of Zone N. 4 to Zone N. 23.

GLOBIGERINOIDES QUADRILOBATUS SACCULIFER (Brady)

Pl. 59, fig. 2

Globigerina sacculifera BRADY, 1877, Geol. Mag., (new ser.), Decade 2, vol. 4, no. 12, p. 535.

Globigerina sacculifera Brady. BRADY, 1879, Quart. Jour. Micr. Sci., (new ser.), vol. 19, p. 287.

Globigerina sacculifera Brady. BRADY, 1884, Rept. Voy. *Challenger*, Zoology, vol. 9, p. 604, pl. 80, figs. 11-17; pl. 82, fig. 4 (these figured specimens are from oceanic surface sediments and plankton).

Globigerina sacculifera Brady. BANNER and BLOW, 1960, Cushman Found. Foram. Res., Contr., vol. 11, p. 21, pl. 4, figs. 1 (lectotype), 2.

"The large, sub-tetrahedroid test consists of about 2 1/2 whorls of ovoid, inflated chambers arranged 3 1/2 to 4 in each convolution of a low trochospire. The equatorial profile is sub-triangular and the equatorial periphery is lobulate. The axial profile is also sub-triangular but approaches an oval shape. The axial periphery is broadly rounded on the earlier chambers, becoming narrowly rounded over the last chamber. All chambers except the last are constant in shape and are regularly enlarging; the last chamber is "sac-like," and differs but little from the volume of the penultimate chamber although it is of

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PLATE 24
JACKSON BLUFF FORMATION ?
WATSON'S LANDING

Figures Page

1. *Globigerinoides conglobatus conglobatus* (Brady). 56
   Maximum diameter, 0.56 mm
   a. Spiral view, X 93
   b. Edge view, X 92
   c. Umbilical view, X 92

2. *Globigerinoides conglobatus conglobatus* (Brady). 56
   Maximum diameter, 0.46 mm
   a. Spiral view, X 121
   b. Umbilical view, X 122

3. *Hastigerina (Hastigerina) siphonifera siphonifera* (d'Orbigny). 124
   Maximum diameter, 0.57 mm
   a. Spiral view, X 103
   b. Edge view, X 101
   c. Umbilical view, X 101

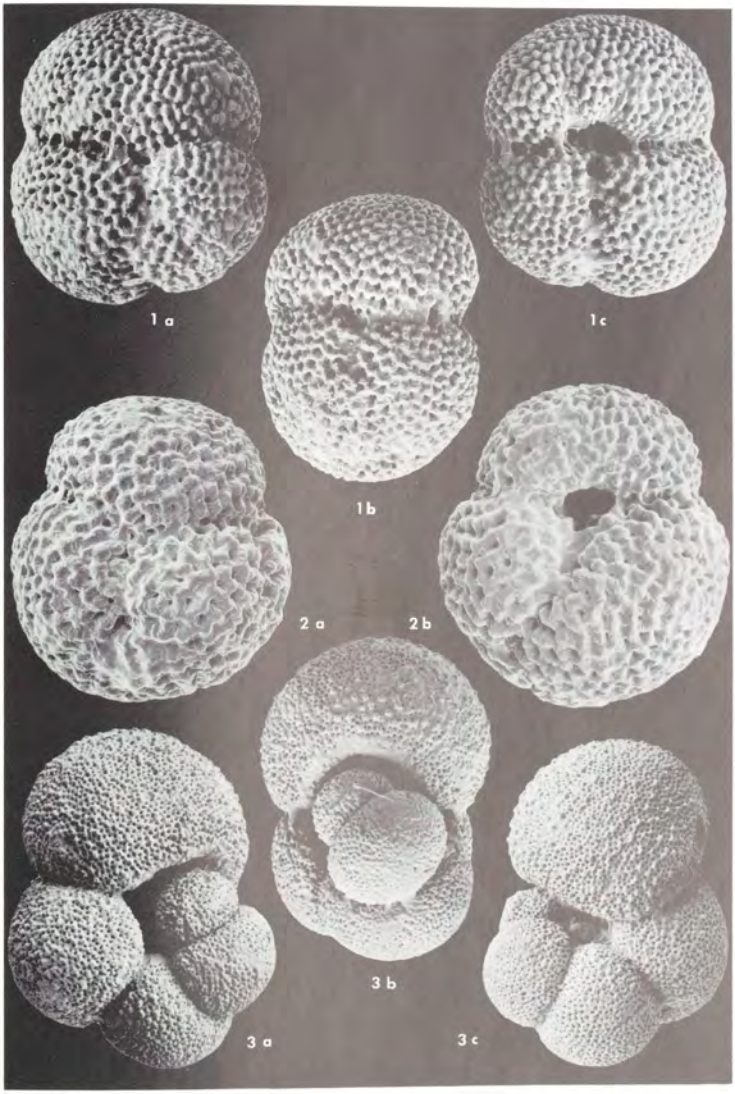

Plate 24

distinctly different shape. The sutures are slightly and broadly depressed, the intercameral sutures are distinctly curved dorsally, meeting the lobulate spiral suture at almost right angles. The ventral intercameral sutures are slightly sinuous to nearly radial. The umbilicus is small, almost but not totally closed, and is shallow. The apertures are multiple; the primary aperture is interiomarginal, intra-umbilical, a moderately low, almost semicircular, slightly asymmetrical arch, with no rim or lip visible. The dorsal supplementary apertures are situated at the base of the chambers, opening in the spiral suture; they are low, virtually semicircular arches with no lips or rims and appear to be present from at least the beginning of the last whorl. Only one supplementary aperture is present in each chamber. The wall is fairly thick and is uniformly and coarsely perforate. The surface of the test is cancellate but with little trace of any original hispidity. Maximum diameter of lectotype: 0.56 mm." (Banner and Blow, 1960)

Lectotype: British Museum (Natural History) P.44033; obtained from an exotic block (of upper Miocene or Pliocene age?) from New Ireland.

Discussion: The form, as understood in collections from the Moín Formation, ranges from Zone N. 6 to Zone N. 23.

GLOBIGERINOIDES RUBER (d'Orbigny)

Pl. 16, fig. 3; Pl. 18, fig. 3;
Pl. 22, fig. 3; Pl. 23, fig. 1;
Pl. 26, fig. 4; Pl. 27, fig. 1;
Pl. 35, fig. 2; Pl. 38, fig. 3;
Pl. 43, fig. 2; Pl. 49, fig. 2;
Pl. 53, fig. 1; Pl. 56, fig. 3;
Pl. 58, fig. 4

Globigerina rubra D'ORBIGNY *in* DE LA SAGRA, 1839, Hist. Phys. Pol. Nat. Cuba, "Foraminifères," p. 82, pl. 4, figs. 12-14.

Globigerina rubra d'Orbigny. BANNER and BLOW, 1960, Cushman Found. Foram. Res., Contr., vol. 11, p. 19, pl. 3, fig. 8 (lectotype).

Globigerinoides ruber (d'Orbigny). CORDEY, 1967, Palaeontology, vol. 10, pt.4, pp. 647-659, pl. 103, figs. 7-14, text-fig. 1a-d, text-fig. 3 (figs. 3a-5b).

Globigerinoides ruber (d'Orbigny). BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 326, pl. 21, figs. 4, 7.

"The fairly large test consists of slightly more than two whorls of strongly inflated chambers arranged three to a whorl in a moderately high trochospire. The equatorial profile is subovate, but the equatorial periphery is strong lobulate. The dorsal surface is distinctly convex and the earlier whorls are clearly visible. The chambers are subglobular to sub-ovoid and are broadly reniform in dorsal aspect, well separated one from the other and are but little embracing. The sutures are distinctly and broadly depressed both dorsally and ventrally; they are strongly curved dorsally, but also radial ventrally. The apertures are multiple. The primary aperture is interiomarginal umbilical, a moderately high, semicircular arch bordered by a distinct, uniformly narrow, rim; the primary aperture is placed and shaped symmetrically with respect to the intercameral suture between the penultimate and antepenultimate chambers. The supplementary apertures are dorsal in position and are situated at the basal suture of each chamber at its junction with the adjacent intercameral suture of the preceding whorl. One or two such supplementary apertures are present in each chamber of the last whrol. The supplementary apertures are high, semicircular arches, with very thin rims. The umbilicus is small, almost closed and very shallow. The wall is calcareous, apparently radial in structure, uniformly

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PLATE 25
JACKSON BLUFF FORMATION ?
WATSON'S LANDING

Figures Page

1. *Globoquadrina altispira globosa* Bolli. 88
Maximum diameter, 0.41 mm
   a. Spiral view, X 147
   b. Edge view, X 129
   c. Umbilical view, X 137

2. *Globorotalia (Turborotalia) acostaensis humerosa* Takayanagi and Saito. 108
Maximum diameter, 0.50 mm
   a. Spiral view, X 126
   b. Edge view, X 126
   c. Umbilical view, X 126

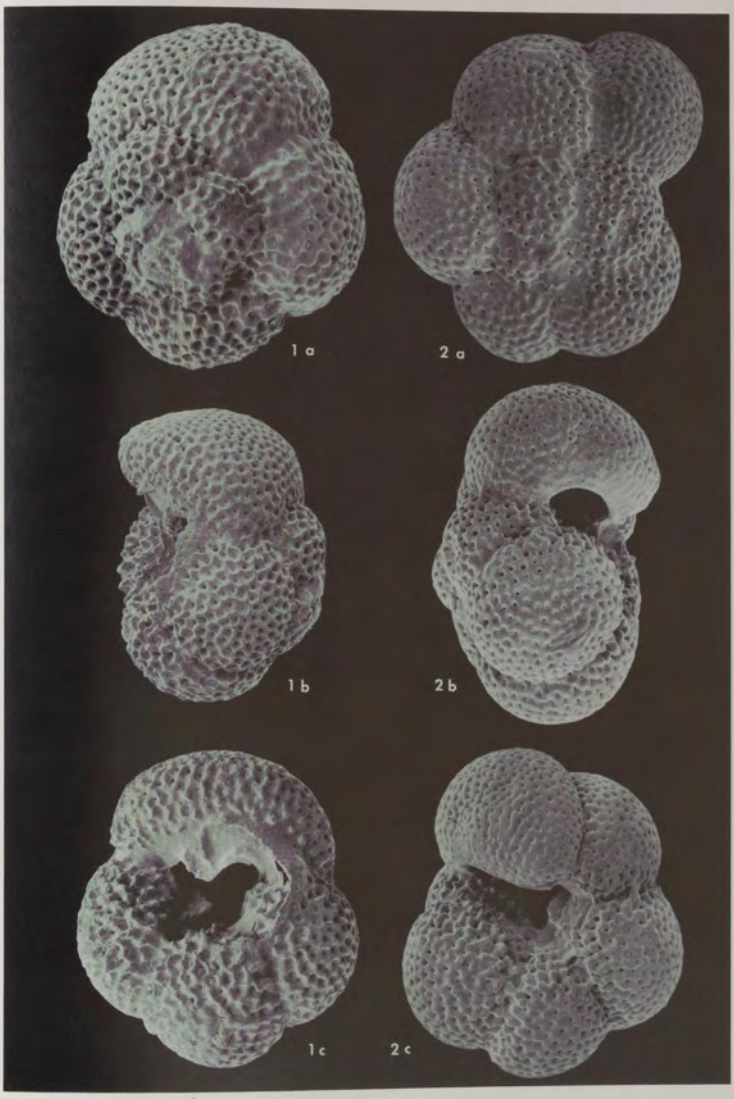

Plate 25

and fairly finely perforate and moderately thin. The surface of the test is slightly rough, but little trace of any original hispidity exists in the lectotype. The earlier part of the test is red coloured, not with the red tint of ferric compounds, but with a deeper and more crimson hue, probably of an organic origin. Maximum diameter of lectotype: 0.62 mm." (Banner and Blow, 1960)

Lectotype: d'Orbigny Collection, Muséum National de l'Histoire Naturelle, Paris; Recent deposits of Cuba.

Discussion: Blow agrees with Cordey in the separation of this species from *Globigerinoides subquadratus* Bronnimann. See his description of *G. subquadratus* (this report). Blow considers the range of *G. ruber* to be from the middle part of Zone N. 16 to Zone N. 23.

GLOBIGERINOIDES SUBQUADRATUS
Bronnimann

Pl. 4, fig. 3

Globigerinoides subquadratus BRONNIMANN *in* TODD, CLOUD, LOW, and SCHMIDT, 1954, Amer. Jour. Sci., vol. 252, p. 680, pl. 1, fig. 5.

Globigerinoides rubra d'Orbigny. BOLLI, 1957, U. S. Natl. Mus., Bull. 215, p. 113, pl. 25, figs. 12a-13b, text-fig. 21, no. 6.

Globigerinoides subquadratus Bronnimann. CORDEY, 1967, Palaeontology, vol. 10, pt. 4, pp. 650-651, pl. 103, figs. 1a, 2a, b-4; text-fig. 1e-h; text-fig. 2 (4a-6c).

Globigerinoides subquadratus Bronnimann. BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, pp. 326-327, pl. 21, figs. 5, 6.

"Test moderately large, consisting of proloculus followed by whorl of four or possibly five chambers, a second (or penultimate) whorl of four chambers gradually and uniformly increasing in size and a final whorl of three chambers. Periphery varies from lobulate to quadrate in outline. Primary aperture usually large, interiomarginal, umbilical, and situated symmetrically with respect to the penultimate and antepenultimate chambers. Two dorsal supplementary apertures are present at the base of the final chamber, and one at the junction of the basal suture and the intercameral suture of the preceding whorl. Umbilicus shallow. Wall radiate calcareous, frequently thickened, with a slightly rugose surface.

"The essential difference between *G. subquadratus* and *G. ruber* is in their ontogeny. The former has a penultimate whorl of four chambers, while the

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PLATE 26
JACKSON BLUFF FORMATION ?
DARLING SLIDE, UPPER HORIZON

Figures Page

1. *Hastigerina (Hastigerina) siphonifera siphonifera* (d'Orbigny). 124
Maximum diameter, 0.44 mm
   a. Spiral view, X 126
   b. Edge view, X 127

2. *Globigerinoides obliquus obliquus* Bolli. 60
Maximum diameter, 0.35 mm
   a. Spiral view, X 133
   b. Umbilical view, X 136

3. *Globorotalia (Turborotalia) acostaensis humerosa* Takayanagi and Saito. 108
Maximum diameter, 0.48 mm
   a. Spiral view, X 126
   b. Umbilical view, X 126
   c. Edge view, X 126

4. *Globigerinoides ruber* (d'Orbigny). 66
Maximum diameter, 0.39 mm
   a. Spiral view, X 140
   b. Umbilical view, X 136

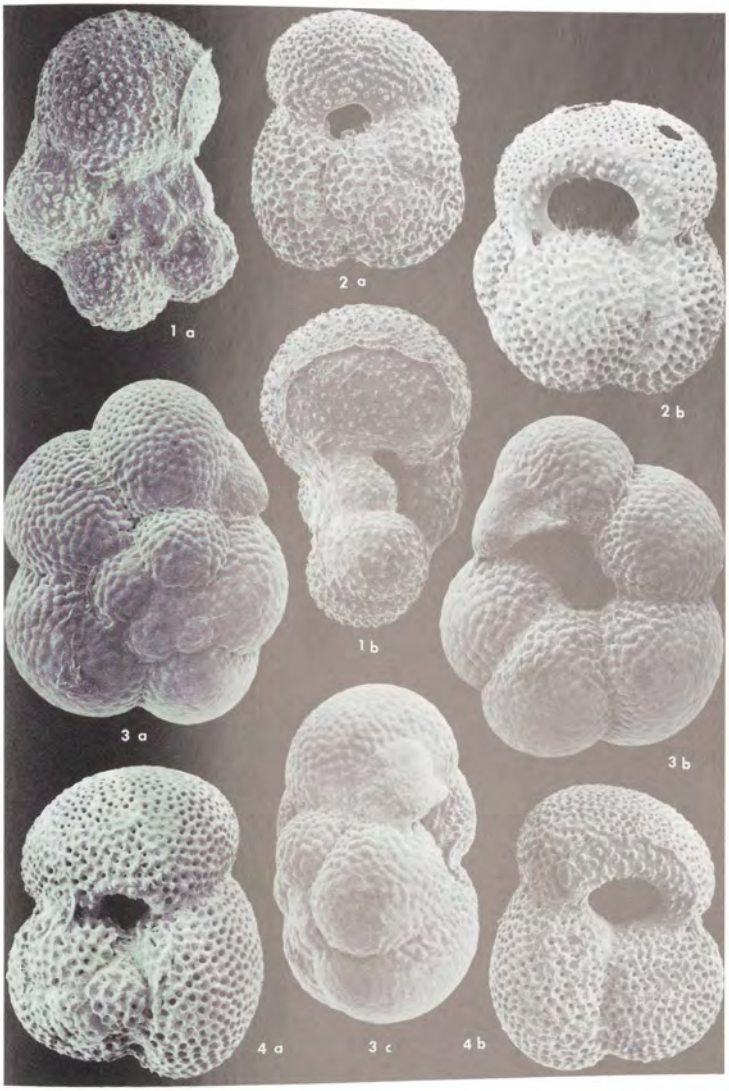

Plate 26

latter consists of a penultimate whorl of three chambers, with the final chamber of the initial whorl to a greater or lesser extent forming part of it; in the following discussion this is termed a whorl of 3 1/2 chambers. However, this fourth chamber is invariably much smaller than the remainder of the chambers in this whorl and thus differs from the relative size of each chamber in the penultimate whorl of *G. subquadratus*. This appears to be a character useful in distinguishing the two species. The other chamber arrangement in *G. ruber* is one in which there are only three chambers in the penultimate whorl. Therefore in *G. subquadratus* removal of three chambers invariably produces a form with four chambers present. However, in *G. ruber* upward of four chambers (frequently six) can be removed before four chambers are seen in ventral view. Many of the specimens in which there is a fourth chamber in the penultimate whorl in dorsal view, when dissected still show the three chambered whorl. However, exceptions occur but this fourth chamber is only just visible." (Cordey, 1957)

Holotype: USNM 548881; from 1.6 miles northeast of the seaward tip of the southwest point of Saipan, Mariana Islands. The dimensions are: length, 0.58 mm; diameter of end chamber, 0.4 mm; diameter of the two preceding chambers, 0.47 mm; diameter of main aperture, ca. 0.11 mm; diameter of accessory aperture of end chamber, ca. 0.07 mm.

Discussion: According to Blow, *G. ruber* and *G. subquadratus* do not overlap, and neither species occurs in Zone N. 14 or N. 15. This relationship holds true for the Gulf Coast sequence, since the *Yoldia* Zone of the Choctawhatchee Formation at Cosson's Farm (Yellow River Formation) does not yield either form, although it is one of the more fossiliferous Florida localities from the standpoint of planktonic microfossils. The range of *G. subquadratus* is from Zone N. 5 to the top of Zone N. 13, while *G. ruber* ranges from Zone N. 16 to Zone N. 23, according to Blow.

Genus GLOBIGERINITA Bronnimann, 1951

GLOBIGERINITA GLUTINATA (Egger)

Pl. 21, fig. 2; Pl. 33, fig. 3;
Pl. 38, fig. 2

Globigerina glutinata EGGER, 1893, Abh. K. Bayer. Akad. Wiss. Munchen, Cl. II, vol. 18, p. 371, pl. 13, figs. 19-21.

Tinophodella ambitacrena LOEBLICH and TAPPAN, 1957, Washington Acad. Sci., Jour., vol. 47, no. 4, p. 114, pl., figs. 2, 3.

Globigerinoides parkerae BERMUDEZ, 1961, Mem. III Congr. Geol. Venezolano, vol. 3, Bol. Geol. Publ. esp. 3 (1960), p. 1.232, pl. 10, figs. 10, 11.

Globigerinita glutinata (Egger). PARKER, 1962, Micropaleontology, vol. 8, no. 2, p. 246, pl. 9, figs. 1-16.

Globigerinita glutinata (Egger). PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, p. 146, pl. 17, figs. 3-5.

PLATE 27
JACKSON BLUFF FORMATION ?
DARLING SLIDE, LOWER HORIZON

Figures Page

1. *Globigerinoides ruber* (d'Orbigny). 66
Maximum diameter, 0.49 mm
   a. Spiral view, X 126
   b. Edge view, X 122
   c. Umbilical view, X 126

2. *Globigerinoides quadrilobatus quadrilobatus* (d'Orbigny). 62
Maximum diameter, 0.60 mm
   a. Spiral view, X 93
   b. Umbilical view, X 91

3. *Globigerinoides obliquus obliquus* Bolli. 60
Maximum diameter, 0.48 mm
   a. Spiral view, X 126
   b. Edge view, X 119
   c. Umbilical view, X 126

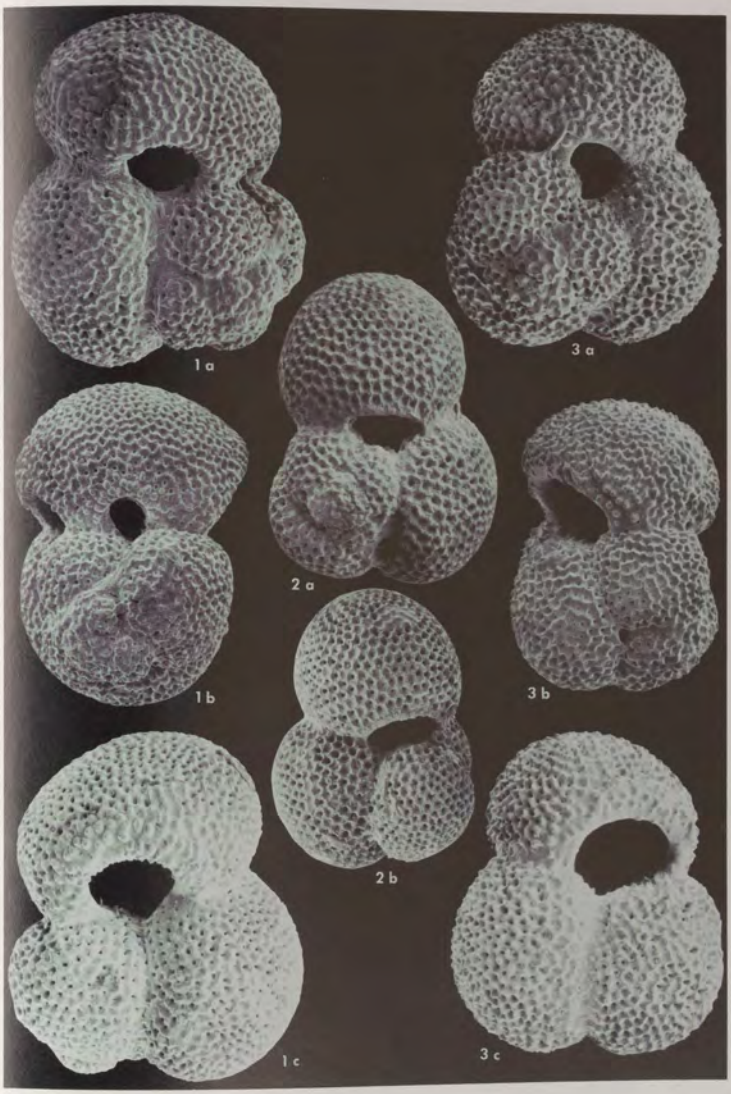

Plate 27

"Das Gehäuse ist der Gestalt nach eine *Globig. triloba* mit etwas höherer Aufrollung der ersten Windung. Die drei Kammern des letzten Umganges liegen, ziemlich wenig in der Grösse verschieden, nebeneinander in der Weise, dass eine einzelne obere, die letzte, und zusammen zwei untere sich gegenüberstehen. Am Saum der letzten Kammer ist auf der Nabelfläche der Oeffnungs-Spalt. Die Nabelmitte ist die einfache Vereinigung der drei Nahte der Kammern. Die Oberfläche der Schale ist ein matt glänzendes Gefüge einer Cementmasse ohne Färbung. Die Scheibenlänge des Gehäuses ist 0.22 mm.

"Die Form des Umrisses gemahnt zum Theil an *Trochammina pauciloculata* aber die Uebereinstimmung mit *Globigerina* ist doch grösser. Von *Globiger. triloba* abzutrennen drängt der Umstrand, dass an manchen Fund-Stellen diese Filzform mehrfach sich findet, dass der Umriss dieser *Gl. glutinans* mehr rundlich bleibt, auch wenn die Schalen verhältnissmassig grösser werden, während bei *Gl. triloba* die letzte Kammer sich etwas mehr aufrichtet. Wo die Schale stachelig auftritt, ist der Unterschied von *Gl. triloba* nicht festzuhalten. Aber gerade bei grösseren Exemplaren tritt in der Regel der Unterschied beider Arten besonders hervor in der Weise, dass *Glob. glutinata* die Schale zart und mattglatt erhält, während die Poren bei *Gl. triloba* sehr gross und mit derbem Zwischenmaschennetz ausgestattet erscheinen." (Egger, 1893)

Holotype: type locality and depository for the type specimen were not given.

Discussion: The range of this form, which Blow (1969, p. 327) recognizes as *Globigerinita ambitacrena* (Loeblich and Tappan) is from Zone N. 5 to Zone N. 23.

GLOBIGERINITA UVULA (Ehrenberg)

Pl. 1, fig. 2; Pl. 15, fig. 2;
Pl. 29, fig. 3; Pl. 52, fig. 1

Pylodexia uvula EHRENBERG, 1861, K. Preuss, Akad. Wiss. Berlin, Monatsber., pp. 276-277, 308.

Pylodexia uvula Eherenberg. EHRENBERG, 1873, K. Akad. Wiss. Berlin, Abh., Jahrg. 1872, pl. 2, figs. 24, 25.

Globigerina sp. BRADY, 1884, Rept. Voy. *Challenger*, Zoology, vol. 9, p. 603, pl. 82, figs. 8, 9.

Globigerina bradyi WIESNER *in* DRYGALSKI, 1931, Deutsche Südpolar Exped. 1901-1903, vol. 20 (Zoology, vol. 12), p. 133.

Globigerinoides minuta NATLAND, 1933, Univ. Calif., Scripps Inst. Oceanography, Bull., Tech. Ser., vol. 3, no. 10, line 34 of table (nomen nudum).

Globigerinoides minuta NATLAND, 1938, Univ. Calif., Scripps Inst. Oceanography, Bull., Tech. Ser., vol. 4, no. 5, p. 150, pl. 7, figs. 2, 3.

Globigerina bradyi Wiesner. BANNER and BLOW, 1960, Cushman Found. Foram. Res., Contr., vol. 11, p. 5, pl. 3, figs. 1 (lectotype), 2.

Globigerinita uvula (Ehrenberg). PARKER, 1962, Micropaleontology, vol. 8, no. 2, p. 252, pl. 8, figs. 14-26.

Globigerinita uvula (Ehrenberg). PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, p. 146, pl. 17, figs. 8, 9.

"Aristerospira laeviuscula elongata, cellulis majoribus, parietibus tenuibus integris, apertura ampla centro adversa. Cellulis 12 1/18''' longa, prima 1/192''', ambitu primo 1/60''' fere. Visceribus fuscis tota repleta." (Ehrenberg, 1861)

Holotype: depository for type specimen not given; type locality given as "E fundo groenlandico

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PLATE 28
JACKSON BLUFF FORMATION ?
DARLING SLIDE, LOWER HORIZON

Figures Page

1. *Globorotaloides hexagona hexagona* (Natland). 124
Maximum diameter, 0.31 mm
   a. Spiral view, X 185
   b. Edge view, X 185
   c. Umbilical view, X 185
   d. View of wall on umbilical side, X 1400

2. *Globorotalia (Turborotalia) acostaensis humerosa* Takayanagi and Saito. 108
Maximum diameter, 0.53 mm
   a. Spiral view, X 112
   b. Edge view, X 112
   c. Umbilical view, X 112

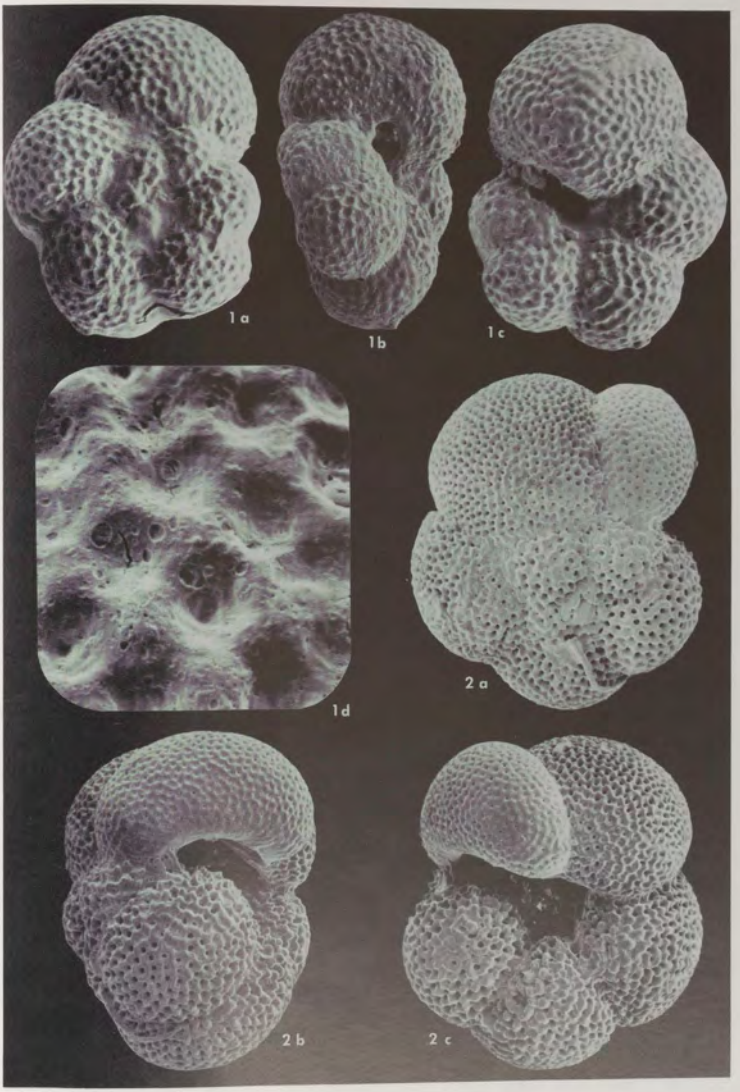

Plate 28

6000' alto; lat., 62° 40' N., long., 29° W., Tiefgrund der Davis-Strasse."

Discussion: Blow (1969, p. 316) gives a range from Zone N. 4 to Zone N. 23 for *Globigerina bradyi* Wiesner.

The aperture of Chipola specimens is a high arch similar to that in the lectotype of Banner and Blow. These authors noted variability in the aperture, and for this reason it is concluded that the figured specimens of Parker (1967) are conspecific, although her forms from the Pacific have a low, lipped aperture.

Genus ORBULINA d'Orbigny, 1839

ORBULINA SUTURALIS Bronnimann

Orbulina suturalis BRONNIMANN, 1951 (part), Cushman Found. Foram. Res., Contr., Vol. 2, pt. 4, p. 135, text-fig. 2, nos. 1-2, 5-8, 10; text-fig. 3, nos. 3-8, 11, 13-16, 18, 20-22; text-fig. 4, nos. 2-4, 7-12, 15-16, 19-22.

Orbulina suturalis Bronnimann. BLOW, 1956, Micropaleontology, vol. 2, no. 1, p. 66, text-fig. 2, nos. 5-7.

Orbulina suturalis Bronnimann. BOLLI, 1957, U.S. Natl. Mus., Bull. 215, p. 115, pl. 27, fig. 4.

"End chamber globular, not entirely enveloping the preceding *Globigerina* chambers. Tests showing all transitional stages from a partly enveloped *Globigerina* to an almost completely enveloped one. In the final stage, the *Globigerina* chambers visible only as a small rounded area, projecting slightly above the general surface. Tests small. No definite aperture present, but subcircular to irregularly shaped openings occur along sutures, separating the *Globigerina* chambers from the globular end chamber and occasionally outside the sutural grooves as well. Wall cancellate, with regularly arranged minute perforations, thin or fairly thick, composed of one or more layers. Diameter of holotype, 0.312 mm." (Bronnimann, 1951)

Holotype: USNM 64181; Naparima area, Trinidad, B. W. I., "upper part of the lower Miocene."

Discussion: The form ranges from the base of Zone N. 9 to Zone N. 23, according to Blow (1969, p. 334).

ORBULINA UNIVERSA d'Orbigny

Pl. 10, fig. 2

Orbulina universa D'ORBIGNY *in* DE LA SAGRA, 1839, Hist. Phys. Pol. Nat. Cuba, "Foraminifères," p. 2, pl. 1, fig. 1.

Orbulina universa d'Orbigny. BLOW, 1956, Micropaleontology, vol. 2, no. 1, p. 55, text-fig. 2, nos. 8, 9.

"*Orbulina.* Testa bullata, sphaerica, tenui, irregulariter, minutissime perforata; apertura circulari.

PLATE 29
JACKSON BLUFF FORMATION ?
DARLING SLIDE, UPPER HORIZON

Figures Page

1. *Globigerina druryi decoraperta* Takayanagi and Saito. 50
   Maximum diameter, 0.24 mm
   a. Spiral view, X 204
   b. Edge view, X 204
   c. Umbilical view, X 204

2. *Globigerina* sp. 17
   Maximum diameter, 0.36 mm
   a. Spiral view, X 142
   b. Edge view, X 142
   c. Umbilical view, X 142

3. *Globigerinita uvula* (Ehrenberg). 72
   Maximum diameter, 0.27 mm
   a. Spiral view, X 206
   b. Edge view, X 206
   c. Umbilical view, X 206

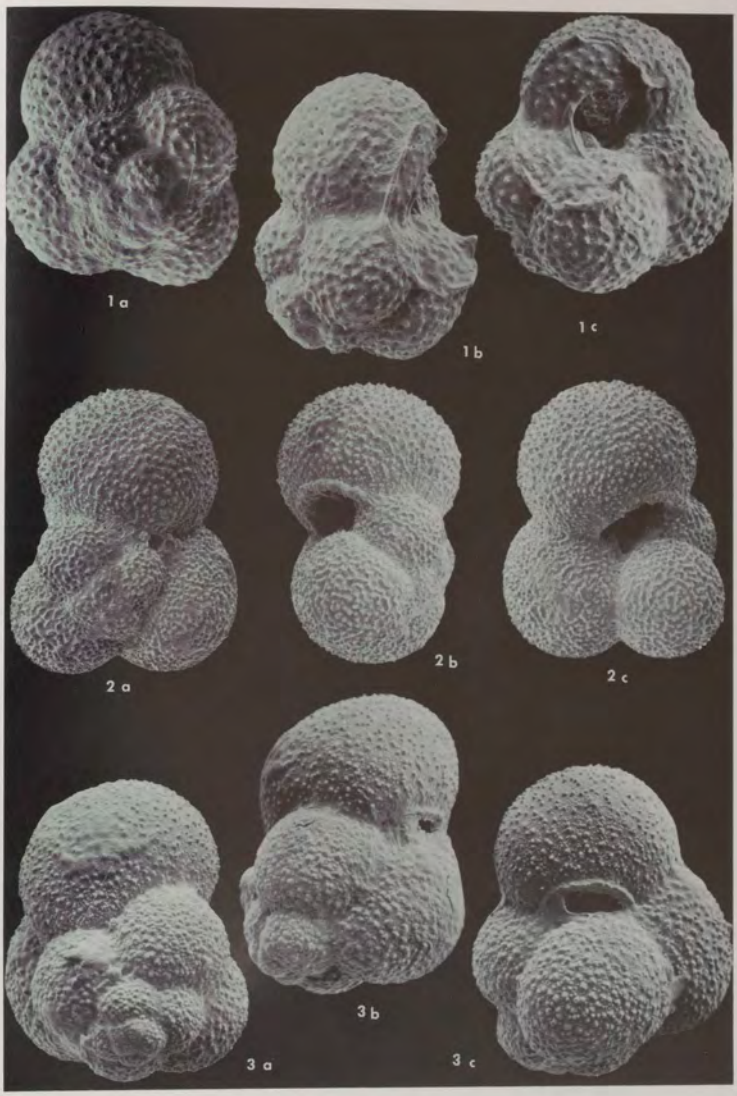

Plate 29

"Dimensions: 1/2 millim. Coquille globuleuse, sphérique, régulière, très mince, assez rugueuse, couverte partout de très petits trous. Ouverture arrondie, Couleur blanc jaunâtre." (d'Orbigny, 1839)

Holotype: depository not given. D'Orbigny's specimens, however, were from Recent sediments, localities enumerated as follows: "Les bords de l'Adriatique près de Rimini (Emilia), Italy; la côte de l'Algérie; Ténériffe (Canaries); Cuba, la Jamaïque Saint-Thomas, la Guadeloupe, et la Martinique (Antilles); les mers de l'Inde."

Discussion. The diagnosis of Blow (1956) is accepted, although there have been suggestions and some evidence (which the writer regards as inconclusive) that this form may embrace several species or even genera (Rhumbler, 1911; Parker, 1962; Bandy *et al.*, 1965). This species, in which the last chamber completely envelops the earlier, globigerine part of the test, ranges from within the early to the middle part of Zone N. 9 to Zone N. 23, according to Blow (1969, p. 334). *Orbulina universa* is abundant at the type locality of the Yellow River Formation (Cosson's Farm) along with *O. suturalis* and *Biorbulina bilobata.* Many of the tests were dissected to reveal the juvenile stage, which, in every case was a globigerine form very similar in test morphology to *Globigerina bulloides bulloides* d'Orbigny.

Genus BIORBULINA Blow, 1956

BIORBULINA BILOBATA (d'Orbigny)

Globigerina bilobata D'ORBIGNY, 1846, Foraminifères fossiles du bassin tertiaire de Vienne, p. 164, pl. 9, figs. 11-14.

Globigerina bilobata d'Orbigny. BANNER and BLOW, 1960, Cushman Found. Foram. Res., Contr., vol. 11, pp. 2-3, pl. 3, fig. 9 (lectotype). (lectotype).

Biorbulina bilobata (d'Orbigny). BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 334, pl. 23, figs. 5, 6.

"The large test is bilobate, consisting exteriorly of two sub-equal and partially embracing spheres, but without any external trace of any chambers earlier than the penultimate. The suture between the penultimate and last chamber is distinct and depressed, and no apertural pores were observed in the suture. No external primary aperture exists, but a very few apertural pores are present, apparently randomly distributed over both the ultimate and penultimate chambers. The wall is calcareous, radial in structure, and is uniformly and coarsely perforate, but otherwise smooth, with little trace of the original hispidity. The surfaces of the ultimate and penultimate chambers are virtually identical, and the wall thicknesses appear to be the same. Maximum dimension of lectotype: 0.76 mm." (Banner and Blow, 1960)

PLATE 30
JACKSON BLUFF FORMATION ?
DARLING SLIDE, UPPER HORIZON

Figures

Page

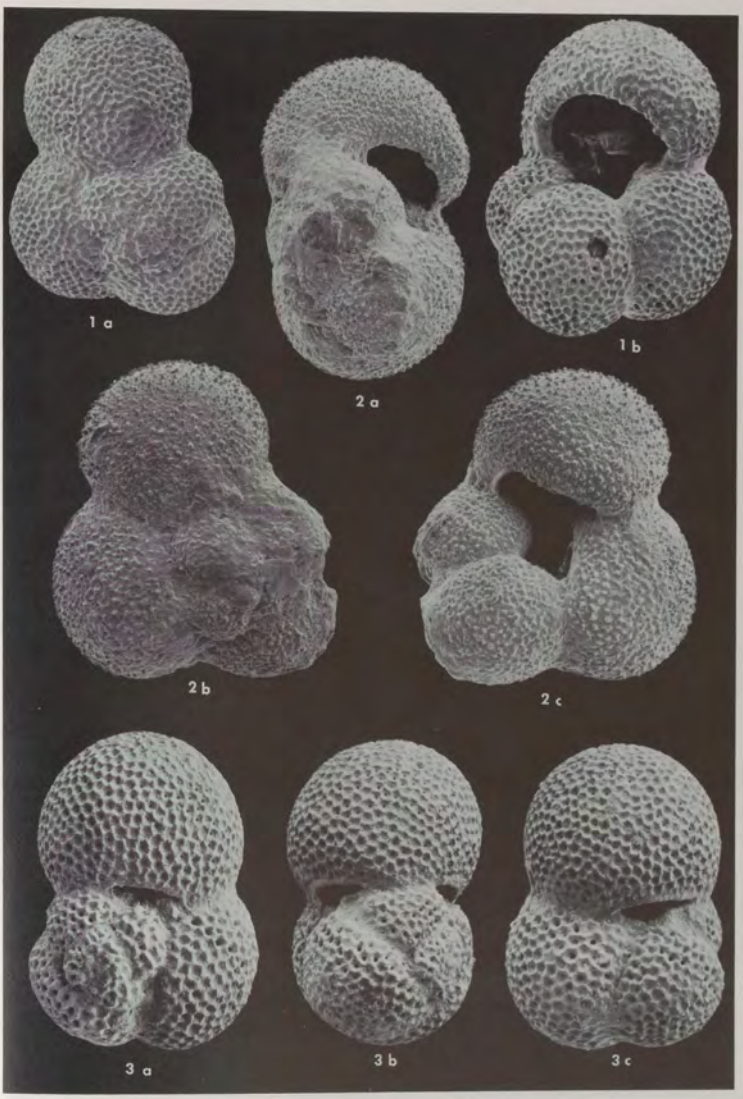

Plate 30

Lectotype: d'Orbigny Collection, Museum National de l'Histoire Naturelle, Paris; Tortonian (?) marly clays, near Nussdorf, Austria.

Discussion: Blow has presented a strong argument for the non-teratoid development of this form from *Globigerinoides sicanus* via *Praeorbulina transitoria,* and he believes that it ranges from near the base of Zone N. 9 to Zone N. 23.

Subfamily SPHAEROIDINELLINAE
Banner and Blow, 1959

Genus SPHAEROIDINELLA Cushman, 1927

SPHAEROIDINELLA DEHISCENS
DEHISCENS (Parker and Jones)

Pl. 45, fig. 2; Pl. 59, fig. 3

Sphaeroidina bulloides d'Orbigny var. *dehiscens* PARKER and JONES, 1865, Roy. Soc. London, Philos. Trans., vol. 155, p. 369, pl. 19, fig. 5.

Sphaeroidina bulloides d'Orbigny var. *dehiscens* Parker and Jones. BANNER and BLOW, 1960, Cushman Found. Foram. Res., Contr., vol. 11, p. 35, pl. 7, fig. 3 (lectotype).

Sphaeroidinella dehiscens dehiscens (Parker and Jones). BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 336, pl. 29, fig. 9.

"The large globose test shows only three chambers externally. The chambers are subspherical, much inflated, partially embracing, rapidly enlarging and appear to be trochospirally coiled. The test is involute both dorsally and ventrally. The sutures are broadly depressed and the periphery of the test is broadly lobulate. The apertures are sutural and multiple. The primary aperture appears to be interiomarginal, umbilical and ventral in position, but it, like the umbilicus, is infilled by extraneous material. The dorsal supplementary aperture is sutural in position but it is also infilled with extraneous material and consequently its true extent and nature cannot be ascertained in the lectotype. The apertures are furnished with thick flange-like lips of clear imperforate shell material; these flanges extend around the umbilical margins of the chambers and on both sides of the supplementary aperture. The sutures appear to be deeply incised in the vicinity of the apertures and the flanges border these incisions throughout their length and in part bridge them. The wall of the test is calcareous, apparently radial in structure and it is uniformly and coarsely perforate except for the flange-like areas. The surface of the

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PLATE 31
JACKSON BLUFF FORMATION ?
DARLING SLIDE, LOWER HORIZON

Figures Page

1. *Globigerina bulloides apertura* Cushman. 46
Maximum diameter 0.40 mm
   a. Spiral view, X 136
   b. Edge view, X 136
   c. Umbilical view, X 136

2. *Globigerina bulloides bulloides* d'Orbigny. 48
Maximum diameter, 0.37 mm
   a. Umbilical view, X 136
   b. Spiral view, X 136

3. *Globigerina druryi decoraperta* Takayanagi and Saito. 50
Maximum diameter, 0.23 mm
   a. Umbilical view, X 189
   b. Spiral view, X 189

4. *Hastigerina (Hastigerina) siphonifera siphonifera* (d'Orbigny). 124
Maximum diameter, 0.38 mm
   a. Edge view, X 133
   b. Umbilical view, X 133

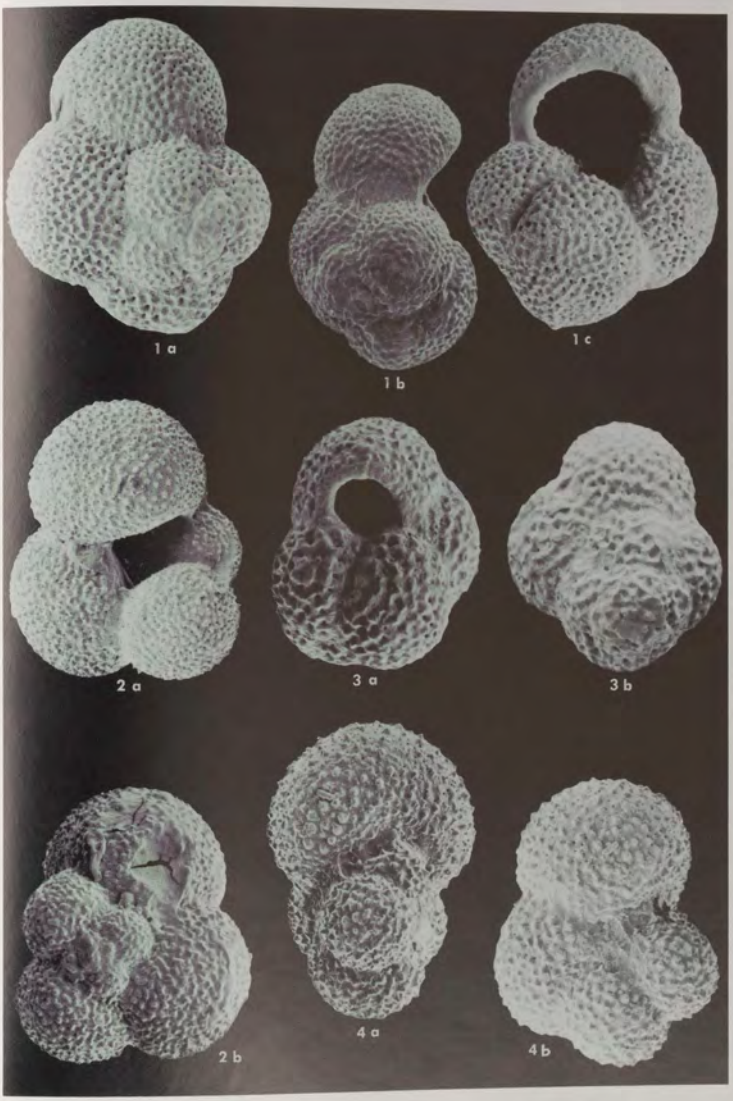

Plate 31

test is smooth and highly polished especially in the vicinity of the apertures where the material of the flanges appears to spread thickly over the chamber surfaces. Maximum diameter of lectotype: 0.88 mm." (Banner and Blow, 1960)

Lectotype: British Museum (Natural History) ZF. 3580; Atlantic Ocean, 2° 20' N., 28° 44' W., at 1080 fathoms.

Discussion: The range of this form is from the base of Zone N. 19, to Zone N. 23 (Blow, 1969).

SPHAEROIDINELLA DEHISCENS DEHISCENS forma IMMATURA (Cushman)

Sphaeroidina dehiscens Parker and Jones var. *immatura* CUSHMAN, 1919, Carnegie Inst. Washington, Publ. No. 291, p. 40, pl. 14, fig. 2.

Sphaeroidinella dehiscens dehiscens forma *immatura* (Cushman). BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 336, pl. 29, figs. 6-8.

"Test exteriorly composed almost entirely of two visible chambers, with a small portion of a third sometimes slightly showing; chambers spherical, walls coarsely perforate, suture between the chambers very slightly fissure-like on opposite sides, otherwise closed and simply depressed. Diameter, 0.4 to 0.5 mm.

"All of the specimens from the Bowden marl seem to belong to this species, but they are very constant in having the characters only slightly developed, the usual separation of the chambers being barely indicated and the division, instead of being a deep-cut fissure, is merely a simple cut in the central part of the sutural region at either side. The specimens also are very small but are uniform in size and in general characters." (Cushman, 1919)

Holotype: depository not designated for the type specimen.

Discussion: Cushman (1919, p. 28) states that all of his specimens are from the Bowden Marl at Bowden, Jamaica. Blow (1969, p. 336 and pl. 29) refers to Cushman's locality as the "Buff Bay Beds" of Cushman and Jarvis (1930), not Buff Bay Formation of Hill (1899). Blow refers specimens from this locality to both *Sphaeroidinella dehiscens* forma *immatura* and to *Sphaeroidinellopsis subdehiscens paenedehiscens* Blow. He considers adult *S. dehiscens dehiscens* forma *immatura* to be phylogenetically primitive forms of *S. dehiscens dehiscens* and to be confined to Zone N. 19.

PLATE 32
JACKSON BLUFF FORMATION ?
DARLING SLIDE, UPPER HORIZON

Figures Page

1. *Globorotalia (Globorotalia) margaritae* Bolli and Bermúdez. 102
   Maximum diameter, 0.49 mm
   a. Spiral view, X 104
   b. Edge view, X 104
   c. Umbilical view, X 104

2. *Globorotalia (Globorotalia) cultrata* subsp. 17
   Maximum diameter, 0.42 mm
   a. Spiral view, X 134
   b. Edge view, X 133
   c. Umbilical view, X 133

3. *Globorotalia (Turborotalia) praeoscitans* Akers, new species 116
   USNM 180584, paratype. Maximum diameter, 0.30 mm
   a. Umbilical view, X 200
   b. Edge view, X 200
   c. Spiral view, X 200

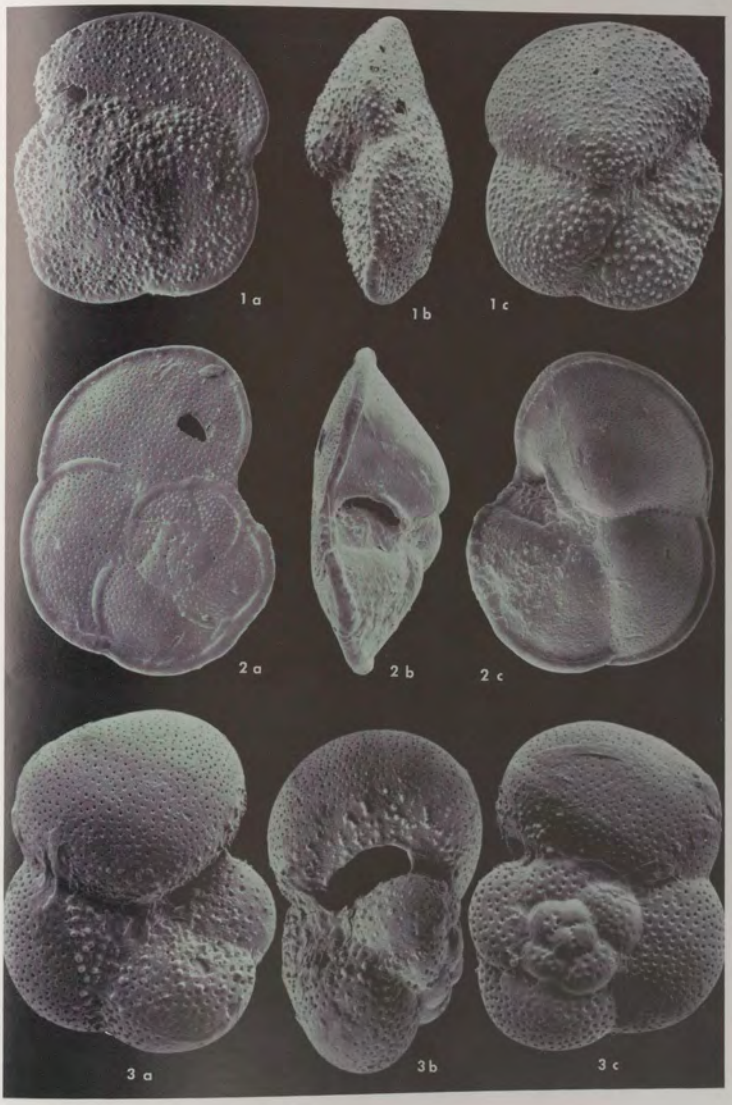

Plate 32

Genus SPHAEROIDINELLOPSIS
Banner and Blow, 1959

SPHAEROIDINELLOPSIS SEMINULINA
KOCHI (Caudri)

Pl. 12, fig. 3

Globigerina sp. KOCH, 1923, Bericht. Schweiz. Pal. Ges., vol. 18, p. 355, text-figs. 82-b.
Globigerina kochi CAUDRI, 1934, Tertiary Deposits of Soemba, p. 144.
Sphaeroidinella seminulina kochi (Caudri). BLOW, 1959, Bull. Amer. Paleontology, vol. 39, no. 178, p. 198, pl. 12, figs. 78-79.
Sphaeroidinellopsis seminulina kochi (Caudri). BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 337, pl. 30, fig. 8.

"It is a small, flat *Globigerina*, on the upper side of which a close somewhat excentric spiral is seen of small chambers, not easily to be distinguished one from another, while on the other side only 4 chambers are visible. These 4 chambers gradually increase in size from the earliest to the latest and the last chamber is slightly elongated horizontally which gives the test something the appearance of a strongly compressed *G. sacculifera*. There are, however, no supplementary apertures on the sutures. The four latest formed chambers lie round an undeep umbilicus; no aperture was observed. The fossils were not good enough to supply further details to Koch's original description." (Caudri, 1934)

Holotype: Naturhistorisches Museum, Basel, Switzerland; Tertiary of Kabu, Residentschaft Surabaja, Java.

Discussion: This form ranges from within the later part of Zone N. 10 to within Zone N. 19, according to Blow (1969, p. 337), whose observations are worth repeating here: "It may seem that the forms distinguished here as *S. seminulina kochi* are only ecological variants of *Sphaeroidinellopsis seminulina seminulina*. However, the multi-chambered forms included in *"kochi"* do not seem to occur throughout the whole of the stratigraphic record of *Sphaeroidinellopsis seminulina seminulina* and only develop much later than the first interval at the end of the stratigraphic range of *S. seminulina* (s.s.). The differences in stratigraphic ranges of the two morphotypes are consistently expressed in both deep-sea core material and in land-based stratigraphical sequences regardless of the depositional environments. Consequently, the writer continues to recognize *"kochi"* as being subspecifically distinct from *"seminulina* (sensu stricto)", at least, for biostratigraphical purposes."

PLATE 33
JACKSON BLUFF FORMATION ?
DARLING SLIDE, LOWER HORIZON

Figures Page

1. *Globorotalia (Globorotalia) margaritae* Bolli and Bermúdez. 102
Maximum diameter, 0.37 mm
   a. Spiral view, X 132
   b. Edge view, X 132
   c. Umbilical view, X 132

2. *Globorotalia (Globorotalia) cultrata limbata* (Fornasini). 98
Maximum diameter, 0.40 mm
   a. Spiral view, X 136
   b. Edge view, X 133
   c. Umbilical view, X 134

3. *Globigerinita glutinata* (Egger). 70
Maximum diameter, 0.23 mm
   a. Umbilical view, X 265
   b. Umbilical view (with more of last chamber in view), X 227

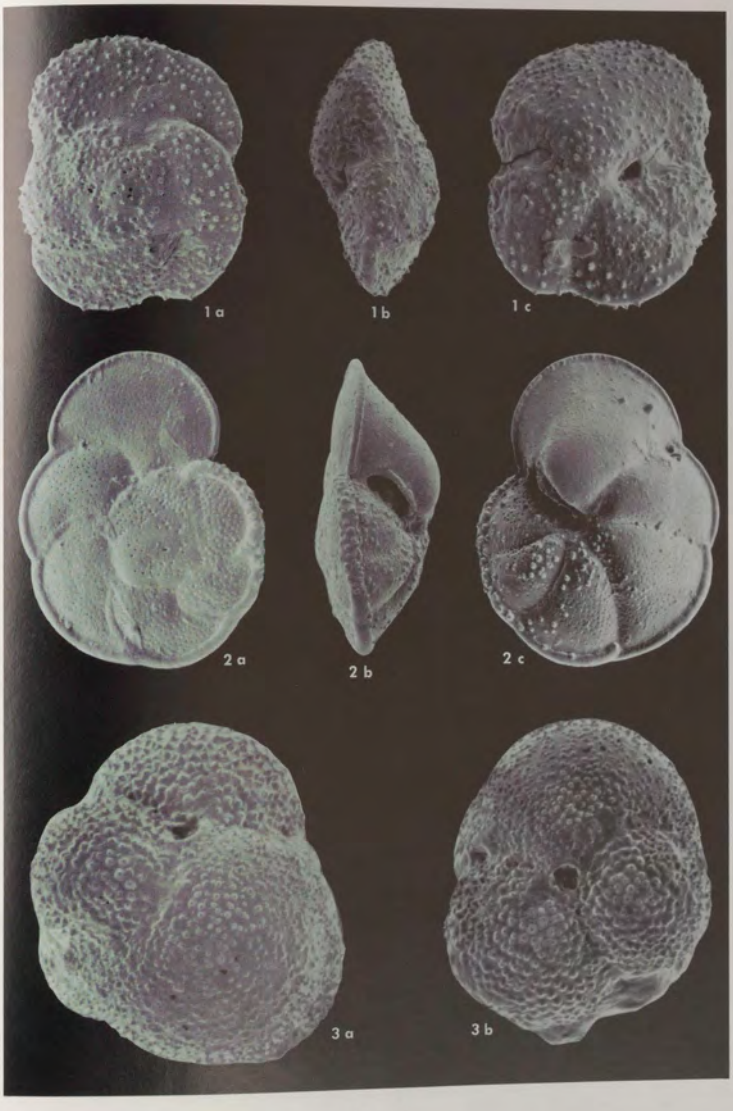

Plate 33

SPHAEROIDINELLOPSIS SEMINULINA SEMINULINA (Schwager)

Pl. 14, fig. 2

Globigerina seminulina SCHWAGER, 1866, *Novara* Exped. 1857-1859, Geol. Theil, vol. 2, pt. 2, p. 256, pl. 7, fig. 112.

Sphaeroidinella seminulina seminulina (Schwager). BLOW, 1959, Bull. Amer. Paleontology, vol. 39, no. 178, pp. 197-198, pl. 12, figs. 74-77a-c.

Globigerina seminulina Schwager. BANNER and BLOW, 1960, Cushman Found. Foram. Res., Contr., vol. 11, p. 24, pl. 7, figs. 7a-b, (neotype).

Sphaeroidinellopsis seminulina seminulina (Schwager). BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, pp. 337-338, pl. 30, fig. 7

"The fairly large test consists of about two whorls of rapidly enlarging, inflated chambers arranged in a low trochospire, with four chambers present in the last whorl. The chambers are initially obscure but probably embracing; they become increasingly well separated, slightly radially elongate and ovoid during the last whorl. The equatorial profile is sub-oval, somewhat elongate in the direction of the last chamber; the equatorial periphery is strongly lobulate. The axial profile is a compressed oval, and the dorsal surface is only very slightly convex. The axial periphery is evenly rounded, tending to become subacute over the last chamber. The dorsal sutures are initially obscure. In the last whorl, the intercameral sutures are slightly but broadly depressed on the ventral and dorsal surfaces and are much more deeply depressed over the periphery. The dorsal intercameral sutures are slightly curved to nearly radial, whilst the ventral intercameral sutures are virtually radial. The umbilicus is broad and probably very deep (infilled in the neotype) and is bordered by broad, clear, hyaline, thickened, crenulate and corrugated flanges, which are the strongly developed lips of the relict parts of the primary apertures of the chambers in the last whorl. The primary aperture is believed to be a low interiomarginal, intraumbilical arch, but it is obscured in the neotype. There are no supplementary apertures present, either dorsally or ventrally. The wall is very thick and coarsely perforate. The surface of the test is covered by a layer of clear shell material which is thickest near the umbilicus; this cortex partially or wholly covers the coarse but sparsely distributed punctations. Maximum diameter of neotype: 0.56 mm." (Banner and Blow, 1960)

Neotype: British Museum (Natural History) P. 44035; obtained by Schwager from the "Pliocene" (? Sarmatian) of Kar Nikobar, sent by him to H. B. Brady.

PLATE 34
JACKSON BLUFF FORMATION
ECPHORA FAUNIZONE
JACKSON BLUFF, BED 9

Figures Page

1. *Globigerina bulloides bulloides* d'Orbigny. 48
Maximum diameter, 0.35 mm
   a. Spiral view, X 164
   b. Umbilical view, X 168

2. *Sphaeroidinellopsis subdehiscens subdehiscens* Blow. 86
Maximum diameter, 0.33 mm
   a. Spiral view, X 164
   b. Umbilical view, X 168

3. *Globigerina druryi decoraperta* Takayanagi and Saito. 50
Maximum diameter, 0.29 mm
   a. Umbilical view, X 168
   b. Spiral view, X 168

4. *Globigerinoides quadrilobatus quadrilobatus* (d'Orbigny). 62
Maximum diameter, 0.65 mm
   a. Spiral view, X 84
   b. Umbilical view, X 80

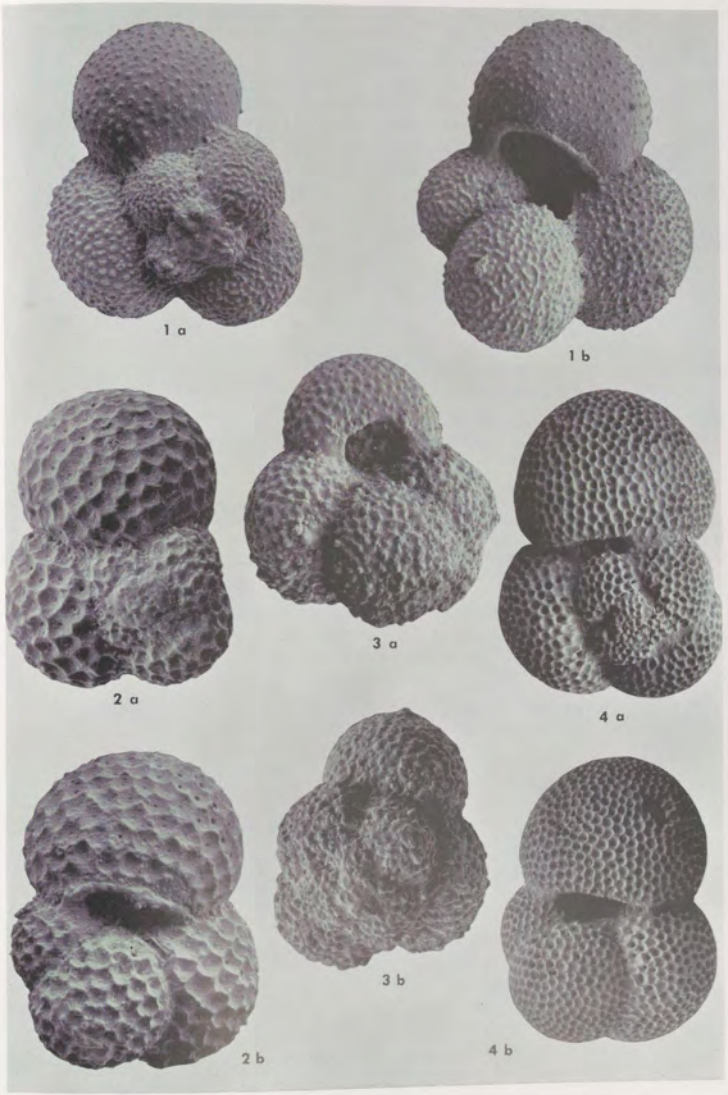

Plate 34

Discussion: According to Blow, the range is "from within Zone N. 6 to usually near the Zone N. 20/Zone N. 19 boundary; however, in deep-sea cores, the taxon may range as high as the earlier part of Zone N. 21." The specimen illustrated from the Blount's Creek locality (pl. 14, fig. 2a-b) is decorticated, as is often the case with individuals of this form (Blow, 1969, p. 337; Parker, 1967, p. 161).

SPHAEROIDINELLOPSIS SUBDEHISCENS SUBDEHISCENS Blow

Pl. 7, fig. 2; Pl. 20, figs. 2-4;
Pl. 34, fig. 2; Pl. 35, figs. 3, 4;
Pl. 39, figs. 1, 3; Pl. 49, fig. 3

Sphaeroidinella dehiscens subdehiscens BLOW, 1959, Bull. Amer. Paleontology, vol. 39, no. 178, p. 195, pl. 12, figs. 71, 72.

Sphaeroidinellopsis subdehiscens subdehiscens (Blow). BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 338, pl. 30, figs. 1-3; pl. 31, pl. 32.

"Test low trochospiral with three, seldom with three and one half, chambers in the last whorl; chambers, in general, rather embracing, sutures not depressed but usually fairly distinct, especially the suture between the last and earlier chambers; equatorial periphery slightly lobate with the test appearing ovate in equatorial profile; axial periphery rounded; umbilicus small or closed; aperture interiomarginal, umbilical, an elongate slit or low arch, often with thickened and crenulate margins composed essentially of a thickening of the outer cortex; wall calcareous, thick, composed of an outer cortex and a thick inner part which is radial in structure; inner part coarsely perforate, outer part smooth and glassy in reflected light; maximum diameter of holotype, 0.50 mm." (Blow, 1959)

Holotype: USNM 625705; Pozón Formation, eastern Falcón, Venezuela.

Discussion: The range, according to Blow (1969, p. 338) is from the base of Zone N. 13 to within Zone N. 19.

Genus GLOBOQUADRINA Finley, 1947

GLOBOQUADRINA ALTISPIRA ALTISPIRA (Cushman and Jarvis)

Pl. 44, fig. 1

Globigerina altispira CUSHMAN and JARVIS, 1936, Cushman Lab. Foram. Res., Contr., vol. 12, pt. 1, p. 5, pl. 1, figs. 13a-c, 14.

PLATE 35
JACKSON BLUFF FORMATION
ECPHORA FAUNIZONE
JACKSON BLUFF, BED 9

Figures Page

1. *Globigerinoides obliquus obliquus* Bolli. 60
Maximum diameter, 0.38 mm
   a. Umbilical view, X 161
   b. Spiral view, X 161

2. *Globigerinoides ruber* (d'Orbigny). 66
Maximum diameter, 0.52 mm
   a. Spiral view, X 104
   b. Umbilical view, X 104

3. *Sphaeroidinellopsis subdehiscens subdehiscens* Blow. 86
Maximum diameter, 0.40 mm
   a. Spiral view, X 144
   b. Umbilical view, X 144

4. *Sphaeroidinellopsis subdehiscens subdehiscens* Blow. 86
Maximum diameter, 0.53 mm
   a. Umbilical view, X 105
   b. Spiral view, X 105

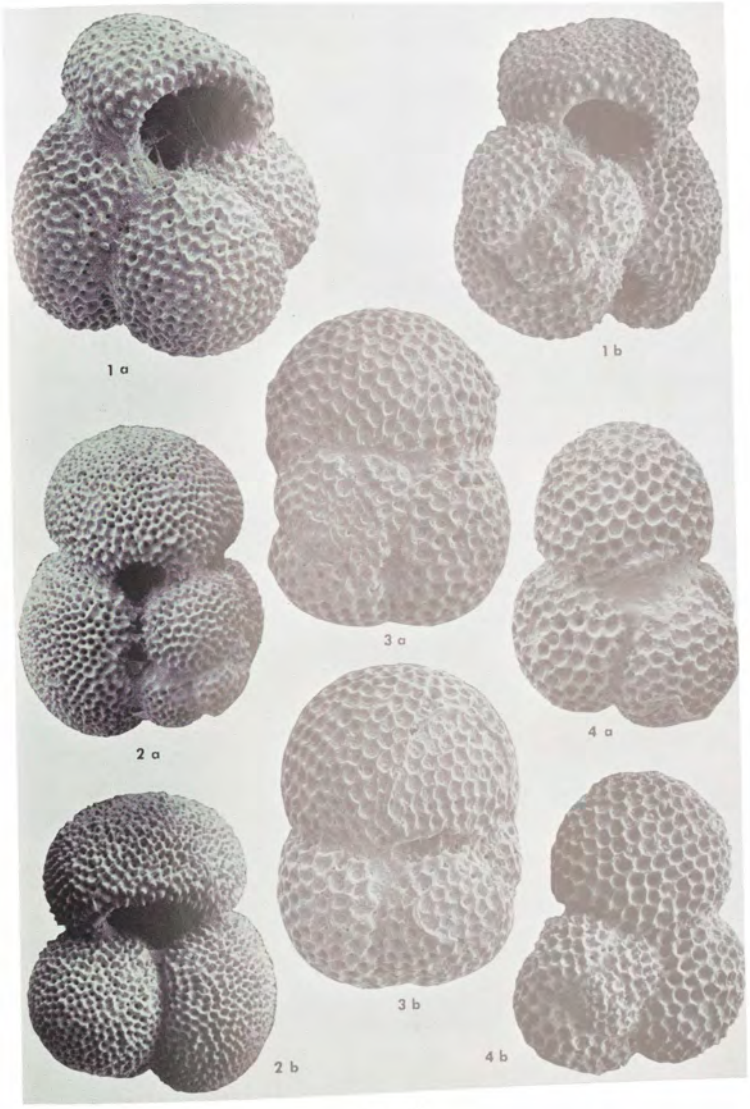

Plate 35

Globoquadrina altispira altispira (Cushman and Jarvis). BOLLI, 1957, U. S. Natl. Mus., Bull. 215, p. 111, pl. 24, figs. 7a-8b.

"Test composed of about three whorls in a high spire; chambers much higher than broad in the adult, strongly inflated on the ventral side with a distinct, thin triangular, plate-like structure extending into the umbilicus, about five in the adult whorl; sutures distinct, depressed; wall finely cancellated; aperture on the inner margin opening into the central umbilicus covered by a plate-like tooth. Length, 0.75-0.80 mm; diameter, 0.70 mm." (Cushman and Jarvis, 1936)

Holotype: USNM 22482; from the "Buff Bay beds" of Cushman and Jarvis (1936; not Buff Bay Formation of Hill, 1899), according to Blow (1969, p. 339).

Discussion: This subspecies is separated here from *Globoquadrina altispira globosa* Bolli, although, with Parker (1967, p. 165), the writer has failed to find any special stratigraphic significance in the separation. Morphologic variation within the species may have been related directly to ecology rather than genetics. Blow (1969) has found *Globoquadrina altispira altispira* to range from within the earlier part of Zone N. 4 to the earlier part of Zone N. 21.

GLOBOQUADRINA ALTISPIRA GLOBOSA
Bolli

Pl. 8, fig. 2; Pl. 11, fig. 1;
Pl. 15, fig. 1; Pl. 20, fig. 1;
Pl. 25, fig. 1; Pl. 40, fig. 1

Globoquadrina altispira globosa BOLLI, 1957, U.S. Natl. Mus., Bull. 215, p. 111, pl. 24, figs. 9, 10.

Globoquadrina altispira globosa Bolli. BLOW, 1959, Bull. Amer. Paleontology, vol. 39, no. 178, p. 183, pl. 11, figs. 52a-c.

"Shape of test medium to high trochospiral; equatorial periphery distinctly lobate. Wall calcareous, perforate, surface finely pitted, with short spines on well preserved specimens. Chambers spherical to very slightly compressed laterally; 15-20, arranged in 3-4 whorls; the 5-6 chambers of the last whorl increase moderately in size. Sutures on spiral side radial, depressed; on umbilical side radial, depressed. Umbilicus fairly wide, deep. Aperture high, covered above by an elongate, toothlike flap; interiomarginal, umbilical. Coiling random in the *Catapsydrax dissimilis* zone, later becoming predominantly sinistral (as is also *Globoquadrina altispira altispira* and *Globoquadrina dehiscens;* Bolli, 1951). Largest diameter of holotype, 0.7 mm." (Bolli, 1957)

Holotype: USNM P5626; from the type locality of the *Catapsydrax dissimilis* Zone, Trinidad.

PLATE 36
JACKSON BLUFF FORMATION
ECPHORA FAUNIZONE
JACKSON BLUFF, BED 9

Figures Page

1. *Globorotalia (Globorotalia) cultrata* subsp. 20
Maximum diameter, 0.58 mm
   a. Spiral view, X 87
   b. Umbilical view, X 90
   c. Edge view, X 87

2. *Globorotalia (Turborotalia) acostaensis humerosa* Takayanagi and Saito. 108
Maximum diameter, 0.48 mm
   a. Spiral view, X 122
   b. Edge view, X 126
   c. Umbilical view, X 122

3. *Globorotalia (Turborotalia) praeoscitans* Akers, new species 116
USNM 180565, paratype. Maximum diameter, 0.31 mm
   a. Edge view, X 162
   b. Umbilical view, X 164
   c. Spiral view, X 162

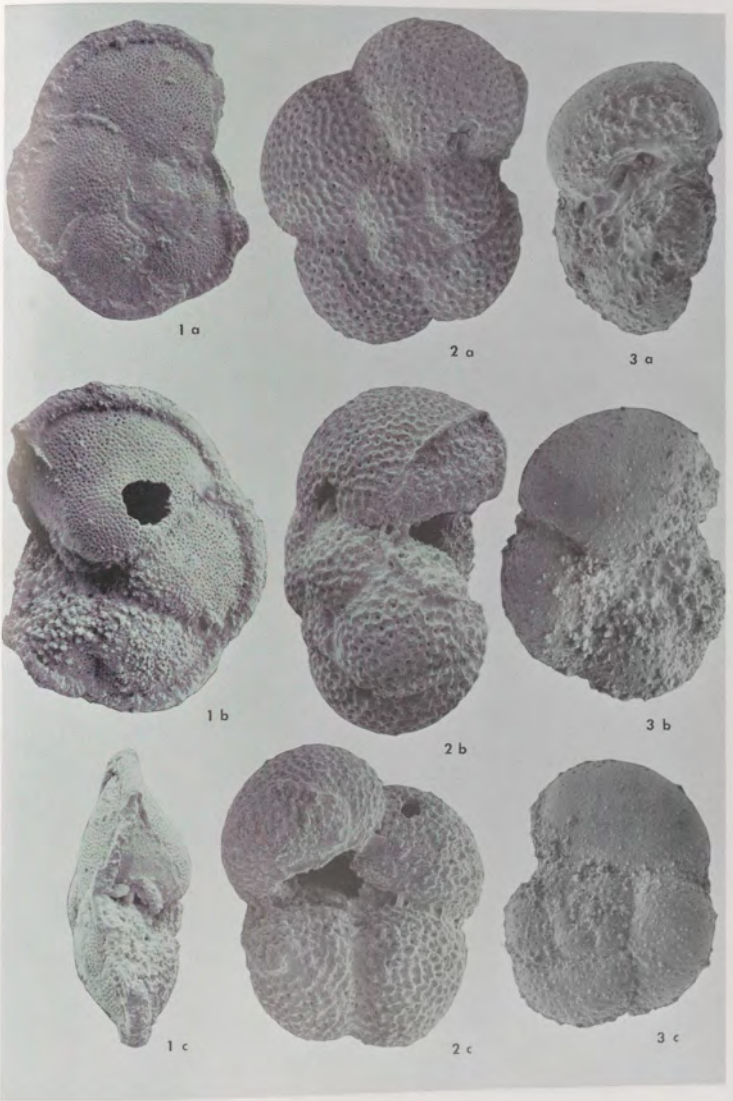

Plate 36

Discussion: The range, according to Blow (1969, p. 399) is from Zone N. 3 to Zone N. 19 or the earliest part of Zone N. 20. Parker (1967, p. 165) sees no stratigraphic basis for separating this form from *G. altispira s. s.*, nor does the writer. However, *G. altispira globosa* is a distinctive morphotype in assemblages investigated for this report with no gradations toward the form with less globular and more elongate chambers.

GLOBOQUADRINA BAROEMOENENSIS (LeRoy)

Pl. 3, fig. 3; Pl. 5; figs. 2-3

Globigerina baroemoenensis LEROY, 1939, Natuurk. Tijdschr. Nedrl.-Indie, Batavia, Java, vol. 99, no. 6, p. 263, pl. 6, figs. 1-2.

Globoquadrina baroemoenensis (LeRoy). BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, pp. 340-341, pl. 28, figs. 4, 8.

"Test medium, about as broad as high, ventral umbilical area widely opened, dorsally shows flattened spiral arrangement of chambers which enlarges rapidly, the last three or four constituting the greater part of the test; chambers distinct, inflated, last one somewhat flattened on outer margin toward lower part; sutures distinct, deeply depressed; wall smooth, moderately perforate; aperture a large opening on ventral side, covered with a distinct, narrow, sometimes protruding lip. Diameter, 0.50 mm." (LeRoy, 1939)

Holotype: in the collections of the Javanese Geological Survey (*teste* Dr. H. M. S. Hartono, *fide* Blow, 1969, p. 340); Telisa Formation of Central Sumatra.

Discussion: The range is from within the later part of Zone N. 2 to Zone N. 16, according to Blow.

Chipola specimens compare closely with LeRoy's holotype figure, as well as with specimens figured by Blow.

GLOBOQUADRINA CONGLOMERATA (Schwager)

Globigerina conglomerata SCHWAGER, 1866, *Novara* Exped. 1857-1859, Geol. Theil. vol. 2, pt. 2, p. 255, pl. 7, fig. 113.

Globigerina conglomerata Schwager. BANNER and BLOW, 1960, Cushman Found. Foram. Res., Contr., vol. 11, p. 7, pl. 2, fig. 3 (neotype).

Globoquadrina conglomerata (Schwager). PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, pp. 165-166, pl. 27, fig. 4.

PLATE 37
JACKSON BLUFF FORMATION
CANCELLARIA FAUNIZONE
JACKSON BLUFF, BED 10

Figures Page

1. *Globigerina bulloides apertura* Cushman. 46
Maximum diameter, 0.39 mm
   a. Spiral view, X 127
   b. Edge view, X 127
   c. Umbilical view, X 129

2. *Globigerina druryi decoraperta* Takayanagi and Saito. 50
Maximum diameter, 0.24 mm
   a. Spiral view, X 204
   b. Edge view, X 204
   c. Umbilical view, X 206

3. *Globigerina bulloides bulloides* d'Orbigny. 48
Maximum diameter, 0.34
   a. Spiral view, X 153
   b. Edge view, X 153
   c. Umbilical view, X 154

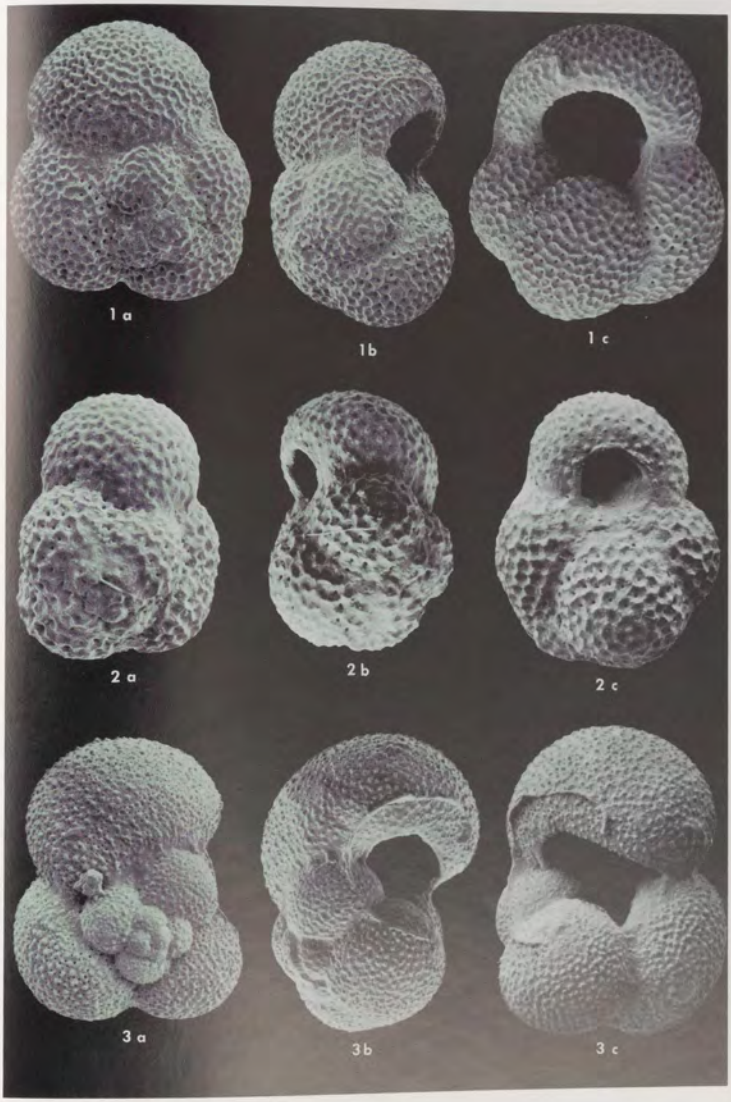

Plate 37

"The large globose test consists of 10 chambers (including the proloculum) arranged in a low trochospire of about two whorls with four chambers in each whorl. The equatorial profile is sub-circular, with a weakly and broadly lobulate equatorial periphery. The axial profile is sub-elliptical, the dorsal side being weakly convex and the ventral side being also convex. The axial periphery is broadly and smoothly rounded. The chambers are appressed, not greatly inflated, but are moderately embracing; in dorsal view they are reniform, becoming much longer circumferentially than broader radially. The sutures are weakly depressed and initially not very distinct. The spiral suture is lobulate and the intercameral sutures are slightly curved to nearly radial, dorsally meeting the spiral suture nearly at right angles. The umbilicus is distinct, moderately broad, quadrate in outline and deep. The primary aperture is a low interiomarginal arch totally confined within the umbilicus. No apertural lip, rim or tooth is visible on the neotype. The apertural face is somewhat flattened; it directly faces the umbilicus and forms a distinct although rounded angle with the remainder of the chamber wall. The wall is coarsely and uniformly perforate. The surface of the test is rough and cancellate, furnished with strong short spines which are particularly well developed along the margins of the umbilicus. Maximum diameter of neotype: 0.75 mm." (Banner and Blow, 1960)

Neotype: British Museum (Natural History) P. 44031; obtained by Schwager from the Pliocene (?) of Kar Nikobar, sent by him to Brady.

Discussion: Blow gives the later parts of Zone N. 19 to Zone N. 23 as the range of this species. Together with *Globorotaloides hexagona, Globoquadrina conglomerata* disappeared from the Atlantic-Caribbean Region just prior to Zone N. 22, although both are living in the Indian and Pacific Oceans.

GLOBOQUADRINA DEHISCENS
(Chapman, Parr, and Collins)

Pl. 8, fig. 1; Pl. 15, fig. 3

Globorotalia dehiscens CHAPMAN, PARR, and COLLINS, 1934, Linn. Soc. London, (Zoology), Jour., vol. 38, no. 262, p. 569, pl. 11, fig. 36.

Globorotalia quadraria CUSHMAN and ELLISOR, 1939, Cushman Lab. Foram. Res., Contr., vol. 15, p. 11, pl. 2, fig. 5.

Globorotalia dehiscens Chapman, Parr, and Collins. FINLAY and MARWICK, 1940, Roy. Soc. New Zealand, Trans., vol. 70, pp. 114, 123, subsequent lists.

Globoquadrina subdehiscens FINLAY, 1947, New Zealand Jour. Sci. Technology, vol. 28, no. 5 (Sec. B), p. 291

Globoquadrina quadraria (Cushman and Ellisor) var. *advena* BERMÚDEZ, 1949, Cushman Lab. Foram. Res., Spec. Pub. 25, p. 287, pl. 22, figs. 36-38.

PLATE 38
JACKSON BLUFF FORMATION
CANCELLARIA FAUNIZONE
JACKSON BLUFF, BED 10

Figures Page

1. *Globigerinoides obliquus extremus* Bolli and Bermúdez. 58
Maximum diameter, 0.49 mm
   a. Spiral view, X 126
   b. Umbilical view, X 126
   c. Edge view, X 126

2. *Globigerinita glutinata* (Egger). 70
Maximum diameter, 0.29 mm
   a. Edge view, X 183
   b. Spiral view, X 183
   c. Umbilical view, X 185

3. *Globigerinoides ruber* (d'Orbigny). 66
Maximum diameter, 0.52 mm
   a. Umbilical view, X 101
   b. Spiral view, X 101
   c. Edge view, X 101

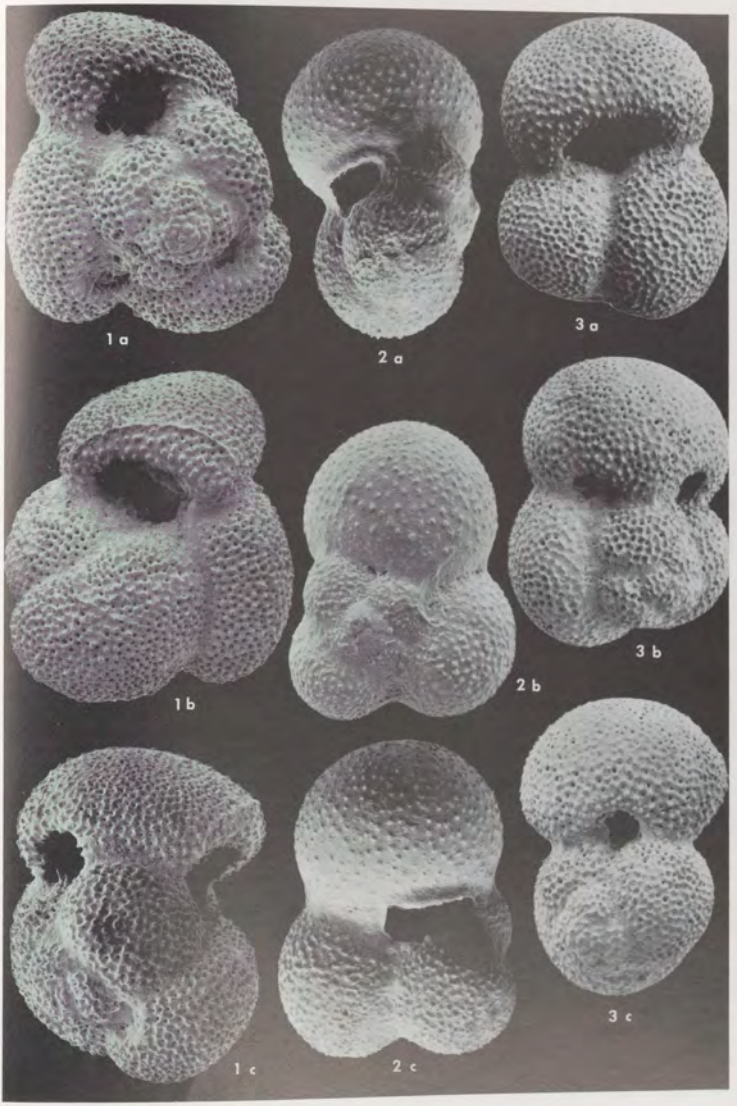

Plate 38

Globoquadrina dehiscens (Chapman, Parr, and Collins). PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, pp. 166-168, pl. 26, figs. 1-3.

"Test subconical, about as broad as high, the dorsal side flattened or slightly convex, the ventral side strongly convex and deeply umbilicate, margin rounded, composed of several whorls with four chambers in the last-formed one, chambers increasing quickly in size and height as added, well inflated, and separated along their inner margins by deep fissures; sutures radial, depressed; surface reticulate or slightly papillate, the apertural face being finely punctate; aperture an elongate slit extending almost the full length of the inner margin of the last-formed chamber and opening into the umbilical cavity. Diameter, 0.55 mm." (Chapman, Parr, and Collins, 1934)

Holotype: Chapman collection; from Kackeraboite Creek, Port Phillip area, Victoria, Australia.

Discussion: Cifelli (see Parker, 1967, p. 167) examined the types of Bermúdez' variety and believes that form to be a synonym of the present species. Bermúdez (1961, p. 1.310) concurs with this interpretation. Blow (1969, p. 341) considers the form of Bermúdez to be subspecifically distinct and to have a range from within the later parts of Zone N. 6 to within Zone N. 15, whereas, he records a range from Zone N. 5 to Zone N. 19 for *G. dehiscens s. l.* The writer has not seen sufficient evidence for differentiation, and he has not seen documentation of *G. dehiscens s.l.* above Zone N. 17, as the zone is defined by Blow (1969).

GLOBOQUADRINA DUTERTREI
(d'Orbigny)

Pl. 60, fig. 2

Globigerina rotundata D'ORBIGNY, 1826, Ann. Sci. Nat., (ser. 1), vol. 7, p. 277, list no. 6 *(nomen nudum).*

Globigerina dutertrei D'ORBIGNY *in* DE LA SAGRA, 1839, Hist. Phys. Pol. Nat. Cuba, "Foraminifères," p. 84, pl. 4, figs. 19-21.

Globigerina rotundata d'Orbigny. FORNASINI, 1898, Palaeontographia Italica, vol. 4, p. 208, text-fig. 3.

Globigerina eggeri RHUMBLER *in* BRANDT, 1901, Nordisches Plankton, Lief 1, no. 14, p. 19, text-fig. 20 (after Brady, 1884, pl. 79, "*G. dubia* Egger").

Globigerina subcretacea LOMNICKI, 1901, Naturf. Ver. Berlin, Abh., vol. 39 (1900), p. 17 [included in synonymy: Brady, 1884, pl. 82, fig. 10 "*G.* (*cretacea* d'Orbigny?)"]

Globigerina dutertrei d'Orbigny. BANNER and BLOW, 1960, Cushman Found. Foram. Res., Contr., vol. 11, p. 11, pl. 2, fig. 1 (lectotype).

PLATE 39
JACKSON BLUFF FORMATION
CANCELLARIA FAUNIZONE
JACKSON BLUFF, BED 10

Figures Page

1. *Sphaeroidinellopsis subdehiscens subdehiscens* Blow. 86
Maximum diameter, 0.34 mm
   a. Spiral view, X 178
   b. Edge view, X 175
   c. Umbilical view, X 175

2. *Globigerinoides quadrilobatus quadrilobatus* (d'Orbigny). 62
Maximum diameter, 0.59 mm
   a. Edge view, X 90
   b. Umbilical view, X 91
   c. Spiral view, X 90

3. *Sphaeroidinellopsis subdehiscens subdehiscens* Blow. 86
Maximum diameter, 0.34 mm
   a. Spiral view, X 178. Resolution along suture.
   b. Edge view, X 175
   c. Umbilical view, X 175

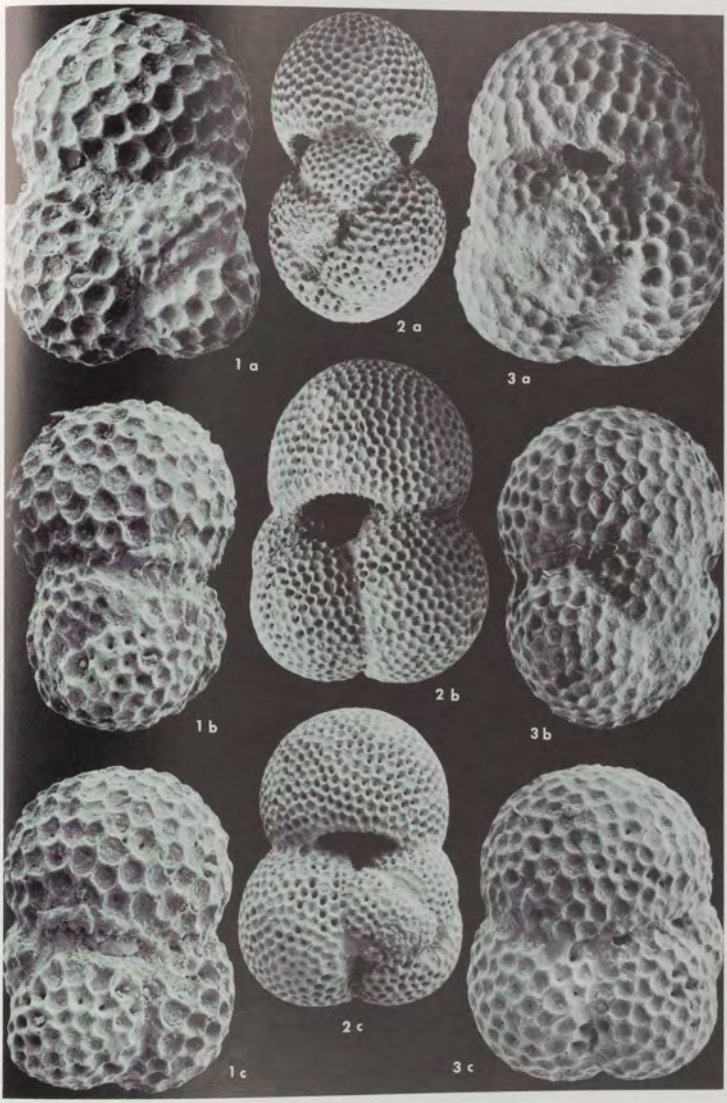

Plate 39

Globigerina eggeri Rhumbler. BANNER and BLOW, 1960, Cushman Found. Foram. Res., Contr., vol. 11, p. 11, pl. 2, fig. 4 (lectotype).

Globigerina rotundata Fornasini. BANNER and BLOW, 1960, Cushman Found. Foram. Res., Contr., vol. 11, p. 19, pl. 2, fig. 2 (lectotype).

Globoquadrina dutertrei (d'Orbigny). PARKER, 1962, Micropaleontology, vol. 8, no. 2, p. 242, pl. 7, figs. 1-13; pl. 8, figs. 1-4.

Globoquadrina dutertrei (d'Orbigny). PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, p. 168, pl. 25, fig. 7.

"*Globigerina*. Testa suborbiculata, convexa, alba, creberrime rugosa, spira convexo-obtusa, anfractibus tribus, distinctis; loculis quinis, oblongatis; suturis excavatis, apertura magna, in umbilico.

"Dimensions: Diamètre 1/2 millim. Coquille globuleuse, discoïde, élevée, partout rugueuse, les rugosités dues au pourtour saillant des nombreux trous dont chaque loge est criblée. Spire convexe, à sommet très obtus, composée de trois tours bien distincts et formée, dans l'état adulte, de dix à douze loges. Loges ovales, dans le sens de l'axe, au nombre de cinq au dernier tour, très séparées, et laissant a leur centre un profond ombilic. Ouverture en croissant, très large, placée sur plus de la moitié de la dernière loge, dans l'ombilic même. Couleur, blanc ou blanc-jaunâtre.

"Par sa spirale bien distincte, composée d'un grand nombre de loges, par les cinq loges de son dernier tour, cette espèce a beaucoup d'analogie avec notre *G. fragilis* fossile, dans les environs de Dax; mais, percée de trous bien plus grands, elle s'en distingue par sa contexture plus poreuse, plus ruguese, et par son ouverture bien plus largement ouverte." (d'Orbigny, 1839)

Holotype: not designated, but d'Orbigny's specimens were from Recent beach sands of Cuba, Martinique, and Guadeloupe.

Discussion: The concept of Parker (1962 and 1967) is followed here for this form, since it agrees more with the writer's own experiences and opinions than does the concept of Blow (1969, p. 318), who recognizes two distinct taxa, *Globigerina dutertrei* d'Orbigny and *Globigerina eggeri eggeri* Rhumbler. Blow believes that these are derived from a third form, *Globigerina eggeri multiloba* Romeo, whereas Parker and the writer consider *Globoquadrina dutertrei* to have developed from *Globorotalia (T.) acostaensis humerosa*. Forms included here under *Globoquadrina dutertrei* range from Zone N. 19 to Zone N. 23 according to Blow, however Parker (1967, p. 168) and the writer cannot document the taxon below Zone N. 21.

PLATE 40
JACKSON BLUFF FORMATION
CANCELLARIA FAUNIZONE
JACKSON BLUFF, BED 10

Figures

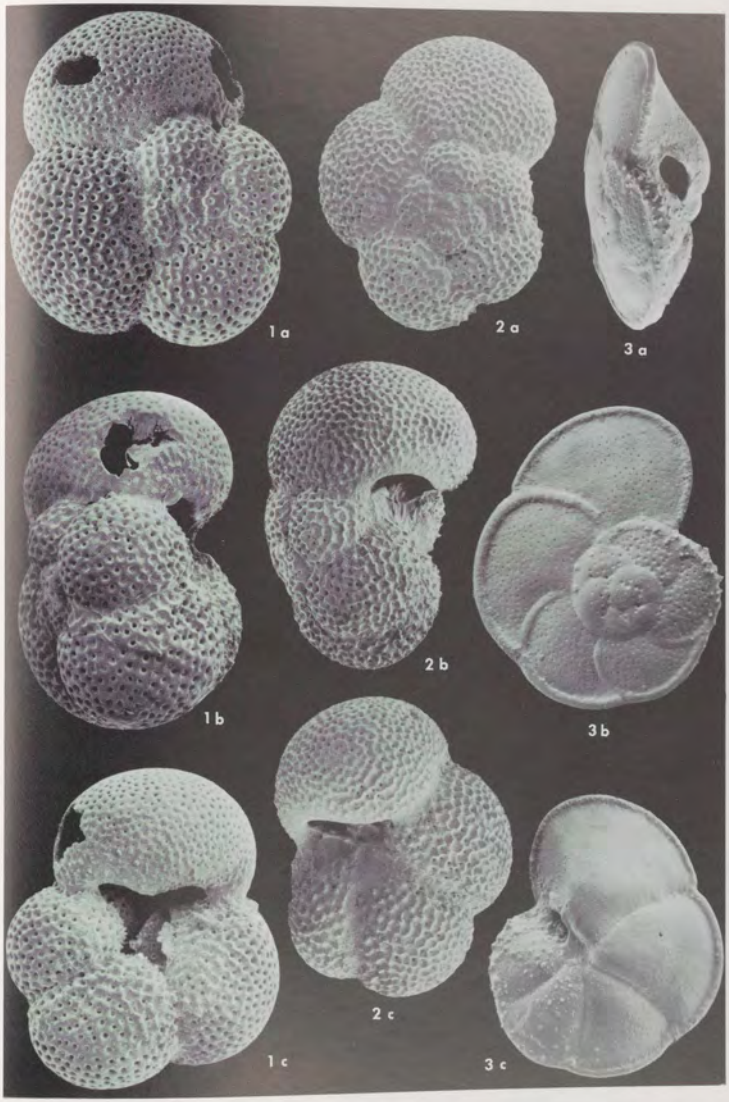

Plate 40

Family GLOBOROTALIIDAE
Cushman, 1927

Genus GLOBOROTALIA Cushman, 1927

GLOBOROTALIA (GLOBOROTALIA)
CULTRATA LIMBATA (Fornasini)

Pl. 33, fig. 2

Rotalia limbata D'ORBIGNY, 1826, Ann. Sci. Nat., (ser. 1), vol. 7, p. 274, list no. 3 *(nomen nudum)*.

Rotalia limbata D'ORBIGNY *in* FORNASINI, 1902, Roy. Acad. Sci. Ist. Bologna, Mem. Sci. Nat. Bologna, ser. 5, vol. 10, p. 56, text-fig. 55, ("disegno inedito"); (lectotype of Banner and Blow, 1960).

Rotalia limbata d'Orbigny. BANNER and BLOW, 1960, Cushman Found. Foram. Res., Contr., vol. 11, pt. 1, pp. 30-31, pl. 5, figs. 3a-c (lectotype designated).

Globorotalia (Globorotalia) cultrata limbata (Fornasini). BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 359, pl. 7, figs. 4-6; pl. 42, figs. 2, 3.

"The test consists of 14 chambers arranged in about 2 1/2 whorls comprising a low trochospire with 6 chambers present in the last whorl. The equatorial profile is sub-circular and the equatorial periphery is moderately lobulate. The axial profile is rhomboidal with an acute carinate periphery. The test is somewhat compressed dorso-ventrally and is almost equally biconvex. The chambers are uniformly and regularly enlarging (with the exception of the abnormally reduced final chamber); in dorsal aspect they are semi-circular, little inflated and do not embrace. In ventral view the chambers are sub-triangular, slightly inflated and partially embracing. The dorsal sutures are slightly depressed and are limbate, being thickened by a deposit of clear shell material which is continuous with the imperforate peripheral carina. The dorsal intercameral sutures are, for the most part, smoothly curved but in the last few chambers they become angular. These sutures meet the spiral suture at right angles and recurve to become almost tangential to the periphery. The ventral intercameral sutures are depressed, not thickened or limbate, but are slightly curved or slightly sinuous and become nearly radial. The umbilicus is small, open and fairly deep. The primary aperture is a low interiomarginal arch, extending from the umbilicus almost to the periphery; it possesses a thin and narrow lip along its length. The apertural face is sub-triangular in apertural view and is only slightly flattened, not being clearly delimited from the ventral face of the last chamber. The umbilical shoulders of the ventral surfaces of the chambers are weakly developed. The wall is finely and uniformly perforate, except for the areas of the imperforate peripheral carina and the dorsal sutural limbations. The surface of the test is smooth except for a weakly developed pustulose area on the ventral side of the first chamber of the last whorl, facing the primary aperture. Maximum diameter of lectotype: 0.44 mm. The lectotype has suffered slight damage and parts of the periphery of the last two chambers have been lost." (Banner and Blow, 1960)

Lectotype: d'Orbigny Collection, Muséum National de l'Histoire Naturelle, Paris; Recent deposits of the Adriatic near Rimini.

Discussion: Range is from Zone N. 13 or N. 14 to Zone N. 21 (Blow, 1969).

GLOBOROTALIA (GLOBOROTALIA)
CULTRATA MENARDII
(Parker, Jones and Brady)

Pl. 9, fig. 2; Pl. 13, fig. 1;
Pl. 17, fig. 2; Pl. 55, fig. 3

PLATE 41
JACKSON BLUFF FORMATION ?
CANCELLARIA FAUNIZONE ?
R. L. GAINER FARM

Figures Page

1. *Globigerina bulloides bulloides* d'Orbigny. 48
Maximum diameter, 0.34 mm

   a. Spiral view, X 179
   b. Edge view, X 175
   c. Umbilical view, X 179

2. *Turborotalita quinqueloba* (Natland). 122
Maximum diameter, 0.23 mm

   a. Edge view, X 315
   b. Spiral view, X 308
   c. Umbilical view, X 311

Plate 41

Rotalia (Rotalie) menardii D'ORBIGNY, 1826, Ann. Sci. Nat., Paris, (ser. 1), vol. 7, p. 273, list no. 26, *(nomen nudum) (teste* Parker, Jones and Brady, 1865).

Rotalia menardii PARKER, JONES and BRADY, 1865, Ann. Mag. Nat. Hist., (ser. 3), vol. 16, p. 20, pl. 3; fig. 81; (lectotype of Banner and Blow, 1960).

Rotalia menardii Parker, Jones and Brady. BANNER and BLOW, 1960, Cushman Found. Foram. Res., Contr., vol. 11, pt. 1, p. 31, pl. 6, figs. 2a-c; (lectotype designated).

Globorotalia (Globorotalia) cultrata menardii (Parker, Jones and Brady). BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, pp. 359-360, pl. 6, figs. 9-11.

"The fairly large test consist of about 3 whorls of fairly rapidly enlarging chambers arranged in a moderately low trochospire. There are about 5 1/2 chambers present in the last whorl (the final chamber being damaged peripherally). The equatorial profile of the test is subcircular and its equatorial periphery is moderately lobulate. In axial profile the test is moderately compressed, being almost equally biconvex and the axial periphery is acute and strongly carinate. In dorsal aspect the chambers are weakly inflated and are little, if at all, embracing; the chambers are nearly as long circumferentially as they are broad radially. The dorsal sutures are slightly depressed and are thickened with a deposit of clear shell material which appears to be continuous with the peripheral imperforate carina. The inner (proximal) ends of the dorsal intercameral sutures meet the moderately lobulate spiral suture almost at right angles, while they become smoothly recurved distally to meet the periphery almost tangentially. In ventral aspect the chambers are sub-triangular and moderately inflated. The ventral intercameral sutures are depressed, not thickened or limbate, and are nearly radial being slightly curved to sinuous. The umbilicus is small (compared to overall test size), but it is open and deep. The inner parts of the ventral chamber sides form inconspicuous umbilical shoulders. The primary aperture is interiomarginal, umbilical-extraumbilical, a moderately high arch extending for the full length of the ventral basal suture of the final chamber. The primary aperture is furnished, along its length, with a uniformly developed thin, but hispid, lip. Relict parts of the apertures of the later chambers of the last whorl, together with their lips, may be seen within the umbilicus. The apertural face of the terminal chamber is slightly flattened although there is no angular delimitation between it and the adjacent ventral face; the apertural face is limited peripherally by a slender continuation of the carina and the face becomes slightly concave in the vicinity of it. The wall is finely perforate except in the imperforate regions of the dorsal sutures and the peripheral carina. The surface of the test is smooth except for weakly hispid areas on the ventral faces of the first two chambers of the last whorl and the adjacent parts of the carina. Maximum diameter of lectotype: 0.76 mm." (Banner and Blow, 1960)

The following distinctions are worthy of repetition here:

"Many authors have supposed that "*Globorotalia menardii* D'ORBIGNY" (*vel* PARKER, JONES, and BRADY 1865) is a full senior synonym of "*Globorotalia cultrata* D'ORBIGNY, 1839"; however, this is not so and the two morphotypes can be recognized. Thus, *G. (G.) cultrata cultrata* possesses a flat, equally biconvex test with the spire opening slowly and regularly. The chambers do not increase rapidly as added and the dorsal intercameral sutures follow a smooth, almost hemi-circular path from the dorsal spiral suture to the peripheral point of attachment of the chamber to its predecessor. On the other hand, *G. (G.) cultrata menardii*, has an unequally biconvex

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PLATE 42
JACKSON BLUFF FORMATION ?
CANCELLARIA FAUNIZONE ?
R. L. GAINER FARM

Figures Page

1. *Globigerina bulloides apertura* Cushman. 46
Maximum diameter, 0.43 mm

   a. Spiral view, X 159
   b. Umbilical view, X 159
   c. Edge view, X 154

2. *Globigerinoides quadrilobatus quadrilobatus* (d'Orbigny). 62
Maximum diameter, 0.58 mm

   a. Spiral view, X 101
   b. Umbilical view, X 101
   c. Edge view, X 101

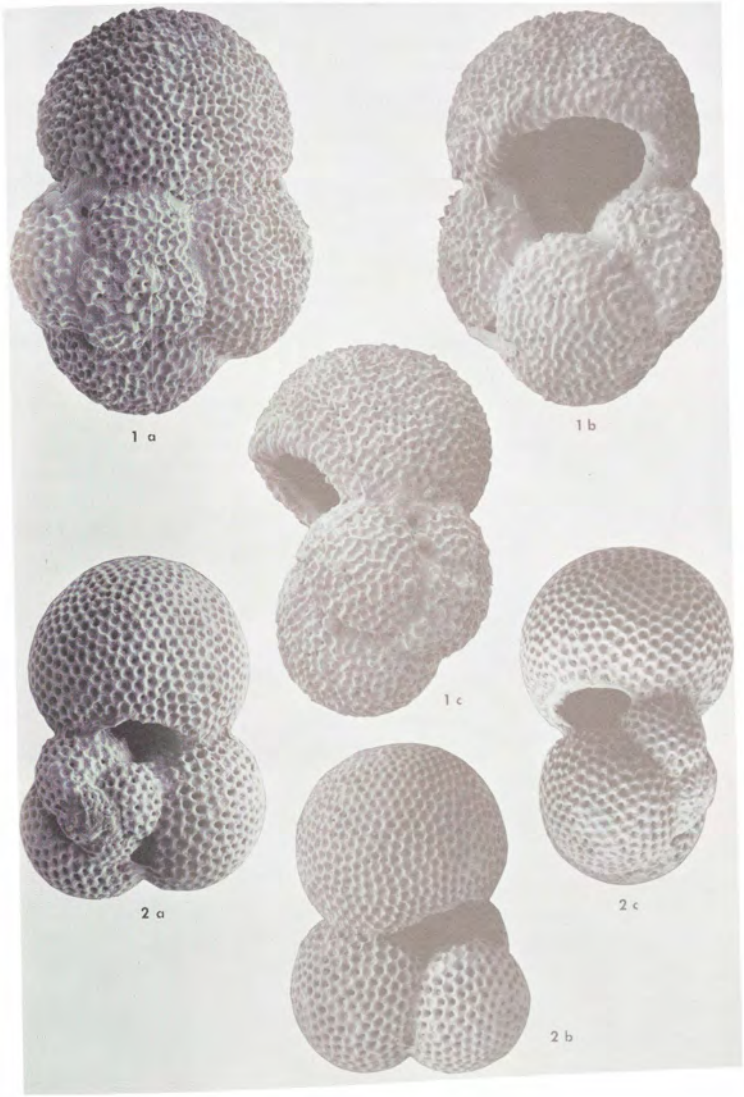

Plate 42

test which is distinctly more vaulted and inflated ventrally than dorsally. Further, in *menardii* the spire opens rapidly and, consequently, the chambers increase rapidly in size as added in the progression of the trochospire; the dorsal intercameral sutures are not smoothly hemi-circular but show a break in their curvature so that there is an approach to a "hockey-stick" shape." (Blow, 1969).

Lectotype: British Museum (Natural History) 1959.7.27.3; obtained by H. B. Brady from Recent marine sediments, at 15 fathoms depth off Laxey, Isle of Man, Irish Sea.

Discussion: The range given for this form by Blow is from within Zone N. 14 (?Zone N. 13) to Zone N. 23.

GLOBOROTALIA (GLOBOROTALIA) MARGARITAE Bolli and Bermúdez

Pl. 19, fig. 4; Pl. 32, fig. 1; Pl. 33, fig. 1

Globorotalia (G.) margaritae BOLLI and BERMÚDEZ, 1965, Boletin Informativo, Asociacion Venezolana de Geologia, Min. y Pet., vol. 8, no. 5, pp. 139-140, pl. 1, figs. 16-18.

Globorotalia cf. *canariensis* (d'Orbigny). BLOW, 1959, Bull. Amer. Paleontology, vol. 39, no. 178, p. 211, pl. 17, figs. 109a-c.

Globorotalia margaritae Bolli and Bermúdez. PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, pp. 179-180, pl. 32, figs. 1, 2.

Globorotalia (Globorotalia) margaritae Bolli and Bermúdez. BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, pp. 363-364, pl. 45, figs. 1-3, 5-6; pl. 44, figs. 1-6.

"Shape of test low trochospiral, compressed and elongate; equatorial periphery slightly lobate; axial periphery acute with a thin keel. Spiral side rounded-convex; umbilical side much less convex. Wall calcareous, finely perforate, surface smooth to very finely pitted. Chambers strongly compressed, seen from the spiral side elongate, fairly narrow and distinctly curved, about 12, arranged in 2 to 2 1/2 whorls; the usually 5 chambers of the last whorl increase fairly rapidly in size. Sutures on spiral side strongly curved but only very slightly depressed; on umbilical side radial to slightly curved, more or less depressed. Umbilicus very narrow. Aperture a slit, bordered above by a small, thin lip, interiomarginal, umbilical-extraumbilical. Coiling sinistral. Largest diameter of holotype: 0.37 mm." (Bolli and Bermúdez, 1965)

Holotype: lost, but H. Bolli is substituting a neotype for this taxon (*teste* R. Cifelli, *fide* Blow, 1969, p. 363).

Discussion: The specimen illustrated, pl. 19, fig. 4, is an immature one, but forms from Alum Bluff, Bed 4, though small, are typical in all other respects. A larger, but broken specimen was found from this locality, in addition to several immature individuals. Range: from within the middle to later parts of Zone N. 16 to within Zone N. 19 (Blow, 1969).

GLOBOROTALIA (GLOBOROTALIA) MIOCENICA Palmer

Globorotalia menardii (d'Orbigny) *miocenica* PALMER, 1945, Bull. Amer. Paleontology, vol. 29, no. 115, p. 70, pl. 1, fig. 10.

Globorotalia (Globorotalia) miocenica Palmer. BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, pp. 365-366, pl. 8, figs. 10-12; pl. 42, figs. 4, 8.

PLATE 43
JACKSON BLUFF FORMATION ?
CANCELLARIA FAUNIZONE ?
R. L. GAINER FARM

Figures

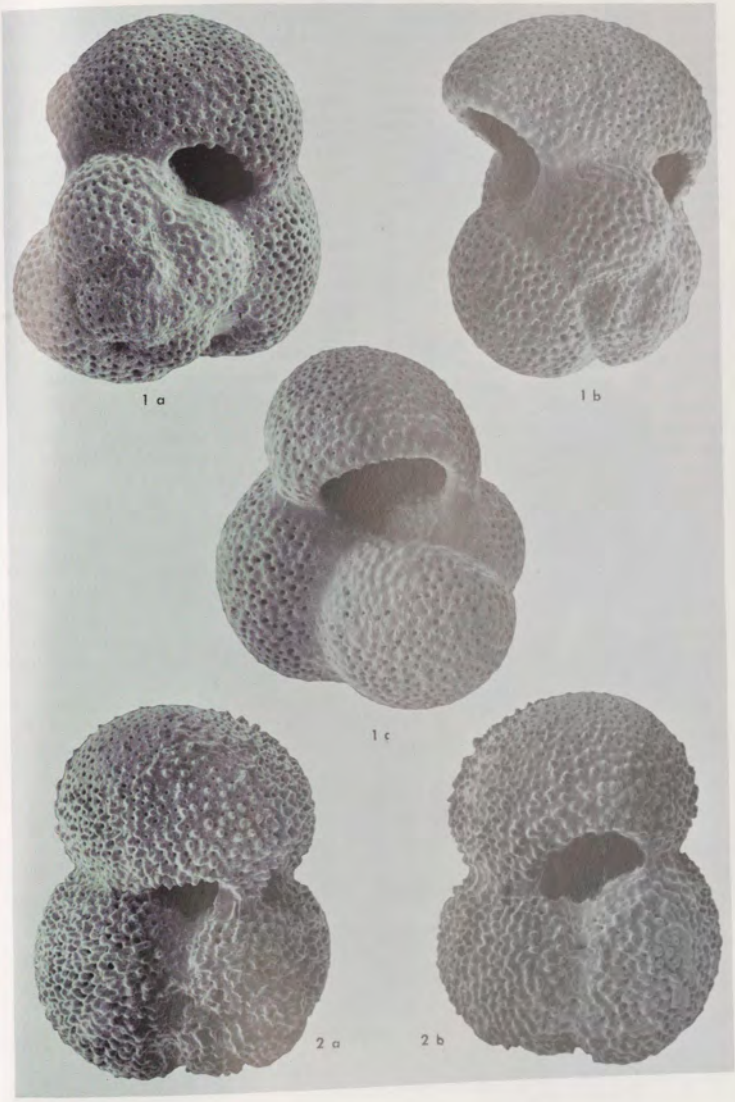

Plate 43

"Test of average size; dorsally flat; ventrally strongly convex; composed of 2 1/2 whorls with about six chambers in the final whorl; dorsal sutures broadly curved, clear, limbate but not generally elevated; spiral suture and periphery with limbate, elevated border; ventral sutures radial, depressed; ventrally the chambers terminate in a small, open umbilical depression. Aperture extending from the umbilical depression to the periphery on the inner base of the final chamber. Surface very finely but distinctly perforate. Maximum diameter of holotype, 0.6 mm; height, 0.02 mm." (Palmer, 1945)

Holotype: Paleontological Research Institution, Ithaca, New York, 20047; Bowden, near Port Morant, Jamaica, at foot of hill where road to old Capt. Baker house turns off the main road to Bowden P. O. and the United Fruit Co. wharf.

Discussion: The range is from the middle part of Zone N. 17 to within the early part of Zone N. 21, according to Blow. This form appears to be restricted to the Atlantic Province (the Gulf of Mexico and Caribbean areas and in deep-sea cores in the Atlantic Ocean). So far, it has not been reported from Pacific regions.

GLOBOROTALIA (GLOBOROTALIA) MULTICAMERATA Cushman and Jarvis

Pl. 19, fig. 2; Pl. 46, fig. 1

Globorotalia menardii (d'Orbigny) var. *multicamerata* CUSHMAN and JARVIS, 1930, Jour. Paleontology, vol. 4, p. 367, pl. 34, fig. 8.

Globorotalia (Globorotalia) multicamerata Cushman and Jarvis. BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 367-368, pl. 7, figs. 7-9; pl. 42, fig. 7.

"Variety differing from the typical in the large number of chambers, more distinctly umbilical depression on the ventral side and the very heavy development of the peripheral keel." (Cushman and Jarvis, 1930)

Holotype: USNM 14129; from 1/2 mile east of Buff Bay, Jamaica.

Discussion: Range, according to Blow, is from within the middle part of Zone N. 17 to within the early to middle part of Zone N. 21. Some workers consider *Globorotalia menardii* var. *fijiensis* Cushman as a synonym of this form. The writer has seen hundreds of specimens from the Suva Formation of Fiji and regards this form, which is marked by a lobate periphery, as a subspecies of *Globorotalia (G.) multicamerata.*

GLOBOROTALIA (GLOBOROTALIA) TRUNCATULINOIDES (d'Orbigny)

Pl. 55, fig. 1

Rotalina truncatulinoides D'ORBIGNY *in* BARKER-WEBB and BERTHELOT, 1839, Hist. Nat. Îles Canaries, "Foraminifères," vol. 2, pt. 2, pl. 132, pl. 2, figs. 25-27.

Globorotalia (Globorotalia) truncatulinoides (d'Orbigny). BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, pp. 403-405, pl. 5, figs. 10-12 (neotype); pl. 49, fig. 6.

"Test coiled in a low trochospire with about 15 chambers comprising the spire and with 5 complete

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PLATE 44
JACKSON BLUFF FORMATION ?
CANCELLARIA FAUNIZONE ?
R. L. GAINER FARM

Figures

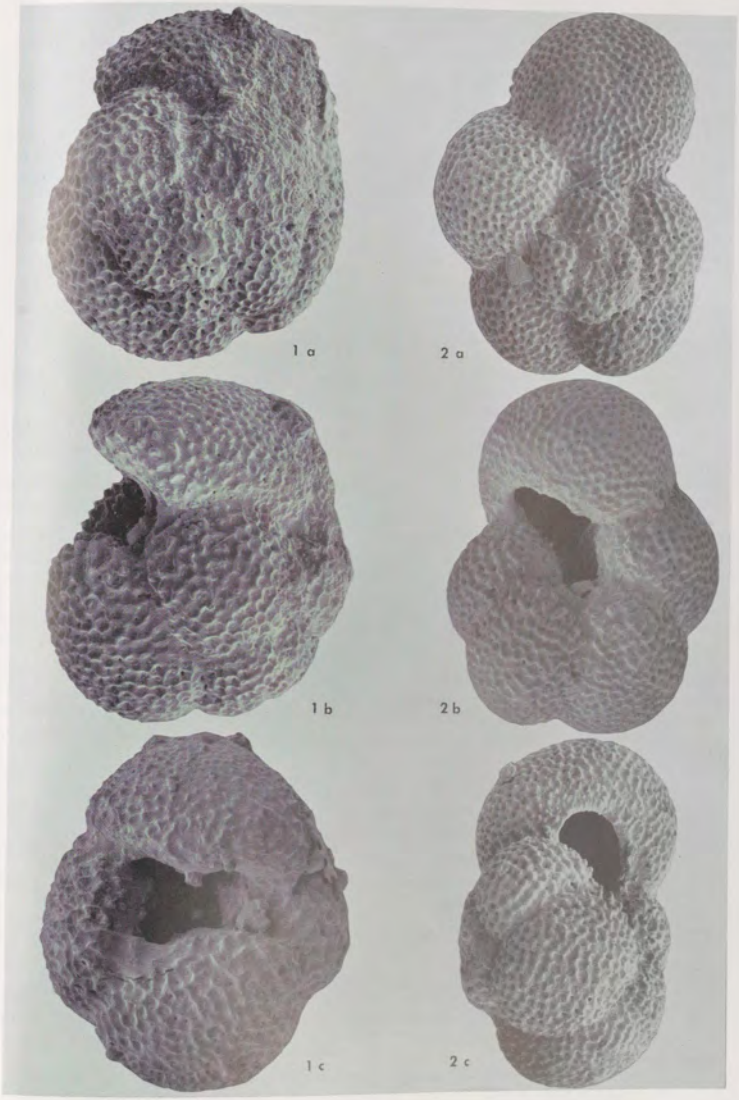

Plate 44

chambers in the last whorl; a small part of a sixth chamber is also visible in the last whorl. Dorsal side of the test flat to slightly concave; ventral side of the test strongly vaulted, acutely conical, so giving an essentially plano-convex test with a distinct carina in axial profile. In equatorial profile the test is not lobulate but almost polygonal in outline with the peripheral margins of the chambers almost flat not strongly curved. In dorsal aspect the chambers are closely appressed but not greatly embracing and not inflated. Dorsal intercameral sutures, radial, virtually straight except for slight retortion at their distal ends; dorsal sutures, slightly limbate and raised. Ventral intercameral sutures slightly incised, distinct, radial to sinuous peripherally. Ventral surfaces of the chambers not significantly inflated, rather compressed and appressed. Umbilicus deep, moderately widely open and sharply delimited by the sudden "in turning" of the umbilical shoulders of the enclosing chambers. The umbilical shoulders of the chambers are pointed and bear pustules. Aperture, interiomarginal, umbilical-extraumbilical, a low arch strictly limited to the basal suture ventral to the carina. Aperture bordered by an asymmetrical lip which is widest at its umbilical end. Relict apertures visible within the umbilicus and the umbilical ends of the earlier apertural lips are also visible. Wall calcareous, radial hyaline, densely but comparatively fine perforate except on the apertural face of the final chamber. The wall is strongly pustulose over the first three chambers of the final whorl immediately adjacent to the aperture. The pustules are densely packed but not fused together, each pustule being clearly delimited and separated one from the other. Pustules also present over the umbilical shoulders of the chambers of the last convolution and over the dorsal surfaces of the chambers of the penultimate whorl. The pores open between the pustules so that there is no significant area of the test without the normal wall-pores which have unrestricted access to the exterior; the pores do not open into pore-pits and do not seem to be modified in any way. Maximum diameter of holotype, 0.78 mm." (Blow, 1969)

Neotype: British Museum (Natural History) 1968.3.27.2; off Gomera, Canary Islands.

Discussion: This form ranges from the base of Zone N. 22 to Zone N. 23, according to Blow. Rare but typical specimens were found in the Waccamaw Formation at TU 875.

Subgenus TURBOROTALIA Cushman and Bermúdez, 1949

GLOBOROTALIA (TURBOROTALIA) ACOSTAENSIS ACOSTAENSIS Blow

Pl. 17, fig. 1

Globorotalia acostaensis BLOW, 1959, Bull. Amer. Paleontology, vol. 39, no. 178, pp. 208-210, pl. 17, figs. 106a-c, 107.

Globoquadrina acostaensis (Blow). PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, pp. 164-165, pl. 24, figs. 3-9.

Globorotalia (Turborotalia) acostaensis Blow. BANNER and BLOW, 1967, Micropaleontology, vol. 13, no. 2, p. 153, pl. 3, fig. 1.

Globorotalia (Turborotalia) acostaensis acostaensis Blow. BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, pp. 344-345, pl. 9, figs. 13-15; pl. 33, figs. 1, 2.

"Test low trochospiral; spire opening regularly but fairly rapidly, with 11-13 chambers composing the spire, usually with 5-6 chambers in the last whorl. Equatorial periphery strongly lobate, with the test appearing subcircular in equatorial profile; axial periphery rounded with the test appearing

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PLATE 45
JACKSON BLUFF FORMATION ?
CANCELLARIA FAUNIZONE ?
R. L. GAINER FARM

Figures

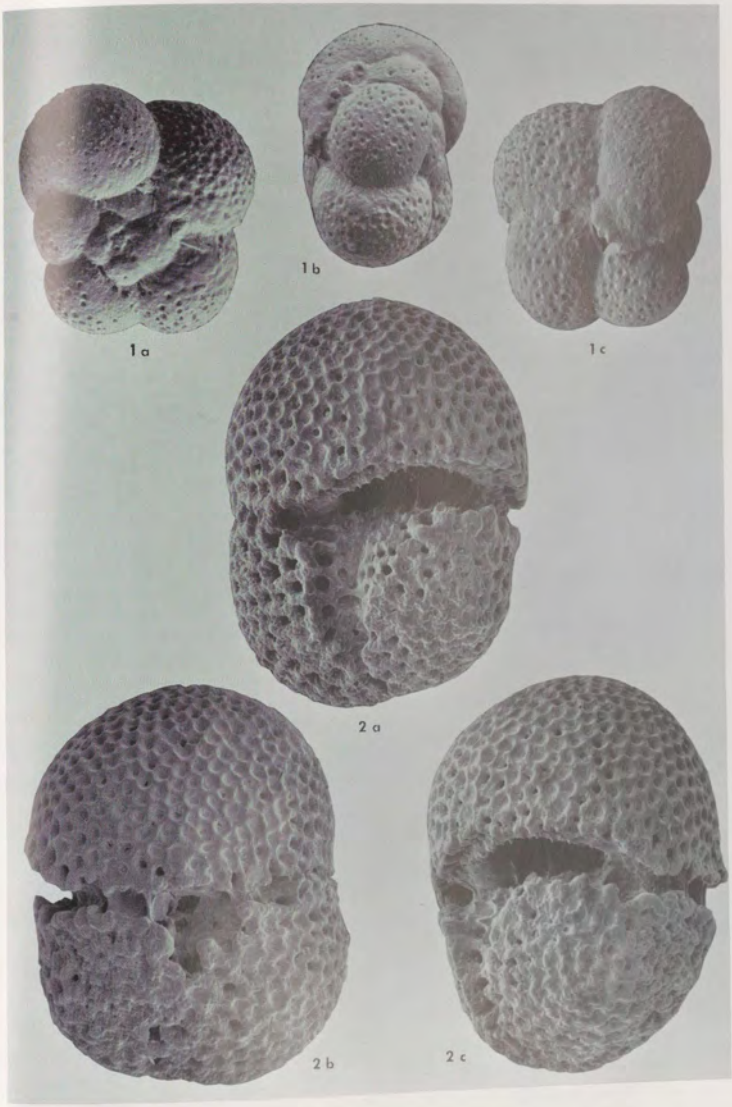

Plate 45

thick and parallel-sided in side view; chambers ovate or subspherical, generally inflated but not well separated; often the last chamber is much reduced in size compared with its predecessor, and it also occasionally becomes somewhat displaced towards the umbilical side. Spiral side slightly convex, almost flat, or occasionally slightly concave due to the inflated nature of the chambers of the last whorl. Umbilical side generally slightly convex, with a small but usually deep umbilicus; sutures of the spiral and umbilical sides radial, depressed; aperture interiomarginal, umbilical-extraumbilical, arched, with a distinctive lip. Maximum diameter of holotype, 0.36 mm." (Blow, 1959)

Holotype: USNM 625707; Pozón Formation, near Pozón, eastern Falcón, Venezuela.

Discussion: The range, according to Blow, is from Zone N. 16 to Zone N. 21. Parker has found this form in Indo-Pacific deep-sea cores where it is variable, showing features of the genus *Globoquadrina*. Specimens were found at Blount's Creek and in the Agueguexquite Formation at TU 638.

GLOBOROTALIA (TURBOROTALIA)
ACOSTAENSIS HUMEROSA
Takayanagi and Saito

Pl. 17, fig. 4; Pl. 19, fig. 3;
Pl. 25, fig. 2; Pl. 26, fig. 3;
Pl. 28, fig. 2; Pl. 36, fig. 2;
Pl. 40, fig. 2; Pl. 44, fig. 2;
Pl. 48, fig. 1; Pl. 54, fig. 2;
Pl. 57, fig. 1

Globorotalia humerosa TAKAYANAGI and SAITO, 1962, Sci. Repts., Tohoku Univ., 2d ser. (Geology), Spec. Vol., No. 5, p. 78, pl. 28, figs. 1, 2.

Globoquadrina humerosa (Takayanagi and Saito). PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, pp. 196-170, pl. 24, figs. 10, 11; pl. 25, figs. 1-6.

Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito. BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, pp. 345-346, pl. 33 and pl. 34.

"Test low trochospiral, biconvex, but occasionally almost flat in spiral side, equatorial periphery lobate axial periphery rounded; chambers ovate, 10 to 14 arranged in about two whorls, usually six to seven in last whorl, chambers increasing in size in last whorl somewhat irregular, frequently last and/or penultimate chambers much reduced in size compared with preceding ones in last whorl; last chamber occasionally somewhat protruding and tending to be displaced towards umbilical side; sutures not limbate, radial to slightly curved, depressed on spiral side, radial to faintly curved, depressed on umbilical side; wall calcareous, thick, cancellate, surface granular in appearance; umbilicus fairly wide and deep,

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PLATE 46
JACKSON BLUFF FORMATION ?
CANCELLARIA FAUNIZONE ?
R. L. GAINER FARM

Figures Page

1. *Globorotalia (Globorotalia) multicamerata* Cushman and Jarvis. 104
Maximum diameter, 0.57 mm
   a. Spiral view, X 87
   b. Edge view, X 85
   c. Umbilical view, X 86

2. *Globorotalia (Globorotalia) cultrata* subsp. 26
Maximum diameter, 0.27 mm
   a. Spiral view, X 182
   b. Edge view, X 180
   c. Umbilical view, X 181

3. *Hastigerina (Hastigerina) siphonifera siphonifera* (d'Orbigny). 124
Maximum diameter, 0.51 mm
   a. Spiral view, X 99
   b. Edge view, X 99
   c. Umbilical view, X 99

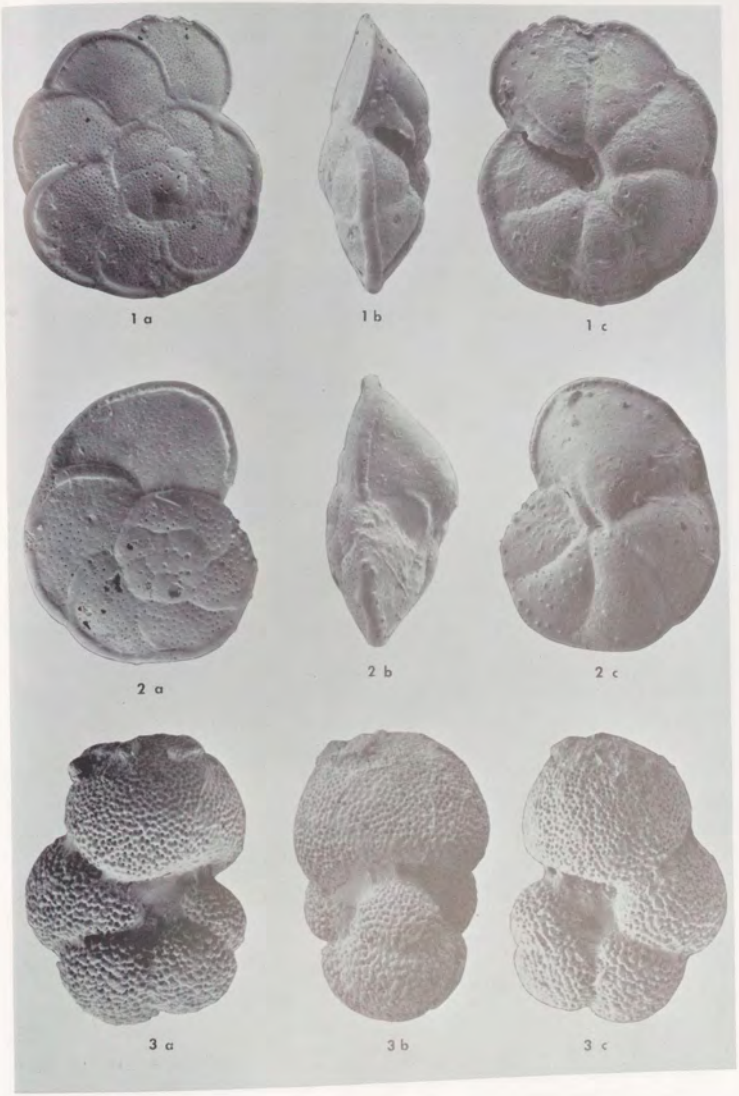

Plate 46

aperture medium to low arch, with a narrow distinct lip, interiomarginal, umbilical-extraumbilical, apertural openings of preceding chambers often connected with last one to make large channeled hollow; coiling of tests is mostly in right direction. Maximum diameter of holotype, 0.46 mm. maximum thickness, 0.32 mm. Maximum diameter of paratype, 0.44 mm, maximum thickness, 0.31 mm." (Takayanagi and Saito, 1962)

Holotype: IGPS 75079; Nobori Formation, Shikoku, Japan.

Discussion: The range, according to Blow, is from Zone N. 16 to Zone N. 23. If Parker and the writer are correct in the derivation of *Globoquadrina dutertrei* (d'Orbigny) from this form, one must question the generic affinities involved. There are differences of opinion on this subject, and the choice made here is purely an arbitrary one. Specimens are recorded at Blount's Creek, Jackson Bluff, Watson's Landing, Darling Slide, Gainer Farm, TU 875 (Waccamaw Formation), and in the Yorktown Formation at TU 613 and TU 1022.

GLOBOROTALIA (TURBOROTALIA) ACOSTAENSIS PSEUDOPIMA Blow

Globorotalia (Turborotalia) acostaensis pseudopima BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, pp. 387-388, pl. 35, figs. 1-7.

"The large test consists of 10 chambers arranged in a low trochospire with 4 1/2 inflated, subspherical chambers in the final whorl (only 4 chambers visible ventrally). The chambers are closely appressed; the ventral intercameral sutures are not deeply incised but are shallow. The umbilicus is small, almost closed and the ventral shoulder of the final chamber overhangs the umbilicus. The aperture is interiomarginal, umbilical-extraumbilical and extends slightly beyond the mid-plane of the periphery and thus encroaches slightly onto the dorsal side. The aperture is a low arch and is bordered by a thickened rim-like lip which is "tucked" under the inflated apertural face of the final chamber. The spire is strongly depressed and does not protrude above the plane of the dorsal surfaces of the last whorl of chambers. The ventral intercameral sutures are sub-radial and the dorsal spiral suture is indistinct. The wall is calcareous, radial hyaline, moderately densely perforate and the pores open into comparatively small but deep pits. The early parts of the test tend to be rather rugose but the final chamber is relatively smooth without distinct hispidity. Maximum diameter of holotype, 0.56 mm." (Blow, 1969)

Holotype: British Petroleum Collections; from the Otim River Section, Sarmi Formation, West Irian, Zone N. 21.

Discussion: Very rare but typical specimens occur in the Waccamaw Formation at both TU 870 and TU 875 (see discussion under Waccamaw Formation). The form is said to range from the base of Zone N. 20 to Zone N. 23.

PLATE 47
YORKTOWN FORMATION
RICE'S PIT

Figures Page

1. *Globigerina bulloides bulloides* d'Orbigny. 48
Maximum diameter, 0.50 mm
   a. Spiral view, X 112
   b. Umbilical view, X 112

2. *Globigerina bulloides bulloides* d'Orbigny. 48
Maximum diameter, 0.41 mm
   a. Spiral view, X 115
   b. Umbilical view, X 114

3. *Globigerina bulloides apertura* Cushman. 46
Maximum diameter, 0.47 mm
   a. Spiral view, X 148
   b. Umbilical view, X 148

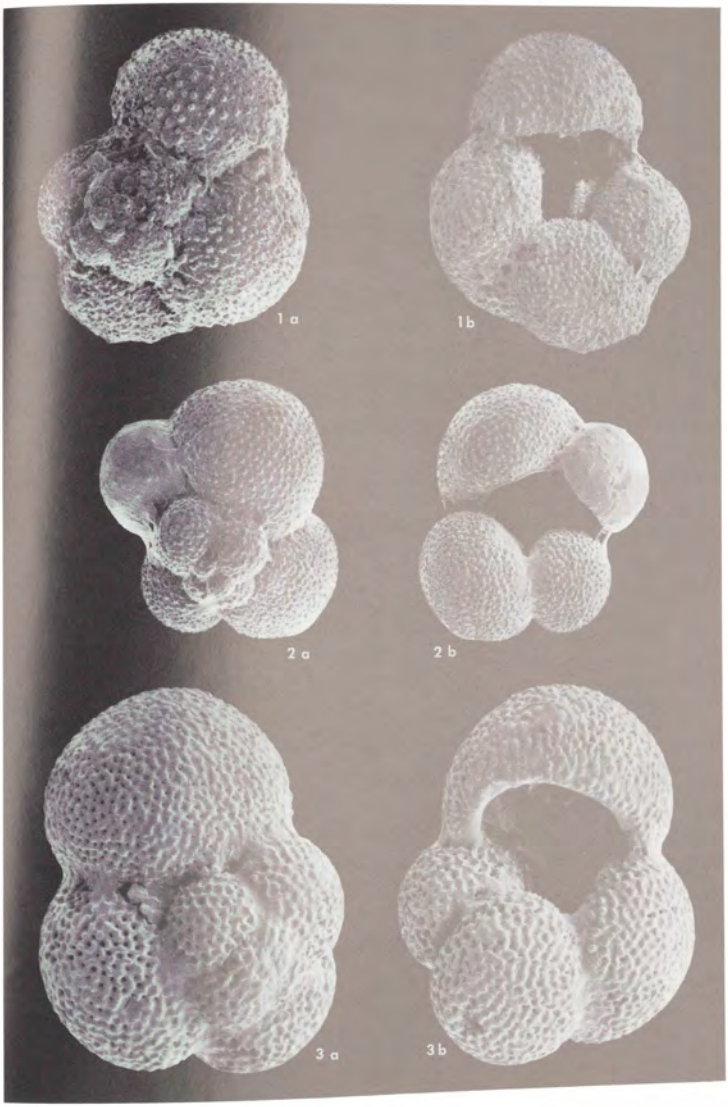

Plate 47

GLOBOROTALIA (TURBOROTALIA) INFLATA (d'Orbigny)

Pl. 52, fig. 3; Pl. 57, fig. 2

Globigerina inflata D'ORBIGNY *in* BARKER-WEBB and BERTHELOT, 1839, Hist. Nat. Îles Canaries, "Foraminifères," vol. 2, pt. 2, p. 134, pl. 2, figs. 7-9.

Globorotalia (Turborotalia) inflata (d'Orbigny). BANNER and BLOW, 1967, Micropaleontology, vol. 13, no. 2 pp. 144-146, pl. 4, figs. 1a-c (neotype), 11.

Globorotalia (Turborotalia) inflata (d'Orbigny). BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 350, pl. 10, figs. 10-12.

"The test of the neotype consists of approximately three whorls of chambers coiled in a low trochospire. The early whorls have five chambers in each whorl, but the last whorl possesses four chambers only. The test is almost wholly involute ventrally and almost wholly evolute dorsally. The chambers are slightly inflated dorsally, relatively strongly inflated ventrally, and subovoid in axial view, the axial profile being distinctly more convex ventrally than dorsally. The dorso-ventral periphery is broadly rounded in axial view and weakly lobulate in equatorial view. Dorsally, the initial sutures are indistinct (except when the test is clarified by liquids), but they become increasingly (although still shallowly) depressed at successive ontogenetic stages. The dorsal intercameral sutures are curved and meet the spiral suture at broad angles. The early chambers, in dorsal view, are reniform in outline, but they become increasingly longer than broad during ontogeny. The later chambers also acquire greater breadth at their posterior than at their anterior ends. The last-formed chamber slightly embraces the outer part of the dorsal surface of the penultimate whorl. Ventrally, the intercameral sutures are distinctly but not strongly depressed, and are subradial. They meet the periphery and the umbilicus at broad angles approaching right angles. The umbilicus is narrow but open and deep; it is sharply delimited by the umbilical shoulders of the first three chambers of the last whorl and by the inner part of the apertural face of the last chamber. The aperture is a broad, high arch, interiomarginal, ventral and intraumbilical-extraumbilical in position, extending along the basal suture of the narrow, convex apertural face almost as far as its junction with he periphery of the penultimate whorl. The aperture possesses no distinct lip, but the apertural face is thickened, hyaline and granular above the aperture throughout its length. The walls of the test are uniformly perforate, but the perforations are superficially obscured in the early chambers by surface granularity, both dorsally and ventrally. The granularity is most marked, dorsally, on the surface of the early whorls, and ventrally, in the area immediately around the umbilicus and immediately facing the aperture. The wall of the last-formed chamber is smooth, except on the apertural face. Maximum diameter: 0.52 mm, maximum thickness: 0.33 mm." (Banner and Blow, 1967)

Neotype: British Museum (Natural History) 1966.2.3.23; from a sample dredged by H.M.S. *Challenger* at Stn. 8, off Gomera, Canary Islands (28° 3' 15" N. lat., 7° 27' 00" W. long.) in 378 meters of water. D'Orbigny's specimens were from the Holocene sands off Santa Cruz, Teneriffe, Canary Islands.

PLATE 48
YORKTOWN FORMATION
RICE'S PIT

Figures

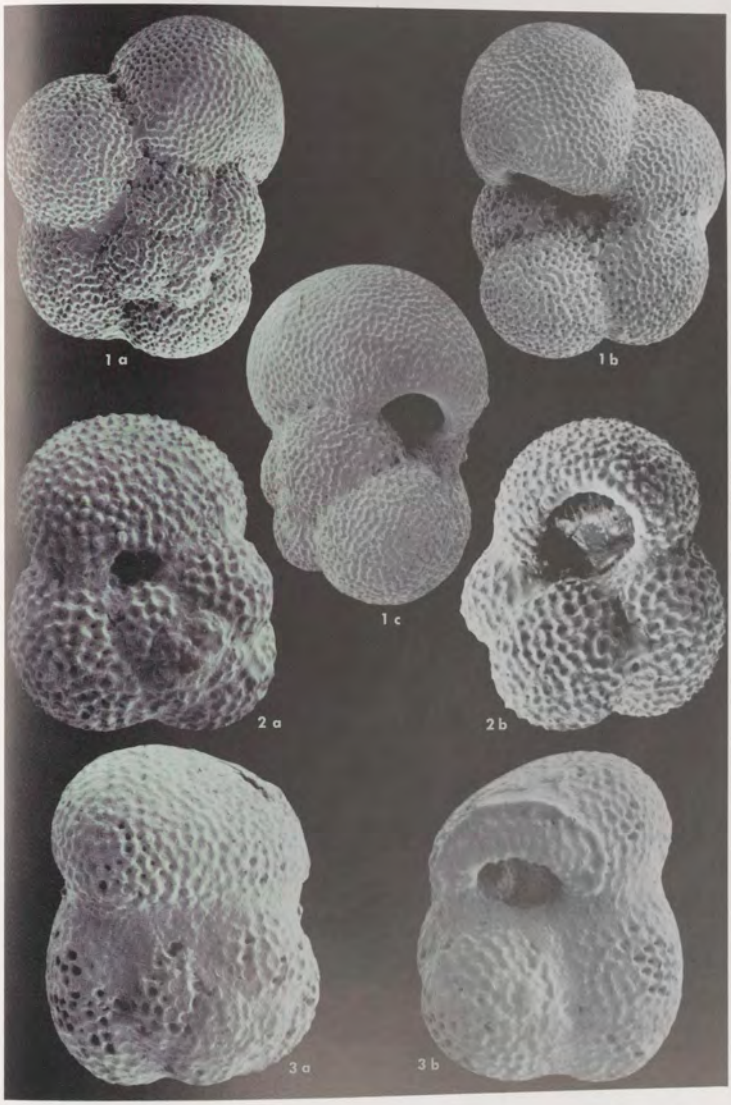

Plate 48

Discussion: The range of this form is from within Zone N. 17 to Zone N. 23, according to Blow. Specimens were identified in the Waccamaw Formation at TU 870 and TU 875.

GLOBOROTALIA (TURBOROTALIA) MINIMA Akers

Pl. 13, fig. 2

Globorotalia canariensis (d'Orbigny) var. *minima* AKERS, 1955, Jour. Paleontology, vol. 29, no. 4, p. 659, pl. 65, figs. 3a-d.

Globorotalia minima Akers. BLOW, 1959, Bull. Amer. Paleontology, vol. 39, no. 178, p. 217, pl. 19, figs. 122a-c.

"Test low trochospiral; spire opening rapidly, with usually six chambers in the last convolution. As seen from the spiral side the chambers are almost equally as broad as long with the exception of the last two chambers. The sutures of the spiral side are not much depressed and are moderately curved. The sutures of the umbilical side are slightly sinuous to almost radial. Equatorial periphery only slightly lobate; axial periphery rounded to subacute, not keeled; aperture interiomarginal, umbilical-extra-umbilical, a low arch with a thin short lip; umbilicus small or closed; wall calcareous, finely perforate." (Blow, 1959)

Holotype: USNM P4754; from core 10,132-10,142 feet, Humble Ellender No. 1 Well, Lirette Field, Terrebonne Parish, Louisiana. The height is 0.22 mm; width, 0.20 mm; thickness, 0.11 mm.

Discussion: There is confusion in the literature regarding the stratigraphy of this Louisiana well (Ellisor, 1940) and the actual source of foraminifera described from it by Cushman and Ellisor (1939). On the basis of these earlier published data, Akers (1955) believed that this form was derived from an older zone than is now known to have been penetrated by the well. Additional drilling with detailed paleontological and electrical log correlations have established that the Humble Ellender No. 1 penetrated beds no older than the *Bigenerina nodosaria directa-Cibicides carstensi* Zone (see Butler, 1962). This interval is correlative with Zone N. 14 and represents the highest occurrence of *Globorotalia minima*, rather than Zone N. 13, as Blow (1969) was led to believe. Blow reports the lowest occurrence of this species within Zone N. 7, although the writer has not seen it in beds that old.

Between 100 and 200 specimens were observed in the core from which the form was described, and all are of the same approximate dimensions of the holotype. Coiling throughout the range in the Ellender well (14 cores between 9,592 and 11,304 feet) was not less than 90% sinistral in any sample. Blow (1959, p. 217) reported that his specimens from the Pozón-El Mene Road section, eastern Falcón,

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PLATE 49
YORKTOWN FORMATION
RICE'S PIT

Figures Page

1. *Globigerinoides quadrilobatus quadrilobatus* (d'Orbigny). 62
Maximum diameter, 0.63 mm
   a. Spiral view, X 94
   b. Umbilical view, X 94

2. *Globigerinoides ruber* (d'Orbigny). 66
Maximum diameter, 0.51 mm
   a. Spiral view, X 110
   b. Umbilical view, X 110

3. *Sphaeroidinellopsis subdehiscens subdehiscens* Blow. 86
Maximum diameter, 0.37 mm
   a. Spiral view, X 162
   b. Umbilical view, X 162

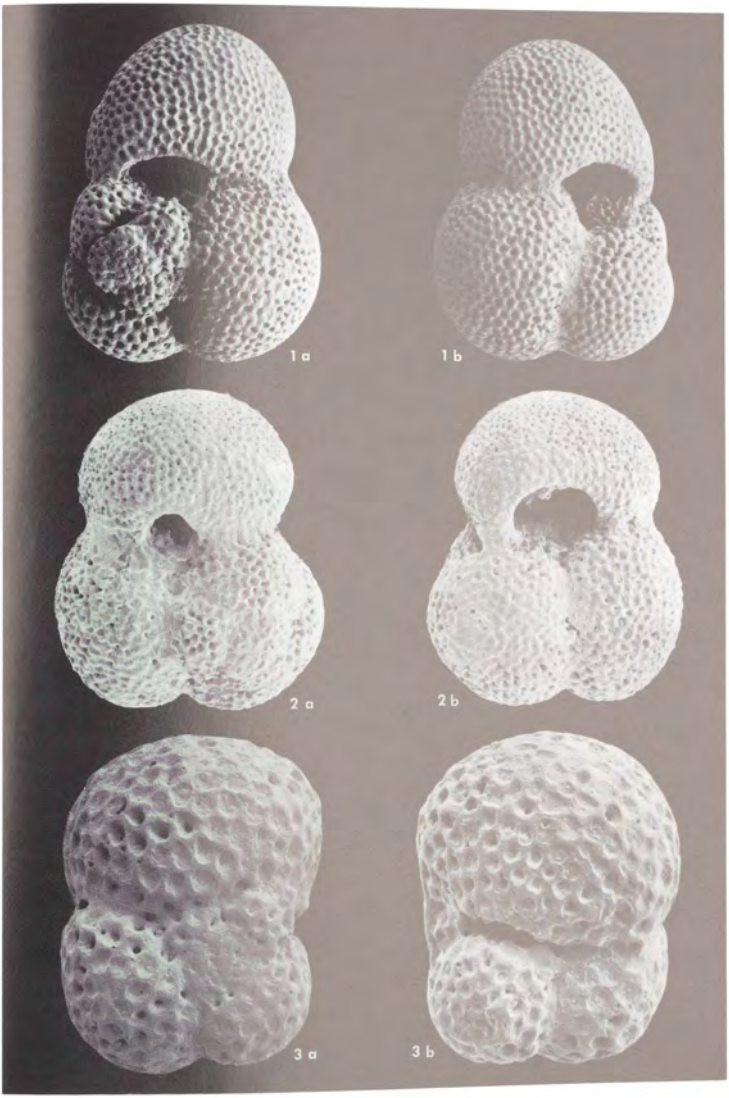

Plate 49

Venezuela, were of the same average dimensions as the Louisiana specimens.

Five specimens were found at the Cosson Farm site, Yellow River Formation. All are sinistrally coiled, and all are close to the dimensions of the holotype. All also compare closely in morphologic detail with the Louisiana specimens, although this is not evident in the scanning electron photomicrographs, because of the translucent character of the test. A comparison of actual specimens from the Yellow River Formation with topotypes is convincing that they are conspecific.

GLOBOROTALIA (TURBOROTALIA) OBESA Bolli

Pl. 3, fig. 1

Globorotalia obesa BOLLI, 1957, U. S. Natl. Mus., Bull. 215, p. 119, pl. 29, figs. 2a-3.
Globorotalia obesa Bolli. BLOW, 1959, Bull. Amer. Paleontology, vol. 39, no. 178, p. 218, pl. 19, figs. 124a-c.

"Shape of test very low trochospiral; equatorial periphery strongly lobate; axial periphery rounded. Wall calcareous, perforate, surface finely pitted, in well-preserved specimens with fine, short spines. Chambers strongly inflated, spherical; ten to twelve, arranged in two to two and one-half whorls; the four to four and one-half chambers of the last whorl increase rapidly in size. Sutures on spiral side radial, strongly depressed; on umbilical side radial, strongly depressed. Umbilicus fairly wide, deep. Aperture a medium to high arch without lip or rim; interiomarginal, umbilical-extraumbilical. Coiling random. Largest diameter of holotype, 0.5 mm." (Bolli, 1957)

Holotype: USNM P5673; Cipero Formation, about 1/6 mile south of Golconda Village, southern Trinidad.

Discussion: In the Cipero Formation, specimens are common in which the final chamber extends over and on to the spiral side, the aperture becoming nearly interiomarginal and peripheral. Blow described this as a gerontic feature of specimens in the Pozón Formation of Venezuela. He considers the species long-ranging (Zone N. 2 to Zone N. 23) and ubiquitous (Blow, 1969, p. 352). Parker (1967, p. 152) considers this species as the "direct forerunner" of *Globigerinella siphonifera* (d'Orbigny).

GLOBOROTALIA (TURBOROTALIA) PRAEOSCITANS Akers, new species

Pl. 32, fig. 3; Pl. 36, fig. 3;
Pl. 50, fig. 2; Pl. 51, fig. 3

Test moderately large, planoconvex, sinistrally coiled with 10 to 13 chambers comprising the spire and four to five chambers in the final whorl. The equatorial profile is slightly lobulate. In axial profile, the test appears cuneiform because of the abrupt inflation, both lateral and vertical, of the final chamber in contrast with the periphery of the antepenultimate chamber. Sutures are distinct and slightly recurved. The wall is finely perforate with a foraminal density which is consistent for all specimens seen. Pustules may occur on both sides of the test, but in some specimens they may be confined to

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PLATE 50
YORKTOWN FORMATION
RICE'S PIT

Figures Page

1. *Hastigerina (Hastigerina) siphonifera siphonifera* (d'Orbigny). 124
Maximum diameter, 0.43 mm

   a. Spiral view, X 150
   b. Edge view, X 148
   c. Umbilical view, X 147

2. *Globorotalia (Turborotalia) praeoscitans* Akers, new species 116
USNM 180583, holotype. Maximum diameter, 0.47 mm

   a. Edge view, X 148
   b. Spiral view, X 139
   c. Umbilical view, X 148

Plate 50

the central region of the umbilical side. The aperture is a large interiomarginal, umbilical-extraumbilical, semi-circular opening with a narrow lip, which is smooth in some specimens but pustulate in others.

Holotype: USNM 180583; pl. 50, fig. 2; Yorktown Formation at Rice's Pit (TU 613); maximum diameter 0.47 mm.

Paratypes: (1) USNM 180584; pl. 32, fig. 3; Jackson Bluff Formation at Darling Slide (TU 712); maximum diameter 0.30 mm. (2) USNM 180585; pl. 36, fig. 3; Jackson Bluff Formation at Jackson Bluff, Bed 9; maximum diameter 0.31 mm. (3) USNM 180586; pl. 51, fig. 3; Yorktown Formation at Rice's Pit (TU 613); maximum diameter 0.42 mm.

Discussion: Globorotalia (T.) praeoscitans, new species, *Globorotalia (T.) oscitans* Todd, *Globorotalia (T.) bononiensis* Dondi, and *Globorotalia (T.) inflata* (d'Orbigny) appear to be an interrelated complex characterized by abrupt and extreme cameral inflation and a very large, arcuate to semicircular aperture which, except in *Globorotalia (T.) inflata,* is demarcated by a narrow lip. *Globorotalia (T.) praeoscitans* is almost twice the diameter of *Globorotalia (T.) oscitans,* has a larger aperture, and is more cuneiform in axial profile. *Globorotalia (T.) bononiensis* is approximately the same size as *Globorotalia (T.) praeoscitans,* and it also has a large aperture, but Dondi's species appears to be biconvex, and the cameral inflation is more gradual. This is also true of *Globorotalia (T.) inflata,* which has the most globose chambers of the complex.

Globorotalia (T.) praeoscitans has been seen also at the Darling Slide locality, Jackson Bluff, Bed 9 (Jackson Bluff Formation, *Ecphora* Faunizone), and in the Yorktown Formation at Wilson's Pit (TU 613). These beds are considered to be lowermost Pliocene to lower middle Pliocene (later part of Zone N. 18 to the later part of Zone N. 19).

Globorotalia (T.) praeoscitans is abundant in Yorktown beds at the Texas Gulf Sulphur Company mine near Aurora, North Carolina (TU 1022). This species and *Globigerina bulloides* are the predominant components of the planktonic assemblage.

GLOBOROTALIA (TURBOROTALIA) SCITULA SCITULA (Brady)

Pulvinulina scitula BRADY, 1882, Roy. Soc. Edinburgh, Proc., vol. 11 (1880-1882), no. 111, pp. 716-717, (no figure); lectotype of Banner and Blow, 1960.

PLATE 51
YORKTOWN FORMATION
RICE'S PIT

Figures Page

1. *Globorotalia (Globorotalia)* sp. 32
Maximum diameter, 0.45 mm

   a. Spiral view, X 134
   b. Umbilical view, X 136
   c. Edge view, X 134

2. *Globorotalia (Globorotalia) cultrata* subsp. 32
Maximum diameter, 0.58 mm

   a. Edge view, X 78
   b. Umbilical view, X 80
   c. Spiral view, X 79

3. *Globorotalia (Turborotalia) praeoscitans* Akers, new species 116
USNM 180586, paratype. Maximum diameter, 0.42 mm

   a. Spiral view, X 132
   b. Edge view, X 133
   c. Umbilical view, X 133

Plate 51

Pulvinulina patagonica (d'Orbigny). BRADY, 1884, Rept. Voy. *Challenger*, Zool., vol. 9, pt. 22, p. 693, pl. 103, figs. 7a-c (*non Rotulina patagonica* d'Orbigny 1839).

Globorotalia scitula (Brady). CUSHMAN and HENBEST, 1940, U. S. Geol. Surv., Prof. Paper 196-A, pt. 2, p. 36, pl. 8, figs. 5a-c.

Globorotalia scitula scitula (Brady). BLOW, 1959, Bull. Amer. Paleontology, vol. 39, no. 178, p. 219, pl. 19, figs. 126a-c.

Pulvinulina scitula Brady. BANNER and BLOW, 1960, Cushman Found. Foram. Res., Contr., vol. 11, pp. 27, 29, pl. 5, figs. 5a-c (lectotype designated).

Globorotalia (Turborotalia) scitula scitula (Brady). BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 356, pl. 39, fig. 7.

"The fairly small test consists of about 14 chambers arranged in nearly three whorls, which comprise a low trochospire with 5-6 chambers in a whorl. The chambers are slightly embracing and uniformly and slowly enlarging; they are little, if at all, inflated dorsally but are slightly inflated ventrally. The equatorial profile of the test is subcircular and possesses a periphery which becomes increasingly, although still weakly, lobulate in ontogeny. The axial profile shows that the test is compressed dorso-ventrally; the peripheral margin is acutely rounded but it is not carinate or secondarily thickened (i.e., no pseudocarina is present). The sutures are slightly depressed, not limbate or thickened, and the spiral suture is weakly lobulate. The dorsal intercameral sutures are strongly recurved and vorticiform; the distal ends of these sutures are smoothly tangential to the periphery. In the earlier ontogenetic stages the proximal ends of the intercameral dorsal sutures meet the spiral suture at a broadly acute angle, but later in ontogeny these sutures meet the spiral suture almost at right angles. The chambers of the last whorl show a decrease in the amount of embrace dorsally and simultaneously become even less inflated on that side of the test than they were earlier; this is associated with a step-like appearance which develops between successive chambers on the dorsal surface of the last whorl. The ventral sutures are nearly radial; initially they are smoothly curved, but later they become slightly sigmoidal. The umbilicus is small and it is almost closed by an umbilical lobe of the last chamber. The primary aperture is interiomarginal, umbilical-extraumbilical; it is a low arch extending from the umbilicus for about three quarters of the length of the terminal basal suture. The aperture possesses a uniformly very narrow and thin lip. The apertural face is slightly concave in its distal region but is smoothly convex near the umbilicus; it is not clearly delimited from the ventral surface of the last chamber. The wall of the test is thin and is uniformly and very finely perforate except for a weakly

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PLATE 52
WACCAMAW FORMATION
TU 875

Figures — Page

1. *Globigerinita uvula* (Ehrenberg). 72
   Maximum diameter, 0.30 mm
   a. Spiral view, X 181
   b. Umbilical view, X 182

2. *Globigerina juvenilis* Bolli. 52
   Maximum diameter, 0.33 mm
   a. Spiral view, X 154
   b. Umbilical view, X 154

3. *Globorotalia (Turborotalia) inflata* (d'Orbigny), a juvenile specimen. 112
   Maximum diameter, 0.31 mm
   a. Spiral view, X 161
   b. Umbilical view, X 161

4. *Globigerina bulloides bulloides* d'Orbigny. 48
   Maximum diameter, 0.46 mm
   a. Umbilical view, X 136
   b. Spiral view, X 138

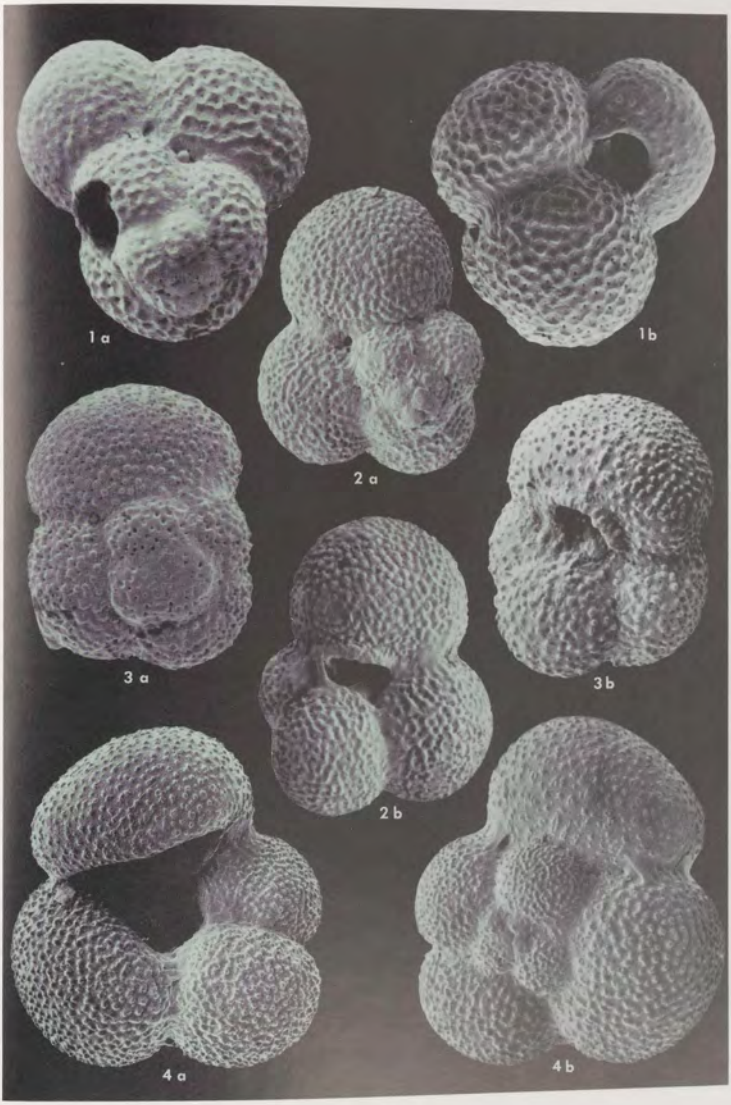

Plate 52

pustulose area on the ventral surface of the first chamber of the last whorl (facing the terminal aperture). The surface of the test is fairly smooth and shows little trace of any original hispidity; it possesses a characteristic glistening and a somewhat translucent appearance. Maximum diameter of lectotype: 0.31 mm." (Banner and Blow, 1960)

Lectotype: British Museum (Natural History) 1959.6.25.1; from the Faroe Channel at a depth of 7530 fathoms.

Discussion: The range of this form is from within the later parts of Zone N. 9 to Zone N. 23 (Blow, 1969). Specimens were identified at Watson's Landing.

GLOBOROTALIA (TURBOROTALIA) SIAKENSIS (LeRoy)

Pl. 5, fig. 1; Pl. 13, fig. 3

Globigerina siakensis LEROY, 1939, Natuurk. Tijdschr. Nederl.-Indie, vol. 99, no. 6, pp. 39-40, pl. 3, figs. 30-31.

Globorotalia mayeri Cushman and Ellisor. BOLLI, 1957, U. S. Natl. Mus., Bull. 215, p. 118, pl. 28, figs. 4a-c.

Globorotalia mayeri Cushman and Ellisor. BLOW, 1959, Bull. Amer. Paleontology, vol. 39, no. 178, p. 214, pl. 18, figs. 116a-c.

Globorotalia (Turborotalia) siakensis (LeRoy). BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 356, pl. 10, figs. 7-9 (holotype refigured); pl. 34, figs. 4, 5.

Blow (1969) clarifies this form as follows: "*Globorotalia (T.) siakensis* has frequently been misidentified as *mayeri*. *G. (T.) siakensis* appears to be ubiquitous in equatorial, tropical and subtropical assemblages. Characteristically, the species possesses virtually radial intercameral sutures both dorsally and ventrally and a distinctly open, but deep, umbilicus. The aperture is a fairly low, elongated arched opening and the apertural lip is not particularly well developed although usually present and distinct. The chambers of the last whorl are subglobular, moderately inflated and not greatly appressed or embracing. Normally 5-6 chambers are present in the final whorl but 7-8 chambers have been observed, rarely, in the final convolution of the test." (Blow, 1969)

Holotype: Geological Museum, Bandung, Indonesia, P.S. 1075a; Miocene ?, Central Sumatra.

Discussion: Range is from the latest part of Zone N. 2 to the top of Zone N. 14, according to Blow. This species was identified in the Chipola Formation and at the Cosson Farm locality (Yellow River Formation).

Genus TURBOROTALITA Blow and Banner, 1962

TURBOROTALITA QUINQUELOBA (Natland)

Pl. 41, fig. 1; Pl. 45, fig. 1

Globigerina quinqueloba NATLAND, 1938, Univ. Calif., Scripps Inst. Oceanography, Bull., Tech. Ser., vol. 4, no. 5, p. 149, pl. 6, fig. 7.

Globigerina groenlandica STSCHEDRINA, 1946, Artich. Nauch. Issl. Inst. Dreif. Eksped. Glavs.

PLATE 53
WACCAMAW FORMATION
TU 875

Figures

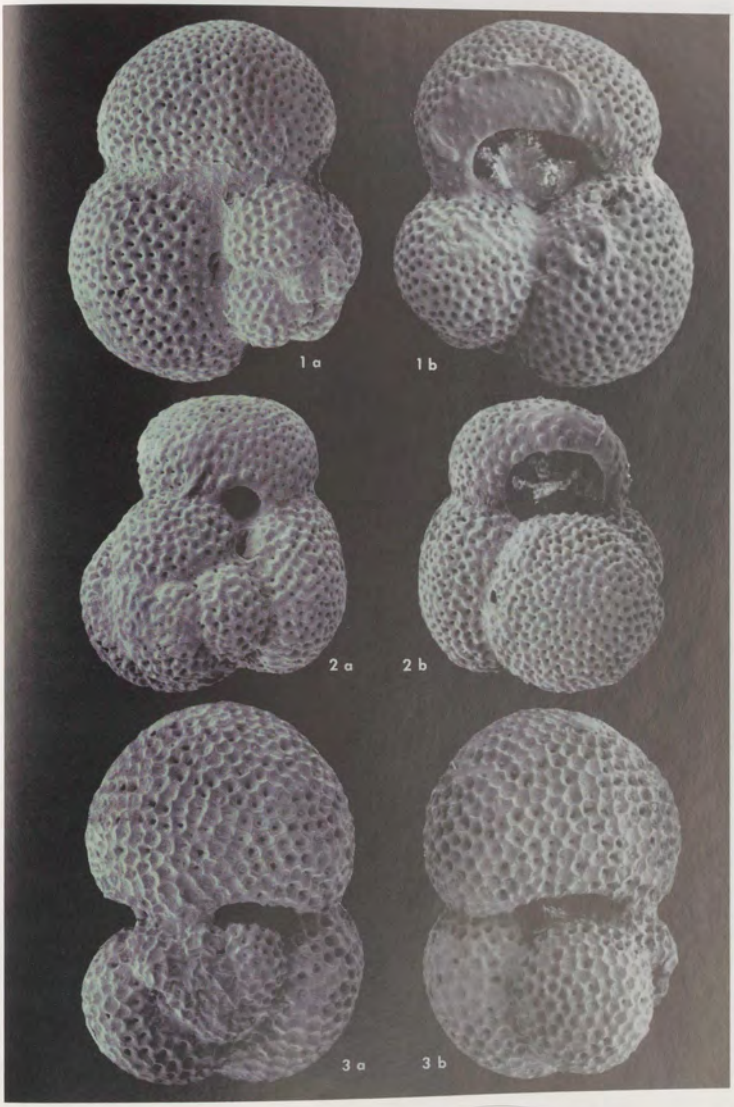

Plate 53

Ledok. Parokh. "G. Sedov" 1937-1940, Trudy, vol. 3 (Biology), p. 145, pl. 4, fig. 23.

"Test small, trochoid, roughly trapezoidal in side view, last convolution made up of five chambers rather rapidly increasing in size as added; chambers inflated, subspherical; walls roughened; sutures depressed; aperture an elongated slit with overhanging lip almost covering the umbilicus. Length, 0.24 mm, breadth 0.22 mm, thickness, 0.14 mm." (Natland, 1938)

Holotype: USNM 22559; off Long Beach, California, in 152 meters of water.

Discussion: The range of this taxon is from within the earlier parts of Zone N. 17 to Zone N. 23 (Blow, 1969). The species is abundant at Watson's Landing, but the specimens are only three quarters the size of the holotype. Otherwise, specimens are typical.

Genus GLOBOROTALOIDES Bolli, 1957

GLOBOROTALOIDES HEXAGONA HEXAGONA (Natland)

Pl. 28, fig. 1

Globigerina hexagona NATLAND, 1938, Univ. Calif., Scripps Inst. Oceanography, Bull., Tech. Ser., vol. 4, no. 5, p. 149, pl. 7, fig. 1.

Globoquadrina hexagona (Natland). PARKER, 1962, Micropaleontology, vol. 8, no. 2, p. 244, pl. 8, figs. 5-13.

Globoquadrina hexagona (Natland). PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, p. 169, pl. 25, figs. 9, 10.

Globorotaloides hexagona hexagona (Natland). BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, pp. 373-374.

"Test medium sized, trochoid, low spired; chambers spherical, rapidly increasing in size as added, five in each whorl; sutures depressed, radiate; walls with coarse reticulations forming hexagonal pits which give the walls a honeycombed appearance; aperture a slightly arculate opening between the umbilicus and the periphery at the base of the last chamber. Length, 0.39 mm; breadth, 0.33 mm; thickness 0.18 mm." (Natland, 1938)

Holotype: USNM 496185; from Recent sediments in 884 meters of water, off Long Beach, California, Lat. 33° 27' 20"N., Long. 118° 19' 00" W.

Discussion: Specimens from the Darling Slide locality are identical with the specimens of Natland and Parker. Blow records a range from within Zone N. 18 to Zone N. 23. The form has been noted as locally extinct, however, above Zone N. 21 in the Atlantic-Caribbean-Gulf of Mexico Province. Absence of the subspecies here has been attributed to the possibility that the Atlantic ocean was affected more than the Indian and Pacific oceans by deterioration of late Pliocene and early Pleistocene climate.

Subfamily HASTIGERININAE
Banner and Blow, 1960

Genus HASTIGERINA Thomson, 1876

HASTIGERINA SIPHONIFERA SIPHONIFERA (d'Orbigny)

Pl. 9, fig. 1; Pl. 12, fig. 2;
Pl. 17, fig. 3; Pl. 24, fig. 3;
Pl. 26, fig. 1; Pl. 31, fig. 4;
Pl. 46, fig. 3; Pl. 50, fig. 1;
Pl. 54, fig. 1; Pl. 60, fig. 1

Globigerina siphonifera D'ORBIGNY *in* DE LA SAGRA, 1839, Hist. Phys. Pol. Nat. Cuba, "Foraminifères," p. 83, pl. 4, figs. 15-18.

PLATE 54
WACCAMAW FORMATION
TU 875

Figures

Plate 54

Globigerina aequilateralis BRADY, 1879, Quart. Jour. Micro. Sci., (new ser.), vol. 19, p. 285.
Globigerina aequilateralis Brady. BRADY, 1884, Rept. Voy. *Challenger*, Zool., vol. 9, p. 605, pl. 80, figs. 18-21.
Globigerina aequilateralis Brady var. *involuta* CUSHMAN, 1917, U. S. Natl. Mus., Proc., vol. 51, no. 2172, p. 662.
Globigerina aequilateralis Brady var. *involuta* Cushman. CUSHMAN, 1921, U. S. Natl. Mus., Bull. 100, p. 293, text-fig. 11.
Hastigerina (Hastigerina) siphonifera (d'Orbigny). BANNER and BLOW, 1960, Micropaleontology, vol. 6, no. 1, p. 22, text-figs. 2 (lectotype), 3.
Globigerinella siphonifera (d'Orbigny). PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, pp. 152-153, pl. 22, fig. 5.
Hastigerina (H.) siphonifera siphonifera (d'Orbigny). BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 375.

"D'Orbigny (1839) in his original description, significantly stated that the spire was planar, and the aperture elongate. The "pointes tubuleuse" seem to refer to the characteristic hispidity and numerous spine bases of the species. In the specimen we designate as lectotype, the coiling is virtually planispiral but one side is slightly more involute than the other and there is also an indication that there is a definite earlier trochospiral stage. D'Orbigny's original specimen (according to his writing) was 1/3 of a mm in diameter; the lectotype is 0.46 mm maximum diameter and probably represents a more perfectly planispiral and later growth stage than that of d'Orbigny's original illustrated specimen. The primary aperture of the lectotype is a low equatorial, interiomarginal arch and extends into the ventral and dorsal umbilici. The aperture is bordered by a thin symmetrical, perforate lip of constant breadth. Relict apertures are present in the umbilical margins of the penultimate chamber." (Banner and Blow, 1960)

Lectotype: d'Orbigny Collection, Museum National de l'Histoire Naturelle, Paris; from Cuba, probably from Recent beach sands.

Discussion: This form ranges from within Zone N. 12 to Zone N. 23, according to Blow. Specimens were found in all formations investigated, which are younger than the Chipola.

Genus PULLENIATINA Cushman, 1927

PULLENIATINA OBLIQUILOCULATA

OBLIQUILOCULATA (Parker and Jones)

Pl. 60, fig. 3

Pullenia obliquiloculata PARKER and JONES *in* CARPENTER, 1862, Introduction to the Study of the Foraminifera, Roy. Soc., p. 183 *(nomen nudum).*
Pullenia sphaeroides (d'Orbigny) var. *obliquiloculata* Parker and Jones. PARKER and JONES, 1865, Roy. Soc. London, Philos. Trans., vol. 155, p. 365, 368, pl. 19, fig. 4.
Pulleniatina obliqueloculata [sic] (Parker and Jones). BOLLI, LOEBLICH and TAPPAN, 1957, U. S. Natl. Mus., Bull. 215, p. 33 (lectotype designated), pl. 4, fig. 3a-b (paralectotype).
Pulleniatina obliquiloculata obliquiloculata (Parker and Jones, 1865, emended). BANNER and

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PLATE 55
WACCAMAW FORMATION
TU 875

Figures Page

1. *Globorotalia (Globorotalia) truncatulinoides* (d'Orbigny). 104
Maximum diameter, 0.45 mm
   a. Spiral view, X 136
   b. Umbilical view, X 136

2. *Globorotalia (Globorotalia)* sp. 36
Maximum diameter, 0.35 mm
   a. Spiral view, X 143
   b. Umbilical view, X 143

3. *Globorotalia (Globorotalia) cultrata menardii* (Parker, Jones and Brady). 98
Maximum diameter, 0.52 mm
   a. Spiral view, X 136
   b. Umbilical view, X 136

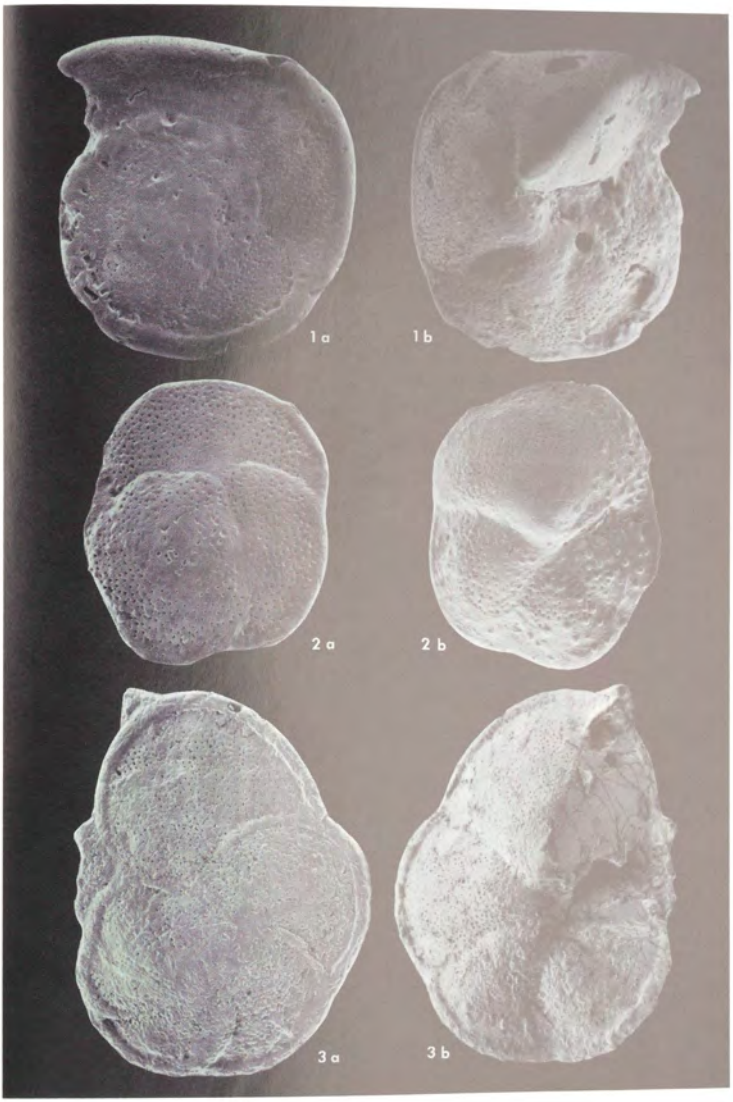

Plate 55

BLOW, 1967, Micropaleontology, vol. 13, no. 2, pp. 137-139, pl. 3, fig. 4 (lectotype figured), pl. 4, fig. 9.

Pulleniatina obliqueloculata obliqueloculata [sic] (Parker and Jones). BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 376.

"The lectotype is a tumid, thick-walled test displaying four and one-half chambers in the last whorl. These chambers appear to be regularly enlarging, and they form a coil which is completely involute ventrally and partially involute dorsally. The first three chambers of the last whorls do not appear to embrace the previous whorl dorsally, but the last-formed two chambers clearly overlap the dorsal surface of the previous whorl. The chambers are globose, and their peripheries are broadly rounded. The walls of the chambers are wholly perforate except for a narrow ventral area facing the aperture. Dorsally, the wall is thicker over the early whorls, where heavy deposition of shell material obscures the shape and disposition of the early chambers. Comparable specimens consist of at least three whorls of chambers in all, with five chambers in the antepenultimate, four in the penultimate, and four and a half in the last. The dorsal exterior surface of the early whorls is smooth and very coarsely perforate, the pores becoming more numerous and of smaller size progressively throughout the last whorl. The pore size and distribution are very similar on both the dorsal and the ventral surfaces of each chamber of the last whorl. The ventral surface is smooth except for a granular area immediately facing the aperture. The dorsal spiral suture and the intercameral sutures of the last whorl are depressed, increasingly so towards the last chamber. The sutures of the early whorls are obscured by shell thickening. The intercameral sutures of the early part of the last whorl are gently recurved, but in the later, more involute part of this whorl they become progressively more radially arranged.

"Ventrally, the chambers completely embrace at their umbilical ends, forming a broad umbilical depression but no true umbilicus. The innermost margin of the last chamber joins the inner ends of the three previous chambers in a continuous, linear, but angular suture. The aperture is a very low, ventral, interiomarginal arch, extending along the base of the very low apertural face from about the periphery of the first chamber of the last whorl almost to the anterior intercameral suture of the second chamber of the last whorl. The aperture possesses no lip, but the inner margin of the apertural face is convex, thickened, hyaline and rim-like throughout the length of the aperture. Scattered small granules occur, especially in the mid-part of the apertural face. The maximum diameter of the test is 0.58 mm, and the maximum thickness is 0.49 mm." (Banner and Blow, 1967)

Lectotype: British Museum, Natural History ZF 3583-ex 94.4.3.1045; from Abrolhos Bank, off the coast of Brazil, 22° 54' S. Lat., 40° 37' W. long., in 260 fathoms.

Discussion: This form ranges from within Zone N. 19 to Zone N. 23, according to Blow. Specimens were found in the Moin Formation at TU 954.

Subfamily CASSIGERINELLINAE
Bolli, Loeblich and Tappan, 1957

PLATE 56
WACCAMAW FORMATION
TU 870

Figures

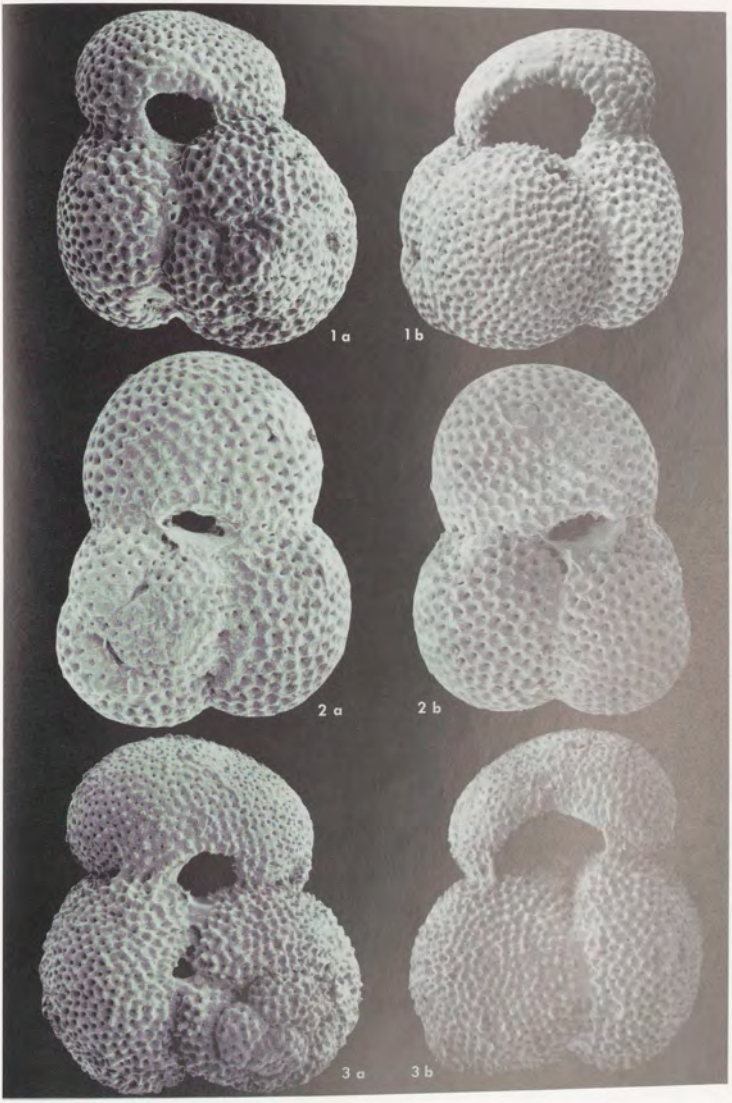

Plate 56

Genus CASSIGERINELLA Pokorný, 1955

CASSIGERINELLA CHIPOLENSIS
(Cushman and Ponton)

Pl. 1, fig. 1; Pl. 2, fig. 1

Cassidulina chipolensis CUSHMAN and PONTON, 1932, Florida Geol. Surv., Bull. 9, p. 98, pl. 15, figs. 2a-c.

Cassidulina chipolensis Cushman and Ponton. CUSHMAN and STAINFORTH, 1945, Cushman Lab. Foram. Res., Spec. Publ. 14, p. 64, pl. 12, fig. 5.

Cassigerinella boudecensis POKORNÝ, 1955, Ustr. Ust. Geol., Vestnik, Prague, vol. 30, pp. 137, 138, pls. 1-3.

Cassigerinella chipolensis (Cushman and Ponton). BOLLI, 1957, U. S. Natl. Mus., Bull. 215, p. 108, pl. 22, figs. 3a-c.

Cassigerinella globolocula IVANOVA *in* BYKOVA *et al.*, 1958, Trudy VNIGRI, vol. 115, no. 9, p. 57, pl. 11, figs. 1-3.

Cassigerinella chipolensis (Cushman and Ponton). CORDEY, 1968, Palaeontology, vol. 11, pt. 3, pp. 368-370, text-fig. 1, figs. f-m.

"Test minute, consisting of subglobular chambers, four pairs making up the last whorl, periphery strongly lobulated; chambers very distinct, inflated, in alternating pairs at each side of the axis of coiling extending over slightly onto the opposite side at the periphery; sutures deeply depressed, distinct; wall smooth, finely perforate; aperture a definite elongate opening in the line of coiling. It is a very small, easily overlooked species, but very distinct in the character of its globular chambers." (Cushman and Ponton, 1932)

Holotype: USNM 16326; Chipola Formation, "USGS Locality 19, at mouth of Senterfeit Branch, a small branch entering the Chipola River 1/2 mile below the type locality of the Chipola Formation on McClelland's farm, Calhoun County, Florida." (See Cushman and Ponton, 1932, p. 15 and fig. 1; this locality is probably TU 1020.)

Discussion: *Cassigerinella globolocula* Ivanova and *C. boudecensis* Pokorný are placed in synonomy with *C. chipolensis* on the basis of remarks by V. Pokorný *in* Eames *et al.* (1962, p. 83). Examination of the various species referred to this genus by means of the scanning electron microscope would be helpful in evaluating their validity. *C. eocaenica* Cordey should be included in such a study. The maximum diameter of the holotype of Cushman and Ponton is 0.17 mm, as calculated from the magnification of their type figure. Most of the Chipola localities sampled for this report yielded *C. chipolensis*, and most of the specimens were too small to be retained on a U. S. Standard sieve no. 120.

The range of *C. chipolensis* is from within the earlier part of Zone P. 18 to within the later part of Zone N. 13, and *C. eocaenica* is found from Zone P. 16 to the early part of Zone P. 19, according to Blow (1969, pp. 377-378).

PLATE 57
WACCAMAW FORMATION
TU 870

Figures Page

1. *Globorotalia (Turborotalia) acostaensis humerosa* Takayanagi and Saito. 108
Maximum diameter, 0.52 mm
   a. Spiral view, X 118
   b. Umbilical view, X 115

2. *Globorotalia (Turborotalia) inflata* (d'Orbigny). 112
Maximum diameter, 0.46 mm
   a. Spiral view, X 119
   b. Umbilical view, X 119

3. *Globigerina bulloides bulloides* d'Orbigny. 48
Maximum diameter, 0.57 mm
   a. Spiral view, X 120
   b. Umbilical view, X 120

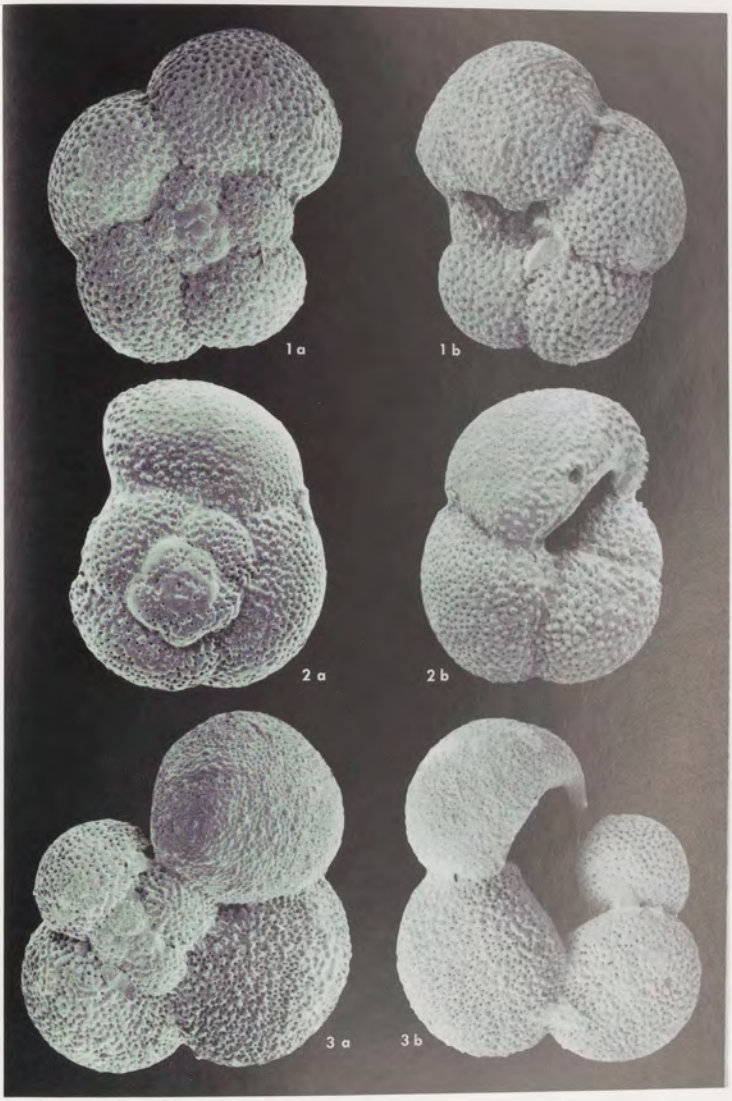

Plate 57

VII. SUPPLEMENTARY LOCALITY DATA

In addition to those localities described in the text, material was also examined from the following Tulane University Department of Geology localities.

Chipola Formation, all sites located in Calhoun County, Florida:

458. Chipola River, east bank, about 0.3 mile north of Farley Creek, NE 1/4, SW 1/4, sec. 20, T1N, R9W.
459. Chipola River, east bank, about 0.4 mile south of Farley Creek, SE 1/4, NW 1/4, sec. 29, T1N, R9W.
546. Tenmile Creek, north bank, about 0.5 mile east of Florida Highway 73, SW 1/4, NE 1/4, sec. 12, T1N, R10W.
547. Chipola River, west bank, NW 1/4, SW 1/4, sec. 29, T1N, R9W.
548. Chipola River, west bank, about 0.3 mile south of Farley Creek, NE 1/4, NW 1/4, sec. 29, T1N, R9W.
549. Chipola River, east bank, NW 1/4, NE 1/4, sec. 32, T1N, R9W.
550. Chipola River, east bank, about 0.6 mile north of Farley Creek, SW 1/4, NE 1/4, sec. 20, T1N, R9W.
551. Chipola River, east bank, about 1/2 mi. below Four Mile Creek, NE 1/4, sec. 32, T1N, R9W, last outcrop of Chipola Formation.
554. Chipola River, east bank, at power line crossing, SE 1/4, SW 1/4, sec. 17, T1N, R9W.
555. Chipola River, east bank, NE 1/4, SW 1/4, sec. 29, T1N, R9W.
655. Tenmile Creek, north bank, about 0.1 mile east of Florida Highway 73, SW 1/4, NW 1/4, sec. 12, T1N, R10W.
711. Chipola River, west bank, about 0.3 mile north of Farley Creek, NE 1/4, SW 1/4, sec. 20, T1N, R9W.
806. Chipola River, west bank, about 0.4 mile south of power line crossing, NE 1/4, NW 1/4, sec. 20, T1N, R9W.
818. Farley Creek, south bank, about 400 feet west of Florida Highway 275, SW 1/4, SW 1/4, sec. 21, T1N, R9W.
820. Farley Creek, upper beds, north bank, immediate vicinity of Florida Highway 275 bridge, SE 1/4, SW 1/4, sec. 21, T1N, R9W.
822. Farley Creek, south bank, 1/4 mile east of bridge on Florida Highway 275, SW 1/4, sec. 21, T1N, R9W.
825. Farley Creek, north bank, at site of abandoned mill, NW 1/4, SW 1/4, sec. 21, T1N, R9W.
830. Tenmile Creek, north bank, at power line crossing, SE 1/4, SE 1/4, sec. 12, T1N, R10W.

PLATE 58
MOÍN FORMATION

Figures Page

1. *Globigerinoides conglobatus conglobatus* (Brady). 56
Maximum diameter, 0.62 mm
   a. Spiral view, X 84
   b. Umbilical view, X 84

2. *Globigerinoides conglobatus conglobatus* (Brady). 56
Maximum diameter, 0.53 mm
   a. Spiral view, X 94
   b. Umbilical view, X 94

3. *Globigerinoides obliquus obliquus* Bolli. 60
Maximum diameter, 0.60 mm
   a. Spiral view, X 98
   b. Umbilical view, X 98

4. *Globigerinoides ruber* (d'Orbigny). 66
Maximum diameter, 0.59 mm
   a. Side view, X 115
   b. Umbilical view, X 115

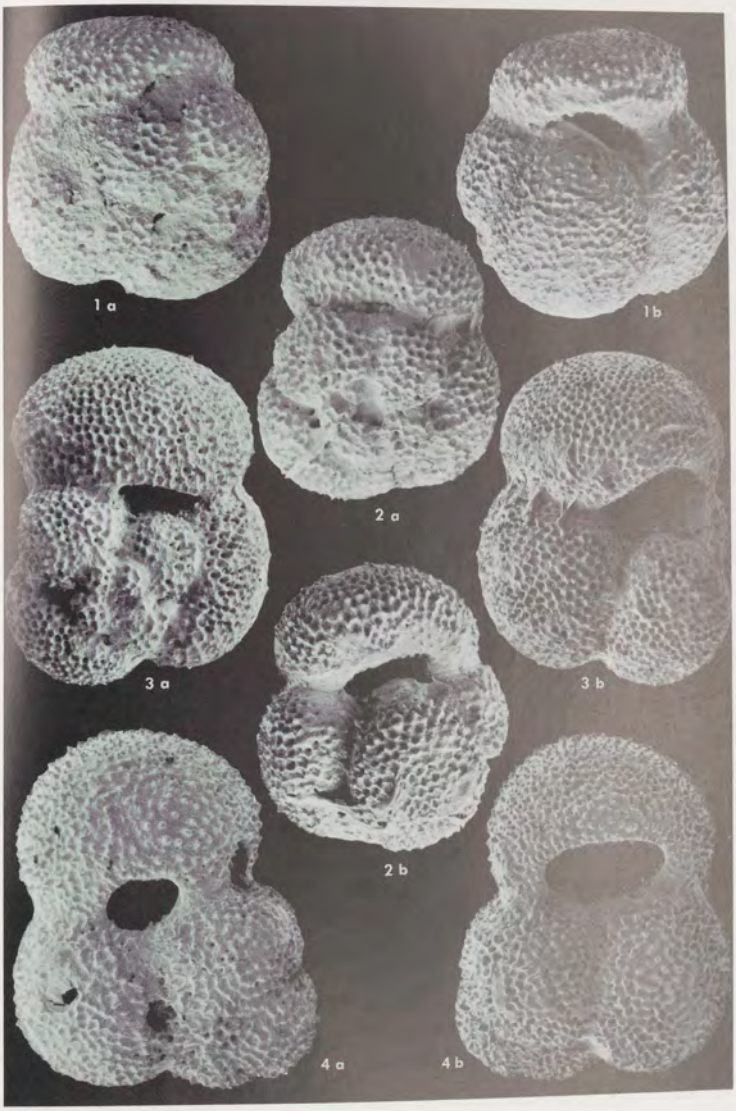

Plate 58

950. Chipola River, west bank, about 2000 feet above mouth of Farley Creek, SW 1/4, sec. 20, T1N, R9W.
951. Tenmile Creek, south bank, just under foot bridge on property of Mr. A. Sexton, about 1 1/4 mile west of Chipola River, SE 1/4, sec. 12, T1N, R10W.
998. Tenmile Creek, north bank, at beginning (west end) of long straight stretch, SE 1/4, sec. 12, T1N, R10W.
999. Farley Creek, south bank, about 1000 yards downstream (west) of bridge on Florida Highway 275, SW 1/4, sec. 21, T1N, R9W.
1019. Chipola River, east bank, about 2000 feet downstream from power line crossing, NW 1/4, sec. 20, T1N, R9W.
1020. Chipola River, in small tributary on east bank, about 1/2 mile below power line crossing, NE 1/4, sec. 20, T1N, R9W.
1021. Tenmile Creek, next big bend upstream from TU 546, north side, NW 1/4, sec. 12, T1N, R10W.

Yorktown Formation:

613. Rice's Pit. On Harris Creek Road, near junction with Fox Hill Road (State Highway 167), just off U. S. Highway 258, Hampton, Virginia.
843. Wilson's Marl Pits. 0.2 miles northeast of Armistead Avenue (= Virginia 172) on Tide Mill Lane (0.9 miles north of U. S. 258), Hampton (York Co.), Virginia.
1022. Lee Creek Mine (Texas Gulf Sulphur Company), at Aurora, North Carolina.
—— Lone Star Cement Pit, Chuckatuck, Virginia. Collected by Wayne E. Moore, 1956.

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PLATE 59
MOÍN FORMATION

Figures

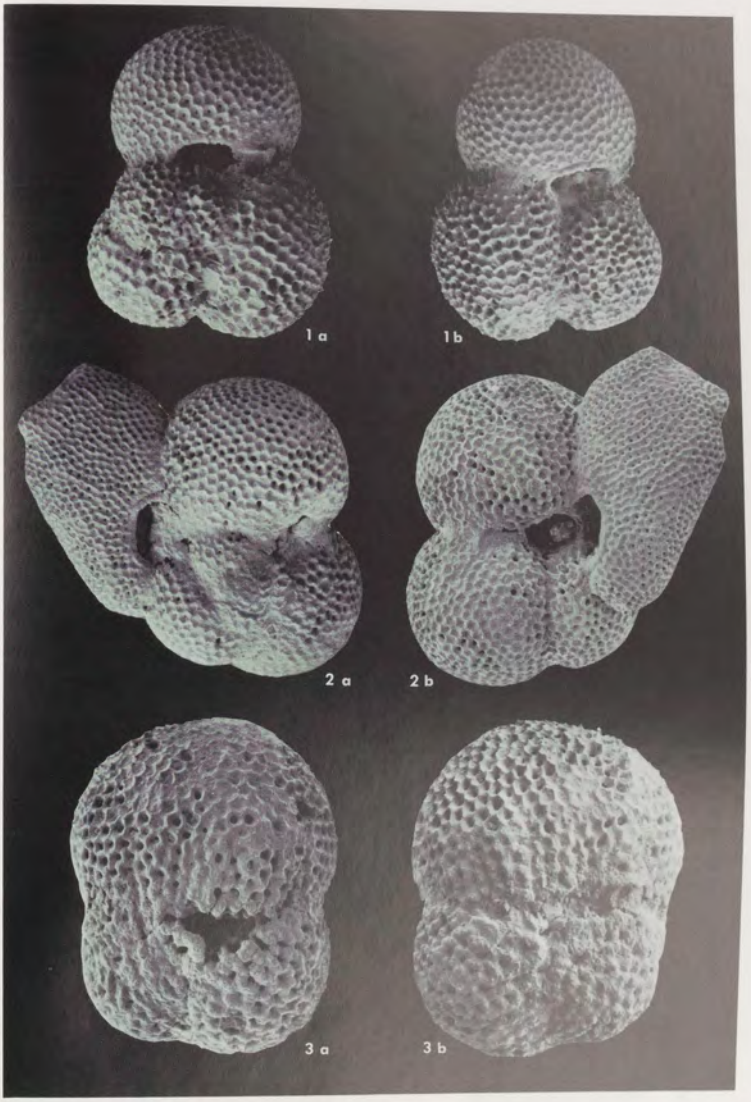

Plate 59

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PLATE 60
MOÍN FORMATION

Figures Page

1. *Hastigerina (Hastigerina) siphonifera siphonifera* (d'Orbigny). 124
Maximum diameter, 0.53 mm
   a. Spiral view, X 119
   b. Umbilical view, X 120

2. *Globoquadrina dutertrei* (d'Orbigny). 94
Maximum diameter, 0.51 mm
   a. Spiral view, X 101
   b. Umbilical view, X 104

3. *Pulleniatina obliquiloculata obliquiloculata* (Parker and Jones). 126
Maximum diameter, 0.50 mm
   a. Spiral view, X 120
   b. Umbilical view, X 120

Plate 60

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