

# 14. NEOGENE PLANKTONIC FORAMINIFERAL BIOSTRATIGRAPHY OF THE WESTERN NORTH ATLANTIC: DSDP LEG 11

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### I. INTRODUCTION

Five of the sites drilled in the western North Atlantic during Leg 11 of the Deep Sea Drilling Project penetrated thick sequences of Neogene sediments (Sites 98, 102, 103, 104 and 106; latest Oligocene included in Hole 98). The rich assemblages of well-preserved planktonic foraminifers that are present throughout these sediments offer an opportunity for documenting the Neogene paleoclimatic and biostratigraphic history of this region. Further, the distribution of evolving populations of foraminifers may be compared with those of other regions in order to clarify temporal and spatial patterns of evolution. As a result, it is hoped to refine the precision with which the record of these organisms may be applied as age determinants in marine sediments.

A detailed stratigraphic analysis is presented below for each of the five subject sites, and the stratigraphic ranges of the most important species are charted (Figures 1 through 6). A regional synthesis is made from these data, and a comparison is made with foraminiferal sequences from other areas, particularly from beneath the continental shelf of the northern

Gulf of Mexico. The section presenting systematic paleontology includes a brief synonymy and a discussion of the species that hold greatest stratigraphic significance. These species are illustrated with scanning electron photomicrographs. An explanation of the abbreviated generic names, which are used throughout this report, is included in the systematic paleontology section.

In the following discussion, the author has attempted to produce the maximum amount of pertinent information possible during the short span of time available for preparation of this initial report. Consequently, some aspects (such as, the effects of calcium-carbonate solution) of necessity, have received cursory treatment, and changes must be expected as more thorough analyses of these cores become available. The major conclusions, however, are supported by substantial evidence, and should remain valid.

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### III. SITE 98

#### Introduction

The upper 27 meters recovered from Site 98 comprise a continuously cored section ranging in age from Holocene to late Miocene. Below this, middle and early Miocene and late Oligocene sediments were alternately drilled and cored. All of the foraminiferal assemblages are predominantly of epipelagic origin, but a few displaced sublittoral specimens also usually occur. The specimens are characteristically well preserved, indicating deposition above the lysocline (4000 to 5000 meters) throughout this period of time.

#### Holocene

The top meter of sediments penetrated in this hole is placed in Zone N. 23 on the basis of the common occurrence of *Globigerina calida* with rare *Sphaeroidinella dehiscens* f. *excavata*. The associated fauna contains abundant specimens of *Globorotalia truncatulinoides*, *Globorotalia cultrata*, *Globigerinoides ruber* f. *rosea*, *Globoquadrina dutertrei*, *Pulleniatina finalis*, and common specimens of *Globigerina rubescens* (pink). This assemblage is also characterized by the excellent preservation of delicate spines on large numbers of specimens. These criteria indicate deposition during Holocene time. The presence of abundant specimens of *Globorotalia cultrata* coupled with the nearly total lack of *Turborotalia inflata* reflects warm surface water and supports the inferred Holocene age.

Ericson, Wollin, and Wollin (1954) have mapped the distribution of dextral versus sinistral specimens of *Globorotalia truncatulinoides* in modern ocean bottom sediments. In the vicinity of the Bahama Islands, their data show that *G. truncatulinoides* is 64 per cent sinistral. This is similar to the coiling direction recorded in the upper meter of Hole 98 (40 to 60 per cent sinistral), and contrasts significantly with the predominantly (98 per cent) dextral assemblages below.

#### Pleistocene

The sediments from 1 to 7.5 meters are soft brown calcarenites, slightly darker and more cohesive than in the upper meter, and contain scattered short sections

of firm, creamy white calcilutite. The brown sediments are characterized by abundant specimens of *Globorotalia truncatulinoides*, *Globigerinoides ruber* f. *rosea*, *Globoquadrina dutertrei*, *Pulleniatina finalis*, common *Globigerina rubescens* (pink), and rare *Globigerina calida*. This assemblage is typical of Zone N. 23. The rarity of *Globorotalia cultrata* with abundant-to-common *Turborotalia inflata* suggests cool surface water, and is in marked contrast to overlying assemblages. This section represents sedimentation during the late Pleistocene (Wisconsin glacial interval). A temperature change (or shift in current pattern) is also suggested by a change to predominantly dextral coiling within *G. truncatulinoides*.

#### Pliocene

The firm white calcilutite, first encountered at 2.25 meters predominantly contains specimens of *Globoquadrina altispira*, *Globorotalia cibaoensis*, *Globorotalia margaritae*, *Globorotalia limbata*, *Globigerina nepenthes*, *Globigerinoides extremus*, *Sphaeroidinellopsis subdehiscens* and *Sphaeroidinellopsis seminulina*. These species constitute diagnostic elements of Zone N. 19, Lower Pliocene. Sections of white Zone N. 19 sediment amounting to 1.4 meters cumulative thickness are scattered at irregular intervals within the brown Pleistocene calcarenite down to 7.5 meters. An uninterrupted sequence of white lower Pliocene sediment is present from 7.5 to 19.5 meters.

The presence of these isolated lower Pliocene segments within the Pleistocene section appears to be a mechanical result of the coring process. The bobbing motion of the ship plus the rotation of the drill string, which was necessary in this interval, allowed the softer Pleistocene sediments to be squeezed into the core barrel after initial penetration of the Pliocene sediments. After additional penetration (to 7.5 meters) the telescoping bumper subs compensated for the motion of the ship allowing continuous recovery of Pliocene sediments. If the 1.4 meters of scattered Pliocene segments are added to the top of the continuous Pliocene interval (7.5 meters plus 1.4 meters), the restored Pliocene begins at 6.1 meters. This contact is unconformable (Zone N. 23 above Zone N. 19). Zones N. 22, N. 21 and N. 20, including the Pliocene-Pleistocene boundary are missing. (See discussion under "Major Stratigraphic Boundaries".)

Zone N. 19 extends from 6.1 to 17 meters, and the lower Pliocene section of Zone N. 18 is present from 17 to 19.5 meters. The planktonic foraminiferal assemblage of the latter section differs from Zone N. 19 chiefly in a decrease in *Globorotalia margaritae* and *Globorotalia cibaoensis*, and the presence of frequent *Globorotalia plesiotumida*.

## Miocene

Miocene sediments are present from 19.5 to 97 meters. Zones N. 18, N. 17 (Upper Miocene) and N. 4 (Lower Miocene) are represented by cores. The Miocene portion of Zone N. 18 differs from the Pliocene portion in the lack of *G. margaritae*; a decrease in *Globoquadrina altispira*, *Globigerina nepenthes*, and *Globigerinoides extremus*; and the presence of *Globorotalia merotumida*, *Globigerinoides mitra*, and *Turborotalia acostaensis*. *Globorotalia limbata*, whose coiling direction is 98 percent sinistral throughout the Lower Pliocene, coils randomly (equally sinistral and dextral) in the uppermost Miocene.

The transition from Zone N. 18 to N. 17 is not sharp; the separation is based mainly on the increase in *G. merotumida*. In addition, Zone N. 17 is typified by frequent to common *Globorotalia plesiotumida*, abundant *T. acostaensis* and *G. altispira*, common *G. extremus*, and frequent *Globorotalia cibaoensis*. Randomly coiled *G. limbata* is present in the upper sample, but is absent below. *T. acostaensis*, which is predominantly sinistral at 61.1 meters, becomes randomly coiled from 61.9 to 63.5 ± meters, and is predominantly dextral from 63.5 to 64 meters.

Lowermost Miocene sediments belonging to Zone N. 4 were recovered in the top of Core 5 (96.6 meters). This is below a 29-meter drilled interval. The foraminiferal assemblage contains abundant *Globigerinoides primordius*, common to few *Turborotalia siakensis*, *Turborotalia pseudokugleri*, *Globigerinita ciperoensis*, *Globigerinita unicava*, *Globigerinita dissimilis*, *Globigerina tripartita*, *Globoquadrina globularis*, and rare *Globigerina sellii*. The presence of rare specimens of *Globigerinoides altiapertura* attests to contamination from the overlying drilled section.

## Oligocene

The frequency of *Globigerinoides primordius* is abruptly reduced at 96.83 meters. This is accompanied by an increase in *Globigerina tripartita* and the introduction of *Turborotalia kugleri*, *Turborotalia mendacis*, *Globigerina angulisuturalis*, and *Globigerina gortanii*. These species form the basis for placing the sediments in Zone N. 3, late Oligocene. Although *G. primordius* continues in rare frequency to 101.35 meters, the other data point strongly to a late Oligocene age.

The core catcher sample of Core 5 (99 meters) contains a large number of benthonic specimens which appear to have been displaced from nearby reefal environments. (See chapter by W. H. Akers in this volume.) Species included are *Miogypsina panamensis*, *Pararotalia mexicana*, *Heterostegina antillea*, and *Lepidocyclina canellei*. These are not of an appreciably older

age than the planktonic forms, and are, therefore, considered to have been contemporaneously displaced rather than redeposited.

## IV. SITE 102

### Introduction

Site 102, drilled on the crest of the Blake-Bahama Outer Ridge in the western Sargasso Sea, contains rich assemblages of well-preserved tropical/subtropical planktonic foraminifers of Holocene to late Miocene age. The foraminiferal assemblages are predominantly of epipelagic origin, but a few sublittoral species are often intermixed.

### Holocene

Approximately one meter of Holocene sediments was penetrated in Hole 102. The planktonic foraminiferal assemblage is one of subtropical aspect, containing abundant specimens of *Globigerinoides ruber* f. *rosea* and pink *Globigerina rubescens*, abundant *Globorotalia truncatulinoides*, *Globoquadrina dutertrei*, common *Globorotalia cultrata*, and few *Globigerina calida*, and *Turborotalia inflata*.

As in Hole 98, Holocene age is based on the presence of *Globigerina calida*, abundant *Globigerinoides ruber* f. *rosea* and *Globigerina rubescens*, and abundant preservation of fragile spines on the foraminiferal tests. Warm surface water is indicated by the relative predominance of *Globorotalia cultrata* over *Turborotalia inflata*. The predominance of sinistrally coiled forms of *Globorotalia truncatulinoides* (90 percent) is in agreement with the work of Ericson, Wollin, and Wollin (1954) who have shown that sinistrally coiled specimens constitute approximately 86 per cent of the *G. truncatulinoides* population in modern sediments of the western Sargasso Sea.

### Pleistocene

At 1.7 meters, a significant change occurs in the foraminiferal assemblage. *Globigerinoides ruber* f. *rosea* and *Globigerina rubescens* are absent. The ratio of *Globorotalia cultrata* to *Turborotalia inflata* is reversed, indicating cold surface water. In addition, *Globorotalia truncatulinoides* becomes 98 per cent dextral. The continued presence of *Globigerina calida* indicates Zone N. 23. These changes are identical to those occurring at a similar depth of penetration in Hole 98. This assemblage is assigned to the Wisconsin glacial interval of the latest Pleistocene. A similar fauna is present throughout the remainder of Core 1 (0 to 9 meters). In the core catcher sample (9 meters), *G. ruber* f. *rosea* reappears, and random coiling is present

among *G. truncatulinoides*. This suggests a return to warm-water conditions similar to the Holocene. Although *T. inflata* is still abundant, *G. cultrata* does reappear in low frequency.

At 27 meters (Core 2) *G. ruber* f. *rosea*, *G. rubescens*, and *G. calida* increase in abundance, and *G. truncatulinoides* is 92 per cent sinistrally coiled. This assemblage is present to 67 meters depth (through Core 3).

Following a drilled interval of 29 meters, a sample at 105 meters (Core 4) contains typical *Globigerina calida*, and is characterized by a change to 95 per cent dextrally coiled *Globorotalia truncatulinoides*. A significant increase in *Globorotalia cultrata* suggests warm water. The absence of *G. calida* with the continued presence of *G. truncatulinoides* in abundance indicates Zone N. 22 of early to middle Pleistocene age. This assemblage is present to 142 meters depth (through Core 5).

At 181 meters (Core 6), *G. cultrata* is reduced in numbers, *Turborotalia tosaensis* is present in low frequency, and *G. truncatulinoides* is randomly coiled. At 190 meters (Core 7), *G. cultrata* is absent, and *G. truncatulinoides* is 99 per cent sinistrally coiled. The absence of *G. cultrata* is in contrast to abundant *T. inflata*, and suggests cooler surface water.

At 220 meters (Core 8) *Globorotalia truncatulinoides* is reduced in frequency. The few specimens present are dextrally coiled from this point to 223.85 meters. Below this, *G. truncatulinoides* is no longer present. The absence of *Globorotalia cultrata* in the lower range of *G. truncatulinoides* suggests cool water.

A sample at 223.91 meters (Core 8) contains a distinctly different planktonic foraminiferal assemblage from those above. It is primarily composed of *Turborotalia inflata*, *Globorotalia conomiozea*, and *Turborotalia humerosa*. *Globorotalia truncatulinoides*, which typified the Pleistocene sediments, is no longer present. This fauna is placed in upper Zone N. 21, late Pliocene. The Pliocene-Pleistocene boundary is placed between 223.85 and 223.91 meters (Core 8, Section 4; 41 centimeters from top of section) on the basis of the first occurrence of *G. truncatulinoides* accompanied by a general change in faunal constituents. A great deal of discussion has been generated regarding the placement of this boundary in deep sea cores and its relationship to the type Calabrian in Italy. As it now stands, it has been established that the inception of *G. truncatulinoides* and the extinction of discoasters (last *Discoaster brouweri*) coincide approximately with the base of the Pleistocene at its type locality at Santa Maria di Catanzaro (Calabria, Italy) (Berggren, Phillips, Bertels, and Wall, 1967; Banner and Blow, 1965; Bandy and Wilcoxon, 1970; Hay and Boudreaux, 1968). This definition is temporarily used here although Saito

(1969) has reported that in the Le Castella section of Italy, the boundary is somewhat older, being characterized by the last *Globigerinoides extremus*. A significant difference in current patterns during the Pliocene is suggested by the lack of displaced sublittoral foraminifers that are common in each Pleistocene core examined from this Hole.

### Pliocene

The upper 51 meters of Pliocene sediments (Core 8) (Zone N. 21) are characterized by abundant *Turborotalia inflata* (predominant), and the persistent occurrence of *Globorotalia conomiozea* (rare to common), and sporadic occurrences of *Turborotalia pseudopima*. In the interval from 266 to 275 meters (Core 9) *T. inflata* disappears, *G. conomiozea* becomes predominant, and *T. humerosa* increases. *Globorotalia limbata*, *Globigerinoides extremus*, and *Globorotaloides* cf. *G. hexagona* appear. At 275 meters (bottom of Core 9), *T. inflata* again is common, *G. conomiozea* decreases, and *G. limbata*, *G. cf. G. hexagona*, and *T. humerosa* are absent.

Below a drilled interval of 31 meters, a sample at 306 meters (Core 10) introduces *Globorotalia miocenica* and *Globorotalia exilis?*, *Globorotalia conomiozea* becomes abundant again, and *G. extremus* becomes an important element in the foraminiferal assemblage for the first time. This coincides with Saito's (1969) interpretation of uppermost Pliocene as exposed at Le Castella, Italy. This association is present through 353 meters (top of Core 11). In the middle of Core 11 (356.4 meters) the first *Globoquadrina altispira*, *Globorotalia multicamerata*, and *Globoquadrina venezuelana* appear with an association of *Globorotalia miocenica* and *Globigerinoides extremus* similar to that immediately above. This is considered the lower part of Zone N. 21, late Pliocene.

Below a drilled interval of 57 meters, a sample at the top of Core 12 (417.1 meters) contains the first sediments from Zone N. 20, late Pliocene. The foraminiferal assemblage undergoes several changes in composition. *Globorotalia conomiozea*, which had been so prevalent in Zone N. 21, is replaced by *Globorotalia crassula*; *Sphaeroidinellopsis seminulina* is introduced, and *Sphaeroidinellopsis subdehiscens* becomes an important constituent of the fauna. A similar assemblage is present in the bottom of Core 12 (423 meters), but here, *G. miocenica* has disappeared and does not return throughout the remaining cored interval. The range of *G. miocenica* here agrees with that observed by Bolli (1970, Leg 4, DSDP) in being restricted to the section above *Globorotalia margaritae*.

The highest early Pliocene (Zone N. 19) sample examined was taken from the top of Core 13 (470.1 meters), below a drilled interval of 44 meters. The

fauna is characterized by abundant *Turborotalia oceanica*, common *Globoquadrina altispira*, few *S. seminulina*, and *Pulleniatina primalis* and rare *G. margaritae*. In the bottom of Core 13 (476 meters), *G. altispira*, *G. margaritae*, and *T. oceanica* are abundant, and the first dextral *Globorotalia limbata* and *Globorotalia cibaensis* appear. A similar fauna continues through the bottom of Core 15 (549 meters), at which point *Globigerina nepenthes* is introduced.

In the top of Core 16 (583.7 meters), below a drilled interval of 27 meters, the early Pliocene portion of Zone N. 18 is encountered; *Globorotalia plesiotumida* is introduced in abundance, *Globorotalia merotumida* is rare, and *Globoquadrina altispira*, *Globigerina nepenthes*, and *Globorotalia margaritae* are abundant.

### Miocene

Late Miocene sediments of Zone N. 18 are first encountered in the bottom of Core 16 (585 meters) with an increase in *G. merotumida* and *G. plesiotumida*, the introduction of abundant *Globigerina multiloba*, and the first abundant occurrence of *Globorotalia cibaensis*.

Below a drilled interval of 25 meters, a sample from Core 17 (618.3 meters) contains neither *G. merotumida* nor *G. plesiotumida*, and is placed in Zone N. 17 (late Miocene). *Globorotalia limbata* changes to predominantly sinistral coiling at this point. A similar assemblage is present through the bottom of Core 18 (636 meters).

An interval of 1.5 meters of sediment was recovered in the last core (Core 19) below a drilled interval of 16 meters. Samples at 659.6 and 661 meters contain *turborotalia continua*, which becomes extinct in Zone N. 16 of the late Miocene (Blow, 1969). The presence of *Globorotalia margaritae* and *Globorotalia merotumida* preclude an age older than N. 16 for the sediments at the bottom of this Hole.

## V. SITE 103

### Introduction

Site 103, located on the southwestern flank of the Blake-Bahama Outer Ridge, penetrated a thick sequence of Holocene to late middle Miocene sediments. Rich assemblages of tropical/subtropical planktonic foraminifers attest to the epipelagic origin of these sediments, although a few displaced sublittoral species also occur. Siliceous skeletal remains became important constituents of the mid-Miocene assemblages.

### Holocene

The uppermost sample from Core 1 (0 to 2 centimeters) contains a Holocene assemblage nearly identical

to that in Holes 98 and 102. Diagnostic species include abundant specimens of *Globigerinoides ruber* f. *rosea* and pink *Globigerina rubescens*, *Globorotalia cultrata* (sinistral), common *Globigerina calida*, rare *Sphaeroidinella dehiscens* f. *excavata*, and abundant *Globorotalia truncatulinoides* (60 per cent sinistrally coiled). Preservation of delicate spines is not evident, however.

### Pleistocene

Lower Pleistocene sediments lie immediately below the Holocene in this Hole. A sample from approximately 6 centimeters below the sea floor contains *Turborotalia tosaensis*, abundant *G. truncatulinoides* (randomly coiled), *Turborotalia inflata*, and rare *G. cultrata* (sinistral). Such an association is indicative of Zone N. 22. The upper Pleistocene portion of Zone N. 23 is, therefore, missing. This assemblage is present to approximately 2.5 meters.

### Pliocene

A second hiatus separates lower Pleistocene from upper Pliocene sediments. A sample at 2.85 meters introduces *Sphaeroidinellopsis seminulina*, *Globorotalia limbata*, and *Sphaeroidinellopsis kochi*, which represent Zone N. 20 of the late Pliocene. Zone N. 21 (latest Pliocene), usually characterized by *Globorotalia miocenica*, is missing. At 3.7 meters, *Globoquadrina altispira*, *Globorotalia multicamerata*, and *Globoquadrina venezuelana* appear for the first time. *Sphaeroidinellopsis subdehiscens* follows at 5.7 meters. Contamination from the Pleistocene is evidenced by the continued presence of *G. truncatulinoides*.

At 7.7 meters (Core 1), *Globorotalia margaritae* heralds Zone N. 19 (early Pliocene). Its appearance is accompanied by a distinct increase in *S. seminulina*, *S. subdehiscens*, *G. altispira*, and *Globigerinoides extremus*. *Turborotalia inflata*, which had been present in abundance throughout most of Zone N. 20, is absent from Zone N. 19—except for a single occurrence in the core catcher of Core 1 (9 meters). The latter occurrence appears to be contamination from younger sediments.

Following a drilled interval of 30 meters, the upper sample of Core 2 (39 meters) ushers in *Globigerina nepenthes*, *Globorotalia cibaensis* and *Turborotalia acostaensis* (dextral), while *G. multicamerata* is no longer present. *Globigerinoides mitra* and *Globorotalia plesiotumida* appear at 42.2 meters, signifying penetration into Zone N. 18, early Pliocene.

### Miocene

The core catcher of Core 2 (48 meters) contains the first *Globorotalia merotumida* in addition to *Globorotalia plesiotumida*, *Globigerinoides mitra*, and abundant *Sphaeroidinellopsis subdehiscens* and *G. nepenthes* (thin, low-spined form). This assemblage is indicative of the late Miocene portion of Zone N. 18.

At 94 meters (top of Core 3), below a drilled interval of 47 meters, the first sediments of Zone N. 17 (late Miocene) are encountered. This sample contains common *G. merotumida*, rare *G. plesiotumida*, few *Turborotalia acostaensis* and *Globorotalia cibaoensis*, common *S. subdehiscens*, and abundant *Globigerina nepenthes* (high spired) as major constituents. The remaining samples of Core 3 are also assigned to Zone N. 17. The uppermost sample from Core 4 (176 meters) was recovered beneath a 67-meter drilled interval. The only notable change is the introduction of *Globorotalia miozea* in common frequency. The assemblage here is similar to those in lower Core 3 and is assigned to Zone N. 17.

At approximately 178 meters (Core 4), the presence of *T. continuosa* signifies Zone N. 16. *Globorotalia miozea* becomes abundant, and is accompanied by *G. nepenthes* (low spired). One meter lower, in the core catcher of Core 4 (179 meters), *T. acostaensis* increases to abundant status, and displays predominantly sinistral coiling in contrast to the dextral forms above. *Turborotalia continuosa* increases slightly, and *G. nepenthes* remains low spired.

Core 5 was recovered after drilling 68 meters. A sample near the top (253 meters) contains abundant *Globoquadrina advena*, rare *Globoquadrina dehiscens*, and abundant *G. nepenthes* (low spired). *Globorotalia limbata* increases to abundance and is sinistrally coiled. This association belongs to Zone N. 15 (mid-late Miocene). In the core catcher of Core 5 (256 meters), *G. advena* is reduced and *G. dehiscens* becomes abundant. At the same time, *Globoquadrina globosa* appears.

The planktonic foraminiferal assemblages of Core 6 (350.5 to 352 meters) are sparse in number of species and individuals. Siliceous microfossils (radiolarians, sponge spicules and diatoms) increase concomitantly. Based on the continued presence of *Globigerina nepenthes*, this short core can be no older than Zone N. 14. One new element, *Turborotalia clemenciae* is present in two samples.

The amount of sediment recovered in the final core (Core 7) at 449 meters was insufficient for foraminiferal analysis.

## VI. SITE 104

### Introduction

Holocene, Pleistocene, late Pliocene, late Miocene, and middle Miocene sediments were recovered at this location on the northeast flank of the Blake-Bahama Outer Ridge. The younger section (Holocene-Pliocene) is thin (approximately 4.5 meters). Sediments of Zone N. 22 unconformably overlie older sediments as they did in Site 103. This hiatus appears to be contemporaneous in both holes, and suggests that the major

erosion west of the Blake-Bahama Outer Ridge occurred during the early Pleistocene, perhaps as a result of circulation changes accompanying sea level fluctuation. Correlation with Holes 102 and 103 documents continuity of the beds across the Ridge and demonstrates significant eastward thinning of the Neogene sediments.

The tropical/subtropical planktonic foraminiferal faunas are rich and well preserved, indicating an epipelagic origin. Radiolarians become an important part of the microfossil assemblages throughout the Miocene.

### Holocene

The uppermost sediments of Hole 104 contain a planktonic foraminiferal assemblage similar to that in the other two holes on the Blake-Bahama Outer Ridge (Holes 102 and 103). In both Holes 103 and 104, however, *Turborotalia inflata* is more abundant in the top sample than in Holes 98 and 102. This may indicate some mixing of Pleistocene with Holocene sediments. Other predominant constituents in the top sample are abundant *Globigerina calida*, *Globigerinoides ruber* f. *rosea*, pink *Globigerina rubescens*, *Globorotalia cultrata*, and *Globorotalia truncatulinoides*. Random coiling of the latter may also indicate some mixing of Pleistocene and Holocene assemblages.

### Pleistocene

In a sample at 0.07 meters, the presence of common *Globorotalia flexuosa*, along with a significant reduction in *G. cultrata*, *G. calida*, *G. ruber* f. *rosea* and pink *G. rubescens*, indicates late Pleistocene sediments (Zone N. 23). Randomly coiled *G. truncatulinoides* and sinistral *T. inflata* are predominant. The remaining sediments of Core 1, down to 4 meters, contain essentially an identical fauna. A sample of brown calcarenite at 3.55 meters and 3.83 meters, however, represents contamination from Holocene sediments, as indicated by the reoccurrence of abundant to common specimens of *Globigerinoides ruber* f. *rosea*, pink *Globigerina rubescens*, *Globigerina calida* and *Globorotalia cultrata*.

At 4 meters, the introduction of *Turborotalia tosaensis* indicates early Pleistocene sediments of Zone N. 22. Simultaneously, a significant reduction occurs in *Globorotalia truncatulinoides* and *Turborotalia inflata*. The remaining samples from Core 1 (to 9 meters) contain sparse faunas of nondiagnostic planktonic foraminifers. *Turborotalia inflata* is persistent but rare. A hiatus is placed within Zone N. 22 at approximately 5.95 meters on the basis of the last persistent occurrence of *G. truncatulinoides* above this point, and the succeeding absence of species typical of Zone N. 21 or N. 20 below. The core catcher sample contains a

mixture of abundant Pleistocene *G. truncatulinoides* and rare middle Pliocene-Miocene *Globigerina nepenthes* (range Zone N. 19-N. 14). The calcareous nannoplankton indicate Zone N. 17 (late Miocene).

### Miocene

Core 2, recovered below a 27-meter drilled interval contains rare *Globoquadrina advena*, indicative of Zone N. 15. In the core catcher of Core 2 (45 meters), *G. advena* increases to abundant status, accompanied by abundant *G. nepenthes*, *Globoquadrina dehiscens*, and common *Globoquadrina altispira*, *Sphaeroidinellopsis seminulina*, and *Sphaeroidinellopsis kochi*.

In the top of Core 3 (below a 27-meter drilled interval), a sample at 62.2 meters contains the earliest rare specimen of *Globigerina nepenthes* along with a reduced assemblage of species similar to that immediately above. Radiolarians become predominant in the assemblage here and continue to T.D. The age of this association cannot be precisely determined, but is interpreted to represent Zone N. 15/14, near the evolutionary development of *G. nepenthes*. A sample from the core catcher of Core 4 (142 meters) is similar, except that *G. nepenthes* is not present. No recovery was made in the attempt at Core 5.

After drilling 77 meters, Core 6 was recovered at 219 to 228 meters. A sample at 219.06 meters contains a few specimens of *Globigerinoides subquadratus* and *Turborotalia siakensis* of Zone N. 13 (middle Miocene). At 228 meters (core catcher of Core 6) the same two species are present with *G. altispira*, *Globigerina druryi*, *Sphaeroidinellopsis subdehiscens* and *S. seminulina*. *Sphaeroidinellopsis subdehiscens* is thought to begin in Zone N. 13 and *G. druryi* disappears in Zone N. 14 (Blow, 1969).

The lack of *Globigerina nepenthes* supports assignment of this sample to Zone N. 13. The presence of *S. subdehiscens* in the top of Core 7 (309.84 meters, below a drilled interval of 78 meters) places this sample also in Zone N. 13.

In the core catcher of Core 7 (315 meters) there is a significant increase and change in the specific elements of the planktonic foraminiferal assemblage. Abundant *Globorotalia peripheroronda*, common *Globorotalia lobata*, *Globorotalia robusta* and *Globorotalia praemenardii* indicate Zone N. 12 of the middle Miocene.

In Core 8, below a drilled interval of 86 centimeters, samples at 409.53 and 410 meters lack *G. peripheroronda* and *G. robusta*. The upper of these two samples contains *Turborotalia praefohsi*. Such an association indicates Zone N. 11.

Core 9 (410.5 to 504 meters) contains few planktonic foraminifers; the microfauna consists primarily of radiolarians and diatoms. In Core 10 (615.5 to 617 meters) a similar association is present, but common *orbulina universa* and *O. suturalis* indicate an age no older than Zone N. 9 of the middle Miocene.

## VII. SITE 106

### Introduction

The upper portion of Site 106 contains numerous intervals of loose sand (Cores 2-4) which appear to have been mixed during coring. They are, therefore, not reliable for biostratigraphic precision. All of the Pleistocene sediments examined contain displaced inner sublittoral foraminifera; in particular, species of *Elphidium* and *Nonionella*. Abundant mica, quartz grains, glauconite, and carbonized wood fragments also are characteristic here, as they were in Site 102. The displaced benthonic species are not present below the Pleistocene. In Hole 106B solution of calcium carbonate is notable in some samples of Pliocene and Miocene age. The assemblages become largely siliceous in Core 5B and calcareous forms are absent in Cores 6B to 8B. Siliceous agglutinated benthonic foraminifers of the *Bathysiphion* type are common to abundant in Cores 4B to 7B (Miocene). The secondarily silicified sediments in Core 8B contain no identifiable foraminifers.

The Miocene and Pliocene foraminiferal assemblages are of tropical/subtropical nature, but in the Pleistocene, cool temperate species, such as *Globigerina bulloides* and *Globigerina pachyderma*, are prevalent.

### Holocene

The uppermost sediments from Hole 106 are difficult to date due to the contrast between a cool temperate assemblage of planktonic foraminifers here, and tropical/subtropical associations southward. The uppermost sample contains abundant *Turborotalia inflata* which is characteristic of the late Pleistocene at the more southerly sites. *Globigerina bulloides*, a cool temperate species, is also present. *Globigerina rubescens* is abundant, but is primarily of white color. Likewise, *Globigerinoides ruber* f. *alba* is more abundant than *G. ruber* f. *rosea*. The presence of abundant sinistral *Globorotalia truncatulinoides*, common *Globorotalia cultrata*, and few *Globigerina calida*, however, lends support to the assignment of this association to the Holocene.

### Pleistocene

The Pleistocene interval is composed of loose sand that appears to have been mixed during coring. As a result, detailed Pleistocene biostratigraphy cannot be reliably

deciphered. In gross aspect, Zone N. 23, characterized by the nearly uniform presence of abundant *T. inflata* along with *G. truncatulinoides* and the rarity of *G. cultrata* indicate cool-water conditions. A cool temperate association with *G. bulloides* and dextral specimens of *G. pachyderma* is present throughout the Pleistocene interval. This contrasts with the lack of *G. bulloides* and *G. pachyderma* southward. Assuming that the sampling is representative, the warmth of the Gulf Stream appears not to have influenced this area during the Pleistocene.

*Globorotalia flexuosa*, observed in the core catcher of Core 1 (7.5 meters), has been used by Ericson, Ewing, Wollin, and Heezen (1961) to indicate the upper Wisconsin interglacial. It was not observed elsewhere in this hole.

*Globorotalia tosaensis*, a characteristic species for Zone N. 22 appears in Core 4 core catcher (196 meters). It is not present below this core, but the continued absence of *Globigerina calida* indicates Zone N. 22 through Core 5 core catcher (349 meters).

#### Pliocene

The upper sample of Hole 106B (370.5 meters) contains no diagnostic species other than *Turborotalia inflata*, which ranges from Pliocene to Holocene. However, at 110 centimeters of Core 1B, *Globigerinoides extremus* and *Globorotalia miocenica* appear, indicating sediments of late Pliocene age (Zone N. 21). The Pliocene-Pleistocene boundary was not cored, but lies in the drilled interval between 349 and 370.5 meters. Zone N. 21 continues throughout Core 1B (to 375 meters).

Below a drilled interval of 76 meters, samples of Core 2B (455.2 meters) introduce *Globigerina nepenthes*, *Globorotalia margaritae*, *Sphaeroidinellopsis seminulina*, *S. subdehiscens*, and *Pulleniatina primalis* of Zone N. 19 (early Pliocene). Zone N. 20 appears to be represented in the overlying drilled interval.

#### Miocene

Core 7B (553 to 562 meters) was recovered below a drilled interval of 93 meters. It is placed in Zone N. 17 (late Miocene) on the basis of *sphaeroidinellopsis paenedehiscens*, *Globorotalia plesiotumida*, *Globorotalia cibaoensis*, *Globigerina riveroae*, and rare *Turborotalia continua*.

A thick, drilled interval (192 meters) precedes Core 4B (758 to 763 meters). Here, the occurrence of *Globoquadrina advena*, and *Globoquadrina dehiscens* with *Globorotalia limbata*, *T. continua*, and persistent *Globigerina nepenthes* indicates Zone N.14 (middle Miocene).

Another thick, drilled interval (172 meters) lies above Core 5B (935 to 944 meters). The core catcher sample indicates Zone N.13, based on the presence of *Globorotalia miozea*, *Turborotalia siakensis*, *T. peripheroacuta*, and *Globorotalia praemenardii*, and the absence of *G. nepenthes*.

The planktonic assemblages from Cores 4B and 5B, are sparse and poorly preserved, indicating deposition below the lysocline (Berger, 1970). They are characterized, in addition, by a persistent assemblage of agglutinated benthonic foraminifers of the *Bathysiphon* type. Radiolarians become an important element of the microfauna in Core 5B and are predominant through Core 8B (at T.D., 1015.5 meters).

Indigenous planktonic foraminifers are absent from Cores 6B to 8B. The core catcher of Core 7B contains a few strongly dissolved specimens, among which are single specimens of *Turborotalia* cf. *T. opima* and *Globigerinita* cf. *G. unicava*. It is doubtful, however, that these specimens actually came from this horizon. They probably are contamination from the overlying drilled interval. Core 8B contains similar contamination (*Globorotalia margaritae* and *G. nepenthes*). Agglutinated *Bathysiphon*-like benthonic foraminifers are again present in Cores 7B and 8B.

### VIII. REGIONAL FAUNAL ASSOCIATIONS

#### Holocene

The Holocene sediments from Leg 11 generally contain an assemblage of planktonic foraminifers that is quite distinct from those of the underlying upper Pleistocene sediments. Abundant *Globorotalia cultrata*, *Globigerinoides ruber* f. *rosea* and pink *Globigerina rubescens*, common *Globigerina calida*, and rare *Sphaeroidinella dehiscens* f. *excavata* are accompanied by abundant *Globorotalia truncatulinoides* (predominantly coiled sinistrally) and *Globoquadrina dutertrei*.

Living *G. cultrata* has been reported (as *Globorotalia menardii*) as a typical indicator of tropical/subtropical waters from the western North Atlantic (Bé, 1959), Sargasso Sea (Bé, 1960; Cifelli, 1967), and Equatorial Atlantic (Cifelli, 1967; Boltovskoy, 1968). This species (along with *Globorotalia tumida* and *Globorotalia flexuosa*), according to Ericson and Wollin (1968), has proven to be "... the most sensitive climatic indicator in cores" from the Atlantic Ocean. Schott (1935), Ericson, Ewing, Wollin and Heezen (1961), and Ericson and Wollin (1968) believe that the occurrence of *G. cultrata* in abundance (without *G. flexuosa*) in the uppermost layer of sediment in cores from the Equatorial Atlantic represent postglacial sedimentation (this is their faunal zone "Z"). Ruddiman (1968) used *Globorotalia cultrata* as one of four species whose distribution in bottom sediments delineate the late

Holocene meander belt of the Gulf Stream. All of the holes under consideration fall within this belt as reflected by the uppermost planktonic foraminiferal assemblages, although they are located in the Sargasso Sea south of the Gulf Stream proper. *Globorotalia cultrata* is abundant to common in the top of each hole, whereas it has been reported to be nearly absent from sediments beneath the Sargasso Sea (Ruddiman, 1968).

Ruddiman observed that *G. cultrata* was one of three Gulf Stream indicators whose distribution pattern in Holocene sediments extends in tongue-like fashion southward from the Gulf Stream along the axis of the Blake-Bahama Outer Ridge. The foraminifers from Holes 102, 103 and 104, which are located on the main ridge of this feature, reflect a similar distribution pattern. Ruddiman suggests that the southward flowing Western Boundary Undercurrent creates this pattern by redistribution of specimens after original deposition. However, such a strong bottom current might just as easily prevent foraminiferal tests from reaching the bottom at its northern extremities, and may concentrate them southward on the Blake-Bahama Outer Ridge as an original site of deposition.

*Globigerinoides ruber* is an abundant tropical/temperate species that displays considerable variation in morphology as well as color of the test. *Globigerinoides ruber* forma *rosea* (Pink colored; Boltovskoy, 1968) is typical in warm open sea conditions. *Globigerinoides ruber* forma *alba* (white colored; Boltovskoy, 1968) may become predominant under conditions of lowered temperature or salinity (Boltovskoy, 1968). The latter phenomenon may explain the sparsity of *G. ruber* forma *rosea* at the northernmost site, Hole 106, in contrast to its abundance in the other four holes.

Parker (1962) has reported a similar distribution within *Globigerina rubescens*. In the Pacific, pink forms are predominant in tropical waters, giving way to white specimens in higher latitudes. This appears to be the case in Hole 106, where only white *G. rubescens* are present along with predominantly white *Globigerinoides ruber*.

*Globigerina rubescens* is not well known from the Holocene in the Atlantic Ocean, due in part to its small size and the fact that its recognition as a distinct species first occurred fairly recently (Hofker, 1956). Parker (1962) called attention to this species in South Pacific sediments and also noted its presence in a few samples from the Atlantic Ocean. It has been reported in low frequencies from plankton tows in the eastern tropical Atlantic (Boltovskoy, 1968), the northern North Atlantic (Cifelli and Smith, 1969), but heretofore was not known from plankton tows in the Western North Atlantic Ocean. Ruddiman, Tolderlund, and Bé (1970) reported it from 8 cores taken in the North

Atlantic. A record of its presence in the Holocene of adjacent regions is limited to that of Orr (1969), who reported it from the northwestern Gulf of Mexico. Bolli (1970) reported *G. rubescens* from Pleistocene sediments in the western South and North Atlantic, but did not distinguish the Holocene interval. He did not report *G. rubescens* from the Pleistocene of the Caribbean Sea.

Frerichs (1968), using seven piston and trigger cores from the Indian Ocean, defined the Holocene/Pleistocene boundary on an increase of radiolarians and a concomitant relative decrease in *Globigerina rubescens* and *Globigerina tenellus* in the Holocene. The Leg 11 cores show just the opposite situation regarding *G. rubescens*. It is much more abundant in the Holocene sediments than in the late Pleistocene. Furthermore, it seems unlikely that this tropical/subtropical species (Parker, 1962, 1967; Be and Hamlin, 1967; Frerichs, 1968; Bé, 1967; Cifelli and Smith, 1969) would increase during glacial intervals. Frerichs (1968) suggests that such a paradox might be explained by a southward shift of *G. rubescens* during cooler glacial stages. It is doubtful, however, that in equatorial areas, which it already occupied, an equatorward restriction of its range would increase its total population in the tropics enough to be detected in the sediments. In the western Atlantic, the relative frequency of *G. rubescens* appears to vary directly with that of *Globorotalia cultrata*, both being more abundant during the Holocene than late Pleistocene. An increase in radiolarians during the Holocene is also reported by Frerichs (1968), therefore, the frequency changes within the *G. rubescens* complex in the Indian Ocean may be more closely related to changing environmental conditions (possible solution of calcium carbonate) that favor siliceous organisms (radiolarians) rather than to water temperature alone. An increase in siliceous organisms is commonly accompanied by reduced calcareous remains.

Most modern investigators agree that *Globorotalia truncatulinoides* is, under normal circumstances, most abundant in temperate latitudes (Bé, 1959, 1960; Boltovskoy, 1969; Parker, 1962, 1967), but it is also an important element in some subtropical areas, such as, the Sargasso Sea and Gulf Stream (Cifelli, 1965; Parker, 1962, 1967). In the present report, this species is abundant in the upper sediments at all sites.

Coiling direction of *Globorotalia truncatulinoides* has been of considerable interest since Ericson, Wollin and Wollin (1954) demonstrated that provinces of like-coiling could be mapped across the North Atlantic Ocean. In the vicinity of the Bahama Islands, these authors showed *Globorotalia truncatulinoides* to be approximately 64 per cent sinistrally coiled. In Hole 98, located in this region, the uppermost assemblage of *G. truncatulinoides* is 60 per cent sinistrally coiled,

agreeing closely with the data of Ericson, Wollin, and Wollin. In the Western Sargasso Sea, 86 per cent sinistral *G. truncatulinoides* was reported by Ericson, Wollin, and Wollin. This agrees well with 98 per cent sinistral specimens in Hole 102, but contrasts significantly with 60 per cent and 50 per cent sinistral specimens recorded at Holes 103 and 104, respectively. The latter holes are in close proximity to Hole 102, therefore, the low sinistral frequency may indicate some mixing of dextral Pleistocene forms along the flanks of the Blake-Bahama Outer Ridge due to coring or perhaps to bioturbation or other natural causes. Bottom currents, such as the Western Boundary Undercurrent, which flows southward along the eastern flank of the Ridge, may also influence the distribution of other species in addition to *Globorotalia cultrata* (see discussion above).

In Hole 106, sinistral specimens make up 75 per cent of the *G. truncatulinoides* assemblage, which is more in agreement with the 86 per cent recorded by Ericson, Wollin and Wollin. With respect to the coiling direction of *G. truncatulinoides*, there seems to be little influence here from the predominantly dextral assemblages recorded beneath the Gulf Stream (Ericson, Wollin, and Wollin, 1954).

Vincent (1970, Mozambique Channel, Indian Ocean) reports a decrease in *Turborotalia inflata* from Pleistocene to Holocene similar to that observed in Holes 98 and 102 of Leg 11. However, in contrast to the Leg 11 cores, Vincent (1970) reports that *G. cultrata* is more abundant in the Pleistocene than Holocene. In Holes 103 and 104, on the flanks of the Blake-Bahama Outer Ridge, *T. inflata* is abundant in the uppermost samples but this is presumably the result of mixing of Pleistocene with Holocene sediments.

In Hole 106, *T. inflata* is also abundant in the Holocene but for different reasons. As Bé and Hamlin (1967) have shown, *T. inflata* is more abundant in waters of this region than in the North Atlantic waters southwest of Hole 106. Therefore, it would also be expected in greater abundance in the sediments here than in more southerly holes.

*Globigerina calida* (in Holocene sediments) to date has been recorded only from the southern Pacific Ocean (Parker, 1962, 1967). Present knowledge of its distribution is scanty, but suggests tropical/subtropical latitudes (Bé, 1967). Its relatively greater abundance in the Holocene sediments in the company of *Globorotalia cultrata* and pink *Globigerina rubescens* supports this suggestion. This Holocene abundance is rather constant in each of the five holes examined in detail.

The presence of well-developed specimens of the temperate species *Globigerina bulloides* (Bé 1959, 1960; Boltovskoy, 1969; Jones, 1968; Cifelli, 1965, 1967) in Hole 106 reflects the cooler waters in its high latitude location.

## Pleistocene

The most consistent criteria that can be used to separate late Pleistocene from Holocene sediment in Leg 11 cores are the relative decreases in *Globorotalia cultrata*, pink *Globigerina rubescens*, *Globigerinoides ruber* f. *rosea*, and *Globigerina calida*, and a concomitant relative increase in *Turborotalia inflata*. Mixing of Holocene and Pleistocene sediments in the tops of Holes 103 and 104 obscures the change in *T. inflata*. The change is also unrecognizable in Hole 106, presumably because *T. inflata* is more abundant in the Holocene sediments at this higher latitude.

*Globorotalia truncatulinoides* changes to predominantly dextral coiling in the late Pleistocene of Holes 98 and 102, and becomes random in Hole 106. Mixing in Holes 103 and 104 obscures this change from Holocene sinistrality.

The most complete record of Pleistocene events is present in Hole 102. Here, more than 220 meters of Pleistocene sediments have accumulated on the crest of the Blake-Bahama Outer Ridge, from which eight cores were recovered. Both Zones N. 23 and N. 22 are well represented, and no missing section within them is indicated. The planktonic foraminiferal assemblage is typically warm temperate. *Globorotalia truncatulinoides* and *T. inflata* are abundant and characteristic throughout. The former species is predominantly dextrally coiled at the top of the Pleistocene, and four zones of alternately sinistral and dextral specimens can be identified in the lower sediments. Ericson and Wollin (1968) have used zones of changed coiling in *Globorotalia truncatulinoides* and the abundance of *Globorotalia cultrata* to define nine Pleistocene climatic intervals. The relationship of the *G. truncatulinoides* zones in Hole 102 to those demonstrated by Ericson and Wollin is not obvious at present. Curiously, *G. cultrata* is nearly absent from all the Pleistocene cores recovered during Leg 11. The intervals in the bottoms of Cores 4 through 6 of Hole 102 and Core 1 of Hole 103 and 104 are the only *in-situ* Pleistocene occurrences of this species in statistically meaningful numbers. It must be remembered, however, that the cored intervals make up only a small portion of the column of sediments penetrated by the drill bit.

*Globigerina calida* and pink *G. rubescens* are also useful in delimiting Zone N. 23. Both species are normally present in the Upper Pleistocene, although reduced in numbers from their Holocene abundance. *Globorotalia tosaensis* is characteristic of Zone N. 22 but was never recorded in abundance, nor was it present in all samples assigned to Zone N. 22. Its maximum frequency and most persistent presence occurred in the upper 3 meters of Hole 103.

Two cool temperate species, *Globigerina bulloides* and *G. pachyderma*, are persistent in low frequency in the Pleistocene of Hole 106. The former species increases in numbers toward the lower part of the Pleistocene (Zone N. 22).

*Globorotalia flexuosa*, upon whose presence Ericson, Ewing, Wollin, and Heezen (1961) have separated a late Pleistocene interglacial interval from the Holocene, is present in common frequency at 7 centimeters from the top of Hole 104 and at 7.5 centimeters from the top of Hole 106. Otherwise, it is noted as only a few specimens in the top sample and at 111 centimeters in Hole 104. The few specimens at 3.83 meters (Hole 104) appear to be contamination as indicated by the common occurrence of *Globigerina calida* and *G. rubescens* (pink) with abundant *Globorotalia cultrata* in the same sample.

The lower part of the Pleistocene (Zone N. 22) is represented by a hiatus in Holes 98, 103, and 104; but at Holes 102 and 106, a progression from Zone N. 21 to N. 22 appears to occur in normal sequence.

### Pliocene

The upper portion in Hole 102, where Zone N. 21 is best developed, is characterized by abundant *Turborotalia inflata* without *Globorotalia truncatulinoides*. The middle is characterized by abundant *Globorotalia conomiozea* and scattered rare *Globigerinoides extremus* (the latter may not be *in situ*). The lower portion of Zone N. 21 is characterized by the presence of common *Globorotalia miocenica* and few *Globigerinoides extremus*. *Globoquadrina altispira* and *Globorotalia multicamerata* appear near the base of this zone. In Hole 102, Zone N. 21 encompasses an interval more than 135 meters thick (a time period of approximately 1 million years, assuming an accumulation rate of 13.5 cm/1000 yrs). The upper portion of the zone is within the drilled interval between Holes 106 and 106B. (See section on "Major Biostratigraphic Boundaries" for discussion of Pliocene-Pleistocene boundary.) Late Pliocene Zone N. 20 is present in Holes 102 and 103. It is characterized by *Sphaeroidinellopsis seminulina* and *S. subdehiscens* with *Globoquadrina altispira* and *Globorotalia multicamerata*. The abundance of *Turborotalia inflata* recorded within Zone N. 20 in Hole 103 is probably contamination from above, as indicated by the simultaneous occurrence of *Globorotalia truncatulinoides*.

*Globorotalia margaritae* and *Pulleniatina primalis* characterize the upper portion of middle Pliocene Zone N. 19 and are joined shortly below by *Globigerina nepenthes*. *Globorotalia cibaoensis* is a prominent constituent of this zone in Hole 98, but diminishes in abundance eastward and northward.

The lower Pliocene portion of Zone N. 18 is present in three holes (98, 102 and 103) where it is characterized by common to few *Globorotalia plesiotumida*, few to rare *Globorotalia merotumida*, and the youngest occurrence of *Globigerinoides mitra* (rare).

In Hole 98, the predominant species throughout the lower Pliocene (N. 19-18) are *Globoquadrina altispira*, *Globorotalia cibaoensis*, *Globigerinoides extremus*, sinistral specimens of *Globorotalia limbata*, *G. margaritae*, and *Globigerina nepenthes*.

Northward, *G. limbata*, *G. cibaoensis* and *G. nepenthes* are considerably diminished, and *P. primalis* becomes an important element. *Globorotalia margaritae* increases slightly and *G. altispira* remains important. Parker (1967) presented evidence that *G. margaritae* may prefer temperate waters. The present data support this, but are not conclusive. Blow (1969) noted that *Globorotalia cibaoensis* seemed to be largely confined to the Caribbean region of the Atlantic/Caribbean Province. Its distribution in the Leg 11 cores agrees well with this observation. *Globigerinoides mitra* is a species whose upper range has been used to indicate lowest Pliocene sediments in the Gulf Coast off Louisiana (Poag and Akers, 1967). This species has rarely been reported from other areas, particularly deep-sea cores. Todd (1957) and McTavish (1966) have reported it from tropical assemblages in the South Pacific, and Bolli (1957) and Blow (1959) have reported it from the Caribbean (Trinidad and Venezuela). It appears to be restricted to tropical-subtropical regions, and although often occurring in small numbers, its distinct morphology allows use of its youngest occurrence as a reliable indicator of early Pliocene-late Miocene time.

### Miocene

The upper Miocene sediments (Zone N. 18) are characterized by an increase in *Globorotalia merotumida* and a corresponding decrease in *Globorotalia plesiotumida*. The former species is abundant in Zone 19 of Hole 98, but decreases in frequency northward. *Turborotalia acostaensis* follows a similar pattern. *Globorotalia miozea*, a temperate species (*vide* Blow, 1969), appears in the lower part of Zone 17 in Hole 102, but is rare elsewhere in this zone.

Zone N. 16 is difficult to recognize due to the minute size of the species (*Turborotalia continuosa*) used to define it. *T. continuosa* appears in Holes 102, 103 and 106; and in the former two holes, it appears to represent Zone N. 16. In Hole 107, however, it occurs rarely in what otherwise is considered to be Zone N. 17.

Upper Zone N. 15 is recognized here on the basis of the upper range of *Globoquadrina advena*, while *Globoquadrina dehiscens* is abundant in the lower portion.

Both extend into Zone N. 14. The earliest occurrence of *Globigerina nepenthes* may be used to separate Zone N. 14 from N. 13 as recommended by Blow (1969) and Berggren (1969).

Middle Miocene sediments were recovered in three holes, but not in a continuous sequence of zones. Lower Zone N. 13 is represented in Holes 104 and 106, and contains *Turborotalia siakensis* with rare *T. peripheroronda*, and *T. peripheroacuta*, but without *G. nepenthes*. Only the presence of *Sphaeroidinellopsis subdehiscens* prevents this assemblage from fitting more easily into Zone N. 12.

Zone N. 12, containing abundant *T. peripheroronda* with *Globorotalia robusta*, *G. lobata* and *G. praemenardii* is present only in Hole 104. Here, *S. subdehiscens* is no longer present.

Zone N. 11 is represented in Hole 104 by an assemblage similar to that of the overlying Zone N. 12, but with the addition of *Turborotalia praefohsi*.

The lowest sample from Hole 104 contains a sparse assemblage which cannot be precisely dated. However, the presence of *Orbulina universa* and *O. suturalis* requires that it be no older than Zone N. 9.

Lower Miocene sediments were recovered in only one hole. The upper portion of Core 5 in Hole 98 is assigned to Zone N. 4 of the earliest Miocene on the basis of abundant *Globigerinoides primordius*, with *Globigerina angulisuturalis*, *G. ciperoensis*, *Turborotalia pseudokugleri*, *T. kugleri*, and *T. mendacis*. *Turborotalia siakensis*, *Globigerinita dissimilis*, *G. ciperoensis*, *G. unicava*, *Globigerina tripartita*, *G. gortanii* and *Globoquadrina globularis* are also well represented. *Globigerina sellii* is rare (see discussion below under "Major Biostratigraphic Boundaries").

### Oligocene

Sediments of latest Oligocene Zone N. 3 were recovered from Core 5 in Hole 98. The foraminiferal assemblage is characterized by an increase in *Globigerina sellii* and a reduction in *Globigerinoides primordius* from abundant to rare to absent. The presence of *T. opima*, abundant *Globigerina angulisuturalis*, persistent *G. gortanii*, and the absence of *T. kugleri* support this age assignment (see discussion below under "Major Stratigraphic Boundaries"). Oligocene sediments older than Zone N. 3 were not recovered in any of the Leg 11 holes.

## IX. MAJOR BIOSTRATIGRAPHIC BOUNDARIES

### Pleistocene/Holocene

The most consistent means of separating Holocene sediments from late Pleistocene sediments in the more

southerly holes of Leg 11 are by the presence of abundant *Globorotalia cultrata*, pink *Globigerina rubescens* and *Globigerinoides ruber* forma *rosea*, and common *Globigerina calida* in the Holocene.

The distinction is not as clear northward (Hole 106), since the above mentioned tropical/subtropical species diminish in numbers as they approach their northern latitudinal limits. In addition, the pink specimens of *G. ruber* and *G. rubescens* are replaced in part by white forms which cannot be differentiated from Pleistocene specimens. Also, cool temperate *Turborotalia inflata*, which is diagnostic for late Pleistocene in low latitudes is present in the Holocene in more temperate latitudes. In this Hole *Globigerina calida* serves as the Holocene marker.

In the Pleistocene, the above mentioned tropical/subtropical species decrease, and in subtropical latitudes, *T. inflata* increases.

The coiling change in *Globorotalia truncatulinoides* from predominantly sinistral above to predominantly dextral below the boundary as noted by Ericson, Ewing, Wollin, and Heezen (1961) may be applied in the southern holes, but at Hole 106, the change is more subtle, from predominantly sinistral to random.

### Pliocene/Pleistocene

It appears that most investigators during the past five years have agreed that the evolutionary appearance of *Globorotalia truncatulinoides* occurs in the vicinity of the base of the type Pleistocene section at Santa Maria di Catanzaro, Calabria, Italy. The precise relationship varies according to author, and is further complicated by the fact that the basal portion of the Calabrian section is not exposed at Santa Maria di Catanzaro. Using this criterion, at least one core recovered during Leg 11 contains the Pliocene-Pleistocene boundary (Core 8, Hole 102). Here, *G. truncatulinoides* is present consistently above 224 meters (Core 8, Section 4, 35 centimeters). It is rare immediately above, and increases to abundance at 190 meters (Core 7, core catcher). Below this point, among seven more samples in Core 8, and seven samples from Core 9, only three contained rare specimens of *G. truncatulinoides*; these are interpreted as contaminants.

In Hole 106, the lowest *G. truncatulinoides* occurs in the bottom of Core 5. Core 6, beneath a 68 meter drilled section contains no *G. truncatulinoides*. However, in view of its absence in some cores above this point, the evidence for its true first appearance here is not conclusive.

During the most recent INQUA Congress in Paris (1969) some Italian workers expressed the view that since the entire basal Calabrian section is exposed at

Le Castella, this locality should be designated as the new type section for the Pliocene-Pleistocene boundary. Saito (1969) has shown that at this locality, *Globigerinoides extremus* occurs below the boundary, while it is absent above the boundary. The same criterion has been used in delimiting the Pliocene-Pleistocene boundary in the Gulf of Mexico region by Poag and Akers (1967) and Poag (1969), where *G. extremus* disappears simultaneously with *Globorotalia miocenica*. A boundary defined by these species is apparently present in two of the Leg 11 holes (102 and 106), but it is not clearly represented in the recovered section. In Hole 102, 82 meters of sediments separate the oldest *G. truncatulinoides* from the youngest recovered *G. miocenica* and *G. extremus*. However, immediately above this final occurrence of *Globorotalia miocenica* and *Globigerinoides extremus* is a drilled interval of 31 meters; this presumably contains the subject boundary. In Hole 106B, *G. miocenica* and *G. extremus* are present at 110 centimeters below the top of Section 1, Core 1 (371.6 meters below sediment surface). A sample at 40 centimeters contains neither of these species, but the fauna is sparse and poorly preserved. Therefore, the presence of the boundary in this core is equivocal. Since the lowest sample from Hole 106 appears to be below the first appearance of *Globorotalia truncatulinoides* and is definitely above *Globorotalia miocenica* and *Globigerinoides extremus*, the boundary probably lies within the 21.5-meter drilled interval which stratigraphically separates Holes 106 and 106B.

#### Miocene/Pliocene

The boundary between these epochs is difficult to define on the basis of planktonic foraminifera. A tentative boundary is defined in only one recovered interval (Hole 102, Core 16). In the Leg 11 cores, *Globigerinoides mitra* becomes extinct just above the boundary. *Globorotalia plesiotumida* is abundant just below it, but may be rare to common above. *Globorotalia merotumida* is rare above, increasing below. A change from dextral *Globorotalia limbata* above, to sinistral below, may be helpful in some areas, but regionally is probably not consistent.

#### Oligocene/Miocene

Blow (1969) uses the first appearance of *Globigerinoides primordius*, as it occurs in the Aquitanian sediments of the Valley of Saucats, S.W. France, to define the base of the Miocene. At the same time he shows that *Globigerina sellii* extends into the lowest Miocene in deep sea cores, and that the extinctions of *Globigerina angulisurealis*, *G. ciperensis*, *Turborotalia kugleri*, *T. pseudokugleri*, *T. mendacis*, and *Globoquadrina globularis* occur in the basal Miocene. He places the extinction of *Globigerina gortanii*, *G. tripartita* and *G. opima nana* in the late Oligocene.

Such an assemblage of species occurs in Core 5 of Hole 98. *Globigerinoides primordius* is abundant in the top of this core (96.6 meters); *Globoquadrina globularis*, *Globigerina tripartita*, and *Turborotalia pseudokugleri* are few, and *Globigerina sellii* is rare. At 96.83 meters, *Globigerinoides primordius* is common, as are *Turborotalia kugleri*, *T. pseudokugleri*, *T. mendacis* and *Globigerina gortanii*.

At 97 meters, *G. primordius* is rare and remains so to 101.37 meters; *Turborotalia kugleri* is absent from 97 meters to T.D. At 97.65 meters, *Globigerina sellii* is common frequency, *Globigerinoides primordius* is absent, *Globigerina angulisurealis* increases to common frequency, and a few specimens tentatively identified as *Globigerina opima* occur. The Oligocene/Miocene boundary is, then, tentatively placed between the reduction of *G. primordius* and the increase in *G. sellii* at 96.83 meters. *G. angulisurealis* increases to abundance at 98.34 meters, supplying additional evidence for late Oligocene age. Foraminiferal assemblages of middle and early Oligocene age were not recovered from Leg 11 cores.

### X. CORRELATION OF LEG 11 CORES WITH GULF OF MEXICO CONTINENTAL SHELF (SUBSURFACE)

During the past six years the writer has been engaged in a biostratigraphic study of the Neogene sediments beneath the Louisiana Continental Shelf, Gulf of Mexico. It is appropriate at this point to emphasize some of the results of this study and to relate the foraminiferal sequences observed in the Gulf of Mexico to those in the Leg 11 cores and elsewhere.

The four classical North American glacial stages, Nebraskan, Kansan, Illinoian, and Wisconsinan (Geikie, 1894; Chamberlin, 1896; Shimek, 1909; along with later modifications) have been used extensively in reference to the Quaternary sediments of the American Gulf Coast (for example, Fisk, 1938; Fisk and MacFarlan, 1955; Doering, 1956; Akers and Holck, 1957; Beard and Lamb, 1968; Beard, 1969). Alternating transgressive and regressive sedimentary units have been assigned to interglacial and glacial stages, respectively. Precise correlation of a particular sedimentary unit with its respective stage has been based on its numerical position in a somewhat conjectural sequence of events. Direct correlation with mid-continent Pleistocene deposits has not been achieved. Most authors have followed Fisk and MacFarlan (1955) in placing the base of the Gulf Coast Nebraskan at the base of the Pleistocene. Akers and Holck (1957) amplified the work of Fisk and MacFarlan (1955) by correlating the cyclical terrace deposits of coastal and central Louisiana with beds beneath the Louisiana Continental Shelf, as penetrated by the Chevron No. 1 well, State Lease 2553 in South Pass, Block 41 (Figures 7 and 8). The

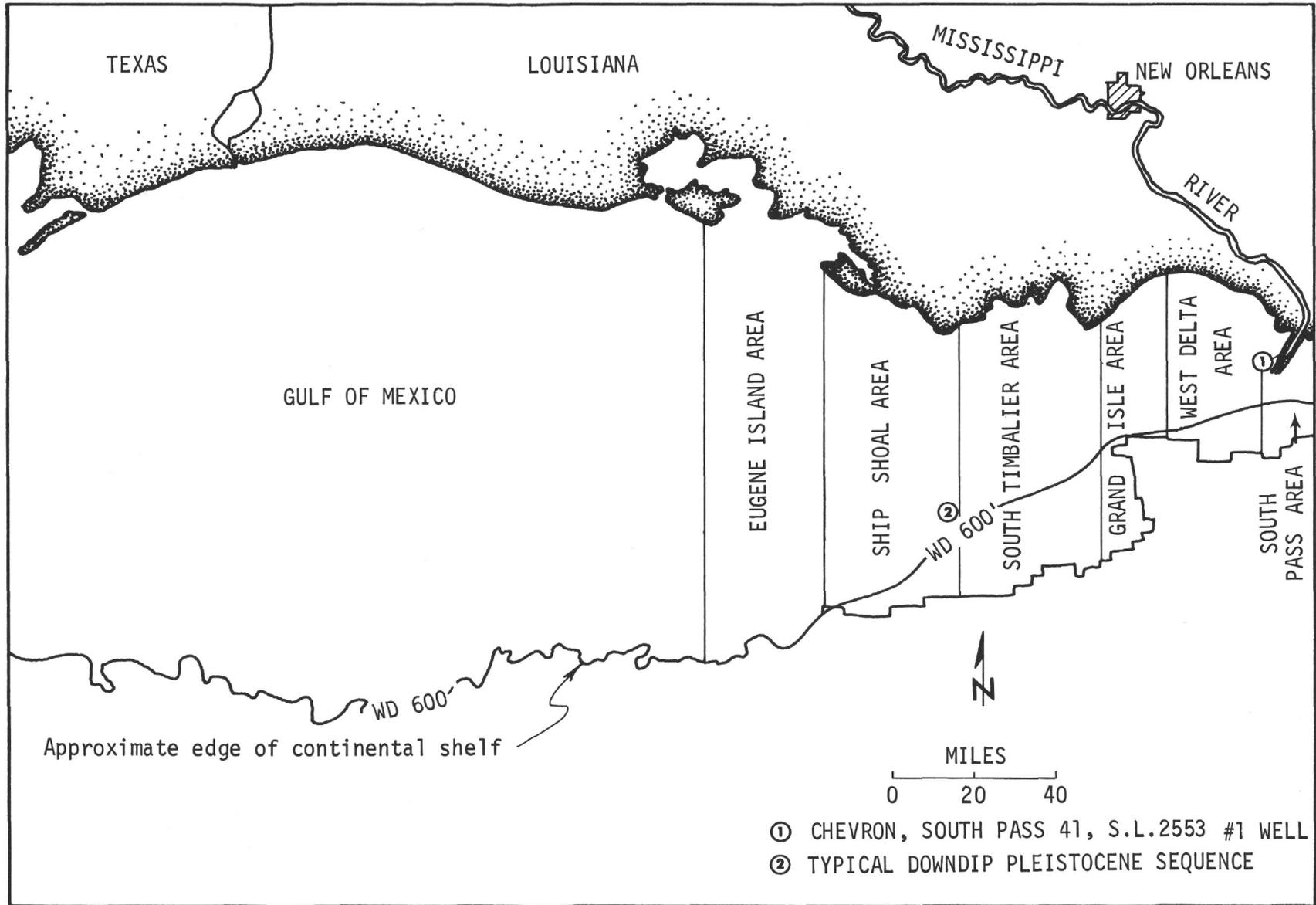


Figure 7. Location map of the Louisiana Offshore Area.

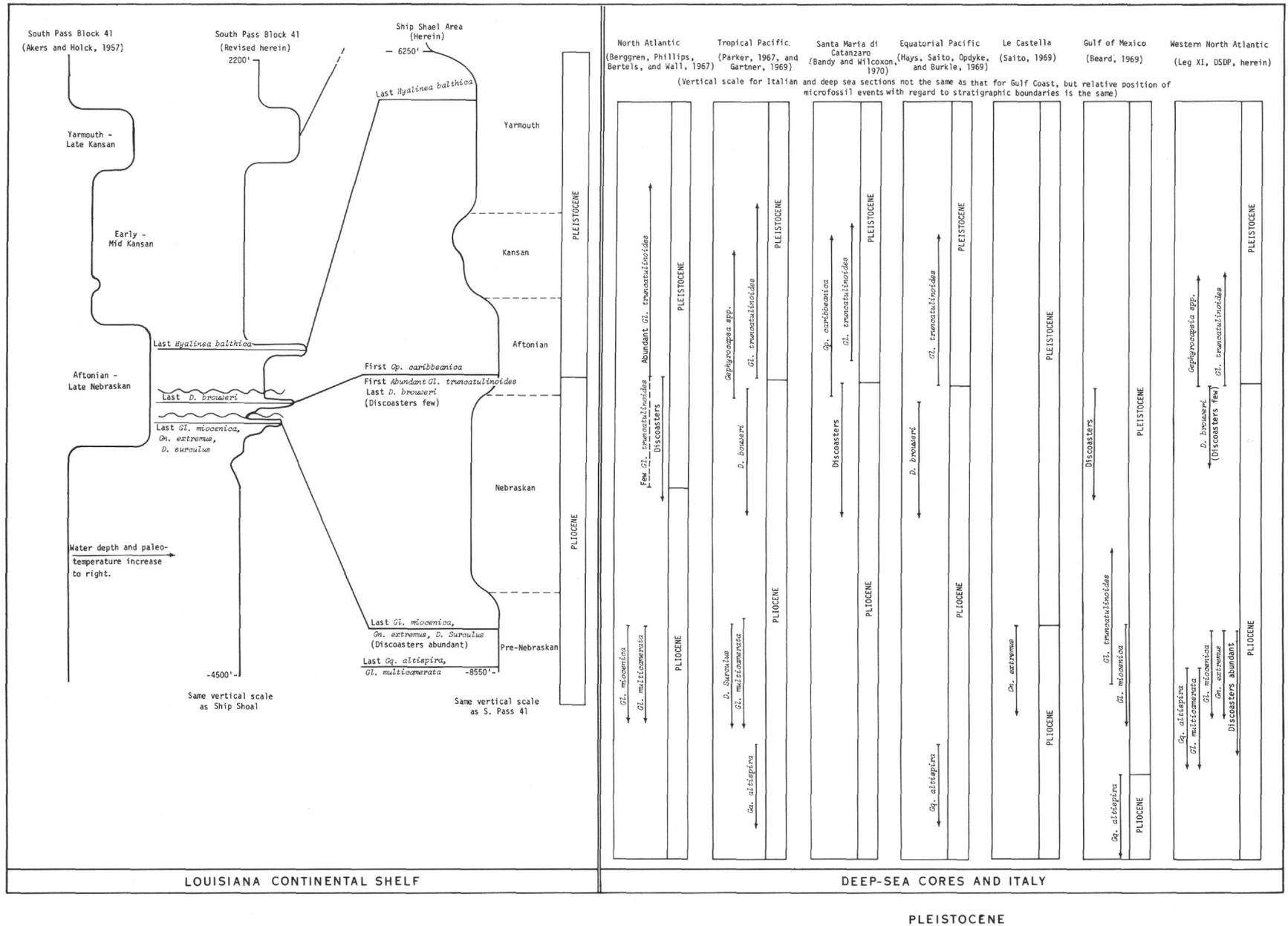


Figure 8. Correlation of Gulf Coast Pliocene-Pleistocene microfossil events with deep-sea cores and Italian type section.

results from this work have served as a focal point for later investigations of the Pliocene and Pleistocene of the Gulf of Mexico.

Since most of the foraminiferal analysis of the South Pass 41 well was completed 10 to 15 years ago, the writer has reexamined the cores and updated the foraminiferal biostratigraphy. This planktonic foraminiferal sequence can now be equated to that of Atlantic and Pacific deep sea cores.

It can be demonstrated (Poag, unpublished) that the single transgressive "Aftonian" stage of Akers and Holck (1957) (which has been subsequently adopted by Beard and Lamb, 1968; Beard, 1969; Lamb, 1969), encompasses in reality three major transgressive shales and two intervening sandy regressive units. The transgressive units contain the following sequence of microfossils from oldest (1) to youngest (3):

3. Final *Hyalinea balthica*
2. Final *Discoaster brouweri* (few discoasters)
1. Final *Globorotalia miocenica*, *Globigerinoides extremus*, and *Discoaster surculus* (abundant discoasters).

In basinward wells, which contain deeper marine sediments of this age, the first abundant occurrence of *Globorotalia truncatulinoides* coincides with the last *D. brouweri*. The last *Globoquadrina altispira* and *Globorotalia multicamerata* occur just below the final occurrence of *Globorotalia miocenica*, but in the same transgressive unit. A revision of the glacial interglacial sequence of Akers and Holck (1957) is shown in Figure 8.

In this scheme, *G. miocenica*, *G. extremus*, and *D. surculus* become extinct in the latest Pliocene (the extinction of *G. altispira* is slightly earlier). The first abundant *Globorotalia truncatulinoides* and the extinction of *Discoaster brouweri* occur together with the earliest *Gephyrocapsa caribbeanica* s. l. in the Aftonian transgression (see Sachs, 1970). *Hyalinea balthica* occurs for the last time in the Gulf of Mexico in the Yarmouth interglacial.

It should be pointed out that *Globoquadrina altispira* does not occur in the South Pass 41 well; Akers and Dorman (1964) show it there, but this is an unfortunate misplot of the data. The shallow water sediment immediately below *Globorotalia miocenica* precludes the occurrence of *G. altispira* until well below 4200 feet in this well. The transgression indicated at 4200 feet by Beard (1969) does not occur. For practical correlation purposes, *G. miocenica* and *G. altispira* mark a coincident horizon in the northeastern Gulf coast.

The occurrence of abundant *Globorotalia truncatulinoides* in the Aftonian agrees with the conclusion of

McIntyre, Be', and Priekstas (1967), that this horizon in Atlantic cores (Ericson, Ewing, and Wollin, 1963) occurred in a warmer water section than that immediately below. It also agrees with Beard and Lamb (1969) who contend that Ericson, Ewing, and Wollin's (1963) boundary is higher than the Gulf Coast Nebraskan. The problem of determining the precise first occurrence of *G. truncatulinoides* is as difficult here as in many deep-sea cores (see Poag and Akers, 1967; and Parker, 1967). However, the first abundant occurrence (more than 3 or 4 specimens per sample) consistently occurs with the final occurrence of *Discoaster brouweri* as described above. The Pliocene-Pleistocene boundary of Parker (1967) and Gartner (1969) appears to correlate also with the Gulf Coast Aftonian as here interpreted. The boundary of Berggren, Phillips, Bertels, and Wall (1967) appears to be slightly younger, within the Gulf Coast Nebraskan.

There is reason to believe that the disappearance of *Globoquadrina altispira* in Gulf Coast sediments occurred at a later date than the 3 million year horizon postulated for the Pacific. (The data supporting such an age for this horizon in the Pacific, moreover, are paleontologically rather tenuous, since the authors who initially suggested this date show that the extinction level for the subject species is reliably present in only one core; Hayes, Saito, Opdyke, and Burkle, 1969.)

Blow (1969) believes that *Globoquadrina altispira* occurs in sediments younger than N. 19 (especially, into N. 21) only in the Caribbean/Atlantic Province. He suggests that the occurrence of abundant *G. altispira* throughout Zone 19 is normal in the Pacific, but that sporadic younger occurrences may be allocthonous.

Parker's (1967) and Gartner's (1969) data from the CAP 38 BP core from the Pacific may be cited as evidence of an earlier disappearance of *G. altispira* than in the Gulf Coast. In this core, the last *Globorotalia multicamerata* occurs at 456 centimeters (although there is a 29-centimeter gap between this and the next higher sample examined). This is in close proximity to the final occurrence of *D. surculus* (here again, there is a 25+ centimeter gap between this sample and the next higher one). The final *Globoquadrina altispira*, however, occurs earlier at 491 centimeters. This point is well established, since samples were also examined at 485 centimeters and 483 centimeters which contained *G. multicamerata*, but not *G. altispira*. In the Gulf Coast, these two species disappear together as in the Leg 11 cores. This is not conclusive evidence, however, since the ranges of other of Parker's (1967) species, such as *Globigerinoides extremus* (last specimen at 483 centimeters), also differ from Gulf Coast and Atlantic occurrences.

Bolli (1970), on the basis of overlapping ranges of *Globoquadrina altispira* and *Turborotalia tosaensis* in

the Pacific, suggests (contrary to Blow, 1969) that *G. altispira* became extinct somewhat earlier in some parts of the Caribbean and Atlantic. The present writer agrees with Blow's opinion, and would urge caution in using the range of *T. tosaensis* for biostratigraphic definition. The morphologic features of this species are so similar to those of the *Turborotalia crassaformis* and primitive *Globorotalia truncatulinoides* groups, that its use as a practical biostratigraphic tool is considerably hindered. Kennett and Geitzenaur (1969), moreover, presented evidence in a Pacific core (Eltanin 21-5) that the variable morphology of the *G. truncatulinoides/tosaensis* plexus may be a phenotypic rather than genotypic response to environment.

*Globorotalia margaritae*, *Pulleniatina primalis* and *Globigerina nepenthes* have similar ranges in the Leg 11 and the Gulf of Mexico cores. *Globorotalia margaritae* and *P. primalis* disappear in the Middle Pliocene a little below *Sphenolithus abies* with the last *G. nepenthes* occurring below them in Zone N. 19.

*Globigerinoides mitra*, although often rare, disappears consistently in lowest Pliocene sediments in both areas. This occurs shortly after the last *Globorotalia plesiotumida* and *Globorotalia merotumida* disappear.

The evolution of the *Globorotalia fohsi* group is a well established Gulf Coast sequence as shown by Akers (1955).

The writer has observed rare specimens of *Globigerinoides primordius* in the outcropping Chickasawhay Formation of eastern Mississippi, where it is associated as in Hole 98 described above, with abundant *Globigerina ciproensis* and *Globigerina angulisuturalis*. It has not been observed in the subsurface of the Gulf Coastal Plain or Continental Shelf, but is present in cores from Leg 10 of the DSDP.

## XI. SYSTEMATIC PALEONTOLOGY

### Introduction

The following section contains a brief discussion of the species regarded as most significant for biostratigraphic interpretations within the Neogene sediments of the western North Atlantic Ocean. The accompanying synonymies are not complete, but are intended to clarify the author's concept of the cited species. The original designation, and subsequent major changes and comprehensive treatments are listed for each species.

The writer has not used the subspecific terminology that is often referred to by foraminiferal specialists. Parker (1967) discussed this problem, concluding that:

. . . it now seems preferable to reserve the subspecific category for "chrono-species" which can be delineated as our knowledge of geographic

variation increases. . . . The use of subspecies to mark variations in assemblages is unrealistic and a waste of an excellent method to convey information of stratigraphic or ecologic value. When one variable plexus changes into another which contains many of the same variations but also added different ones, it is more appropriate to recognize the change specifically as a whole, rather than add new subspecies to the list to show added variations.

This point of view is adhered to in the present work.

Hypotypes are deposited in the Texas A&M Department of Oceanography Micropaleontology Collection, College Station, Texas.

### Order FORAMINIFERIDA Eichwald, 1830

**Superfamily** GLOBIGERINACEA Carpenter, Parker, and Jones, 1862

**Family** GLOBIGERINIDAE Carpenter, Parker, and Jones, 1862

### Genus *Globigerina* d'Orbigny, 1826

#### *Globigerina angulisuturalis* Bolli (Plate 11, Figures 1 and 2)

*Globigerina ciproensis angulisuturalis* Bolli, 1957, U.S. Nat. Museum, Bull. 215, p. 109, pl. 22, Figs. 11a-c.

*Globigerina angulisuturalis* Bolli. Blow, 1969. Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 316, pl. 1, figs. 2-6; pl. 11, figs. 8, 9; pl. 12, figs. 1, 2.

Remarks: This species occurs in abundance in the lower portion of Core 5, Hole 98. It is typically developed, with roundly excavated sutures.

Hypotype: TAMDOM No. 6.

#### *Globigerina angustiumbilitata* Bolli (Plate 11, Figures 3 and 4)

*Globigerina ciproensis angustiumbilitata* Bolli, 1957, U. S. Nat. Museum, Bull. 215, p. 109, pl. 11, figs. 12a-c, 13a-c; p. 164, pl. 36, figs. 6a, b.

*Globigerina angustiumbilitata* Bolli. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 316.

Remarks: This species occurs in Core 5, Hole 98.

Hypotype: TAMDOM No. 7.

#### *Globigerina bulloides* d'Orbigny (Plate 1, Figures 7 and 8)

*Globigerina bulloides* d'Orbigny, 1826, Ann. Sci. Nat., Ser. 1, vol. 7, p. 277, no. 1; Modèles, no. 17, 76.

*Globigerina bulloides bulloides* d'Orbigny. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 316, pl. 14, figs. 1, 2.

Remarks: Typical specimens are present consistently in the upper portions of Hole 106. The short, rounded spines shown clearly in the SEM illustrations are diagnostic features of this species.

Hypotype: TAMDOM No. 8.

*Globigerina calida* Parker  
(Plate 1, Figures 9 and 10)

*Globigerina calida* Parker, 1962, Micropaleontology, vol. 8, no. 2, p. 221, pl. 1, figs. 9a-c, 10a-b, 11(not fig. 12).

*Globigerina calida calida* Parker. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 317, pl. 13, figs. 9, 10.

Remarks: This species is reported here for the first time from the Western North Atlantic Ocean. It is most abundant in Holocene deposits and is, therefore, a useful guide to sediments of this age.

Hypotype: TAMDOM No. 9.

*Globigerina ciproensis* Bolli  
(Plate 11, Figures 5 and 6)

*Globigerina ciproensis* Bolli, 1954, Contr. Cushman Found. Foram. Res., vol. 5, pt. 1, p. 1.

*Globigerina ciproensis ciproensis* Bolli. Bolli, 1957, U. S. Nat. Museum, Bull. 215, p. 109, p. 22, figs. 10a, b.

*Globigerina ouachitaensis ciproensis* Bolli. Blow and Banner, 1962, Cambridge Univ. Press, Part 2, p. 20, pl. X1e-g; figs. 9i-iii.

*Globigerina ouachitaensis ciproensis* forma *typica* Bolli. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 320, pl. 17, Fig. 7.

Remarks: This species occurs abundantly in Core 5, Hole 98.

Hypotype: TAMDOM No. 10.

*Globigerina gortanii* Borsetti  
(Plate 11, Figures 12 and 13)

*Globigerina gortanii* Borsetti, 1959, Giorn. Geol., Bologna, vol. 27.

*Globigerina turritilina turritilina* Blow and Banner, 1962, Cambridge Univ. Press, part 2, p. 98, pl. XIII d-g.

*Globigerina gortanii gortanii* Borsetti. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 320, pl. 17, fig. 1.

Remarks: This species occurs abundantly in Core 5, Hole 98.

Hypotype: TAMDOM No. 11.

*Globigerina multiloba* Romeo  
(Plate 7, Figures 6 and 7)

*Globigerina multiloba* Romeo, 1965, Riv. Ital. Paleo. Strat., vol. 71, no. 4, p. 1266, pl. 118, figs. 1a-c, 2a-b, 3a-c (not figs. 4a-b, 5a-b, 6a-b, 7a-b).

*Globigerina eggeri multiloba* Romeo. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 318, pl. 3, figs. 15-17.

Remarks: The restricted umbilicus and tightly coiled test appear to be reliable for distinguishing this small species from *T. humerosa*.

Hypotype: TAMDOM No. 12.

*Globigerina nepenthes* Todd  
(Plate 6, Figures 5-8)

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

*Globigerina nepenthes* Todd, Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 320, pl. 14, fig. 5.

Remarks: Two distinct morphotypes of this species are represented: 1) A high spired form with coarsely spinose test and conical peripheral outline; 2) a low spired form with more densely encrusted test and rounded peripheral outline. A separate stratigraphic distribution for these two forms is not obvious in the Leg 11 cores.

Hypotype: TAMDOM No. 13.

*Globigerina pachyderma* (Ehrenberg)  
(Plate 2, Figures 13 and 14)

*Aristerospira pachyderma* Ehrenberg, 1961, K. Preuss. Akad. Wiss. Berlin, Monatsber. p. 276, 277, 303.

*Globigerina incompta* Cifelli, 1961, Cushman Found. Foram. Res., Contr. vol. 12, p. 84, pl. 4, figs. 1-7.

*Globigerina borealis* Brady. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 316.

Remarks: Small, subquadrate, heavily calcified specimens appear to be referable to *G. pachyderma*. It is herein recorded from sediments as old as Zone N. 21 (late Pliocene), but is more common in the Pleistocene. All specimens observed are of the dextrally coiled type.

Hypotype: TAMDOM No. 14.

*Globigerina rubescens* Hofker  
(Plate 1, Figure 6)

*Globigerina rubescens* Hofker, 1956, Copenhagen, Univ., Zool. Mus., Spolia, vol. 15, p. 234, pl. 35, figs. 18-21.

*Globigerina rubescens* Hofker. Parker, 1962, Micropaleontology, vol. 8, no. 2, p. 226, pl. 2, figs. 17-18.

Remarks: This small species is quite abundant in the fine fraction of the Holocene samples. Its pink form in abundance is a good guide to Holocene sediments. White specimens replace the pink forms in the Holocene in Hole 106 apparently as a result of the lower temperature at this higher latitude location. Its coarse texture and well defined lip surrounding the semicircular aperture are distinctive. This is the first documented record of this species in the sediments of the Western Atlantic.

Hypotype: TAMDOM No. 15.

*Globigerina sellii* Borsetti  
(Plate 11, Figures 7-11)

*Globigerina sellii* Borsetti, 1959, Giorn. Geol., Bologna, Vol. 27.

*Globigerina Clarae* Bermúdez, 1961, Congr. Geol. Venez., vol. III, Bd. Geol., p. 1, 166, pl. 2, figs. 4a-d.

*Globigerina oligocaenica* Blow and Banner, 1962, Cambridge Univ. Press, p. 88, pl. X, figs. G, L-N.

*Globigerina sellii* Borsetti. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 322, pl. 19, figs. 4-6.

Remarks: The coarsely spinose texture is strongly developed in specimens from Core 5, Hole 98. This species was originally thought to be restricted to the Oligocene, but Blow (1969) reports it in earliest Miocene (Zone N.4). Saito reports it from equatorial sites in the Atlantic (DSDP, Leg 3). The writer has seen it in samples from the Gulf of Mexico (DSDP, Leg 10).

Hypotype: TAMDOM No. 16.

*Globigerina tripartita* Koch  
(Plate 10, Figures 11 and 12)

*Globigerina bulloides* var. *tripartita* Koch, 1926. Eclog. Geol. Helv., vol. 19, no. 3, p. 746, text figs. 21a-b.

*Globigerina rohri* Bolli, 1957, U.S. Nat. Museum, Bull. 215, p. 109, pl. 23, figs. 1a-4b.

*Globigerina tripartita tripartita* Koch. Blow and Banner, 1962, Cambridge Univ. Press, p. 96, pl. Xa-f; fig. 18.

*Globigerina tripartita* Koch. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 322, pl. 16, fig. 6.

Remarks: This species is abundant in Core 5, Hole 98.

Hypotype: TAMDOM No. 17.

Genus *Globigerinoides* Cushman, 1927

*Globigerinoides altiapertura* Bolli  
(Plate 10, Figure 2)

*Globigerinoides triloba altiapertura* Bolli, 1957, U.S. Nat. Museum, Bull. 215, p. 113, pl. 25, figs. 7a-8.

*Globigerinoides quadrilobatus altiapertura* Bolli. Blow, 1969, First Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 325.

Remarks: Specimens of this species occur in the top samples of Core 5, Hole 98, below a drilled interval. The age of the sediments in which it occurs is lower Zone N. 4, which is slightly older than its previously reported earliest occurrence. *G. altiapertura* is derived from *Globigerinoides primordius* within Zone N. 4, but in the section presumably slightly younger than the present samples, *G. altiapertura* is considered to be contamination from the overlying drilled interval.

Hypotype: TAMDOM No. 18.

*Globigerinoides extremus* Bolli and Bermúdez  
(Plate 3, Figure 13)

*Globigerinoides obliquus extremus* Bolli and Bermúdez, 1965, Bol. Inf., Assoc. Venez. de Geol., Min. y Pet., vol. 8, no. 5, p. 159, pl. 1, figs. 10-12.

*Globigerinoides obliquus extremus* Bolli and Bermúdez. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 324, pl. 21, figs. 2, 3.

Remarks: This species disappears approximately coincident with *Globorotalia miocenica* in the latest Pliocene as herein interpreted.

Hypotype: TAMDOM No. 19.

*Globigerinoides mitra* Todd  
(Plate 7, Figures 1 and 2)

*Globigerinoides mitra* Todd, 1956, U.S. Geol. Survey, Profess. Paper 280-H, p. 302, pl. 78, figs. 3, 6.

*Globigerinoides mitra* Todd. Bolli, 1957, U.S. Nat. Museum, Bull. 215, p. 114, pl. 26, figs. 1a-4.

*Globigerinoides mitra* Todd. Poag and Akers, 1967, p. 171, pl. 16, figs. 19-21.

Remarks: This large high-spined species becomes extinct in the earliest Pliocene (Zone N. 18). It appears

to be restricted to tropical and subtropical regions where it has been reported in the Caribbean, Gulf of Mexico, and Pacific regions. This is its first record in North Atlantic sediments, as well as its first record from the deep sea. It occurs in Holes 98 and 103.

Hypotype: TAMDOM No. 20

*Globigerinoides primordius* Blow and Banner  
(Plate 10, Figures 1 and 2)

*Globigerinoides quadrilobatus primordius* Blow and Banner, 1962, Cambridge Univ. Press, p. 115, pl. IX, figs. Dd-Ef.

*Globigerinoides quadrilobatus primordius* Blow and Banner. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, pl. 20, figs. 1, 5, 6.

Remarks: This species is abundant in Core 5 of Hole 98, and here marks the earliest Miocene (Zone N. 4). Rare specimens occur below this abundant occurrence in what are interpreted to be latest Oligocene (Zone N. 3) sediments. The writer cannot rule out the possibility that this lower rare occurrence is contamination, but the specimens appear to be in normal position. Apertures are more highly arched than Blow's (1969) illustrations. They are more nearly like those figures by Blow and Banner (1962) and Bolli (1970).

Hypotype: TAMDOM No. 21.

*Globigerinoides ruber* (d'Orbigny)  
(Plate 1, Figure 5)

*Globigerina rubra* d'Orbigny, 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). Parker, 1962, Micropaleontology, vol. 8, no. 2, p. 230, pl. 3, figs. 11-14; pl. 4, figs. 1-10.

Remarks: The pink form of this species (forma *rosea*) occurs in abundance in the Holocene sediments except in Hole 106. At the latter location, it is replaced by the white form (f. *alba*) presumably as a result of ecological differences (lower temperature) at this high latitude locality.

Hypotype: TAMDOM No. 22.

Genus *Globorotalia* Cushman, 1927

*Globorotalia cibaoensis* Bermúdez  
(Plate 5, Figures 7 and 8)

*Globorotalia cibaoensis* Bermúdez, 1949, Cushman Lab. Foram. Res., Spec. Pub. No. 25, pl. 285, pl. 22, figs. 21-23.

*Globorotalia miozea cibaoensis* Bermúdez. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., Vol. 1, p. 366, pl. 8, figs. 4-9, pl. 45, fig. 8.

Remarks: This species is a predominant element in the early Pliocene and late Miocene sediments in the southerly sites. Its more abundant occurrence in low latitudes is in accord with similar observations recorded by Blow (1969).

Hypotype: TAMDOM No. 23.

*Globorotalia conomiozea* Kennett  
(Plate 3, Figures 1 and 2)

*Globorotalia conomiozea* Kennett, 1966, Micropaleontology, vol. 12, no. 2, p. 235, text-fig. 10a-c.

*Globorotalia crassula conomiozea* Kennett. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 360, pl. 41, figs 5-8.

Remarks: This species occurs in abundance in the late Pliocene and early Pleistocene (Zones N. 22-21) of Hole 102.

Hypotype: TAMDOM No. 24.

*Globorotalia crassula* Cushman and Stewart  
(Plate 3, Figures 11 and 12)

*Globorotalia crassula* Cushman and Stewart, 1930, San Diego Nat. Hist. Trans., vol. 6, p. 77, pl. 7, fig. 1b (not figs. 1a, 1c).

*Globorotalia crassula crassula* Cushman and Stewart. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 361, pl. 9, figs. 1-3.

Remarks: This species occurs in abundance in the late Pliocene (Zone N. 21) of Hole 102.

Hypotype: TAMDOM No. 25.

*Globorotalia cultrata* (d'Orbigny)  
(Plate 1, Figures 3 and 4)

*Rotalia menardii* d'Orbigny, 1826, Ann. Sci. Nat., ser. 1, vol. 7, p. 273, no. 26.

*Rotalina cultrata* d'Orbigny, 1839, Hist. Phys. Pol. Nat. Cuba, "Foraminifères", p. 76, pl. 5, figs. 7-9.

*Rotalina cultrata* d'Orbigny. Banner and Blow, 1960, Cushman Found. Foram. Res., Contr., vol. 11, p. 34, pl. 6, fig. 1a-c (lectotype).

*Globorotalia cultrata* (d'Orbigny). Bermúdez, 1961, Congr. Geol. Venez., Vol. III, Bol. Geol., p. 1, 286, pl. 15, figs. 2a-c.

*Globorotalia cultrata* (d'Orbigny). Parker, 1962, Micro-paleontology, vol. 8, no. 2, p. 235, pl. 5, figs. 3-5.

*Globorotalia cultrata cultrata* (d'Orbigny). Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 358, pl. 6, figs. 4-8.

Remarks: Typical sinistral specimens of this species are abundant to common in the Holocene sediments and in some Pleistocene intervals. It is not present below the Pleistocene.

Hypotype: TAMDOM No. 26.

*Globorotalia exillis?* Blow  
(Plate 3, Figures 7 and 8)

*Globorotalia cultrata exilis?* Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 396, pl. 7, figs. 1-3; pl. 42, figs. 1, 5.

*Globorotalia exilis A?* Bolli, 1970, Initial Rept. DSDP, vol. 4, p. 581, pl. 7, figs. 14-16.

Remarks: The specimens tentatively ascribed here to *G. exilis* appear to be somewhat more robust and have more nearly circular outlines (only moderately lobate) than Blow's (1969) figured specimens. They are closer to Bolli's *G. exilis A*, and are predominantly dextral as Bolli (1970) reports. The range of this species in Hole 102 is coincident with *Globorotalia miocenica* (Zones N. 22 and N. 21), thus supporting Bolli's (1970) concept of the *Globorotalia exilis/Globorotalia miocenica* Zone defined on the basis of the range of the nominate species above the last *Globorotalia margaritae*.

Hypotype: TAMDOM No. 27.

*Globorotalia fohsi* forma *lobata* Bermúdez  
(Plate 9, Figures 1 and 2)

*Globorotalia lobata* Bermúdez, 1949, Cushman Lab. Foram. Res., Spec. Publ. no. 25, p. 286, pl. 22, figs. 15-17.

*Globorotalis fohsi lobata* Bermúdez. Bolli, 1950, Cushman. Found. Foram. Res., Contr., vol. 1, p. 88, pl. 15, figs. 7, 8.

*Globorotalia fohsi* forma *lobata* Bermúdez. Blow and Banner, 1966, Micropaleontology, vol. 12, no. 3, text-fig. 4, figs. 1-3.

*Globorotalia fohsi* forma *lobata* Bermúdez. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 362.

Remarks: Typical specimens are present in the middle Miocene of Hole 104.

Hypotype: TAMDOM No. 28

*Globorotalia fohsi* forma *robusta* Bolli  
(Plate 9, Figures 3 and 4)

*Globorotalia fohsi* var. *robusta* Bolli, 1950, Cushman Found. Foram. Res., Contr., vol. 1, p. 89, pl. 15, fig. 3.

*Globorotalia fohsi robusta* Bolli. Bolli, 1957, U.S. Nat. Museum, Bull., 215, p. 119, pl. 28, fig. 16.

*Globorotalia fohsi* forma *robusta* Bolli. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., Vol. 1, p. 363.

Remarks: Typical specimens occur in the middle Miocene of Hole 104.

Hypotype: TAMDOM No. 29.

*Globorotalia limbata* (Fornasini)  
(Plate 6, Figures 1 and 2)

*Rotalia limbata* Fornasini, 1902, R. Accad. Sci. Ist. Bologna, Mem. Sci. Nat. Bologna, Ser. 5, vol. 10, p. 56, fig. 55.

*Globorotalia (Globorotalia) cultrata limbata* (Fornasini). Banner and Blow, 1960, Cushman Found. Foram. Res., Contr., vol. 11, pt. 1, pl. 5, figs. 3a-c, (lectotype).

*Globorotalia (Globorotalia) cultrata limbata* (Fornasini). Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 359, pl. 7, fig. 4-6; pl. 42, figs. 2, 3.

Remarks: Specimens ascribed to this species are closely similar to the pencil illustrations of Blow (1969, pl. 7, figs. 4-6). They are more heavily keeled, however, than Blow's stereoscan illustration (1969, pl. 42, figs. 2, 3).

Hypotype; TAMDOM No. 30.

*Globorotalia margaritae* Bolli and Bermúdez  
(Plate 5, Figures 5 and 6)

*Globorotalia margaritae* Bolli and Bermúdez, 1965, Assoc. Venez. Geol. Min. Petr. Bol. Inf., vol. 8, no. 5, pl. 139, pl. 1, figs. 16-18.

*Globorotalia margaritae* Bolli and Bermúdez. Blow 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 363, pl. 45, figs. 1-3, 5-6; pl. 44, figs. 1-6.

Remarks: This species is typical of Zones N. 19-17 and occurs with these intervals in abundance. It is one of the most diagnostic species for distinguishing sediments of Zone N. 19 age from those of Zone N. 20.

Hypotype: TAMDOM No. 31.

*Globorotalia merotumida* Blow and Banner  
(Plate 6, Figures 11 and 12)

*Globorotalia merotumida* Blow and Banner, 1965, Nature, vol. 207, no. 5004, p. 1352, figs. 1a-c.

*Globorotalia merotumida* Blow and Banner. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 364, pl. 9, figs. 4-6.

Remarks: This small species, along with *Globorotalia plesiotumida* is present in abundance in the upper Miocene sediments of Zones N. 18 and No. 17.

Hypotype: TAMDOM No. 32.

*Globorotalia miocenica* Palmer  
(Plate 3, Figures 3 and 4)

*Globorotalia menardii* var. *miocenica* Palmer, 1945, Bull. Am. Paleontology, vol. 29, no. 115, p. 70, pl. 1, fig. 11.

*Globorotalia miocenica* Palmer. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 365, pl. 42, figs. 4-8.

Remarks: This species occurs in abundance in the middle of Zone N. 21. It has been used to mark the upper limit of the Pliocene by some authors (Poag and Akers, 1967; see discussion under "Major Stratigraphic Boundaries").

Hypotype: TAMDOM No. 33.

*Globorotalia miozea* Finlay  
(Plate 7, Figures 8 and 9)

*Globorotalia miozea* Finlay, 1939, Roy. Soc. New Zealand, Trans. Proc., vol. 69, pt. 3, p. 326, pl. 29, fig. 159-161.

*Globorotalia miozea* Finlay. Hornibrook, 1958, Micro-paleontology, vol. 4, no. 1, p. 33, pl. 1, figs. 6-10.

*Globorotalia miozea miozea* Finlay. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 366, pl. 45, fig. 7.

Remarks: Specimens that appear to belong to this species are heavily calcified in the early chambers giving the early keel a thick, broadly rounded appearance.

Hypotype: TAMDOM No. 34.

*Globorotalia multicamerata* Cushman and Jarvis  
(Plate 4, Figures 3 and 4)

*Globorotalia menardii* var. *multicamerata* Cushman and Jarvis, 1930, J. Paleontology, vol. 4, p. 367, pl. 34, fig. 8.

*Globorotalia menardii* var. *fijiensis* Cushman, 1934, Bernice P. Bishop Museum, Bull. 119, p. 136, pl. 17, fig. 5.

*Globorotalia multicamerata* Cushman and Jarvis. Phleger, Parker, and Peirson, 1953, Rept. Swedish Deep-Sea Exped., vol. 7, pt. 1, p. 20, pl. 3, figs. 9, 12.

*Globorotalia multicamerata* Cushman and Jarvis. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 367, pl. 7, figs. 7-9; pl. 42, fig. 7.

Remarks: Typical specimens of this species were encountered in the late Pliocene. Its final appearance corresponds with that of *Globoquadrina altispira*. It appears to occur in younger sediments here and in the Gulf of Mexico than it does in the Pacific. (See discussion under "Major Stratigraphic Boundaries.")

Hypotype: TAMDOM No. 35.

*Globorotalia pertenuis* Beard  
(Plate 4, Figures 1 and 2)

*Globorotalia pertenuis* Beard, 1969, Gulf Coast Assoc. Geol. Soc., Trans., vol. 9, p. 552, pl. 1, figs. 1-6; pl. 2, figs. 5, 6; pl. 3, fig. 4.

Remarks: This distinct species is a member of the dextral *Globorotalia* complex that characterizes the later Pliocene.

Hypotype: TAMDOM No. 36.

*Globorotalia plesiotumida* Blow and Banner  
(Plate 6 Figures 9 and 10)

*Globorotalia tumida plesiotumida* Blow and Banner, 1965, Nature, vol. 207, no. 5004, p. 1353, figs. 2a-c.

*Globorotalia tumida plesiotumida* Blow and Banner. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 371, pl. 47, figs. 6-8.

Remarks: This small species, in conjunction with *Globorotalia merotumida* marks the late Miocene (Zones N. 18-17). When these two species are abundant, larger species of *Globorotalia* are generally absent or rare in the sediments. The elongation of the final chamber was used here to distinguish *G. plesiotumida* from *G. merotumida*.

Hypotype: TAMDOM No. 37.

*Globorotalia praefohsi* Blow and Banner  
(Plate 9, Figures 7 and 8)

*Globorotalia praefohsi* Blow and Banner, 1966, Micro-paleontology, vol. 12, no. 3, p. 195, pl. 1, figs. 3-4; pl. 1, figs. 6-7, 10-11.

Hypotype: TAMDOM No. 38.

*Globorotalia praemenardii* Cushman and Stainforth  
(Plate 9, Figures 5 and 6)

*Globorotalia praemenardii* Cushman and Stainforth, 1945, Cushman Lab. Foram. Res., Spec. Publ., no. 14, p. 70, pl. 13, fig. 14.

*Globorotalia praemenardii* Cushman and Stainforth. Bolli, 1957, U.S. Nat. Museum, Bull. 215, p. 120, pl. 20, fig. 4.

*Globorotalia praemenardii praemenardii* Cushman and Stainforth. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 369, pl. 6, figs. 1-3.

Remarks: Specimens referable to this species occur in Hole 104 in middle Miocene sediments (Zone N. 12).

Hypotype: TAMDOM No. 39.

*Globorotalia truncatulinoides* (d'Orbigny)  
(Plate 2, Figures 1 and 2)

*Rotalina truncatulinoides* d'Orbigny, 1839, Hist. Nat. Iles Canaries, vol. 2, pt. 2, pl. 2, ?figs. 25-27.

*Pulvinulina micheliana* (d'Orbigny). Brady, 1884, Rept. Voyage H.M.S. Challenger, Zool., vol. 9, pl. 104, figs. 1a-c, 2a-b.

*Globorotalia truncatulinoides* Cushman, 1931, U.S. Nat. Museum Bull. 104, pt. 8, p. 97, pl. 17, fig. 4.

*Globorotalia truncatulinoides truncatulinoides* (d'Orbigny). Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 403, pl. 5, figs. 10-12, pl. 49, fig. 6.

Remarks: This species is abundant throughout the Holocene and Pleistocene. Its earliest *in-situ* occurrence is used to mark the Pliocene-Pleistocene boundary, in accordance with its appearance near the base of the Calabrian at Santa Maria di Catanzaro, Italy. This appears to correspond with the Aftonian interglacial stage as currently used in the American Gulf Coast (see discussion under "Major Stratigraphic Boundaries").

Hypotype: TAMDOM No. 40.

Genus *Turborotalia* Cushman and Bermúdez, 1949

*Turborotalia acostaensis* (Blow)  
(Plate 6, Figures 13 and 14)

*Globorotalia acostaensis* Blow, 1959, Bull. Am. Paleontology, vol. 39, no. 178, p. 208, pl. 17, figs. 106a-c, 107.

*Globorotalia (Turborotalia) acostaensis acostaensis* Blow. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 344, pl. 9, figs. 13-15, pl. 33, figs. 1, 2.

Remarks: In the Leg 11 cores, this species occurs in Pliocene and Miocene sediments, but is more typical of (more abundant in) the late Miocene.

Hypotype: TAMDOM No. 41.

*Turborotalia clemenciae* Bermúdez  
(Plate 8, Figures 10 and 11)

*Turborotalia clemenciae* Bermúdez, 1961, Congr. Geol. Venez., vol. III, Bol. Geol., p. 1, 321, pl. 17, figs. 10a-b.

*Globorotalia minutissima* Bolli. Blow, 1969, (not Bolli, 1957) Bull. Am. Paleontology, vol. 39, no. 178, p. 218, pl. 19, figs. 123a-c.

*Globorotalia (Turborotalia) clemenciae* Bermúdez. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 347, pl. 35, fig. 8.

Remarks: Specimens of this minute species are present in the late Miocene of Holes 98, 102, and 103.

Hypotype: TAMDOM No. 42.

*Turborotalia continuosa* (Blow)  
(Plate 8, Figures 8 and 9)

*Globorotalia opima continuosa* Blow, 1959, Bull. Am. Paleontology, vol. 39, no. 178, p. 218, pl. 18, figs. 125a-c.

*Globorotalia (Turborotalia) continuosa* Blow. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 347, pl. 3, figs. 4-6.

Remarks: Specimens referable to this species appear to be reliable indicators of Zone N. 16.

Hypotype: TAMDOM No. 43.

*Turborotalia crassaformis* (Galloway and Wissler)  
(Plate 3, Figures 9 and 10)

*Pulvinulina crassa* (d'Orbigny). Brady, 1884 (not *Rotalina crassa* d'Orbigny). Rept. Voy. Challenger, Zool., vol. 9, p. 694, pl. 103, figs. 12a-c.

*Globigerina crassaformis* Galloway and Wissler, 1927, J. Paleontology, vol. 1, p. 41, pl. 7, fig. 12.

*Globorotalia punctulata* (Fornasini). Phleger, Parker, and Peirson, 1953, Swedish Deep-Sea Exped. vol. 7, pt. 1, p. 20, pl. 4, figs. 8-12.

*Globorotalia (Turborotalia) crassaformis crassaformis* (Galloway and Wissler). Blow, 1969, Intern. Conf.

Plank. Microfoss., Proc., vol. 1, p. 347, pl. 4, figs. 1-3; pl. 37, figs. 1-4.

Hypotype: TAMDOM No. 44.

*Turborotalia humerosa* (Takayanagi and Saito)  
(Plate 2, Figures 9 and 10)

*Globorotalia humerosa* Takayanagi and Saito, 1962, Toboku Univ. Sci. Repts., ser. 2, (Geol.) Spec. vol. no. 5, p. 78, pl. 28, figs. 1-2.

*Globoquadrina humerosa* (Takayanagi and Saito). Parker, 1967, Bull. Am. Paleontology, vol. 52, no. 235, p. 169, pl. 24, figs. 10, 11; pl. 25, figs. 1-6.

*Globorotalia (Turborotalia) acostaensis humerosa* Takayanagi and Saito. Blow, 1969, Intern. Conf. Plank. Microfoss. Proc., vol. 1, p. 345, pl. 33, figs. 4, 5, 7-9; pl. 34, figs. 1-3.

Hypotype: TAMDOM No. 45.

*Turborotalia inflata* (d'Orbigny)  
(Plate 2, Figures 3 and 4)

*Globigerina inflata* d'Orbigny, 1839, Hist. Nat. Isles Canaries, "Foraminifères", vol. 1, pt. 2, Zool., p. 134, pl. 2, figs. 7-9.

*Globorotalia inflata* (d'Orbigny). Parker, 1962, Micropaleontology, vol. 8, no. 2, p. 236, pl. 5, figs. 6-9.

*Globorotalia (Turborotalia) inflata* (d'Orbigny). Banner and Blow, 1967, Micropaleontology, vol. 13, no. 2, p. 145, pl. 4, figs. 1a-c.

*Globorotalia (Turborotalia) inflata* (d'Orbigny). Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 350, pl. 10, figs. 10-12.

Remarks: An increase in the abundance of this cool-water species usually occurs a few centimeters below the surface sediments in the more southerly holes. This is interpreted to reflect cooler water temperature during the late Pleistocene.

Hypotype: TAMDOM No. 46.

*Turborotalia kugleri* (Bolli)  
(Plate 9, Figures 15 and 16)

*Globorotalia kugleri* Bolli, 1957, U.S. Nat. Museum, Bull., 215, p. 118, pl. 28, figs. 5a-6.

*Globorotalia (Turborotalia) kugleri* Bolli. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 350, pl. 10, figs. 1-3; pl. 38, figs. 1-4.

Remarks: This species is abundant in the upper portion of Core 5, Hole 98, where it is used as an indication of

earliest Miocene time (Zone N. 4). The flattening of the umbilical face of the last chambers as seen in peripheral view serves to separate it from the more rounded *T. pseudokugleri*.

Hypotype: TAMDOM No. 47.

*Turborotalia mayeri* (Cushman and Ellisor)  
(Plate 9, Figures 19 and 20)

*Globorotalia mayeri* Cushman and Ellisor, 1939, Cushman Lab. Foram. Res., Contr. vol. 15, pt. 1, p. 11, pl. 2, figs. 4a-c (not *G. mayeri* Bolli, 1957).

*Globorotalia (Turborotalia) mayeri* Cushman and Ellisor, Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 351, pl. 3, figs. 7-9.

Hypotype: TAMDOM No. 48.

*Turborotalia mendacis* (Blow)  
(Plate 9, Figures 17 and 18)

*Globorotalia (Turborotalia) mendacis* Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 390, pl. 38, figs. 5-9.

Remarks: This small species is present in the latest Oligocene of Hole 98, where it is accompanied by its close homeomorphs, *T. kugleri* and *T. pseudokugleri*.

Hypotype: TAMDOM No. 49.

*Turborotalia oceanica* (Cushman and Bermúdez)  
(Plate 3, Figures 5 and 6)

*Globorotalia oceanica* Cushman and Bermúdez, 1949, Cushman Lab. Foram. Res., Contr., vol. 25, p. 43, pl. 8, figs. 13-15.

*Globorotalia (Turborotalia) crassaformis oceanica* Cushman and Bermúdez. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 348, pl. 4, figs. 7-9, pl. 37, fig. 5.

Hypotype: TAMDOM No. 50.

?*Turborotalia Opima* (Bolli)  
(Plate 11, Figure 14)

?*Globorotalia opima opima* Bolli, 1957, U.S. Nat. Museum, Bull. 215, p. 117, pl. 28, figs. 1a-2.

?*Globorotalia (Turborotalia) opima opima* Bolli. Blow 1969, First Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 353, pl. 39, figs. 2, 3.

Remarks: The specimens recorded here are not typical, and are only tentatively assigned to this species in its broad sense. Blow (1969) expresses doubt that the two forms, *opima opima* and *opima nana* are stratigraphically separated at their youngest occurrence.

Hypotype: TAMDOM No. 51.

*Turborotalia peripheroacuta* (Blow and Banner)  
(Plate 9, Figures 9 and 10)

*Globorotalia (Turborotalia) peripheroacuta* Blow and Banner, 1966, Micropaleontology, vol. 12, no. 3, p. 294, pl. 1, figs. 2a-c, pl. 2, figs. 4-5, 13.

Remarks: This species was observed only in Hole 104 (Zone N. 11).

Hypotype: TAMDOM No. 52.

*Turborotalia peripheroronda* (Blow and Banner)  
(Plate 9, Figures 11 and 12)

*Globorotalia (Turborotalia) peripheroronda* Blow and Banner, 1966, Micropaleontology, vol. 12, no. 3, p. 294, pl. 1, figs. 1a-c; pl. 2, figs. 1-3.

Remarks: Typical specimens of this species occur in Hole 104, Core 7.

Hypotype: TAMDOM No. 53.

*Turborotalia pseudokugleri* (Blow)  
(Plate 9, Figures 13 and 14)

*Globorotalia* cf. *kugleri* Bolli, 1957, U.S. Nat. Museum Bull. 215, pl. 28, figs. 7a-c (not *G. kugleri* Bolli, 1957, p. 118, pl. 28, figs. 5a-6).

*Globorotalia (Turborotalia) pseudokugleri* Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 391, pl. 10, figs. 4-6; pl. 39, figs. 5-6.

Remarks: This species occurs with *T. Kugleri* in the early Miocene (Zone N. 4) in Hole 98. It occurs more persistently through Zone N. 3, however, than does *T. kugleri*. Its more rounded outline in peripheral view separates it from *T. kugleri*.

Hypotype: TAMDOM No. 54.

*Turborotalia siakensis* (LeRoy)  
(Plate 8, Figures 12 and 13)

*Globorotalia siakensis* LeRoy, 1939, Natuurk. Tijdschr. Nederl. Indië, vol. 99, no. 6, p. 239, pl. 3, figs. 30, 31.

*Globorotalia mayeri* Cushman and Ellisor. Bolli, 1957 (not Cushman and Ellisor, 1939) U.S. Nat. Museum, Bull. 215, p. 118, pl. 28, figs. 4a-c.

*Globorotalia mayeri* Cushman and Ellisor. Blow, 1959, (not Cushman and Ellisor, 1939), Bull. Am. Paleontology, vol. 39, no. 178, p. 214, pl. 18, figs. 116a-c.

*Globorotalia (Turborotalia) siakensis* LeRoy, Blow, 1969, Intern. Conf. Plank. Microfoss. Proc., vol. 1, p. 356, pl. 10, figs. 7-9; pl. 3, 4, figs. 4, 5.

Hypotype: TAMDOM No. 55.

*Turborotalia tosaensis* (Takayanagi and Saito)  
(Plate 2, Figures 11 and 12)

*Globorotalia tosaensis* Takayanagi and Saito, 1961, Sci. Repts. Tohoku Univ., ser. 2 (Geol) Spec. vol. no. 5, p. 81, pl. 28, figs. 11, 12.

*Globorotalia (Turborotalia) tosaensis tosaensis* Takayanagi and Saito. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 357, pl. 4, figs. 10-12; pl. 40, figs. 4-7.

Remarks: Forms with a rounded periphery and no keel appear to be referable to this species. Its sparsity and scattered occurrence limit the practical use of this species as a biostratigraphic tool in the Leg 11 cores.

Hypotype: TAMDOM No. 56.

Genus *Globoquadrina* Finlay, 1947

*Globoquadrina advena* Bermúdez  
(Plate 8, Figures 3 and 4)

*Globoquadrina quadraria* var. *advena* Bermúdez, 1949, Cushman Lab. Foram. Res., Spec. Publ. no. 25, p. 287, pl. 22, figs. 36-38.

*Globoquadrina dehiscens* (Chapman, Parr, and Collins). Bolli, 1957, U.S. Nat. Museum, Bull. 215, p. 111, pl. 24, figs. 4a-c (not figs. 3a-c).

*Globoquadrina dehiscens advena* Bermúdez. Blow, 1959, Bull. Am. Paleontology, vol. 39, no. 178, p. 182, pl. 8, figs. 50a-b.

*Globoquadrina dehiscens advena* Bermúdez. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 341, pl. 29, fig. 2.

Remarks: The distinction between this species and *Globoquadrina dehiscens* is not completely clear in the Leg 11 cores. Those specimens ascribed to *G. advena*, however, have four large chambers in the final whorl, the last of which partly covers the umbilicus. The umbilicus is typically open (except for a broad tooth) in *G. dehiscens*. The latter usually also contains only 3½ chambers in the final whorl.

Hypotype: TAMDOM No. 57.

*Globoquadrina altispira* (Cushman and Jarvis)  
(Plate 5, Figures 1 and 2)

*Globigerina altispira* Cushman and Jarvis, 1936, Cushman Lab. Foram. Res., Contr., vol. 12, p. 5, pl. 1, figs. 13, 14.

*Globoquadrina altispira altispira* (Cushman and Jarvis). Bolli, 1957, U.S. Nat. Museum, Bull. 215, p. 111, pl. 24, figs. 7a-8b.

*Globoquadrina altispira* (Cushman and Jarvis). Parker, 1967, Bull. Am. Paleontology, vol. 52, no. 235, p. 165, pl. 25, fig. 8.

*Globoquadrina altispira altispira* (Cushman and Jarvis). Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 339.

Remarks: This species appears to become extinct at a younger horizon in the western Atlantic than in the Pacific (see discussion under "Major Stratigraphic Boundaries"). It disappears from the Leg 11 cores concurrently with *Globorotalia multicamerata* as it does in the Gulf of Mexico.

Hypotype: TAMDOM No. 58.

*Globoquadrina dehiscens* (Chapman, Parr, and Collins)  
(Plate 8, Figures 6 and 7)

*Globorotalia dehiscens* Chapman, Parr, and Collins, 1934, Linn. Soc. London, J. Zool. vol. 38, no. 262, p. 569, pl. 11, figs. 36a-c.

*Globoquadrina dehiscens* (Chapman, Parr, and Collins). Bolli, 1957, U.S. Nat. Museum Bull. 215, p. 111, pl. 24, figs. 3a-c (not figs 4a-c).

*Globoquadrina dehiscens dehiscens* (Chapman, Parr, and Collins). Blow, 1969, Intern. Conf. Plank. Microfoss. Proc., vol. 1, p. 341, pl. 28, fig. 1.

Remarks: In the Leg 11 cores, this species has a more open umbilicus and fewer chambers in the final whorl than *Globoquadrina advena*.

Hypotype: TAMDOM No. 59.

*Globoquadrina dutertrei* (d'Orbigny)  
(Plate 2, Figures 5 and 6)

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

*Globigerina dutertrei* d'Orbigny, 1839, Hist. Phys. Pol. Nat. Cuba, "Foraminiferes," p. 84, pl. 4, figs. 19-21.

*Globigerina eggeri* Rhumbler, 1901, Nordisches Plankton, Lief 1, no. 14, p. 19, text-fig. 20.

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

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

*Globoquadrina dutertrei* (d'Orbigny). Parker, 1961, Micropaleontology, vol. 8, no. 2, p. 242, pl. 7, figs. 1-13, pl. 8, figs. 1-4.

*Globoquadrina dutertrei* (d'Orbigny). Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 318, pl. 14, figs. 6, 7).

*Globoquadrina dutertrei* (d'Orbigny). Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 318, pl. 15, figs. 5, 6.

*Neogloboquadrina dutertrei* (d'Orbigny). Bandy, Frerichs, and Vincent, 1967, Cushman Found. Foram. Res., Contr., vol. 18, pt. 4, p. 152.

Hypotype: TAMDOM No. 60.

*Globoquadrina globosa* Bolli  
(Plate 8, Figures 1 and 2)

*Globoquadrina altispira globosa* Bolli, 1957, U.S. Nat. Museum, Bull. 215, p. 111, pl. 24, figs. 9a-10c.

*Globoquadrina altispira globosa* Bolli. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 339.

Remarks: A few specimens of this species occur in the late Miocene of Hole 103.

Hypotype: TAMDOM No. 61.

*Globoquadrina globularis* Bermúdez  
(Plate 10, Figures 3 and 4)

*Globoquadrina globularis* Bermúdez, 1961, Congr. Geol. Venez., vol. III, Bol. Geol. P. 1311, pl. 13, figs. 4-6.

*Globoquadrina altispira globularis* Bermúdez. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc. vol. 1, p. 340.

Remarks: This species is present in the early Miocene and late Oligocene of Hole 98.

Hypotype: TAMDOM No. 62.

*Globoquadrina venezuelana* (Hedberg)  
(Plate 4, Figures 7 and 8)

*Globigerina venezuelana* Hedberg, 1937, J. Paleontology, vol. 11, no. 8, p. 681, pl. 92, figs. 7a-b.

*Globoquadrina venezuelana* (Hedberg). Parker, 1967, Bull. Am. Paleontology, vol. 52, no. 235, p. 171, pl. 26, figs. 4-10.

*Globigerina venezuelana* Hedberg. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 322.

Hypotype: TAMDOM No. 63.

**Genus *Globorotaloides* Bolli, 1957**

*Globorotaloides hexagona* (Natland)  
(Plate 2, Figures 7 and 8)

*Globigerina hexagona* Natland, 1938, Univ. Calif. Scripps Inst. Oceanography, Bull., Tech. Ser., vol. 4, no. 3, p. 149, pl. 7, fig. 1.

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

*Globorotaloides hexagona hexagona* (Natland). Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 373.

Hypotype: TAMDOM No. 64.

*Globorotaloides suteri* Bolli  
(Plate 8, Figures 12 and 13)

*Globorotaloides suteri* Bolli, 1957, U.S. Nat. Museum, Bull., 215, p. 117, pl. 27, figs. 9a-13b.

*Globorotaloides suteri* Bolli. Blow, 1969, First Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 374.

Hypotype: TAMDOM No. 65.

**Genus *Pulleniatina* Cushman, 1927**

*Pulleniatina primalis* Banner and Blow  
(Plate 4, Figures 5 and 6)

*Pulleniatina primalis* Banner and Blow, 1967, Micropaleontology, vol. 13, no. 2, p. 142, pl. 1, figs. 3-8? pl. 3, figs. 2a-c.

Remarks: Excellent specimens are common in sediment recovered from Hole 102. Its final appearance occurs near the top of Zone N. 19 (or perhaps in lower Zone N. 20 as reported by Blow, 1969). There seems to be a considerable difference in the uppermost range of this species in the Atlantic and Pacific. Parker (1967) and Hays, Saito, Opdyke, and Burkle (1969) report *P. primalis* as high as Zone N. 22 in Pacific cores. According to the latter authors, it overlaps the lower range of *Globorotalia truncatulinoides*.

Hypotype: TAMDOM No. 66.

**Genus *Sphaeroidinella* Cushman, 1927**

*Sphaeroidinella dehiscens* (Parker and Jones)  
Forma *Excavata*  
(Plate 1, Figure 2)

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

*Sphaeroidina dehiscens* (Parker and Jones). Brady, 1884, Rept. Voyage H.M.S. *Challenger*, Zool., vol. 9, pl. 84, fig. 8.

*Sphaeroidinella dehiscens* (Parker and Jones). Cushman, 1927, Cushman Lab. Foram. Res., Contr., vol. 3, p. 90, pl. 19, fig. 2.

*Sphaeroidinella dehiscens excavata* Banner and Blow, 1965, Nature, vol. 108, no. 5016, p. 1164.

*Sphaeroidinella dehiscens excavata* Banner and Blow. Banner and Blow, 1967, Micropaleontology, vol. 13, no. 2, p. 1531, pl. 4, fig. 5.

*Sphaeroidinella dehiscens excavata* Banner and Blow. Blow 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 336, pl. 10, Fig. 14.

Remarks: This species in the broad sense including forma *excavata*, was sparse in most samples where it was present. It was most consistently observed in the Holocene and late Pleistocene.

Hypotype: TAMDOM No. 67.

**Genus *Sphaeroidinellopsis* Banner and Blow, 1959**

*Sphaeroidinellopsis kochi* (Caudri)  
(Plate 6, Figures 3 and 4)

*Globigerina* sp. Koch, 1923, Eclogae geol. Helvetiae, vol. 18, no. 2, p. 355, text figs. 8a-b.

*Globigerina kochi* Caudri, 1934, Tertiary deposits of Soemba, p. 144.

*Sphaeroidinella kochi* (Caudri). Glaessner, 1943, Roy. Soc. Victoria, Proc., vol. 55, (new ser.) pt. 9, p. 69 (list).

*Sphaeroidinella grimsdalei* (Keyzer). Bolli, 1957, U.S. Nat. Museum, Bull. 215, p. 114, pl. 26, figs. 12a-c, (not figs. 8-11).

*Sphaeroidinellopsis seminulina kochi* (Caudri). Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 336, pl. 30, fig. 8.

Hypotype: TAMDOM No. 68.

*Sphaeroidinellopsis seminulina* (Schwager)  
(Plate 5, Figure 3)

*Globigerina seminulina* Schwager, 1866, *Novara* Exped. 1857-1859, Geol. Theil., Band 2, Abth. 2, p. 256, pl. 7, fig. 112.

*Sphaeroidinella rutschi* Cushman and Renz, 1944 (part) Cushman, Lab. Foram. Res., Contr., vol. 17, p. 25, pl. 4, figs. 5a, b (not fig. 5c).

*Sphaeroidinella grimsdalei* (Keijzer). Bolli, 1957, U.S. Nat. Museum, Bull. 215, p. 114, pl. 26, figs. 8-11 (not figs. 12a-c).

*Sphaeroidinellopsis seminulina seminulina* (Schwager). Blow, 1959, Bull. Am. Paleontology, vol. 39, no. 178, p. 197, pl. 12, figs. 74-77.

*Sphaeroidinellopsis seminulina seminulina* (Schwager). Blow, 1969, First Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 337, pl. 30, fig. 7.

Hypotype: TAMDOM No. 69.

*Sphaeroidinellopsis subdehiscens* (Blow)  
(Plate 5, Figure 4)

*Sphaeroidinella rutschi* Cushman and Renz, Renz, 1948, Geol. Soc. America, Mem. 32, p. 167, pl. X, fig. 1c (not fig. 1a, b).

*Sphaeroidinella rutschi* Cushman and Renz, Bolli, 1957, U.S. Nat. Museum, Bull. 215, p. 115, pl. 26, figs. 6a-7b.

*Sphaeroidinella dehiscens subdehiscens* Blow, 1959, Bull. Am. Paleontology, vol. 39, no. 178, p. 195, pl. 12, figs. 71a-c, 72.

*Sphaeroidinellopsis subdehiscens subdehiscens* (Blow). Blow, 1969, Intern. Conf. Plank. Microfoss., Proc. vol. 1, p. 338, pl. 30, figs. 1-3, 6? pl. 31, figs. 1-3, pl. 32, figs. 1-3.

Hypotype: TAMDOM No. 70.

**Genus *Candeina* d'Orbigny, 1839**

*Candeina? parkerae?* Bermúdez  
(Plate 7, Figures 3-5)

?*Globigerinoides parkerae* Bermúdez, 1961, Cong. Geol. Venez., vol. III, Bol. Geol. p. 1, 232, pl. 10, figs. 10, 11.

?*Globigerinoides parkerae* Bermúdez. Blow, 1969, Intern. Conf. Plank. Microfoss. Proc., vol. 1, p. 325, pl. 22, figs. 1-4.

Remarks: Specimens tentatively assigned to this species display morphological features not noted previously.

The multiple apertures, rather than being rimmed by narrow lips (see Blow, 1969, pl. 22, figs. 1-6), are covered by triangular flaps of test material. Aside from these flaps, this form appears to be related more closely to *Candeina* than to *Globigerinoides*.

Hypotype: TAMDOM No. 71.

**Genus *Globigerinita* Brönnimann, 1951**

*Globigerinita ciproensis* Blow and Banner  
(Plate 10, Figures 5 and 6)

*Catapsydrax dissimilis* (Cushman and Bermúdez). Bolli, 1957, U.S. Nat. Museum, Bull. 215, p. 36, pl. 7, figs. 8a-c (not figs. 6, 7).

*Catapsydrax dissimilis* (Cushman and Bermúdez). Blow, 1959, Bull. Am. Paleontology, vol. 39, no. 178, p. 203, pl. 12, figs. 88-90.

*Globigerinita dissimilis ciproensis* Blow and Banner, 1961, p. 107, pl. XIV, figs. A-C.

*Globigerinita dissimilis ciproensis* Blow and Banner. Blow, 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 328, pl. 24, fig. 2.

Remarks: Excellent specimens of this species occur in Core 5 of Hole 98 (late Oligocene-early Miocene).

Hypotype: TAMDOM No. 72.

*Globigerinita dissimilis* (Cushman and Bermúdez)  
(Plate 10, Figures 7 and 8)

*Globigerina dissimilis* Cushman and Bermúdez, 1937, Cushman Lab. Foram. Res., Contr., vol. 13, p. 25, pl. 3, figs. 4-6.

*Catapsydrax dissimilis* (Cushman and Bermúdez), Bolli, Loeblich, and Tappan, 1957, U.S. Nat. Museum Bull. 215, p. 36, pl. 7, figs. 6-8.

*Dissimiloglobigerina dissimilis* (Cushman and Bermúdez). Reiss, 1957, Geol. Survey, State Israel, Study on Foraminifera, p. 4.

*Globigerinita dissimilis dissimilis* (Cushman and Bermúdez). Blow 1969, Intern. Conf. Plank. Microfoss., Proc., vol. 1, p. 327, pl. 25, figs. 6, 7.

Remarks: Excellent specimens of this species are present in Core 5, Hole 98 (late Oligocene-early Miocene).

Hypotype: TAMDOM No. 73.

*Globigerinita unicava* (Bolli, Loeblich, and Tappan)  
(Plate 10, Figures 9 and 10)

*Catapsydrax unicavus* Bolli, Loeblich, and Tappan,  
1957, U.S. Nat. Museum Bull. 215, p. 166, pl. 37, ?fig.  
7 (?figs. 9a-c).

*Globigerinita unicava unicava* (Bolli, Loeblich, and  
Tappan). Blow, 1969, Intern. Conf. Plank. Microfoss,  
Proc., vol. 1, p. 330, pl. 24, figs. 8, 9.

Remarks: Excellent specimens of this species are  
present in Core 5, Hole 98 (late Oligocene, early  
Miocene).

Hypotype: TAMDOM No. 74.

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PLATE 1

Holocene

- Figure 1      *Globigerinid* (juvenile) with spines - Hole 98, Core 1, Section 1, top; X180.
- Figure 2      *Sphaeroidinella dehiscens* forma *excavata* - Hole 98, Core 1, Section 1, top; X90.
- Figures 3, 4      *Globorotalia cultrata* - Hole 98, Core 1, Section 1, top; X80.
- Figure 5      *Globigerinoides ruber* forma *rosea* - Hole 98, Core 1, Section 1, top; X90.
- Figure 6      *Globigerina ruscens* - Hole 98, Core 1, Section 1, top; X 90.
- Figures 7, 8      *Globigerina bulloides* - Hole 106, Core 2, Core Catcher; X90.
- Figures 9, 10      *Globigerina calida* - Hole 98, Core 1, Section 1, top; X90.

PLATE 1

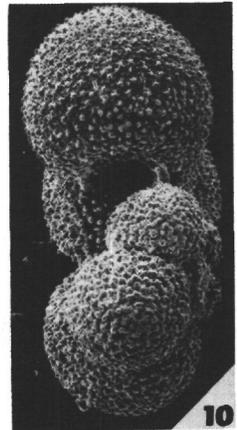
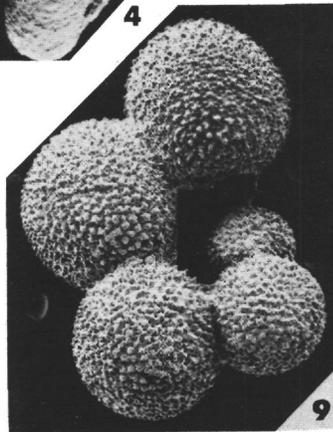
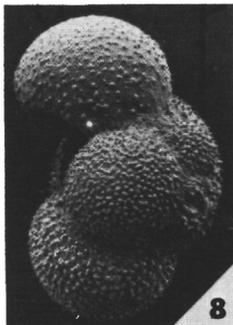
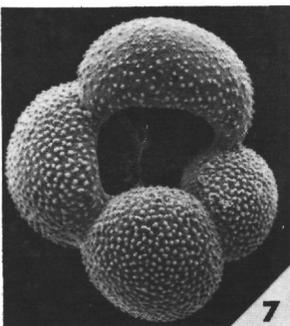
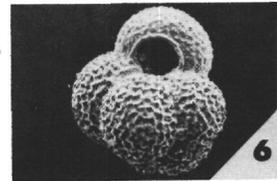
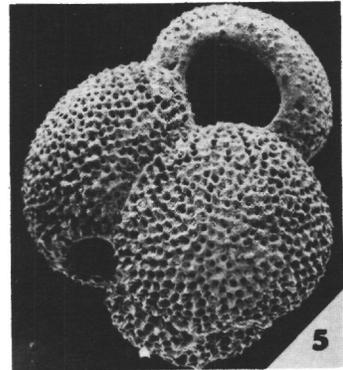
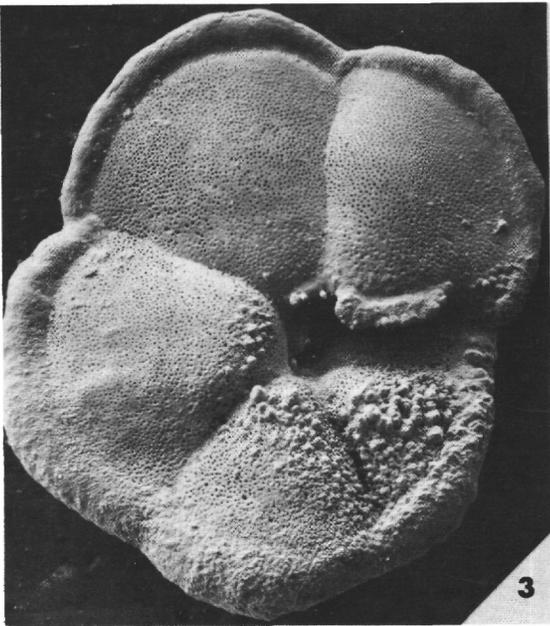
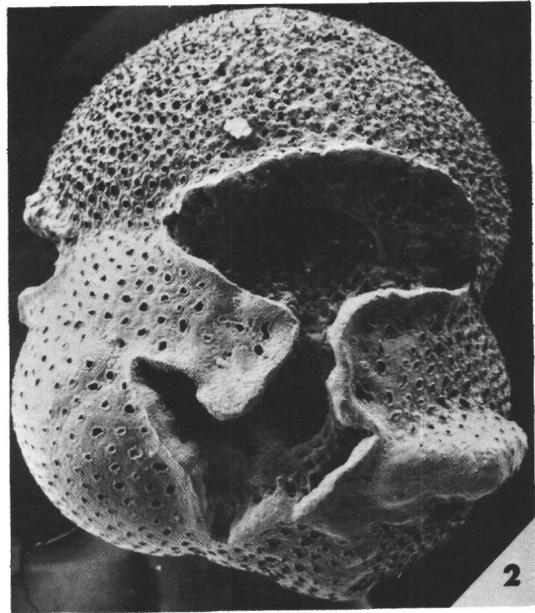
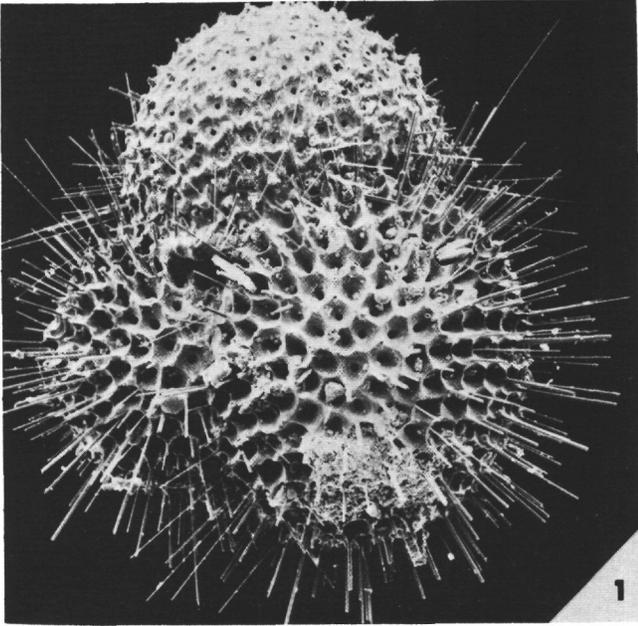


PLATE 2  
Holocene - Pleistocene

- Figures 1, 2 *Globorotalia truncatulinoides* - Hole 98, Core 1, Section 1, top; X90.
- Figures 3, 4 *Turborotalia inflata* - Hole 98, Core 1, Section 4, 85 cm; X90.
- Figures 5, 6 *Globoquadrina dutertrei* - Hole 98, Core 1, Section 4, 85 cm; X90.
- Figures 7, 8 *Globorotaloides hexagona* - Hole 102, Core 9, Section 4, 10 cm; X90.
- Figures 9, 10 *Turborotalia humerosa* - Hole 102, Core 9, Section 6, 1 cm; X90.
- Figures 11, 12 *Turborotalia tonsaensis* - Hole 103, Core 1, Section 1, 23 cm; X95.
- Figures 13, 14 *Globigerina pachyderma* - Hole 106, Core 4, Core Catcher; X100.

PLATE 2

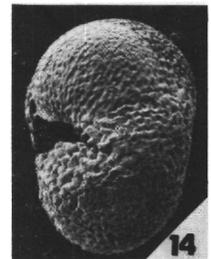
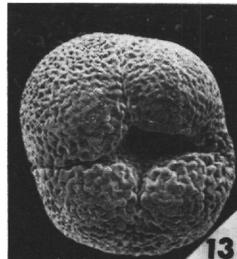
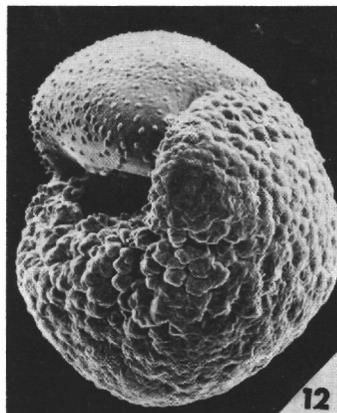
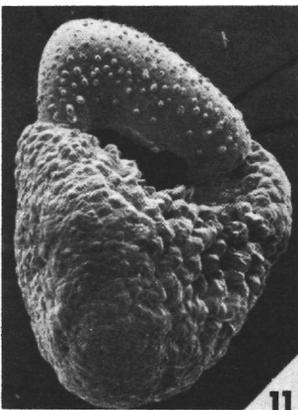
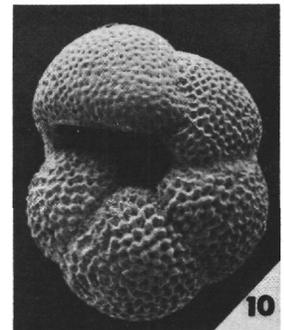
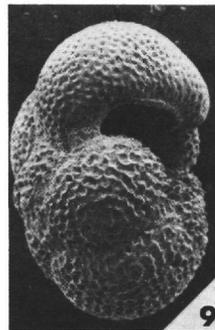
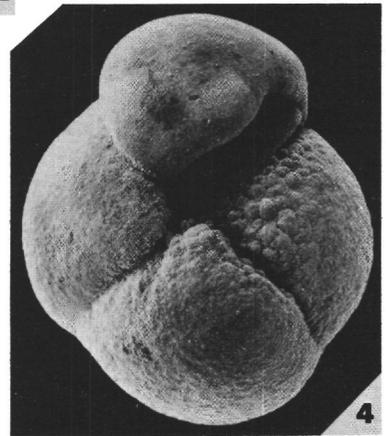
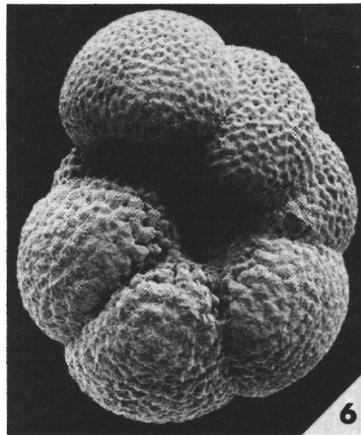
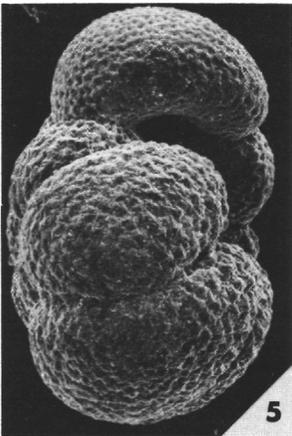
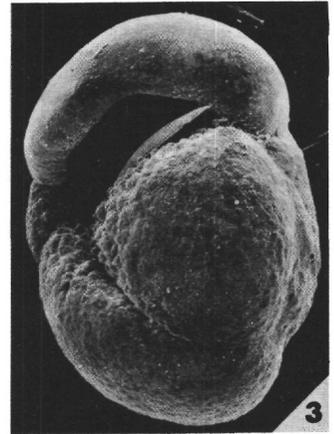
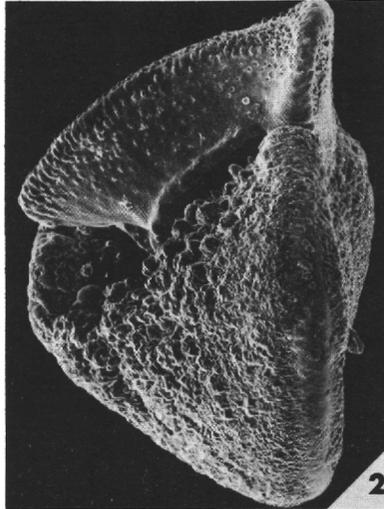
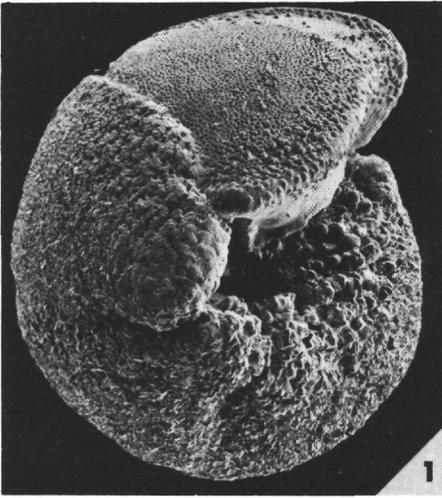


PLATE 3  
Early Pleistocene - Late Pliocene

- Figures 1, 2     *Globorotalia conomiozea* - Hole 102, Core 9, Section 3, 1 cm; X90.
- Figures 3, 4     *Globorotalia miocenica* - Hole 102, Core 10, top; X90.
- Figures 5, 6     *Turborotalia oceanica* - Hole 102, Core 13, Core Catcher; X90.
- Figures 7, 8     *Globorotalia exilis?* - Hole 102, Core 11, Core Catcher; X90.
- Figures 9, 10    *Turborotalia crassaformis* - Hole 102, Core 13, Core Catcher; X90.
- Figures 11, 12   *Globorotalia crassula* - Hole 102, Core 12, Section 1, 19 cm; X90.
- Figure 13        *Globigerinoides extremus* - Hole 98, Core 1, Core Catcher; X90.

PLATE 3

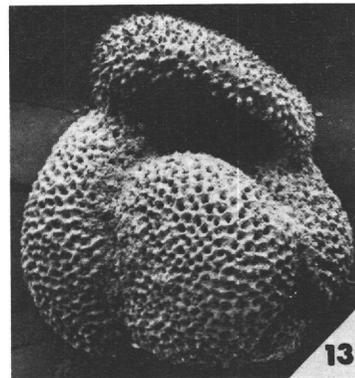
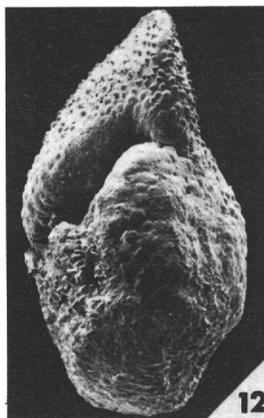
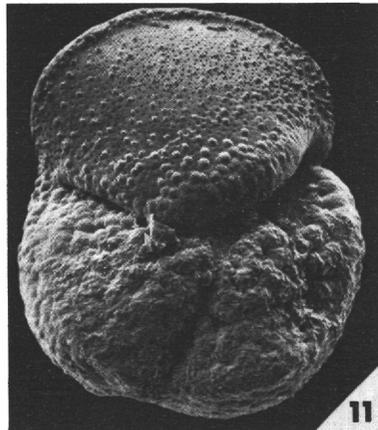
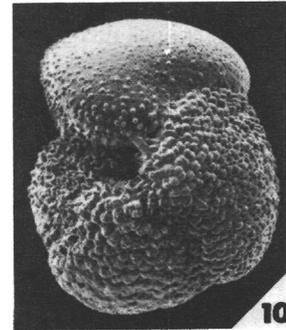
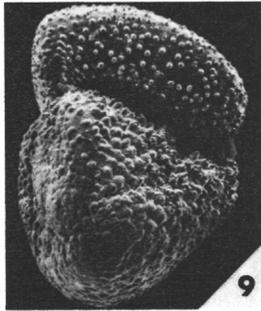
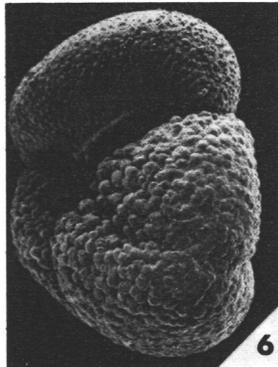
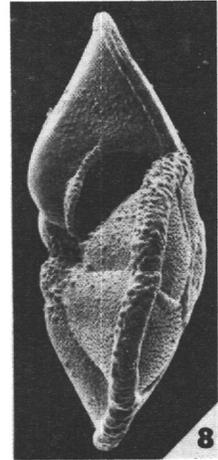
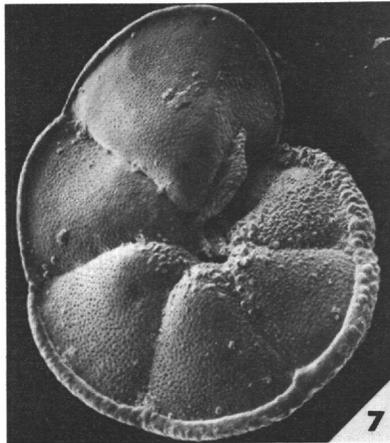
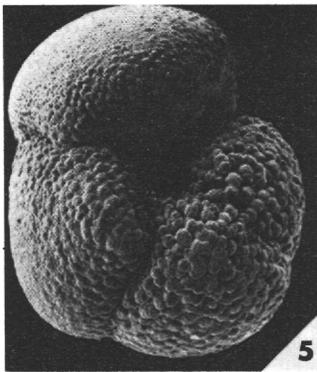
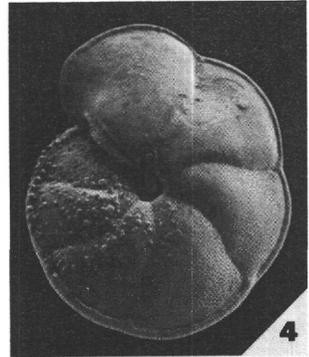
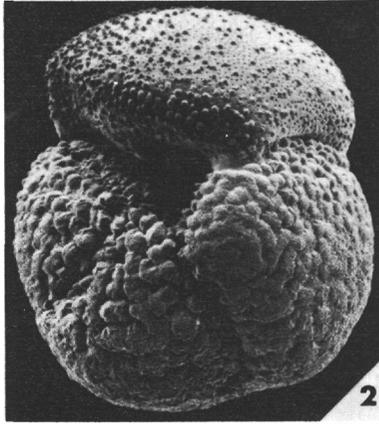
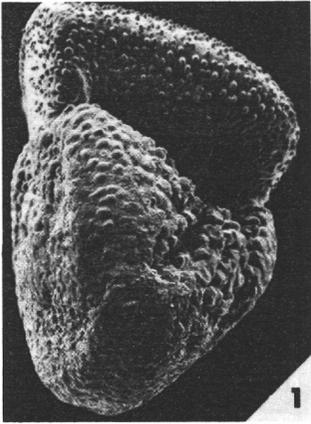


PLATE 4  
Late Pliocene

- Figures 1, 2     *Globorotalia pertenuis* - Hole 102, Core 10, top; X90.
- Figures 3, 4     *Globorotalia multicamerata* - Hole 102, Core 11, Core  
Catcher; X73.
- Figures 5, 6     *Pulleniatina primalis* - Hole 102, Core 13, Core  
Catcher; X90.
- Figures 7, 8     *Globoquadrina venezuelana* - Hole 102, Core 13, Core  
Catcher; X90.

PLATE 4

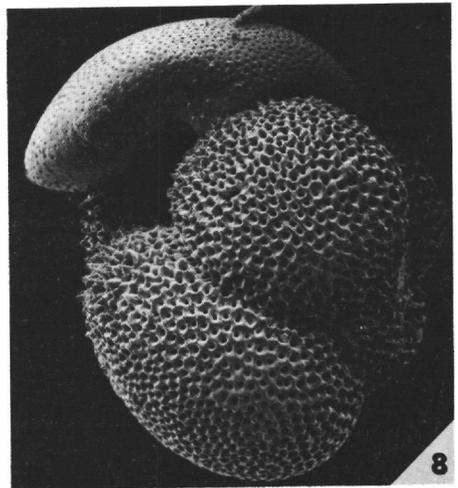
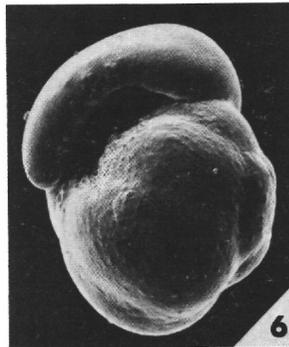
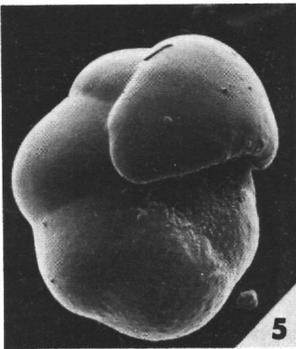
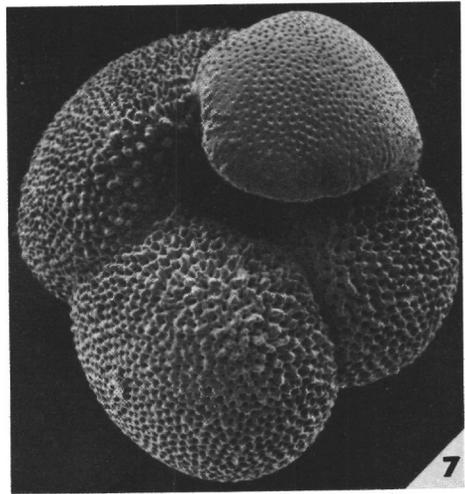
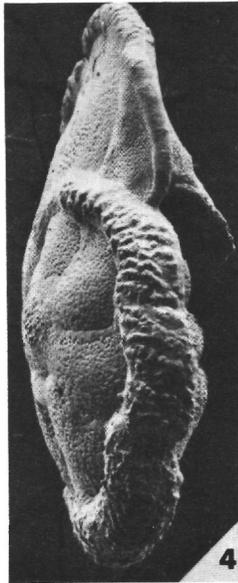
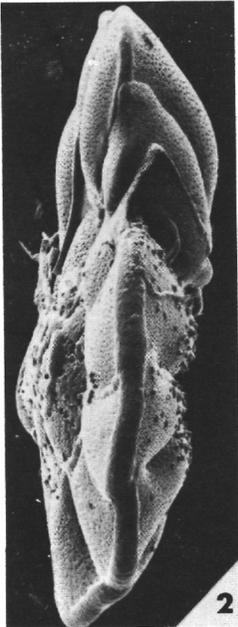
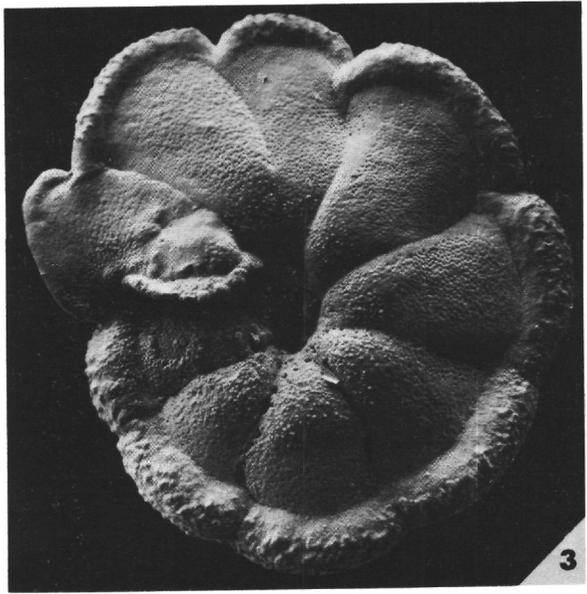
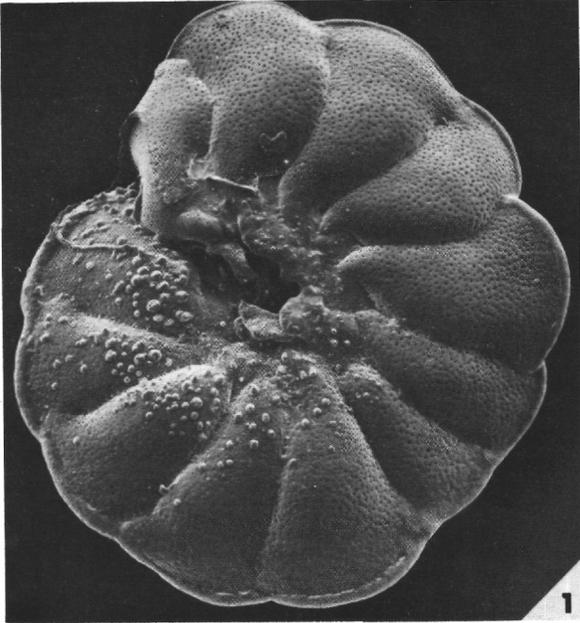


PLATE 5  
Late Pliocene

- Figures 1, 2     *Globoquadrina altispira* - Hole 98, Core 1, Core Catcher; X90.
- Figure 3        *Sphaeroidinellopsis seminulina* - Hole 98, Core 1, Core Catcher; X90.
- Figure 4        *Sphaeroidinellopsis subdehiscens* - Hole 98, Core 1, Core Catcher; X90.
- Figures 5, 6    *Globorotalia margaritae* - Hole 98, Core 1, Core Catcher; X90.
- Figures 7, 8    *Globorotalia cibaoensis* - Hole 98, Core 2, Section 5, 85 cm; X90.

PLATE 5

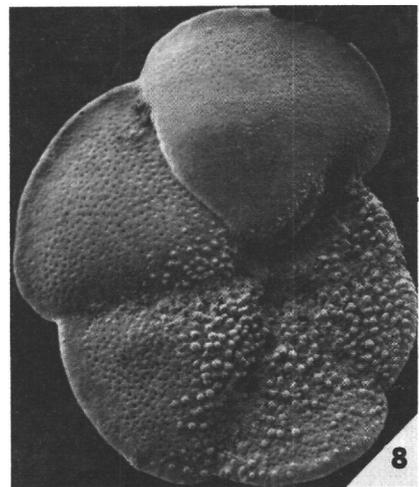
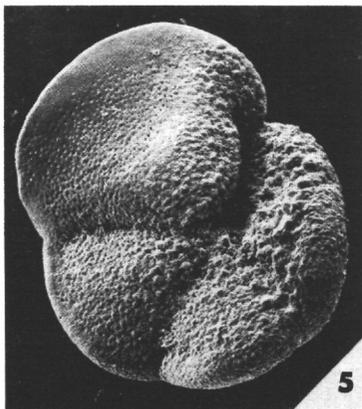
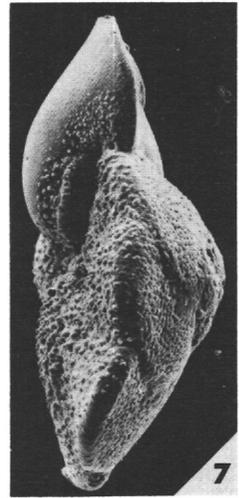
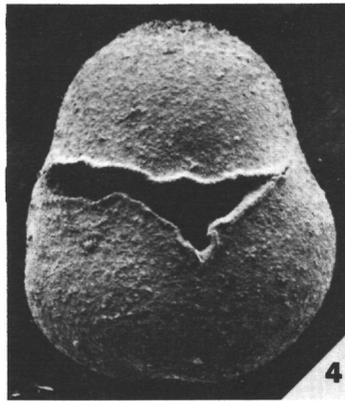
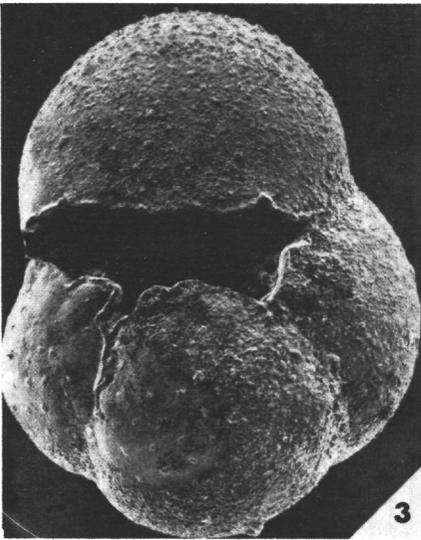
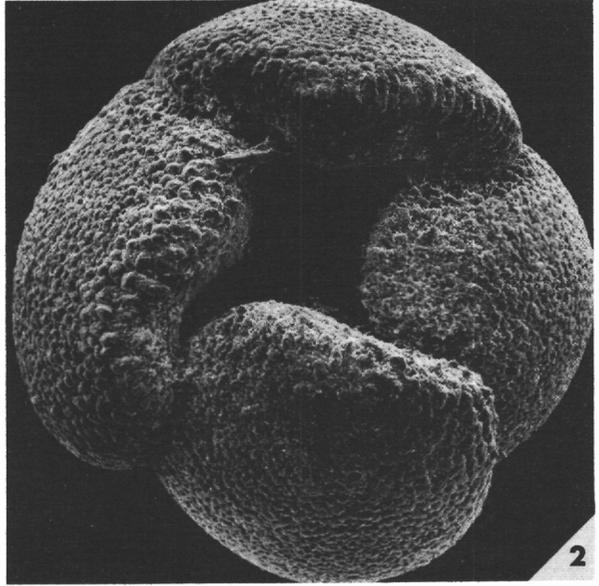
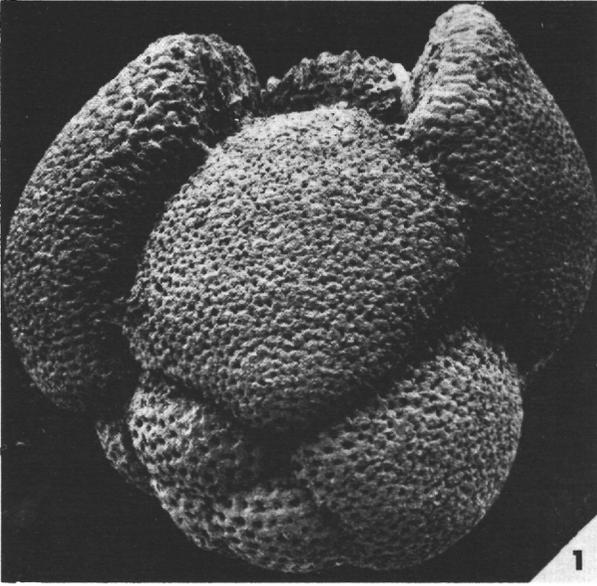


PLATE 6

Early Pliocene - Late Miocene

- Figures 1, 2     *Globorotalia limbata* - Hole 98, Core 2, Section 1, 10 cm; X80.
- Figures 3, 4     *Sphaeroidinellopsis kochi* - Hole 104, Core 7, Core Catcher; X98.
- Figures 5-8     *Globigerina nepenthes* - Figures 5, 6; Low-spined form - Hole 98, Core 2, Section 1, 10 cm; Figures 7, 8; High-spined form - Hole 102, Core 18, Core Catcher; X90.
- Figures 9, 10     *Globorotalia plesiotumida* - Hole 98, Core 4, Section 6, 14 cm; X90.
- Figures 11, 12     *Globorotalia merotumida* - Hole 98, Core 4, Section 6, 14 cm; X90.
- Figures 13, 14     *Turborotalia acostaensis* - Hole 98, Core 4, Section 5, 10 cm; X90.

PLATE 6

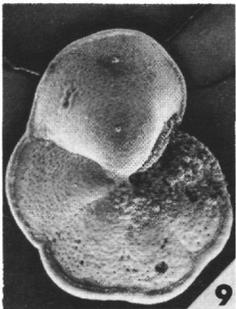
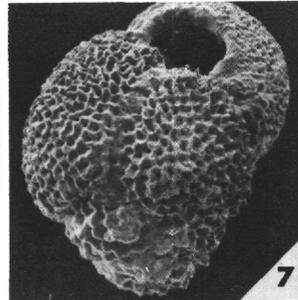
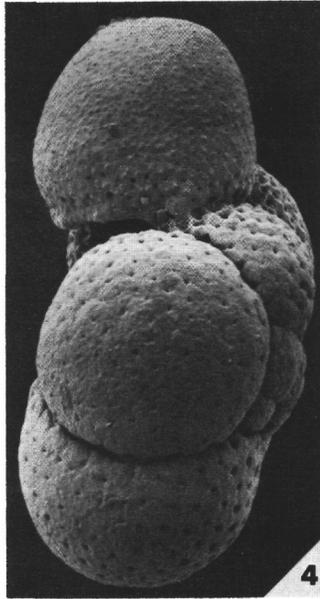
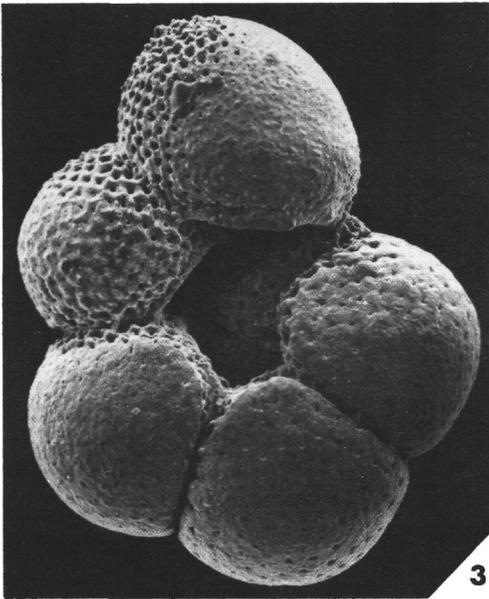
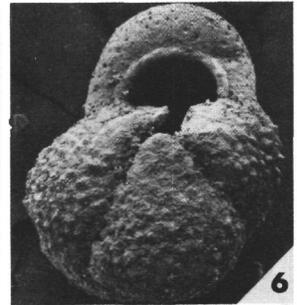
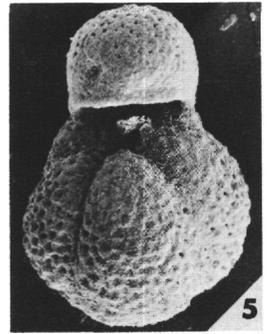


PLATE 7

Late Miocene

- Figures 1, 2     *Globigerinoides mitra* - Hole 98, Core 3, Section 2,  
100 cm; X90.
- Figures 3-5     *Candeina ? parkerae?* - Hole 103, Core 6, Section 1,  
12 cm. Figures 3, 4; X98; Figure 5: enlargement of  
Figure 4 showing apertural flaps, X480.
- Figures 6, 7     *Globigerina multiloba* - Hole 102, Core 18, Core  
Catcher; X90.
- Figures 8, 9     *Globorotalia miozea* - Hole 102, Core 18, Core  
Catcher; X90.

PLATE 7

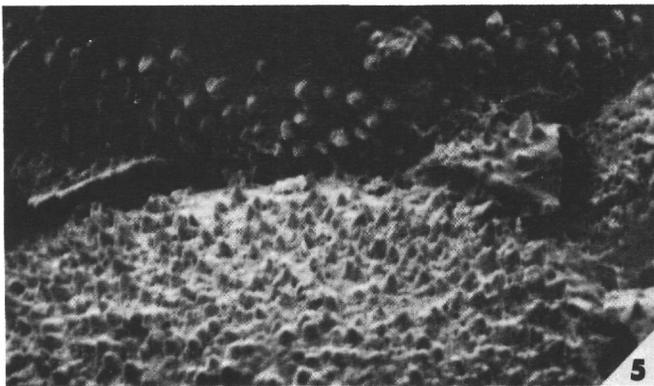
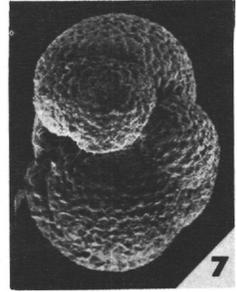
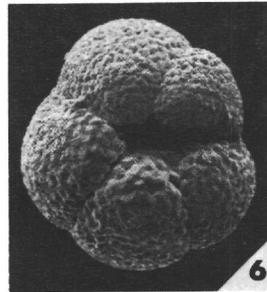
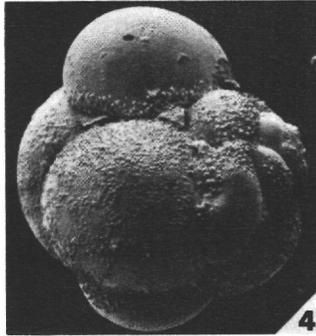
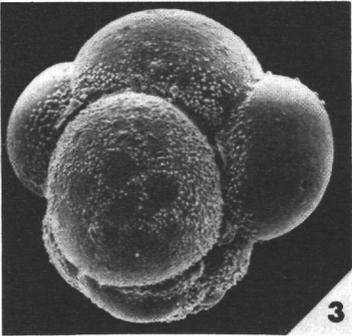
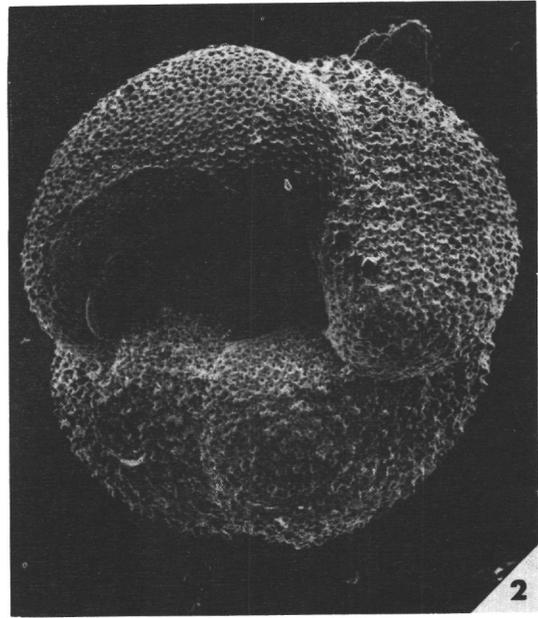
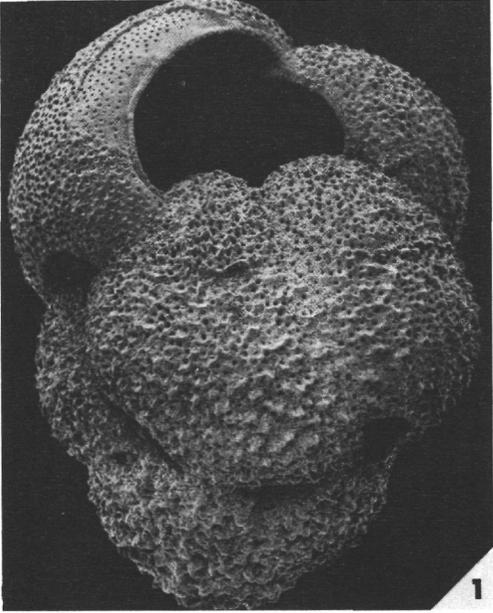


PLATE 8

Late Miocene

- Figure 1, 2      *Globoquadrina globosa* - Hole 103, Core 5, Core Catcher; X100.
- Figures 3-5      *Globoquadrina advena* - Hole 104, Core 1, Core Catcher. Figures 3, 4: X98; Figure 5: enlargement of umbilical shoulder of antepenultimate chamber of Figure 3 showing test wall thickening; X490.
- Figures 6, 7      *Globoquadrina dehiscens* - Hole 103, Core 5, Core Catcher; X100.
- Figures 8, 9      *Turborotalia continuosa* - Hole 102, Core 19, Core Catcher; X90.
- Figures 10, 11      *Turborotalia clemenciae* - Hole 102, Core 19, Core Catcher; X90.
- Figures 12, 13      *Turborotalia siakensis* - Hole 98, Core 5, Section 1, 60 cm; X90.

PLATE 8

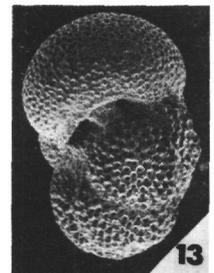
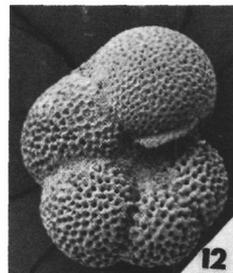
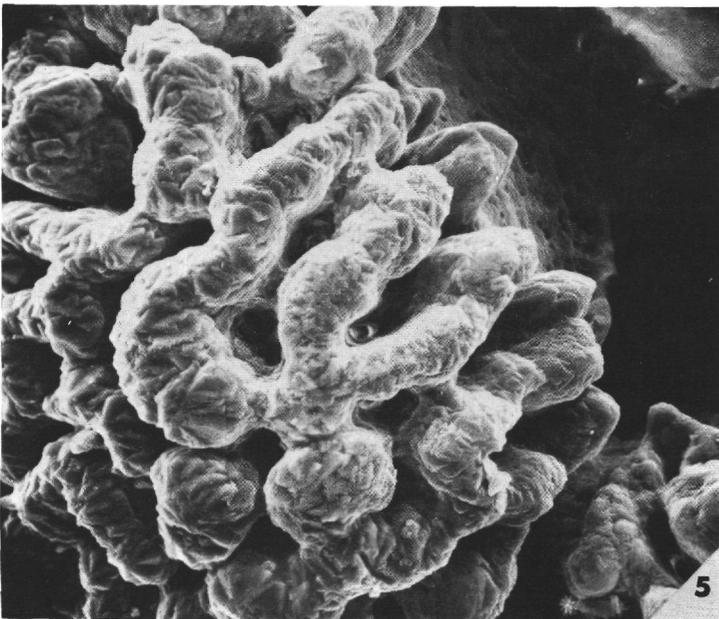
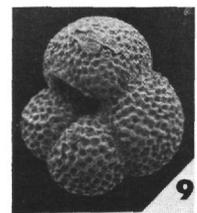
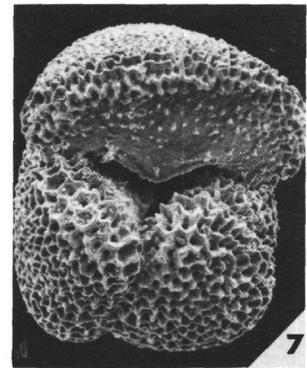
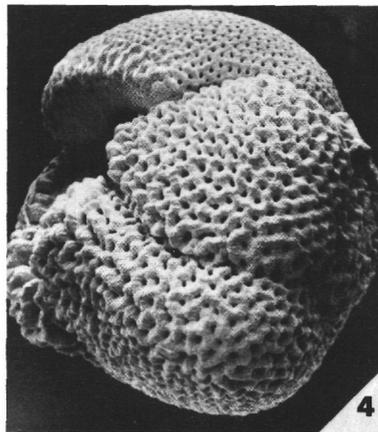
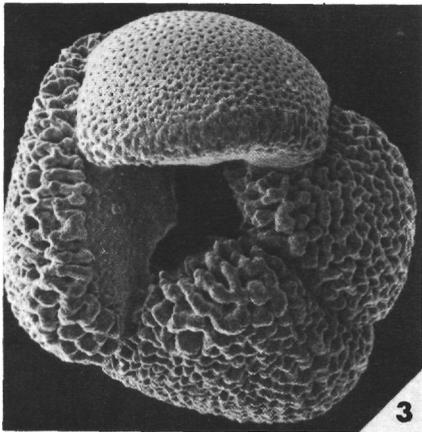
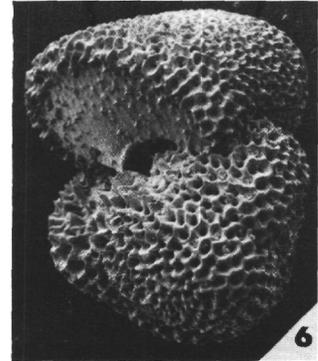
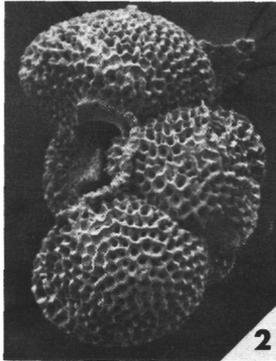


PLATE 9  
Middle Miocene

- Figures 1, 2     *Globorotalia fohsi* forma *lobata* - Hole 104, Core 7, Core Catcher; X96.
- Figures 3, 4     *Globorotalia fohsi* forma *robusta* - Hole 104, Core 7, Core Catcher; X98.
- Figures 5, 6     *Globorotalia praemenardii* - Hole 104, Core 7, Core Catcher; X98.
- Figures 7, 8     *Globorotalia praefohsi* - Hole 103, Core 8, Section 5, 103 cm; X98.
- Figures 9, 10    *Globorotalia peripheroacuta* - Hole 104, Core 7, Core Catcher; X96.
- Figures 11, 12   *Turborotalia peripheroronda* - Hole 104, Core 7, Core Catcher; X96.
- Figures 13, 14   *Turborotalia pseudokugleri* - Hole 98, Core 5, Section 1, 83 cm; X90.
- Figures 15, 16   *Turborotalia kugleri* - Hole 98, Core 5, Section 1, 83 cm; X90.
- Figures 17, 18   *Turborotalia mendacis* - Hole 98, Core 5, Section 1, 83 cm; X90.
- Figures 19, 20   *Turborotalia mayeri* - Hole 104, Core 8, Core Catcher; X100.

PLATE 9

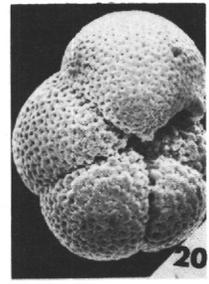
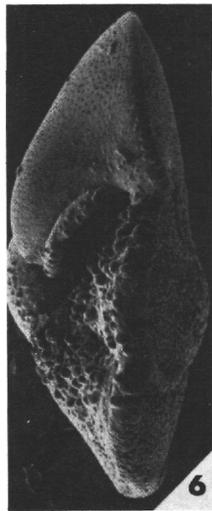
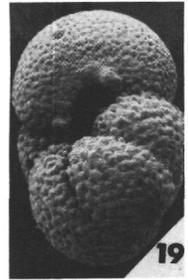
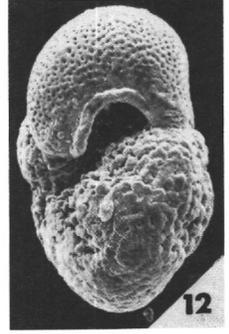
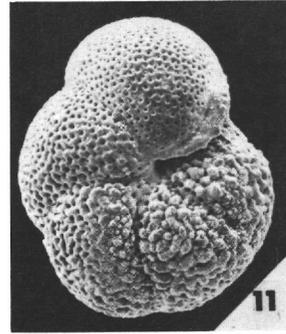
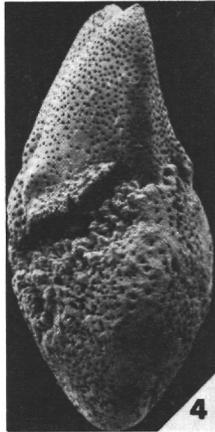
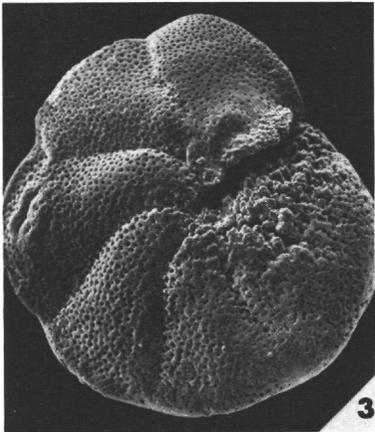
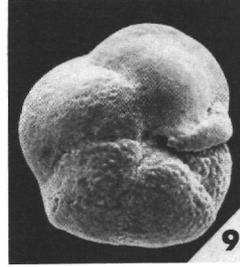
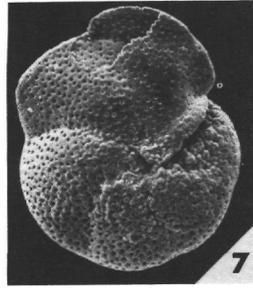
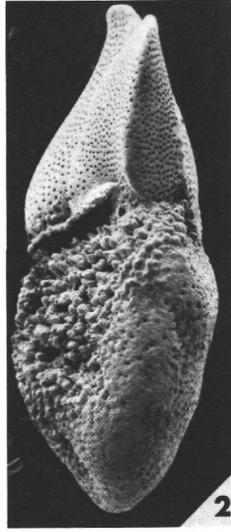
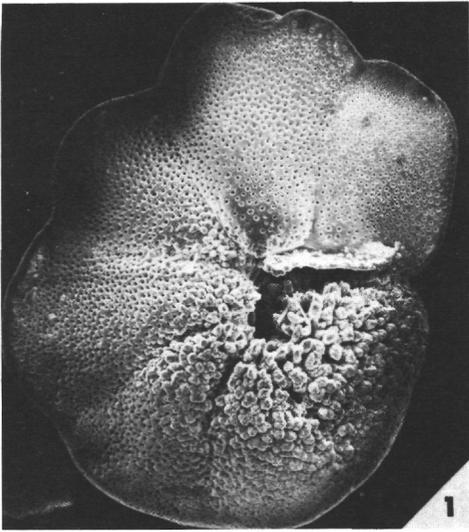


PLATE 10

Early Miocene - Late Oligocene

- Figure 1 *Globigerinoides primordius* - Hole 98, Core 5, Section 1, 60 cm; X90.
- Figure 2 *Globigerinoides altiapertura* - Hole 98, Core 5, Section 1, 60 cm; X90.
- Figures 3, 4 *Globoquadrina globularis* - Hole 98, Core 5, Section 1, 83 cm; X90.
- Figures 5, 6 *Globigerinita ciperoensis* - Hole 98, Core 5, Section 1, 83 cm; X90.
- Figures 7, 8 *Globigerinita dissimilis* - Hole 98, Core 5, Section 1, 83 cm; X90.
- Figures 9, 10 *Globigerinita unicava* - Hole 98, Core 5, Section 1, 83 cm; X90.
- Figures 11, 12 *Globigerina tripartita* - Hole 98, Core 5, Section 1, 83 cm; X90.
- Figures 13, 14 *Globorotaloides suteri* - Hole 98, Core 5, Core Catcher; X90.

PLATE 10

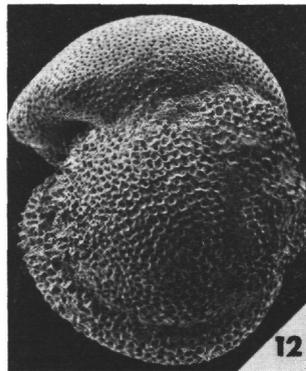
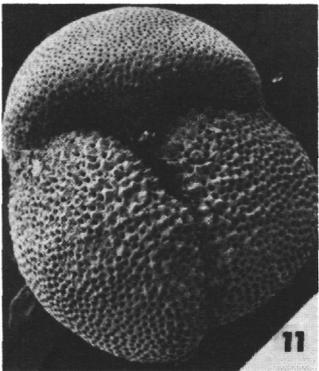
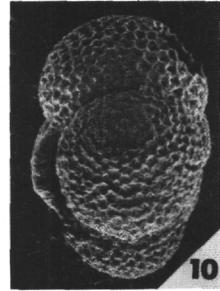
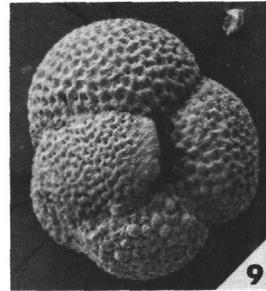
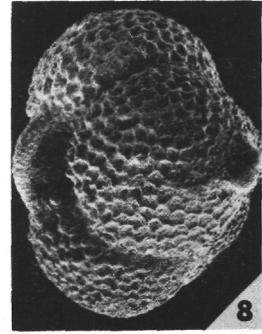
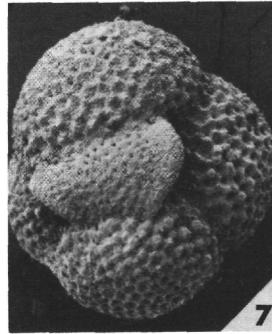
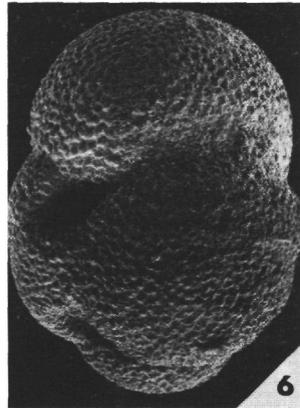
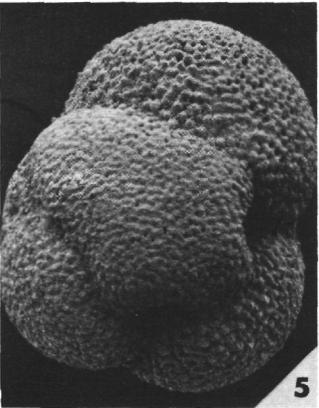
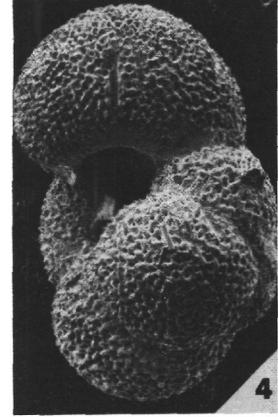
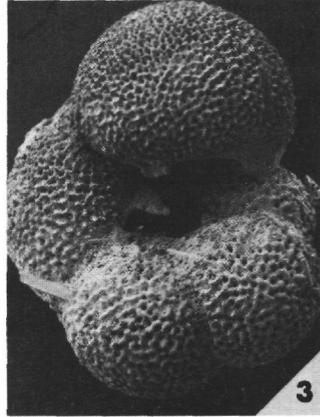
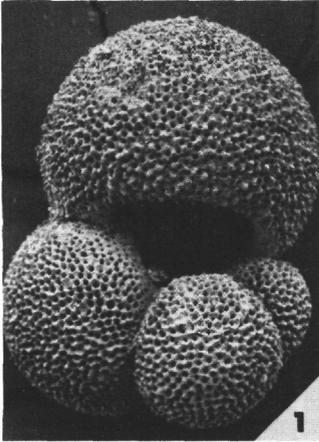


PLATE 11

Late Oligocene

- Figures 1, 2     *Globigerina angulisuturalis* - Hole 98, Core 5, Section 1, 83 cm; X90.
- Figures 3, 4     *Globigerina angustiumblicata* - Hole 98, Core 5, Core Catcher; X90.
- Figures 5, 6     *Globigerina ciperoensis* - Hole 98, Core 5, Section 1, 84 cm; X90.
- Figures 7-9     *Globigerina selli* - Hole 98, Core 5, Core Catcher; Figures 7, 8: X90.; Figure 9: enlargement of spinose final chamber of same specimen illustrated in Figures 7 and 8; X420.
- Figures 10, 11     *Globigerina sellii* - Hole 98, Core 5, Section 1, 100 cm; X90.
- Figures 12, 13     *Globigerina gortanii* - Hole 98, Core 5, Section 1, 83 cm; X90.
- Figure 14     ?*Turborotalia opima* - Hole 98, Core 5, Core Catcher; X90.

PLATE 11

