# 25. PLANKTONIC FORAMINIFERAL BIOSTRATIGRAPHY OF THE EASTERN EQUATORIAL PACIFIC – DSDP LEG 9

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CONTENTS

## GENERAL INTRODUCTION

Drilling operations on Leg 9 yielded 5045 feet (1537.7 meters) of core from 9 sites in the eastern equatorial Pacific (Figures 1 and 2). The cores yielded Upper Eocene to Pleistocene planktonic foraminiferal faunas and no major intraformational stratigraphic faunal breaks were recorded. At seven of the sites the uppermost faunas were Pleistocene, whereas at Site 76 the youngest faunas were Upper Pliocene and at Site 78 they were Middle Miocene with a possible thin surface veneer of Upper Pleistocene or Recent faunas.

Continuous coring at Site 77 (Upper Eocene through to Pleistocene) and at Site 78 (Lower Oligocene through to Middle Miocene) yielded biostratigraphic control for six subsequent sites which were not continuously cored.

As pointed out by Bolli (1970, DSDP Leg 4, in press), one of the most important aspects of shipboard work is the sampling of cores by the paleontologists. Care was taken to avoid areas of obvious contamination, such as, the surface and tops of the cores. Normally a number of samples were taken immediately after the cores were cut into sections and before they were cut vertically which inevitably disturbed the sediment by movement. Downhole contamination was usually evidenced by the presence of "pipe scale" in both sediment samples and was even more obvious in the washed foraminiferal residues.

Most of the examined samples were of unconsolidated sediment and were easily washed through a 240 mesh sieve. The resulting residue was rapidly dried under an infrared lamp. Rare samples of hard siliceous sediment (for example, 77B, Cores 17 and 18) and also baked sediment from immediately overlying basalt at Sites 77 through 84 were treated with "varsol" before being boiled in water. A mixture of sodium pyrophosphate and 15 per cent hydrogen peroxide was also used to break down hard semi-consolidated sediments.

The following number of samples were examined:

| Site | Number Samples Examined | Core Recovery (feet) | (meters) |
|---|---|---|---|
| 76 | 16 | 85 | |
| 77 | 209 | 1492 | |
| 78 | 75 | 990 | |
| 79 | 55 | 510 | |
| 80 | 34 | 281 | |
| 81 | 23 | 129 | |
| 82 | 32 | 238 | |
| 83 | 73 | 617 | |
| 84 | 78 | 703 | |
| Total: | 595 | 5045 | |

Within the time available, work was concentrated on recording a maximum number of species and subspecies from each sample, and on Leg 9 a total of 121 named and 10 unnamed species (including benthonic species) were documented from the Upper Eocene to Pleistocene.

A number of new species and subspecies were encountered and these will be described and illustrated in a subsequent publication.

Although some observations were made on coiling direction of selected taxa and, in general, the results roughly corresponded with published data by Hays *et al.* (1969) on the Pliocene-Pleistocene, insufficient time was available to count adequate numbers of specimens and, consequently, results will be published at a future date. In the systematic section, coiling direction has been recorded for a few species of *Globorotalia*– usually where the coiling direction has been observed to be constant through time sequences.

For the shipboard and subsequent work, the publications of Parker (1967) and Hays *et al.* (1969) were found to be particularly relevant and useful especially for the Upper Miocene to Pleistocene. These publications and those by others, for example, by Bolli (1957a, b, c), were found to be scientifically acceptable because the stratigraphic ranges of taxa recorded therein were tied down to well documented stratigraphic sections. Generalized stratigraphic ranges of taxa which are not documented from definite stratigraphic sequences can be misleading and are best disregarded, mainly because the presented model is incomplete and therefore cannot be adequately tested.

The authors would like to express their gratitude to H. M. Bolli for scanning electron photographs of the zonal markers, as well as the technical staffs in the Geology Departments at the Universities of Canterbury and Oregon for suggestions and assistance in photography, plate and manuscript preparation.

## STRATIGRAPHIC RANGES OF TAXA

There is a prevailing concept that each named Cenozoic taxon has a total stratigraphic range which is applicable to all areas of the world (for example, shipboard paleontological manual). The stratigraphic ranges of taxa recorded on Leg 9 are empirical records within the examined area and it is obvious that certain taxa have different stratigraphic ranges in other parts of the world (for example, *Globoquadrina dehiscens* appears much earlier in the Oligocene in New Zealand and Australia, and *G. pachyderma* also appears earlier in the Upper Miocene of New Zealand).

Very rarely when a zonal marker was absent within its known stratigraphic range another supplementary

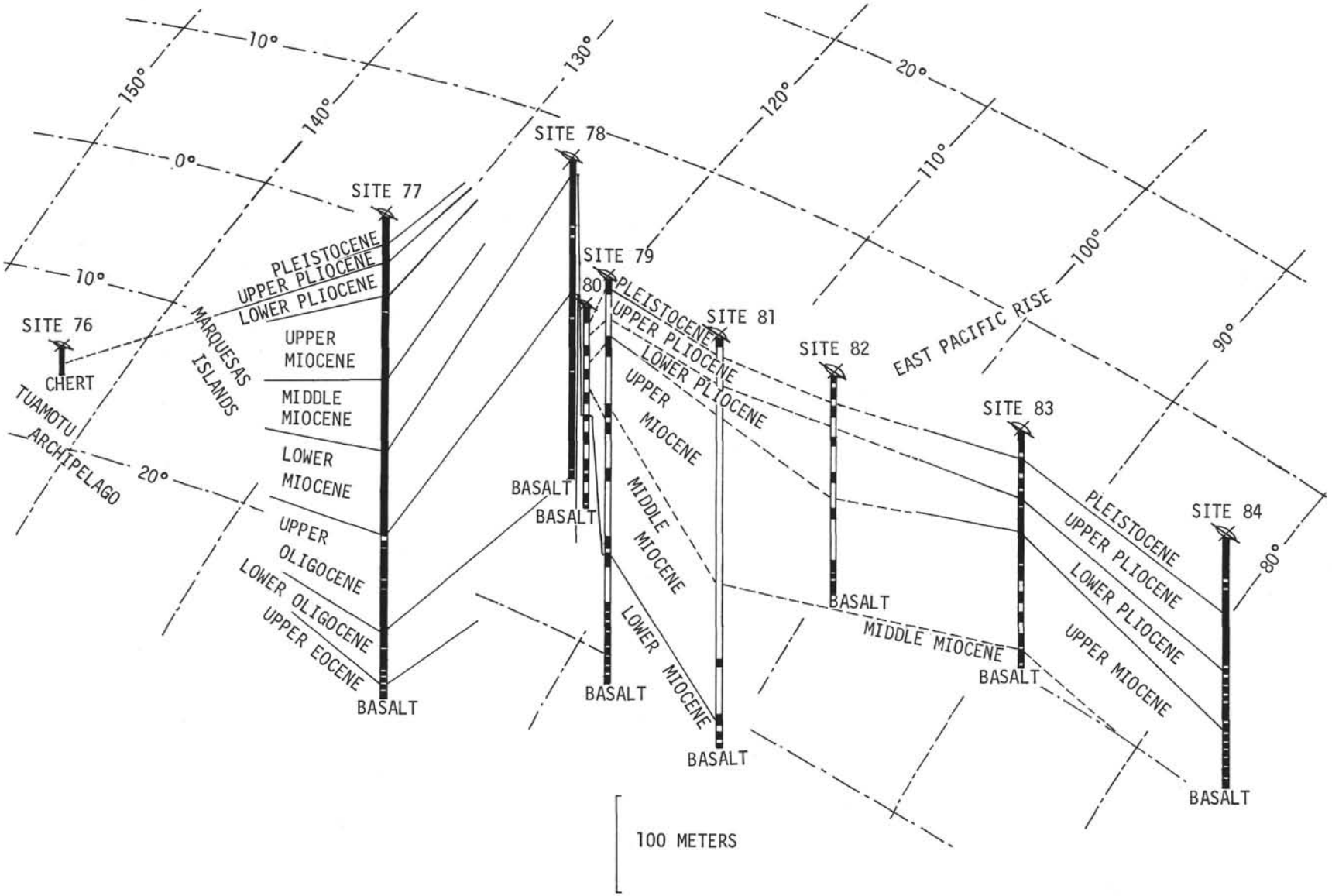


Figure 1. *DSDP Leg 9 series correlations (cored intervals in black).*

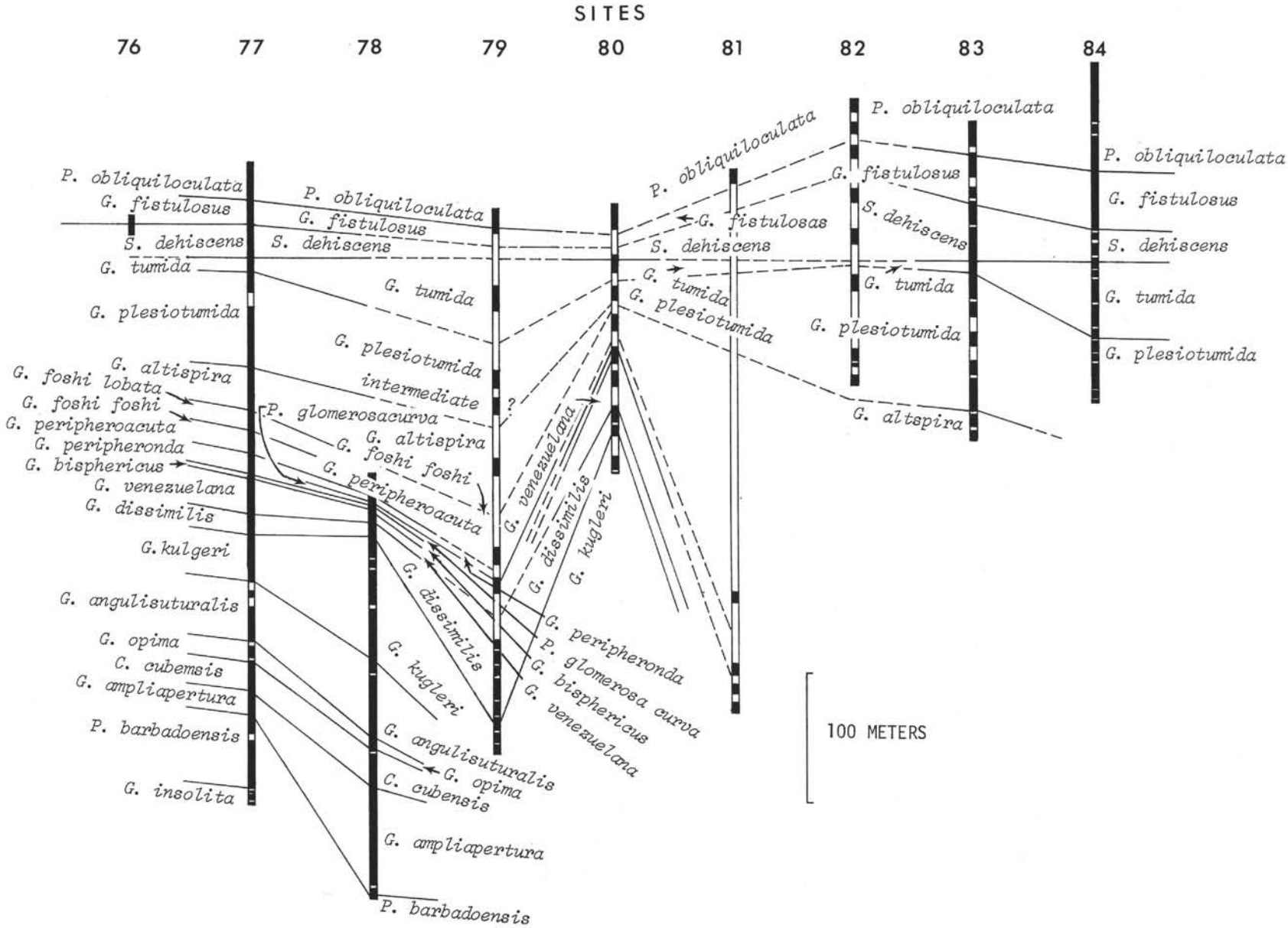


Figure 2. *DSDP Leg 9 foraminiferal zone correlations (cored intervals in black).*

taxon was used to determine the comparative age of the sediment sample. At Site 81 (Core 7, bottom sample) the presence of *H. bermudezi* was used to identify the *G. bisphericus* Subzone.

The initial appearance of *Orbulina* in the area is best explained by assuming that most specimens of both *Orbulina* and *Praeorbulina* from the lower part of the Middle Miocene were removed in solution. For some unexplained reason *O. universa* is relatively common in the Upper Cenozoic but possible explanations are: (1) *Orbulina* developed a more solution resistant test, (2) there was a large increase in the number of specimens in the original ocean in the Upper Cenozoic.

## PLANKTONIC FORAMINIFERAL ZONES

### Introduction

Bolli (1957a, b, c) published a planktonic foraminiferal zonal scheme for the Trinidad Paleocene to Miocene and has subsequently subdivided the Pliocene-Pleistocene into zones (Bolli, 1966; Bolli and Bermudez, 1965; Bolli, 1970). Banner and Blow (1965) and Blow (1969) attempted to modify Bolli's original zonal scheme using an abbreviated letter and number method of naming the zones which is unacceptable to existing stratigraphic codes.

When zonal markers, which were used originally to define both the zones and zonal boundaries, are absent or are very rare in sediment sequences, the biostratigraphic zones become unworkable or even unrecognizable units. Some of the zones proposed by Bolli (1957a), Banner and Blow (1965) and Blow (1969) were not recognizable in sediment sequences obtained on Leg 9 in the tropical eastern Pacific. Examples include the *Globorotalia truncatulinoides* Zone ("N22-23") and *Globorotalia tosaensis* Zone ("N21") of Banner and Blow (1965) and Blow (1969). Consequently, some new zones have been established for the area examined and some of the zones may have further application in deep-sea sediments of the tropical belt (Figure 3). The test of any zonal scheme is that it should be workable and the proposed zonal scheme was thoroughly tested and used for subdividing and correlating Cenozoic sediments obtained on Leg 9.

Most of the zones used on Leg 9 are stratigraphically fairly large units and normally within each zone there are datum horizons which can be used to accurately position a sample within a named zone.

Some of the published zones (for example, Blow, 1969; Berggren, 1969) appear to represent such short time intervals that they should be relegated to subzonal rank. Some of these sub-zones (for example, published zones of the *G. fohsi* lineage) are useful in thick continental shelf deposits but in the condensed sequences from deep-sea-cores they are virtually useless. It is predicted on the basis of existing data that some of the zones established on Leg 9 will be further subdivided into subzones. Included in this category are the Upper Pliocene-Pleistocene *Globigerinoides fistulosus* and *Pulleniatina obliquiloculata* Zones.

According to Hays *et al.* (1969) who examined piston cores from the eastern tropical Pacific, both *Globorotalia truncatulinoides* and *Globorotalia tosaensis* represented only 1 to 2 per cent of the total fauna throughout their observed stratigraphic ranges. At seven sites of Leg 9, both taxa were probably less than 1 per cent of the total fauna, and an explanation for this paucity can be based on their original paleogeographic distribution. *G. truncatulinoides* is abundant in the North Pacific between 20°N and 40°N (Bradshaw, 1959) and it seems likely that both *G. truncatulinoides* and *G. tosaensis* had similar non-tropical distribution in the Pleistocene. Coupled with this postulate is the evidence from Leg 9 that the tests of both species appear to be solution prone which would tend to further reduce the number of fossil specimens.

Other stratigraphically important species were not present in examined samples–not because of their original absence from the Cenozoic oceanic water of eastern Pacific tropical belt but because their tests had gone into solution during descent to the accumulating deep-sea sediments. Examples include *Globigerinoides primordius* Banner and Blow, and the taxa of the *Orbulina* lineage from *Praeorbulina glomerosa curva* to *Orbulina suturalis* were very rare or absent within their known stratigraphic ranges. A list of solution prone taxa is provided with the environmental discussion.

There are a number of biostratigraphic problems which arise because certain taxa are prone to solution in deep oceanic water, and the primary aim of the proposed zonal scheme is to establish the basis of a planktonic foraminiferal zonal scheme for tropical deep-sea sediments. The zonal markers which have been selected appear to be relatively resistant to corrosion and solution.

Existing Cenozoic planktonic foraminiferal zonal schemes for the equatorial region have been mainly established on faunas obtained from continental shelf and slope sediments, thus avoiding the problems of carbonate solution of the tests. Stratigraphically important solution resistant taxa include species of *Globorotalia, Sphaeroidinella, Globoquadrina* and *Pulleniatina*, although there are exceptions. Thus Hays *et al.* (1969) noted the following extinct taxa as solution susceptable species: *Globorotalia margaritae* Bolli and Bermudez, *Globigerina nepenthes* Todd, *Globoquadrina altispira* Cushman and Jarvis and *Globigerinoides fistulosus* (Schubert). While agreeing that the first two species are

| SERIES SUBSERIES | LEG 9 D.S.D.P. PLANKTONIC FORAMINIFERAL ZONES | DEFINITION OF ZONAL BOUNDARIES IA = APPEARANCE E = EXTINCTION | BOLLI 1957 a,b,c 1966, 1970 IN PRESS BOLLI & BERMUDEZ 1966 | BANNER & BLOW (1965) PARKER (1967) BLOW (1969) |
|---|---|---|---|---|
| PLEISTOCENE | *Pulleniatina obliquiloculata* | | *G. truncatulinoides truncatulinoides* | N-22-23 |
| | | *G. fistulosus* (E) | | |
| UPPER PLIOCENE | *Globigerinoides fistulosus* | | *G. truncatulinoides tosaensis* | N-21 |
| | | *G. fistulosus* (IA) | | |
| LOWER PLIOCENE | *Sphaeroidinella dehiscens* | | *G. exilis/ G. miocenica* | N-19-20 |
| | | *S. dehiscens (IA)* | | |
| UPPER MIOCENE | *Globorotalia tumida* | | *G. margaritae* | N-18 |
| | | *G. tumida* (IA) | | |
| | *Globorotalia plesiotumida* | | *G. dutertrei– G. obliquus extremus* | N-17 |
| | | *G. plesiotumida (IA)* | | |
| MIDDLE MIOCENE | *Globoquadrina altispira* | | *G. acostaensis G. fohsi lobata* | N-12-16 |
| | | *G. fohsi lobata* (E) | | |
| | *Globorotalia fohsi lobata* | | *G. fohsi lobata* | N-10-11 |
| | *Globorotalia fohsi fohsi– Globorotalia peripheroacuta* | *G. foshi lobata* (IA) | *G. fohsi fohsi G. fohsi barisanensis* | |
| | | *G. peripheroacuta* (IA) | | |
| | *Globorotalia peripheroronda* | | | N-9 |
| | *Praeorbulina glamerosa curva subzone* | *P. glomerosa curva* (IA) | *G. insueta* | N-8 |
| | *Globigerinoides bisphericus subzone* | *P. glomerosa curva* (IA) | | N-7 |
| LOWER MIOCENE | *Globoquadrina Venezualana* | *P. glomerosa curva* (IA) | | |
| | *Globigerinita dissimilis* | | *G. dissimilis (E) C. dissimilis* | N-5-6 |
| | | *G. kugleri* (E) | | |
| | *Globorotalia kugleri* | | *G. kugleri* | N-4 |
| | | *G. kugleri* (IA) | | |
| UPPER OLIGOCENE | *Globigerina angulisuturalis* | | *G. ciperoensis ciperoensis* | N-3 |
| | | *G. opima* (E) | | |
| | *Globorotalia opima* | | *G. opima opima* | N-2 |
| | | *C. cubensis* (E) | | |
| | *Chiloguembelina cubensis* | | | |
| | | *G. opima* (IA) | | |
| | *Globigerina ampliapertura* | | *G. ampliapertura* | N-1 |
| | | *P. barbadoensis* (E) | | |
| LOWER OLIGOCENE | *Pseudohastigerina barbadoensis* | | *C. chipolensis H. micra* | P-18-19 |
| | | *G. insolita* (E) | | |
| UPPER EOCENE | *Globorotalia insolita* | | *G. cerroazulensis* | P-17 |

Figure 3. *Correlation of Leg 9 Foraminiferal Zones.*

comparatively rare in sediments examined on Leg 9, both *G. altispira* and *G. fistulosus* were usually common and well-preserved.

### Accuracy Control

Accuracy of Cenozoic biostratigraphic correlation by means of planktonic foraminifera is dependent on a number of qualitative methods and is also dependent on a number of assumptions. An important aspect of the methods includes the accurate and consistent identification of taxa used for correlation. This is normally qualitative and therefore subject to operator interpretation and errors. Although it is possible for one operator to be consistently right or wrong regarding an identification of a taxon throughout its stratigraphic range, it was possible on Leg 9 to harmoniously have two operators and thus the taxonomic identifications were constantly checked.

Some of the assumptions used in the inter-site correlations on Leg 9 include:

A blanket-assumption that within their known stratigraphic ranges certain well-documented taxa had been widely distributed in the upper oceanic layers of the examined area of the eastern equatorial Pacific. It was further assumed that the phylogenetic events used in inter-site correlation had been widespread synchronous events.

This relatively uncomplicated and over-simplified model had to be modified because it was complicated by further assumptions that the oceanic current pattern had remained fixed and unchanging from the Upper Eocene to Pleistocene: for example, the equator and the related equatorial currents had been in a constant position.

A further complication is envisaged: if it is accepted that there has been sea-floor spreading during the Upper Eocene to Pleistocene then parts of the sea floor have moved under different water masses which could have contained slightly different faunas and, also, the sea floor moved under different areas of productivity at different times.

There is some evidence that some taxa have not been uniformly distributed within the east-west equatorial belt traversed on Leg 9. This appears to be especially true for the Pliocene-Pleistocene: for example, *Pulleniatina spectabilis* was limited to the western Site 77B, and *Globorotalia inflata* and *G. pachyderma* were only found in the eastern Sites 83 and 84 except for one record of *G. inflata* at Site 77. It is therefore possible that known climatic changes affected the distribution of faunas in the Pliocene-Pleistocene.

An additional complication is the apparent selective action of solution on foraminiferal tests which could explain the interrupted stratigraphic record of a particular species at one or more localities (see Site Range Charts). Although certain taxa were probably originally present in the oceanic water overlying Sites 77 and 78 (see map), some calcium carbonate tests were apparently selectively removed into solution in the lower part of the Middle Miocene at Site 77, as compared with Site 78 which are kilometers apart (see Figure 1). Alternative explanations include (1) a complicated distribution pattern of taxa in the examined area and (2) a large hiatus at Site 77. Neither explanation is acceptable because the first one is too special, and in the second the sediments appear to be present over the critical time interval but some of the taxa are missing.

Within the resolution of accuracy of the foraminiferal zonal scheme it was not possible to detect and differentiate Recent faunas from Pleistocene faunas in the uppermost core samples at the various sites.

### Zonal Parameters and Characteristics

*Pulleniatina obliquiloculata* **Zone**

**Definition:**
*Top:* Not defined, but the zone includes all faunas above the extinction of *Globigerinoides fistulosus* (Schubert).
*Base:* Extinction of *Globigerinoides fistulosus* (Schubert).

**Age:** Pleistocene-Recent.

**Taxa:**

*Extinctions within zone:*

| | |
|---|---|
| *Globigerina praedigitata* | *Globorotalia humerosa* (in lower part of zone) |
| *Globigerinoides bolli* | *G. tosaensis* |
| *G. obliquus* (in lower part of zone) | *Pulleniatina primalis* |

*Initial appearances within zone:*

| | |
|---|---|
| *Globorotalia fimbriata* | *Hastigerina pelagica* |
| *G. pachyderma* | *H. rhumbleri* |

*Species present and ranging throughout zone:*

| | |
|---|---|
| *Candeina nitida* | *Globorotalia crassaformis* |
| *Globigerina bradyi* | *G. crassula* |
| *Globigerina bulloides* | *G. dutertrei* |
| *G. calida* | *G. hirsuta* |
| *G. digitata* | *G. inflata* |
| *G. falconensis* | *G. menardii* |
| *G. juvenilis* | *G. tumida flexuosa* |
| *G. rubescens* | *G. tumida tumida* |
| *Globigerinella aequilateralis* | *G. scitula* |
| | *G. ungulata* |
| *Globigerinoides conglobatus* | *Globorotaloides hexagona* |
| *G. ruber* | *Orbulina universa* |
| *G. sacculifer* | *Pulleniatina obliquilo-* |
| *G. trilobus* | |

*Globoquadrina venezuelana*
*Globigerinita glutinata*
*culata*
*Sphaeroidinella dehiscens*
*Turborotalita humilis*

*Species restricted to zone:*
*Globorotalia fimbriata*
*G. truncatulinoides pachytheca*
*G. truncatulinoides*

**Reference Section:** Site 77B: 00° 28.90′N, 133° 13.70′W.

**Occurrence of Zone:** Continuously cored at Sites 77, 79, 84 and spot cored at Sites 80, 81, 82 and 83 (Figures 1 and 2).

**Potential Subzones:** Based on coiling changes of *P. obliquiloculata.*

**Correlation:** Bolli (1970, Leg 4, in press): *G. truncatulinoides truncatulinoides* Zone.
Banner and Blow (1965), Blow (1969): Broadly equivalent to Zones N22-23.
Parker (1967): Broadly equivalent to Zones N22-23.
International series: Pleistocene-Recent.

### *Globigerinoides fistulosus* Zone

**Definition:**
*Top:* Extinction of *Globigerinoides fistulosus* (Schubert).
*Base:* Initial evolutionary appearance of *Globigerinoides fistulosus* (Schubert).

**Age:** Upper Pliocene.

**Taxa:**
*Extinctions within zone:*
*Globigerina apertura*
*Globigerina decoraperta*
*Globoquadrina altispira*
*Globorotalia exilis*
*G. multicamerata*
*Orbulina bilobata*
*Sphaeroidinella seminulina*

*Initial appearances within zone:*
*Globigerina digitata*
*Globorotalia dutertrei*
*G. inflata*
*G. tosaensis*
*G. ungulata*

*Species present and ranging throughout zone:*
*Candeina nitida*
*Globigerina bulloides*
*G. calida*
*G. juvenilis*
*Globigerinoides conglobatus*
*Globigerinella aequilateralis*
*G. obliquus*
*G. ruber*
*G. trilobus*
*Globigerinita glutinata*
*Globoquadrina venezuelana*
*Globorotalia crassaformis*
*G. crassula*
*G. hirsuta*
*G. humerosa*
*G. inflata*
*G. sacculifer*
*G. miocenica*
*G. scitula*
*G. tumida flexuosa*
*G. tumida tumida*
*Globorotaloides hexagona*
*G. menardii*
*Orbulina universa*
*Pulleniatina obliquiloculata*
*P. primalis*
*Sphaeroidinella dehiscens*

*Species restricted to zone:*
*Globigerinoides fistulosus*
Datum Planes Within Zone:
Extinctions of:
*Globoquadrina altispira*
*Globorotalia multicamerata*
*G. exilis*

**Reference Section:** Site 77B: 00° 28.90′N, 133° 13.70′W.

**Occurrence of Zone:** Continuously cored at Sites 77 and 84, and spot-cored at Sites 76, 79, 80, 82 and 83 (Figures 1 and 2).

**Correlation:** Bolli (1970, Leg 4, in press): *G. truncatulinoides* cf. *tosaensis* Zone.
Banner and Blow (1965), Blow (1969): Broadly equivalent to Zone N21.
Parker (1967): Broadly equivalent to Zone N21.
International series: Upper Pliocene.

### *Sphaeroidinella dehiscens* Zone

**Definition:**
*Top:* Initial evolutionary appearance of *Globigerinoides fistulosus* (Schubert).
*Base:* Initial evolutionary appearance of *Sphaeroidinella dehiscens* (Parker & Jones).

**Age:** Lower-Upper Pliocene.

**Taxa:**
*Extinctions within zone:*
*Globigerina nepenthes*
*Globoquadrina dehiscens*
*Globorotalia acostaensis*
*G. cibaoensis*
*G. margaritae*
*G. pseudomiocenica*

*Initial appearances within zone:*
*Globigerina rubescens*
*Globorotalia crassaformis*
*G. hirsuta*
*Pulleniatina obliquiloculata*
*Sphaeroidinella dehiscens*

*Species present and ranging throughout zone:*
*Candeina nitida*
*Globigerina apertura*
*G. bradyi*
*G. bulloides*
*G. calida*
*G. ruber*
*G. sacculifer*
*G. decoraperta*
*G. juvenilis*
*Globigerinella aequilateralis*
*Globigerinoides bolli*
*G. conglobatus*
*G. obliquus*
*G. multicamerata*

*G. trilobus*
*Globigerinita glutinata*
*Globoquadrina altispira*
*G. venezuelana*
*Globigerinita glutinata*
*Globorotalia exilis*
*G. humerosa*
*G. menardii*
*G. miocenica*
*G. pseudomiocenica*
*G. scitula*
*G. tumida flexuosa*
*G. tumida tumida*
*Globorotaloides hexagona*
*Orbulina bilobata*
*Orbulina universa*
*Pulleniatina primalis*
*Sphaeroidinella seminulina*
*S. subdehiscens*

*Species restricted to zone:*
*Globorotalia crassaformis viola*
*Pulleniatina spectabilis*

**Reference Section:** Site 77B: 00° 28.90'N, 133° 13.70'W.

**Occurrence of Zone:** Continuously cored at Sites 77 and 84, and spot cored at Sites 76, 82 and 85 (Figures 1 and 2).

**Potential Subzones:** Based on the total range of *P. spectabilis* in the lower part of *S. dehiscens* Zone at the western Site 77B.

**Correlation:** Bolli (1970, Leg 4, in press): *G. exilis/G. miocenica* Zone–upper *G. margaritae* Zone.
Banner and Blow (1965), Blow (1969): Broadly equivalent to Zones N19-20.
Parker (1967): Broadly equivalent to Zones N19-20.
International series: Lower-Upper Pliocene.

### *Globorotalia tumida* Zone

**Definition:**
*Top:* Initial evolutionary appearance of *Sphaeroidinella dehiscens* (Parker and Jones).
*Base:* Initial evolutionary appearance of *Globorotalia tumida* (Brady).

**Age:** Upper Miocene-Lower Pliocene.

**Taxa:**
*Extinctions within zone:*
*G. merotumida*
*G. plesiotumida*

*Initial appearances within zone:*
*Globigerina apertura*
*G. crassula*
*Globorotalia margaritae*
*G. tumida flexuosa*
*Globorotalia tumida tumida*

*Species present and ranging throughout zone:*
*Candeina nitida*
*Globigerina bulloides*
*Globigerina calida*
*G. decoraperta*
*G. juvenilis*
*G. ruber*
*G. sacculifer*
*G. trilobus*
*Globigerinita glutinata*
*Globoquadrina altispira*
*G. venezuelana*
*G. dehiscens*
*Globorotalia acostaensis*
*Globorotalia anfracta*
*G. cibaoensis*
*G. exilis*
*G. nepenthes*
*G. praedigitata*
*Globigerinella aequilateralis*
*Globigerinoides conglobatus*
*G. obliquus*
*G. humerosa*
*G. menardii*
*G. multicamerata*
*G. pseudomiocenica*
*Globorotaloides hexagona*
*Orbulina bilobata*
*O. universa*
*Pulleniatina primalis*
*Sphaeroidinella seminulina*
*S. subdehiscens*

**Reference Section:** Site 77B: 00° 28.90'N, 133° 13.70'W.

**Occurrence of Zone:** Continuously cored at Sites 77, 83 and 84, and spot cored at Sites 79 and 80 (Figures 1 and 2).

**Correlation:** Bolli (1970, in press): Broadly equivalent to the *G. margaritae* Zone.
Banner and Blow (1965), Blow (1969): Broadly equivalent to Zone N18.
Parker (1967): Broadly equivalent to Zone N18.
International series: Upper Miocene-Lower Pliocene.

### *Globorotalia plesiotumida* Zone

**Definition:**
*Top:* Initial evolutionary appearance of *Globorotalia tumida* (Brady).
*Base:* Initial evolutionary appearance of *Globorotalia plesiotumida* Blow.

**Age:** Upper Miocene.

**Taxa:**
*Extinctions within zone:*
*Globorotalia continuosa*

*Initial appearances within zone:*
*Candeina nitida*
*Globigerinoides conglobatus*
*Globorotalia exilis*
*G. humerosa*
*G. multicamerata*
*G. plesiotumida*
*G. pseudomiocenica*
*Pulleniatina primalis*

*Species present and ranging throughout zone:*
*Globigerina bulloides*
*G. calida*
*G. decoraperta*
*G. juvenilis*
*G. nepenthes*
*G. ruber*
*G. sacculifer*
*G. praedigitata*
*G. woodi*
*Globigerinella aequilateralis*
*Globigerinoides bolli*
*G. obliquus*
*Globorotaloides hexagona*

*G. trilobus*
*Globigerinita glutinata*
*Globoquadrina altispira*
*G. dehiscens*
*G. venezuelana*
*Globorotalia acostaensis*
*G. cibaoensis*
*G. menardii*
*G. merotumida*
*G. miocenica*
*G. scitula*
*Orbulina bilobata*
*Orbulina suturalis*
*O. universa*
*Sphaeroidinella seminulina*
*S. subdehiscens*

**Reference Section:** Site 77B: 00° 29.90′N, 133° 13.70′W.

**Occurrence of Zone:** Continuously cored at Site 77, and spot cored at Sites 79, 80, 82, 83 and 84 (Figures 1 and 2).

**Potential Subzones:** Based on the initial appearance of *Pulleniatina primalis.*

**Correlation:** Bolli (1966, 1970, Leg 4, in press) Bolli and Bermudez (1966): Broadly equivalent to *G. dutertrei-G. obliquus extremus* Zone.
Banner and Blow (1965), Blow (1969): Broadly equivalent to Zone N17.
Parker (1967): Broadly equivalent to Zone N17.
International series: Upper Miocene.

### *Globoquadrina altispira* Zone

**Definition:**
*Top:* Initial appearance of *Globorotalia plesiotumida* Banner and Blow.
*Base:* Extinction of *Globorotalia fohsi lobata.*

**Age:** Middle-Upper Miocene.

**Taxa:**
*Extinctions within zone:*
*Globorotalia siakensis*
*Orbulina suturalis*

*Initial appearances within zone:*
*Globigerina bulloides*
*G. calida*
*G. decoraperta*
*Globorotalia acostaensis*
*G. cibaoensis*
*G. merotumida*
*Orbulina bilobata*
*Sphaeroidinella subdehiscens*

*Species present and ranging throughout zone:*
*Globigerina bradyi*
*G. praedigitata*
*Globigerinella aequilateralis*
*Globigerinoides bolli*
*G. obliquus*
*G. ruber*
*Globigerinita glutinata*
*Globoquadrina altispira*
*G. dehiscens*
*G. venezuelana*
*Globorotalia continuosa*
*G. menardii*
*G. sacculifer*
*G. trilobus*
*O. universa*
*Globorotaloides hexagona*
*Sphaeroidinella seminulina*

**Reference Section:** Site 77B: 00° 28.90′N, 133° 13.70′W.

**Occurrence of Zone:** Continuously cored at Site 77, and spot cored at Sites 79 and the top of the zone penetrated at Site 83 (Figures 1 and 2).

**Potential Subzone:** Based on the initial appearance of *G. merotumida*, although there is evidence that its initial appearance is diachronous within the examined area as for example at Sites 77 and 83.

**General:** The *G. altispira* Zone is a fairly large stratigraphic unit and it was not subdivided on Leg 9 because of the relatively poor faunas in the examined area.

**Correlation:** Bolli (1957a): *G. fohsi robusta-G. mayeri-G. menardii-G. acostaensis* Zones.
Banner and Blow (1965), Blow (1969): Broadly equivalent to Zones N12-16.
Parker (1967): Upper part of *G. altispira* Zone equivalent to Zone N16.
International series: Middle-Upper Miocene.

### *Globorotalia fohsi lobata* Zone

**Definition:**
*Top:* Extinction of *Globorotalia fohsi lobata* Bermudez.
*Base:* Initial evolutionary appearance of *G. fohsi lobata* Bermudez.

**Age:** Middle Miocene.

**Taxa:**
*Extinctions within zone:*
*Globorotalia fohsi fohsi*

*Initial appearances within zone:*
*Globorotalia menardii*

*Species present and ranging throughout zone:*
*Globigerina nepenthes*
*G. juvenilis*
*Globigerinoides bolli*
*G. ruber*
*G. sacculifer*
*G. trilobus*
*Globoquadrina altispira*
*G. dehiscens*
*G. venezuelana*
*Globorotalia continuosa*
*G. siakensis*
*Orbulina universa*
*Sphaeroidinella seminulina*

*Species limited to the zone:*
*Globorotalia fohsi lobata*

**Reference Section:** Site 77B: 00° 28.90′N, 133° 13.70′W.

**Occurrence of Zone:** Continuously cored at Site 77B (Figures 1 and 2).

**General:** *Globorotalia fohsi robusta*, which Bolli (1957a) regarded as the terminal taxon of the *G. fohsi* lineage and which was used as zonal marker in Trinidad, was not identified in the examined area.

**Correlation:** Bolli (1957a): Equivalent to the *G. fohsi lobata* Zone.
Banner and Blow (1965), Blow (1969): Broadly equivalent to the middle part of Zone N12.
International series: Middle Miocene.

### *Globorotalia fohsi fohsi-Globorotalia peripheroacuta* Zone

**Definition:**
*Top:* Initial evolutionary appearance of *Globorotalia fohsi lobata* Bermudez.
*Base:* Initial evolutionary appearance of *Globorotalia peripheroacuta* Banner and Blow.

**Age:** Middle Miocene.

**Taxa:**
*Extinctions within zone:*
*Globigerina foliata*
*Globigerinoides mitra*
*Globorotalia* cf. *minutissima*
*G. peripheroronda*
*G. praemenardii*
*Hastigerinella bermudezi*

*Initial appearances within zone:*
*Globigerina praedigitata*
*Globigerinoides bolli*
*Globorotalia fohsi fohsi*
*G. scitula*
*Orbulina suturalis*
*O. universa*

*Species present and ranging throughout zone:*
*Globigerina bradyi*
*G. juvenilis*
*G. falconensis*
*G. foliata*
*Globoquadrina altispira*
*G. dehiscens*
*G. venezuelana*
*Globorotalia continuosa*
*G. praemenardii*
*Globigerinatella aequilateralis*
*Globigerinoides ruber*
*G. trilobus*
*Globigerinita glutinata*
*G. siakensis*
*Globorotaloides hexagona*
*Orbulina universa*
*Sphaeroidinella seminulina*

*Species limited to zone:*
*Globigerina bulbosa*
*Globorotalia peripheroacuta*
*G.* cf. *miozea*
*G. obesa*

**Reference Section:** Site 77B: 00° 28.90′N, 133° 13.70′W.

**Occurrence of Zone:** Continuously cored at Site 77B, and spot cored at Sites 78, 79, 80 and 81 (Figures 1 and 2).

**Potential Subzone:** Based on the extinction of *G. peripheroacuta.*

**Correlation:** Bolli (1957): Equivalent to the *G. fohsi fohsi* Zone.
Banner and Blow (1965), Blow (1969): Broadly equivalent to the Zones N10 and the lower part of N12.
International series: Middle Miocene.

### *Globorotalia peripheroronda* Zone

**Definition:**
*Top:* Initial evolutionary appearance of *Globorotalia peripheroacuta* Banner and Blow.
*Base:* Initial evolutionary appearance of *Praeorbulina glomerosa curva* (Blow).

**Age:** Middle Miocene.

*Praeorbulina glomerosa curva* Subzone

**Definition:**
*Top:* Extinction of *Praeorbulina glomerosa curva.*
*Base:* Initial evolutionary appearance of *Praeorbulina glomerosa curva.*

**Remarks:** The *P. glomerosa curva* Zone is positioned in the lower part of the *G. peripheroronda* Zone.

**Taxa:**
*Extinctions within zone:*
*Globigerinatella insueta*
*Globigerinoides bisphericus*
*Globorotalia archaeomenardii*
*G. praescitula.*

*Initial appearance within zone:*
*Sphaeroidinella seminulina*

*Species present and ranging throughout zone:*
*Globigerina bradyi*
*G. foliata*
*G. juvenilis*
*G. falconensis*
*Globigerinoides mitra*
*G. ruber*
*G. sacculifer*
*G. trilobus*
*Globigerinita glutinata*
*Globoquadrina altispira*
*G. dehiscens*
*G. venezuelana*
*Globorotalia continuosa*
*G.* cf. *minutissima*
*G. praemenardii*
*G. peripheroronda*
*G. siakensis*
*Globorotaloides hexagona*
*Hastigerinella bermudezi*

*Species limited to zone:*
*Globoquadrina langhiana*
*Globorotalia archaeomenardii*
*Praeorbulina glomerosa circularis*

**Datum planes within zone:**
*Extinction:*
*Globigerinatella insueta*

*Initial appearances:*
*Globorotalia praemenardii*
*Sphaeroidinella seminulina*

**Reference Section:** Site 78: 07° 57.00'N, 127° 21.35'W.

**Occurrence of Zone:** Completely penetrated and continuously cored at Sites 77B and 78, and spot cored at Sites 79, 80 and 81 (Figures 1 and 2).

**Correlation:** Bolli (1957a): Equivalent to the upper part of the *G. barisanensis* (= *G. peripheroronda*) Zone. Banner and Blow (1965), Blow (1969): Broadly equivalent to Zone N9.
International series: Middle Miocene.

### *Globoquadrina venezuelana* Zone

**Definition:**
*Top:* Initial evolutionary appearance of *Praeorbulina glomerosa curva* (Blow).
*Base:* Extinction of *Globigerinita dissimilis* (Cushman & Bermudez).

**Age:** Lower Miocene.

*Globigerinoides bisphericus* Subzone

**Definition:**
*Top:* Initial evolutionary appearance of *Praeorbulina glomerosa curva* (Blow).
*Base:* Initial evolutionary appearance of *Globigerinoides bisphericus* Todd.

**Remarks:** The *G. bisphericus* Subzone is positioned in the upper part of the *G. venezuelana* Zone.

**Taxa:**
*Extinctions within zone:*
*Cassigerinella chipolensis*

*Initial appearances within zone:*
*Globigerinatella insueta*
*Globigerinoides bisphericus*
*G. mitra*
*G. ruber*
*G. sacculifer*
*Globorotalia archaeomenardii*
*G. praemenardii*
*Globoroloides hexagona*
*Hastigerinella bermudezi*

*Species present and ranging throughout zone:*
*Globigerina bradyi*
*G. juvenilis*
*G. foliata*
*Globigerinoides obliquus*
*G. ruber*
*G. trilobus*
*Globoquadrina altispira*
*G. dehiscens*
*G. venezuelana*
*Globorotalia continuosa*
*G. peripheroronda*
*G. praescitula*
*G. siakensis*

*Species limited to zone:*
*Globorotalia* cf. *bella*

**Datum planes within zone:**
*Initial appearances:*
*Globigerinoides bisphericus*
*Hastigerinella bermudezi*

**Reference Section:** Site 77B: 00° 28.90'N, 133° 13.70'W.

**Occurrence of Zone:** Continuously cored at Sites 77 and 78, and spot cored at Sites 80 and 81 (Figures 1 and 2).

**Correlation:** Bolli (1957a): Equivalent to the *G. insueta* Zone except for the upper part *G. insueta* Zone above the appearance of *Praeorbulina glomerosa curva.* Banner and Blow (1965), Blow (1969): Broadly equivalent to Zones N7-8.
International series: Upper Aquitanian to Lower Burdigalian: Lower Miocene.

### *Globigerinita dissimilis* Zone

**Definition:**
*Top:* Extinction of *Globigerinita dissimilis* (Cushman and Bermudez).
*Base:* Extinction of *Globorotalia kugleri* Bolli.

**Age:** Lower Miocene.

**Taxa:**
*Extinctions within zone:*
*Globigerina angustiumbilicata*
*Globigerinita dissimilis*
*Globorotaloides suteri*

*Initial appearances within zone:*
*Globigerina foliata*
*Globigerinoides obliquus*
*Globorotalia praescitula*

*Species present and ranging throughout zone:*
*Cassigerinella chipolensis*
*Globigerina bradyi*
*G. juvenilis*
*G. angustiumbilicata*
*Globigerinoides altiperturus*
*Globoquadrina altispira*
*G. dehiscens*
*G. tripartita*
*G. venezuelana*
*Globorotalia continuosa*
*G.* cf. *minutissima*

*G. trilobus*
*Globigerinita glutinata*
*G. peripheroronda*
*G. siakensis*

*Species limited to zone:*
*Globorotaloides stainforthi*

**Reference Section:** Site 79: 02° 33.02′N, 121° 34.00′W.

**Occurrence of Zone:** Continuously cored at Sites 77 and 78, and spot cored at Sites 79 and 80 (Figures 1 and 2).

**General:** Relatively thin development at both Sites 77 and 78 with apparently thicker sequences at both Sites 79 and 80.

**Correlation:** Bolli (1957a): Equivalent to the combined *G. dissimilis* and *G. stainforthi* Zones.
Banner and Blow (1965), Blow (1969): Approximately equivalent to the Zones N5-N6.
International series: Lower Miocene.

### *Globorotalia kugleri* Zone

**Definition:**
*Top:* Extinction of *Globorotalia kugleri* Bolli.
*Base:* Initial appearance of *G. kugleri.*

**Age:** Lower Miocene

**Taxa:**
*Extinctions within zone:*
*Globorotalia nana*

*Initial appearances within zone:*
*Globigerina juvenilis*
*Globigerinoides trilobus*
*Globigerinita glutinata*
*Globoquadrina altispira*
*G. dehiscens*
*Globorotalia peripheroronda*

*Species present and ranging throughout zone:*
*Cassigerinella chipolensis*
*Globigerina angustiumbilicata*
*G. bradyi*
*Globigerinita dissimilis*
*Globoquadrina tripartita*
*G. venezuelana*
*Globorotalia continuosa*
*G.* cf. *minutissima*
*G. siakensis*
*Globorotaloides suteri*
*G. unicava*

*Species limited to zone:*
*Globigerinoides primordius*
*Globorotalia kugleri*
*G. mendacis*

**Datum planes within zone:**
*Initial appearance:*
*Globigerinoides trilobus*

**Reference Section:** Site 78: 07° 57.00′N, 127° 21.35′W.

**Occurrence of Zone:** Continuously cored at Sites 77 and 78, and spot cored at Sites 79 and 80 (Figures 1 and 2).

**Potential Subzones:**

| *Zone* | *Subzones* |
|---|---|
| *G. kugleri* | *G. kugleri-G. trilobus* |
| | *G. kugleri-G. tripartita* |

**General:** Compared with the other zones, the *G. kugleri* Zone has a comparatively large number of initial appearances, which amount to eight in the examined area as compared with seven recorded by Bolli in Trinidad (1957a).

**Correlation:** Bolli (1957a): Equivalent to the *G. kugleri* Zone.
Banner and Blow (1965), Blow (1969): Equivalent to the upper part of Zone N3 and Zone N4.
International series: Lower Miocene: Aquitanian Stage (see Jenkins, 1966b).

### *Globigerina angulisuturalis* Zone

**Definition:**
*Top:* Initial appearance of *Globorotalia kugleri* Bolli
*Base:* Extinction of *Globorotalia opima* Bolli.

**Age:** Upper Oligocene.

**Taxa:**
*Extinctions within zone:*
*Globigerina angulisuturalis*
*G. euapertura*
*G. ouachitaensis*

*Initial appearances within zone:*
*Globigerina bradyi*
*Globorotalia continuosa*

*Species present and ranging throughout zone:*
*Cassigerinella chipolensis*
*Globigerina angustiumbilicata*
*G. euapertura*
*Globigerinita dissimilis*
*Globoquadrina tripartita*
*Globoquadrina venezuelana*
*Globorotalia* cf. *minutissima*
*G. nana*
*G. pseudokugleri*
*G. siakensis*
*Globorotaloides suteri*

**Reference Section:** Site 78: 07° 57.00′N, 127° 21.35′W.

**Occurrence of Zone:** Continuously cored at Sites 77 and 78 (Figures 1 and 2).

**General:** At Site 78, *G. angulisuturalis* ranges from the *C. cubensis* Zone to the upper part of the *G. kugleri* Zone, and its highest frequency is in the *G. angulisuturalis* Zone although it was not found in four of the samples.

**Correlation:** Bolli (1957a): *Globigerina ciperoensis* Zone.
Banner and Blow (1965), Blow (1969): Broadly equivalent to Zone N3.
International series: Upper Oligocene.

### *Globorotalia opima* Zone

**Definition:**
*Top:* Extinction of *Globorotalia opima* Bolli.
*Base:* Extinction of *Chiloguembelina cubensis* (Palmer).

**Age:** Upper Oligocene.

**Taxa:**
*Extinctions within zone:*
*Globorotalia opima*

*Initial appearances within zone:*
*Globorotalia* cf. *minutissima*

*Species present and ranging throughout zone:*

| | |
|---|---|
| *Cassigerinella chipolensis* | *Globigerinita dissimilis* |
| *Globigerina angusti-umbilicata* | *Globoquadrina tripartita* |
| *G. ciperoensis* | *G. venezuelana* |
| *G. euapertura* | *Globorotalia nana* |
| | *Globorotaloides unicava* |

**Reference Section:** Site 77B: 00° 28.90′N, 133° 13.70′W.

**Occurrence of Zone:** Continuously cored at Sites 77 and 78 (Figures 1 and 2).

**Correlation:** Bolli (1957a): Upper part of the *G. opima* Zone.
Banner and Blow (1965), Blow (1969): Broadly equivalent to the upper part of Zone N2.
International series: Upper Oligocene.

### *Chiloguembelina cubensis* Zone

**Definition:**
*Top:* Extinction of *Chiloguembelina cubensis* (Palmer).
*Base:* Initial appearance of *Globorotalia opima* Bolli.

**Age:** Upper Oligocene.

**Taxa:**
*Extinctions within zone:*
*Globigerina ampliapertura*
*G. selli*
*Globorotalia gemma*
*G.* cf. *siakensis*

*Initial appearances within zone:*
*Globorotalia opima*
*G. siakensis*

*Species present and ranging throughout zone:*

| | |
|---|---|
| *Cassigerinella chipolensis* | *Globigerina ouachitaensis* |
| *Chiloguembelina cubensis* | *Globigerinita dissimilis* |
| *Globigerina angulisuturalis* | *Globoquadrina tripartita* |
| *G. angustiumbilicata* | *G. venezuelana* |
| *G. euapertura* | *Globorotalia nana* |
| *G. gortani* | *G.* cf. *siakensis* |
| | *Globorotaloides unicava* |

**Reference Section:** Site 77B: 00° 28.90′N, 133° 13.70′W.

**Occurrence of Zone:** Continuously cored at Sites 77 and 78 (Figures 1 and 2).

**General:** A differently defined *C. cubensis* Zone has previously been used by Lindsay (1969) in South Australia; the lower boundary is defined by the extinction of *Globigerina linaperta* Finlay and the upper boundary is defined by the extinction of *C. cubensis.*

**Correlation:** Bolli (1957a): *G. opima opima* Zone.
Banner and Blow (1965), Blow (1969): Broadly equivalent to the lower part of N2.
International series: Upper Oligocene.

### *Globigerina ampliapertura* Zone

**Definition:**
*Top:* Initial appearance of *Globorotalia opima* Bolli.
*Base:* Extinction of *Pseudohastigerina barbadoensis* Blow.

**Age:** Upper Oligocene.

**Taxa:**
*Extinctions within zone:*
*Globigerina* cf. *angiporoides*
*G. tapuriensis*

*Initial appearances within zone:*
*Globigerina angulisuturalis*

*Species present and ranging throughout zone:*

| | |
|---|---|
| *Cassigerinella chipolensis* | *G. selli* |
| *Chiloguembelina cubensis* | *Globigerinita dissimilis* |
| *Globigerina ampliapertura* | *Globoquadrina tripartita* |

*G. angulisuturalis*
*G. angustiumbilicata*
*G. euapertura*
*G. gortanii*
*Globorotalia gemma*
*Globorotalia nana*
*Globorotalia* cf. *siakensis*
*Globorotaloides suteri*
*G. selli*
*G. tapuriensis*

**Datum planes within zone:**
*Extinction:*
*G. tapuriensis*

**Reference Section:** Site 78: 07° 57.00'N, 127° 21.35'W.

**Occurrence of Zone:** Continuously cored at Sites 77 and 78 (Figures 1 and 2).

**Potential Subzone:** Based on the extinction of *G. tapuriensis.*

**Correlation:** Bolli (1957a): *G. ampliapertura* Zone.
Banner and Blow (1965), Blow (1969): Broadly equivalent to Zone N1.
International series: Upper Oligocene.

### *Pseudohastigerina barbadoensis* Zone

**Definition:**
*Top:* Extinction of *Pseudohastigerina barbadoensis* Blow.
*Base:* Extinction of *Globorotalia insolita* Jenkins.

**Age:** Lower Oligocene.

**Taxa:**
*Extinctions within zone:*
*Globigerina linaperta* n. subsp.
*Pseudohastigerina micra*

*Initial appearances within zone:*
*Cassigerinella chipolensis*
*Globigerina* cf. *angiporoides*
*G. euapertura*
*G. gortanii*
*G. selli*
*G. tapuriensis*
*Globoquadrina tripartita*
*G. venezuelana*
*Globorotalia* cf. *siakensis*

*Species present and ranging throughout zone:*
*Chiloguembelina cubensis*
*Globigerina ampliapertura*
*G. angustiumbilicata*
*Globigerinita dissimilis*
*Globorotalia gemma*
*G. nana*
*Globorotaloides suteri*

*Species limited to zone:*
*Pseudohastigerina barbadoensis*

**Potential datum planes within zone:**

| *Extinction:* | *Initial appearances:* |
|---|---|
| *P. micra* | *Cassigerinella chipolensis* |
| | *Globigerina euapertura* |
| | *G. gortanii* |
| | *G. selli* |
| | *G. tapuriensis* |

**Reference Section:** Site 77B: 00° 28.90'N, 133° 13.70'W.

**Occurrence of Zone:** Continuously cored at Site 77B, and spot cored at Site 78 (Figures 1 and 2).

**Potential Subzone:** Based on initial appearance of *G. euapertura.*

**General:** *P. barbadoensis* was found to be fairly common within its zone, although in some samples it appeared to be missing (see range chart).

**Correlation:** Bolli (1957a): Upper *G. cerroazulensis* Zone-lower *G. ampliapertura* Zone.
Banner and Blow (1965), Blow (1969): Broadly equivalent to Zone P19.
International series: Upper Eocene-Lower Oligocene.

### *Globorotalia insolita* Zone

**Definition:**
*Top:* Extinction of *Globorotalia insolita* Jenkins.
*Base:* Not defined and it is considered that at Site 77B, only the uppermost part of the zone was penetrated.

**Age:** Upper Eocene.

**Taxa:**
*Species present and ranging throughout upper part of zone:*
*Chiloguembelina cubensis*
*Globigerina ampliapertura*
*G. linaperta* n. subsp.
*Globigerinita dissimilis*
*Globorotalia gemma*
*G. insolita*
*G. nana*
*Globorotaloides suteri*
*G. unicava*
*Pseudohastigerina micra*

**Reference Section:** Site 77B: 00° 28.90'N, 133° 13.70'W.

**Occurrence of Zone:** Spot cored at Site 77B (Figures 1 and 2).

**General:** The zonal marker was first described from the upper half of the Upper Eocene *Globigerina linaperta* Zone in New Zealand (Jenkins, 1966a). The planktonic foraminiferal fauna found in the *G. insolita* Zone is limited to only ten taxa and the explanation for such a relatively low diversity is not obvious.

**Correlation:** Bolli (1957a): Broadly equivalent to the *G. cerroazulensis-G. semiinvoluta* Zones (in part).
Banner and Blow (1965), Blow (1969): Broadly equivalent to Zones P17 (?)-18.
International series: Upper Eocene.

## PALEOENVIRONMENTS

### Introduction

While working on age determinations of faunas and intersite correlations on Leg 9 a number of additional phenomena were noticed with respect to foraminiferal specimens and their stratigraphic and spatial distributions. The presence of two individuals aboard the *Glomar Challenger* Leg 9 with primary interests in foraminifera provided the necessary time to study some of these phenomena aboard ship as well as later at shore laboratories. This additional work may be divided into three parts. The first includes the assembly and structuring of a new zonal scheme for Leg 9. The second portion includes the systematic section with illustrations by scanning electron microscope and additional observations on all of the planktonic foraminiferal species. The final portion includes a consideration of the environmental phenomena.

### Environments

A primary departure from the DSDP paleontologic routine on Leg 9 was the establishment and utilization of a foraminiferal zonal scheme other than that offered with the Core Description Manual: Part VII, based on Banner and Blow (1965) and Blow (1969). The latter zonal scheme seems to be a modification of Bolli's (1957a,b,c) zonation of Tertiary sediments of Trinidad. Deep-sea sediments encountered on Leg 9 differ from Caribbean sediments considerably with respect to the foraminiferal faunal content. Probably two of the more important disparities between Caribbean and Eastern Pacific sediments are to be found in the varying apparent paleodepth and the chemical and physical characteristics of the overlying water masses. Difficulty in assigning Blow's "N" and "P" zonal numbers to the Eastern Pacific sediments was most intense in the deepest sediments on the western part of the leg. These sediments were encountered at the outset of the leg, and it was soon apparent that a new or modified zonation would have to be introduced in order to submit meaningful correlation data to the future cruise program. Analysis of our zonation as well as that of Bolli (1957) and Blow (1969) in light of the growing literature on deep sea solution of biocarbonates has convinced us that one of the major shortcomings of Blow's zonal scheme in the Eastern Pacific lies in its failure to anticipate the effects of solution on the zonal indices.

### Solution

The most authoritative work to date on the destructive solution of planktonic foraminifera is that of Berger (1967, 1968 a,b, 1970 a). It is fortuitous that Berger's latest paper (1970a) deals with solution of foraminifera in water masses overlying the East Pacific Rise in the area traversed by the *Glomar Challenger* during Leg 9. It should be borne in mind that this discussion is not meant to be a definitive treatment of diversity and solution for Leg 9 foraminiferal faunas. Diversity figures presented here are the product of faunal counts made at all hours of the day and night, aboard ship, by two individuals in varying states of fatigue. Occasionally during the continuous coring procedure only zonal species were counted in a fauna. In these few cases, the remainder of the "background fauna" was later tabulated either aboard ship between sites or later in shore laboratories. Nonetheless, all of these factors contributed more to a qualitative rather than quantitative treatment of the phenomena. Time restrictions in the publication schedule prohibited further work and refinement of these data for the Initial Core Description. It is our desire here to point out some interesting trends and suggest some comparisons with published data to stimulate further research.

For the purpose of discussion, we will distinguish three "states" of solution to which any given foraminiferal fauna may have been subject. "Initial" solution is a condition recognized more by negative evidence than by positive. Under this condition, a particular portion of the fauna has been selectively dissolved, and the remainder of the fauna exhibits little evidence of solution. Species destroyed under this condition are largely the spinose and thin-walled types (for example, *Globigerina* spp., *Globigerinoides* spp.). Faunas that have been subject to this initial solution only very rarely exhibit definite signs of solution, such as partially dissolved tests, and the spinose and delicate species are usually totally absent. The intermediate stage of intensity in destructive solution seems to be the easiest to recognize as individuals remaining bear visible evidence of solution. In this latter stage of solution, all small thin-walled or juvenile individuals are destroyed as are most or all spinose types. In addition even robust individuals that have resisted total solution usually have partially dissolved penultimate and ultimate chambers in their tests (for example, *Globorotalia* spp., *Globoquadrina* spp.). "Total" solution signifies the complete removal of the foraminifera. Intervals that exhibit total solution in Leg 9 cores cannot be considered to reflect a local abatement of biologic productivity because, as Berger has observed elsewhere (1970), the remainder of the fossil fauna and flora be it nannoplankton, phytoplankton or Radiolaria do not exhibit a similar waning productivity.

Foraminiferal species have been ranked by various authors with respect to their susceptibility to solution. The hierarchies thus proposed which rank species from low to high resistance have been based on various lines of evidence including observational data from sediments (Schott, 1935), data from field experiments (Berger, 1967) and laboratory experimental data (Berger, 1970).

Because little published data is available on the southeast Pacific biota with respect to annual productivity, there is no way of distinguishing between truly rare foraminiferal species and solution susceptible species in a given geographic area. Two papers on living foraminifera (Parker, 1960 and Bradshaw, 1959) give an approximation of the frequency of Holocene species. Berger's (1970) (Table 1) ranking of Holocene species with respect to susceptibility to solution seems to most closely approximate results obtained on Leg 9 for Pliocene, and Pleistocene faunas.

**TABLE 1**
**Hierarchy of Resistance to Solution**
**(after Berger, 1970)**

| | | |
|---|---|---|
| Low Resistance | 1 | *Globigerinoides ruber* |
| | 2 | *Orbulina universa* |
| | 3 | *Globigerinella aequilateralis* |
| | 4 | *Globigerina rubescens* |
| | 5 | *Globigerinoides sacculifer* |
| | 6 | *Globigerinoides tenellus* |
| | 7 | *Globigerinoides conglobatus* |
| | 8 | *Globigerina bulloides* |
| | 9 | *Globigerina quinqueloba* |
| | 10 | *Globigerinita glutinata* |
| | 11 | *Candeina nitida* |
| | 12 | *Globorotalia hirsuta* |
| | 13 | *Globorotalia truncatulinoides* |
| | 14 | *Globorotalia inflata* |
| | 15 | *Globorotalia cultrata* |
| | 16 | *Globoquadrina dutertrei* |
| | 17 | *Globigerina pachyderma* |
| | 18 | *Pulleniatina obliquiloculata* |
| | 19 | *Globorotalia crassaformis* |
| | 20 | *Sphaeroidinella dehiscens* |
| | 21 | *Globorotalia tumida* |
| High Resistance | 22 | *Turborotalia humilis* |

Departures in Leg 9 foraminiferal faunas from the solution susceptibility ranking proposed by Berger (1970) are relatively minor. *Globigerinoides ruber* and *Orbulina universa* were found to be far more common in sediments than their high susceptibility to solution would suggest. Parker and Bradshaw (*ibid*) have, on the other hand, tabulated very high local tropical abundances for both of these species. *Globorotalia inflata, Globorotalia pachyderma* and *Turborotalia humilis* were rare in Leg 9 cores despite their apparent high resistance to solution. However, these latter species, in addition to *Globigerina bulloides,* are all characteristic of Holocene high latitude water masses. Local occurrences of these species have been interpreted elsewhere as evidence of incursions of high latitude water masses.

In keeping with Berger's model, sediments from Leg 9 cores which are characterized as having been subject to "initial" solution usually lack several of the species of *Globigerina* and *Globigerinoides* in Table 1. "Second" stage faunas consist of species of *Sphaeroidinella, Globoquadrina, Pulleniatina* and *Globorotalia* with varying degrees of damage to the test. Faunal diversity moreover follows the solution state very closely.

### Diversity

Diversity of faunas may be the product of several factors including: actual biologic diversity which may fluctuate substantially through time with diversity reductions due to predepositional, penecontemporaneous and post-depositional solution. Increase in diversity may result from undetected contamination, but the effects of contamination were easily recognized on Leg 9, due to a number of characteristics of mixed faunas. Contaminants were found to be almost invariably solution resistant species in both downhole contamination and stratigraphic reworking. Two of the commonest species involved in downhole contamination for example were *Pulleniatina obliquiloculata* and *Globorotalia tumida,* and both species were usually accompanied by pipe-scale in contaminated samples. *Globorotalia kugleri* was common in stratigraphically reworked faunas at Site 76 attesting to its solution resistance.

Lipps (1970) has dealt with the evolution of faunal diversity through time. He noted persistent and coordinated fluctuations in the diversities of several groups of marine plankton, and he suggested an ingenius model with respect to high latitude sea surface temperatures to explain those fluctuations. Leg 9 faunas appear to bear out Lipps' observations to the effect that lowest foraminiferal diversities are found in Oligocene faunas and the highest in the late Miocene and Pliocene. Keeping these underlying primary fluctuations in mind, nevertheless, it is not difficult to distinguish between this primary diversity and low diversity brought about by solution.

### Solution and the Lysocline

Berger (1967) has proposed the term "lysocline" for the level in a marine profile where the maximum change takes place with respect to the solution index. This interface seems to be more useful than "calcium carbonate compensation depth" because it is more easily recognized and measured than the latter level. "Compensation depth" has been defined as the level at which the solution rate depth profile and the rate of

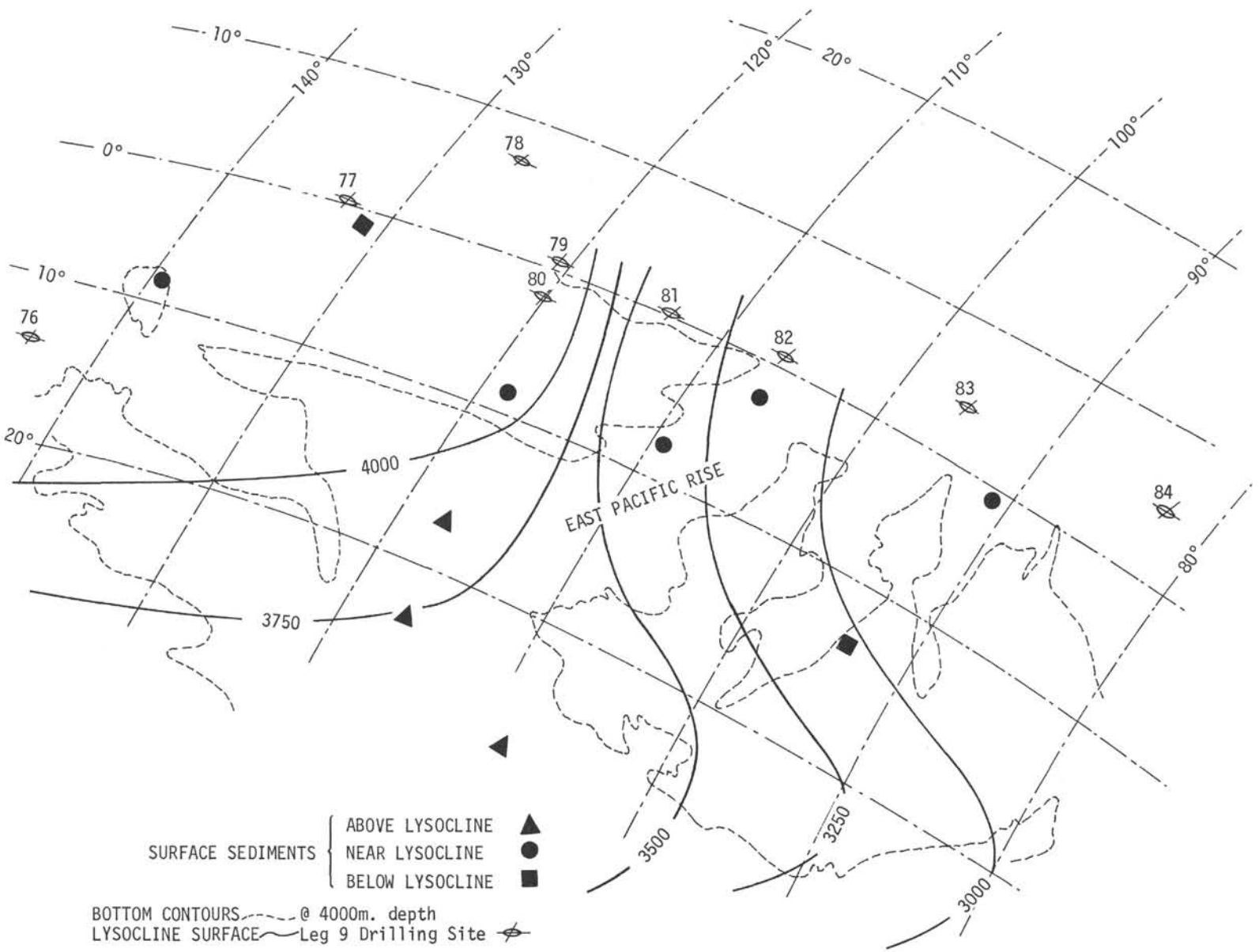


Figure 4. *Lysocline surface in the Southeast Pacific (after Berger 1970).*

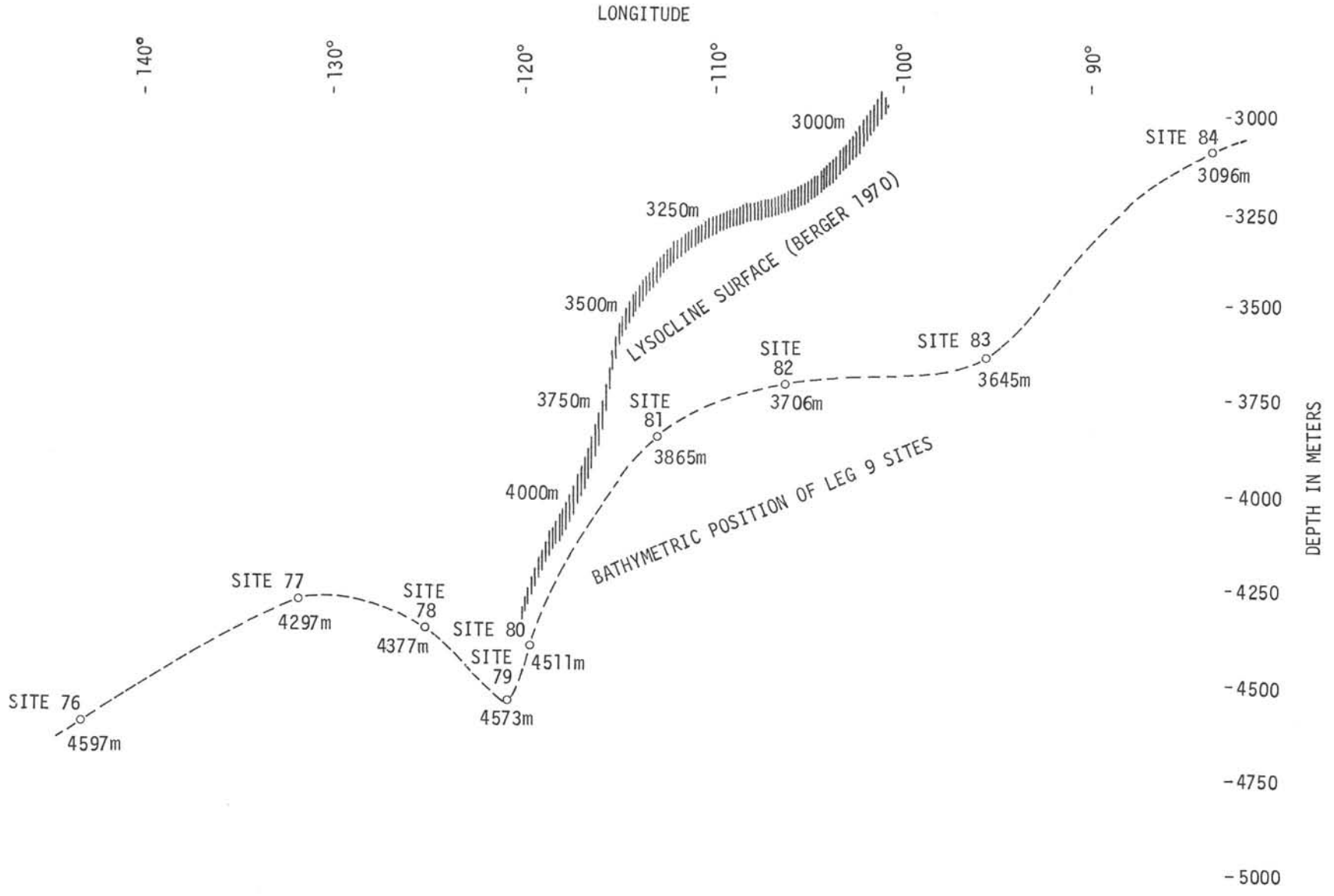


Figure 5. *Bathymetry of Leg 9 sites and the lysocline in the Eastern Equatorial Pacific.*

supply of calcium carbonate to the ocean floor are equal. Berger (1968) has related the lysocline to the top of the Antarctic bottom water in the Atlantic, and it seems probable that a similar condition exists in the Pacific. According to Berger (1970) the entire Pacific Ocean is in an undersaturated condition with respect to calcium carbonate except for the uppermost few hundred meters. Berger (1970) has used data supplied by Blackman (1966) to postulate the lysocline surface in the southeast Pacific. The lysocline (Figures 4 and 5) takes the shape of a quarter bowl over the East Pacific Rise and opens toward the west. By superimposing the Leg 9 drilling sites on Berger's map (Figure 4), we see that while every site is presently below the lysocline, Sites 79 and 80 display the greatest proximity to this interface. We can see no appreciable change in diversities of Late Pleistocene faunas over the same geographic area, but there are sufficient faunal changes to support Berger's thesis.

By plotting the relative abundances in Leg 9 late Pleistocene intervals for Berger's solution susceptible species, (Table 2) it is seen that almost all of the species exhibit increased abundance toward the east. The most abrupt increases are between Sites 79 and 80. It is also worth noting the ephemeral distribution patterns of some of the indices to important datums used by Blow (1969), for example, *Orbulina* sp., *Globigerinoides* spp., *Candeina* sp., etc. Because we lack experimental data for the specimens, it is difficult to assign relative susceptibility to the tests of extinct species. We may suggest, on the other hand, a short list of species used for zonal parameters that failed empirically in the southeast equatorial Pacific due to apparent high susceptibility to solution. These would include: *Globigerina nepenthes, Globigerina angulisuturalis, Globigerinatella insueta, Globigerinoides primordius, Globorotalia tosaensis, Globorotalia truncatulinoides,* and *Orbulina suturalis.*

**TABLE 2**
**Late Pleistocene Occurrences of Solution Susceptible Species[a]**

| | Sites | | | | | | |
|---|---|---|---|---|---|---|---|
| | 77 | 79 | 80 | 81 | 82 | 83 | 84 |
| 1. *Globigerinoides ruber* | + | \| | + | * | + | * | ● |
| 2. *Orbulina universa* | + | + | * | * | * | * | ● |
| 3. *Globigerinella aequilateralis* | * | \| | + | + | + | * | ● |
| 4. *Globigerina rubescens* | · | · | | | · | \| | + |
| 5. *Globigerionoides sacculifer* | + | + | * | \| | * | * | * |
| 6. *Globigerinoides conglobatus* | + | + | | + | + | + | * |
| 7. *Globigerina bulloides* | · | · | + | | | \| | * |
| 8. *Globigerina quinqueloba* | · | | | | | | |
| 9. *Globigerinita glutinata* | + | · | \| | + | · | * | * |
| 10. *Cadeina nitida* | | | | | | | \| |

Symbols* Absent
Very rare ·
Rare |
Scattered +
Common *
Abundant ●

[a]These values are the product of rapid counts of 50 to 100 specimens where very rare=1 specimen, rare=2-5 specimens, scattered=irregular high and low frequencies through the interval examined, common=up to 10% of the fauna, abundant=10% of the fauna or more.

Berger (1970) has suggested that the lysocline surface itself is related to the upper layer of the Antarctic bottom water. Following this thesis, we might assume that at some time before the Pleistocene, the lysocline should have occupied a lower level in the bathymetric column than at present. This should be displayed by foraminiferal faunas in pre-Pleistocene sediments either as an increase in diversity or in the increased appearance of solution susceptible species. Examination of diversity values for each site (Figure 6) does not show any appreciable increase below the Pleistocene. Diversity instead appears to decrease steadily below the *Sphaeroidinella dehiscens* Zone and drops to near zero in much of the *Globoquadrina altispira* Zone. Similarly, diversity values in much of the *Globoquadrina venezuelana* Zone drop to near zero. These lows in diversity do not correspond to the suggested model by Lipps (1970) and appear to be local to the area under study. Pleistocene and Holocene faunas from sediments in the North Pacific may respond indirectly to physical characteristics of the Antarctic Ocean. As Berger (1970) has previously pointed out, both Nayudu (1964) and Saidova (1965) have observed a marked increase in diversity of North Pacific Pleistocene faunas at approximately the Pleistocene/Holocene interface. This is interpreted by Berger as the result of a marked decrease in solution in the South Pacific over the same time interval. The low diversity high solution intervals of the *G. altispira* and *G. venezuelana* zones of Leg 9 might be interpreted as temporary upward fluctuations in the lysocline. If we examine the faunal diversity by zones (Figure 7), we find that the low diversity intervals are restricted to Sites 77, 78 and 79. Further to the east in Sites 80 through 84 diversities appear to return to "normal" for both of these zones. This seems to imply that these low diversities are the product of intersection of the sediments with the calcium carbonate compensation depth where virtually no calcite is deposited. The diversity values presented here correspond almost perfectly with calcium carbonate percentage curves appearing elsewhere in this report. Intervals of low diversity are invariably also intervals of low calcium carbonate percentage. Similar trends were noted by Arrhenius (1948).

It may be now worth while to try to interpret some of the solution phenomena characteristic of Leg 9 cores with respect to the lysocline and compensation depth. It should be kept in mind that because of the ephemeral nature of the Antarctic water masses and the phenomena of sea floor spreading, pre-Pleistocene marine profiles will bear little relation to the present lysocline. Faunas characterized here as having "initial" solution undoubtedly lie near to just above the lysocline. In these faunas only species with the thin delicate tests–the most solution susceptible species–are removed by the undersaturated waters above the lysocline. For intermediate stage solution, where destruction is apparent both in faunal diversity and physical appearance of solution, the resistant species would imply a proximity to the lysocline, but the sediments bearing such a fauna would certainly lie below the lysocline. "Total" solution faunas would imply deposition of sediments well below the lysocline and undoubtedly near, if not below, the compensation depth. Comparing diversities of faunas from Cenozoic epochs in the geographic area covered in Leg 9, we may thus characterize the individual epochs with respect to the state of solution of their foraminiferal faunas and implied position of the lysocline. The marked vacillation in diversities of the Pleistocene and Pliocene faunas suggests that the lysocline lay very near the bottom (as at present) and periodically intersected the sediments. Miocene sediments appear to have been near to above the lysocline with the exception of the *G. altispira* and *G. venezuelana* Zones when the lysocline intersected the bathymetric profile in an area east of Site 80. Assuming the lysocline existed during the Oligocene and Eocene, it appears to have been sited well below the level of sedimentation, as diversities remain stable throughout both of these epochs.

**Faunal Mixing**

The greatest majority of foraminifera recorded on Leg 9 comprised typical equatorial assemblages with a full complement of characteristics considered requisite for low latitude faunas including high diversity and keeled globorotalids. Faunas with low diversities were shown to be the product of solution, and the few known high latitude indices that did appear in faunas were never common. In discussions of the solution of foraminiferal tests, it was noted that although *Globorotalia pachyderma* and *Globorotalia inflata* are solution resistant species, both appeared to occur increasingly in cores toward the east part of the leg. Other solution resistant species occurred uniformly throughout the leg. A third species which is solution susceptible (*Globigerina bulloides*) also appeared increasingly toward the east, but in a completely different pattern than other solution susceptible species (Figure 8). Parker (1960) and Bradshaw (1959) have both noted that *Globigerina bulloides* appears primarily at high latitudes. In the South Pacific it was also reported in near equatorial waters but this is believed to be due to life at greater depths. *Globorotalia inflata* has been reported by both of the above authors as common in central waters in the Pacific north of latitude 25°N and south of latitude 25°S. *Globorotalia pachyderma* was reported by Bradshaw primarily north of latitude 40°N. Arctic and Antarctic foraminiferal faunas are composed almost entirely of the latter species, and it is extremely rare in temperate or tropical waters.

The plotted distribution of high latitude foraminifera encountered on Leg 9 is illustrated in (Figure 8), and two areas are delineated where high latitude indices

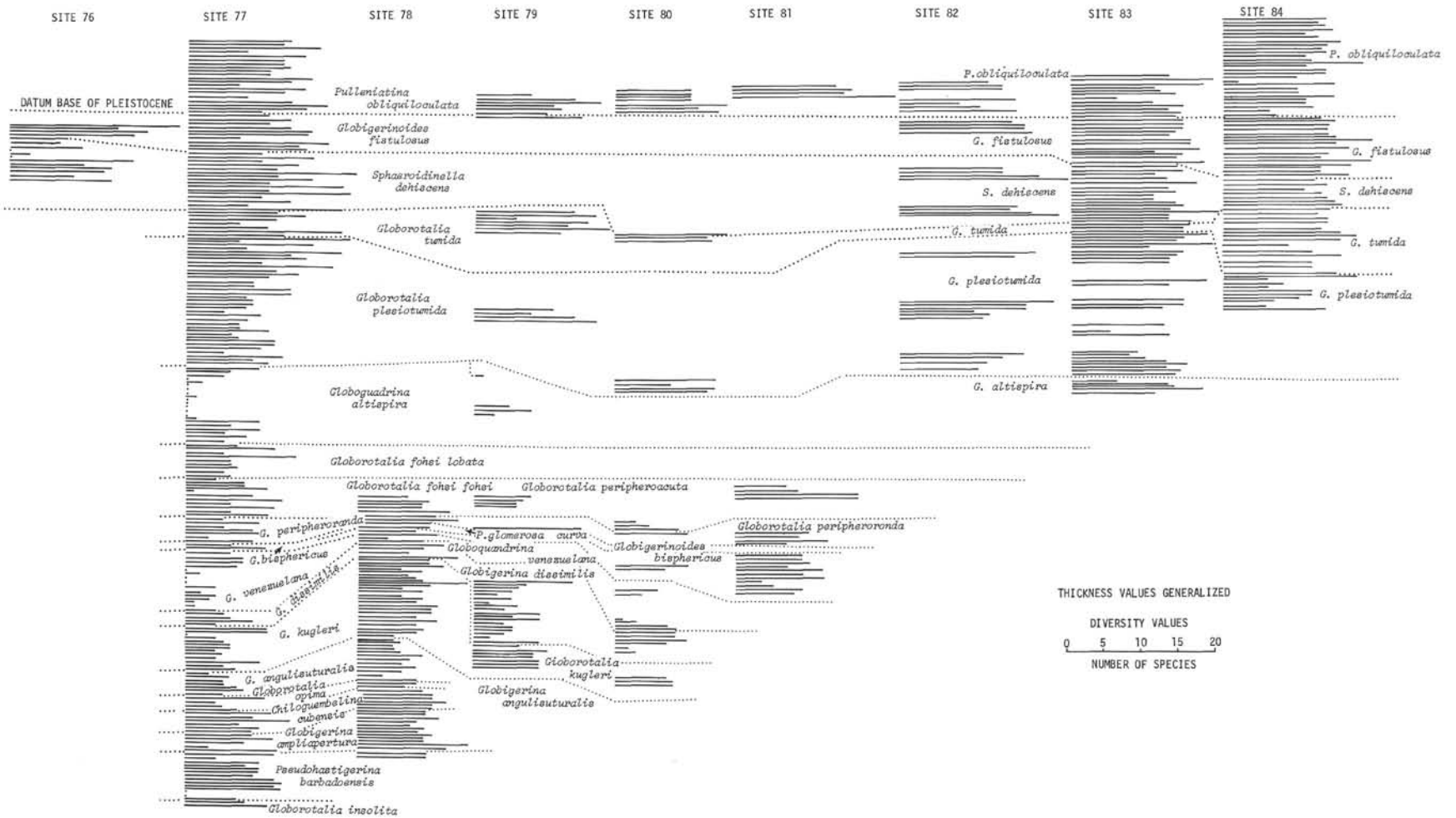


Figure 6. *Diversity values by zone for Leg 9 foraminiferal faunas.*

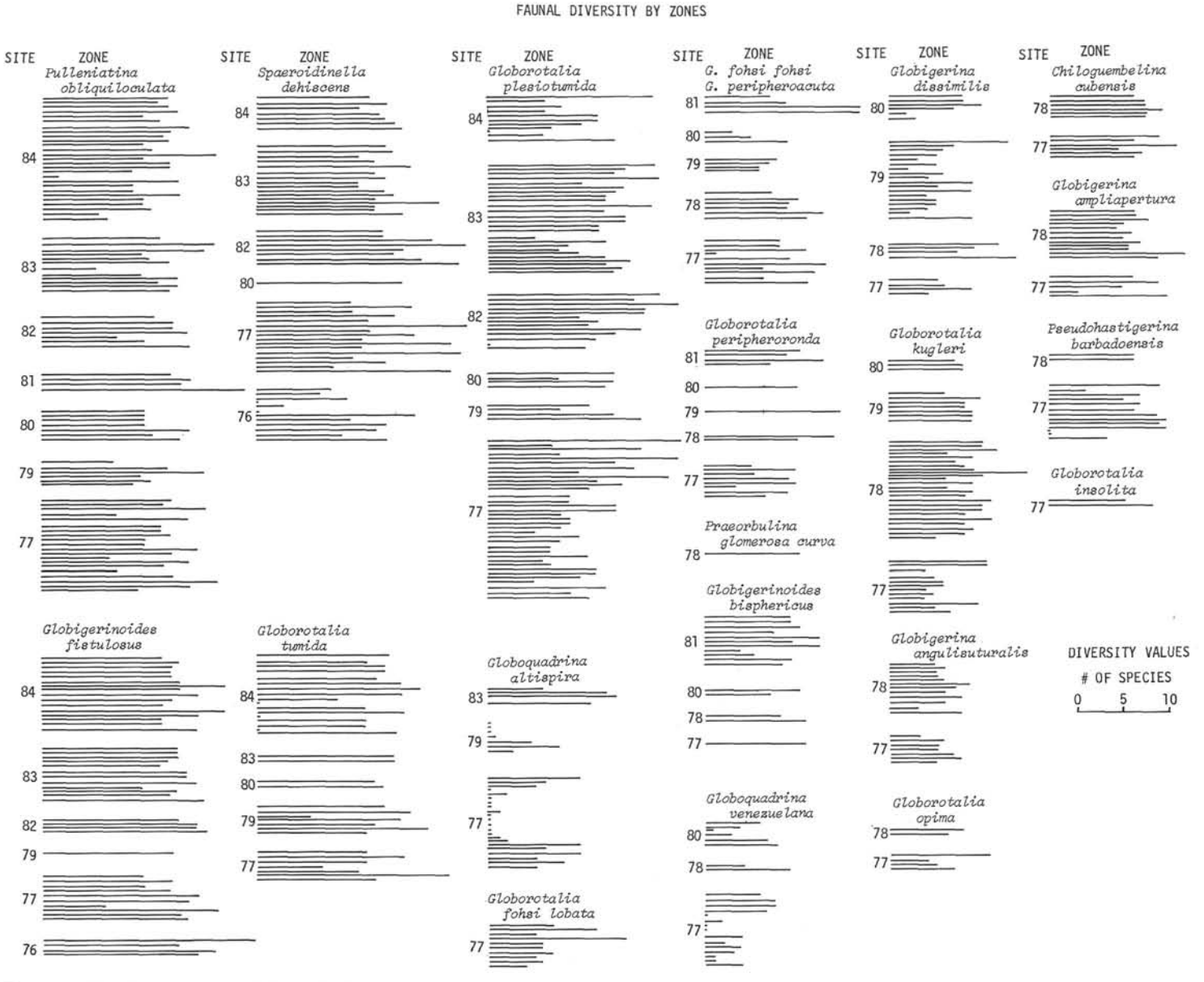


Figure 7. *Distribution of high latitude foraminifera.*

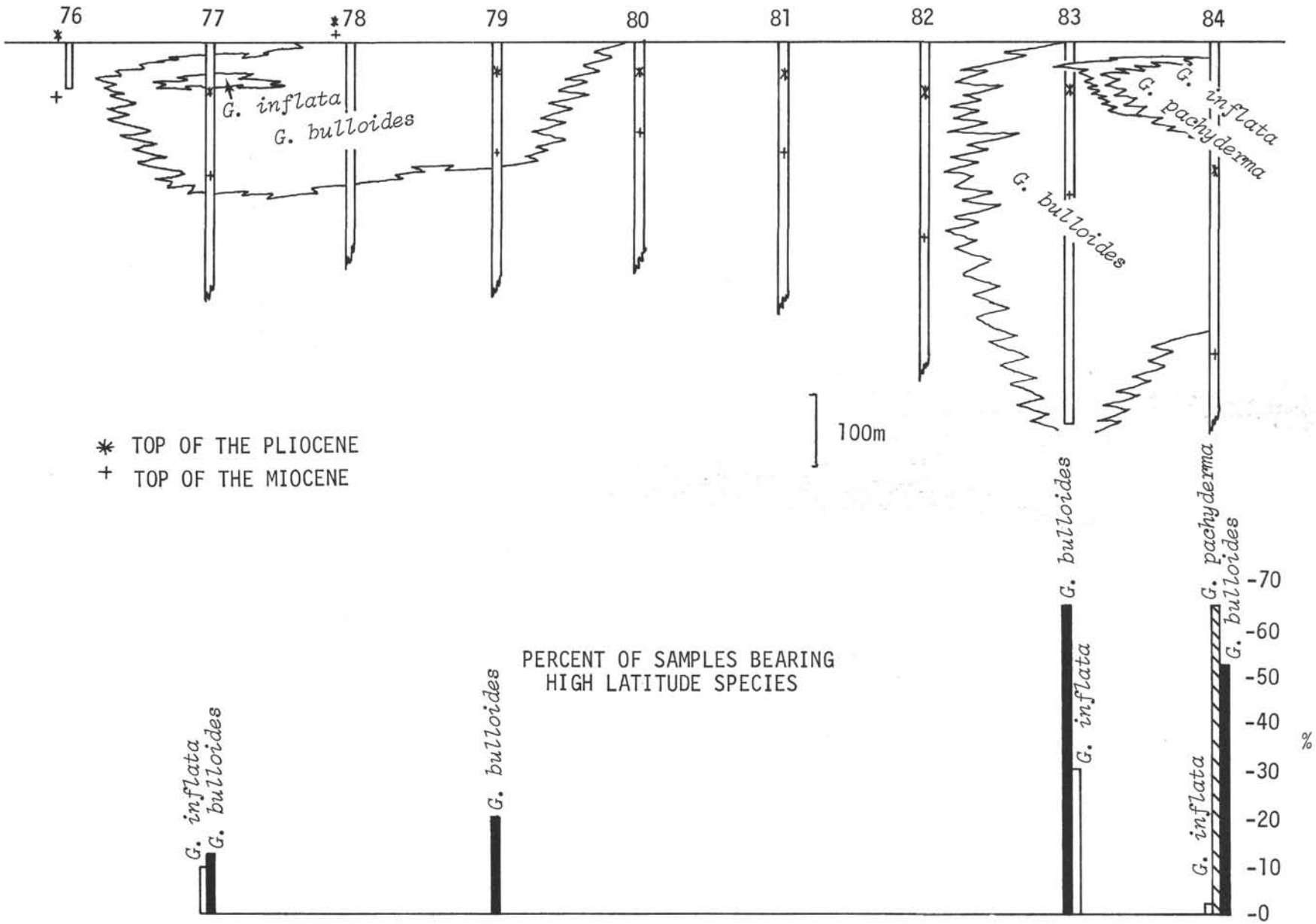


Figure 8. *Distribution of high latitude foraminfera.*

were reported in the eastern and western portions of the leg. The occurrence of these species was not tabulated in counts. Plotting the percentage of samples bearing high latitude indices within the stratigraphic range of each high latitude species in the Pliocene and Pleistocene yields a qualitative picture of the frequency of each of these species (Figure 8). Two of the three species (*G. bulloides* and *G. inflata*) occur in both of the areas but appear in the western sites in only 10 to 20 per cent of the samples within the stratigraphic range of each species. In the eastern sites, not only do all three species occur, but their appearance in samples within their range is as high as 65 per cent. There seems to be sufficient evidence to suggest a slight mixing of allochthonous high latitude faunas with the autochthonous tropical fauna in the area of Sites 77 through 79 during the Pliocene and Pleistocene, and substantial mixing at Sites 83 and 84 during roughly the same time interval.

### Foraminiferal Pigmentation

Two species of foraminifera bearing pigmented tests were recorded from Leg 9 faunas: *Globigerinoides ruber* and *Globigerina rubescens*. Bé and Hamlin (1967) have attributed the pigmentation in *G. ruber* to the organic chemical phenophytin. This chemical is apparently volatile with respect to time and/or diagenetic exposure, as pigmented specimens are rare in pre-Pliocene sediments. Although *G. rubescens* did not appear to exhibit any demonstrable physical disparities between the pigmented and non-pigmented elements of the populations, pigmented specimens of *G. ruber* seemed to be predominantly the smaller specimens in any given population. Color variation in *G. ruber* ranges from deep red through pink and orange, whereas pigmented specimens of *G. rubescens* were invariably a light pink. The ephemeral nature of the pigmenting element in both of these species has been suggested elsewhere (Orr, 1969) as a qualitative indicator of sedimentation rate. Rapid sedimentation rates should preserve more pigmented specimens in a given geographic area.

Stratigraphically, *Globigerinoides ruber* was recorded on Leg 9 primarily within the Pliocene and the Pleistocene from the *Sphaeroidinella dehiscens* Zone to the *Pulleniatina obliquiloculata* Zone inclusive, and sporadically within the Miocene as low as the *Globorotalia kugleri* Zone (Site 78). *Globigerina rubescens* occurred almost completely within the Pleistocene *Pulleniatina obliquiloculata* Zone with rare occurrences in the Pliocene. Because of the susceptibility of both species to solution, they were found predominantly in sediments from the eastern half of the cruise, particularly in Sites 81 through 84. By making a simple tabulation of samples with pigmented specimens to samples without (Figure 9), we discount the increasing eastward abundance of both species and develop a profile of the distribution of pigmented specimens.

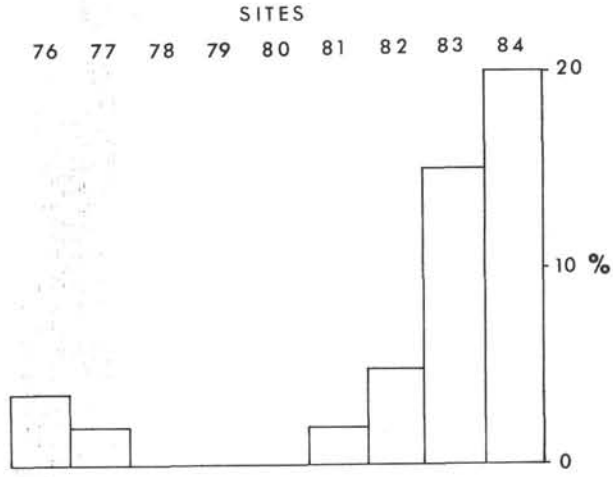


Figure 9. *Percentage of Pliocene-Pleistocene samples with pigmented specimens.*

Although better evidence exists elsewhere to suggest an increasing sedimentation rate in the Pleistocene and Pliocene to the east, these data certainly corroborate that conclusion. Further, this data indicates that the interpretation of isolated samples with high frequencies of pigmented specimens as being the product of high sedimentation rates would not be unreasonable in the light of existing evidence.

## SYSTEMATICS

### Introduction

Genera, species and subspecies have been placed in alphabetical order and every recorded species and subspecies has been treated in the following way–(1) Remarks–relevant comments; (2) Coiling–observations restricted to only a few of the taxa; (3) Stratigraphic occurrence–zonal record at various sites; (4) Stratigraphic range–in terms of both locally recognized zones which have been correlated with series-subseries; (5) Recorded stratigraphic range–published information relevant to the region.

One hundred and twenty-one previously named species and subspecies have been recorded, and most of these have been illustrated by scanning-electron photographs (Plates 1 through 41). A number of specifically unnamed taxa have also been illustrated and some of these are probably new species.

For information regarding original references describing the named taxa, the readers are referred to Ellis and Messina (1940, et. seq.) and for reasonably up-to-date and diverging opinions regarding taxonomic position and synonymies, readers should consult Bolli (1957a, b), Parker (1967) and Blow (1969).

Genus *Candeina* d'Orbigny, 1839

*Candeina nitida* d'Orbigny (Plate 1, Figures 1 through 4):

Remarks: Specimens recovered from the Upper Miocene-Pleistocene at Sites 82, 83 and 84 differ from Holocene specimens in three respects (a) supplementary apertures are twice as large and only half as numerous as in Holocene specimens, (b) the specimens are low-spired forms, and (c) the rate of chamber expansion is very rapid as compared to Holocene forms.

*C. nitida* appears to increase markedly in numbers towards the eastern part of the examined area. This presents a problem of whether it is due to the original paleogeographic distribution of *C. nitida* or whether it is due to shallower holes at Sites 82, 83 and 84.

There is a possible *"C. pre-nitida"* in the *G. tumida* Zone at Site 84.

Stratigraphic occurrence: Site 82: *G. plesiotumida* Zone to *S. dehiscens* Zone. Site 83: *G. plesiotumida* Zone to *G. fistulosus* Zone. Site 84: *G. tumida* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *G. plesiotumida* Zone to *P. obliquiloculata* Zone; Upper Miocene to Pleistocene.

Recorded stratigraphic range: Bolli *et al.* (1957) recorded the range of *Candeina* as Upper Miocene to Recent. Parker (1967) recorded *Candeina nitida* in Indo-Pacific deep-sea cores "throughout the core sequences from Zone N17 to Quaternary".

Genus *Cassigerinella* Pokorny, 1955

*Cassigerinella chipolensis* (Cushman and Ponton) (Plate 1, Figures 5 through 8):

Remarks: *C. chipolensis* was found to be sporadic in occurrence and comparatively rare in the examined area.

No specimens of *Cassigerinella* were found in the Upper Eocene sediments at Site 77, but *C. chipolensis* was found in the Lower Oligocene immediately above the Eocene; and, a specimen from the lowermost Oligocene sample from Site 77 has been illustrated (Plate 1, Figure 8). *C. chipolensis* appears to have become extinct much earlier in the Lower Miocene *G. bisphericus* Subzone in the examined area, as compared with its Middle Miocene extinction in Trinidad (see below).

Stratigraphic occurrence: Site 77: Lower *P. barbadoensis* Zone to *G. kugleri* Zone. Site 78: Lower *G. ampliapertura* Zone to *G. bisphericus* Subzone. Site 79: *G. kugleri* Zone. Site 80: *G. kugleri* Zone to *G. dissimilis* Zone.

Stratigraphic range: Lower *P. barbadoensis* Zone to *G. bisphericus* Subzone; lower Oligocene to upper part of the Lower Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded *C. chipolensis* in the Trinidad Oligocene *G. ampliapertura* Zone to the Middle Miocene *G. fohsi robusta* Zone.

Genus *Chiloguembelina* Loeblich and Tappan, 1956

*Chiloguembelina cubensis* (Palmer) (Plate 1, Figure 9):

Remarks: At Sites 77 and 78, *C. cubensis* became extinct within the stratigraphic range of *Globorotalia opima* Bolli and its extinction level has been used to subdivide the original *G. opima opima* Zone of Bolli (1957a) into an upper *G. opima* Zone and a lower *G. cubensis* Zone. No evidence was found of *C. cubensis* extending above this level except at Site 76 where it occurs reworked in Lower Pliocene sediments and at Site 78 in two isolated samples in the upper *G. kugleri* Zone with reworked *Globigerina angulisuturalis*; similar reworking could explain records of *C. cubensis* above the *C. cubensis* Zone (for example, see Blow, 1969). There are two varieties present in some of the large populations of *C. cubensis* which can be distinguished by the angle formed by two lines joining the edges of the chambers when the test is seen in side view.

In some samples there are very large numbers of *C. cubensis*, as for example at Site 78 in the core-catcher sample of Core 34.

Stratigraphic occurrence: Site 77: *G. insolita* Zone to *C. cubensis* Zone. Site 78: *P. barbadoensis* Zone to *C. cubensis* Zone.

Stratigraphic range: *G. insolita* Zone to *C. cubensis* Zone; Upper Eocene to Upper Oligocene.

Recorded stratigraphic range: Beckmann (1957) recorded the range of *C. cubensis* in Trinidad as Middle Eocene *G. lehneri* Zone to Oligocene *G. opima opima* Zone.

Genus *Globigerapsis*
Bolli, Loeblich and Tappan, 1957

*Globigerapsis* (?) sp. (Plate 2, Figures 1, 2 and 3):

Remarks: A single specimen possibly belonging to *Globigerapsis* was found in the core-catcher sample of Core 48 at Site 77, in the Lower Oligocene *P. barbadoensis* Zone. As can be seen in the illustration (Plate 2, Figure 1), the specimen has two apertures at the base of the final chamber.

Genus *Globigerina* d'Orbigny, 1826

*Globigerina* sp. 1 (Plate 3, Figures 1 through 6):

Remarks: *Globigerina* sp. 1 appears to be related to *G. tapuriensis*, but has a less centrally placed umbilical aperture.

Stratigraphic occurrence: Site 77B, Core 39, Section 4, Top; *G. opima* Zone, Oligocene.

*Globigerina* sp. 2 (Plate 2, Figures 4, 5 and 6):

Remarks: A low apertured form which could be related to *G.* cf. *angiporoides*, but occurs stratigraphically later at Site 77B.

Stratigraphic occurrence: Site 77B, Core 41, core-catcher, *C. cubensis* Zone, Oligocene.

*Globigerina ampliapertura* Bolli (Plate 2, Figures 7, 8 and 9):

Remarks: *G. ampliapertura* is relatively common at both Sites 77 and 78 within its stratigraphic range in the Upper Eocene-Oligocene. Bolli (1957a) showed no overlap between *G. ampliapertura* and *Globorotalia opima opima* Bolli, but this occurs in Oligocene sediments at both Sites 77 and 78.

Stratigraphic occurrence: Site 77: *G. insolita* Zone to *C. cubensis* Zone. Site 78: *P. barbadoensis* Zone to *C. cubensis* Zone.

Stratigraphic range: *G. insolita* Zone to *C. cubensis* Zone; Eocene to Oligocene.

Recorded stratigraphic range: Bolli (1957a,b) recorded *G. ampliapertura* from the Upper Eocene *G. cocoaensis* Zone to the Oligocene *G. ampliapertura* Zone in Trinidad, and Blow and Banner (in Eames *et al.*, 1962) recorded its range in Lindi, Tanganyika from the Upper Eocene *G. turritilina turritilina* Zone to the Lower Miocene *G. ampliapertura* Zone.

*Globigerina* cf. *angiporoides* Hornibrook (Plate 5, Figures 4 and 5):

Remarks: *Globigerina* cf. *angiporoides* differs from *G. angiporoides* in normally having the final chamber slightly larger than the penultimate (whereas, in *G. angiporoides* it is slightly smaller), and also differing in not having the final chamber slightly enveloping and overlapping the antepenultimate chamber as in *G. angiporoides* (see Hornibrook, 1965).

Paleogeographically, *G. angiporoides* was probably a cooler-water form, being most abundant in the New Zealand Upper Eocene-Lower Oligocene (Jenkins, 1966a), and *G.* cf. *angiporoides* is its possible extension into the tropical region.

Stratigraphic occurrence: Site 77: One doubtful record in the *P. barbadoensis* Zone. Site 78: Upper *P. barbadoensis* Zone to lower *G. ampliapertura* Zone.

Stratigraphic range: Upper *P. barbadoensis* Zone to lower *G. ampliapertura* Zone; Oligocene.

*Globigerina angulisuturalis* Bolli (Plate 4, Figures 1 through 4):

Remarks: *G. angulisuturalis* is comparatively rare and has a sporadic occurrence within its Oligocene stratigraphic range at both Sites 77 and 78. Specimens occur high within the *G. kugleri* Zone at Site 78, but these are probably due to reworking because they also occur with reworked *C. cubensis*. There are two isolated records in the *G. ampliapertura* Zone, one record at both Sites 77 and 78: these occurrences could be due to downhole contamination, but there is no evidence for this except that previously published records show its first appearance in the *G. opima opima* Zone. A variety of *G. angulisuturalis* with four chambers in the final whorl from the *G. kugleri* Zone of Site 79 has been illustrated (Plate 4, Figure 4).

Stratigraphic occurrence: Site 77: *G. ampliapertura* Zone to *G. angulisuturalis* Zone. Site 78: *G. ampliapertura* Zone to *G. angulisuturalis* Zone, with one doubtful record in the lower *G. kugleri* Zone. Site 79: *G. kugleri* Zone (specimen with 4 chambers in the final whorl).

Stratigraphic range: *G. ampliapertura* Zone to *G. angulisuturalis* Zone with doubtful records in the *G. kugleri* Zone; Oligocene.

Recorded stratigraphic range: Bolli (1957a) recorded its Oligocene range in Trinidad as *G. opima opima* Zone to *G. ciperoensis ciperoensis* Zone and Banner and Blow (in Eames *et al.*, 1962) recorded a similar stratigraphic range in Lindi, Tanganyika.

*Globigerina angustiumbilicata* Bolli (Plate 4, Figures 5 and 6; Plate 5, Figures 6, 7 and 8):

Remarks: *G. angustiumbilicata* was found to be relatively rare and sporadic in occurrence within its stratigraphic range in the eastern equatorial Pacific, but its total stratigraphic range compares favorably with its Trinidad range (Bolli, 1957a,b).

Stratigraphic occurrence: Site 77: *P. barbadoensis* Zone to *G. kugleri* Zone. Site 78: *G. kugleri* Zone. Site 79: One record in the *G. dissimilis* Zone. Site 80: One doubtful record in the *G. kugleri* Zone.

Stratigraphic range: *P. barbadoensis* Zone to the *G. dissimilis* Zone; Lower Oligocene to Lower Miocene.

Recorded stratigraphic range: Bolli (1957a,b) recorded its range in Trinidad from the Upper Eocene *G. cocoaensis* Zone to Lower Miocene *G. dissimilis* Zone.

*Globigerina apertura* Cushman (Plate 5, Figures 1, 2 and 3):

Remarks: *G. apertura* was found to be rare and sporadic in occurrence within its Upper Miocene-Pliocene stratigraphic range in the examined area. There is some evidence of a close morphological relationship between it and *Globigerina decoraperta* Takayanagi and Saito, as for example in Samples 77B-7-4, 19 to 21 centimeters and 83-5, core catcher. Comparison of the test wall ornamentation supports this hypothesis (see Plate 6, Figures 4, 5 and 6).

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: Upper *G. tumida* Zone to the lower part of the *S. dehiscens* Zone. Site 80: Lower *S. dehiscens* Zone. Site 83: One doubtful record in the *G. fistulosus* Zone. Site 84: Doubtful records from *G. plesiotumida* Zone to *G. fistulosus* Zone.

Stratigraphic range: *G. tumida* Zone to *G. fistulosus* Zone; Upper Miocene to Pliocene.

Recorded stratigraphic range: *G. apertura* was originally described from the Miocene Yorktown Formation of Virginia (Cushman, 1918; fide Ellis and Messina, 1940 *et seq.*). More recently *G. apertura* has been recorded from the Lower Pliocene of New Zealand (Jenkins, 1967).

*Globigerina bradyi* Wiesner (Plate 4, Figures 7, 8 and 9):

Remarks: At Sites 77 and 80, the initial appearance of *G. bradyi* is well up within the *G. kugleri* Zone, which is different from its record in Trinidad by Bolli (1957a) who showed it starting at the base of the *G. kugleri* Zone. At Site 78, its initial appearance is in the upper *G. angulisuturalis* Zone.

Within the examined area at Sites 77 to 80 (inclusive) there are very large numbers of *G. bradyi* within the Lower Miocene *G. kugleri* Zone. In one such large population at Site 79 (Core 13, Section 4, top), many specimens have become triserially coiled.

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: *G. kugleri* Zone to *S. dehiscens* Zone. Site 78: Upper *G. angulisuturalis* Zone to *G. fohsi fohsi-G. peripheroacuta* Zone. Site 79: *G. kugleri* Zone to *G. peripheroronda* Zone. Site 80: *G. kugleri* Zone to *G. venezuelana* Zone. Site 81: *G. bisphericus* Subzone to *G. fohsi fohsi-G. peripheroacuta* Zone. Site 83: One record in the *G. altispira* Zone. Site 84: *P. obliquiloculata* Zone.

Stratigraphic range: *G. angulisuturalis* Zone to *P. obliquiloculata* Zone; Lower Miocene to Pleistocene.

Recorded stratigraphic range: Bolli (1957a) recorded its Miocene range in Trinidad as *G. kugleri* Zone to *G. menardii* Zone. Jenkins (1966, 1967) recorded its range in New Zealand from the Oligocene *G. euapertura* Zone to the Upper Pleistocene part of the *G. inflata* Zone.

*Globigerina bulbosa* Le Roy (Plate 6, Figures 1, 2 and 3):

Remarks: In the examined area there was only one record of *G. bulbosa*, and this was at Site 81. The final chamber in the illustrated specimen is not as elongate and bulbose as illustrated in Le Roy's holotype. (Le Roy, 1944; fide Ellis and Messina, 1940 *et seq.*).

Stratigraphic occurrence: Site 81: One record in the *G. fohsi fohsi-G. peripheroacuta* Zone.

Recorded stratigraphic range: Blow (1959) recorded its range in Venezuela as *G. fohsi lobata* Zone to *S. seminulina* Zone.

*Globigerina bulloides* d'Orbigny (Plate 7, Figures 1, 2 and 3):

Remarks: *G. bulloides* is very rare and sporadic in occurrence with some indication that it is more common in the upper Cenozoic of the eastern sites and the illustrated specimens are from Site 83.

Present distribution in the Pacific indicates that it is more common in higher latitudes (Bradshaw, 1959; Parker, 1962; Kustanowich, 1963).

Stratigraphic occurrence: Site 77: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 78: One doubtful specimen in the *G. kugleri* Zone. Site 79: *G. tumida* Zone to *P. obliquiloculata* Zone, with one doubtful record in the *G. dissimilis* Zone. Site 80: *P. obliquiloculata* Zone. Site 82: Three doubtful records in the *G. plesiotumida* Zone. Site 83: *G. altispira* Zone to *P. obliquiloculata* Zone. Site 84: *G. tumida* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *G. altispira* Zone to *P. obliquiloculata* Zone; Middle Miocene to Pleistocene.

Recorded stratigraphic range: Blow (1959) was able to subdivide *G. bulloides* in the Miocene of Venezuela into *G. praebulloides, G. parabulloides* and *G. bulloides* with the last named having a restricted range of *G. menardii menardii-G. nepenthes* Zone to *G. bulloides* Zone. In New Zealand, Jenkins (1966a, 1967) has recorded the range of *G. bulloides* from the Oligocene *G. angiporoides angiporoides* Zone to the Upper Pleistocene part of the *G. inflata* Zone.

*Globigerina calida* Parker (Plate 7, Figures 4 and 5):

Remarks: *G. calida* was found to be comparatively rare within its stratigraphic range at most sites except at the eastern Site 84, where it was relatively common. A juvenile and a typical adult form have been illustrated (see also Parker, 1967).

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 80: *G. tumida* Zone to *S. dehiscens* Zone. Site 81: *P. obliquiloculata* Zone. Site 82: *S. dehiscens* Zone to *P. obliquiloculata* Zone. Site 83: *G. altispira* Zone to *P. obliquiloculata* Zone. Site 84: *G. tumida* Zone to *P. obliquiloculata* Zone with one doubtful record in the *G. plesiotumida* Zone.

Stratigraphic range: *G. altispira* Zone to *P. obliquiloculata* Zone; Upper Miocene to Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded *G. calida* in Indo-Pacific deep-sea cores from the late Miocene Zone N17 to the Quaternary Zone N23.

*Globigerina ciperoensis* Bolli (Plate 7, Figures 7 and 8):

Remarks: *G. ciperoensis* is rare and sporadic at Site 77, but more common at Site 78. It has a longer stratigraphic range in this area as compared with its Oligocene range in Trinidad (see below).

Stratigraphic occurrence: Site 77: *G. opima* Zone to *G. angulisuturalis* Zone, with two records in the *G. kugleri* Zone which are probably reworked. Site 78: *G. angulisuturalis* Zone to *G. kugleri* Zone.

Stratigraphic range: Upper *G. opima* Zone to *G. kugleri* Zone; Upper Oligocene to Lower Miocene.

Recorded stratigraphic range: In Trinidad Bolli (1957a) recorded its Oligocene stratigraphic range as *G. ampliapertura* Zone to the top of the *G. ciperoensis* Zone.

*Globigerina decoraperta* Takayanagi and Saito (Plate 6, Figures 4, 5 and 6):

Remarks: *G. decoraperta* is relatively rare in the examined area, and it could be a solution prone species. At Site 77 *G. decoraperta* has a slightly shorter stratigraphic range than *Globigerina nepenthes* Todd. In New Zealand there is good evidence that *G. nepenthes* evolved from *G. decoraperta* in the Middle Miocene (Jenkins, 1970), but there was no supporting evidence for this hypothesis in the examined area.

Stratigraphic occurrence: Site 77: *G. altispira* Zone to lower *S. dehiscens* Zone. Site 82: *G. plesiotumida* Zone. Site 83: *G. altispira* Zone to *G. plesiotumida* Zone. Site 84: *G. plesiotumida* Zone to lower *G. fistulosus* Zone.

Stratigraphic range: *G. altispira* Zone to *G. fistulosus* Zone; Upper Miocene to Upper Pliocene.

Recorded stratigraphic range: Takayanagi and Saito (1962) recorded the range of *G. decoraperta* from the Middle-Upper Miocene Nabori Formation of Japan. Jenkins (1967) recorded its range in New Zealand as Middle Miocene *O. suturalis* Zone to the Pleistocene part of the *G. inflata* Zone.

*Globigerina digitata* Brady (Plate 6, Figures 7 and 8):

Remarks: *G. digitata* was comparatively rare in the examined area but occasionally useful as a Pleistocene marker. Its record at Site 83 in the upper *G. fistulosus* Zone could be due to downhole contamination. A juvenile and an adult form have been illustrated (Plate 6, Figures 7 and 8).

Stratigraphic occurrence: Site 77: Upper *P. obliquiloculata* Zone. Site 79: *P. obliquiloculata* Zone. Site 81: *P. obliquiloculata* Zone. Site 82: One doubtful specimen in the *P. obliquiloculata* Zone. Site 83: Upper *G. fistulosus* Zone to *P. obliquiloculata* Zone. Site 84: *P. obliquiloculata* Zone.

Stratigraphic range: Upper *G. fistulosus* Zone to *P. obliquiloculata* Zone; Upper Pliocene to Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded the range of *G. digitata* in Indo-Pacific deep-sea cores as Zones N22, 23 of Quaternary age.

*Globigerina eamesi* Blow (Plate 8, Figures 1, 2 and 3):

Remarks: There is only one record of *G. eamesi* and this at Site 77; its rarity could be explained either by solution effects or that it was restricted to cooler waters in the Cenozoic. The latter may be more likely because it has a much longer stratigraphic range in New Zealand as compared with Venezuela (see Blow, 1959).

Stratigraphic occurrence: Site 77, one record in the upper part of the *G. kugleri* Zone; Lower Miocene.

Recorded stratigraphic range: Blow (1959) first described *G. eamesi* from Venezuela having a range of *G. menardii-G. nepenthes* Zone to *S. seminulina* Zone in the Upper Miocene. In New Zealand it has a much longer stratigraphic range from the Oligocene *G. euapertura* Zone to the Pleistocene part of the *G. inflata* Zone (Jenkins, 1966a, 1967).

*Globigerina* cf. *eamesi* Blow (Plate 8, Figures 4, 5 and 6):

Remarks: A single small spiney specimen of *G.* cf. *eamesi* was found in the *G. angulisuturalis* Zone at Site

77B. It differs from *G. eamesi* in having 5 chambers in the final whorl and an umbilical-extra umbilical aperture.

Stratigraphic occurrence: Site 77B: One record in the *G. angulisuturalis* Zone; upper Oligocene.

*Globigerina euapertura* Jenkins (Plate 9, Figures 1 through 6):

Remarks: *G. euapertura* is fairly common within its stratigraphic range at Sites 77 and 78. *Globigerina praesepsis* Blow is here regarded as a junior synonym of *G. euapertura*; this is based on the range of variation in *G. euapertura.*

Stratigraphic occurrence: Site 77: Lower *P. barbadoensis* Zone to *G. angulisuturalis* Zone. Site 78: Upper *P. barbadoensis* Zone to the lower *G. angulisuturalis* Zone.

Stratigraphic range: Lower *P. barbadoensis* to *G. angulisuturalis* Zone; Oligocene.

Recorded stratigraphic range: Jenkins (1960) recorded the range of *G. euapertura* in a south-east Australian Oligocene sequence as pre-*G. dehiscens* Zone to *G. dehiscens* Zone and in New Zealand from the Oligocene *G. brevis* Zone to the Lower Miocene *G. woodi connecta* Zone (Jenkins, 1966a). Blow and Banner (in Eames *et al.*, 1962) recorded its range in Lindi, East Africa as Upper Eocene *G. turritilina turritilina* Zone to Lower Miocene *G. ciperoensis ciperoensis* Zone.

*Globigerina* cf. *euapertura* (Plate 9, Figures 7, 8 and 9):

Remarks: The specimens from Sites 77, 78 and 79 are somewhat smaller than *G. euapertura*, being about half the normal adult test size. A more detailed study of such features as the wall ornamentation and apertural characters will be necessary to determine whether there is a specific difference. *G.* cf. *euapertura* also has a higher stratigraphic range than *G. euapertura*, although there is an overlap in the Upper Oligocene *G. angulisuturalis* Zone at Site 77.

Stratigraphic occurrence: Site 77: Upper *G. angulisuturalis* Zone to *G. kugleri* Zone. Site 78: *G. kugleri* Zone. Site 79: *G. dissimilis* Zone.

Stratigraphic range: Upper *G. angulisuturalis* Zone to *G. dissimilis* Zone; Upper Oligocene to Lower Miocene.

*Globigerina falconensis* Blow:

Remarks: *G. falconensis* was found to be very rare in the examined area.

Stratigraphic occurrence: Site 77: *G. fohsi fohsi-G. peripheroacuta* Zone to *P. obliquiloculata* Zone. Site 78: One record *G. peripheroacuta* Zone. Site 79: One record *G. peripheroronda* Zone. Site 80: One record of *G. fohsi fohsi-G. peripheroacuta* Zone? Site 81: One record *P. obliquiloculata* Zone. Site 84: One record *P. obliquiloculata* Zone.

Stratigraphic range: *G. fohsi fohsi-G. peripheroacuta* Zone to *P. obliquiloculata* Zone; Middle Miocene to Pleistocene.

Recorded stratigraphic range: Blow (1959) recorded its range in a Venezuelan Miocene sequence as *G. insueta-G. bispherica* Subzone to *G. bulloides* Zone. Parker (1967) recorded its range in Indo-Pacific deep-sea cores as "Zones N. 20, N. 21 and Quaternary".

*Globigerina foliata* Bolli (Plate 7, Figure 6):

Remarks: *G. foliata* was found to be relatively rare and sporadic within its Lower-Middle Miocene stratigraphic range in the examined area.

Stratigraphic occurrence: Site 77: *G. venezuelana* Zone to *G. fohsi fohsi-G. peripheroacuta* Zone. Site 78: *G. dissimilis* Zone to *G. fohsi fohsi-G. peripheroacuta* Zone. Site 79: One doubtful record in *P. obliquiloculata* Zone. Site 80: *G. venezuelana* Zone to *G. peripheroronda* Zone. Site 81: *G. bisphericus* Subzone-*G. fohsi fohsi-G. peripheroacuta* Zone.

Stratigraphic range: *G. dissimilis* Zone to *G. fohsi fohsi-G. peripheroacuta* Zone; Lower to Middle Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded *G. foliata* in Trinidad Miocene from the *C. dissimilis* Zone to the *G. menardii* Zone.

*Globigerina gortanii* (Borsetti) (Plate 7, Figures 9, 10 and 11):

Remarks: Examined specimens are not as high-spired as either the holotype (Borsetti, 1959) or its junior synonym *G. turritilina* recorded by Blow and Banner, in Eames *et al.* (1962).

Stratigraphic occurrence: Site 77: Lower *P. barbadoensis* Zone to the upper *C. cubensis* Zone. Site 78: Upper *P. barbadoensis* Zone into the *C. cubensis* Zone, with questionable specimens in the *G. opima* Zone.

Stratigraphic range: Lower *P. barbadoensis* Zone to *C. cubensis* Zone; Oligocene.

Recorded stratigraphic range: Banner and Blow (*ibid.*) recorded the *G. gortanii* (as *G. turritilina*) range in Lindi, East Africa from the Upper Eocene *G. turritilina turritilina* Zone to the *G. oligocaenica* Zone.

*Globigerina juvenilis* Bolli (Plate 10, Figures 1 through 5):

Remarks: *G. juvenilis* is closely related to *Globigerinita glutinata* but differs from it in not possessing a bulla (see Plate 17, Figure 1); and within the Lower Miocene-Pleistocene in the examined area, *G. juvenilis* was found to be fairly common. Forms with the normal umbilical aperture and forms with additional apertures on the spiral side have been illustrated from a Pleistocene sample from Site 84.

Stratigraphic occurrence: Site 77: Upper *G. kugleri* Zone to *P. obliquiloculata* Zone. Site 78: *G. kugleri* Zone to *G. peripheroronda* Zone, with one isolated record in the *G. augulisuturalis* Zone which is probably due to downhole contamination. Site 79: *G. kugleri* Zone to *G. dissimilis* Zone. Site 80: *G. kugleri* Zone to *G. venezuelana* Zone. Site 81: *G. fohsi fohsi-G. peripheroacuta* Zone to *P. obliquiloculata* Zone. Site 82: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 83: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 84: *G. plesiotumida* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *G. kugleri* Zone to *P. obliquiloculata* Zone; Lower Miocene to Pleistocene.

Recorded stratigraphic range: Bolli (1957a) recorded its Miocene range from the *G. kugleri* Zone to the *G. menardii* Zone. In New Zealand its first appearance has been recorded earlier, in the Oligocene *G. euapertura* Zone (Jenkins, 1966a) and ranges through to the Upper Pleistocene part of the *G. inflata* Zone (Jenkins, 1967).

*Globigerina linaperta* Finlay n. subsp. (Plate 10, Figures 6, 7 and 8):

Remarks: The main morphological difference between *G. linaperta* n. subsp. and *G. linaperta linaperta* is that it possesses rounded uncompressed chambers.

Stratigraphic occurrence and range: Site 77: *G. insolita* Zone to lower *P. barbadoensis* Zone; Upper Eocene to Lower Oligocene.

*Globigerina nepenthes* Todd (Plate 10, Figures 9, 10 and 11):

Remarks: *G. nepenthes* was found to be relatively rare in the examined samples and this may be due to its solution prone test as noted by Hays *et al.* (1969).

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone. Site 77: *G. fohsi lobata* Zone to lower *S. dehiscens* Zone. Site 82: *G. plesiotumida* Zone with one doubtful record in the *S. dehiscens* Zone. Site 83: *G. plesiotumida* Zone. Site 84: *G. plesiotumida* Zone.

Stratigraphic range: *G. fohsi lobata* Zone to *S. dehiscens* Zone; Middle Miocene to Lower Pliocene.

Recorded stratigraphic range: Parker (1967) recorded the Miocene-Pliocene range of *G. nepenthes* in Indo-Pacific deep-sea cores as Zone N16-N19. Hays *et al.* (1969) showed its range in sediments of the eastern equatorial Pacific with its Pliocene extinction level at 3.7 million years at the upper boundary of the "a" normal event of the Gilbert Reversed epoch.

*Globigerina ouachitaensis* Howe and Wallace:

Remarks: *G. ouachitaensis* was found in Oligocene sediments at Sites 77 and 78, where its occurrence was both sporadic and rare.

Stratigraphic occurrence: Site 77: *C. cubensis* Zone to *G. angulisuturalis* Zone, and one doubtful specimen in the upper *G. kugleri* Zone which is probably due to reworking. Site 78: One record in the *P. barbadoensis* Zone.

Stratigraphic range: *P. barbadoensis* Zone to the *G. angulisuturalis* Zone; Lower Oligocene to Upper Oligocene.

Recorded stratigraphic range: Banner and Blow (in Eames *et al.*, 1962) recorded the range of *G. ouachitaensis* in the Lindi area of East Africa from the Upper Eocene *G. semiinvoluta* Zone to the Lower Miocene *G. opima opima* Zone. Its extinction level was recorded in the type Lower Aquitanian by Jenkins (1966b), where it occurred with *G. angulisuturalis.*

*Globigerina praedigitata* Parker (Plate 8, Figures 7, 8 and 9):

Remarks: *G. praedigitata* was found to be both sporadic and rare within the examined area; this could possibly be due to its having a solution prone test. Two juvenile and one adult test have been illustrated from the *P. obliquiloculata* Zone of Site 84.

Stratigraphic occurrence: Site 77: One record in the *G. fistulosus* Zone. Site 80: *G. tumida* Zone to *P. obliquiloculata* Zone with one doubtful record in the *G. plesiotumida* Zone. Site 81: *G. fohsi fohsi-G. peripheroacuta* Zone and one doubtful record in the *G. peripheroronda* Zone. Site 82: *G. plesiotumida* Zone to *G. fistulosus* Zone. Site 83: *G. altispira* Zone to *G. plesiotumida* Zone. Site 84: *G. fistulosus* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *G. fohsi fohsi-G. peripheroacuta* Zone to *P. obliquiloculata* Zone; Middle Miocene to Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded its range in Indo-Pacific deep-sea cores from the Late Miocene Zone N17 to Upper Pliocene Zone N21.

*Globigerina quinqueloba* Natland:

Remarks: Parker (1962) recorded the northern limits of *G. quinqueloba* in the South Pacific as 19°S, and Parker (1967) recorded its first appearance in Late Miocene Zone N17 as occurring "in samples where there has not been a great deal of solution of calcium carbonate". Therefore its paucity in the eastern equatorial Pacific samples examined on Leg 9 is best explained by its original geographic distribution when it was probably limited to non-tropical parts of the ocean, especially in the Upper Cenozoic, and coupled with this is the report by Parker that it may have a solution prone test.

Stratigraphic occurrence: Site 77: One record in the uppermost *P. obliquiloculata* Zone.

Stratigraphic range: Uppermost *P. obliquiloculata* Zone; Pleistocene.

Recorded stratigraphic range: The high latitude nature of *G. quinqueloba* is emphasized by its long stratigraphic record in New Zealand where it has been recorded from the Lower Miocene *G. woodi connecta* Zone through to the Upper Pleistocene part of *G. inflata* Zone (Jenkins, 1966a, 1967).

*Globigerina rubescens* Hofker (Plate 11, Figures 1, 2 and 3):

Remarks: Specimens of *G. rubescens* from the Pleistocene *P. obliquiloculata* Zone are pink in color confirming Parker's observations (1967). In the examined area *G. rubescens* was found to be relatively rare. The record of *G. rubescens* in Pliocene samples from Site 82 could be due to downhole contamination.

Stratigraphic occurrence: Site 77: *P. obliquiloculata* Zone. Site 79: *P. obliquiloculata* Zone with one doubtful record in the *G. plesiotumida* Zone. Site 82: *S. dehiscens* Zone to *P. obliquiloculata* Zone. Site 83: *P. obliquiloculata* Zone. Site 84: *P. obliquiloculata* Zone.

Stratigraphic range: *S. dehiscens* Zone to *P. obliquiloculata* Zone; Pliocene to Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded its range in Indo-Pacific deep-sea cores as Pliocene-Quaternary Zones N20-N23.

*Globigerina selli* (Borsetti) (Plate 11, Figures 4, 5 and 6):

Remarks: *G. selli* was found to be relatively rare within its stratigraphic range at Sites 77 and 78, but its range is much longer compared with its recorded range in Lindi, East Africa (see below).

Stratigraphic occurrence: Site 77: *P. barbadoensis* Zone to *C. cubensis* Zone. Site 78: *G. ampliapertura* Zone.

Stratigraphic range: *P. barbadoensis* Zone to *C. cubensis* Zone; Oligocene.

Recorded stratigraphic range: Banner and Blow (in Eames *et al.*, 1962) recorded its range in Lindi, East Africa as limited to the Oligocene *G. selli* Zone (their *G. oligocaenica* Zone).

*Globigerina tapuriensis* Banner and Blow (Plate 11, Figures 7, 8 and 9):

Remarks: *G. tapuriensis* was found to be relatively rare in the samples examined from its Oligocene range at Sites 77 and 78.

Stratigraphic occurrence: Site 77: *P. barbadoensis* Zone to *G. ampliapertura* Zone. Site 78: Lower *G. ampliapertura* Zone.

Stratigraphic range: *P. barbadoensis* Zone to *G. ampliapertura* Zone; Oligocene.

Recorded stratigraphic range: Banner and Blow (in Eames *et al.*, 1962) limited its range to the *G. selli* Zone (their *G. oligocaenica* Zone) in Lindi, East Africa.

*Globigerina woodi* Jenkins (Plate 11, Figures 10, 11 and 12):

Remarks: *G. woodi* was found to be sporadic and very rare in the examined area.

Stratigraphic occurrence: Site 77: One record in the upper *G. plesiotumida* Zone. Site 78: One record in the *G. kugleri* Zone. Site 79: One doubtful record in the *G. kugleri* Zone.

Stratigraphic record: *G. kugleri* Zone to *G. plesiotumida* Zone; Lower to Upper Miocene.

Recorded stratigraphic range: *G. woodi woodi* originally recorded from a southeast Australian Oligo-Miocene sequence from the *G. woodi* Zone to *G. menardii miotumida* Zone (Jenkins, 1960) and subsequently recorded in New Zealand from the *G. woodi woodi* Zone to *G. mayeri mayeri* Zone (Jenkins, 1966a, 1967).

Genus *Globigerinatella* Cushman and Stainforth, 1945

*Globigerinatella insueta* Cushman and Stainforth (Plate 12, Figures 1, 2 and 3):

Remarks: *G. insueta* was found to be relatively rare and sporadic within its Lower-Middle Miocene range in the examined area. Such a poor record presents a problem as to whether it is due to a relatively low number in the original paleogeographic distribution pattern in the area sampled at Sites 77, 79, 80 and 81, solution effects or a combination of both factors. From a paleogeographic plot of the published records of *G. insueta* (Jenkins, 1965), it is reasonable to assume that the eastern Pacific track of Leg 9 was well within its original Lower Middle Miocene distribution within the tropic belt. Therefore, its rarity is here considered to be mainly due to solution effects.

Stratigraphic occurrence: Site 78: *G. bisphericus* Subzone to lower *G. peripheroronda* Zone. Site 79: One record in the *G. peripheroronda* Zone. Site 80: One doubtful record in the *G. venezuelana* Zone. Site 81: One record in the *G. bisphericus* Subzone.

Stratigraphic range: *G. bisphericus* Subzone to *G. peripheroronda* Zone with one possible record in the *G. venezuelana* Zone; Lower to Middle Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded its Lower-Middle Miocene range in Trinidad as *G. stainforthi* Zone to the *G. insueta* Zone.

Genus *Globigerinella* Cushman, 1927

*Globigerinella aequilateralis* (Brady) (Plate 12, Figures 4 and 5):

Remarks: *G. aequilateralis* is fairly sporadic and rare in the lower part of its stratigraphic range, as for example at Site 77, but fairly common within the Plio-Pleistocene interval. *Globorotalia obesa* Bolli is here considered to be ancestral to *G. aequilateralis*, but it has only been recorded on Leg 9 at Site 81 in the *G. fohsi fohsi-G. peripheroacuta* Zone.

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 79: *G. fohsi fohsi-G. peripheroacuta* Zone to *P. obliquiloculata* Zone. Site 80: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 81: *P. obliquiloculata* Zone. Site 82: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 83: *G. altispira* Zone to *P. obliquiloculata* Zone. Site 84: *G. tumida* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *G. fohsi fohsi-G. peripheroacuta* Zone to *P. obliquiloculata* Zone; Middle Miocene to Pleistocene.

Recorded stratigraphic range: Bolli (1957a) recorded *G.* cf. *aequilateralis* in the Miocene *G. mayeri* Zone to *G. menardii* Zone of Trinidad. Parker (1967) recorded *G. aequilateralis* (as *G. siphonifera*) in Indo-Pacific deep-sea cores as Middle Miocene to Quaternary.

Genus *Globigerinoides* Cushman, 1927

*Globigerinoides altisperturus* Bolli:

Remarks: *G. altiaperturus* was found to be very rare and sporadic within its Lower Miocene range in the examined area; it could be a solution prone species.

Stratigraphic occurrence: Site 78: One doubtful record in the *G. kugleri* Zone. Site 79: *G. dissimilis* Zone with one doubtful record in the *G. kugleri* Zone. Site 81: Two doubtful records in the *G. bisphericus* Subzone.

Stratigraphic range: *G. dissimilis* Zone; Lower Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded its range in the Lower Miocene of Trinidad as *C. dissimilis* Zone to the lower part of the *C. stainforthi* Zone.

*Globigerinoides bisphericus* Todd (Plate 12, Figures 6, 7 and 8):

Remarks: *G. bisphericus* has been used on Leg 9 in preference to *G. sicanus* which is here considered to be a *nomen nudum*. The stratigraphic range of *G. bisphericus* has been used at Sites 77 to 81 to define a subzone in the upper part of the *G. venezuelana* Zone, although it does range into the base of the succeeding *G. peripheroronda* Zone.

Stratigraphic occurrence: Site 77: One record in the *G. bisphericus* Subzone. Site 78: *G. bisphericus* Subzone to lower *G. peripheroronda* Zone. Site 79: One doubtful record in the *G. peripheroronda* Zone. Site 80: *G. bisphericus* Subzone to the *G. peripheroronda* Zone. Site 81: *G. bisphericus* Subzone.

Stratigraphic range: *G. bisphericus* Subzone to lower *G. peripheroronda* Zone; Lower to Middle Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded its Lower-Middle Miocene range in Trinidad as upper *G. insueta* Zone to the lower part of the *G. fohsi barisanensis* Zone.

*Globigerinoides bolli* Blow (Plate 14, Figures 1, 2 and 3):

Remarks: *G. bolli* was found to be relatively rare in the examined area and is possibly a solution prone species.

Stratigraphic occurrence: Site 77: *G. fohsi lobata* Zone to top of the *S. dehiscens* Zone. Site 81: *G. fohsi fohsi-G. peripheroacuta* Zone and one isolated record

in the *P. obliquiloculata* Zone. Site 82: *G. plesiotumida* Zone to *S. dehiscens* Zone. Site 83: *G. plesiotumida* Zone to *S. dehiscens* Zone. Site 84: *G. plesiotumida* Zone.

Stratigraphic range: *G. fohsi fohsi-G. peripheroacuta* Zone to *S. dehiscens* Zone; Middle Miocene to Pliocene.

Recorded stratigraphic range: Blow (1959) recorded its range in the Miocene of Venezuelana as *G. mayeri-G. lenguaensis* Subzone to the *G. bulloides* Zone. Parker (1967) extended its range in Indo-Pacific deep-sea cores from Middle Miocene Zone N16 to the base of the Upper Pliocene Zone N21.

*Globigerinoides conglobatus* (Brady) (Plate 14, Figures 4 and 5):

Remarks: *G. conglobatus* is relatively rare in the lower parts of its stratigraphic range in the Upper Miocene-Lower Pliocene, but fairly common in the Upper Pliocene and Pleistocene.

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 79: *G. tumida* Zone to *P. obliquiloculata* Zone. Site 81: *P. obliquiloculata* Zone. Site 82: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 83: *G. tumida* Zone to *P. obliquiloculata* Zone. Site 84: *G. tumida* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *G. plesiotumida* Zone to *P. obliquiloculata* Zone; Upper Miocene to Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded *G. conglobatus* from the Middle Miocene Zone N16 to the Pleistocene Zone N23.

*Globigerinoides fistulosus* (Schubert) (Plate 13, Figures 1 through 9):

Remarks: *G. fistulosus* was found to be fairly common in the examined area, and it was chosen as a zonal marker in the Upper Pliocene. There is a wide range of variation in its morphology and nine specimens have been illustrated to show this.

Stratigraphic occurrence: Site 76: *G. fistulosus* Zone. Site 77: *G. fistulosus* Zone. Site 82: *G. fistulosus* Zone. Site 83: *G. fistulosus* Zone with two doubtful records in the upper *S. dehiscens* Zone and lower *P. obliquiloculata* Zone. Site 84: *G. fistulosus* Zone with doubtful records in the lower *P. obliquiloculata* Zone.

Stratigraphic range: *G. fistulosus* Zone; Upper Pliocene.

Recorded stratigraphic range: Parker (1967) recorded it in Indo-Pacific deep-sea cores from the Pliocene Zone N19 to the lower part of the Quaternary Zones N22, 23. Hays *et al.* (1969) recorded it in the eastern equatorial Pacific from the base of the Mammoth Magnetic Event to the top of the Olduvai Normal Magnetic Event.

*Globigerinoides mitra* Todd (Plate 14, Figures 6 and 7):

Remarks: *G. mitra* was found to be rare within the examined area and to have a much shorter Miocene stratigraphic range as compared with Trinidad (Bolli, 1957a, see below). The relationship of *G. mitra* to *G. ruber* needs to be examined to determine whether *G. mitra* is a "gigantic" form of *G. ruber.*

Stratigraphic occurrence: Site 78: *G. peripheroronda* Zone to the base of the *G. fohsi fohsi-G. peripheroacuta* Zone. Site 80: *G. bisphericus* Subzone.

Stratigraphic range: *G. bisphericus* Subzone to *G. fohsi fohsi-G. peripheroacuta* Zone; Lower to Middle Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded its stratigraphic range in the Trinidad Miocene from the *C. dissimilis* Zone to the *G. menardii* Zone, where it was questioned in the lower four zones.

*Globigerinoides obliquus* Bolli (Plate 14, Figures 8, 9 and 10):

Remarks: *G. obliquus* was found to be relatively common within the examined area and there is evidence that it ranges into the base of the Pleistocene as for example at Sites 79, 80 and 84.

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: *G. plesiotumida* to *G. fistulosus* Zone with doubtful specimens in *P. obliquiloculata* and *G. altispira* Zones. Site 78: *G. dissimilis* Zone to *G. venezuelana* Zone. Site 79: *G. tumida* Zone to lower *P. obliquiloculata* Zone. Site 80: *G. plesiotumida* Zone to lower *P. obliquiloculata* Zone. Site 81: One doubtful record in *P. obliquiloculata* Zone. Site 82: *G. plesiotumida* Zone to *G. fistulosus* Zone with one doubtful record in *P. obliquiloculata* Zone. Site 83: *G. altispira* Zone to *P. obliquiloculata* Zone. Site 84: *G. plesiotumida* Zone to lower *P. obliquiloculata* Zone.

Stratigraphic range: *G. dissimilis* Zone to lower *P. obliquiloculata* Zone; Lower Miocene to Lower Pleistocene.

Recorded stratigraphic range: Bolli (1957a) recorded its Miocene stratigraphic range in Trinidad as *G. kugleri*

Zone to *G. menardii* Zone. Parker (1967) recorded its range in Indo-Pacific deep-sea cores from the Middle Miocene Zone N16 to the Upper Pliocene Zone N21.

*Globigerinoides primordius* Banner and Blow (Plate 14, Figures 11, 12 and 13):

Remarks: *G. primordius* was found to be too rare to be of any use as a Lower Miocene marker and its paucity is probably due to its having a solution prone test. The only time *G. primordius* was found in relatively large numbers was at Site 76, where it was reworked into Pliocene sediments.

Stratigraphic occurrence: Site 78: *G. kugleri* Zone. Site 79: One doubtful record in *G. dissimilis* Zone.

Stratigraphic range: *G. kugleri* Zone; Lower Miocene.

Recorded stratigraphic range: Banner and Blow (in Eames *et al.*, 1962) recorded it from the Lower Miocene *G. kugleri* Zone of Trinidad.

*Globigerinoides ruber* (d'Orbigny) (Plate 16, Figures 1, 2 and 3):

Remarks: *G. ruber* was found to be relatively common within the upper part of its stratigraphic range in the Pliocene-Pleistocene and sporadic and rare in the Miocene. Cooler water forms with flattened chambers and higher spires were found in Pleistocene sediments at Site 84 (see also Orr, 1969).

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: *G. venezuelana* Zone to *P. obliquiloculata* Zone. Site 78: *G. bisphericus* Subzone to *G. fohsi fohsi-G. peripheroacuta* Zone with one record in the *G. kugleri* Zone. Site 79: *G. peripheroronda* Zone to *P. obliquiloculata* Zone. Site 80: *G. venezuelana* Zone to *P. obliquiloculata* Zone. Site 81: *G. bisphericus* Subzone to *P. obliquiloculata* Zone. Site 82: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 83: *G. altispira* Zone to *P. obliquiloculata* Zone. Site 84: *G. tumida* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *G. venezuelana* Zone to *P. obliquiloculata* Zone; Lower Miocene to Pleistocene.

Recorded stratigraphic range: Bolli (1957a) recorded it from the Miocene *C. dissimilis* Zone to the *G. menardii* Zone in Trinidad. Parker (1962) recorded it from Recent sediments in the Pacific and recorded its first appearance in the Late Miocene Zone N17 in Indo-Pacific deep-sea cores (1967).

*Globigerinoides sacculifer* (Brady) (Plate 15, Figures 1 through 11):

Remarks: *G. sacculifer* was found to be relatively common in the upper part of its stratigraphic range from Upper Miocene to Pleistocene, but rare in the Middle to Upper Miocene. Both primitive and advanced forms of *G. sacculifer* have been illustrated (see also Parker, 1967).

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: *G. venezuelana* Zone to *P. obliquiloculata* Zone. Site 79: *G. peripheroronda* Zone to *P. obliquiloculata* Zone. Site 80: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 81: *P. obliquiloculata* Zone. Site 82: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 83: *G. altispira* Zone to *P. obliquiloculata* Zone. Site 84: *G. plesiotumida* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *G. venezuelana* Zone to *P. obliquiloculata* Zone; Lower Miocene to Pleistocene.

Recorded stratigraphic range: Bolli (1957a) recorded it from the Lower Miocene *G. kugleri* Zone to Upper Miocene *G. menardii* Zone in Trinidad. Parker (1967) recorded it from Middle Miocene Zone N16 to Quaternary N22, 23 in Indo-Pacific deep-sea cores.

*Globigerinoides trilobus* (Reuss) (Plate 16, Figures 4 through 9):

Remarks: *G. trilobus* was found to be one of the most common species of *Globigerinoides* although it was fairly rare in the Lower to Middle Miocene. *G. trilobus* is distinguished from *G. sacculifer* in not possessing a sac-like final chamber.

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: Upper *G. kugleri* Zone to *P. obliquiloculata* Zone. Site 78: *G. kugleri* Zone to *G. fohsi fohsi-G. peripheroacuta* Zone. Site 79: Lower *G. kugleri* Zone to *P. obliquiloculata* Zone. Site 80: *G. kugleri* Zone to *P. obliquiloculata* Zone. Site 81: *G. bisphericus* Subzone to *P. obliquiloculata* Zone. Site 82: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 83: *G. altispira* Zone to *P. obliquiloculata* Zone. Site 84: *G. plesiotumida* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *G. kugleri* Zone to *P. obliquiloculata* Zone; Lower Miocene to Pleistocene.

Recorded stratigraphic range: Bolli (1957a) recorded it from the Lower *C. dissimilis* Zone to the Upper Miocene *G. menardii* Zone in Trinidad.

Genus *Globigerinita* Bronnimann, 1951

*Globigerinita dissimilis* (Cushman and Bermudez) (Plate 16, Figures 10, 11 and 12):

Remarks: *G. dissimilis* was found to be an excellent marker within its Upper Eocene-Lower Miocene range, mainly because it was one of the most common species within this interval; it appears to be a solution resistant species. Close to its extinction level in the Lower Miocene, specimens appear to become progressively reduced in size.

Stratigraphic occurrence: Site 77: *G. insolita* Zone to *G. dissimilis* Zone. Site 78: Upper *P. barbadoensis* Zone to *G. dissimilis* Zone. Site 79: *G. kugleri* Zone to *G. dissimilis* Zone. Site 80: *G. kugleri* Zone to *G. dissimilis* Zone.

Stratigraphic range: *G. insolita* Zone to *G. dissimilis* Zone; Upper Eocene to Lower Miocene.

Coiling: Dextral.

Recorded stratigraphic range: Bolli (1957a) recorded its range in Trinidad from the Oligocene *G. ampliapertura* Zone to the Lower Miocene *C. stainforthi* Zone.

*Globigerinita glutinata* (Egger) (Plate 17, Figure 1):

Remarks: *G. glutinata*, which is closely related to *Globigerina juvenilis* Bolli, was found to be relatively rare in the examined area in the lower part of its stratigraphic range but much more common in the Pliocene-Pleistocene. Observations indicate that the Pleistocene specimens are much larger than pre-Pleistocene forms. Specimens with multiple apertures on the spiral side were common at Site 84 in the interval *S. dehiscens* Zone to *P. obliquiloculata* Zone.

Stratigraphic occurrence: Site 76: *G. fistulosus* Zone. Site 77: *G. kugleri* Zone to *P. obliquiloculata* Zone. Site 78: *G. kugleri* Zone to *G. dissimilis* Zone. Site 79: *G. kugleri* Zone to *P. obliquiloculata* Zone. Site 80: *G. kugleri* Zone to *P. obliquiloculata* Zone. Site 81: *G. fohsi fohsi-G. peripheroacuta* Zone to *P. obliquiloculata* Zone. Site 82: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 83: *G. altispira* Zone to *P. obliquiloculata* Zone. Site 84: *G. plesiotumida* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *G. kugleri* Zone to *P. obliquiloculata* Zone; Lower Miocene to Pleistocene.

Recorded stratigraphic range: Bolli (1957a) recorded its range in the Trinidad Miocene (as *G. naparimaensis*) from the Lower Miocene *C. dissimilis* Zone to the Upper Miocene *G. menardii* Zone.

Genus *Globoquadrina* Finlay, 1947

*Globoquadrina* sp. 1 (Plate 17, Figures 2, 3 and 4):

Remarks: A number of specimens having umbilical teeth were recorded in the Oligocene *P. barbadoensis* Zone at Site 77B: these were referred to *Globoquadrina* sp. 1.

Stratigraphic occurrence: Site 77B, Core 48, core-catcher; *P. barbadoensis* Zone, Oligocene.

*Globoquadrina altispira* (Cushman and Jarvis) (Plate 17, Figures 5, 6 and 7):

Remarks: The *G. altispira* extinction level is within the *G. fistulosus* Zone, and was correlated with the top of the Kaena Event by Hays *et al.* (1969); it appears to be a good datum within the examined area. *G. altispira* was fairly common in Upper Cenozoic samples and it appears to have a solution resistant test.

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: Upper *G. kugleri* Zone to the lower part of the *G. fistulosus* Zone with two doubtful records in the *G. opima* and *G. angulisuturalis* Zones. Site 78: Upper *G. kugleri* Zone to the *G. fohsi fohsi-G. peripheroacuta* Zone. Site 79: Upper *G. kugleri* Zone to *G. tumida* Zone. Site 80: *G. dissimilis* Zone to *S. dehiscens* Zone. Site 81: *G. bisphericus* Subzone to *G. fohsi fohsi-G. peripheroacuta* Zone. Site 82: *G. plesiotumida* Zone to *S. dehiscens* Zone. Site 83: *G. altispira* Zone to lower *G. fistulosus* Zone. Site 84: *G. plesiotumida* Zone to lower *G. fistulosus* Zone.

Stratigraphic range: Upper *G. kugleri* Zone to lower *G. fistulosus* Zone; Lower Miocene to Upper Pliocene.

Recorded stratigraphic range: Bolli (1957a) recorded *G. altispira* from the Lower Miocene *C. stainforthi* Zone to the Middle Miocene *G. fohsi robusta* Zone in Trinidad. Parker (1967) recorded it in Indo-Pacific deep-sea cores from Middle Miocene Zone N16 to Pliocene Zone N20, and Hays *et al.* (1969) recorded its extinction at the top of the Pliocene Kaena Magnetic Event in the eastern Pacific equatorial deep-sea cores.

*Globoquadrina dehiscens* (Chapman, Parr and Collins) (Plate 17, Figures 8, 9 and 10):

Remarks: *G. dehiscens* has been recorded stratigraphically earlier in the South Pacific region of southeastern Australia and New Zealand at the base of the Oligocene *G. dehiscens* Zone (Jenkins, 1960, 1966a). It later spread into the tropical regions reaching the eastern Pacific in the *G. kugleri* Zone and Trinidad slightly later in the *C. stainforthi* Zone (Bolli, 1957a). This is contrary to the view published by Banner and Blow in Eames *et al.* (1962) who recorded the evolution and origin of *G. dehiscens* in Zone N5 of Banner and Blow (1965).

Stratigraphic occurrence: Site 77: *G. kugleri* Zone to the lower *S. dehiscens* Zone. Site 78: *G. kugleri* Zone to *G. fohsi fohsi-G. peripheroacuta* Zone. Site 79: *G. kugleri* Zone to *G. altispira* Zone. Site 80: *G. venezuelana* Zone to *G. plesiotumida* Zone. Site 81: *G. bisphericus* Subzone to *G. fohsi fohsi-G. peripheroacuta* Zone. Site 82: *G. plesiotumida* Zone. Site 83: *G. plesiotumida* Zone with one doubtful record in the *S. dehiscens* Zone. Site 84: *G. plesiotumida* Zone to *S. dehiscens* Zone.

Stratigraphic range: *G. kugleri* Zone to *S. dehiscens* Zone; Lower Miocene to Lower Pliocene.

Recorded stratigraphic range: Bolli (1957a) recorded *G. dehiscens* in Trinidad from the Lower Miocene *C. stainforthi* Zone to the Upper Miocene *G. menardii* Zone. Parker (1967) recorded its range in Indo-Pacific cores as Middle Miocene Zone N16 to Late Miocene Zone N18. The extinction level of *G. dehiscens* in New Zealand has been recorded in the Upper Miocene *G. miotumida miotumida* Zone and a possible reworked record in the Lower Pliocene *G. inflata* Zone.

*Globoquadrina langhiana* Cita and Gelati (Plate 17, Figures 11, 12 and 13):

Remarks: *G. langhiana* was found to be rare within its short Middle Miocene range in the examined area. Similar short stratigraphic ranges have been recorded in Italy and New Zealand (see below).

Stratigraphic occurrence: Site 77: *G. peripheroronda* Zone. Site 79: One doubtful record in the *G. peripheroronda* Zone. Site 81: Two doubtful records in the *G. bisphericus* Subzone.

Stratigraphic range: *G. peripheroronda* Zone; Middle Miocene.

Recorded stratigraphic range: In the type Langhian, Cita and Gelati (1960) recorded it from the Miocene *G. dehiscens* Zone. Jenkins (1967) recorded a short stratigraphic range for *G. langhiana* from the Middle Miocene upper *P. glomerosa curva* Zone to the *O. suturalis* Zone in New Zealand.

*Globoquadrina tripartita* (Koch) (Plate 18, Figures 1, 2 and 3):

Remarks: *G. tripartita* was found to be relatively common within its stratigraphic range at Sites 77, 78, 79 and 80; it appears to have a solution resistant test.

Stratigraphic occurrence: Site 77: *P. barbadoensis* Zone to *G. angulisuturalis* Zone. Site 78: *G. ampliapertura* Zone to *G. dissimilis* Zone with one record of a doubtful specimen in each of the *P. barbadoensis* and *G. venezuelana* Zones. Site 79: *G. kugleri* Zone. Site 80: *G. kugleri* Zone to *G. dissimilis* Zone.

Stratigraphic range: *P. barbadoensis* Zone to *G. dissimilis* Zone; Lower Oligocene to Lower Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded *G. tripartita* (as *G. rohri*) in Trinidad from the Oligocene *G. ampliapertura* Zone to the Lower Miocene *C. dissimilis* Zone.

*Globoquadrina venezuelana* (Hedberg) (Plate 18, Figures 4, 5 and 6):

Remarks: *G. venezuelana* is the longest ranging planktonic foraminiferal species in the Cenozoic, and it was found to be relatively common within the examined area; it appears to have a solution resistant test.

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: *P. barbadoensis* Zone to *P. obliquiloculata* Zone. Site 78: *C. cubensis* Zone to *G. fohsi fohsi-G. peripheroacuta* Zone. Site 79: *G. kugleri* Zone to *G. fohsi fohsi-G. peripheroacuta* Zone. Site 80: *G. dissimilis* Zone to *P. obliquiloculata* Zone. Site 81: *G. bisphericus* Subzone to *P. obliquiloculata* Zone. Site 82: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 83: *G. altispira* Zone to *P. obliquiloculata* Zone. Site 84: *G. plesiotumida* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *P. barbadoensis* Zone to *P. obliquiloculata* Zone; Lower Oligocene to Pleistocene.

Recorded stratigraphic range: Bolli (1957a, b) recorded its range in Trinidad as Middle Eocene *P. mexicana* Zone to Upper Miocene *G. menardii* Zone. Parker (1967) recorded its range in Indo-Pacific deep-sea cores as Middle Miocene Zone N16 to Quaternary Zones N22, 23.

Genus *Globorotalia* Cushman, 1927

*Globorotalia* sp. 1 (Plate 19, Figures 1 and 2):

Remarks: One specimen of a very small unkeeled *Globorotalia* was recovered from the *G. insolita* Zone at Site 77B, and because of its distinctive morphology it has been illustrated.

Stratigraphic occurrence: Site 77B, Core 53, core-catcher; *G. insolita* Zone, Upper Eocene.

*Globorotalia* sp. 2 (Plate 19, Figures 3 and 4):

Remarks: A single specimen of a small distinctive unkeeled *Globorotalia* was recovered from the *C. cubensis* Zone at Site 77B. It has a flattened spiral side, six chambers in the final whorl and a small lipped aperture in an extra-umbilical position.

Stratigraphic occurrence: Site 77B, Core 41, core-catcher; *C. cubensis* Zone; Oligocene.

*Globorotalia* sp. 3 (Plate 19, Figures 5, 6 and 7):

Remarks: Two specimens of a small unkeeled *Globorotalia* with a distinctive "hooded" aperture were found in the *G. bisphericus* Subzone at Site 78.

Stratigraphic occurrence: Site 78, Core 3, core-catcher; *G. bisphericus* Subzone, Lower Miocene.

*Globorotalia* sp. 4 (Plate 18, Figures 7 through 12):

Remarks: A number of unkeeled *Globorotalia* with distinct umbilical "teeth" were recovered from the *P. glomerosa curva* Zone at Site 78. The umbilical tooth development is similar to those found in the *G. acostaensis-G. dutertrei* lineage.

Stratigraphic occurrence: Site 78, Core 3, Section 3, top; *P. glomerosa curva* Zone, Middle Miocene.

*Globorotalia acostaensis* Blow (Plate 19, Figures 8, 9 and 10):

Remarks: According to Banner and Blow (1967) the transition from *G. acostaensis* to *G. humerosa* Takayanagi and Saito takes place in the Middle Miocene Zone N16, but Parker (1967) recorded the first occurrence of *G. humerosa* in Indo-Pacific deep-sea cores in Late Miocene Zone N18. In the examined area the evolutionary transition from *G. acostaensis* to *G. humerosa* appears to take place within the Upper Miocene *G. plesiotumida* Zone.

At Site 77 there is an overlap in the ranges of *G. acostaensis* and *G. siakensis* Le Roy in the *G. altispira* Zone, whereas Blow (1959) recorded *G. acostaensis* appearing after the extinction of *G. siakensis* (= his *G. mayeri*) in Venezuela.

Stratigraphic occurrence: Site 77: Upper *G. altispira* Zone to the upper *G. tumida* Zone. Site 79: *G. altispira* Zone to *G. plesiotumida* Zone. Site 80: *G. plesiotumida* Zone. Site 82: *G. plesiotumida* Zone to lower *S. dehiscens* Zone. Site 83: *G. altispira* Zone to *G. tumida* Zone, with one doubtful record in the *S. dehiscens* Zone. Site 84: *G. plesiotumida* Zone and one record in the upper *G. tumida* Zone.

Stratigraphic range: *G. altispira* Zone to the *S. dehiscens* Zone; Upper Miocene to Lower Pliocene.

Recorded stratigraphic range: Blow (1959) recorded the range of *G. acostaensis* in Upper Miocene of Venezuela as *G. menardii menardii-G. nepenthes* Zone to the *G. bulloides* Zone. Parker (1967) recorded its range in Indo-Pacific deep-sea cores as Middle Miocene Zone N16 to Late Miocene Zone N18.

*Globorotalia anfracta* Parker (Plate 20, Figures 4, 5 and 6):

Remarks: *G. anfracta* was found to be very rare and sporadic in occurrence in the examined area.

Stratigraphic occurrence: Site 77: One doubtful record in the *S. dehiscens* Zone. Site 79: *G. tumida* Zone. Site 82: Two doubtful records in the *G. plesiotumida* and *S. dehiscens* Zones.

Stratigraphic range: *G. tumida* Zone; Upper Miocene.

Recorded stratigraphic range: Parker (1967) recorded its range in Indo-Pacific deep-sea cores as Upper Pliocene Zone N21 to Quaternary N22, 23.

*Globorotalia archaeomenardii* Bolli (Plate 20, Figures 1, 2 and 3):

Remarks: Bolli (1957a) suggested that *G. archaeomenardii* is ancestral to *G. praemenardii*, and in Site 77 there is an overlap of the two species in the *G. peripheroronda* Zone. In Trinidad Bolli (*ibid.*) recorded a longer stratigraphic range for *G. archaeomenardii* (see below).

Stratigraphic occurrence: Site 77: Upper part of the *G. peripheroronda* Zone. Site 79: *G. peripheroronda* Zone. Site 81: *G. bisphericus* Subzone.

Stratigraphic range: *G. bisphericus* Subzone to *G. peripheroronda* Zone; Lower to Middle Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded its range in the Trinidad Middle Miocene as *G. insueta* Zone to *G. fohsi fohsi* Zone.

*Globorotalia* cf. *bella* Jenkins (Plate 20, Figures 7 and 8):

Remarks: *G.* cf. *bella* was very rare in the examined area, occurring only at Site 77, and these specimens have a slightly higher arched aperture than *G. bella.*

Stratigraphic occurrence: Site 77: One record in the lower *G. venezuelana* Zone.

Recorded stratigraphic range: Jenkins (1967) recorded the range of *G. bella* in New Zealand from the Lower Miocene *G. trilobus* Zone to the Middle Miocene *O. suturalis* Zone.

*Globorotalia cibaoensis* Bermudez (Plate 20, Figures 9, 10 and 11):

Remarks: *G. cibaoensis* was relatively rare in the examined area and completely absent within its stratigraphic range at Sites 76, 79 and 84. This apparently complicated areal distribution is difficult to explain.

Stratigraphic occurrence: Site 77: Upper *G. plesiotumida* to lower *G. tumida* Zone with two possible

occurrences in the *G. altispira* Zone. Site 80: *G. plesiotumida* Zone to *G. tumida* Zone. Site 82: *G. plesiotumida* Zone to *S. dehiscens* Zone. Site 83: *G. altispira* Zone to *S. dehiscens* Zone.

Stratigraphic range: *G. altispira* Zone to *S. dehiscens* Zone; Upper Miocene to Lower Pliocene.

Recorded stratigraphic range: Parker (1967) recorded its range in Indo-Pacific deep-sea cores as Middle Miocene Zone N16 to late Miocene Zone N18.

*Globorotalia continuosa* Blow (Plate 21, Figures 1, 2 and 3):

Remarks: *G. continuosa* appears to be related to *G. siakensis* but *G. siakensis* becomes extinct earlier in the *G. altispira* Zone and *G. continuosa* in the *G. plesiotumida* Zone. *G. siakensis* appears slightly earlier in the Oligocene.

One of the illustrated specimens has a small final chamber and is related to *G. acostaensis* (Plate 21, Figure 1).

Stratigraphic occurrence: Site 77: *G. angulisuturalis* Zone to upper *G. plesiotumida* Zone. Site 78: *G. venezuelana* to *G. fohsi fohsi-G. peripheroacuta* Zone, with one doubtful record in the *G. kugleri* Zone. Site 79: *G. kugleri* Zone to *G. dissimilis* Zone. Site 80: One record in the *G. kugleri* Zone. Site 81: *G. bisphericus* Subzone to *G. fohsi fohsi-G. peripheroacuta* Zone. Site 82: *G. plesiotumida* Zone. Site 83: *G. altispira* Zone.

Stratigraphic range: *G. angulisuturalis* Zone to *G. plesiotumida* Zone; Upper Oligocene to Upper Miocene.

Recorded stratigraphic range: Blow (1959) recorded its range in Venezuela as Lower Miocene *C. stainforthi* Zone to Upper Miocene *S. seminulina* Zone. Parker (1967) recorded it in the Middle Miocene Zone N16 Indo-Pacific deep-sea cores.

*Globorotalia crassaformis crassaformis* (Galloway and Wissler) (Plate 21, Figures 4 through 7):

Remarks: *G. crassaformis crassaformis* was fairly rare within its Pliocene-Pleistocene range in the examined area, but it was recorded at eight sites.

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: Upper *S. dehiscens* Zone to the upper *P. obliquiloculata* Zone. Site 79: *G. fistulosus* Zone. Site 80: *P. obliquiloculata* Zone. Site 81: *P. obliquiloculata* Zone. Site 82: *G. fistulosus* Zone. Site 83: *G. fistulosus* Zone to *P. obliquiloculata* Zone. Site 84: *G. fistulosus* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *S. dehiscens* Zone to *P. obliquiloculata* Zone; Lower Pliocene to Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded its range in Indo-Pacific deep-sea cores as Lower Pliocene Zone N19 to Quaternary Zones N22, 23. A similar range was recorded in New Zealand by Jenkins (1967).

*Globorotalia crassaformis* cf. *viola* Blow (Plate 21, Figures 8 and 9):

Remarks: *G. crassaformis viola* differs from *G. crassaformis crassaformis* in having a distinctive keel: the only record of the former subspecies was at Site 77, where the keel was not developed and is similar to a form with an angled periphery recorded by Bolli (Initial Core Descriptions, Leg 4: Plate 3, Figures 4, 5 and 6).

Stratigraphic occurrence: Site 77: One record in the *S. dehiscens* Zone; Pliocene.

Recorded stratigraphic range: Blow (1969) recorded the range of *G. crassaformis viola* as Upper Miocene Zone N18 to the Quaternary Zone N23.

*Globorotalia crassula* Cushman and Stewart (Plate 21, Figures 10 through 15):

Remarks: *G. crassula* was fairly rare at most sites with the exception of Site 84, where its occurrence was sporadic within its stratigraphic range. Two forms of *G. crassula* have been illustrated, one with 4 chambers in the final whorl and the other with 5.

Stratigraphic occurrence: Site 77: Two records in the *G. fistulosus* Zone and *P. obliquiloculata* Zone. Site 80: One record in the *P. obliquiloculata* Zone. Site 82: Three doubtful records in the *G. fistulosus-P. obliquiloculata* Zones. Site 83: *G. fistulosus* Zone to *P. obliquiloculata* Zone. Site 84: *G. tumida* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *G. tumida* Zone to *P. obliquiloculata* Zone; Upper Miocene to Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded its range in Indo-Pacific deep-sea cores as lower Pliocene Zone N19 to Quaternary Zones N22, 23.

*Globorotalia dutertrei* (d'Orbigny) (Plate 22, Figures 1 through 6):

Remarks: *G. dutertrei* was one of the most common species in the Upper Pliocene-Pleistocene sediments examined on Leg 9. Rare high-spired forms were found sporadically within normal low-spired populations, as for example in Samples 77B-2-2, 8 to 10 centimeters

and 82-1, core catcher and a specimen from the latter site has been illustrated (Plate 22, Figures 4, 5 and 6). *G. dutertrei* appears to have a solution resistant test.

Stratigraphic occurrence: Site 77: *G. fistulosus* Zone to *P. obliquiloculata* Zone. Site 79: *G. fistulosus* Zone? to *P. obliquiloculata* Zone. Site 80: *P. obliquiloculata* Zone. Site 81: *P. obliquiloculata* Zone. Site 82: *G. fistulosus* Zone to *P. obliquiloculata* Zone; with two isolated and doubtful records in the *S. dehiscens* Zone. Site 83: *G. fistulosus* Zone to *P. obliquiloculata* Zone. Site 84: *G. fistulosus* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *G. fistulosus* Zone to *P. obliquiloculata* Zone; Upper Pliocene to Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded its range in Indo-Pacific deep-sea cores as Upper Pliocene Zone N21 to Quaternary Zones N22, 23.

*Globorotalia exilis* Blow (Plate 23, Figures 1 through 9):

Remarks: At Sites 77, 78 and 79, *G. exilis* first appeared within the *Globorotalia tumida* Zone, but appeared earlier in the more eastern Sites 82, 83 and 84 in the *G. plesiotumida* Zone. The extinction of *G. exilis* appears to mark a relatively consistent datum in the *G. fistulosus* Zone. *Globorotalia multicamerata* Cushman is related to *G. exilis* with 7 to 9 regularly developed chambers in the final whorl.

*G. exilis* is normally dextrally coiled, but there are some sinistral populations: two sinistrally coiled specimens have been illustrated from the *S. dehiscens* Zone of Site 77B.

Stratigraphic occurrence: Site 76: *S. dehiscens* to *G. fistulosus* Zone. Site 77: *G. tumida* Zone to *G. fistulosus* Zone. Site 79: *G. tumida* Zone to *G. fistulosus* Zone? Site 80: *G. tumida* Zone to *S. dehiscens* Zone. Site 82: *G. plesiotumida* Zone to lower *G. fistulosus* Zone. Site 83: *G. plesiotumida* Zone to *G. fistulosus* Zone. Site 84: *G. plesiotumida* Zone to *G. fistulosus* Zone.

Stratigraphic range: *G. plesiotumida* Zone to *G. fistulosus* Zone; Upper Miocene to Upper Pliocene.

Recorded stratigraphic range: Blow (1969) recorded its stratigraphic range as N18-N20. Bolli (Leg 4, Initial Core Description Report, 1970) recorded its range as *G. exilis-G. miocenica* Zone, but also extended it into the older *G. margaritae* Zone.

*Globorotalia fimbriata* (Brady) (Plate 24, Figures 1 and 2):

Remarks: *G. fimbriata* with its distinctive fimbriate keel was found to be very rare in the examined area.

Stratigraphic occurrence: Site 82: One record in the *P. obliquiloculata* Zone. Site 83: *P. obliquiloculata* Zone.

Stratigraphic range: *P. obliquiloculata* Zone; Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded its range in Indo-Pacific deep-sea cores as Pliocene Zone N21 to Quaternary Zones N22, 23. Bolli (Leg 4, Initial Core Description Report, 1970) recorded *G. fimbriata* in the Pleistocene *G. truncatulinoides truncatulinoides* Zone.

*Globorotalia fohsi fohsi* Bolli:

Remarks: At Sites 77, 78 and 81, *G. fohsi praefohsi* Blow and Banner was included within the morphological range of *G. fohsi fohsi.*

Stratigraphic occurrence: Site 77: *G. fohsi fohsi-G. peripheroacuta* Zone to *G. fohsi lobata* Zone. Site 78: *G. fohsi fohsi-G. peripheroacuta* Zone. Site 81: *G. fohsi fohsi-G. peripheroacuta* Zone.

Stratigraphic range: *G. fohsi fohsi-G. peripheroacuta* to *G. fohsi lobata* Zone; Middle Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded its Middle Miocene range in Trinidad as *G. fohsi fohsi* Zone to *G. fohsi lobata* Zone.

*Globorotalia fohsi lobata* Bermudez (Plate 24, Figures 3, 4 and 5):

Remarks: On Leg 9 it was accepted that *G. fohsi lobata* is a valid taxon and Blow's (1969) reduction of this subspecies to a "forma" was rejected. Intermediate forms linking *G. fohsi lobata* to its ancestor *G. fohsi fohsi* were found in the upper *G. fohsi fohsi-G. peripheroacuta* Zone at Site 77.

Stratigraphic occurrence: Site 77: *G. fohsi lobata* Zone; Middle Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded its Middle Miocene range in Trinidad as limited to the *G. fohsi lobata* Zone.

*Globorotalia gemma* Jenkins (Plate 22, Figures 7 through 11):

Remarks: At Sites 77 and 78 some specimens of *G. gemma* showed a tendency to become pseudoplanispirally coiled, and badly preserved specimens in the Upper Eocene-Lower Oligocene can be confused with *Pseudohastigerina micra* (Cole). A pseudoplanispirally coiled form has been illustrated from the *G. ampliapertura* Zone of Site 78 (Plate 22, Figures 9 and 10).

In the *G. opima* Zone at Site 77, there are some specimens of *G.* cf. *gemma* which appear to link *G. gemma* to *G.* cf. *minutissima* Bolli.

Stratigraphic occurrence: Site 77: *G. insolita* Zone to the *C. cubensis* Zone with one doubtful record in the *G. angulisuturalis* Zone. Site 78: Upper *P. barbadoensis* Zone to the *C. cubensis* Zone.

Stratigraphic range: *G. insolita* Zone to *C. cubensis* Zone; Lower to Upper Oligocene.

Recorded stratigraphic range: Jenkins (1966a) recorded the range of *G. gemma* as limited to the Upper Eocene-Lower Oligocene *G. brevis* Zone in New Zealand.

*Globorotalia hirsuta* (d'Orbigny) (Plate 27, Figures 1 and 2):

Remarks: *G. hirsuta* was found to be very rare within its Pliocene-Pleistocene range in the examined area, and Parker (1962, 1967) also found it to be relatively rare in the Pacific.

Stratigraphic occurrence: Site 77: *P. obliquiloculata* Zone, with one record each in the *G. fistulosus* and *S. dehiscens* Zones. Site 79: *P. obliquiloculata* Zone. Site 81: *P. obliquiloculata* Zone. Site 83: *P. obliquiloculata* Zone. Site 84: *P. obliquiloculata* Zone.

Stratigraphic range: *S. dehiscens* Zone to *P. obliquiloculata* Zone; Pliocene to Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded it in Indo-Pacific cores (mainly from the Indian Ocean) from Pliocene Zone N21 to Quaternary Zones N22, 23.

*Globorotalia humerosa* Takayanagi and Saito (Plate 24, Figures 6, 7 and 8):

Remarks: *G. humerosa* was found to be a relatively common species in the Upper Miocene to Lower Pleistocene. It appears to have evolved from *G. acostaensis* Blow in the *G. plesiotumida* Zone and evolved into *G. dutertrei* (d'Orbigny) in the *G. fistulosus* Zone. All three species appear to have solution resistant tests.

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 79: *G. tumida* Zone (with one record in the *G. altispira* Zone). Site 80: *G. tumida* Zone to *S. dehiscens* Zone. Site 82: *G. plesiotumida* Zone to *G. fistulosus* Zone. Site 83: *G. plesiotumida* Zone to *G. fistulosus* Zone. Site 84: *G. plesiotumida* Zone to lower *P. obliquiloculata* Zone.

Stratigraphic range: *G. plesiotumida* Zone to lower *P. obliquiloculata* Zone; Upper Miocene to Lower Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded its range in Indo-Pacific deep-sea cores as Late Miocene Zone N18 to Upper Pliocene Zone N21.

*Globorotalia inflata* (d'Orbigny) (Plate 25, Figures 1 and 2):

Remarks: *G. inflata* was found to be very rare in the western Sites 77 and 80, but was more abundant towards the eastern part of the examined area; however, even at Sites 83 and 84 its occurrence was sporadic.

Coiling: Sinistral.

Stratigraphic occurrence: Site 77: One record in the lower *P. obliquiloculata* Zone. Site 80: One doubtful record in the *G. tumida* Zone. Site 83: *P. obliquiloculata* Zone. Site 84: *G. fistulosus* Zone.

Stratigraphic range: *G. fistulosus* Zone to *P. obliquiloculata* Zone; Upper Pliocene to Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded its range in Indo-Pacific deep-sea cores as Upper Pliocene Zone N21 to Quaternary Zones N22, 23. Jenkins (1967) recorded its range in New Zealand as Lower Pliocene to Pleistocene.

*Globorotalia insolita* Jenkins (Plate 25, Figures 3 through 8):

Remarks: The occurrence of *G. insolita* in the Upper Eocene at Site 77 is the only record outside the New Zealand Upper Eocene (Jenkins, 1966a). The specimens from Site 77 do not possess as highly arched apertures as recorded in the holotype, and in some specimens the aperture is obscured by a flap-like outgrowth similar to that found in *Turborotalia humilis* but lacking the umbilical sutural apertures of this taxon. These apertural differences may be sufficient to merit a new name but the New Zealand specimens will first have to be examined with a scanning electron microscope.

Coiling: In Sample 77B-Core 53-Section 6, core-catcher: 54 dextral and 46 sinistral.

Stratigraphic occurrence: Site 77: *G. insolita* Zone, with questionable specimens in the lowermost *P. barbadoensis* Zone.

Stratigraphic range: *G. insolita* Zone; Upper Eocene.

Recorded stratigraphic range: Jenkins (1966a) recorded its range in New Zealand from the Upper Eocene *G. linaperta* Zone.

*Globorotalia kugleri* Bolli (Plate 25, Figures 9, 10 and 11):

Remarks: *G. kugleri* was found to be an excellent marker at Sites 77, 78, 79 and 80, and as in Trinidad (Bolli, 1957a) its total range has been used to define a Lower Miocene zone.

Stratigraphic occurrence: Site 77: *G. kugleri* Zone. Site 78: *G. kugleri* Zone. Site 79: *G. kugleri* Zone. Site 80: *G. kugleri* Zone.

Stratigraphic range: *G. kugleri* Zone; Lower Miocene.

Recorded stratigraphic range: Bolli (1957a) showed it limited to the Upper Oligocene *G. kugleri* Zone in Trinidad.

*Globorotalia margaritae* Bolli and Bermudez (Plate 26, Figures 1, 2 and 3):

Remarks: *G. margaritae* was found to be very rare within the area examined and appears to be more common in the western part at Site 77.

Stratigraphic occurrence: Site 77: *G. tumida* Zone to *S. dehiscens* Zone with doubtful specimens in the *G. plesiotumida* Zone. Site 79: One doubtful record in the *G. tumida* Zone. Site 84: One doubtful record in the *G. tumida* Zone.

Stratigraphic range: *G. tumida* Zone to *S. dehiscens* Zone; Upper Miocene to Lower Pliocene.

Recorded stratigraphic range: Parker (1967) recorded its range in Indo-Pacific deep-sea cores from the late Miocene Zone N18 to Pliocene Zone N20.

*Globorotalia mendacis* Blow:

Remarks: *G. mendacis* was found to be very rare in the examined area with only one definite record at Site 80.

Stratigraphic occurrence: Site 78: One doubtful occurrence at the base of Core 18, well before the first appearance of *Globorotalia kugleri.* Site 80: *G. kugleri* Zone.

Stratigraphic range: *G. kugleri* Zone; Lower Miocene.

Recorded stratigraphic range: Blow (1969) recorded its range as Zones N2-N4.

*Globorotalia menardii* (Parker, Jones and Brady) (Plate 26, Figures 4 through 6):

Remarks: *G. menardii* was found to be relatively common within the examined area, but was usually less common in the Pliocene-Pleistocene as compared with *Globorotalia tumida* (Brady).

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: *G. fohsi lobata* Zone to *P. obliquiloculata* Zone. Site 79: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 80: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 81: *P. obliquiloculata* Zone. Site 82: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 83: *G. altispira* Zone to *P. obliquiloculata* Zone. Site 84: *G. plesiotumida* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *G. fohsi lobata* Zone to *P. obliquiloculata* Zone; Middle Miocene to Pleistocene.

Recorded stratigraphic range: In the Trinidad Miocene, Bolli (1957a) recorded the initial appearance of *G. menardii* in the *G. fohsi robusta* Zone and extended its range to the *G. menardii* Zone. Parker (1967) recorded its range (as *G. cultrata*) in Indo-Pacific deep-sea cores as Middle Miocene Zone N16 to Quaternary Zones N22, 23.

*Globorotalia merotumida* Banner and Blow (Plate 26, Figures 7, 8 and 9):

Remarks: Within its range *G. merotumida* appears to grade into *G. plesiotumida* and in some samples appears to be its juvenile form. A similar difficulty of identification was experienced by Parker (1967).

Stratigraphic occurrence: Site 77: *G. altispira* Zone to *G. plesiotumida* Zone. Site 79: *G. plesiotumida* Zone. Site 80: *G. plesiotumida* Zone. Site 82: *G. plesiotumida* Zone. Site 83: *G. plesiotumida* Zone to *G. tumida* Zone. Site 84: One doubtful specimen in the *G. plesiotumida* Zone.

Stratigraphic range: *G. altispira* Zone to *G. tumida* Zone; Upper Miocene.

Recorded stratigraphic range: Parker (1967) recorded its range in Indo-Pacific deep-sea cores as Middle Miocene Zone N16 to late Miocene Zone N17.

*Globorotalia* cf. *minutissima* Bolli (Plate 27, Figures 3 through 8):

Remarks: *G.* cf. *minutissima* differs from *G. minutissima* Bolli in having a higher spired test and a larger umbilical-extraumbilical aperture. Some of the specimens appear to be related to *G. angustiumbilicata* Bolli (Plate 27, Figures 5 and 6).

Stratigraphic occurrence: Site 77: *G. opima* Zone to *G. fohsi fohsi-G. peripheroacuta* Zone. Site 78: *G. angulisuturalis* Zone to *G. bisphericus* Subzone. Site 79: *G. kugleri* Zone to *G. dissimilis* Zone. Site 80: *G. kugleri* Zone to *G. venezuelana* Zone. Site 81: *G. bisphericus* Subzone to *G. fohsi fohsi-G. peripheroacuta* Zone.

Stratigraphic range: *G. opima* Zone to *G. fohsi fohsi-G. peripheroacuta* Zone; Upper Oligocene to Middle Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded *G. minutissima* from the base of the *C. stainforthi* Zone to the *G. menardii* Zone in the Trinidad Miocene.

*Globorotalia miocenica* Palmer (Plate 28, Figures 1, 2 and 3):

Remarks: *G. miocenica* was only recorded at the most eastern Site 84: this tends to confirm the hypothesis that it is an Atlantic species, because it could have migrated into the eastern equatorial Pacific through the "Gulf" of Panama during the Upper Miocene-Upper Pliocene.

Stratigraphic occurrence: Site 84: *G. plesiotumida* Zone to *G. fistulosus* Zone.

Stratigraphic range: *G. plesiotumida* Zone to *G. fistulosus* Zone; Upper Miocene to Upper Pliocene.

Recorded stratigraphic range: Bolli (1970, Leg 4, Initial Core Description Report) recorded its range in the Pliocene from the upper part of *G. margaritae* Zone to *G. exilis/G. miocenica* Zone.

*Globorotalia* cf. *miozea* Finlay (Plate 27, Figures 9, 10 and 11):

Remarks: *G.* cf. *miozea* was very rare in the examined area being limited to the western Sites 77, 79 and 81. The specimens differ from *G. miozea* in having a less rounded peripheral outline, but this may be due to forms not possessing the small final chamber as in the *G. miozea* holotype.

Stratigraphic occurrence: Site 77: Rather doubtful specimens in the *G. fohsi fohsi-G. peripheroacuta* Zone to the *G. altispira* Zone. Site 79: One doubtful record in the *G. altispira* Zone. Site 81: *G. fohsi fohsi-G. peripheroacuta* Zone.

Stratigraphic range: *G. fohsi fohsi-G. peripheroacuta* Zone; Middle Miocene.

Recorded stratigraphic range: Jenkins (1967) recorded the range of *G. miozea miozea* in the New Zealand Middle Miocene from the *G. trilobus trilobus* Zone to *G. mayeri mayeri* Zone.

*Globorotalia multicamerata* Cushman & Jarvis (Plate 28, Figures 4, 5 and 6):

Remarks: *G. multicamerata* was found to be fairly rare at most sites except at Site 83, where it was fairly common and where it appeared to be related to *G. exilis*. The extinction level of *G. multicamerata* in the *G. fistulosus* Zone seems to be a fairly reliable datum at Sites 77, 82 and 83.

Stratigraphic occurrence: Site 77: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 79: One doubtful record in the lower *P. obliquiloculata* Zone. Site 80: One doubtful record in the *P. obliquiloculata* Zone. Site 82: *S. dehiscens* Zone to lower *G. fistulosus* Zone. Site 83: *G. plesiotumida* Zone to *G. fistulosus* Zone. Site 84: *G. tumida* Zone to *S. dehiscens* Zone.

Stratigraphic range: *G. plesiotumida* Zone to *G. fistulosus* Zone; Upper Miocene to Upper Pliocene.

Recorded stratigraphic range: Parker (1967) recorded its range in Indo-Pacific deep-sea cores from Middle Miocene Zone N16 to Pliocene Zone N21.

*Globorotalia nana* Bolli (Plate 28, Figures 7, 8 and 9):

Remarks: *G. nana* was found to be relatively common within its stratigraphic range; tests reached their maximum size in the *G. opima* Zone.

Stratigraphic occurrence: Site 77: *G. insolita* Zone to *G. opima* Zone. Site 78: *P. barbadoensis* Zone to *G. kugleri* Zone. Site 79: One doubtful record in the *G. dissimilis* Zone.

Stratigraphic range: *G. insolita* Zone to *G. kugleri* Zone; Upper Eocene to Lower Miocene.

Recorded stratigraphic range: In Trinidad Bolli (1957a,b) recorded *G. nana* from Middle Eocene *T. rohri* Zone to the Oligocene *G. ciperoensis* Zone. In New Zealand it ranges from the Upper Eocene *G. inconspicua* Zone to the Middle Miocene *P. glomerosa curva* Zone (Jenkins, 1966a, 1967).

*Globorotalia obesa* Bolli:

Remarks: *G. obesa* was only found in one sample at Site 81. From its recorded Miocene occurrence in Trinidad (Bolli, 1957a), *G. obesa* was expected in the examined area; its absence could be due to solution effects.

Stratigraphic occurrence and record: Site 81: One record in the *G. fohsi fohsi-G. peripheroacuta* Zone.

Recorded stratigraphic range: Bolli (1957a) recorded its range in Trinidad as Lower Miocene *C. dissimilis* Zone to Upper Miocene *G. menardii* Zone.

*Globorotalia opima* Bolli (Plate 28, Figures 10, 11 and 12):

Remarks: Within its Oligocene stratigraphic range, *G. opima* seems to grade into *G. nana* Bolli, but is

distinguished by having 5 chambers in the final whorl and in having a more open aperture.

Stratigraphic occurrence: Site 77: *C. cubensis* Zone to Upper *G. opima* Zone. Site 78: *C. cubensis* Zone to upper *G. opima* Zone.

Stratigraphic range: *C. cubensis* Zone to *G. opima* Zone; Oligocene.

Recorded stratigraphic range: Bolli (1957a) recorded its range in Trinidad as limited to the Oligocene *G. opima* Zone.

*Globorotalia* cf. *pachyderma* (Ehrenberg) (Plate 29, Figures 1 and 2):

Remarks: *G.* cf. *pachyderma* was only found in the two most eastern Sites 83 and 84, where it occurs with other cooler water indicators.

Stratigraphic occurrence: Site 83: One record in the *P. obliquiloculata* Zone. Site 84: *P. obliquiloculata* Zone.

Stratigraphic range: *P. obliquiloculata* Zone; Pleistocene.

Recorded stratigraphic range: Jenkins (1967) recorded its range in New Zealand as Upper Miocene *G. miotumida miotumida* Zone to Recent. Bandy *et al.* (1969) recorded a similar initial appearance in the Upper Miocene of southeastern Alaska.

*Globorotalia* aff. *panda* Jenkins (Plate 29, Figures 3, 4 and 5):

Remarks: Rare specimens of a keeled *Globorotalia* with a flattened umbilical side and convex spiral side were recorded in Pleistocene sediments. The illustrated specimen has been referred to *G.* aff. *panda* and is probably a homeomorph of *G. panda* originally described from the Middle-Miocene of south-east Australia (Jenkins, 1960).

Stratigraphic occurrence: Site 84: *P. obliquiloculata* Zone; Pleistocene.

*Globorotalia peripheroacuta* Blow and Banner (Plate 29, Figures 6, 7 and 8):

Remarks: *G. peripheroacuta* were found to be relatively common within its short Middle Miocene stratigraphic range where it grades in its lower range into *G. peripheroronda* and in its upper range into *G. praefohsi-G. fohsi* populations.

Stratigraphic occurrence: Site 77: Lower part of the *G. fohsi fohsi-G. peripheroacuta* Zone. Site 78: Lower part of the *G. fohsi fohsi-G. peripheroacuta* Zone. Site 79: Lower part of the *G. fohsi fohsi-G. peripheroacuta* Zone. Site 80: One doubtful record in the *G. fohsi fohsi-G. peripheroacuta* Zone. Site 81: *G. fohsi fohsi-G. peripheroacuta* Zone.

Stratigraphic range: *G. fohsi fohsi-G. peripheroacuta* Zone; Middle Miocene.

Recorded stratigraphic range: Blow and Banner (1966) recorded the range of *G. peripheroacuta* from the *G. (T.) peripheroacuta* Zone to the *G. (G.) fohsi* s.l. Zone.

*Globorotalia peripheroronda* Blow and Banner (Plate 29, Figures 9, 10 and 11):

Remarks: *G. peripheroronda* evolved into *G. peripheroacuta* in the lowermost part of the *G. peripheroacuta* Zone, and at this level at Site 78 there is a complete morphological gradation between the two taxa.

Stratigraphic occurrence: Site 77: *G. venezuelana* Zone to lower *G. fohsi fohsi-G. peripheroacuta* Zone. Site 78: *G. kugleri* Zone to lower *G. fohsi fohsi-G. peripheroacuta* Zone. Site 79: *G. kugleri* Zone to lower *G. fohsi fohsi-G. peripheroacuta* Zone. Site 80: *G. venezuelana* Zone to *G. fohsi fohsi-G. peripheroacuta* Zone.

Stratigraphic range: First appearance in the upper part of the *G. kugleri* Zone and ranges through into the lower part of the *G. fohsi fohsi-G. peripheroacuta* Zone; Lower to Middle Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded its range (as *G. barisanensis*) in Trinidad as Lower Miocene *G. kugleri* Zone to the Middle Miocene lower *G. fohsi fohsi* Zone.

*Globorotalia plesiotumida* Banner and Blow (Plate 30, Figures 1, 2 and 3):

Remarks: *G. plesiotumida* was found to be relatively common within its Upper Miocene stratigraphic range, and in the lower *G. tumida* Zone there is some evidence at Site 77B that it evolved into *G. tumida.*

Stratigraphic occurrence: Site 77: Base of the *G. plesiotumida* Zone to base of the *G. tumida* Zone. Site 79: *G. plesiotumida* Zone to *G. tumida* Zone. Site 80: *G. plesiotumida* Zone to *G. tumida* Zone. Site 82: *G. plesiotumida* Zone. Site 83: *G. plesiotumida* Zone, with doubtful records in the upper *G. altispira* Zone and lower *G. tumida* Zone. Site 84: *G. plesiotumida* Zone to lower *G. tumida* Zone.

Stratigraphic range: *G. plesiotumida* Zone to lower *G. tumida* Zone; Upper Miocene.

Recorded stratigraphic range: Parker (1967) recorded its stratigraphic range in Indo-Pacific deep-sea cores as limited to the Late Miocene Zone N17.

*Globorotalia praemenardii* Cushman and Stainforth (Plate 30, Figures 4, 5 and 6):

Remarks: *G. praemenardii* was found to be relatively rare in the examined area. At Site 77 there is an overlap in the ranges of *G. archaeomenardii* and *G. praemenardii* in the *G. peripheroronda* Zone which is slightly before the overlap as recorded in Trinidad by Bolli (1957a).

Stratigraphic occurrence: Site 77: *G. peripheroronda* Zone to *G. fohsi fohsi-G. peripheroacuta* Zone. Site 78: *G. peripheroronda* Zone to the *G. fohsi fohsi-G. peripheroacuta* Zone. Site 79: *G. fohsi fohsi-G. peripheroacuta* Zone to *G. altispira* Zone. Site 81: *G. bisphericus* Subzone to *G. fohsi fohsi-G. peripheroacuta* Zone.

Stratigraphic range: *G. bisphericus* Subzone to *G. fohsi fohsi-G. peripheroacuta* Zone; Lower to Middle Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded a slightly later appearance in the Trinidad Middle Miocene with a range of *G. fohsi fohsi* Zone to *G. fohsi robusta* Zone.

*Globorotalia praescitula* Blow (Plate 31, Figure 1):

Remarks: *G. praescitula* was found to be comparatively rare although it was recorded within its stratigraphic range at Sites 77 through 81, inclusive.

Stratigraphic occurrence: Site 77: *G. venezuelana* Zone to *G. bisphericus* Subzone. Site 78: *G. dissimilis* Zone to *G. peripheroronda* Zone. Site 79: *G. dissimilis* Zone to *G. peripheroronda* Zone. Site 80: One doubtful record in the *G. fohsi fohsi-G. peripheroacuta* Zone. Site 81: *G. bisphericus* Subzone to *G. peripheroronda* Zone.

Stratigraphic range: *G. dissimilis* Zone to *G. peripheroronda* Zone; Lower to Middle Miocene.

Recorded stratigraphic range: Blow (1959) recorded its range in Venezuela as Lower Miocene *C. stainforthi* Zone to Middle Miocene *G. fohsi barisanensis* Zone.

*Globorotalia* cf. *pseudokugleri* Blow (Plate 31, Figures 2 and 3):

Remarks: The only *in situ* record of *G. pseudokugleri* was in the Upper Oligocene at Site 78, but the figured specimen is from the reworked Lower Miocene fauna in the Pliocene at Site 76.

Stratigraphic occurrence: Site 78: Upper part of the *G. angulisuturalis* Zone.

Stratigraphic range: *G. angulisuturalis* Zone; upper Oligocene.

Recorded stratigraphic range: Blow (1969) recorded the range of *G. pseudokugleri* in the Zones N3 to N4.

*Globorotalia pseudomiocenica* Bolli and Bermudez (Plate 30, Figures 7, 8 and 9):

Remarks: At Sites 77 and 84, there is some evidence that *G. pseudomiocenica* is related to *Globorotalia exilis*. Within its stratigraphic range *G. pseudomiocenica* was found to be sporadic and rare.

Stratigraphic occurrence: Site 77: *G. plesiotumida* to *S. dehiscens* Zone. Site 80: *S. dehiscens* Zone. Site 83: *S. dehiscens* Zone with one doubtful record in the *G. plesiotumida* Zone. Site 84: *G. tumida* Zone to *S. dehiscens* Zone with one record in the *G. plesiotumida* Zone which could be due to downhole contamination.

Stratigraphic range: *G. plesiotumida* Zone to *S. dehiscens* Zone; Upper Miocene to Pliocene.

Recorded stratigraphic range: Bolli (1970; Leg 4 report) recorded it from the *G. margaritae* Zone.

*Globorotalia scitula* (Brady) (Plate 31, Figures 4 and 5):

Remarks: *G. scitula* was found to be sporadic and rare within the examined area where it was found mainly within the upper part of its range in the Pliocene-Pleistocene.

Stratigraphic occurrence: Site 77: *G. fohsi fohsi-G. peripheroacuta* Zone to *P. obliquiloculata* Zone. Site 79: One record in *P. obliquiloculata* Zone. Site 81: *P. obliquiloculata* Zone. Site 82: One doubtful record in the *S. dehiscens* Zone. Site 83: *S. dehiscens* Zone to *P. obliquiloculata* Zone. Site 84: *S. dehiscens* Zone to *P. obliquiloculata* Zone.

Coiling: Dextral.

Stratigraphic range: *G. fohsi fohsi-G. peripheroacuta* Zone to *P. obliquiloculata* Zone; Middle Miocene to Pleistocene.

Recorded stratigraphic range: Bolli (1957a) recorded *G. scitula* in the Trinidad Miocene from the *G. fohsi fohsi* Zone to *G. menardii* Zone. Parker (1967) recorded it in Indo-Pacific deep-sea cores from the Late Miocene Zone N17 to Quaternary Zones N22, 23.

*Globorotalia siakensis* (Le Roy) (Plate 32, Figures 1, 2 and 3):

Remarks: *G. siakensis* seems to be one of the longest ranging *Globorotalia* in the Cenozoic and within its stratigraphic range it is relatively common and appears to have a solution resistant test.

Stratigraphic occurrence: Site 77: *G. opima* Zone to lower *G. altispira* Zone. Site 78: *C. cubensis* Zone to *G. fohsi fohsi-G. peripheroacuta* Zone. Site 79: *G. kugleri* Zone to *G. altispira* Zone. Site 80: *G. dissimilis* Zone to *G. fohsi fohsi-G. peripheroacuta* Zone. Site 81: *G. bisphericus* Subzone to *G. fohsi fohsi-G. peripheroacuta* Zone.

Stratigraphic range: *C. cubensis* Zone to *G. altispira* Zone; Oligocene to Upper Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded it (as *Globorotalia mayeri*) as ranging from the Oligocene *G. opima opima* Zone to the Middle Miocene *G. mayeri* Zone in Trinidad.

*Globorotalia* cf. *siakensis* (Le Roy) (Plate 32, Figures 4 through 9):

Remarks: *G.* cf. *siakensis* is closely related to *G. siakensis* but has a tendency to have a more tightly coiled test and sometimes results in a pseudobilateral symmetry. It is probably the ancestor of *G. siakensis.*

Stratigraphic occurrence: Site 77: *P. barbadoensis* Zone to *C. cubensis* Zone. Site 78: *G. ampliapertura* Zone to *C. cubensis* Zone.

*Globorotalia tosaensis* Takayanagi and Saito (Plate 33, Figures 1, 2 and 3):

Remarks: *G. tosaensis* was found to be relatively rare and sporadic in occurrence and appears to become progressively rarer eastwards in the examined area. A transition between *Globorotalia crassaformis* (Galloway and Wissler) and *G. tosaensis* was found at Site 77 (Core 3, Section 5, 13 to 15 centimeters) in the *G. fistulosus* Zone. A gradation between *G. tosaensis* and *Globorotalia truncatulinoides* was found at Site 77 in the *P. obliquiloculata* Zone. The rarity of *G. tosaensis*, due possibly to solution effects, makes it practically useless as a zonal marker in the eastern equatorial Pacific.

Coiling: Dextral.

Stratigraphic occurrence: Site 76: *G. fistulosus* Zone. Site 77: *G. fistulosus* Zone to *P. obliquiloculata* Zone. Site 79: Lower *P. obliquiloculata* Zone. Site 80: Lower *P. obliquiloculata* Zone. Site 82: One doubtful record in the *P. obliquiloculata* Zone. Site 83: *P. obliquiloculata* Zone. Site 84: *G. fistulosus* to *P. obliquiloculata* Zone.

Stratigraphic range: *G. fistulosus* Zone to *P. obliquiloculata* Zone; Upper Pliocene to Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded its range in Indo-Pacific deep-sea cores as Upper Pliocene Zone N21.

*Globorotalia truncatulinoides* (d'Orbigny) (Plate 33, Figures 4, 5 and 6):

Remarks: *G. truncatulinoides* was found to be very rare in the examined area, and this is probably due to its original nontropical paleogeographic distribution pattern in the Upper Cenozoic, combined with a susceptibility to solution (see Berger, 1970). Because of its rarity, it was found to be useless as a zonal marker in the examined area. *G. truncatulinoides* was recorded only in the western Sites 77, 80 and 82, and its absence in the more eastern Sites 83 and 84 is not clearly understood.

Coiling: Dextral.

Stratigraphic occurrence: Site 77: *P. obliquiloculata* Zone. Site 80: *P. obliquiloculata* Zone. Site 82: One doubtful record in the *P. obliquiloculata* Zone.

Stratigraphic range: *P. obliquiloculata* Zone; Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded its range in Indo-Pacific deep-sea cores as Quaternary Zones N22, 23.

*Globorotalia truncatulinoides pachytheca* Blow (Plate 33, Figures 7, 8 and 9):

Remarks: *G. truncatulinoides pachytheca* is here regarded as a possible thinner-walled tropical representative of *G. truncatulinoides.*

Stratigraphic occurrences: Site 77: One record in the *P. obliquiloculata* Zone. Site 81: One record in the *P. obliquiloculata* Zone.

Stratigraphic range: *P. obliquiloculata* Zone; Pleistocene.

Recorded stratigraphic range: Blow (1969) recorded its range in Zones N22 and 23.

*Globorotalia tumida flexuosa* (Koch) (Plate 31, Figures 6, 7 and 8):

Remarks: *G. tumida flexuosa* was one of the most common keeled *Globorotalia* within its Upper Miocene-Pleistocene range where it normally grades into *G. tumida tumida* (Brady).

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: Base of the *G. tumida* Zone to *P. obliquiloculata* Zone. Site 79: *G. tumida* Zone to *P. obliquiloculata* Zone. Site 80: *P. obliquiloculata* Zone. Site 81: *P. obliquiloculata* Zone. Site 82: *S. dehiscens* Zone to *P. obliquiloculata* Zone. Site 83: *G. tumida* Zone to *P. obliquiloculata* Zone. Site 84: *G. tumida* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *G. tumida* Zone to *P. obliquiloculata* Zone; Upper Miocene to Pleistocene.

Recorded stratigraphic range: Parker (1967) regarded it as synonymous with *G. tumida* and recorded the latter's range as late Miocene Zone N18 to Quaternary Zone N22, 23.

*Globorotalia tumida tumida* (Brady) (Plate 34, Figures 1, 2 and 3):

Remarks: Within its stratigraphic range in the Upper Miocene-Pleistocene, *G. tumida tumida* and *G. tumida flexuosa* are the most common sub-species of keeled *Globorotalia*, and appear to be relatively solution resistant (see Berger, 1970).

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: *G. tumida* Zone to *P. obliquiloculata* Zone. Site 79: *G. tumida* Zone to *P. obliquiloculata* Zone. Site 80: *G. tumida* Zone to *P. obliquiloculata* Zone. Site 81: *P. obliquiloculata* Zone. Site 82: *S. dehiscens* Zone to the *G. fistulosus* Zone. Site 83: *G. fistulosus* Zone to *P. obliquiloculata* Zone. Site 84: *G. tumida* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *G. tumida* Zone to *P. obliquiloculata* Zone; Upper Miocene to Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded its range in Indo-Pacific deep-sea cores as late Miocene Zone N18 to Quaternary Zones N22, 23.

*Globorotalia* cf. *tumida* Brady (Plate 34, Figures 4 through 9):

Remarks: Heavily keeled specimens of *Globorotalia* were recovered from the *P. obliquiloculata* Zone at Site 77B. The photographed specimens which have been referred to *G.* cf. *tumida* also show the development of umbilical shoulders, reminiscent of some of the Paleocene-Eocene "*Globorotalia*".

Stratigraphic occurrence: Site 77B, Core 2, Section 5, 66 to 68 centimeters; *P. obliquiloculata* Zone, Pleistocene.

*Globorotalia ungulata* Bermudez (Plate 35, Figures 1 through 6):

Remarks: *G. ungulata* was found to be very rare in the examined area.

Stratigraphic occurrence: Site 77: One record in the *P. obliquiloculata* Zone. Site 82: One record in the *G. fistulosus* Zone, and two doubtful records in the *P. obliquiloculata* Zone. Site 84: *P. obliquiloculata* Zone.

Stratigraphic range: *G. fistulosus* Zone to *P. obliquiloculata* Zone; Upper Pliocene to Pleistocene.

Recorded stratigraphic range: Blow (1969) recorded its range as Zones N19-N23.

Genus *Globorotaloides* Bolli, 1957

*Globorotaloides hexagona* (Natland) (Plate 36, Figures 1 through 9):

Remarks: *G. hexagona* was found to be relatively common in the examined area and possibly more common in the sediments of the eastern Sites 83 and 84. It rarely develops a bulla but more commonly has a reduced final chamber. There is also some variation in the degree of test ornamentation from coarse to fine, and specimens have been illustrated to demonstrate this.

It is here suggested that *H. bermudezei* may have evolved from *G. hexagona* in the Lower Miocene.

*G. hexagona* appears to have a solution resistant test.

Stratigraphic occurrence: Site 77: Lower *G. plesiotumida* Zone to *P. obliquiloculata* Zone, with one isolated doubtful record in the *G. fohsi fohsi-G. peripheroacuta* Zone. Site 79: *G. peripheroronda* Zone to *G. fistulosus* Zone. Site 80: *G. bisphericus* Subzone to *P. obliquiloculata* Zone. Site 81: *G. bisphericus* Subzone to *P. obliquiloculata* Zone. Site 82: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 83: *G. altispira* Zone to *P. obliquiloculata* Zone. Site 84: *G. plesiotumida* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *G. bisphericus* Subzone to *P. obliquiloculata* Zone; Lower Miocene to Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded its range in deep-sea cores as Late Miocene Zone N17 to Quaternary Zones N22, 23.

*Globorotaloides stainforthi* (Bolli, Loeblich and Tappan) (Plate 35, Figures 7, 8 and 9):

Remarks: *G. stainforthi* was very rare and sporadic in occurrence in the *G. dissimilis* Zone at Sites 77 through 80.

Stratigraphic occurrence: Site 77: *G. dissimilis* Zone. Site 78: *G. dissimilis* Zone. Site 79: Two doubtful records in the *G. dissimilis* Zone. Site 80: *G. dissimilis* Zone.

Stratigraphic range: *G. dissimilis* Zone; Lower Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded it in the Lower Miocene from the base of the *G. dissimilis* Zone to middle of the *G. inseuta* Zone.

*Globorotaloides suteri* Bolli (Plate 36, Figures 10 and 11; Plate 37, Figures 1, 2 and 3):

Remarks: *G. suteri* was found to be rare and sporadic within its stratigraphic range in the examined area, and it appears to have become extinct before the appearance of *G. hexagona.*

Stratigraphic occurrence: Site 77: *G. insolita* Zone to *P. barbadoensis* Zone with single doubtful records in the *G. angulisuturalis, G. venezuelana* and *G. fohsi lobata* Zones. Site 78: *G. ampliapertura* Zone to *G. dissimilis* Zone. Site 80: *G. kugleri* Zone (one record).

Stratigraphic range: *G. insolita* Zone to *G. dissimilis* Zone; Upper Eocene to Lower Miocene.

Recorded stratigraphic range: Bolli (1957a,b) recorded its range in Trinidad as Middle Eocene *P. mexicana* Zone to the Middle Miocene *G. insueta* Zone.

*Globigerinita unicava* (Bolli, Loeblich and Tappan):

Remarks: *G. unicava* was found to be very rare in the examined area within its Upper Eocene-Lower Miocene range.

Stratigraphic occurrence: Site 77: *G. insolita* Zone to *G. opima* Zone. Site 78: One record in the *G. kugleri* Zone. Site 79: One doubtful record in the *G. dissimilis* Zone.

Stratigraphic Range: *G. insolita* Zone to *G. kugleri* Zone; Upper Eocene to Lower Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded its stratigraphic range from the Oligocene *G. ampliapertura* Zone to the Lower Miocene *C. stainforthi* Zone.

Genus *Hantkenina* Cushman, 1924

*Hantkenina alabamensis* Cushman (Plate 37, Figure 8):

Remarks: Specimens of *H. alabamensis* were reworked into the Pliocene sediments at Site 76. Some of the reworked specimens were found to be exceptionally well-preserved, and this is shown by the illustrated specimen which still retains many of its long spines.

Genus *Hastigerina* Thompson, 1876

*Hastigerina pelagica* (d'Orbigny):

Remarks: One doubtful record of *H. pelagica* was recorded in the *P. obliquiloculata* Zone at Site 84: its thin test wall which is probably solution prone accounts for its rarity.

Recorded stratigraphic range: Parker (1967) recorded its range in Indo-Pacific cores as Late Miocene Zone N17 to Quaternary Zones N22, 23.

Genus *Hastigerinella* Cushman, 1927

*Hastigerinella bermudezi* Bolli (Plate 38, Figures 1, 2 and 3):

Remarks: *H. bermudezi* has a distinctive form and was fairly common at Sites 78 and 80. It is a good marker in the *G. bisphericus* Subzone- lower *G. fohsi fohsi-G. peripheroacuta* Zone and may be identified even from individual broken chambers. At Site 78 there is an overlap in the ranges of *H. bermudezi* and *Globigerinatella insueta* which was not recorded in Trinidad by Bolli (1957a: see below). Both juvenile and adult forms have been illustrated (Plate 38, Figures 2 and 3).

Stratigraphic occurrence: Site 77: *G. peripheroronda* Zone to *G. fohsi foshi-G. peripheroacuta* Zone. Site 78: *G. bisphericus* Subzone to lower *G. fohsi fohsi-G. peripheroacuta* Zone. Site 79: Two doubtful records in the *G. peripheroronda* Zone. Site 80: *G. bisphericus* Subzone to *G. peripheroronda* Zone. Site 81: *G. bisphericus* Subzone to *G. peripheroronda* Zone.

Stratigraphic range: *G. bisphericus* Subzone to *G. fohsi fohsi-G. peripheroacuta* Zone; Lower to Middle Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded *H. bermudezi* from the Middle Miocene *G. fohsi barisanensis* Zone of Trinidad.

*Hastigerinella rhumbleri* Galloway (Plate 37, Figures 4, 5 and 6):

Remarks: *H. rhumbleri* has a very delicate test and was only found in one sample at Site 84.

Stratigraphic occurrence and range: Site 84: *P. obliquiloculata* Zone; Pleistocene.

Recorded stratigraphic range: According to Bolli *et al.* (1957), *H. rhumbleri* has been recorded from the Recent.

Genus *Hastigerinoides* Bronnimann, 1952

*Hastigerinoides* (?) sp. (Plate 37, Figure 7):

Remarks: A specimen possibly belonging to the genus *Hastigerinoides* was recovered from the *C. cubensis* Zone at Site 77B. If it is *Hastigerinoides* then it may have been reworked into the *C. cubensis* Zone from Cretaceous rocks during the Oligocene.

Stratigraphic occurrence: Site 77B, Core 42, core-catcher; *C. cubensis* Zone, Oligocene.

Genus *Orbulina* d'Orbigny, 1839

*Orbulina bilobata* (d'Orbigny) (Plate 38, Figure 4):

Remarks: Following the work of Parker (1967) it was thought that *O. bilobata* was a good marker at the top of the Miocene, but in the examined area its extinction level was found to be diachronous and unreliable for correlation.

Stratigraphic occurrence: Site 77: *G. plesiotumida* Zone and one isolated record in the *G. fistulosus* Zone. Site 79: *G. altispira* Zone to *G. tumida* Zone. Site 80: *G. plesiotumida* Zone. Site 82: *G. plesiotumida* Zone to *S. dehiscens* Zone with one isolated record in the *G. fistulosus* Zone. Site 83: *G. plesiotumida* Zone to *S. dehiscens* Zone. Site 84: *G. plesiotumida* Zone to *S. dehiscens* Zone.

Stratigraphic range: *G. altispira* Zone to *S. dehiscens* Zone possibly ranging into the *G. fistulosus* Zone; Upper Miocene to Pliocene.

Recorded stratigraphic range: Blow (1959) recorded its range in Venezuela as *G. insueta-G. bispherica* Zone to the *G. bulloides* Zone. Parker (1967) recorded its range in Middle to late Miocene in Indo-Pacific deep-sea cores as Zones N16-N18, with specimens stratigraphically higher (Zones N19 or 20) in Core MSN 56 P (Indian Ocean).

*Orbulina suturalis* Bronnimann (Plate 38, Figures 5 and 6):

Remarks: Both *O. suturalis* and its *Praeorbulina* ancestors in the Middle Miocene were found to be very rare or missing in the examined area; this is possibly due to solution of the tests. Berger (1970) ranks *O. universa*, which evolved from *O. suturalis*, as having a very low resistance to solution.

Stratigraphic occurrence: Site 78: *G. fohsi fohsi-G. peripheroacuta* Zone. Site 79: One record in the *G. altispira* Zone.

Stratigraphic range: *G. fohsi fohsi-G. peripheroacuta* Zone to *G. altispira* Zone; Middle to Upper Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded its Miocene range in Trinidad as upper *G. insueta* Zone to *G. menardii* Zone.

*Orbulina universa* d'Orbigny:

Remarks: *O. universa* was found to be fairly sporadic and rare in Middle to Upper Miocene sediments but much more common in the Pliocene-Pleistocene. The explanation of this apparent increase is not understood because *O. universa* tests are reported to have low resistance to solution (Berger, 1970).

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: Lower *G. fohsi fohsi-G. peripheroacuta* Zone to *P. obliquiloculata* Zone. Site 79: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 80: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 81: *G. fohsi fohsi-G. peripheroacuta* Zone to *P. obliquiloculata* Zone. Site 82: *G. plesiotumida* Zone to *P. obliquiloculata* Zone. Site 83: *G. altispira* Zone to *P. obliquiloculata* Zone. Site 84: *G. plesiotumida* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *G. fohsi fohsi-G. peripheroacuta* Zone to *P. obliquiloculata* Zone; Middle Miocene to Pleistocene.

Recorded stratigraphic range: Bolli (1957a) recorded its Miocene range in Trinidad as upper *G. insueta* Zone to the *G. menardii* Zone. Parker (1967) recorded it throughout the Indo-Pacific core sequence examined, from Middle Miocene Zone N16 to Quaternary Zone N23.

Genus *Praeorbulina* Olsson, 1964

*Praeorbulina glomerosa circularis* (Blow) (Plate 38, Figures 7, 8 and 9):

Remarks: *P. glomerosa circularis* was only recorded in one Middle Miocene sample at Site 81.

Stratigraphic occurrence and range: Site 81: One record in the *G. peripheroronda* Zone; Middle Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded its range in the Trinidad Middle Miocene as *G. insueta* Zone to *G. fohsi barisanensis* Zone.

*Praeorbulina glomerosa curva* (Blow) (Plate 38, Figures 10 and 11):

Remarks: The only record of *P. glomerosa curva* occurred in a Middle Miocene sample at Site 78 with specimens showing a morphological transition into *Globigerinoides bisphericus* Todd.

Stratigraphic occurrence: Site 78: *P. glomerosa curva* Subzone; Middle Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded its range in the Trinidad Middle Miocene as *G. insueta* Zone to *G. fohsi barisanensis* Zone.

Genus *Pseudohastigerina* Banner and Blow, 1959

*Pseudohastigerina barbadoensis* Blow (Plate 40, Figures 1 and 2):

Remarks: *P. barbadoensis* is readily distinguished from *P. micra* (Cole) by deeper cut sutures and in having more chamber in the final whorl. There is an overlap in the ranges of the two taxa in the lower Oligocene at Site 77.

Stratigraphic occurrence: Site 77: *P. barbadoensis* Zone. Site 78: *P. barbadoensis* Zone.

Stratigraphic range: *P. barbadoensis* Zone; lower Oligocene.

Recorded stratigraphic range: Blow (1969) recorded its range as Zones P16-P19.

*Pseudohastigerina micra* Cole:

Remarks: *P. micra* was found to be relatively rare in the Upper Eocene-Lower Oligocene sediments at Site 77.

In New Zealand *P. micra* ranges into the base of the Oligocene *G. brevis* Zone whereas *G. insolita* became extinct in the underlying Upper Eocene *G. linaperta* Zone. Similar biostratigraphic events occur at Site 77, where *G. insolita* became extinct before the extinction of *P. micra* (see Site 77 chart).

Stratigraphic occurrence: Site 77: *G. insolita* Zone to lower *P. barbadoensis* Zone; Upper Eocene to Lower Oligocene.

Recorded stratigraphic range: Bolli (1957b) recorded its range in Trinidad for the Middle Eocene *H. aragonensis* Zone to Upper Eocene *G. cocoaensis* Zone. Banner and Blow (in Eames *et al.*, 1962) recorded it in the Upper Eocene-Lower Oligocene of Lindi, East Africa.

Genus *Pulleniatina* Cushman, 1927

*Pulleniatina obliquiloculata* (Parker and Jones) (Plate 39, Figures 1 and 2):

Remarks: *P. obliquiloculata* was found to be well preserved and relatively abundant within its Pliocene-Pleistocene stratigraphic range. Because of this, it has been chosen as the name bearer of the zone for the Pleistocene after the extinction of *Globigerinoides fistulosus*. High spired forms were found in two samples at Site 84: Core 11, core-catcher and Core 8, core-catcher. Included in *P. obliquiloculata* are forms previously referred to as *P. finalis* (see Plate 39, Figures 1 and 2).

Stratigraphic occurrences: Site 76: *G. fistulosus* Zone. Site 77: *S. dehiscens* Zone to *P. obliquiloculata* Zone. Site 79: *G. fistulosus* Zone (?) to *P. obliquiloculata* Zone. Site 80: *P. obliquiloculata* Zone. Site 81: *P. obliquiloculata* Zone. Site 82: *G. fistulosus* Zone to *P. obliquiloculata* Zone. Site 83: *G. fistulosus* Zone to *P. obliquiloculata* Zone. Site 84: *G. fistulosus* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *S. dehiscens* Zone to *P. obliquiloculata* Zone; Pliocene to Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded its Pliocene-Pleistocene range in Indo-Pacific deep-sea cores as Zone N19 to N22, 23. Hays *et al.* (1969) showed a later initial appearance for *P. obliquiloculata* in the Gauss Normal Paleomagnetic Event.

*Pulleniatina primalis* Banner and Blow (Plate 39, Figures 3 through 10):

Remarks: *P. primalis* was found to be relatively common and well preserved within its Upper Miocene-Lower Pleistocene stratigraphic range; it appears to have a solution resistant test.

The initial appearance of *P. primalis* in the *G. plesiotumida* Zone could be a useful biostratigraphic datum although its immediate ancestor is not known. Specimens have been photographed to illustrate the smooth walled form (Plate 39, Figures 5, 6 and 7), the rough walled form (Plate 39, Figures 8, 9 and 10) and the high spired form (Plate 39, Figures 3 and 4).

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: *G. plesiotumida* Zone to *G. fistulosus* Zone. Site 79: *G. tumida* Zone with one doubtful record in the *P. obliquiloculata* Zone. Site 80: *G. plesiotumida* Zone to *S. dehiscens* Zone. Site 82: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 83: *G. plesiotumida* Zone to lower *P. obliquiloculata* Zone. Site 84: *G. tumida* Zone to upper *G. fistulosus* Zone.

Stratigraphic range: *G. plesiotumida* Zone to lower *P. obliquiloculata* Zone; Upper Miocene to Lower Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded its Late Miocene-Pliocene range in Indo-Pacific deep-sea cores from Zone N17-N21. Hays *et al.* (1969) recorded it in the equatorial eastern Pacific from the Gilbert Reversed to the Olduvai Normal Paleomagnetic Event.

*Pulleniatina spectabilis* Parker (Plate 39, Figures 11, 12 and 13):

Remarks: *P. spectabilis* was found only at Site 77 with one doubtful specimen at Site 79 and a possible

ancestor in the *S. dehiscens* Zone at Site 83. *P. spectabilis* is a good stratigraphic marker, but its value is diminished by its restriction in the examined area to the western Site 77.

Stratigraphic occurrence: Site 77: *S. dehiscens* Zone. Site 79: One doubtful specimen in *G. tumida* Zone.

Stratigraphic range: *S. dehiscens* Zone; Lower Pliocene.

Recorded stratigraphic range: Parker (1967) recorded *P. spectabilis* from the upper late Miocene Zone N18 to the Pliocene Zone N21 in Indo-Pacific deep-sea cores. Hays *et al.* (1969) recorded a shorter range in eastern Pacific within the Pliocene Gilbert Reversed Magnetic Event and this range is similar to that obtained at Site 77.

Genus *Sphaeroidinella* Cushman, 1927

*Sphaeroidinella dehiscens* (Parker and Jones) (Plate 40, Figures 3 through 8):

Remarks: The initial appearance of *S. dehiscens* is at a similar stratigraphic level to that recorded by Parker (1967); at Site 77, it coincides with the initial appearance of *P. spectabilis.* Hays *et al.* (1969) recorded what appears to be a much earlier appearance of *S. dehiscens* in relation to the initial appearance of *P. spectabilis.*

Specimens have been illustrated to demonstrate the relationship of *S. dehiscens* to *G. sacculifer* (Plate 40, Figure 8) and to *G. fistulosus* (Plate 40, Figures 5, 6 and 7).

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: *S. dehiscens* Zone to *P. obliquiloculata* Zone (with doubtful specimens in the *G. tumida* Zone). Site 79: *G. fistulosus* Zone (?) to *P. obliquiloculata* Zone. Site 80: *S. dehiscens* Zone to *P. obliquiloculata* Zone. Site 81: *P. obliquiloculata* Zone. Site 82: *S. dehiscens* Zone to *P. obliquiloculata* Zone. Site 83: *S. dehiscens* Zone to *P. obliquiloculata* Zone. Site 84: *S. dehiscens* Zone to *P. obliquiloculata* Zone.

Stratigraphic range: *S. dehiscens* Zone to *P. obliquiloculata* Zone; lower Pliocene to Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded the stratigraphic range of *S. dehiscens* as basal Pliocene Zone N19 to the Quaternary Zones N22, 23. Hays *et al.* (1969) recorded the Pliocene-Pleistocene range of *S. dehiscens* in terms of magnetic events from the Gilbert Reversed through to the Brunhes Normal.

*Sphaeroidinella grimsdalei* (Keijzer):

Remarks: There was only one record of *S. grimsdalei* in the examined area, at Site 79.

Stratigraphic occurrence: Site 79: *G. altispira* Zone; Upper Miocene.

Recorded stratigraphic range: Bolli (1957a) recorded its Miocene range in Trinidad as *G. fohsi barisanensis* Zone to the *G. menardii* Zone.

*Sphaeroidinella seminulina* (Schwager) (Plate 40, Figures 9, 10 and 11):

Remarks: *S. seminulina* was found to be relatively common within its stratigraphic range, although more common in the Pliocene part of its range. Some rare specimens were found to have loosely coiled tests with 5 chambers in the final whorl. Another illustrated specimen has a sac-like final chamber suggesting an affinity with *G. sacculifer* (Plate 40, Figure 10).

Stratigraphic occurrence: Site 76: *S. dehiscens* to *G. fistulosus* Zone. Site 77: Upper *G. peripheroronda* Zone to top *S. dehiscens* Zone. Site 78: *G. peripheroronda* to *G. fohsi fohsi-G. peripheroacuta* Zone. Site 79: *G. altispira* Zone to *G. tumida* Zone. Site 80: *G. fohsi fohsi-G. peripheroacuta* Zone. Site 81: *G. peripheroronda* Zone to *G. fohsi fohsi-G. peripheroacuta* Zone. Site 82: *G. plesiotumida* Zone to *S. dehiscens* Zone. Site 83: *G. altispira* Zone to lower *G. fistulosus* Zone. Site 84: *G. plesiotumida* Zone to upper *S. dehiscens* Zone.

Stratigraphic range: *G. peripheroronda* Zone to the *G. fistulosus* Zone; Middle Miocene to Upper Pliocene.

Recorded stratigraphic range: Parker (1967) recorded its range in Indo-Pacific deep-sea cores as Middle Miocene Zone N16 to Pliocene Zone N21. Hays *et al.* (1969) recorded its range in terms of paleomagnetic events from the Gilbert Reversed to the base of the normal event between the Mammoth and Kaena Events.

*Sphaeroidinella subdehiscens* Blow (Plate 41, Figures 1 and 2):

Remarks: Parker (1967) recorded its extinction in the lower part of Zone N19 (i.e., *G. tumida* Zone), whereas Hays *et al.* (1969) recorded it stratigraphically higher in the equivalent of the lower part of Zone N21 in the *G. tosaensis* Zone. At Site 77, its extinction level overlaps the range of *G. fistulosus* as recorded by Hays *et al.* (1969) and Parker (1967).

Stratigraphic occurrence: Site 76: *S. dehiscens* Zone to *G. fistulosus* Zone. Site 77: Lower *G. altispira* Zone to lower *G. fistulosus* Zone. Site 79: *G. plesiotumida* Zone to *G. tumida* Zone. Site 80: *G. plesiotumida* Zone to *S. dehiscens* Zone. Site 82: *G. plesiotumida* Zone to *S. dehiscens* Zone. Site 83: *G. altispira* Zone

to *S. dehiscens* Zone. Site 84: *G. plesiotumida* Zone to *S. dehiscens* Zone; with two doubtful records in the *G. fistulosus* Zone.

Stratigraphic range: *G. altispira* Zone to *G. fistulosus* Zone; Upper Miocene to Upper Pliocene.

Recorded stratigraphic range: Parker (1967) recorded the range of *S. subdehiscens* in Indo-Pacific deep-sea cores from the Middle Miocene Zone N16 to the Pliocene Zone N20. Hays *et al.* (1969) recorded its range in terms of paleomagnetic events from the Gilbert Reversed to the normal event between the Mammoth and Kaena Reversed Events.

Genus *Turborotalita* Blow and Banner, 1962

*Turborotalita humilis* (Brady) (Plate 41, Figures 3 and 4):

Remarks: *T. humilis* was found in only one Pleistocene sample at Site 77.

Stratigraphic occurrence: Site 77: One record in upper *P. obliquiloculata* Zone; Pleistocene.

Recorded stratigraphic range: Parker (1967) recorded it throughout the late Miocene-Quaternary sequence Zones N17-N22, 23 in Indo-Pacific deep-sea cores.

Genus *Siphotextularia* Finlay, 1939

*Siphotextularia* (?) sp. (Plate 41, Figures 5 through 9):

Remarks: A large population of a small *Siphotextularia* (?) was found in Core 53, core-catcher sample of the *G. insolita* Zone at Site 77B. The maximum length of an adult test is 0.20 millimeters (Plate 41, Figure 5) and this test readily dissolves in dilute hydrochloric acid.

There are two distinct forms in the population: one having a test with more inflated chambers (Plate 41, Figures 5, 6 and 7) and the other a more elongate test (Plate 41, Figures 8 and 9).

From an examination of Ellis and Messina (1940 *et seq.*) it would appear that the *Siphotextularia* recorded at Site 77B is probably a new species.

Stratigraphic occurrence: Site 77B: *G. insolita* Zone; Upper Eocene.

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## PLATE EXPLANATIONS

All figures are of different specimens unless stated in plate explanations: this is the reason for size differences of different figures of the same species.

## PLATE 1

Figures 1-4 — *Candeina nitida* d'Orbigny.
1: Side view, X 97.
2: Spiral view, X97.
3: Spiral view, X 97.
4: Side-umbilical view, X 97.
Site 82, Core 2, Section 5, top; *S. dehiscens* Zone, Pliocene.

Figures 5-8 — *Cassigerinella chipolensis* Cushman and Ponton.
5: Umbilical view, X242.
6: Side view, X193. .
7: Spiral view, X242. .
Site 77B, Core 51, core-catcher.

8: Umbilical view, X242.
Site 77B, Core 52, Section 2, 36-38 cm; *P. barbadoensis* Zone, Lower Oligocene.

Figure 9 — *Chiloguembelina cubensis* Palmer.
Side view, X266.6.
Site 77B, Core 51, core-catcher; *P. barbadoensis* Zone, Lower Oligocene.

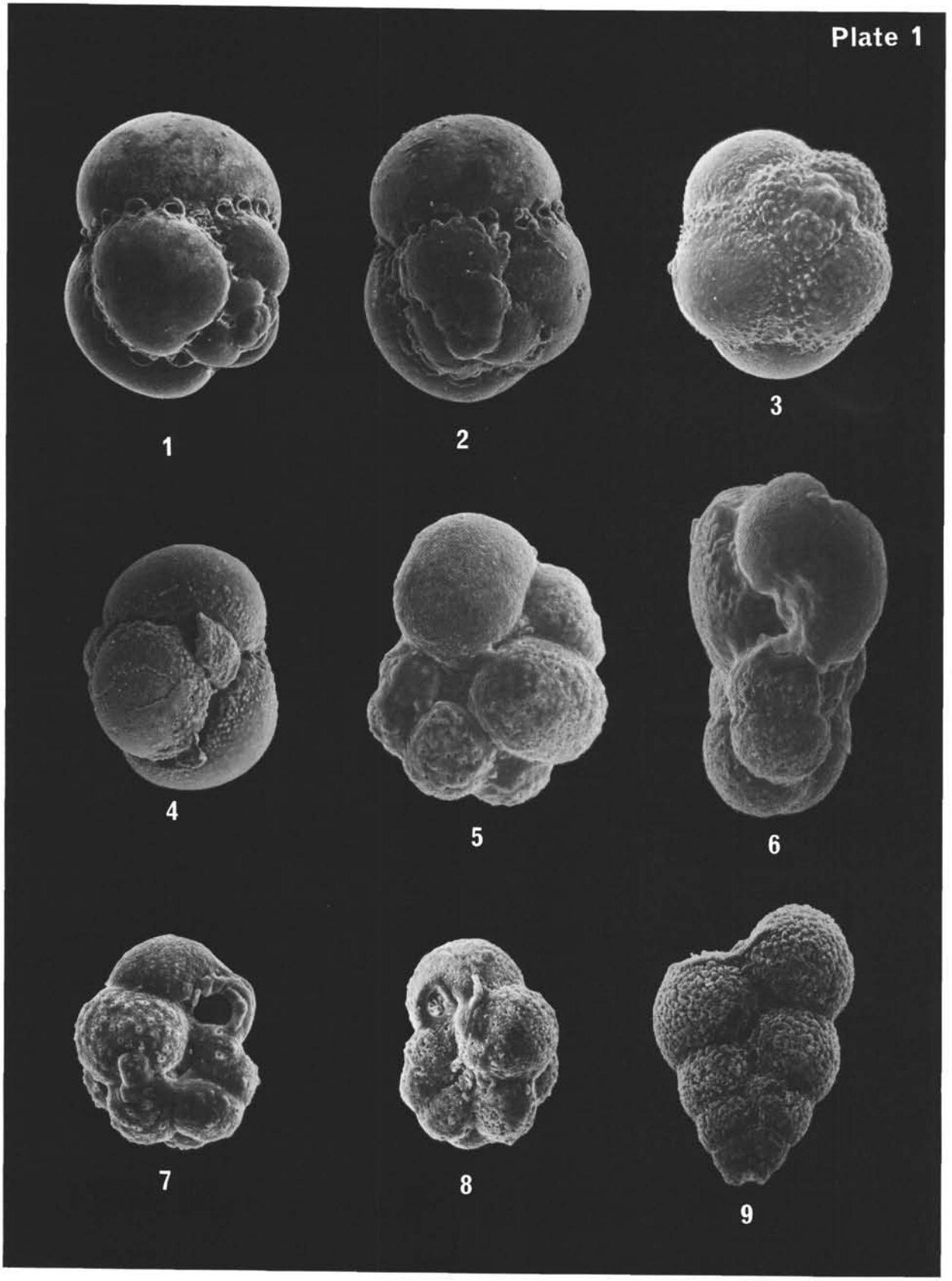
Plate 1
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PLATE 2

Figures 1-3 *Globigerapsis* sp.
Three views of same specimen:
1: Umbilical view (oblique), X 97.
2: Side view, X 97.
3: Spiral view, X 97.
Site 77B, Core 48, core-catcher; *P. barbadoensis* Zone, Lower Oligocene.

Figures 4-6 *Globigerina* sp. 2.
4: Umbilical view, X 97.
5: Side view, X 97.
6: Spiral view, X 97.
Site 77B, Core 45, Section 6, 16-18 cm; *G. ampliapertura* Zone, Oligocene.

Figures 7-9 *Globigerina ampliapertura* Bolli.
7: Umbilical view, X 123.
8: Side view, X 123.
Site 78, Core 32, core-catcher; *G. ampliapertura* Zone, Oligocene.
9: Spiral view, X 132.
Site 77B, Core 41, core-catcher; *C. cubensis* Zone, Oligocene.

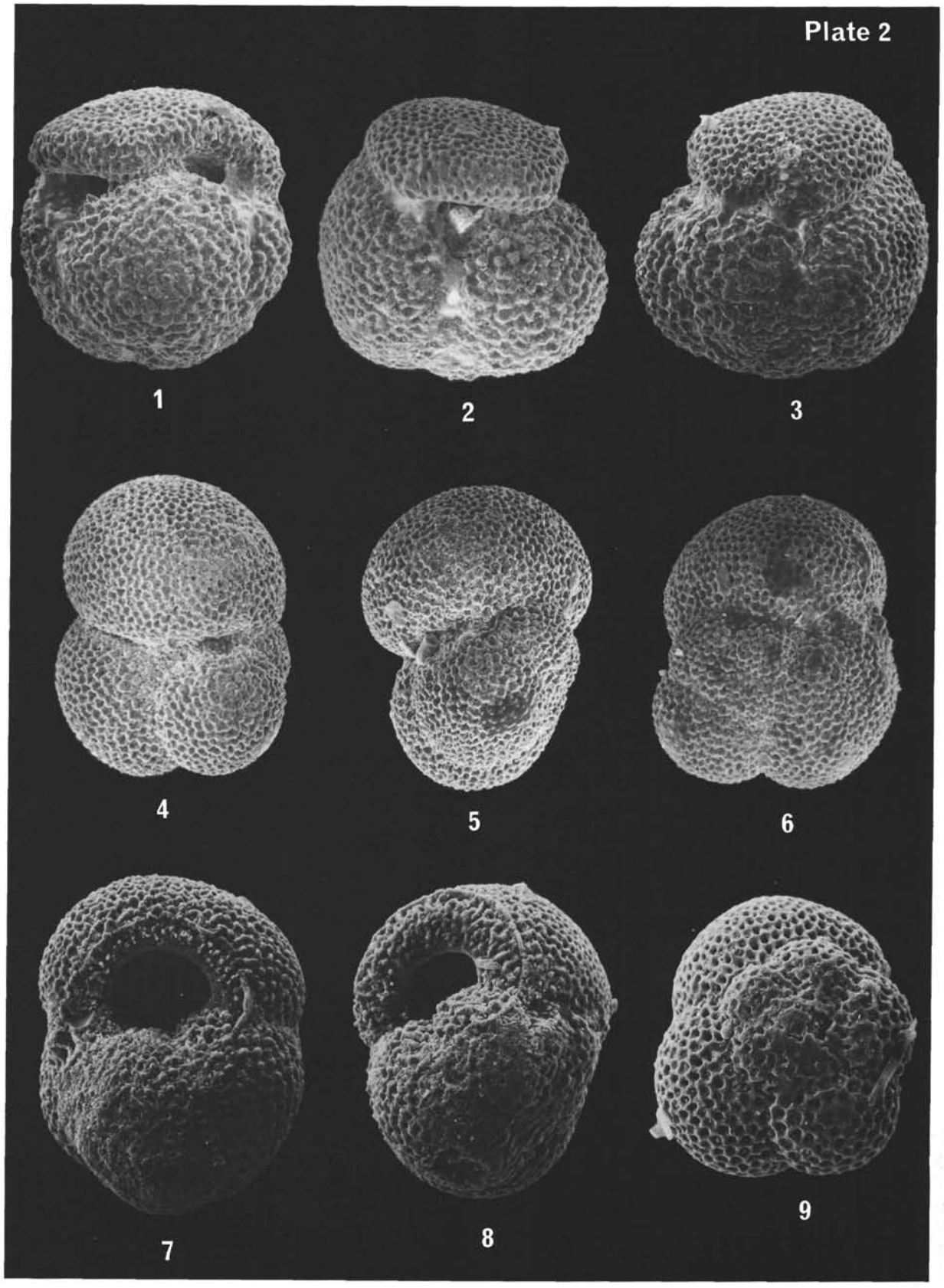
Plate 2
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PLATE 3

Figures 1-6 *Globigerina* sp. 1.
Three views each of 2 specimens:
1: Umbilical view, ×110.
2: Side view, ×110.
3: Spiral view, ×110.

Specimen b:
4: Umbilical view, ×110.
5: Side view, ×110.
6: Side view, ×220.
Site 77B, Core 39, Section 4, top; *G. opima* Zone, Oligocene.

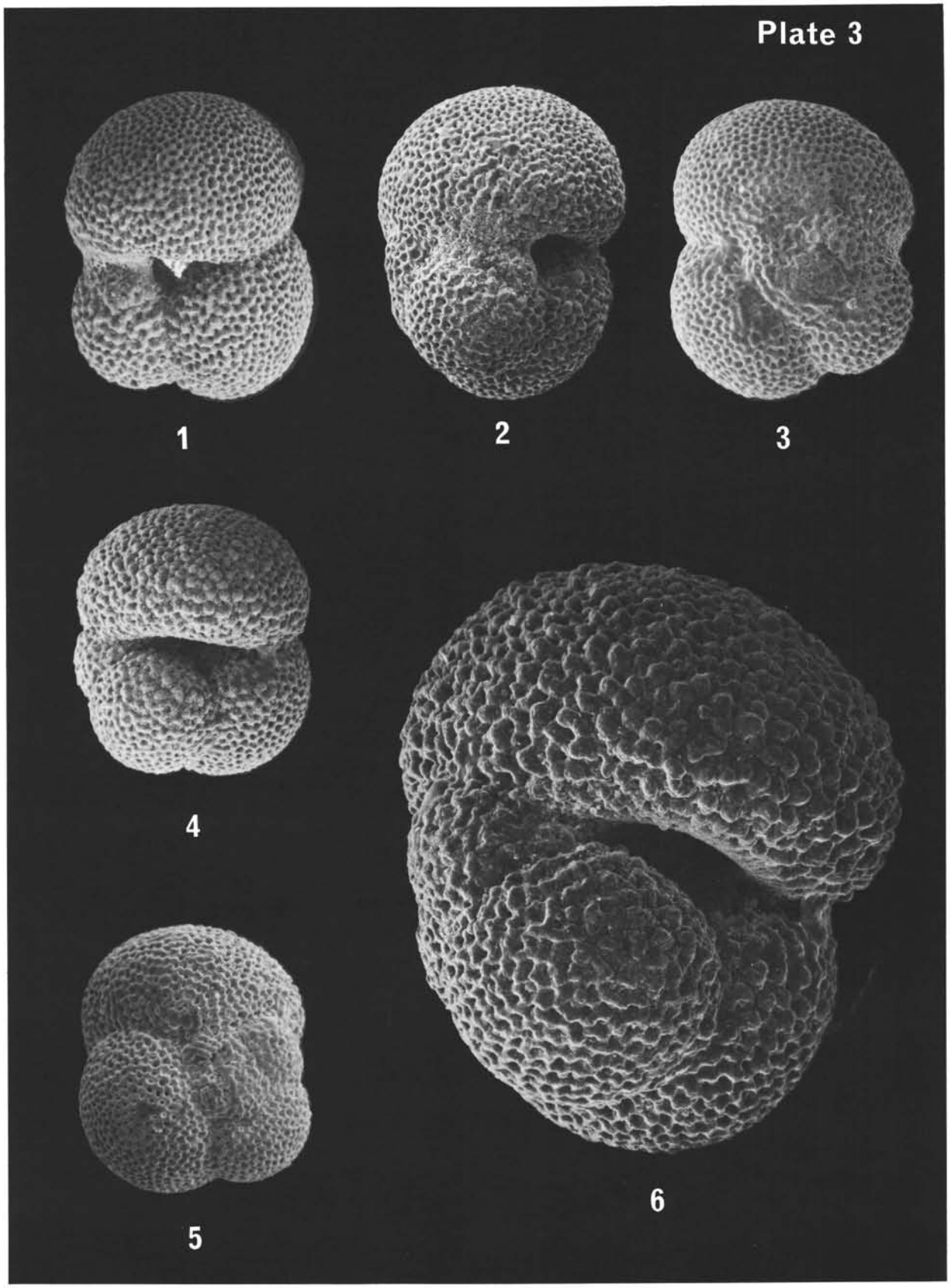
Plate 3
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PLATE 4

Figures 1-3 *Globigerina angulisuturalis* Bolli.
1: Umbilical view, X 220.
2: Side view, X 220.
3: Spiral view, X 220.
Site 78, Core 25, core-catcher; *C. cubensis* Zone, Upper Oligocene.

Figure 4 *Globigerina angulisuturalis* Bolli.
Specimen with 4 chambers in final whorl:
Umbilical view, X 242.
Site 79, Core 15, core-catcher; *G. kugleri* Zone, Lower Miocene.

Figures 5, 6 *Globigerina angustiumbilicata* Bolli.
5: Side view, X193.
6: Spiral view, X193.
Site 77B, Core 31, Section 5, top; *G. kugleri* Zone, Lower Miocene.

Figures 7-9 *Globigerina bradyi* Weisner.
Two specimens:

Specimen a:
7: Umbilical view, X 242.
8: Side view, X 242.

Specimen b:
9: Spiral view, X 242.
Site 79, Core 9, Section 6, core-catcher; *C. dissimilis* Zone, Lower Miocene.

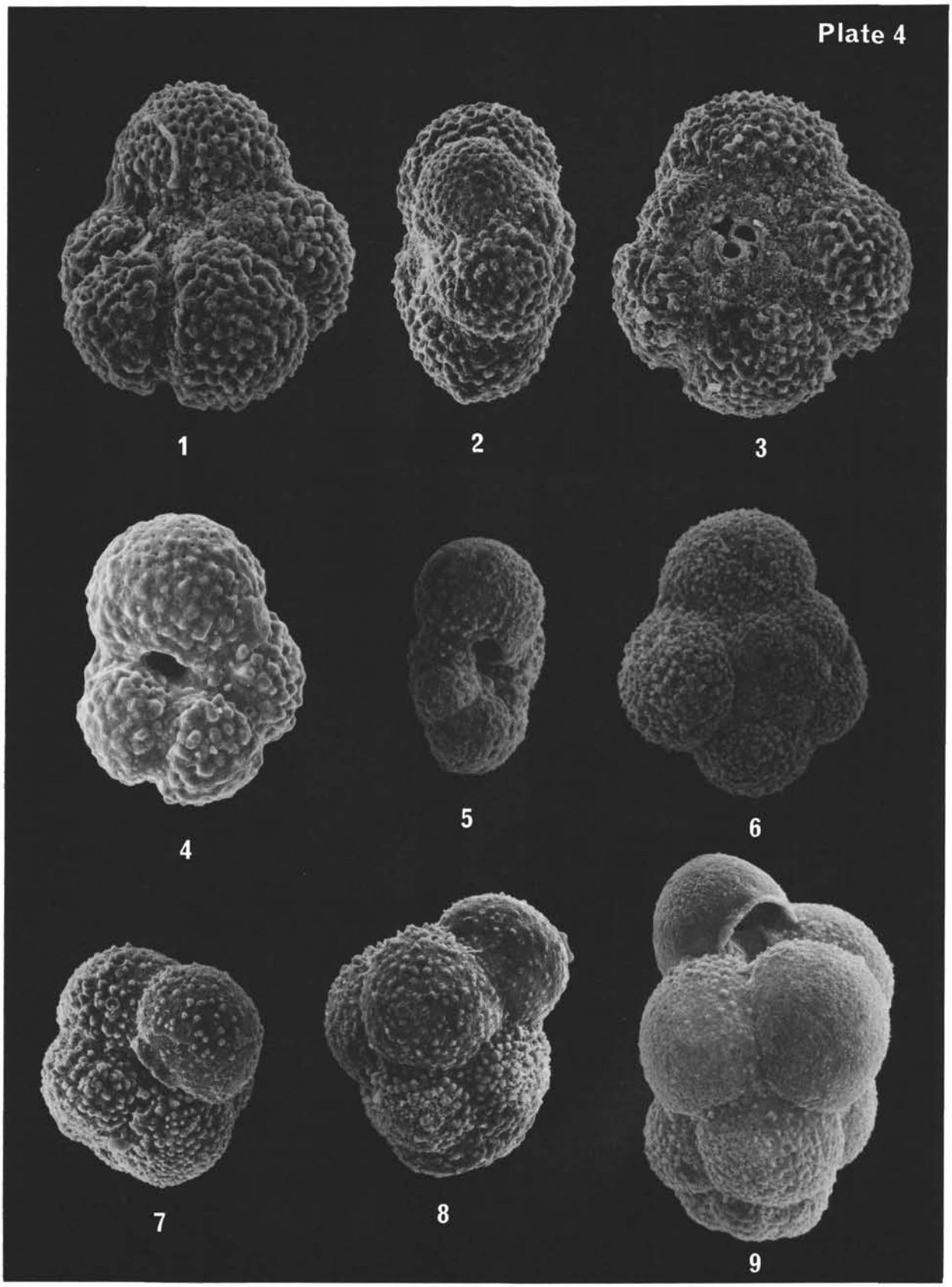
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PLATE 5

Figures 1-3 *Globigerina apertura* Cushman.
1: Spiral view, X220.
2: Side view, X220.
3: Umbilical view, X220.
Site 80A, Core 2, Section 1, top; *S. dehiscens* Zone, Pliocene.

Figures 4, 5 *Globigerina* cf. *angiporoides* Hornibrook.
Two specimens:
4: Umbilical view, X220.
5: Spiral view, X220.
Site 77B, Core 49, Section 6, core-catcher; *P. barbadoensis* Zone, Lower Oligocene.

Figures 6-8 *Globigerina angustiumbilicata* Bolli.
6: Umbilical view, X220.
7: Side view, X220.
8: Spiral view, X220.
Site 77B, Core 45, Section 6, 16-18 cm; *G. ampliapertura* Zone, Oligocene.

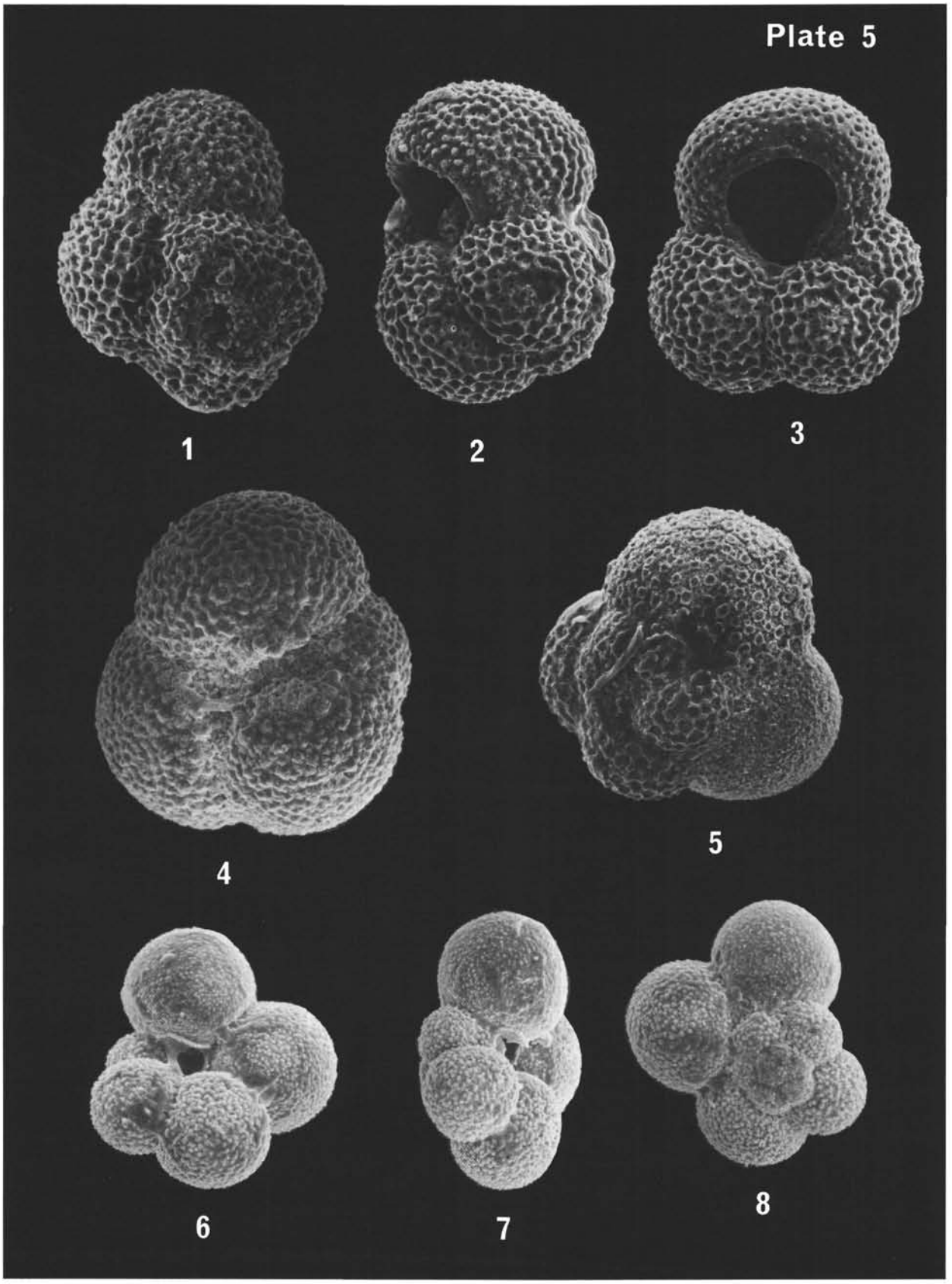
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PLATE 6

Figures 1-3 *Globigerina bulbosa* Le Roy.
Three views of the same specimen:
1: Umbilical view, ×220.
2: Side view, ×220.
3: Spiral view, ×220.
Site 81, Core 2, core-catcher; *G. fohsi fohsi-G. periperoacuta* Zone, Middle Miocene.

Figures 4-6 *Globigerina decoraperta* Takayanagi and Saito.
4: Umbilical view, ×220.
5: Side view, ×220.
6: Spiral view, ×220.
Site 77B, Core 7, Section 4, 19-21 cm; *S. dehiscens* Zone, Pliocene.

Figures 7, 8 *Globigerina digitata* Bradyi.
7: Spiral view (juvenile), ×220.
8: Umbilical view, ×110.
Site 81, Core 1, Section 1, top; *P. obliquiloculata* Zone, Pleistocene.

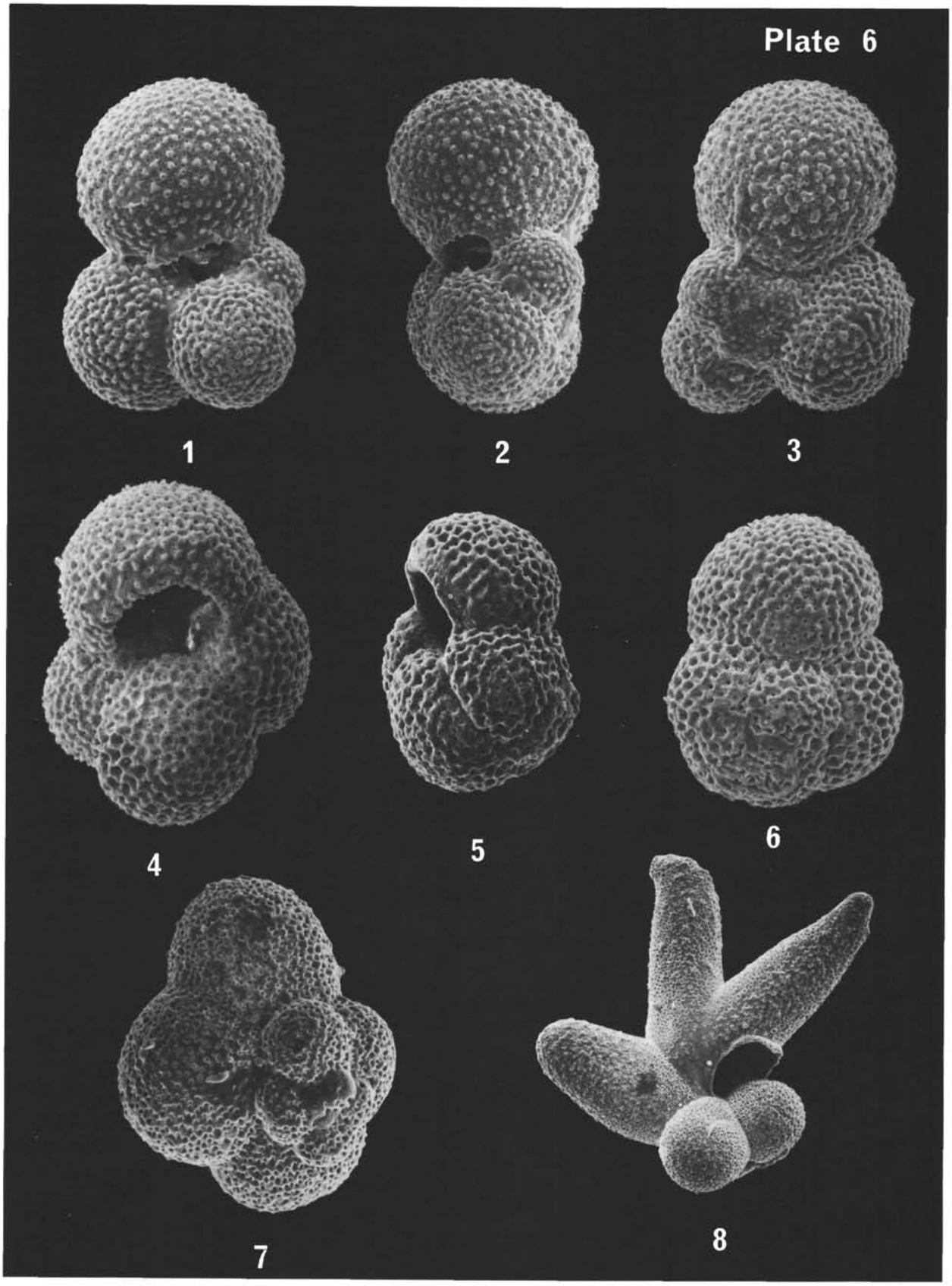
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PLATE 7

Figures 1-3 *Globigerina bulloides* d'Orbigny.
1: Side view, X 97.
2: Umbilical view, X 97.
3: Spiral view, X 97.
Site 83, Core 1, Section 2, top; *P. obliquiloculata* Zone, Pleistocene.

Figures 4, 5 *Globigerina calida* Parker
4: Umbilical view, X 48.
5: Spiral view (juvenile), X 97.
Site 77A, Core 1, Section 5, 101-103 cm; *P. obliquiloculata* Zone, Pleistocene.

Figure 6 *Globigerina foliata* Bolli.
Umbilical view (re-touched aperture), X 242.
Site 80A, Core 4, core-catcher; *G. venezuelana* Zone, Lower Miocene.

Figures 7, 8 *Globigerina ciperoensis* Bolli.
7: Side view, X 137.
8: Umbilical view, X 97.
Site 78, Core 11, Section 6, core-catcher; *G. kugleri* Zone, Lower Miocene.

Figures 9-11 *Globigerina gortanii* Borsetti.
9: Umbilical view, X 48.
10: Side view, X 97.
11: Spiral view, X 48.
Site 77B, Core 48, core-catcher; *P. barbadoensis* Zone, Lower Oligocene.

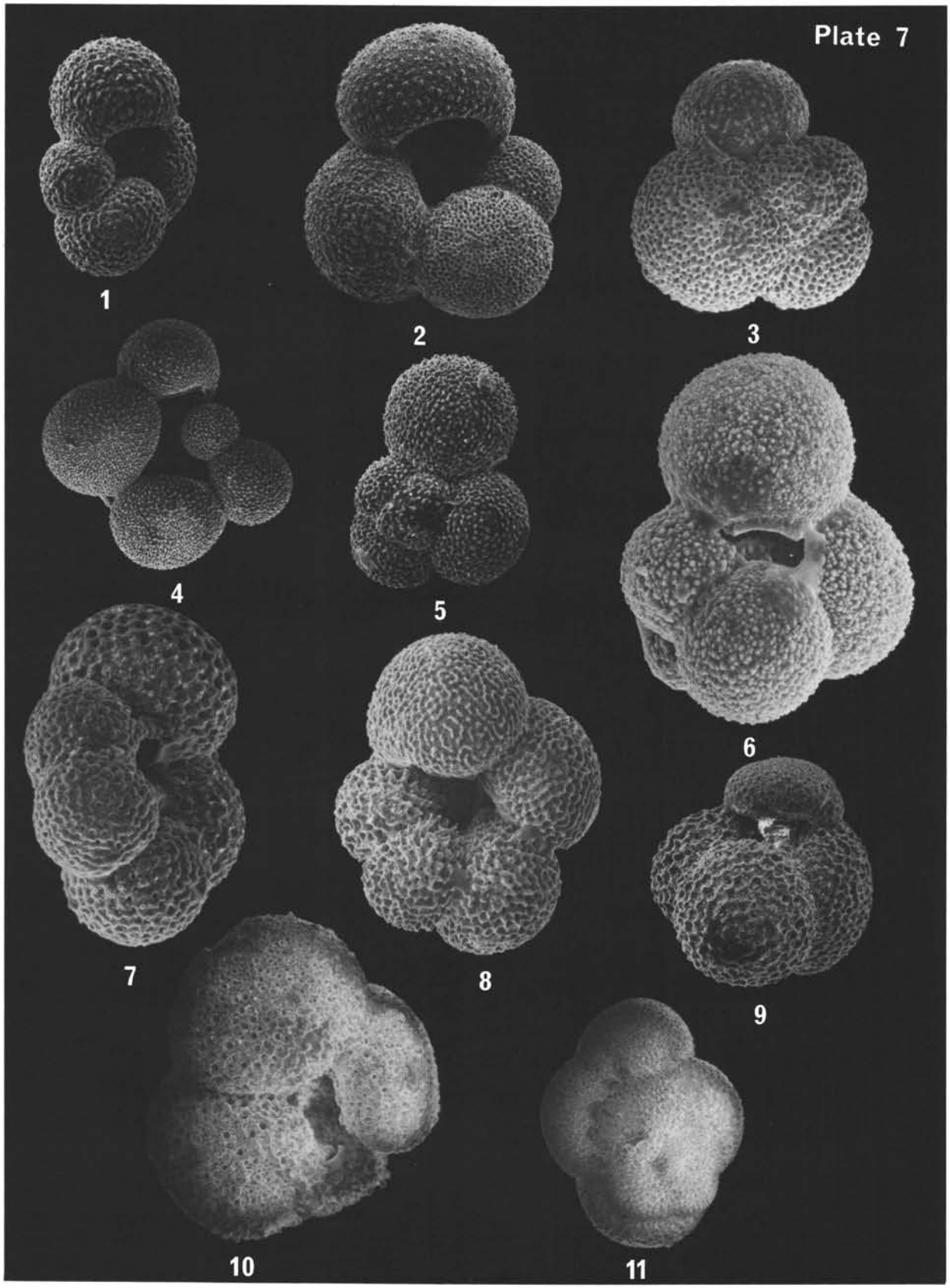
Plate 7
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PLATE 8

Figures 1-3 *Globigerina eamesi* Blow.
Three views of the same specimen:
1: Umbilical view, X220.
2: Side view, X220.
3: Spiral view, X220.
Site 77B, Core 31, Section 3, top; *G. kugleri* Zone, Lower Miocene.

Figures 4-6 *Globigerina* cf. *eamesi* Blow.
Three views of the same specimen:
4: Umbilical view, X220.
5: Side view, X220.
6: Spiral view, X220.
Site 77B, Core 36, core-catcher; *G. angulisuturalis* Zone, Upper Oligocene.

Figures 7-9 *Globigerina praedigitata* Parker.
7: Umbilical view (juvenile), X220.
8: Spiral view (juvenile), X220.
9: Side view (adult), X110.
Site 84, Core 4, Section 3, top; *P. obliquiloculata* Zone, Pleistocene.

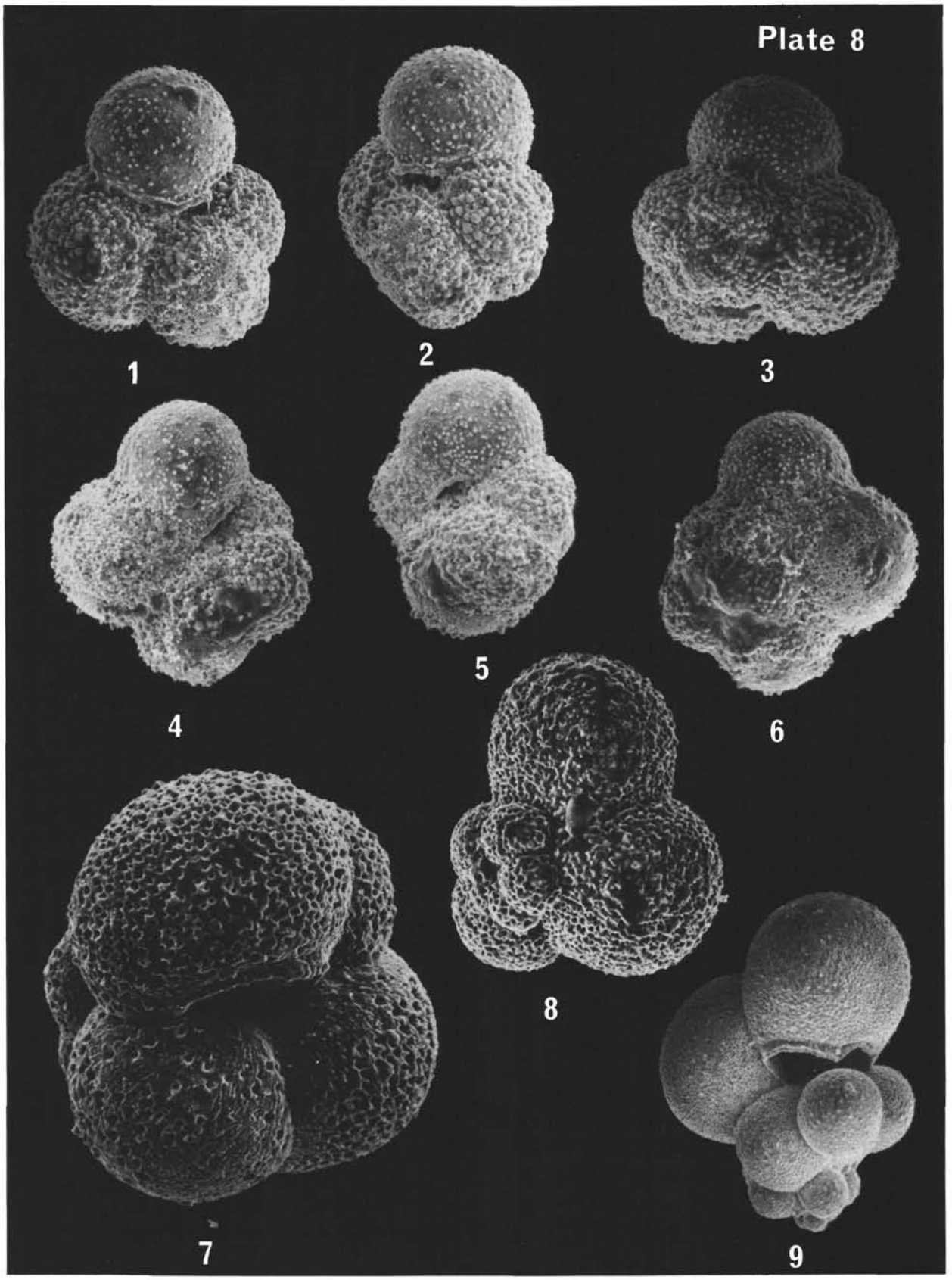
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PLATE 9

Figures 1-6 *Globigerina euapertura* Jenkins.
1: Umbilical view, X 97.
2: Side view, X 97.
3: Spiral view, X 97.
Site 77B, Core 41, Section 4, top.

4: Umbilical view, X 97.
5: Side view, X 97.
6: Spiral view, X 97.
Site 77B, Core 41, core-catcher, *C. cubensis* Zone, Oligocene.

Figures 7-9 *Globigerina* cf. *euapertura* Jenkins.
7: Umbilical view, X 97.
8: Umbilical view, X 97.
9: Umbilical view, X 97.
Site 77B, Core 31, Section 3, top; *G. kugleri* Zone, Lower Miocene.

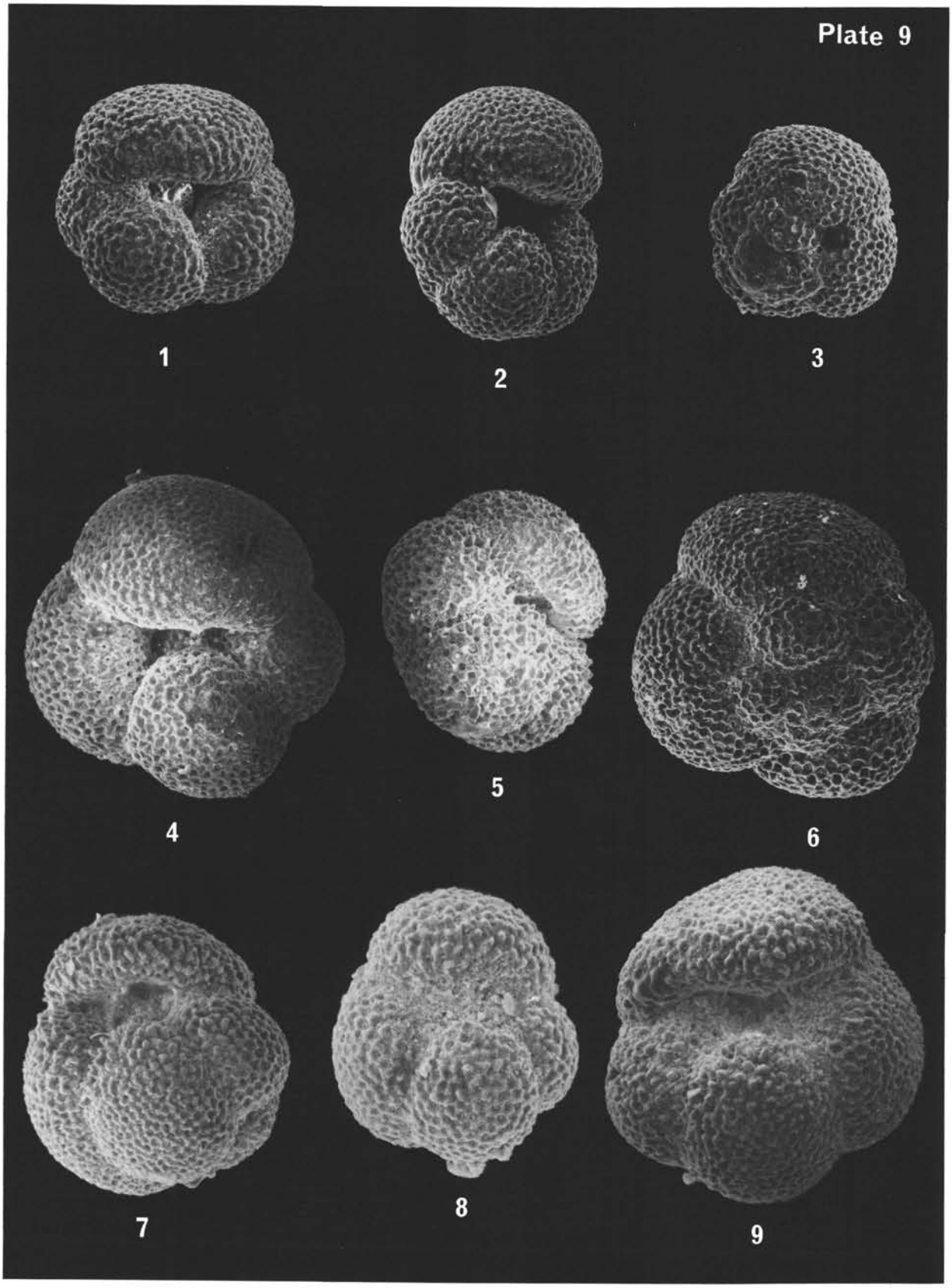
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PLATE 10

Figures 1-5 *Globigerina juvenilis* Bolli.
Specimens with only an umbilical aperture:
1: Umbilical view (re-touched), X 97.
2: Spiral view, X 97.

Specimens with additional spiral side apertures:
3: Umbilical view, X 97.
4: Side view, X 97.
5: Spiral view (re-touched), X 146.6.
Site 84, Core 6, Section 2, top; *P. obliquiloculata* Zone, Pleistocene.

Figures 6-8 *Globigerina linaperta* Finlay n. subsp.
6: Umbilical view, X 97.
7: Side view, X 97.
8: Spiral view, X 97.
Site 77B, Core 51, core-catcher; *P. barbadoensis* Zone, Lower Oligocene.

Figures 9-11 *Globigerina nepenthes* Todd.
9: Umbilical view, X 97.
10: Side view, X 97.
11: Spiral view, X 259.
Site 77B, Core 10, Section 5, top; *G. plesiotumida* Zone, Upper Miocene.

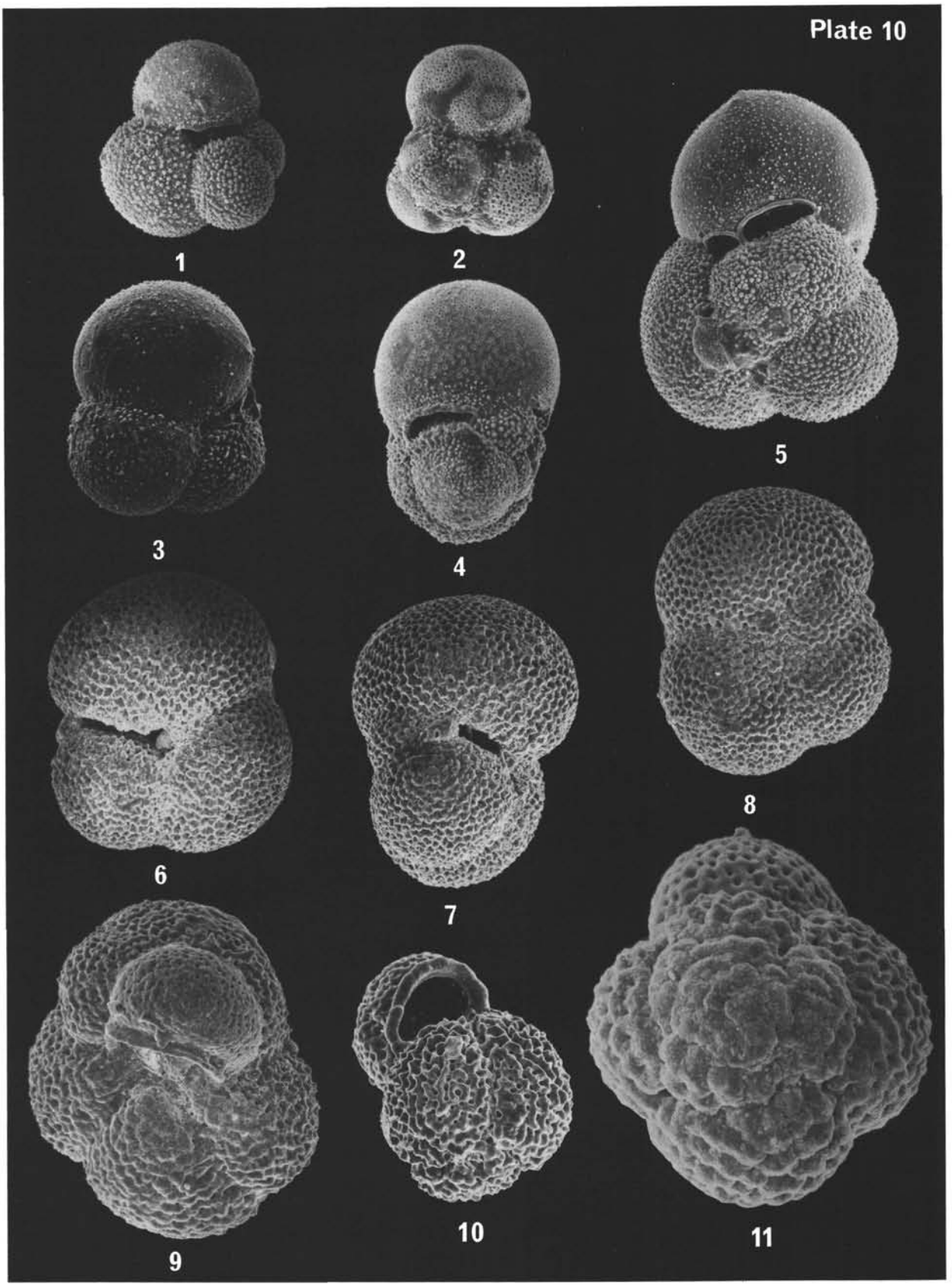
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PLATE 11

Figures 1-3 *Globigerina rubescens* Hofker.
1: Umbilical view, X 97.
2: Umbilical view, X 97.
3: Spiral view, X 97.
Site 77A, Core 1, top; *P. obliquiloculata* Zone, Pleistocene.

Figures 4-6 *Globigerina selli* Borsetti.
4: Umbilical view, X 97.
5: Side view, X 97.
6: Spiral view, X 97.
Site 77B, Core 45, core-catcher; *P. barbadoensis* Zone, Lower Oligocene.

Figures 7-9 *Globigerina tapuriensis* Banner and Blow.
7: Umbilical view, X 97.
8: Side view, X 97.
9: Spiral view, X 97.
Site 77B, Site 51, core-catcher; *P. barbadoensis* Zone, Lower Oligocene.

Figures 10-12 *Globigerina woodi* Jenkins.
10: Umbilical view, X 97.
11: Side view, X 97.
12: Spiral view, X 97.
Site 78, Core 10, core-catcher; *G. kugleri* Zone, Lower Miocene.

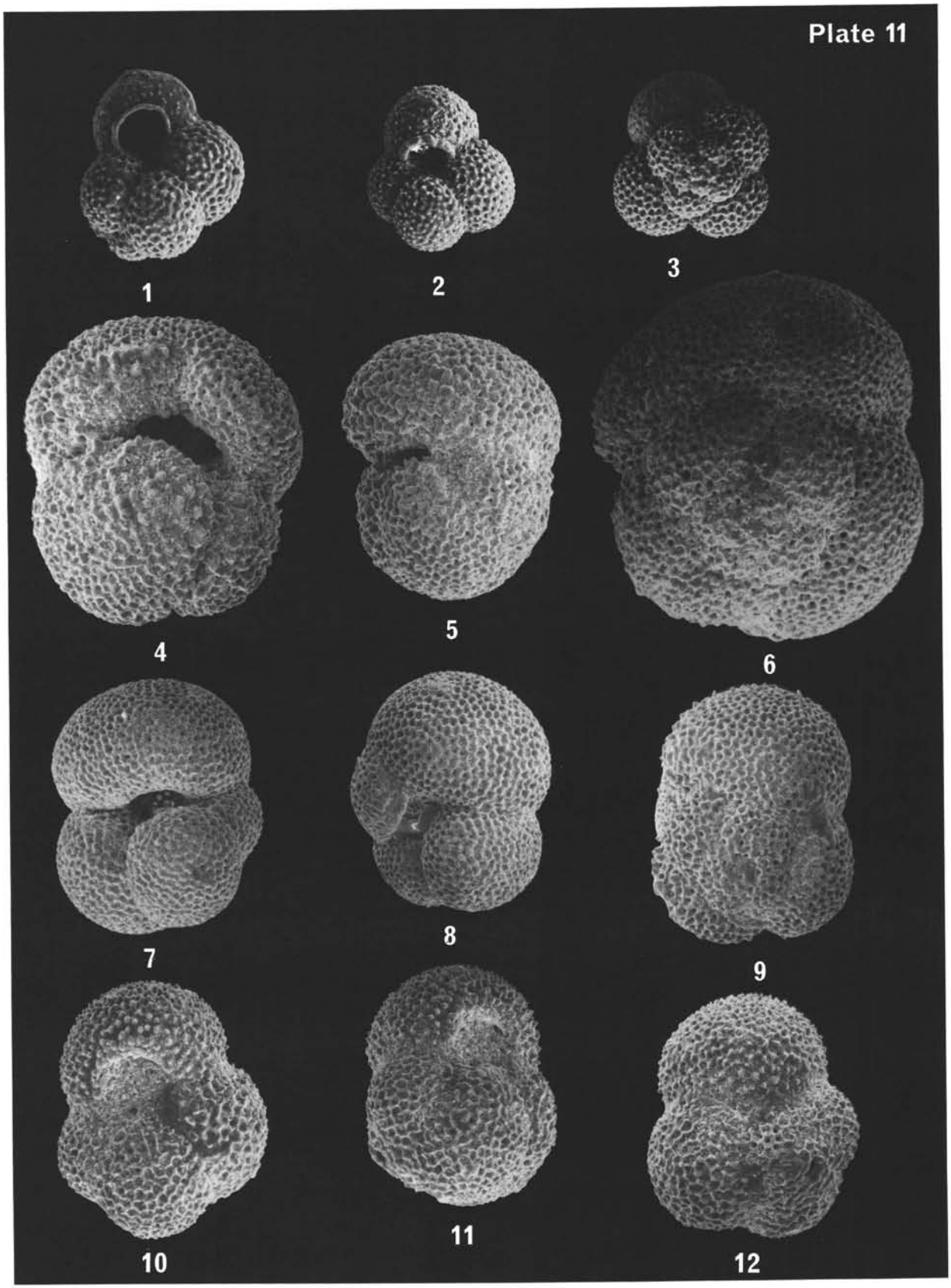
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PLATE 12

Figures 1-3 *Globigerinatella insueta* Cushman and Stainforth.
1: Side view, X 97.
2: Side view, X 97.
3: Spiral view, X 97.
Site 78, Core 3, Section 3, top; *P. glomerosa curva* Subzone, Middle Miocene.

Figures 4, 5 *Globigerinella aequilateralis* Brady.
4: Apertural view, X 97.
5: Umbilical view, X 48.
Site 83, Core 1, Section 2, top; *P. obliquiloculata* Zone, Pleistocene.

Figures 6-8 *Globigerinoides bisphericus* Todd.
6: Umbilical view, X 75.
7: Side view, X 79.
Site 78, Core 3, core-catcher.
8: Spiral-side, X113.3.
Site 78, Core 3, Section 3, top; *G. bisphericus* Subzone, Lower Miocene.

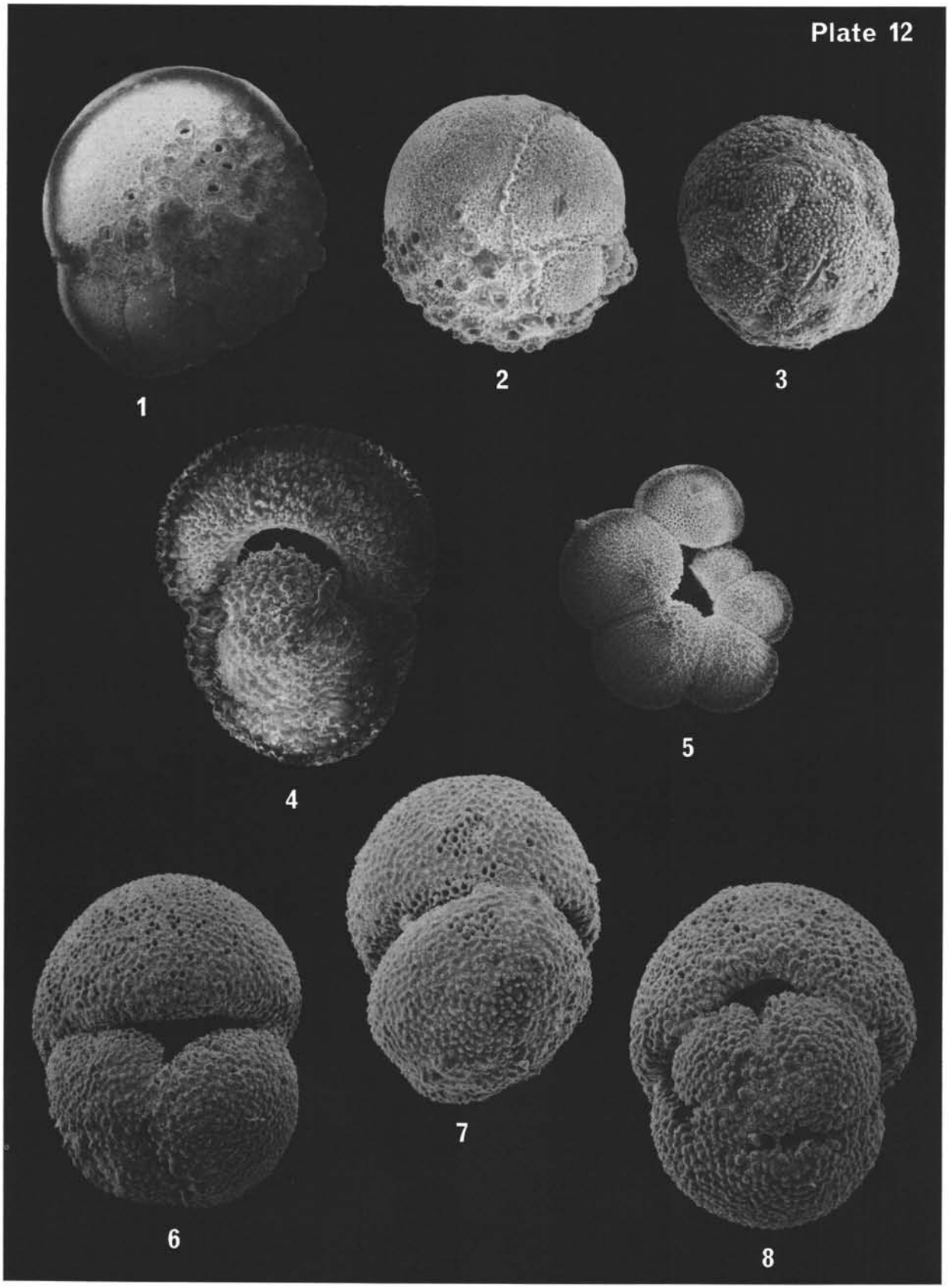
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PLATE 13

Figure 1 — *Globigerinoides fistulosus* Schubert.
Spiral view, X110.
Site 83A, Core 5, core-catcher; *G. fistulosus* Zone, Upper Pliocene.

Figures 2, 3 — *Globigerinoides fistulosus* Schubert.
2: Spiral view, X90.
Site 77B, Core 3, Section 1, 71-73 cm.

3: Umbilical view, X70.
Site 76, Core 1, core-catcher; *G. fistulosus* Zone, Upper Pliocene.

Figures 4-9 — *Globigerinoides fistulosus* Schubert.
4: Spiral view, X55.
Site 76, Core 1, core-catcher.

5: Spiral view, X55.
6: Spiral view, X55.
7: Spiral view, X55.
Site 77B, Core 3, Section 1, 71-73 cm.

8: Spiral view, X55.
9: Spiral view, X55.
Site 83A, Core 6, Section 3, top; *G. fistulosus* Zone, Upper Pliocene.

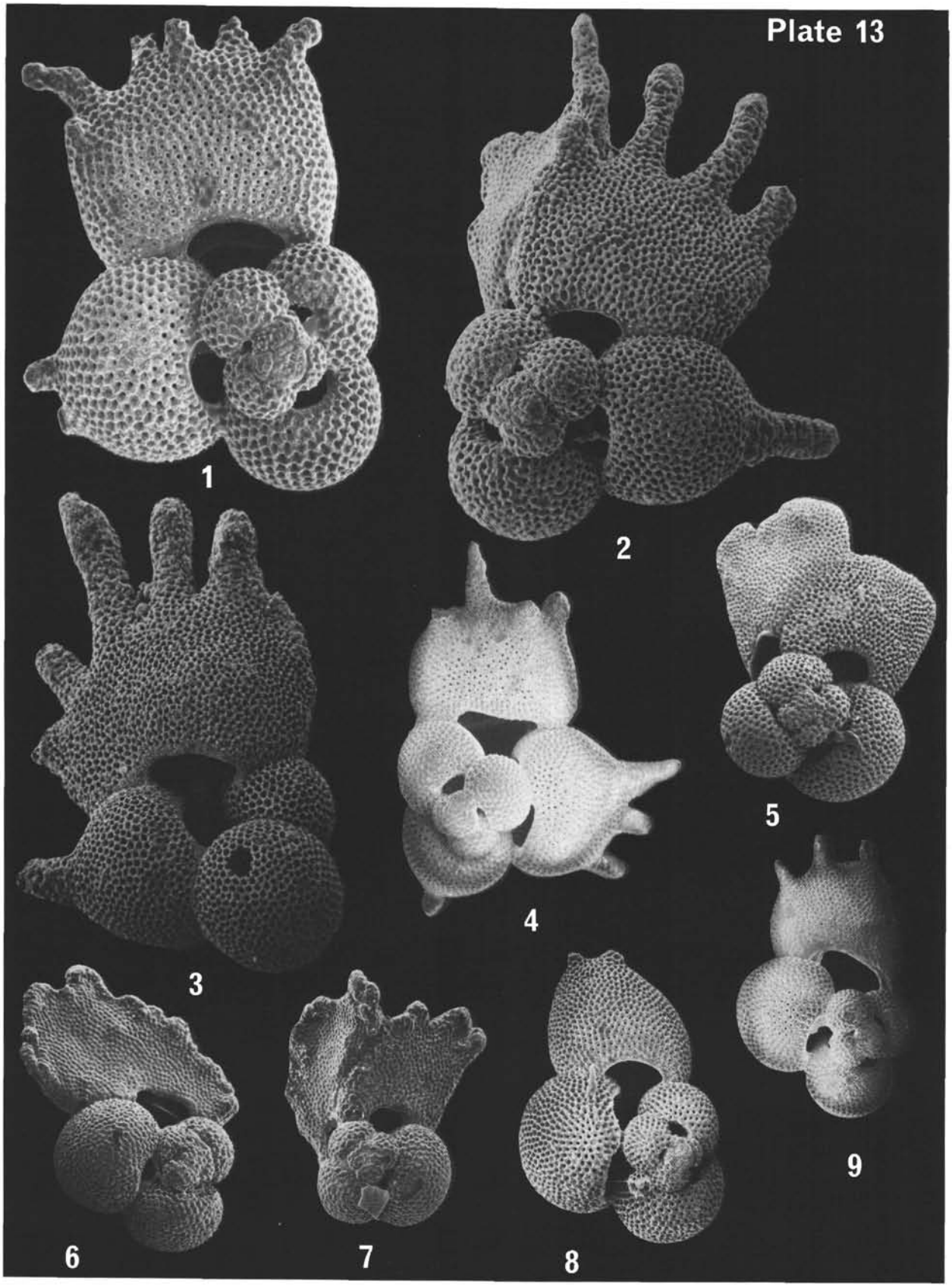
Plate 13
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PLATE 14

Figures 1-3 *Globigerinoides bolli* Blow
1: Umbilical view, X97.
2: Spiral view, X 97.
3. Side view, X 97.
Site 77B, Core 5, Section 2, 3-5 cm; *S. dehiscens* Zone, Pliocene.

Figures 4, 5 *Globigerinoides conglobatus* Brady
4: Umbilical view, X 48.
5: Umbilical view of specimen with a bulla, X 48.
Site 76A, Core 1, core-catcher; *G. fistulosus* Zone, Pliocene.

Figures 6, 7 *Globigerinoides mitra* Todd
6: Side view, X 48.
7: Spiral view, X 48.
Site 78, Core 2, Section 5, top; *G. fohsi fohsi-G. peripheroacuta* Zone, Middle Miocene

Figures 8-10 *Globigerinoides obliquus* Bolli.
Three views of one specimen:
8: Umbilical view, X 48.
9: Side view, X 48.
10: Spiral view, X 48.
Site 77B, Core 10, Section 5, top; *G. plesiotumida* Zone, Upper Miocene.

Figures 11-13 *Globigerinoides primordius* Banner and Blow.
Three views of one specimen:
11: Umbilical view, X 97.
12: Side view, X97.
13: Spiral view, X97.
Site 78, Core 14, core-catcher; *G. kugleri* Zone, Lower Miocene.

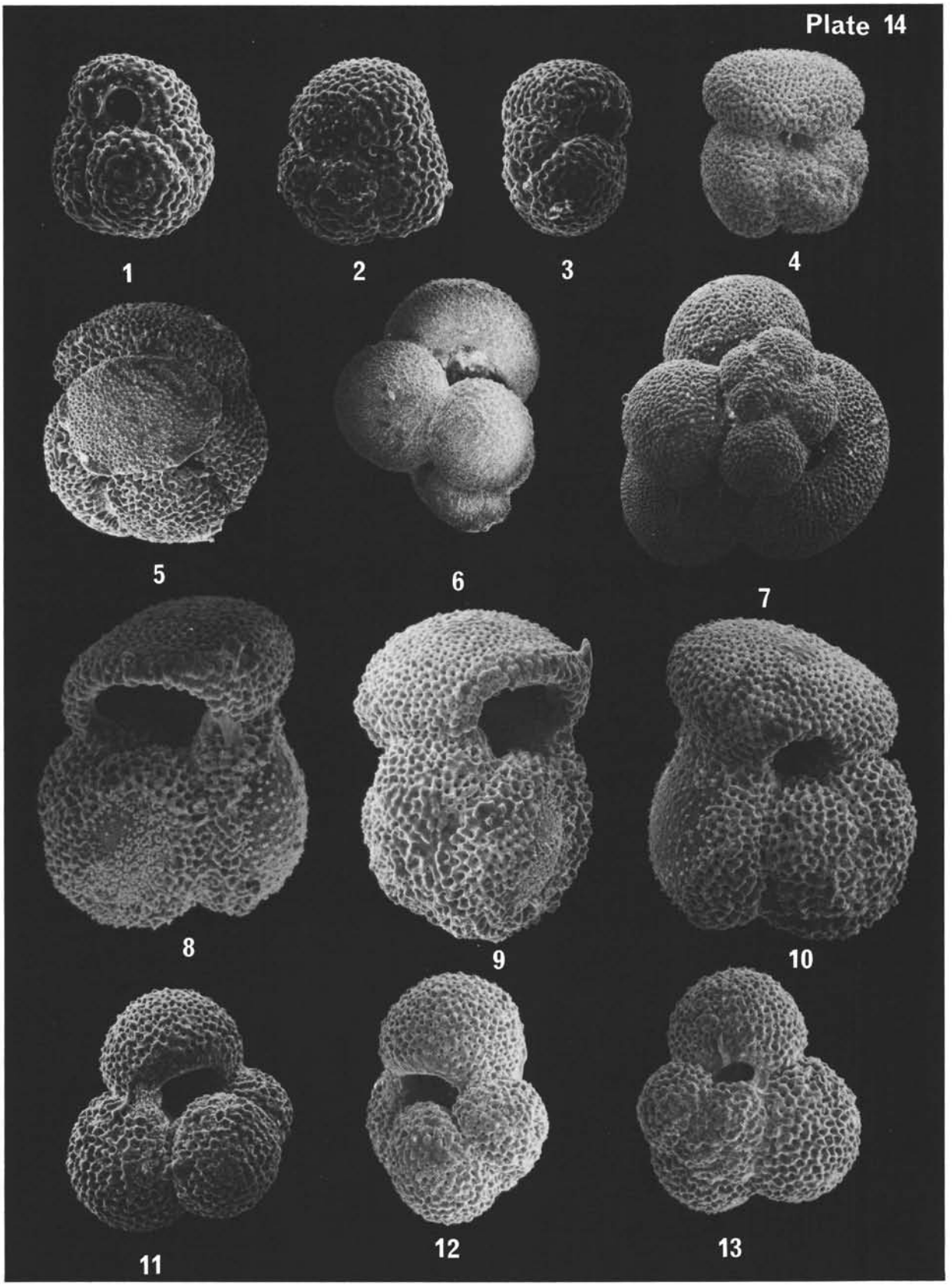
Plate 14
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PLATE 15

Figures 1-5 *Globigerinoides sacculifer* Brady.
1: Umbilical view, X 48.
2: Side view, X 48.
3: Spiral view, X 48.
Site 79, Core 1, Section 3, top; *P. obliquiloculata* Zone, Pleistocene.

4: Spiral view, X 48.
5: Spiral view, X 48.
Site 83A, Core 6, Section 3, 13-16 cm; *G. fistulosus* Zone, Upper Pliocene.

Figures 6, 7 *Globigerinoides sacculifer* Brady.
Two specimens, ancestral to *G. fistulosus:*
6: Umbilical view, X 97.
Site 83A, Core 6, Section 4, 141-143 cm; *S. dehiscens* Zone, Pliocene.

7: Spiral view, X 97.
Site 83A, Core 6, Section 5, top; *S. dehiscens* Zone, Pliocene.

Figures 8-10 *Globigerinoides sacculifer* Brady.
An early "primitive" form; 3 views of same specimen:
8: Umbilical view, X 48.
9: Side view, X 48.
10: Spiral view, X 48.
Site 83, Core 7, Section 5, top; *G. altispira* Zone, Middle-Upper Miocene.

Figure 11 *Globigerinoides sacculifer* Brady.
An early "primitive" form:
Umbilical view, X 48.
Site 83, Core 7, Section 5, top; *G. altispira* Zone, Middle-Upper Miocene.

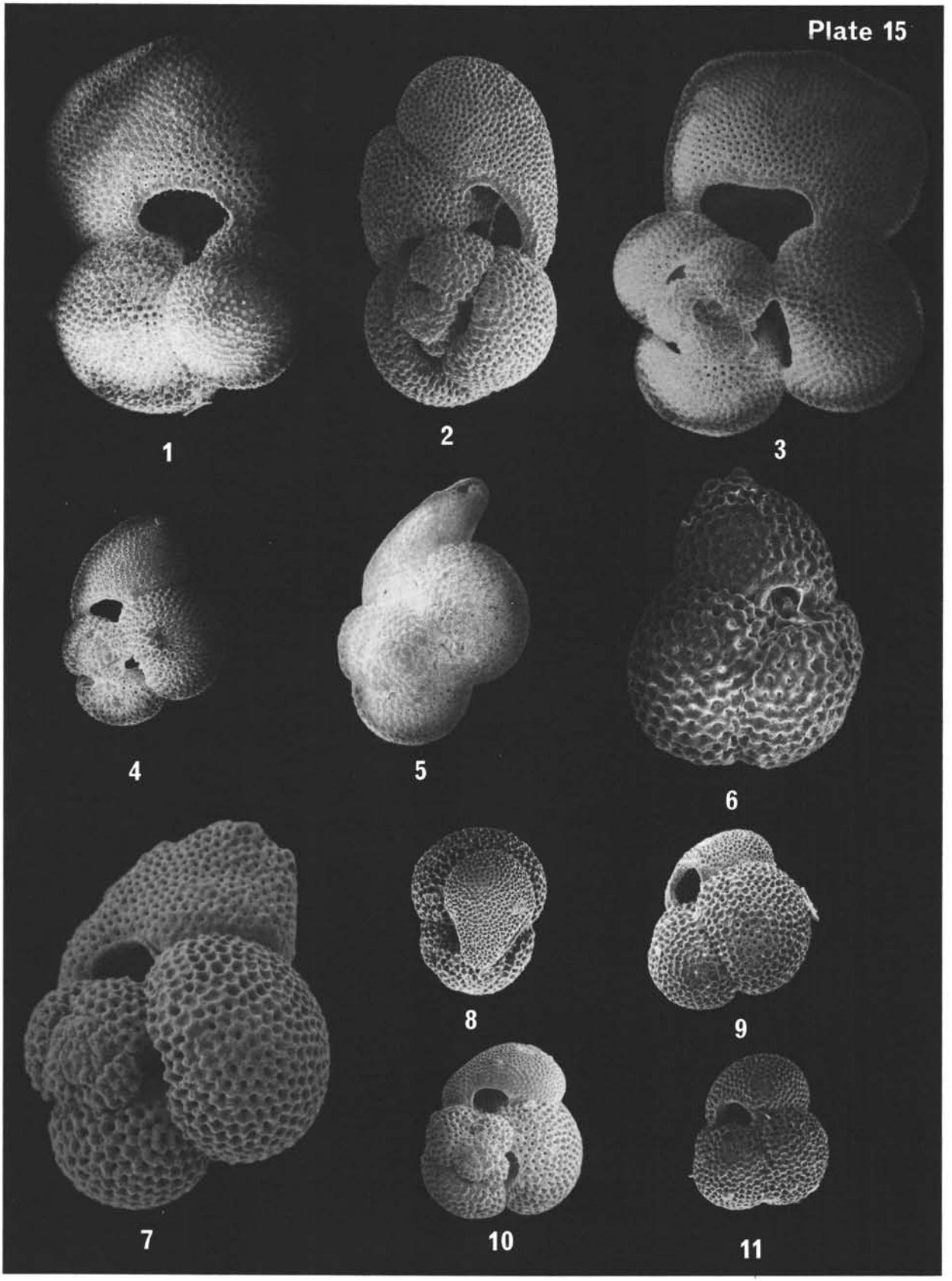
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PLATE 16

Figures 1-3 *Globigerinoides ruber* d'Orbigny.
1: Side view, X48.
2: Umbilical view, X 97.
3: Spiral view, X 48.
Site 84, Core 1, core-catcher; *P. obliquiloculata* Zone, Pleistocene.

Figures 4-9 *Globigerinoides trilobus* Reuss.
4: Umbilical view, X 97.
5: Side view, X 97.
6: Side view, X 97.
Site 79A, Core 4, core-catcher; *G. peripheroronda* Zone, Middle Miocene.

7: Umbilical view, X97.
8: Side view, X97.
9: Spiral view, X 97.
Site 81, Core 3, Section 2, top; *G. peripheroronda* Zone, Middle Miocene.

Figures 10-12 *Globigerinita dissimilis* Cushman and Bermudez.
10: Side view, X 88.
11: Umbilical view, X 88.
12: Spiral view, X 79.
Site 77B, Core 30, core-catcher; *G. dissimilis* Zone, Lower Miocene.

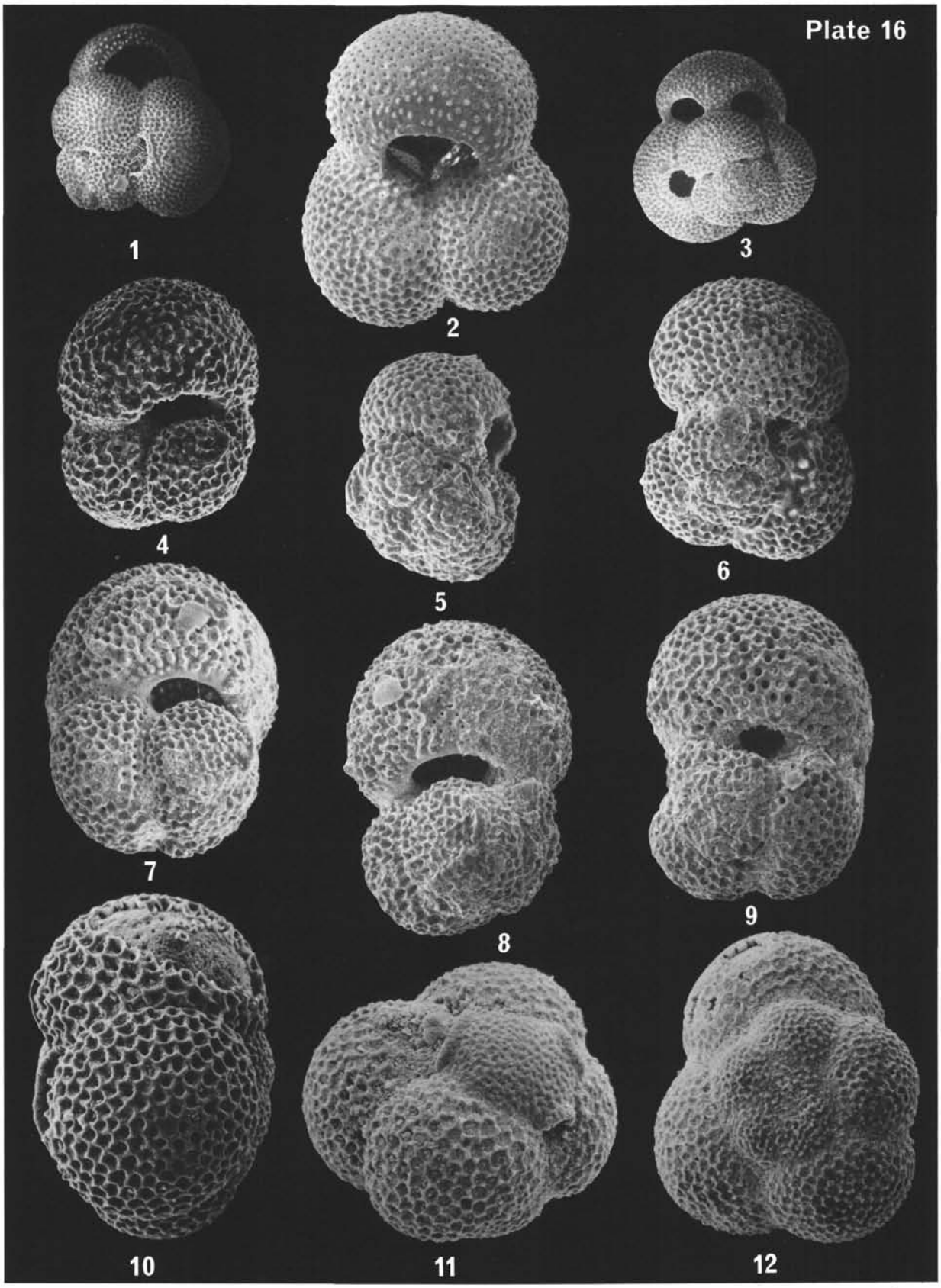
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PLATE 17

Figure 1 — *Globigerinita glutinata* Egger.
Umbilical view, X 97.
Site 79, Core 7, Section 5, Top; *P. obliquiloculata* Zone, Pleistocene.

Figures 2-4 — *Globoquadrina* sp. 1.
Three views of one specimen:
2: Umbilical view, X 48.
3: Side view, X 48.
4: Spiral view, X 48.
Site 77B, Core 48, core-catcher, *P. barbadoensis* Zone, Oligocene.

Figures 5-7 — *Globoquadrina altispira* Cushman and Jarvis.
5: Umbilical view, X 75.
6: Side view, X 61.
7: Spiral view, X 75.
Site 78, Core 3, Section 1, 50-52 cm; *G. peripheroronda* Zone, Middle Miocene.

Figures 8-10 — *Globoquadrina dehiscens* Chapman, Parr and Collins
8: Umbilical view, X 97.
9: Side view, X 97.
10: Spiral view, X 48.
Site 77B, Core 12, Section 5, top; *G. plesiotumida* Zone, Upper Miocene.

Figures 11-13 — *Globoquadrina langhiana* Cita and Gelati.
11: Umbilical view, X 97.
12: Side view, X 97.
13: Spiral view, X 97.
Site 77B, Core 24, Section 6, 16-18 cm; *G. peripheroronda* Zone, Middle Miocene.

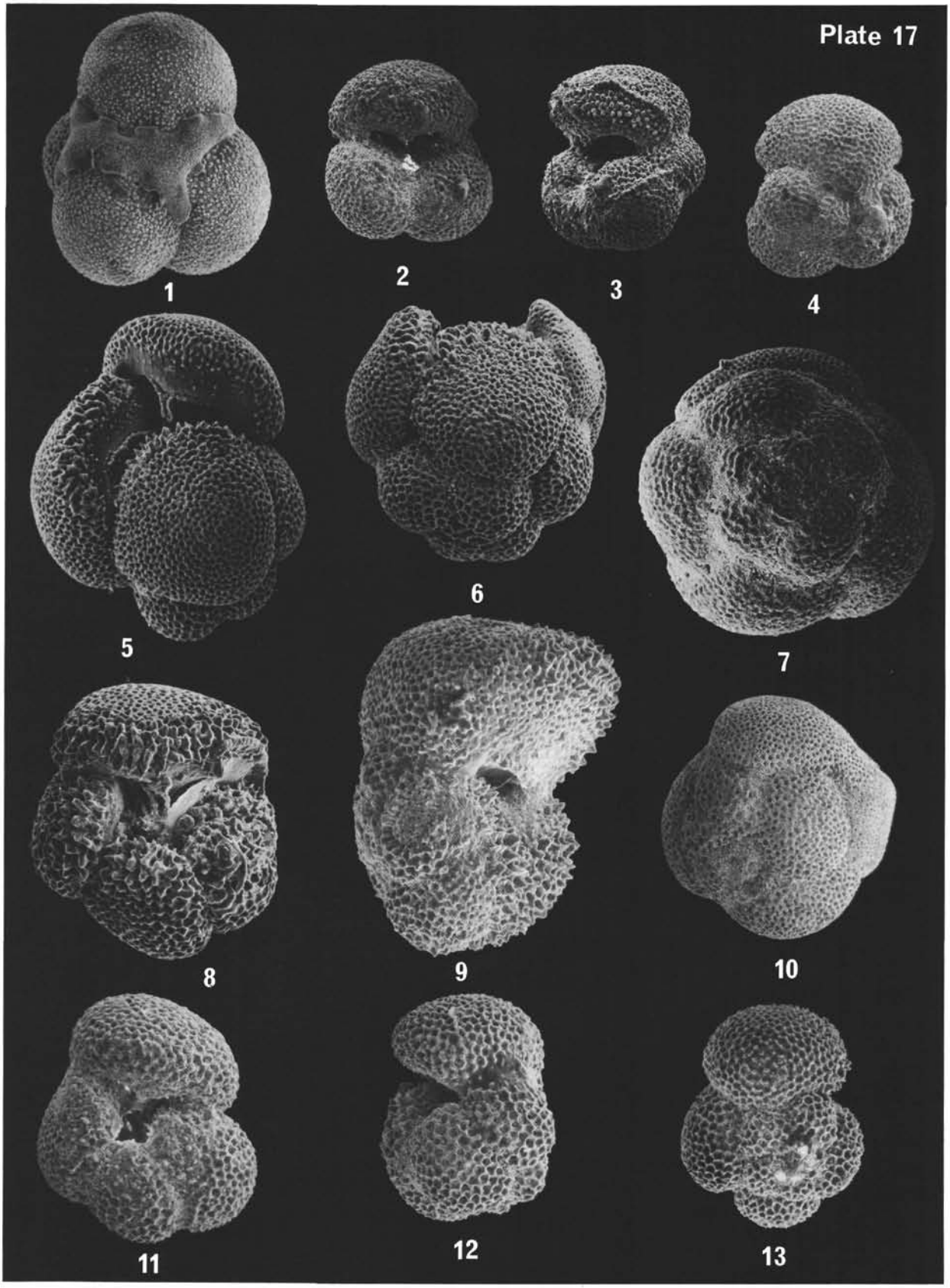
Plate 17
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PLATE 18

Figures 1-3 *Globoquadrina tripartita* Koch.
1: Umbilical view, X 48.
2: Side view, X 48.
3: Spiral view, X 48.
Site 78, Core 26, Section 5, top; *C. cubensis* Zone, Oligocene.

Figures 4-6 *Globoquadrina venezuelana* Hedberg.
4: Umbilical view, X 44.
5: Side view, X 66.
6: Spiral view, X 66.
Site 77A, Core 1, core-catcher; *P. obliquiloculata* Zone, Pleistocene.

Figures 7-12 *Globorotalia* sp. 4.
Three views of 1 specimen:
7: Umbilical view, X 97.
8: Side view, X 97.
9: Spiral view, X 97.

Three views of 1 specimen:
10: Umbilical view, X 97.
11: Side view, X 97.
12: Spiral view, X 97.
Site 78, Core 3, Section 3, top; *P. glomerosa curva* Subzone, Middle Miocene.

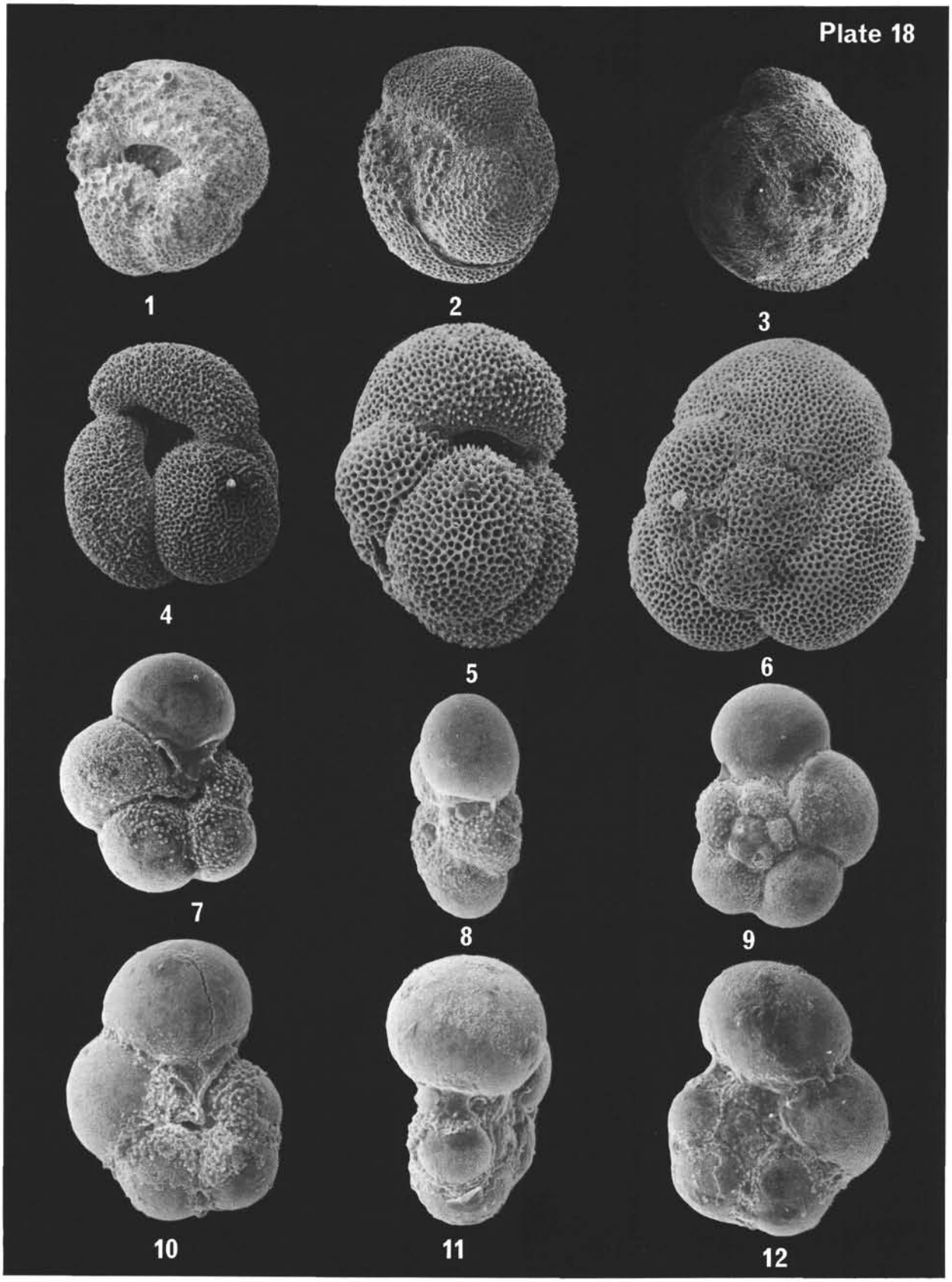
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PLATE 19

Figures 1, 2 — *Globorotalia* sp. 1.
Two views of 1 specimen:
1: Umbilical view, X 242.
2: Spiral view, X 242.
Site 77B, Core 53, core-catcher; *G. insolita* Zone, Upper Eocene.

Figures 3, 4 — *Globorotalia* sp. 2.
3: Side view, X 242.
4: Umbilical view, X 242.
Site 77B, Core 41, core-catcher; *C. cubensis* Zone, Oligocene.

Figures 5-7 — *Globorotalia* sp. 3.
Specimen a:
5: Umbilical view, X 242.

Specimen b:
6: Side view, X 242.
7: Spiral view, X 242.
Site 78, Core 3, core-catcher; *G. bisphericus* Subzone, Lower Miocene.

Figures 8-10 — *Globorotalia acostaensis* Blow.
8: Umbilical view, X 97.
9: Side view, X 97.
10: Spiral view, X 97.
Site 77B, Core 10, Section 5, top; *G. plesiotumida* Zone, Upper Miocene.

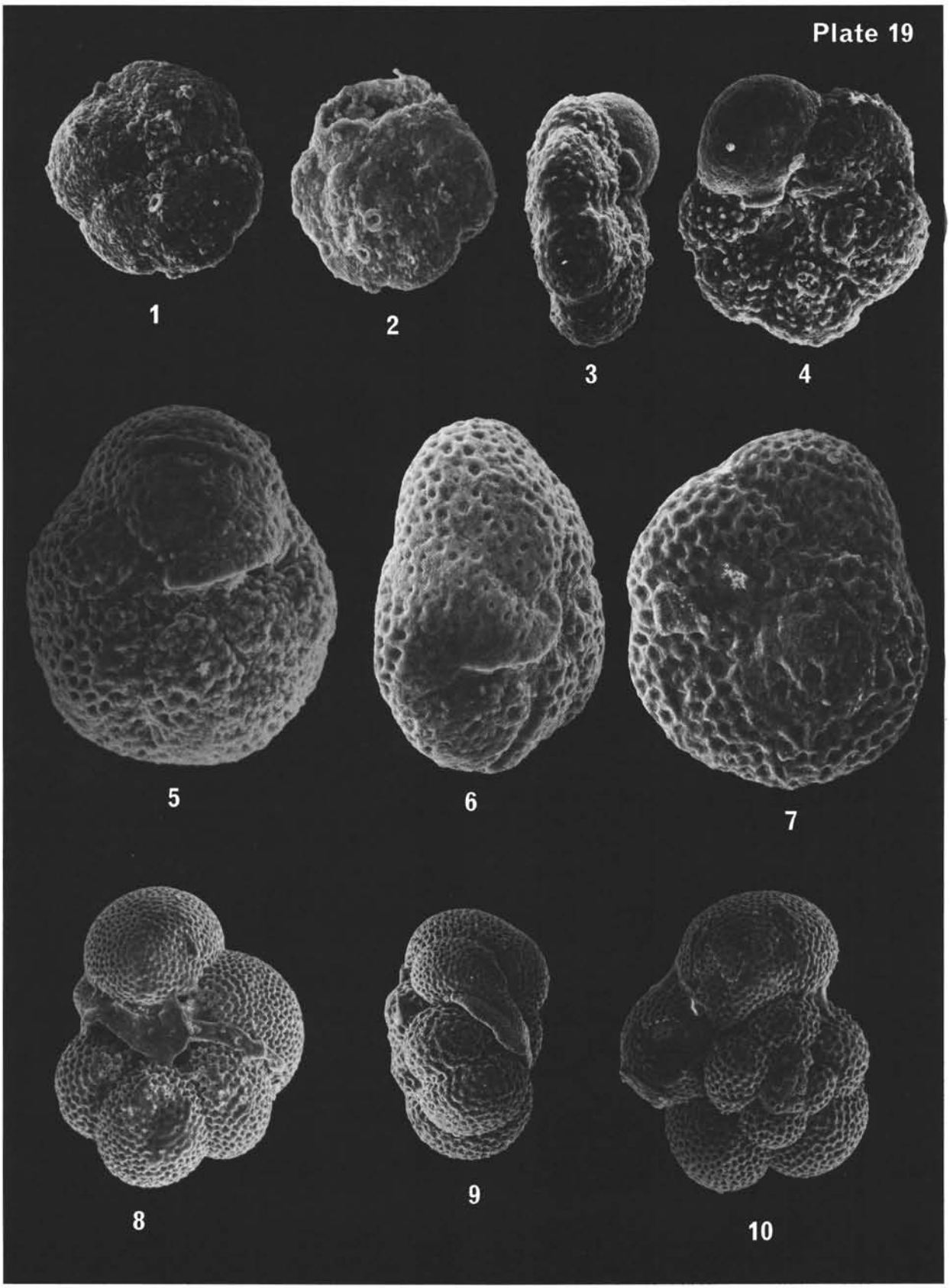
Plate 19
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PLATE 20

Figures 1-3 *Globorotalia anchaeomenardii* Bolli.
1: Umbilical view, X 97.
2: Side view, X 97.
3: Spiral view, X 97.
Site 81, Core 5, Section 2, top; *G. bisphericus* Subzone, Lower Miocene.

Figures 4-6 *Globorotalia anfracta* Parker.
4: Umbilical view, X 97.
5: Side view, X 97.
6: Spiral view, X 97.
Site 79, Core 2, core-catcher; *G. tumida* Zone, Upper Miocene.

Figures 7, 8 *Globorotalia* cf. *bella* Jenkins.
7: Side view, X 97.
8: Spiral view, X 97.
Site 77B, Core 28, Section 4, 12-14 cm; *G. venezuelana* Zone, Lower Miocene.

Figures 9-11 *Globorotalia cibaoensis* Bermudez.
9: Umbilical view, X 73.
10: Spiral view, X 145.
11: Side view, X 145.
Site 80, Core 2, Section 5, top; *G. plesiotumida* Zone, Upper Miocene.

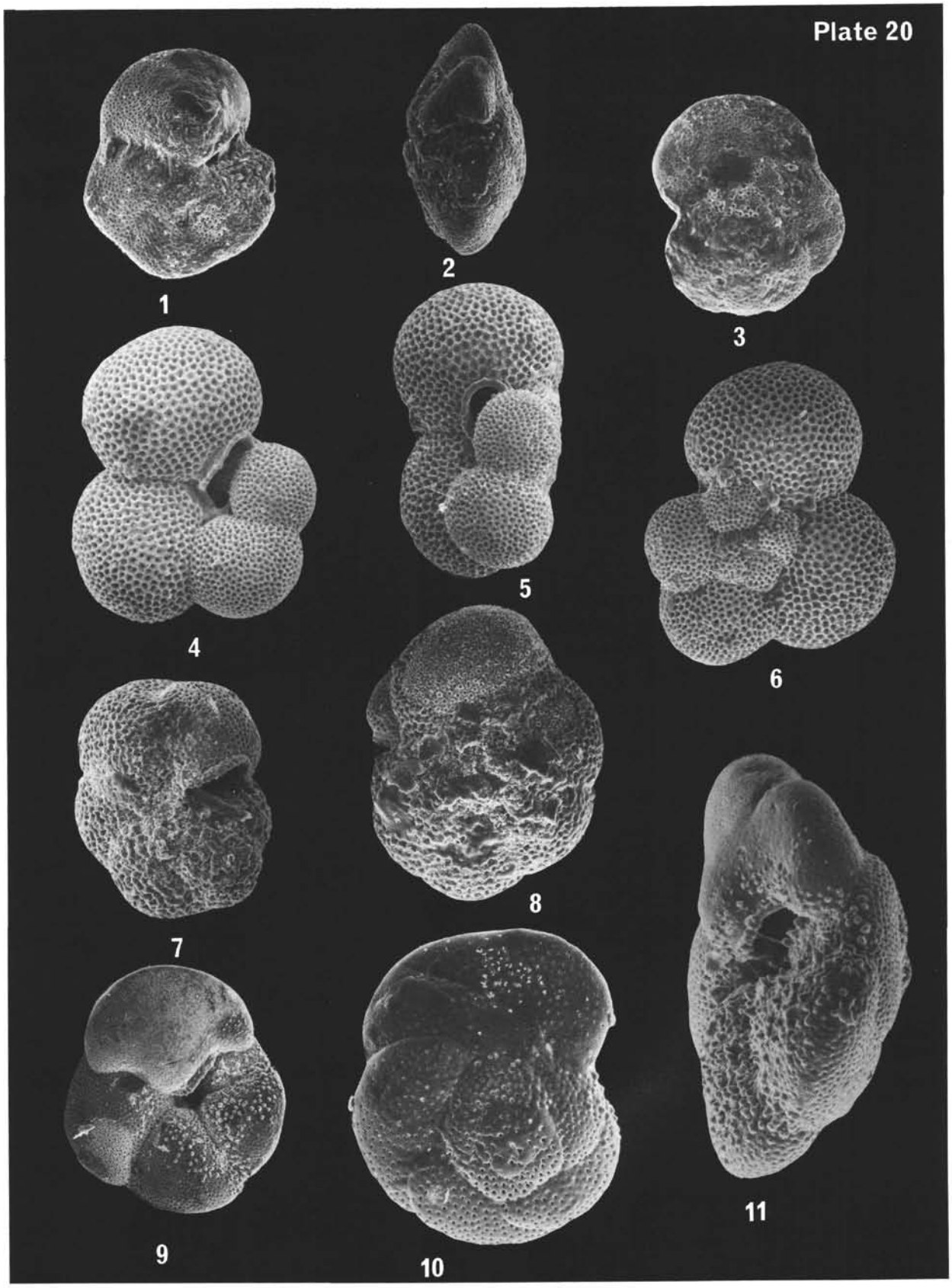
Plate 20
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PLATE 21

Figures 1-3 *Globorotalia continuosa* Blow.
1: Umbilical view, X 97.
2: Side view, X 97.
3: Spiral view, X 97.
Site 77B, Core 14, Section 3, top; *G. plesiotumida* Zone, Upper Miocene.

Figures 4-7 *Globorotalia crassaformis crassaformis* Galloway and Wissler.
4: Umbilical view, X 48.
5: Umbilical view (juvenile), X73.3.
6: Side view, X 48.
7: Spiral view, X 48.
Site 77B, Core 4, Section 2, 25-27 cm; *G. fistulosus* Zone, Pliocene.

Figures 8, 9 *Globorotalia crassaformis* cf. *viola* Blow.
8: Umbilical view, X 97.
9: Side view, X 97.
Site 77B, Core 5, Section 6, 20-22 cm; *S. dehiscens* Zone, Pliocene.

Figures 10-15 *Globorotalia crassula* Cushman and Stewart.
Three views of 1 specimen:
10: Umbilical view, X 48.
11: Side view, X73.3.
12: Spiral view, X48.

Three views of 1 specimen:
13: Umbilical view, X 48.
14: Side view, X48.
15: Spiral view, X 48.
Site 8D, Core 1, Section 1, top; *P. obliquiloculata* Zone, Pleistocene.

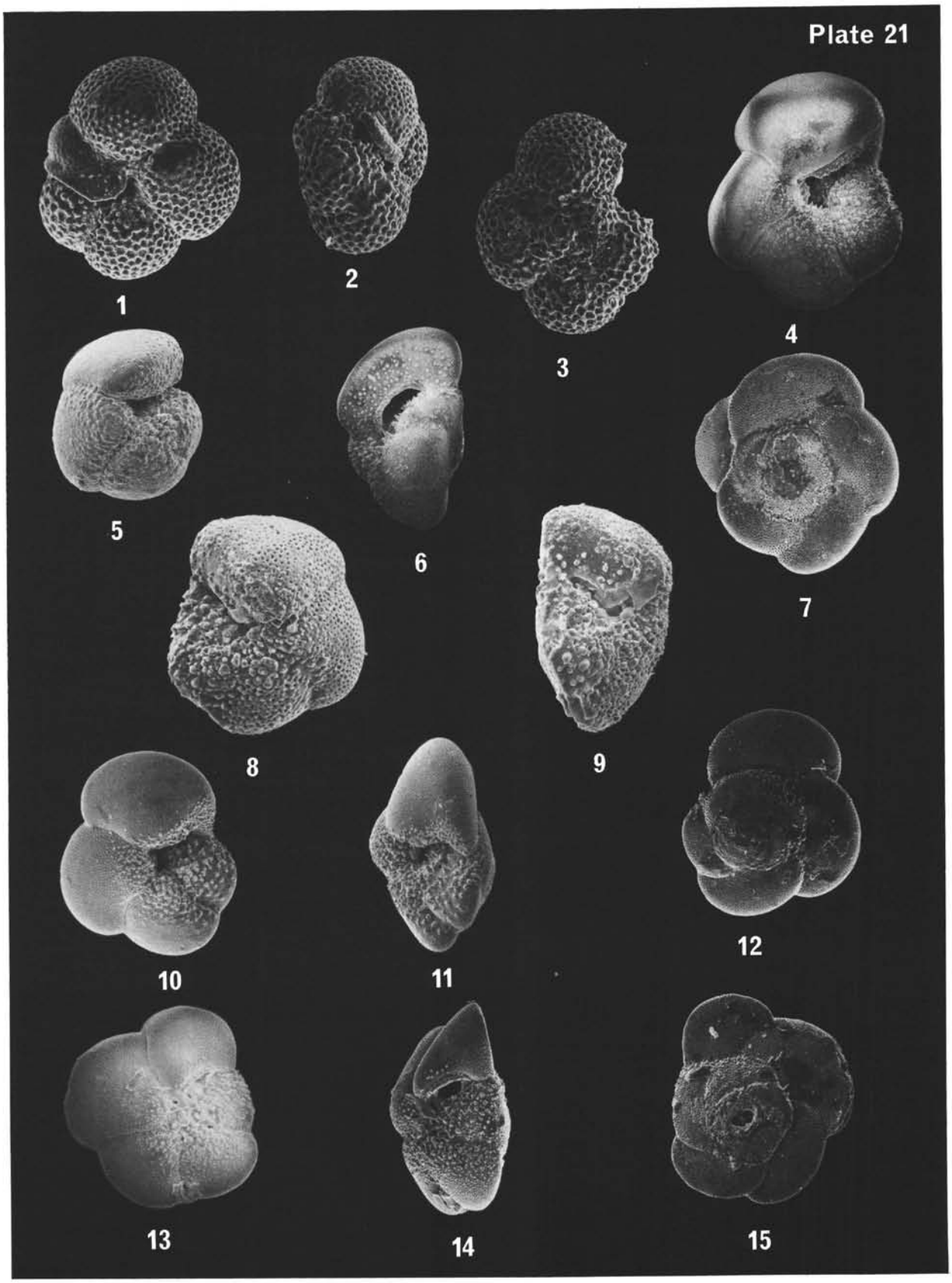
Plate 21
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PLATE 22

Figures 1-3 *Globorotalia dutertrei* d'Orbigny.
1: Umbilical view, X 48.
2: Side view, X 48.
3: Spiral view, X 48.
Site 77B, Core 1, Section 2, 39-42 cm; *P. obliquiloculata* Zone, Pleistocene.

Figures 4-6 *Globorotalia dutertrei* d'Orbigny.
High-spired form:
4: Umbilical view, X 48.
5: Side view, X 48.
6: Spiral view, X 48.
Site 82, Core 1, core-catcher; *P. obliquiloculata* Zone, Pleistocene.

Figures 7-10 *Globorotalia gemma* Jenkins.
7: Umbilical view, X 242.
8: Side view (retouched aperture), X 242.
Site 77B, Core 43, core-catcher; *C. cubensis* Zone, Oligocene.

Two views of one pseudoplanispirally coiled form:
9: Umbilical view, X 242.
10: Side view, X 242.
Site 78, Core 34, core-catcher; *G. ampliapertura* Zone, Oligocene.

Figure 11 *Globorotalia gemma* Jenkins.
A pseudoplanispirally coiled form:
Umbilical view, X 242.
Site 77B, Core 41, core-catcher; *C. cubensis* Zone, Oligocene.

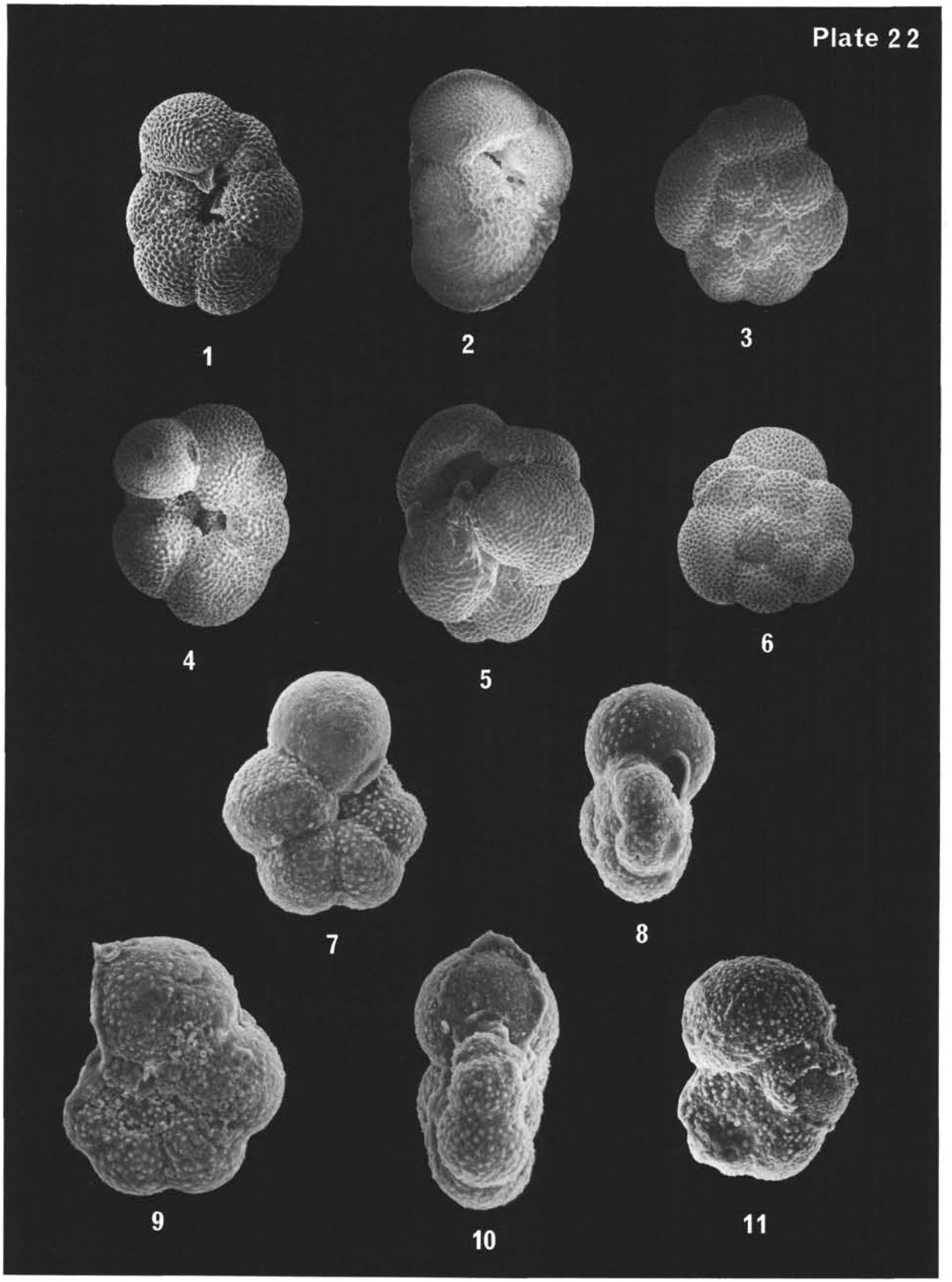
Plate 22
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PLATE 23

Figures 1-3 *Globorotalia exilis* Blow.
1: Umbilical view, X 48.
2: Side view, X 48.
3: Spiral view, X 48.
Site 80A, Core 2, Section 1, top; *S. dehiscens* Zone, Pliocene.

Figures 4-9 *Globorotalia exilis* Blow.
Two specimens of the sinistrally coiled form:
Specimen a:
4: Umbilical view, X 48.
5: Side view, X 48.
6: Spiral view, X48.

Specimen b:
7: Umbilical view, X 48.
8: Side view, X 48.
9: Spiral view, X48.
Site 77B, Core 7, Section 4, 19-21 cm; *S. dehiscens* Zone, Pliocene.

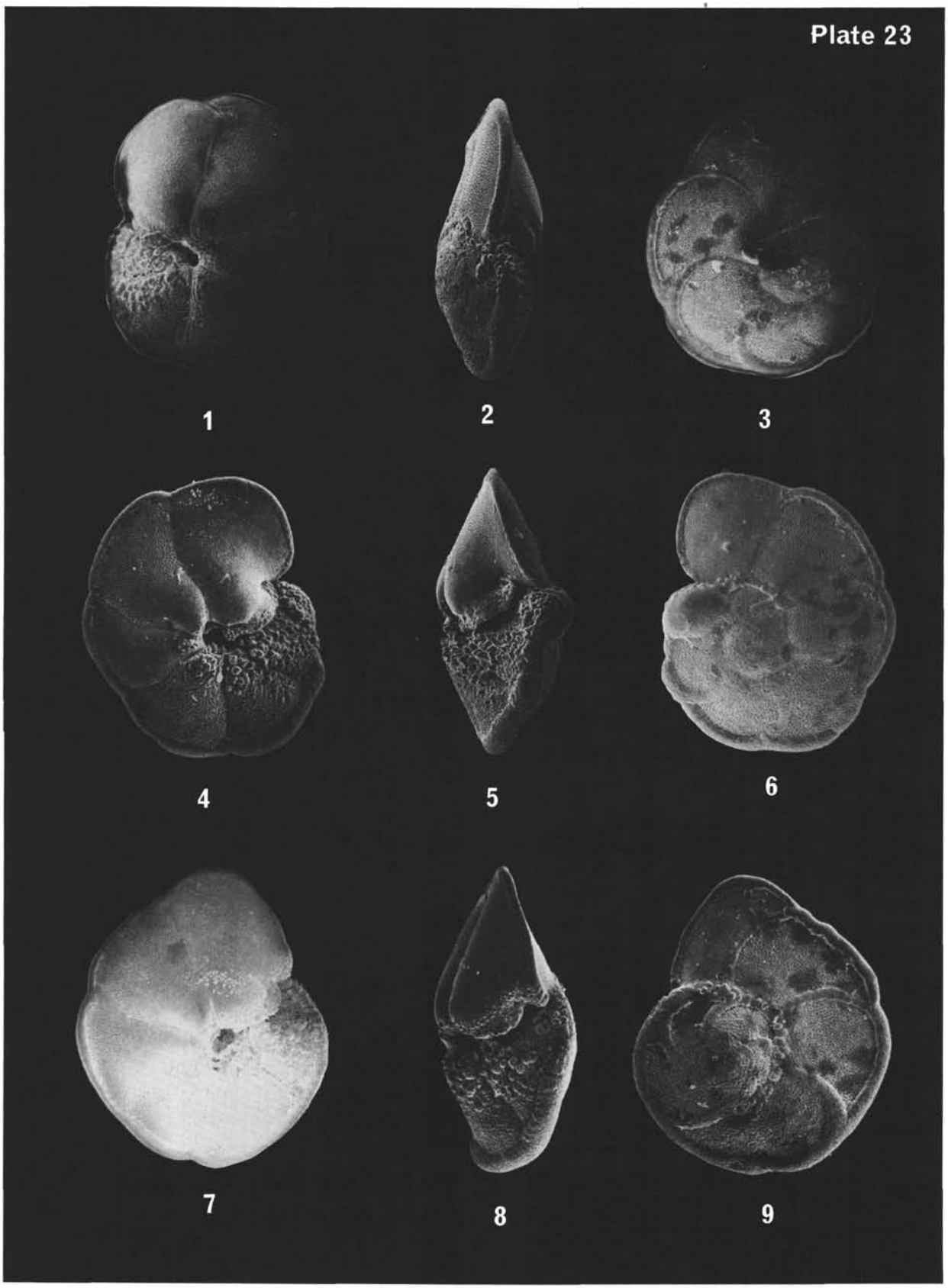
Plate 23
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PLATE 24

Figures 1, 2 — *Globorotalia fimbriata* Brady.
1: Umbilical view, X48.
2: Spiral view, X 48.
Site 82, Core 1, core-catcher; *P. obliquiloculata* Zone, Pleistocene.

Figures 3-5 — *Globorotalia fohsi lobata* Bermudez.
3: Umbilical view, X 71.
4: Side view, X 79.
5: Spiral view, X 79.
Site 77B, Core 21, core-catcher; *G. fohsi lobata* Zone, Middle Miocene.

Figures 6-8 — *Globorotalia humerosa* Takayanagi and Saito.
6: Umbilical view, X 97.
7: Side view, X 97.
8: Spiral view, X 97.
Site 77B, Core 5, core-catcher; *S. dehiscens* Zone, Pliocene.

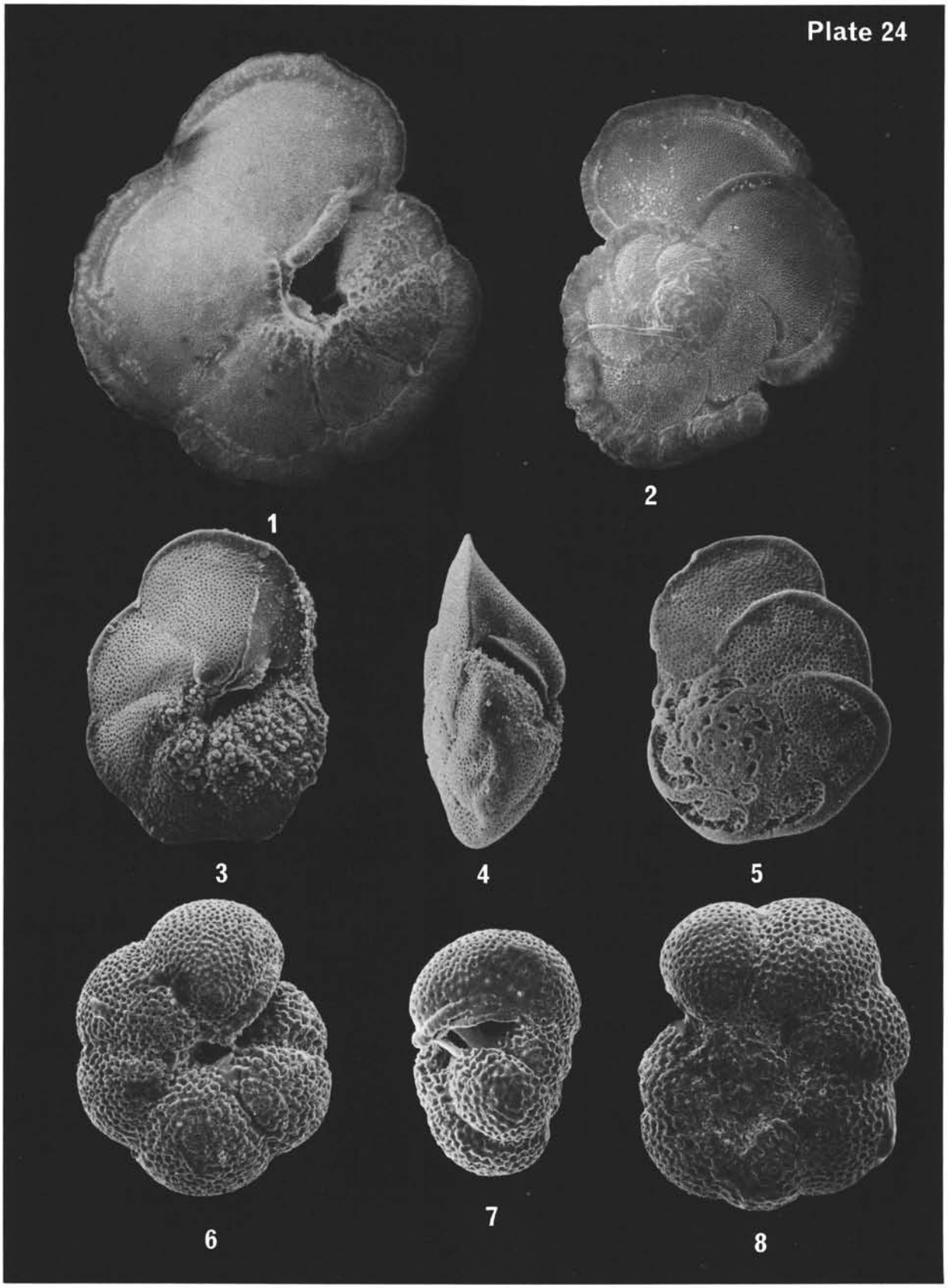
Plate 24
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PLATE 25

Figures 1, 2 *Globorotalia inflata* d'Orbigny.
1: Side view, X 97.
2: Umbilical view, X 97.
Site 83, Core 1, Section 2, top; *P. obliquiloculata* Zone, Pleistocene.

Figures 3-8 *Globorotalia insolita* Jenkins.
3: Umbilical view, X264.
4: Side view, X 220.
5: Spiral view, X396.
6: Umbilical view, X 242.
7: Umbilical view, X 242.
8: Umbilical view, X242.
Site 77B, Core 53, core-catcher; *G. insolita* Zone, Upper Eocene.

Figures 9-11 *Globorotalia kugleri* Bolli.
9: Umbilical view, X141.
10: Side view, X158.
11: Spiral view, X150.
Site 79, Core 13, Section 4, top; *G. kugleri* Zone, Lower Miocene.

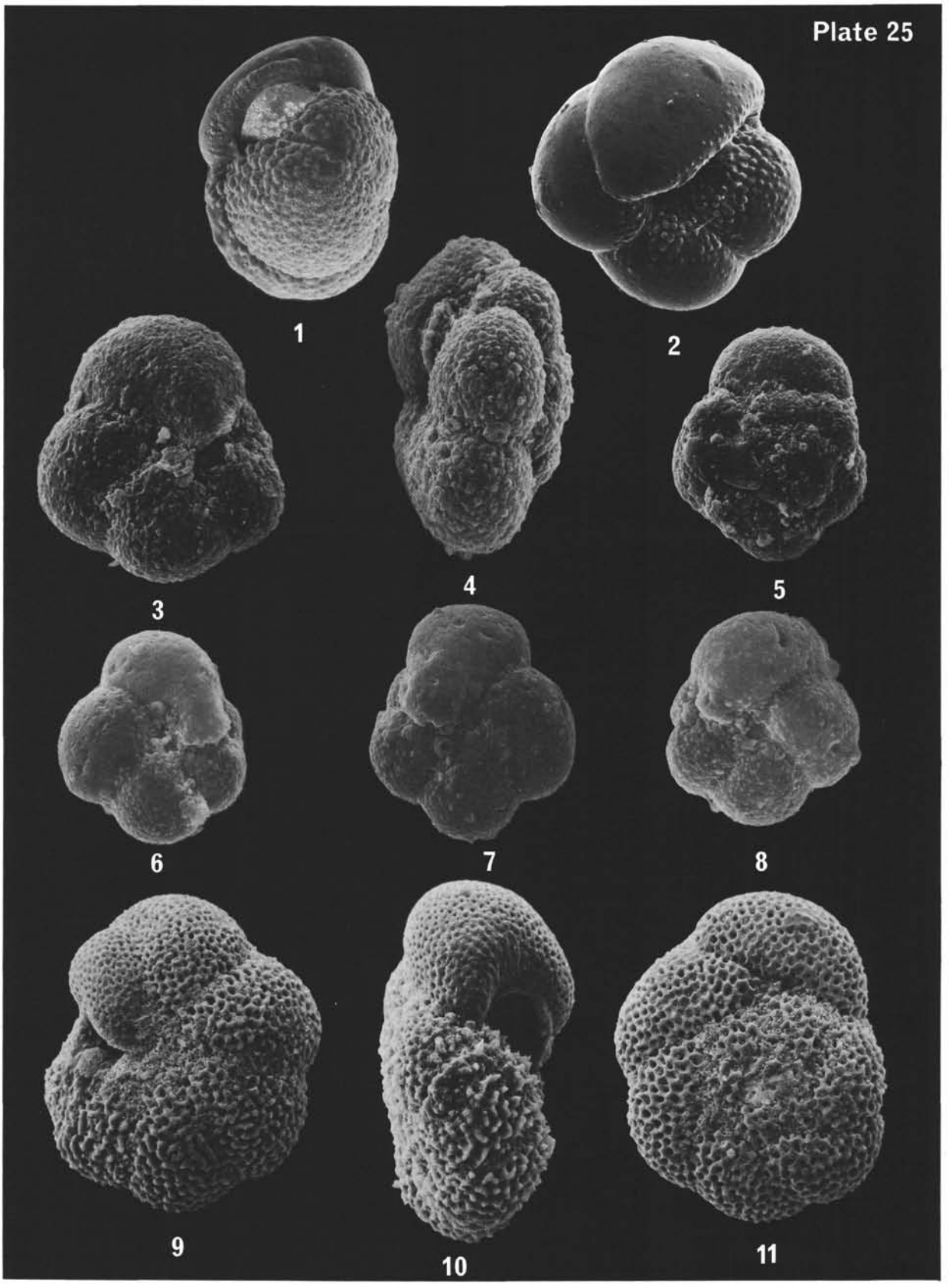
Plate 25
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PLATE 26

Figures 1-3 *Globorotalia margaritae* Bolli and Bermudez.
1: Umbilical view, X 48.
2: Side view, X 48.
3: Spiral view, X 48.
Site 77B, Core 6, Section 2, 33-35 cm; *S. dehiscens* Zone, Pliocene.

Figures 4-6 *Globorotalia menardii* d'Orbigny.
4: Umbilical view, X 48.
5: Side view, X 48.
6: Spiral view, X 48.
Site 81, Core 1, Section 1, top; *P. obliquiloculata* Zone, Pleistocene.

Figures 7-9 *Globorotalia merotumida* Banner and Blow.
7: Umbilical view, X132.
8: Side view, X132.
9: Spiral view, X132.
Site 77B, Core 13, Section 6, 16-18 cm; *G. plesiotumida* Zone, Upper Miocene.

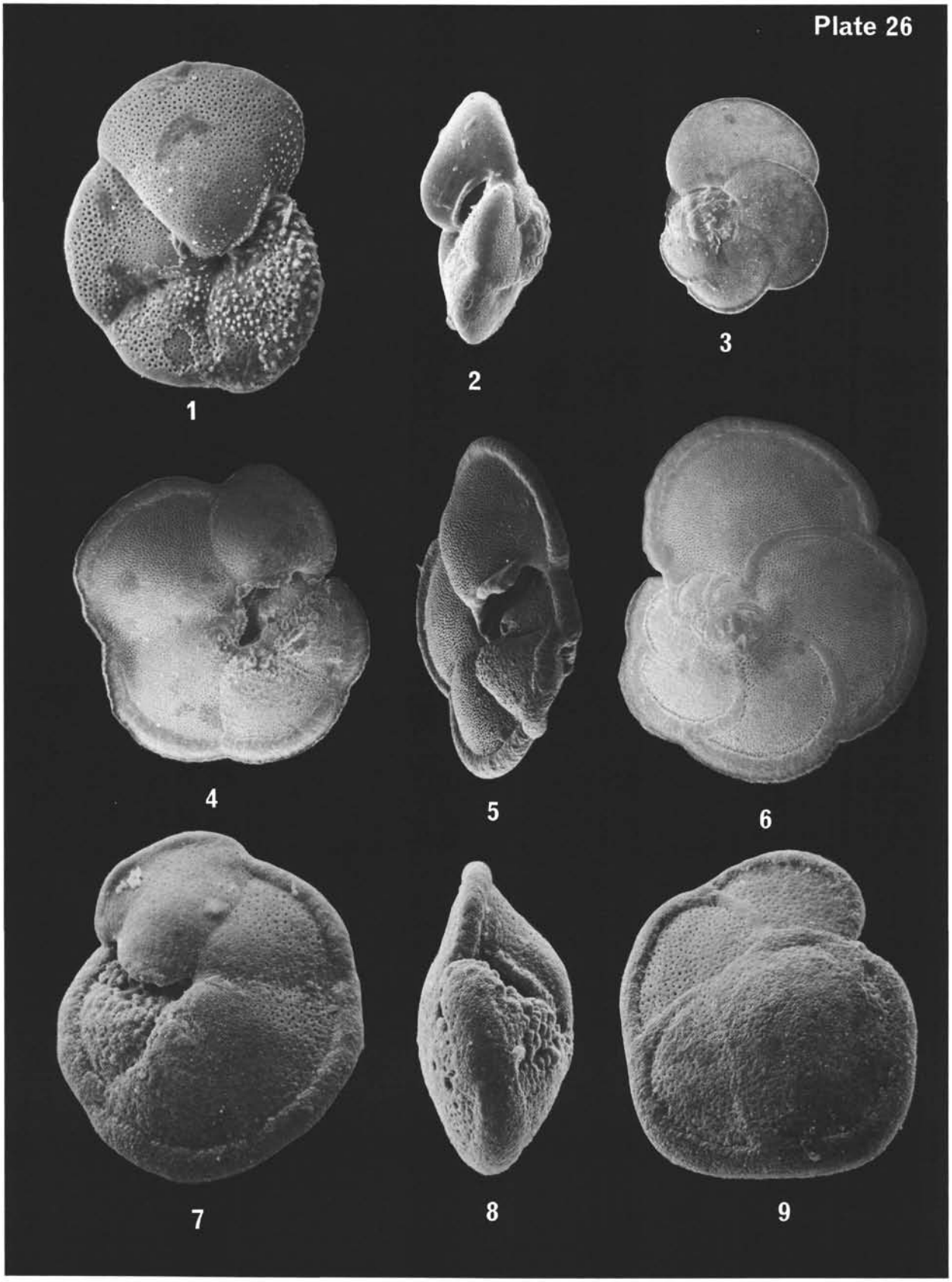
Plate 26
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PLATE 27

Figures 1, 2 — *Globorotalia hirsuta* d'Orbigny.
1: Side view (aperture re-touched), X 97.
2: Spiral view, X 48.
Site 77B, Core 2, Section 5, 66-68 cm; *P. obliquiloculata* Zone, Pleistocene.

Figures 3, 4 — *Globorotalia* cf. *minutissima* Bolli.
3: Umbilical view, X 193.
4: Spiral view, X 242.
Site 78, Core 17, core-catcher; *G. angulisuturalis* Zone, Upper Oligocene.

Figures 5-7 — *Globorotalia* cf. *minutissima* Bolli.
Two views of 1 specimen:
5: Umbilical view, X 193.
6: Spiral view, X 193.
7: Spiral view, X 97.
Site 77B, Core 31, Section 5, top; *G. kugleri* Zone, Lower Miocene.

Figure 8 — *Globorotalia* cf. *minutissima* Bolli..
Umbilical view, X 242.
Site 77B, Core 41, core-catcher; *C. cubensis* Zone, Oligocene.

Figures 9-11 — *Globorotalia* cf. *miozea* Finlay.
9: Umbilical view, X 97.
10: Side view, X 97.
11: Spiral view, X 97.
Site 81, Core 2, Section 2, top; *G. fohsi fohsi-G. peripheroacuta* Zone, Middle Miocene.

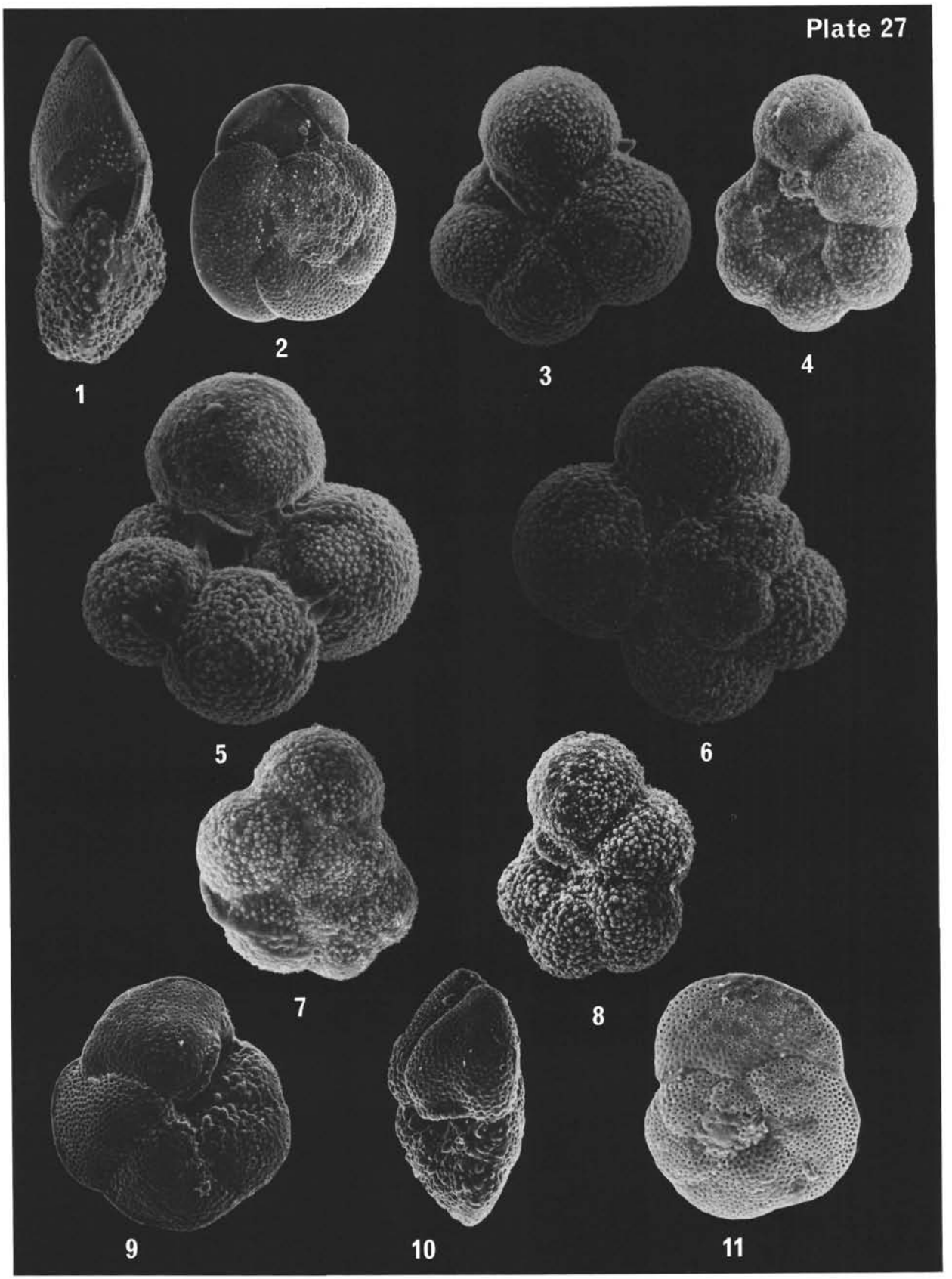
Plate 27
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PLATE 28

Figures 1-3 *Globorotalia miocenica* Palmer.
1: Umbilical view, X 97.
2: Side view, X 48.
3: Spiral view, X 48.
Site 83, Core 7, Section 3, top; *S. dehiscens* Zone, Pliocene.

Figures 4-6 *Globorotalia multicamerata* Cushman and Jarvis.
4: Umbilical view, X 24.
5: Side view, X 48.
6: Spiral view, X 48.
Site 80A, Core 2, Section 5, top; *G. plesiotumida* Zone, Upper Miocene.

Figures 7-9 *Globorotalia nana* Bolli.
7: Umbilical view, X 48.
8: Side view, X 48.
9: Spiral view, X 48.
Site 78, Core 22, core-catcher; *G. opima* Zone, Oligocene.

Figures 10-12 *Globorotalia opima* Bolli.
10: Umbilical view, X 88.
11: Side view, X 88.
12: Spiral view, X 88.
Site 77B, Core 39, core-catcher; *G. opima* Zone, Oligocene.

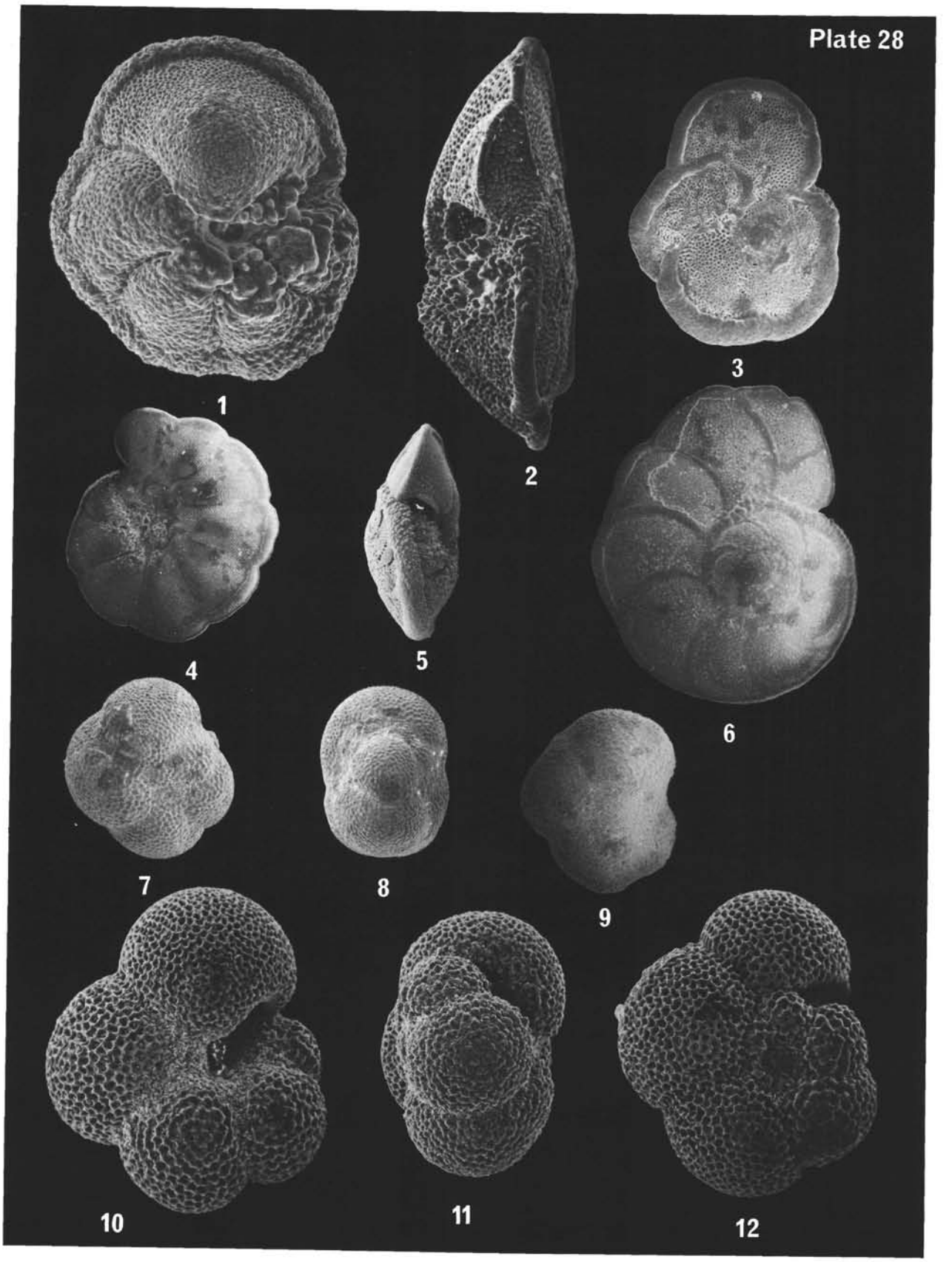
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PLATE 29

Figures 1, 2 — *Globorotalia* cf. *pachyderma* Ehrenberg.
1: Umbilical view, X 97.
2: Spiral view, X 97.
Site 83, Core 2, Section 5, top; *P. obliquiloculata* Zone, Pleistocene.

Figures 3-5 — *Globorotalia* aft. *panda* Jenkins.
3: Umbilical view, X 48.
4: Side view, X48.
5: Spiral view, X 48.
Site 84, Core 5, core-catcher; *P. obliquiloculata* Zone, Pleistocene.

Figures 6-8 — *Globorotalia peripheroacuta* Blow and Banner.
6: Umbilical view, X123.
7: Side view, X123.
Site 78, Core 1, Section 5, top.
8: Spiral view, X213.3.
Site 77B, Core 23, Section 3, top; *G. fohsi fohsi-G. peripheroacuta* Zone, Middle Miocene.

Figures 9-11 — *Globorotalia peripheroronda* Blow and Banner.
9: Umbilical view, X158.
Site 77B, Core 24, Section 5, top.
10: Side view, X176.
11: Spiral view, X176.
Site 79A, Core 4, core-catcher; *G. venezuelana* Zone, Lower Miocene.

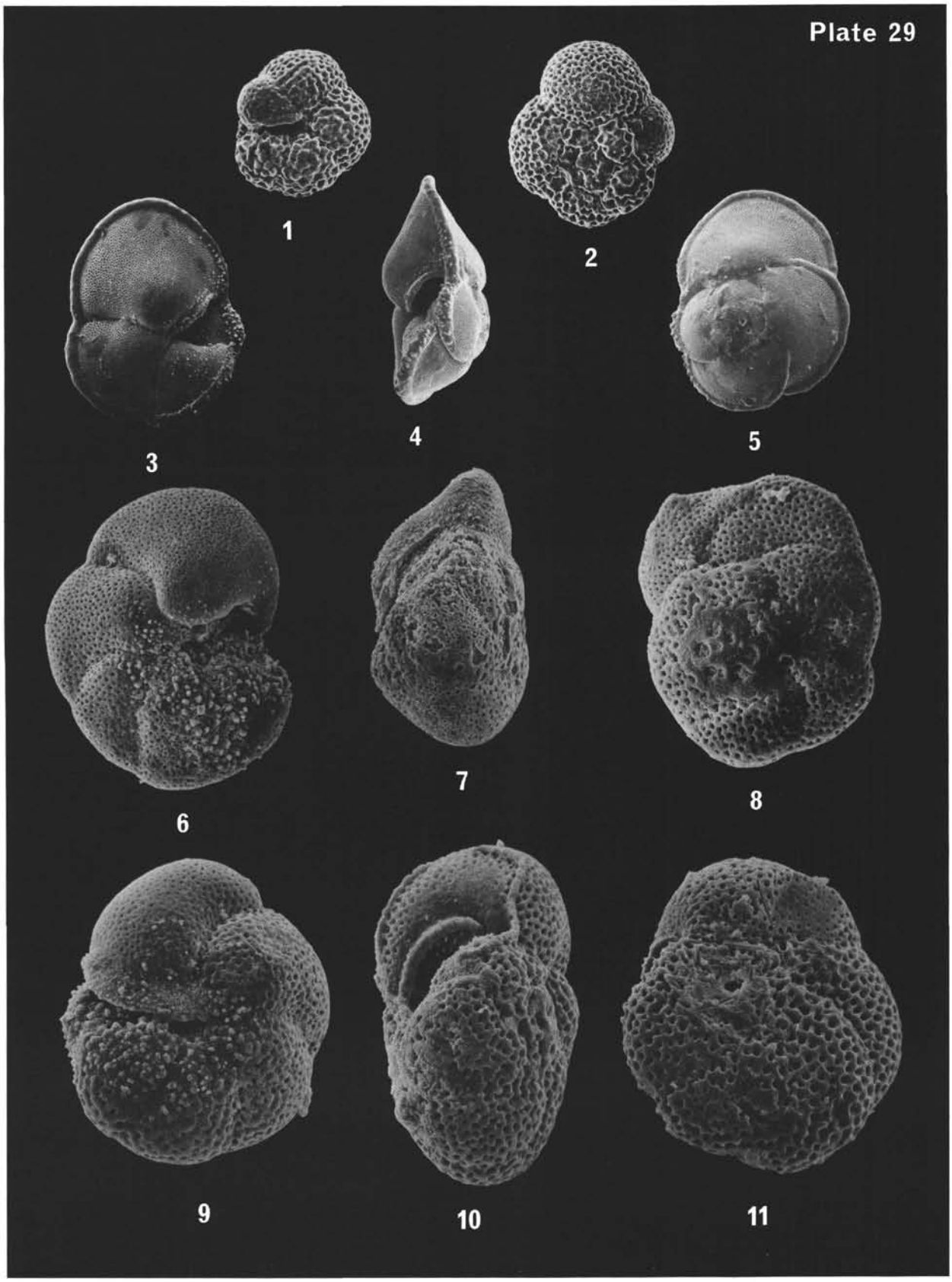
Plate 29
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PLATE 30

Figures 1-3 *Globorotalia plesiotumida* Banner and Blow.
1: Umbilical view, X 88.
Site 77B, Core 10, Section 5, top.

2: Side view, X 123.
3: Spiral view, X 88.
Site 77B, Core 9, Section 6, 3-5 cm; *G. plesiotumida* Zone, Upper Miocene.

Figures 4-6 *Globorotalia praemenardii* Cushman and Stainforth.
4: Umbilical view, X 97.
5: Side view, X 97.
6: Spiral view, X 97.
Site 78, Core 2, Section 3, top; *G. fohsi fohsi-G. peripheroacuta* Zone, Middle Miocene.

Figures 7-9 *Globorotalia pseudomiocenica* Bolli and Bermudez.
7: Umbilical view, X 97.
8: Side view, X 193.
9: Spiral view, X 97.
Site 83, Core 4, Section 3, top; *S. dehiscens* Zone, Pliocene.

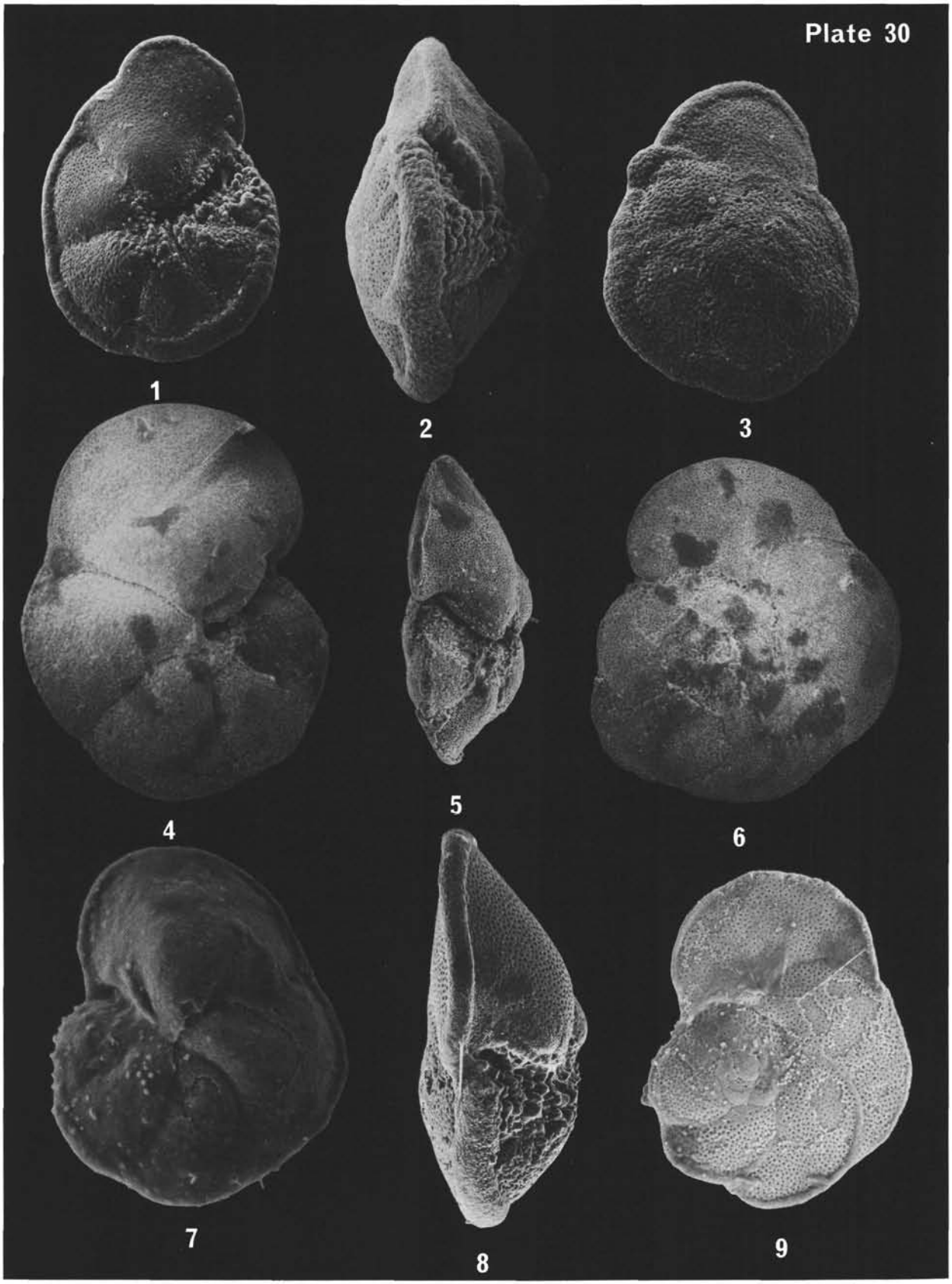
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PLATE 31

Figure 1 — *Globorotalia praescitula* Blow.
Side view, X220.
Site 81, Core 3, Section 3, top; *G. peripheroronda* Zone, Middle Miocene.

Figures 2, 3 — *Globorotalia* cf. *pseudokugleri* Blow.
2: Side view, X220.
3: Spiral view, X220.
Site 76, Core 1, Section 5, top; reworked into the *G. fistulosus* Zone, Pliocene.

Figures 4, 5 — *Globorotalia scitula* Brady.
4: Umbilical view, X220.
5: Side view, X220.
Site 77B, Core 6, Section 2, 33-35 cm; *S. dehiscens* Zone, Pliocene.

Figures 6-8 — *Globorotalia tumida flexuosa* Koch.
6: Umbilical view, X55.
7: Spiral view, X55.
8: Spiral view, X55.
Site 77B, Core 5, Section 2, 3-5 cm; *S. dehiscens* Zone, Pliocene.

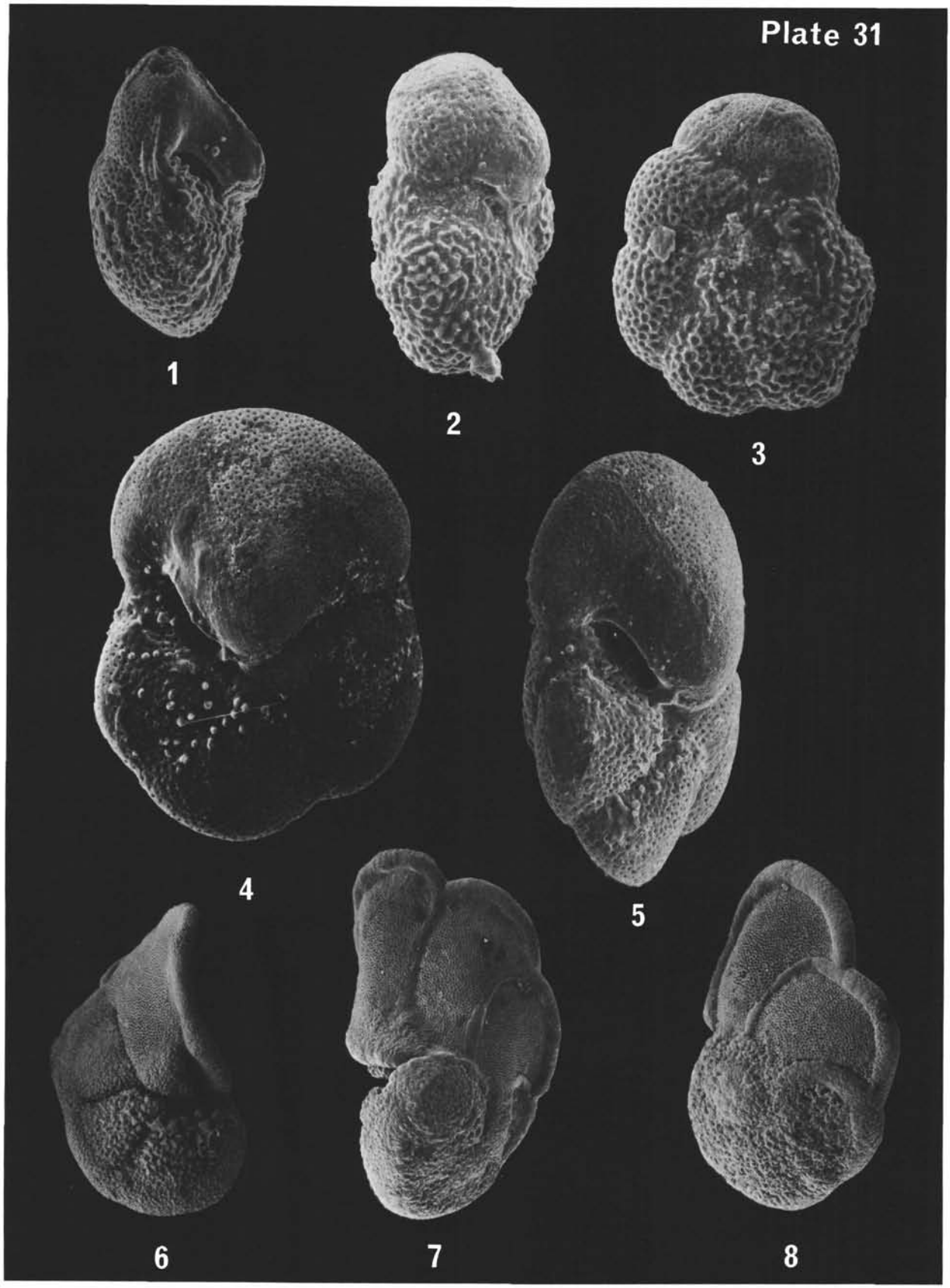
Plate 31
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PLATE 32

Figures 1-3 *Globorotalia siakensis* Le Roy.
1: Umbilical view, X132.
2: Side view, X132.
Site 77B, Core 39, Section 4, top; *G. opima* Zone, Oligocene.

3: Spiral side, X132.
Site 77B, Core 20, core-catcher; *G. fohsi lobata* Zone, Middle Miocene.

Figures 4-9 *Globorotalia* cf. *siakensis* Le Roy.
Three views of the same specimen:
4: Umbilical view, X 97.
5: Side view, X 97.
6: Spiral view, X 97.

Three views of the same specimen:
7: Umbilical view, X . 97
8: Side view, X 97.
9: Spiral view, X 97.
Site 77B, Core 45, Section 4, top; *G. ampliapertura* Zone, Oligocene.

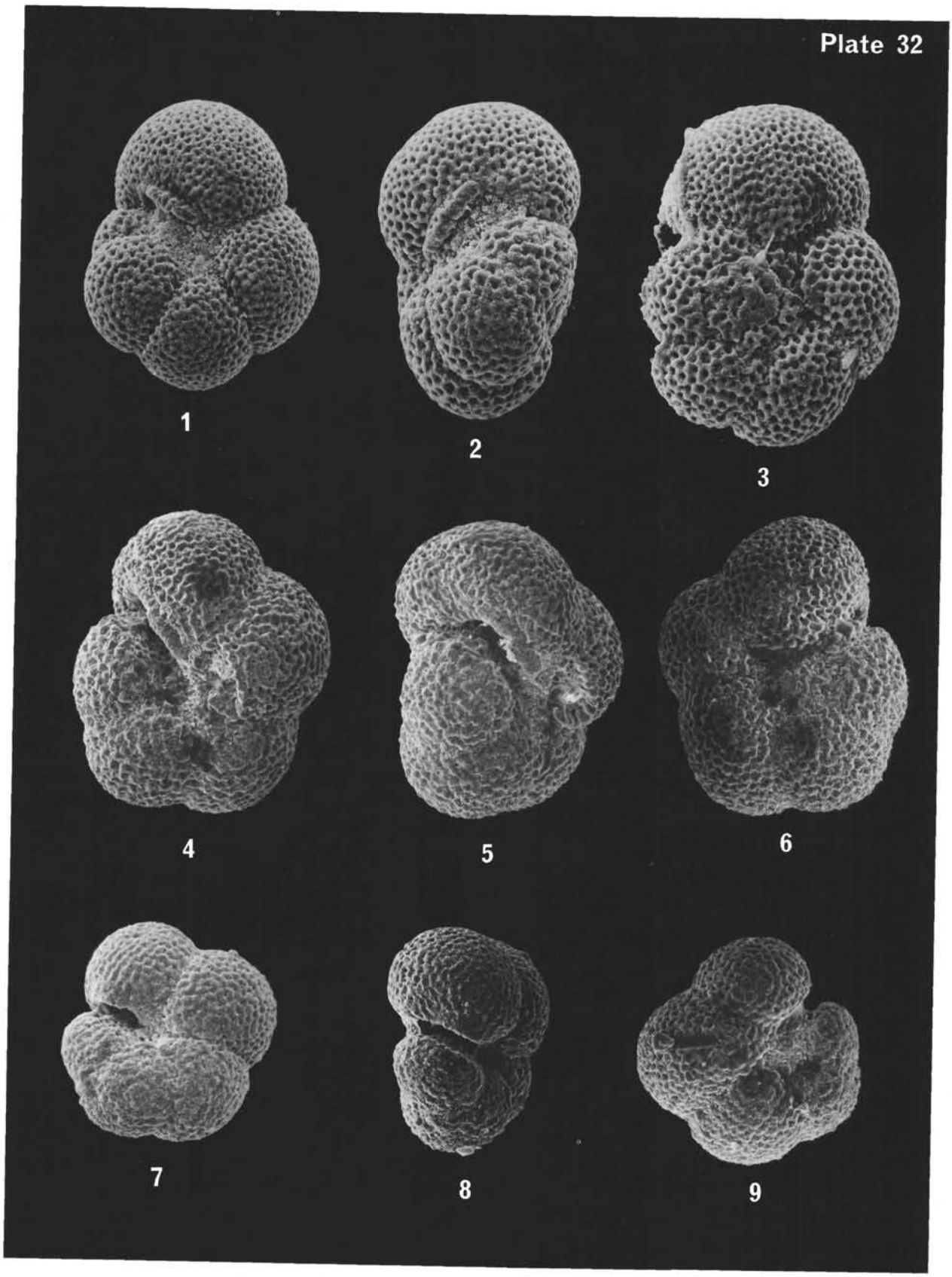
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PLATE 33

Figures 1-3 *Globorotalia tosaensis* Takayanagi and Saito.
1: Umbilical view, X123.
2: Side view, X123.
3: Spiral view, X123.
Site 77B, Core 1, core-catcher; *P. obliquiloculata* Zone, Pleistocene.

Figures 4-6 *Globorotalia truncatulinoides* d'Orbigny.
4: Umbilical side, X 97.
5: Side view, X97.
6: Spiral view, X 97.
Site 80, Core 1, Section 5, top; *P. obliquiloculata* Zone, Pleistocene.

Figures 7-9 *Globorotalia truncatulinoides pachytheca* Blow.
7: Umbilical view, X 97.
8: Side view, X 97.
9: Spiral view, X 97.
Site 81, Core 1, Section 5, top; *P. obliquiloculata* Zone, Pleistocene.

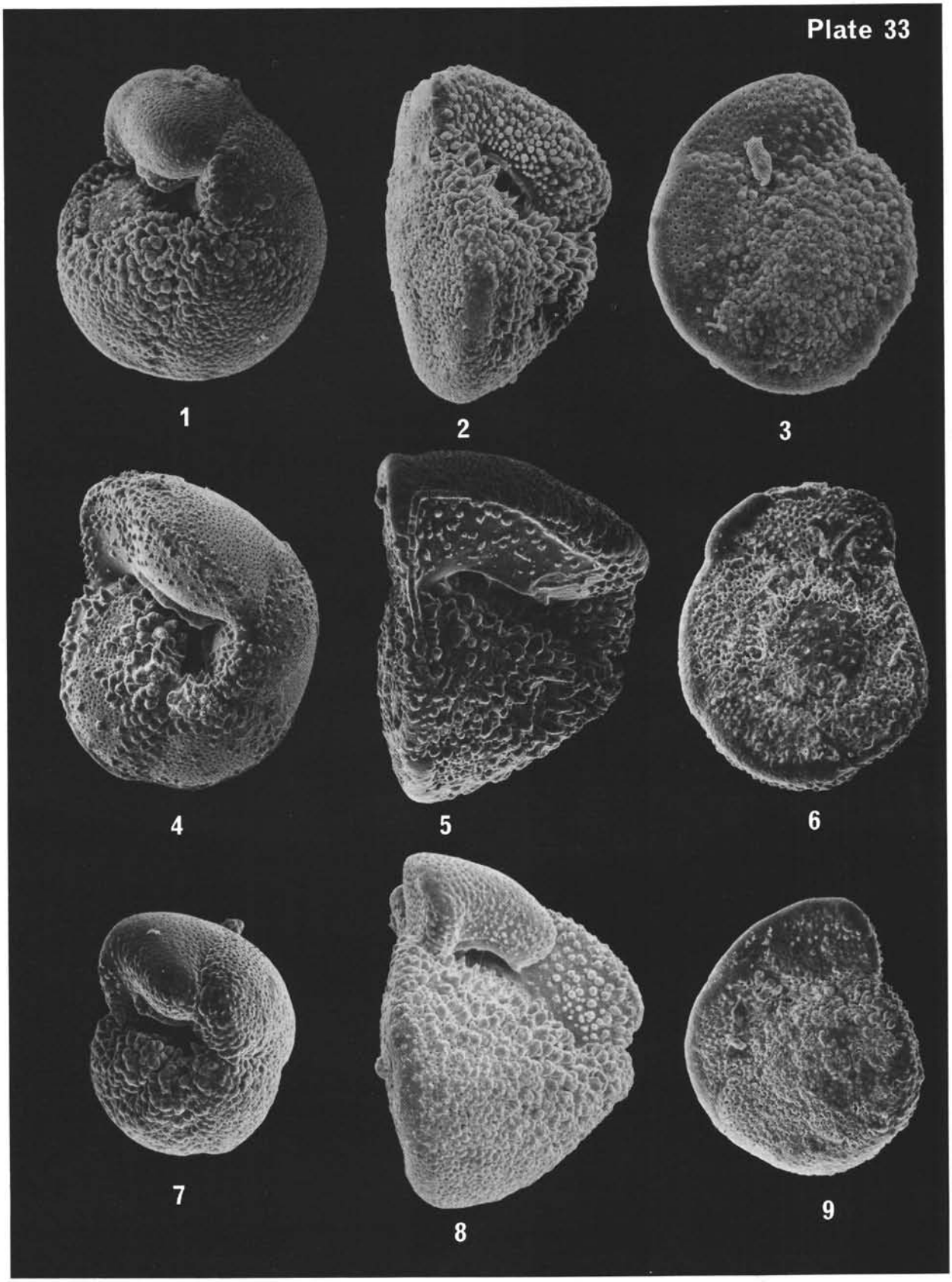
Plate 33
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PLATE 34

Figures 1-3 *Globorotalia tumida tumida* Brady.
1: Umbilical view, X35.
2: Side view, X 35.
3: Spiral view, X35.
Site 76, Core 1, core-catcher; *G. fistulosus* Zone, Upper Pliocene.

Figures 4-9 *Globorotalia* cf. *tumida* Brady.
Three views of 1 specimen:
4: Umbilical view, X 97.
5: Side view, X 97.
6: Spiral view, X 97.

Three views of 1 specimen:
7: Umbilical view, X 97.
8: Side view, X 97.
9: Spiral view, X 97.
Site 77B, Core 2, Section 5, 66-68 cm; *P. obliquiloculata* Zone, Pleistocene.


Plate 34
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PLATE 35

Figures 1-6 *Globorotalia ungulata* Bermudez.
Three views of 1 specimen:
1: Umbilical view, X 48.
2: Side view, X 48.
3: Spiral view, X 48.

Three views of 1 specimen:
4: Umbilical view, X 48.
5: Side view, X 48.
6: Spiral view, X48.
Site 77A, Core 1, Section 5, 101-103 cm; *P obliquiloculata* Zone, Pleistocene.

Figures 7-9 *Globorotaloides stainforthi* (Bolli, Loeblich and Tappan).
7: Umbilical view, X 97.
8: Side view, X 97.
9: Spiral view, X 97.
Site 77B, Core 30, Section 3, top; *G. dissimilis* Zone, Lower Miocene.

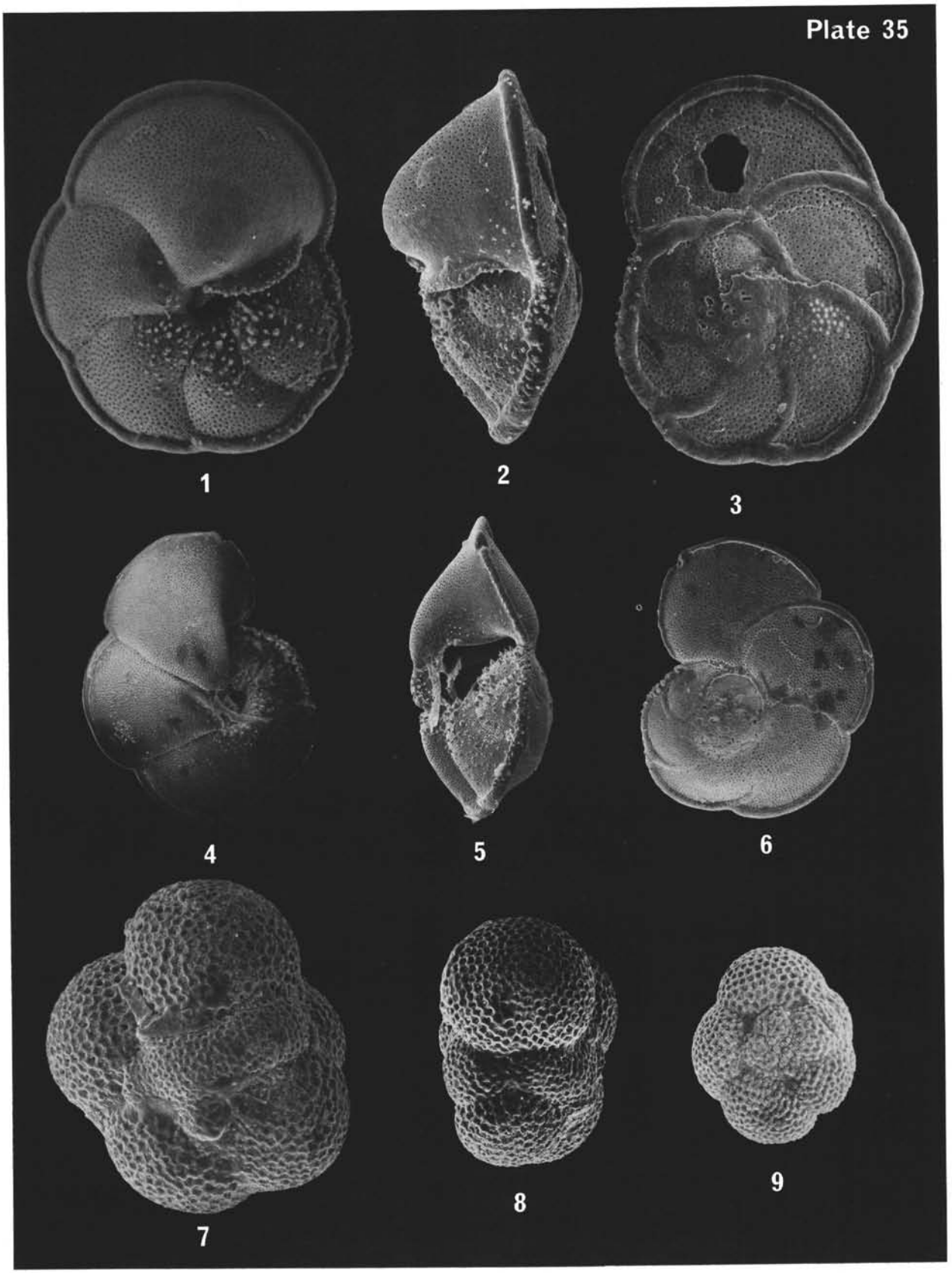
Plate 35
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PLATE 36

Figures 1-4 *Globorotaloides hexagona* Natland.
1: Umbilical view (showing a bulla), X 97. .
2: Umbilical view (showing remains of a bulla), X 97.
3: Umbilical view (without a bulla), X 97.
4: Spiral view, X 97.
Site 80A, Core 1, core-catcher; *P. obliquiloculata* Zone, Pleistocene.

Figures 5-9 *Globorotaloides hexagona* Natland.
Three views of a specimen with a less coarsely ornamented wall:
5: Umbilical view, X 97.
6: Side view, X 97.
7: Spiral view, X 97.

Two views of a similar specimen:
8 Umbilical view, X 97.
9: Side view, X 97.
Site 82A, Core 3, Section 1, top; *S. dehiscens* Zone, Pliocene.

Figures 10, 11 *Globorotaloides suteri* Bolli.
Two views of one specimen:
10: Side view, X 242.
11: Spiral view, X 242.
Site 77B, Core 51, core-catcher; *P. barbadoensis* Zone, Lower Oligocene.

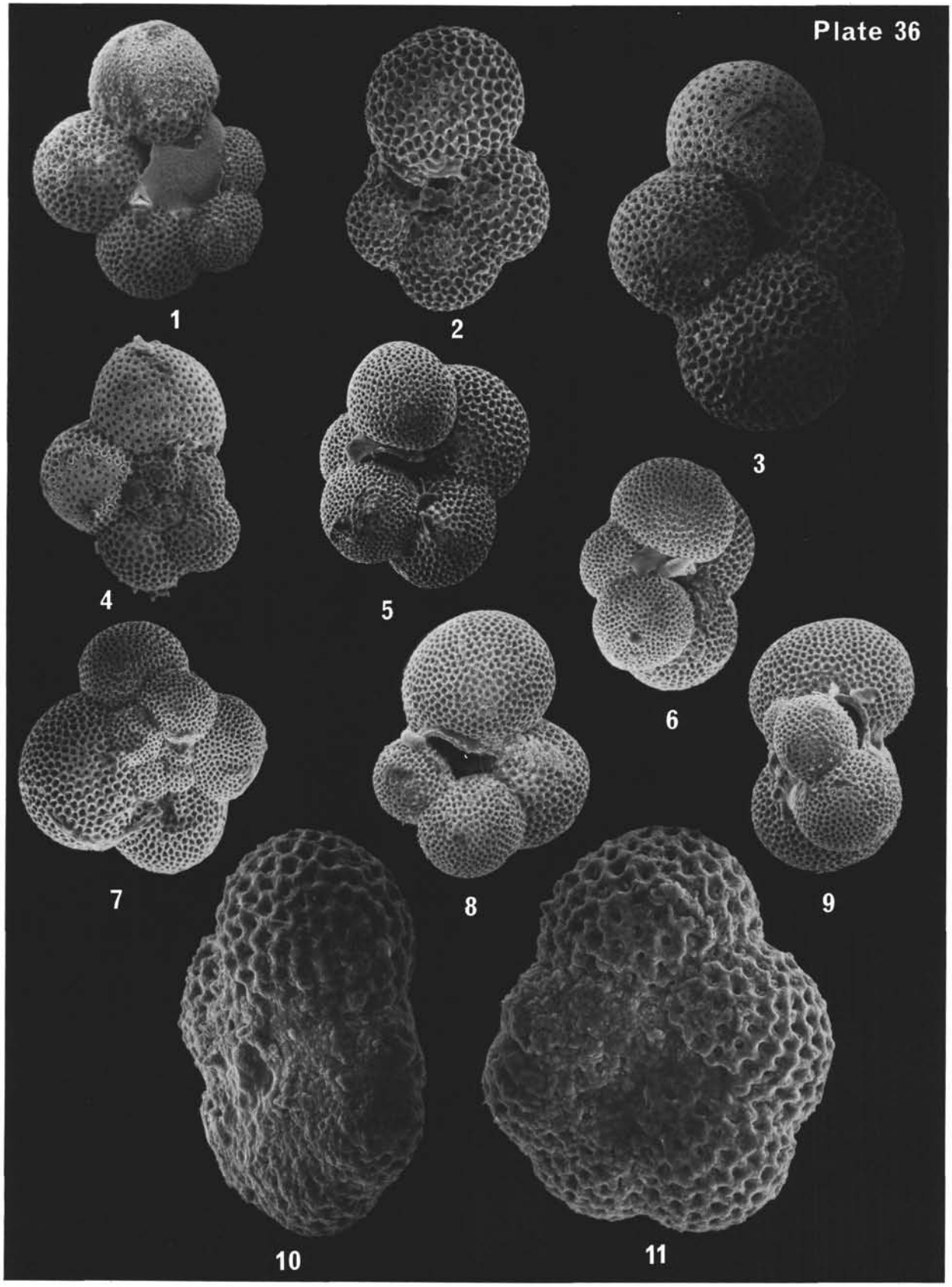
Plate 36
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PLATE 37

Figures 1-3 *Globorotaloides suteri* Bolli.
Three views of one specimen:
1: Umbilical view, X220.
2: Side view, X220.
3: Spiral view, X220.
Site 77B, Core 51, core-catcher; *P. barbadoensis* Zone, Lower Oligocene.

Figures 4-6 *Hastigerinella rhumbleri* Galloway.
Three views of same specimen:
4: Side view, X110.
5: Side-Umbilical view, X110.
6: Spiral view, X110.
Site 84, Core 1, core-catcher; *P. obliquiloculata* Zone, Pleistocene.

Figure 7 *Hastigerinoides* (?) sp.
Umbilical view, X220.
Site 77B, Core 42, core-catcher; reworked from Cretaceous into the *C. cubensis* Zone, Oligocene.

Figure 8 *Hantkenina alabamensis* Cushman.
Umbilical view, X110.
Site 76A, Core 2, Section 6, 8-10 cm; reworked into *S. dehiscens* Zone, Pliocene.

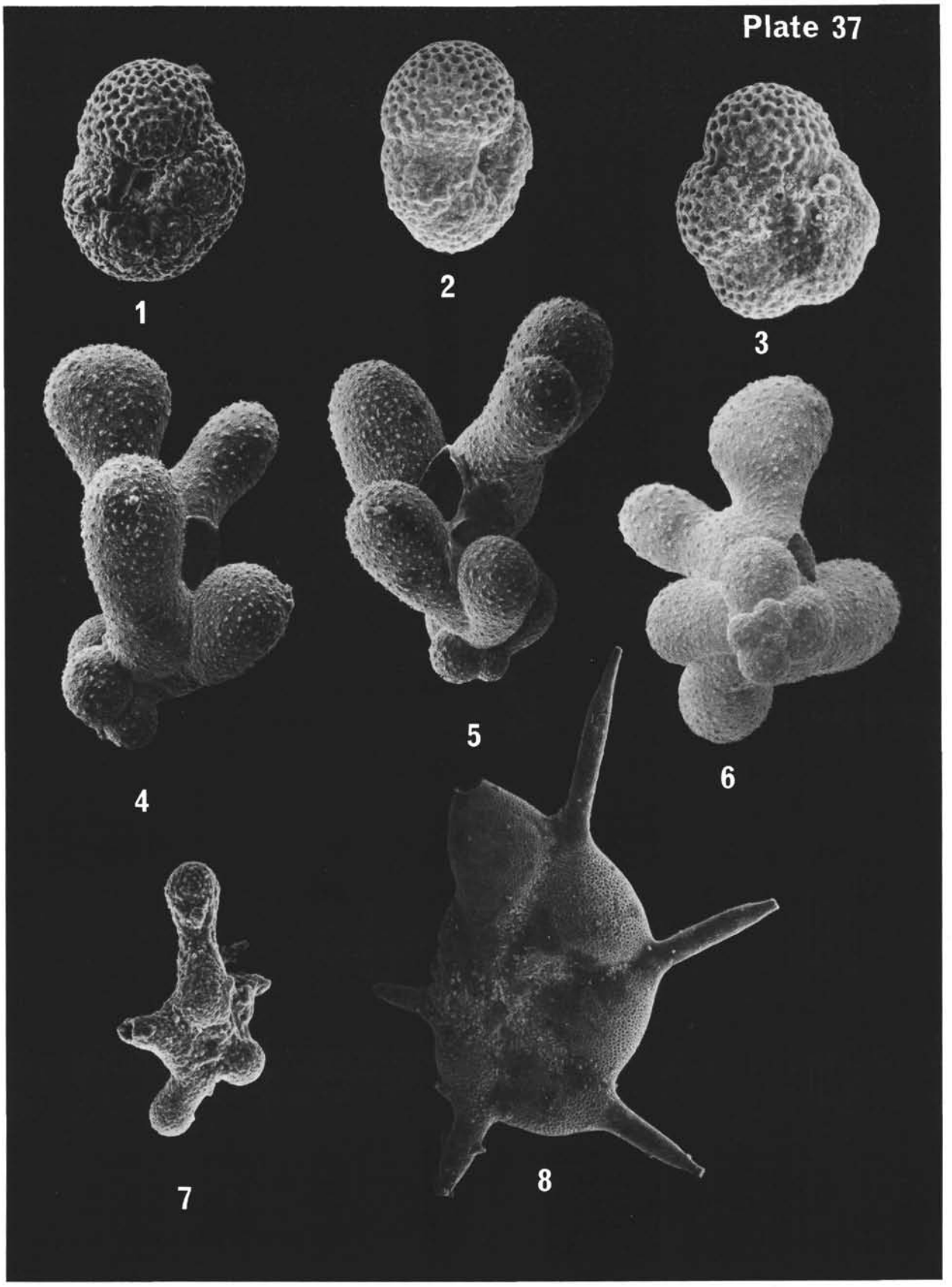
Plate 37
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PLATE 38

Figures 1-3 *Hastigerinella bermudezi* Bolli.
1: Umbilical view, X 48.
2: Umbilical view, X 48.
3: Spiral view, X 48.
Site 77B, Core 24, Section 6, core-catcher; *G. peripheroronda* Zone, Middle Miocene.

Figure 4 *Orbulina bilobata* d'Orbigny.
Side view, X 48.
Site 77B, Core 12, Section 6, core-catcher; *G. plesiotumida* Zone, Upper Miocene.

Figures 5, 6 *Orbulina suturalis* Bronnimann.
5: Side view, X 48.
6: Side view, X 97.
Site 78, Core 1, Section 5, top; *G. fohsi fohsi-G. peripheroacuta* Zone, Middle Miocene.

Figures 7-9 *Praeorbulina glomerosa circularis* Blow.
Three views of 1 specimen:
7: Side view, X 97.
8: Side view, X 97.
9: Spiral view, X 97.
Site 81, Core 3, Section 2, top; *G. peripheroronda* Zone, Middle Miocene.

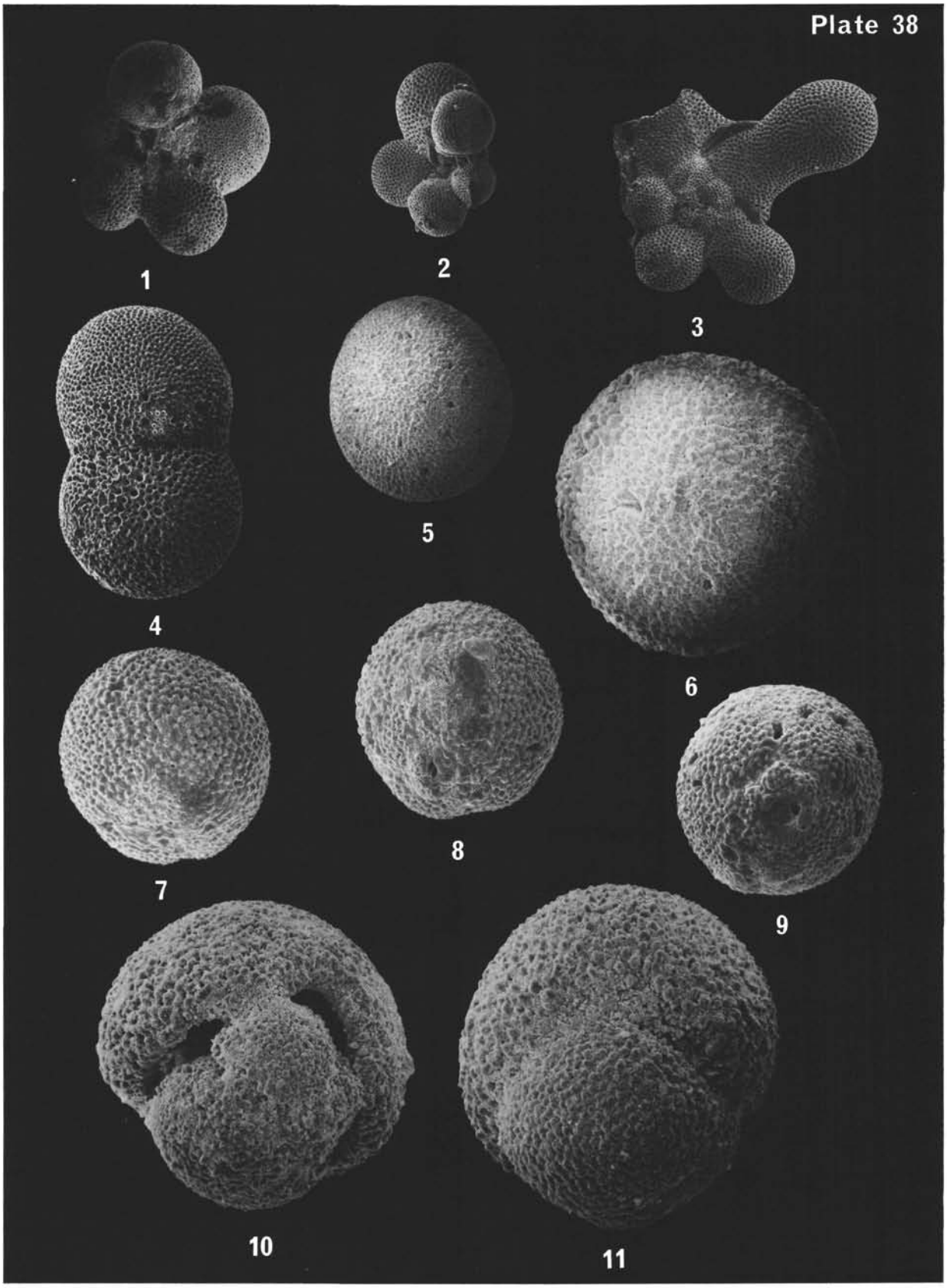
Plate 38
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PLATE 39

Figures 1, 2 — *Pulleniatina obliquiloculata* Parker and Jones.
1: Side view (*P. finalis*), X 71.
2: Umbilical view, X 88.
Site 77B, Core 1, Section 2, 39-41 cm; *P. obliquiloculata* Zone, Pleistocene.

Figures 3-7 — *Pulleniatina primalis* Banner and Blow.
Two specimens with smooth walls:
3: Side view (high spired form), X 97.
4: Side view, X 97.
Site 83A, Core 9, core-catcher; *S. dehiscens* Zone, Pliocene.

Three views of one specimen:
5: Umbilical view, X 48.
6: Side view, X 48.
7: Spiral view, X 48.
Site 82A, Core 3, Section 1, top; *S. dehiscens* Zone, Pliocene.

Figures 8-10 — *Pulleniatina primalis* Banner and Blow.
Coarse walled (unthickened) forms:
8: Umbilical view, X 48.
9: Side view, X 48.
10: Spiral view, X 48.
Site 83A, Core 9, core-catcher; *S. dehiscens* Zone, Pliocene.

Figures 11-13 — *Pulleniatina spectabilis* Parker.
11: Umbilical view, X 48.
12: Side view, X 48.
13: Spiral view, X 48.
Site 77B, Core 6, Section 4, 23-25 cm; *S. dehiscens* Zone, Pliocene.

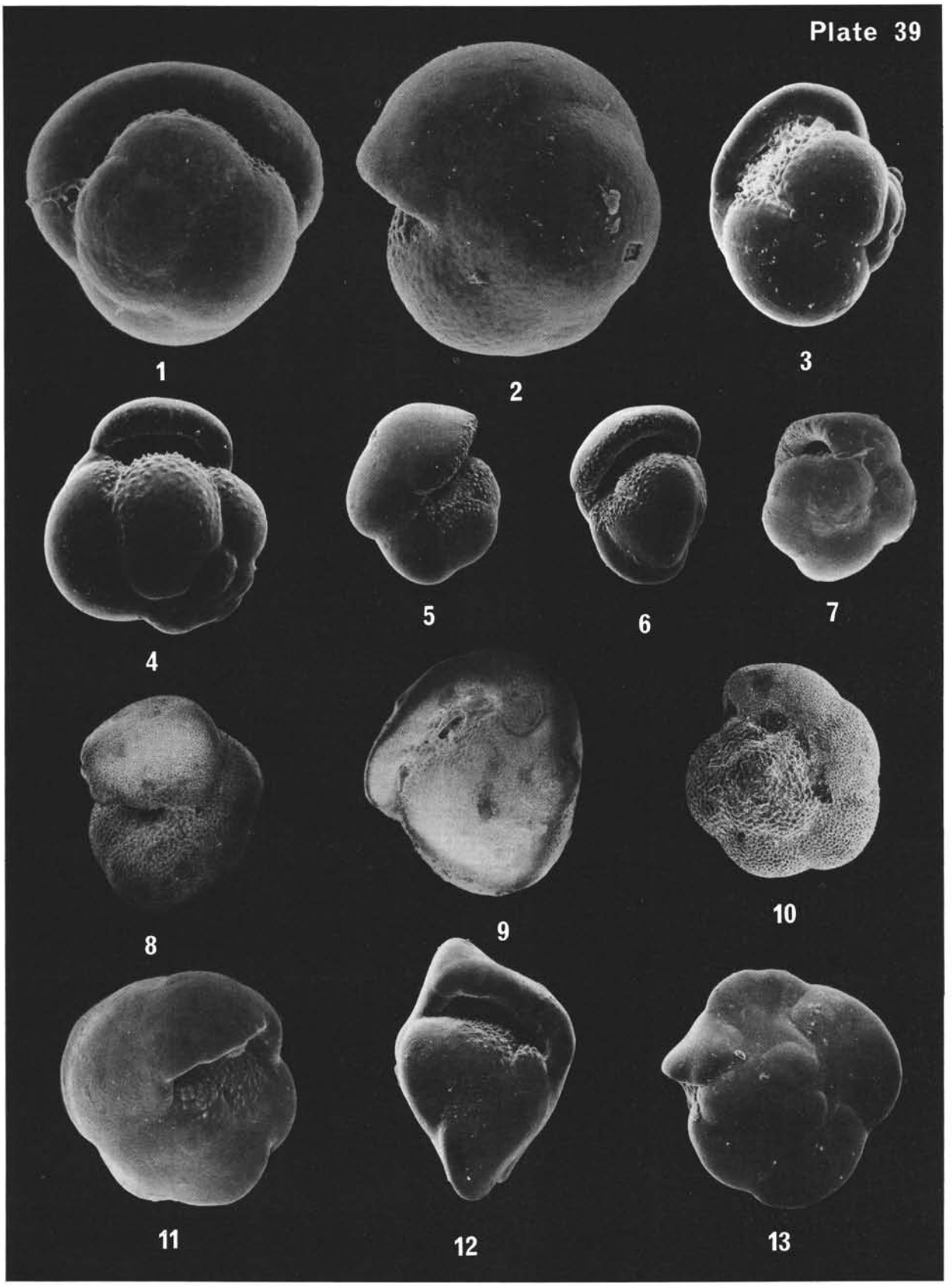
Plate 39
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PLATE 40

Figures 1, 2 — *Pseudohastigerina barbadoensis* Blow.
1: Side view, X220.
2: Peripheral view, X 220.
Site 77B, Core 51, core-catcher; *P. barbadoensis* Zone, Lower Oligocene.

Figures 3, 4 — *Sphaeroidinella dehiscens* Parker and Jones.
3: Umbilical view, X61.
4: Side view, X 44.
Site 77B, Core 2, Section 6, 12-14 cm; *P. obliquiloculata* Zone, Pleistocene.

Figures 5-7 — *Sphaeroidinella dehiscens* Parker and Jones.
Three specimens showing possible affinity to *G. fistulosus:*
5: Side view, X48.
6: Side view, X48.
Site 84, Core 14, core-catcher; *G. fistulosus* Zone, Upper Pliocene.
7: Umbilical view, X48.
Site 83A, Core 6, Section 3, 13-16 cm; *S. dehiscens* Zone, Pliocene.

Figure 8 — *Sphaeroidinella dehiscens* Parker and Jones.
A specimen showing an affinity to *G. sacculifer:*
Spiral view, X 48.
Site 83A, Core 6, Section 3, 13-16 cm; *G. fistulosus* Zone, Upper Pliocene.

Figures 9-11 — *Sphaeroidinella seminulina* Schwager.
9: Umbilical view, X48.
10: Side view, X48.
11: Spiral view, X48.
Site 78, Core 1, Section 5, top; *G. fohsi fohsi-G. peripheroacuta* Zone, Middle Miocene.

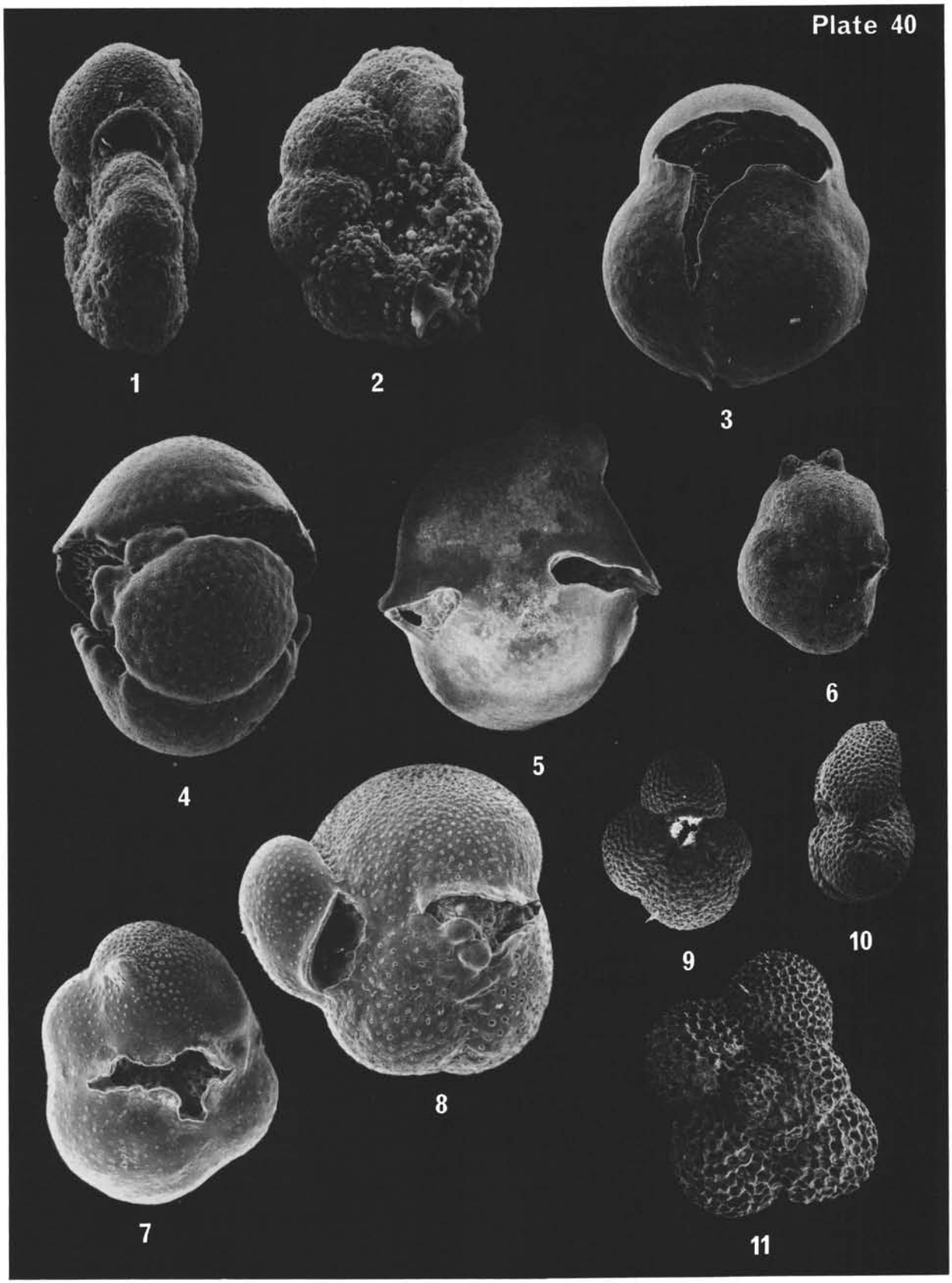
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PLATE 41

Figures 1, 2 *Sphaeroidinella subdehiscens* Blow.
1: Umbilical view, X 75.
2: Spiral view, X 79.
Site 77B, Core 11, core-catcher; *G. plesiotumida* Zone, Upper Miocene.

Figures 3, 4 *Turborotalita humilis* Brady
3: Umbilical view, X 242.
4: Spiral view, X 242.
Site 77B, Core 2, Section 4, 7-9 cm; *P. obliquiloculata* Zone, Pleistocene.

Figures 5-9 *Siphotextularia* (?) sp.
Forms with more inflated chambers:
5: Side-apertural view, X 193.
6: Side-apertural view, X 193.
7: Side-apertural view, X 193.

Forms with more elongate test:
8: Side-apertural view, X 193.
9: Side-apertural view, X 193.
Site 77B, Core 53, core-catcher; *G. insolita* Zone, Upper Eocene.

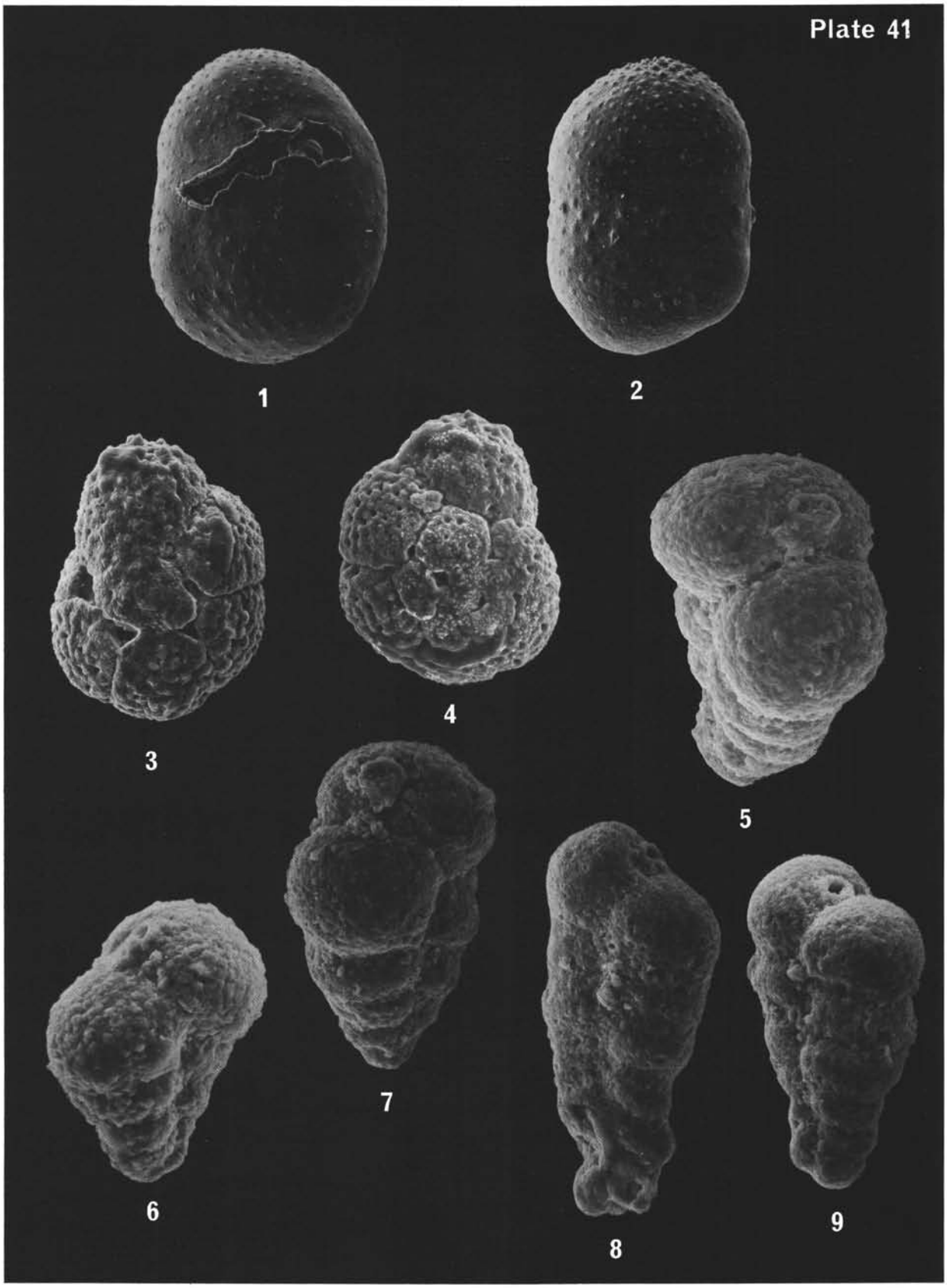
Plate 41
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