33. LATE CRETACEOUS TO PLEISTOCENE FORAMINIFERA FROM THE SOUTHEAST PACIFIC BASIN, DSDP LEG 35

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ABSTRACT

During DSDP Leg 35, Sites 322, 323, 324, and 325 were drilled in the Southeast Pacific Basin, in the Antarctic region. Late Cretaceous to Pleistocene planktonic and benthonic foraminifera were investigated from the recovered sediments. The Pliocene and Pleistocene assemblages yielded a nearly monospecific planktonic fauna of *Neogloboquadrina pachyderma*. Only a few, probably displaced, benthonic forms were found. The late and middle Miocene sediments were barren of foraminifera. A lower bathyal to abyssal fauna of arenaceous foraminifera existed throughout the region during the early Miocene. In the shallower continental slope area (Site 325) this fauna was accompanied by a sparse assemblage of deep-water calcareous benthonic species and an isolated occurrence of *Globorotalia zealandica incognita*. The age assignment of this species is foraminiferal Zone N6-N7; Burdigalian. The lower boundary of this fauna could be Oligocene, inasmuch as the observed benthonic species, especially *Cyclammina*, range from Oligocene to Miocene.

A new fauna of arenaceous foraminifera, found only at Site 323, occurs below this unit. The fauna occurs in sediments from Paleogene to Late Cretaceous age. This section of brown claystone contains a 5-meter thick layer of well-preserved calcareous sediments. It is of early Paleocene age (Danian) from the *Globigerina edita* Zone and it falls in the nannoplankton *Cruciplacolithus tenuis* to *Chiasmolithus danicus* zones.

The oldest sediments recovered from Site 323 were deposited during the Late Cretaceous in a fairly shallow environment. Some calcareous nannoplankton were preserved, however, the calcareous foraminifera were dissolved indicating that deposition was near the carbonate compensation depth (CCD). The Danian foraminiferal fauna indicates a depositional depth of upper to middle bathyal, at about 2000 meters. The level of the CCD must have changed considerably at this time. Another fluctuation in the CCD occurred at the end of the Danian as is represented by a zone without carbonate deposition.

A hiatus probably exists between the Paleocene and ?Oligocene-early Miocene sediments. More recent arenaceous assemblages indicate lower bathyal to abyssal conditions. The sea floor of the abyssal plain has subsided to a depth of about 3000-4000 meters, and the continental rise at Site 325 to about 2000-3000 meters. Even arenaceous benthonic foraminifera are missing from sediments younger than early Miocene, and deposition consisted almost exclusively of siliceous fossils.

INTRODUCTION

Leg 35 was the third DSDP cruise into Antarctic waters. Four sites were drilled in the Southeast Pacific Basin (Bellingshausen Abyssal Plain and Bellingshausen Sea) between 60° and 69°S (Figure 1). Sites 322 and 323 were located on the abyssal plain at water depths of about 5000 meters, whereas Sites 324 and 325 were drilled on the continental rise at depths of 4449 and 3745 meters, respectively.

A large part of the section was cored from sediments deposited below the CCD. Consequently, calcareous fossils were extremely rare which unfortunately hindered investigations of foraminifera. Only a few meters of lower Paleocene (Danian) calcareous sediments were recovered at Site 323. Low species diversity, characteristic of high polar latitudes, also contributed to the scarcity of foraminiferal faunas. The cores recovered indicate that a well-developed arenaceous foraminiferal fauna was present throughout the Bellingshausen region from Late Cretaceous to the early Miocene time. Benthonic foraminifera are absent in overlying sediments and no planktonic foraminifera were observed in the middle and late Miocene. Consequently, siliceous fossil groups provided the most information for the biostratigraphy of Leg 35.

The figured specimens are deposited at the Museum of Natural History, Basel, under the numbers C 30854-31030.

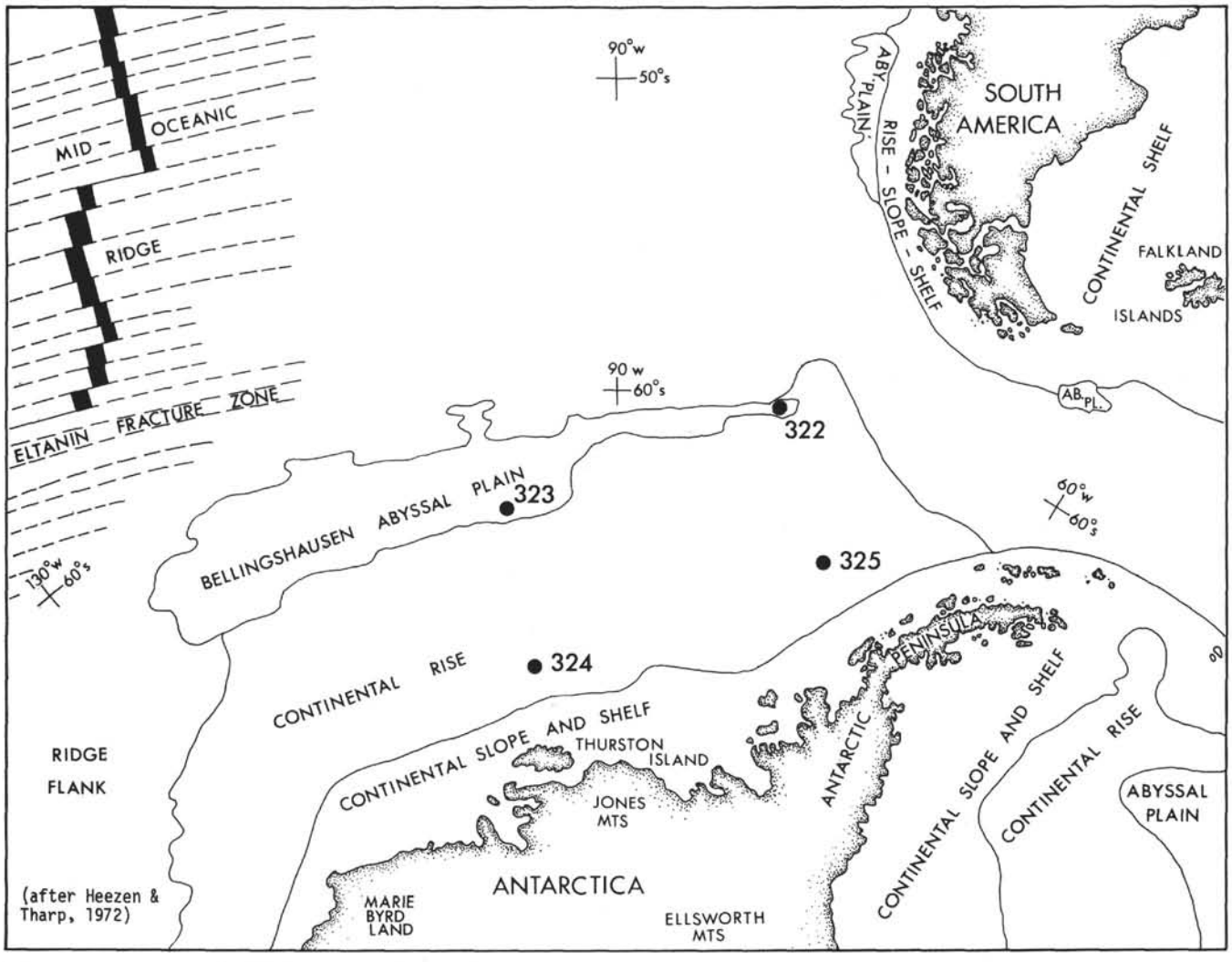

Figure 1. *Location of drill sites of DSDP Leg 35.*

SITE 322

Site 322, located in the eastern part of the Bellingshausen Abyssal Plain (60°1.45′S; 79°25.49′W), was drilled in a water depth of 5026 meters. Drilling penetrated 514 meters of sediments and 30 meters of igneous rocks. Coarse terrigenous material, which was nearly barren of foraminifera, dominated the sediments. Cores 322-6 to 322-9 (437-475 m subbottom) yielded a few specimens of agglutinated and calcareous foraminifera (*Rhabdammina*, *Reophax*, *Siphonodosaria*, *Nonion*, *Bulimina*, *Cassidulina*) which were probably reworked and polished by transporting agents. The upper 495 meters was Pliocene and Miocene as determined by means of diatoms and radiolarians. The section between 495 and 509 meters was barren of all fossils.

Below these intervals a 5.5-meter unit (322-11-4 to 11-6) of dark gray and brown claystone overlies the basaltic basement. In this claystone a few arenaceous foraminifera are found together with fish teeth and manganese micronodules. The foraminifera are badly preserved and semidissolved, and because they were easily destroyed during sample preparations, species could only be recognized in unwashed sampled. Within this sparse fauna, the more frequently occurring forms are *Rhabdammina*, *Rhizammina*, *Reophax*, and *Glomospira*, along with the stratigraphically important forms, *Haplophragmoides carinatus*, *Cyclammina* cf. *grangei*, *C. incisa*, *C.* cf. *japonica*, and *C.* cf. *rotundata*. The stratigraphic position of this interval with its fauna of arenaceous foraminifera is somewhat uncertain. The only markers are the species of *Haplophragmoides* and *Cyclammina* which range mainly from Oligocene to early Miocene. By comparison with Site 325, an age assignment to the early Miocene is probable; an extension to the Oligocene questionable.

SITE 323

Site 323 was situated in the central part of the Bellingshausen Abyssal Plain (63°40.84′S; 97°59.69′W) in a water depth of 4993 meters; 701 meters of sediment and 30 meters of basalt were penetrated. Diatomaceous clay and silty claystone were encountered down to 640 meters subbottom. Sediments from Pliocene to early Miocene age (based on siliceous microfossils) comprised the uppermost 500 meters. The section between 500 and 550 meters was barren of fossils, except for a few fragments of arenaceous foraminifera in Sample 323-10, CC. A sparse fauna of arenaceous foraminifera was

found down to 640 meters in the silty claystone. The assemblage is similar to that from Site 322 (lowermost sedimentary unit) and to that from Site 325 (lower part, beginning in Core 7). For this reason Cores 323-10 to 323-13 are dated by comparison as ?Oligocene to early Miocene. In Core 323-14 a lithologic change occurs within Section 2. Below 640 meters the sediments are brown Fe-claystone. This change is also evidenced in the residue of washed samples where the fine detrital quartz, characteristic of the silty clay, is missing and small manganese nodules are present. Arenaceous foraminifera are rare; fish teeth are more common. Although Core 323-14 is nearly barren, the fauna of Core 323-15 (upper part) is similar to the arenaceous assemblage in the Danian and Late Cretaceous below. *Rzehakina* spp., *Bolivinopsis spectabilis*, and fragments of *Reophax* and *Paratrochamminoides* are characteristic of the fauna. Consequently, all of Core 15 is probably Danian. The Fe-claystone unit between Core 323-14, Section 2 and 323-15, Section 5 is about 24 meters thick. Either this unit includes all of the younger Paleocene, Eocene, and most of the Oligocene, or it contains an unconformity and hiatus in sedimentation.

The only samples with well-developed calcareous sediments are found between 662.3 and 667.2 meters (323-15-5, 127-129 cm to 323-16-2, 119-121 cm). The fauna is moderately well preserved and consists mostly of planktonic foraminifera and calcisphaerulids. Calcareous benthonic foraminifera are common; the arenaceous benthonics are of less importance. Fish teeth are common as was true in the intervals without carbonate. Manganese nodules are absent in the upper part of this unit, but occur again in Core 16. Individuals of the fauna are greatly reduced in size. This is true not only of the planktonic foraminifera but also for most of the calcareous benthonics. Important species for stratigraphic determinations are the planktonic species *Globigerina edita*, *G. fringa*, *G. triloculinoides*, and *Globoconusa daubjergensis*. This assemblage is characteristic of the early Paleocene *Globigerina edita* Zone (Hillebrandt, 1965; Olsson, 1970a, b). The *G. edita* Zone corresponds to the lower part of the *Globoconusa daubjergensis-G. pseudobulloides* Zone (P1 a-b) of Berggren (1969). In the Trinidad zonation of Bolli (1966) it includes the *G. eugubina* and *G. pseudobulloides* zones. The underlying interval, between 667 meters and basement at 701 meters subbottom, consists of brown claystone with a limited number of calcareous nannofossils, arenaceous foraminifera and, in the lower part, radiolarians. Manganese nodules are absent below Core 323-16, Section 4. *Rzehakina epigona* div. spp., *Hormosina ovulum*, *Paratrochamminoides* cf. *irregularis*, *Glomospira* spp., *Kalamopsis grzybowskii*, and *Nodellum velascoense* characterize the arenaceous foraminiferal fauna. These species range from Late Cretaceous to Paleogene and although they do not provide a more restricted age assignment, the age is in agreement with a Cretaceous age, based on the radiolarians, and the more delimited Maestrichtian age based on calcareous nannoplankton.

SITE 324

The southernmost site of Leg 35 was drilled on the Antarctic continental rise (69°3.21'S; 98°47.20'W) at a water depth of 4449 meters. The site was abandoned after drilling through 218 meters of Pleistocene and Pliocene clays and silts. A sparse population of planktonic foraminifera consisting of left-coiling *Neogloboquadrina pachyderma* and a few specimens of *Globigerina quinqueloba* was recovered. This assemblage is typical of high latitudes.

SITE 325

Site 325 was drilled on the Antarctic continental rise in the southeastern corner of the Bellingshausen Sea (65°2.79'S; 73°40.40'W) at a water depth of 3745 meters. Clay, silt, sandstone, and conglomerate were penetrated to a depth of 718 meters subbottom. In the Pleistocene to late Pliocene sediments of Core 325-1, left-coiling *Neogloboquadrina pachyderma* is common. Most of the Pliocene and late Miocene sediments are barren of foraminifera. Beginning with Core 7 (520 m subbottom) a rich fauna of predominantly primitive arenaceous foraminifera is present. In the middle to early Miocene part of the section, thin interbedded layers of nannofossil chalk contain a few badly preserved globigerinids.

Within the terrigenous sediments a few calcareous benthonic species also occur together with the arenaceous fauna. Such species as *Laticarinina pauperata*, *Pyrgo murrhina*, *Lenticulina* spp., and *Gyroidina* sp. are typical of deeper water environments. The arenaceous genera are dominated by primitive forms such as *Rhabdammina*, *Rhizammina*, *Reophax*, and *Saccammina*. An interesting occurrence of *Bolboforma* was noted in one interval (325-8-2, 133-135 cm). *Bolboforma* is a small lagena-like organism of uncertain affinities which is stratigraphically limited to the Oligocene and Miocene. This interval seems to correlate with the early Miocene from northern Germany. Consequently, this unusual fossil group is treated in a special paper (Rögl and Hochuli, this volume).

A second useful marker (*Globorotalia zealandica incognita*) was also found in one sample (325-10-1, 94-96 cm). This species occurs in the early Awamoan stage in New Zealand (Walters, 1965) and ranges from the *G. woodi connecta* to the early *G. trilobus trilobus* zones after Jenkins (1973). Berggren and Amdurer (1973) give the range of the species as late N6 to early N7 zones. Hence, sediments recovered from the lower part of the hole at Site 325 fall within the early Miocene.

PLANKTONIC FORAMINIFERA

Pliocene-Pleistocene

The upper cores from Sites 324 and 325 contain a nearly monospecific fauna of planktonic foraminifera. The assemblage reflects conditions similar to those of the present-day Southern Ocean. At Site 324 only Cores 5 to 8 yielded *Neogloboquadrina pachyderma* (Ehrenberg) which is left coiling and shows a development typical of the Antarctic variety (Kennett, 1970). In one sample (324-6, CC) a few specimens of *Globigerina quinqueloba* Natland were also found. The same fauna was observed in Core 1 of Site 325. No significant differences exist between these Pliocene-Pleistocene specimens and the Recent forms.

Early Miocene

A few Miocene planktonic foraminifera were identified from Site 325. Below Core 325-1, which contained the Pliocene-Pleistocene fauna, Cores 325-2 to 325-6 were barren of foraminifera. A well-developed arenaceous fauna, a few calcareous benthonic, and a few planktonic foraminifera are present in and below Core 325-7. A badly preserved *Globigerina* sp. was found in Samples 325-7-2, 56-58 cm and 325-8-2, 133-135 cm. It has three and a half chambers and is perhaps related to *Globigerina globularis* Roemer.

Globorotalia zealandica incognita Walters was observed in Sample 325-10-1, 94-96 cm (Plate 2, Figures 14-17). This species is described from the lower part of the Awamoan stage of New Zealand and ranges from the late *G. woodi connecta* to the early *G. trilobus trilobus* zones, after Jenkins (1973). The evolutionary lineage of *Globorotalia zealandica* extends from late N6 to early N7 zones of Blow, after Berggren and Amdurer (1973). This early Miocene age is supported by the occurrence of a few specimens of the *Globorotalia peripheroronda* group in the same sample and within Core 325-8. The equivalent European stage name is Burdigalian.

Early Paleocene (Danian)

A 5-meter thick calcareous layer in Cores 15 and 16 from Site 323 contains a fairly good planktonic foraminiferal fauna. The individuals were very small, similar to the forms from the *Globigerina eugubina* Zone in the lowermost Paleocene. Most specimens are between 80 to 150 μm in diameter, whereas *Globigerina triloculinoides* s.s. is commonly 200-250 μm and ranges to 350 μm.

The following species were observed (see Plates 1 and 2): *Globigerina edita* Subbotina, *G. fringa* Subbotina, *G.* cf. *fringa* (high spired), *G. triloculinoides triloculinoides* Plummer, *G.* cf. *triloculinoides nana* Khalilov, *Globoconusa daubjergensis* (Brönnimann), *Globorotalia* cf. *inconstans* (Subbotina), *Chiloguembelina crinita* (Glaessner), *C. gradata* (Khalilov), *C.* cf. *midwayensis strombiformis* Beckmann, *C.* cf. *subtriangularis* Beckmann. Distribution of the species is shown in Figure 2.

This fauna cannot be compared with the standard zonation of Bolli (1966) or Berggren (1969) because the typical zonal markers were not found at Site 323. The only useful species in the present material is *Globigerina edita*. It is used by Hillebrandt (1965) for the definition of his *Globigerina edita* Zone in the Paleogene of Zumaya, Spain. This zone was later used as the basal Paleocene zone in the Hornerstown formation of New Jersey by Olsson (1970a, b). It is defined by the range of *Globigerina edita* and is equivalent to the *Globigerina eugubina* and *G. pseudobulloides-G. daubjergensis* zones of Luterbacher and Premoli-Silva (1964).

BENTHONIC FORAMINIFERA

Two major benthonic foraminiferal assemblages are recognized in the Leg 35 sediments. A Neogene assemblage, which is best developed at Site 325, consists predominantly of arenaceous species accompanied by a few calcareous forms. A second assemblage comprises a Paleogene to Late Cretaceous arenaceous fauna

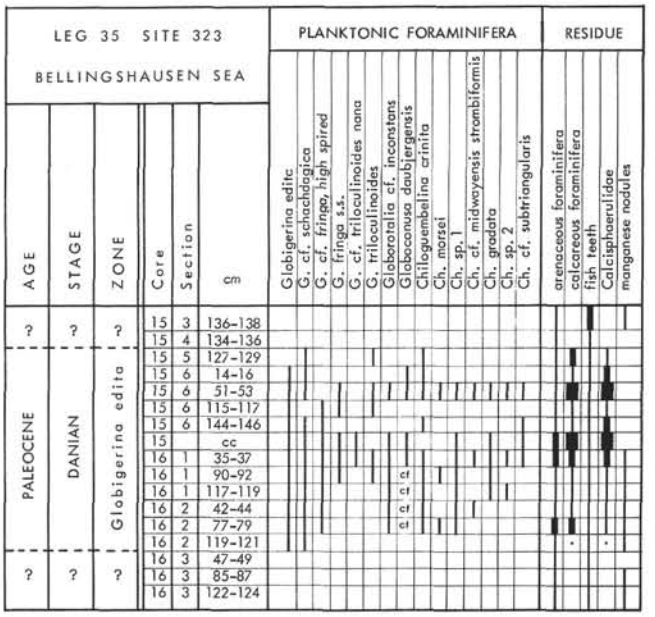

Figure 2. *Distribution of planktonic foraminiferal species, Site 323.*

supplemented by Danian calcareous species. This fauna occurs only at Site 323. Scattered, reworked benthonic foraminifera occur commonly in the younger sediments from middle Miocene to Pleistocene.

?Oligocene to Early Miocene

At Site 325, Cores 7 to 10 contain a diversified fauna of arenaceous benthonic foraminifera with a few scattered individuals of calcareous species. The more primitive species were dominant. The age of this fauna, as determined by the planktonic foraminifera, is the later part of the early Miocene (N6 to N7). Examples of the arenaceous species are partially documented in Plates 3 and 4. The following species were identified: *Ammobaculites agglutinans* (d'Orbigny), *Ammodiscus peruvianus* Berry, *Ammoflintia argentea* Echols, *Ammolagena clavata* (Jones and Parker), *Bathysiphon filiformis* Brady, *B. nodosariaformis* Subbotina, *Cribrostomoides arenaceus* (Heron-Allen and Earland), *C. crassimargo* (Norman), *C. subglobosus* (Sars), *Cyclammina incisa* (Stache), *C. japonica Asano, C.* cf. *rotundata* Chapman and Crespin, *Dorothia minima* (Karrer), *Eggerella bradyi* (Cushman), *E. propinqua* (Brady), *Glomospira charoides* (Jones and Parker), *G. gordialis* (Jones and Parker), *Haplophragmoides carinatus* Cushman and Renz, *H. bradyi* (Robertson), *H. indentatus* Voloshinova, *H. quadratus* Earland, *H.* cf. *scitulum* (Brady), *Hormosina glabra* Cushman and Stainforth, *H. globulifera* Brady, *H. ovulum* (Grzybowski), *Hyperammina friabilis* Brady, *Jaculella acuta* Brady, *Karreriella siphonella* (Reuss), *Martinotiella communis* (d'Orbigny), *Nodellum velascoense* (Cushman), *Psammosphaera fusca* Schulze, *Pseudobolivina antarctica* Wiesner, *Recurvoides contortus* (Earland), *R. turbinatus* (Brady), *Reophax distans* Brady, *R.* cf. *guttifer* Brady, *R. nodulosus* Brady, *R. pilulifer* Brady, *R. sabulosus* Brady, *R. trinitatensis* (Cushman and Renz), ?*Reophax difflugi-*

formis (Brady), *Rhabdammina abyssorum* Sars, *R. linearis* Brady, *Rhizammina algaeformis* Brady, *Saccammina* cf. *complanata* (Franke), *S. placenta* (Grzybowski), *Tolypammina vagans* (Brady), ?*Tolypammina frigida* (Cushman), *Trochammina compacta* Parker, *T. globigeriniformis* (Parker and Jones), *T. squammata* Jones and Parker, *Trochamminoides proteus* (Karrer).

Calcareous benthonic foraminifera include: *Astrononion pusillum* Hornibrook, *Bulimina pupoides* d'Orbigny, *Cassidulina subglobosa* Brady, *Cibicidoides pseudoungerianus* (Cushman), *Dentalina havanensis* Cushman and Renz, *D.* spp., *Eponides umbonatus* (Reuss), *Fissurina orbignyana* Seguenza, *F. submarginata* (Boomgart), *Gyroidina girardana* (Reuss), *G. planulata* Cushman and Renz, *Heterolepa* cf. *mexicana* (Nuttall), *Lagena clavata* d'Orbigny, *L. laevis* (Montagu), *Laticarinina pauperata* (Parker and Jones), *Lenticulina convergens* (Bornemann), *L. gibba* (d'Orbigny), *L. loculosa* (Stache), *Melonis* sp., *Nonion depressulum* (Walker and Jacobs), *Nonionella* sp., *Pleurostomella alternans* Schwager, *Pullenia bulloides* d'Orbigny, *Pyrgo murrhina* (Schwager), *Quinqueloculina collumnosa* Cushman, *Qu.* spp., *Stilostomella elongata* (Cushman and Jarvis).

At Site 322 the lowermost sedimentary unit of dark gray and brown, carbonate free, deep-sea claystone yielded poorly preserved arenaceous foraminifera which are comparable to the fauna of Site 325. This interval may be as old as Oligocene, inasmuch as the stratigraphically important species of *Cyclammina* range from Oligocene to Miocene. No additional control was provided by other fossil groups. The following species were observed, some only on the surface of unwashed samples: *Ammodiscus catinus* Hoglund, *Bathysiphon* sp., *Cyclammina* cf. *grangei* Finlay, *C. incisa* (Stache), *C. japonica* Asano, *Glomospira charoides* (Jones and Parker), *G. gordialis* (Jones and Parker), *G. irregularis* (Grzybowski), *Haplophragmoides carinatus* Cushman and Renz, *Hormosina* cf. *ovula* (Grzybowski), *Reophax* spp., *Rhabdammina* sp., *Rhizammina* sp., *Saccammina placenta* (Grzybowski).

Cores 10 to 13 at Site 323 also contain a similar fauna of arenaceous foraminifera which occurs in a carbonate-free, gray to greenish-gray and brown claystone. Fossil preservation is as poor as at Site 322. Therefore, only a small number of species could be determined including: *Bathysiphon* spp., *Cribrostomoides subglobosus* (Sars), *Cyclammina* cf. *japonica* Asano, *Glomospira irregularis* (Grzybowski), *Haplophragmoides carinatus* Cushman and Renz, *Hyperammina* sp., *Karreriella siphonella* (Reuss), *Reophax* sp., *Recurvoides contortus* (Earland), *R. turbinatus* (Brady), *Rhabdammina abyssorum* Sars, *Rhizammina algaeformis* Brady, *Trochammina squammata* Jones and Parker.

The age assignment of ?Oligocene to early Miocene is also based on the presence of *Cyclammina* and *Haplophragmoides.*

A comparison of the different faunal assemblages shows a remarkable similarity in species composition. Because of their more restricted range, the species of *Cyclammina* and *Haplophragmoides* provide the most useful data for stratigraphic interpretation. Only one specimen, *Cyclammina* cf. *grangei*, was found at Site 322 and consequently no precise age assignment can be made. The species, however, is described from the New Zealand Eocene. *Cyclammina incisa* is also described from the Tertiary of New Zealand and according to Hornibrook (1961) ranges from late Eocene to early Miocene. According to Crespin (1950) it is widespread in the Australian Oligocene to early Miocene. The most common species in all the Leg 35 sites was *Cyclammina japonica*, which is described from the Miocene of Japan and ranges from Oligocene to Miocene in the Pacific region according to Petracca (1972). *Haplophragmoides carinatus* has the same range in the Caribbean area.

An early Miocene age (N6/7) for these arenaceous assemblages could only be determined with certainty from Site 325 material. However, because the difference in faunal diversity is related to state of preservation and stratigraphically useful species are common to all sites, this age assignment should be the same throughout the investigated area. The stratigraphic position of the lower boundary of this fauna remains unknown as it was not penetrated at Site 325. For this reason the age of the questionable parts at Sites 322 and 323 is given as ?Oligocene to early Miocene.

Paleogene to Late Cretaceous

At Site 323 Late Cretaceous sediments overlie basement. Below the ?Oligocene to early Miocene fauna described above a change in lithology is present within Core 323-14 which is probably related to a hiatus in sedimentation. Within Core 323-14 no identifiable specimens were found, but in Core 323-15 the species are the same as the Danian to Late Cretaceous forms found in the unit below.

Iron-rich, yellowish-brown claystone occurs below 75 cm in Core 14, Section 2. These sediments yield arenaceous foraminifera as follows: *Bolivinopsis spectabilis* (Grzybowski), *Paratrochamminoides* cf. *irregularis* (White), *Reophax* sp., *Rhabdammina* sp., *Rzehakina* cf. *epigona inclusa* (Grzybowski), *Rzehakina* sp., *Saccammina complanata* (Franke).

The underlying interval contains a well-developed arenaceous and calcareous foraminiferal fauna. The sediments are early Paleocene (Danian) based on nannofossils and planktonic foraminifera. The fauna consists of a large number of species, many of which are comprised of dwarfed specimens; this is especially true of the calcareous forms. The diameter of most specimens is between 120 μm and 150 μm with only a few exhibiting "normal" dimensions of several hundred microns.

The Danian arenaceous species are as follows: *Ammodiscus cretaceus* (Reuss), *A. peruvianus* Berry, *Bolivinopsis spectabilis* (Grzybowski), *Dorothia* cf. *retusa* Cushman and Renz, *D. oxycona* (Reuss), *Glomospira charoides* (Jones and Parker), *G. irregularis* (Grzybowski), ?*Glomospirella* sp., *Hyperammina* sp., *Kalamopsis grzybowskii* (Dylaz), *Nodellum velascoense* (Cushman), *Paratochamminoides* cf. *irregularis* (White), *Reophax splendidus* Grzybowski, *Rhabdammina* sp., *Rhizammina* sp., *Rzehakina epigona epigona* (Rzehak), *R. epigona inclusa* (Grzybowski), *Saccammina complanata* (Franke), *Spiroplectammina dentata* (Alth), *S. israelskyi* Hillebrandt, *Tritaxia* cf. *jarvisi* Cushman.

Danian calcareous benthonic species are: *Alabamina* sp., *Aragonia ouezzanensis* (Rey), *Bulimina* cf. *kugleri* Cushman and Renz, *B.* cf. *prolixa* Cushman and Parker,

B. stokesi Cushman and Renz, *Charltonina florialis* (White), *Chrysalgonium* spp., *Dentalina* spp., *Ellipsodimorphina subcompacta* Liebus, *Ellipsoidina* sp., *Eponides bollii* Cushman and Renz, *Eponides* spp., *Fissurina* spp., *Glandulina* sp., *Globulina gibba* d'Orbigny, *Gyroidina octocamerata* Cushman and Hanna, *Gyroidinoides* sp., *Lagena* spp., *Lenticulina* spp., *Loxostomoides alabamensis* (Cushman), *Marginulina* sp., *Nodosaria* spp., *Nonion durhami* Mallory, *N. planatum* Cushman and Thomas, *Nonion* sp., *Nonionella robusta* Plummer, *Nuttallides* sp., *Osangularia* sp., *Pleurostomella* spp., *Stilostomella* sp., ?*Turrilina* sp.

Arenaceous foraminifera were again dominant below this carbonate-bearing unit to basement. The uppermost part of the unit is Danian; the lower part, Cores 323-17 and 323-18, is Maestrichtian, based on calcareous nannoplankton. The arenaceous fauna does not change appreciably compared with the Danian fauna, except that more highly evolved genera such as *Spiroplectammina*, *Dorothia*, and *Tritaxia* are not present. The distribution of arenaceous foraminifera at Site 323 is shown in Figure 3. A Late Cretaceous to Paleogene age is the most concise age determination which can be made based on the arenaceous foraminifera

To resolve the question of age of the upper part (Cores 323-14 and 323-15), an attempt was made to calculate an accumulation rate. The age of the basement is late Cretaceous—Maestrichtian or slightly older—or about 70-72 m.y.B.P. Thirty-two meters of claystone found between the Danian sediments and basement were accumulated in about 5.5 to 7.5 m.y. The accumulation rate is therefore 0.4 to 0.6 cm/1000 yr. The unit between the dated Danian and the beginning of coarser terrigenous sediments is 23.6 meters thick. If the accumulation was continuous between Paleocene and ?Oligocene-early Miocene, the accumulation rate decreases to <0.1 cm/1000 yr. If there is a hiatus between Paleocene sediments and the change in accumulation rate, then the rate was about 0.3 cm/1000 yr. The latter value seems more reasonable compared with the rates in the intervals below for which there are better data. For this reason it seems more likely that there is a gap in sedimentation between Paleocene and ?Oligocene-early Miocene. The lithologic change within Core 323-14 probably coincides with the lower boundary of the ?Oligocene-early Miocene arenaceous fauna.

ECOLOGICAL INTERPRETATION

The development of the faunas of the Bellingshausen region can be traced best in material from Site 323. Good biostratigraphic control is provided in the Late Cretaceous to Pliocene sections recovered at this site. The Late Cretaceous sedimentation begins at a depth at which only arenaceous benthonic foraminifera are found together with a rich radiolarian assemblage. However, the presence of calcareous nannoplankton indicates that deposition took place slightly above the carbonate compensation depth (CCD). In the upper part of Core 323-17 and the lower part of Core 323-16 the calcareous nannofossils are also absent. They are present, however, below the first occurrence of calcareous foraminifera in the Danian sediments. The Danian section, with the earliest and latest part missing, has a highly diversified fauna of calcareous and arenaceous foraminifera. The plankton/benthos ratio is always higher than 2:1. Such a fauna, with numerous species, is characteristic of water depths from the upper to middle bathyal zone perhaps at about 2000 meters.

In the latest Danian the carbonate was again dissolved and consequently the upper part of Core 323-15 and Core 323-14 yielded only arenaceous foraminifera and a few fish teeth. The age of this unit is uncertain, but it probably is some time within the Paleocene.

A change in lithology, documented by silt-size detrital quartz in the washed residue, occurs within the upper part of Core 323-14. The fauna also changes in its species composition. The new assemblage is comparable to that found in the ?Oligocene to early Miocene in the lowermost part of the hole at Site 322. Site 322 is also located on the abyssal plain. Both sites can be correlated to the lower part of the section at Site 325 based on the arenaceous fauna, which in turn was dated as early Miocene by means of the planktonic foraminifera.

The development of the fauna in the Bellingshausen area is best explained by a fluctuating CCD. The level of calcium carbonate solution must have been fairly shallow during Maestrichtian time. Within the Danian a sharp drop in the CCD allowed preservation of the calcareous foraminifera. The specimens show no evidence of dissolution. The drop in the CCD is in contrast to the otherwise recorded worldwide rise in the CCD during the Danian (Worsley, 1974). The fauna, with more than 50% planktonic specimens and a dominance of calcareous benthonic genera (*Nuttallides*, *Nonion*, *Pullenia*, *Gyroidina*, *Gyroidinoides*, *Eponides*, and small Lagenidae), is interpreted as having been deposited in an upper to middle bathyal environment of about 2000 meters.

The termination of calcareous deposition, as with its onset, is abrupt and suggests yet another fluctuation of the CCD. However, a deepening of the basin is not clearly recognized in the faunal development at this time.

A sharp change in the composition of the arenaceous assemblage occurs in Core 323-13. The new fauna was apparently distributed throughout the Bellingshausen region and is best developed and preserved on the continental slope at Site 325. The time this new faunal type appeared could not be determined with certainty, but the fauna could extend down into the Oligocene (see discussion above). The age of the similar fauna at Site 325 is early Miocene. The fauna occurs in a deep-sea clay at Site 322, in a silty claystone at Site 323, and in a silty claystone to sandstone at Site 325. The populations are typical for the abyssal region. The predominant types are the more primitive genera such as *Rhabdammina*, *Rhizammina* and *Reophax*, accompanied by *Cribrostomoides*, *Recurvoides*, and *Cyclammina*. A sparse fauna of calcareous deep water benthonics occurs at Site 325. *Pyrgo murrhina*, *Quinqueloculina* spp., *Laticarinina pauperata*, and *Lenticulina* spp. are the more common forms. The fauna at Site 325 (continental rise) corresponds to a middle to lower bathyal environment (Bandy and Echols, 1964; Herb, 1971) and indicates a water depth of between 2000 and 3000 meters in the early Miocene. The ocean floor in the Bellingshausen Abyssal

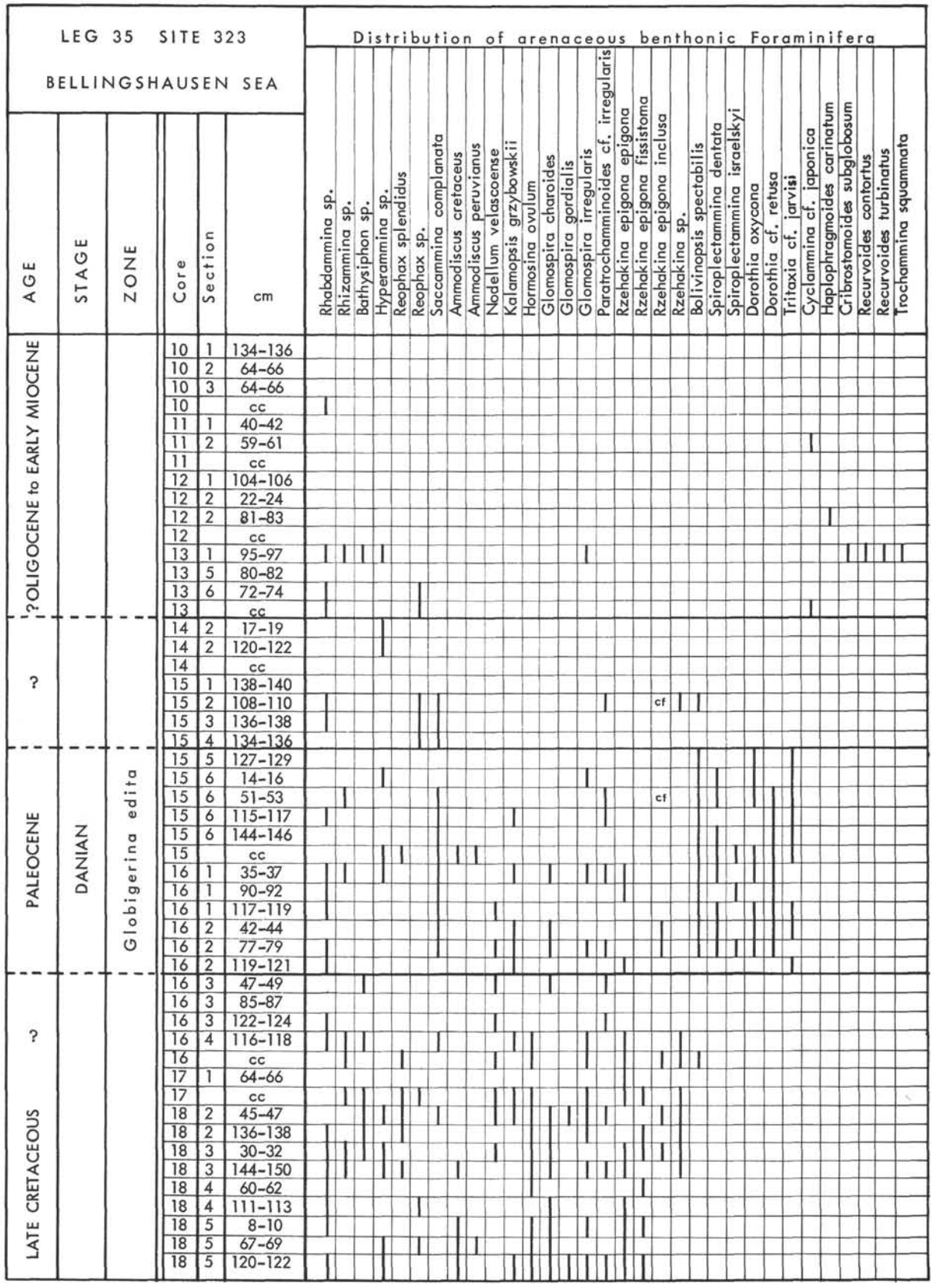

Figure 3. *Distribution of arenaceous benthonic foraminifera, Site 323.*

Plain was at about 3000 to 4000 meters at the same time. The depth zonation is in agreement with an expected depth of the basement using diagrams from Berger and Winterer (1974).

Beginning with the middle to late Miocene benthonic foraminiferal populations disappeared from the deeper part of the Bellingshausen Sea and only a few, probably displaced specimens, were found in the younger samples of Leg 35. Only siliceous fossils are common. The reason for the lack of benthonic foraminifera is not clear, but is perhaps related to Antarctic glaciation.

ACKNOWLEDGMENTS

The author wishes to express his gratitude to the Deep Sea Drilling Project for the opportunity to participate on Leg 35 and to the Swiss National Science Foundation, which supported the work. The laboratory facilities of the Geology Department, Swiss Federal Institute of Technology, Zurich, were used. I wish to thank the shipboard paleontologists B.U. Haq, H.J. Schrader, and F.M. Weaver for interesting discussions, and Ms. I. Premoli-Silva (Milano), J.P. Beckmann, and H.M. Bolli (Zurich) for solving some special problems related to the foraminiferal faunas. H.P. Funk and K. Kelts helped with discussions of sedimentary problems, and to K. Kelts I am also obliged for his reading of the manuscript. H.E. Franz and U. Gerber (Geol. Dept., Zurich) kindly prepared SEM micrographs and photoprints.

REFERENCES

Bandy, O.L. and Echols, R.J., 1964. Antarctic foraminiferal zonation: Antarctic Res. Ser., v. 1, p. 73-91.

Berger, W.H. and Winterer, E.L., 1974. Plate stratigraphy and the fluctuating carbonate line: Spec. Publ. Int. Assoc. Sediment., v. 1, p. 11-48.

Berggren, W.A., 1969. Cenozoic chrono-stratigraphy, planktonic foraminiferal zonation and the radiometric time scale: Nature, v. 224, p. 1072-1075.

Berggren, W.A. and Amdurer, M., 1973. Late Paleogene (Oligocene) and Neogene planktonic foraminiferal biostratigraphy of the Atlantic Ocean (Lat. 30°N to Lat. 30°S): Riv. Ital. Paleontol., v. 79, p. 337-392.

Bolli, H.M., 1966. Zonation of Cretaceous to Pliocene marine sediments based on planktonic foraminifera: Bol. Inform. Asoc. Venez. Geol. Min. Petrol., v. 9, p. 3-32.

Crespin, I., 1950. Some Tertiary foraminifera from Victoria, Australia: Contrib. Cushman Found. Foram. Res., v. 1, p. 70-75.

Herb, R., 1971. Distribution of Recent benthonic foraminifera in the Drake Passage: Antarctic Res. Ser., v. 17, p. 251-300.

Hillebrandt, A.v., 1965. Foraminiferen-Stratigraphie im Alttertiär von Zumaya (Provinz Guipuzcoa, NW-Spanien) und ein Vergleich mit anderen Tethys-Gebieten: Abh. Bayer. Akad. Wiss., math. naturwiss. Kl., N. F., v. 123, p. 1-62.

Hornibrook, N. de B., 1961. Tertiary foraminifera from Oamaru District (N.Z.). Part 1—Systematics and distribution: Paleontol. Bull. New Zealand Geol. Surv., v. 34, p. 1-192.

Jenkins, D.G., 1973. Should the Altonian of Scott (1972) be rejected or subdivided: New Zealand J. Geol. Geophys., v. 16, p. 311-318.

Kennett, J.P., 1970. Comparison of Globigerina pachyderma (Ehrenberg) in Arctic and Antarctic areas: Contrib. Cushman Found. Foram. Res., v. 21, p. 47-49.

Luterbacher, H.P. and Premoli Silva, I., 1964. Biostratigrafia del limite Cretaceo-Terziario nell'Appennino Centrale: Riv. Ital. Paleontol., v. 70, p. 67-128.

Olsson, R.K., 1970a. Paleocene planktonic foraminiferal biostratigraphy and paleozoography of New Jersey: J. Paleontol., v. 44, p. 589-597.

———, 1970b. Planktonic foraminifera from base of Tertiary, Millers Ferry, Alabama: J. Paleontol., v. 44, p. 598-604.

Petracca, A.N., 1972. Tertiary microfauna, Mackenzie delta area, arctic Canada: Micropaleontology, v. 18, p. 355-368.

Walters, R., 1965. The Globorotalia zealandica and G. miozea lineages: New Zealand J. Geol. Geophys., v. 8, p. 109-127.

Worsley, T., 1974. The Cretaceous-Tertiary boundary event in the Ocean. *In* Hay, W.W. (Ed.), Studies in Paleo-Oceanography, Spec. Publ. Soc. Econ. Paleontol. Min., v. 20, p. 94-125.

ADDITIONAL SELECTED REFERENCES

Asano, K., 1950. Some Lituolidae from the Tertiary of Japan: Contrib. Cushman Found. Foram. Res., v. 1, p. 75-79.

Beckmann, J.P., 1957. Chiloguembelina Loeblich and Tappan and related foraminifera from the Lower Tertiary of Trinidad, B.W.I.: U.S. Nat. Mus. Bull., v. 215, p. 83-95.

Beckmann, J.P. and Koch, W., 1964. Vergleiche von Bolivinoides, Aragonia und Tappanina (Foraminifera) aus Trinidad (Westindien) und Mitteleuropa: Geol. Jb., v. 83, p. 31-64.

Bertels, A., 1970. Los foraminiferos planctonicos de la cuenca Cretacico-Terciaria en Patagonia septentrional (Argentina), con consideraciones sobre la estratigrafia de Fortin General Roca (Provincia de Rio Negro): Ameghiniana, v. 7, p. 1-56.

Douglas, R.G., 1973. Benthonic foraminiferal biostratigraphy in the Central North Pacific, Leg 17, Deep Sea Drilling Project. *In* Winterer, E.L., Ewing, J.I., et al., Initial Report of the Deep Sea Drilling Project, Volume 17: Washington (U.S. Government Printing Office), p. 607-671.

Echols, R., 1971. Distribution of foraminifera in sediments of the Scotia Sea area, Antarctic waters: Antarctic Res. Ser., v. 15, p. 93-168.

Hillebrandt, A.v., 1962. Das Paleozän und seine Foraminiferen-fauna im Becken von Reichenhall und Salzburg: Abh. Bayer. Akad. Wiss., math. naturwiss. Kl., N. F., v. 108, p. 1-182.

Hiltermann, H., 1974. Rzehakina epigona und Unterarten dieser Foraminifere: Paläont. Z., v. 48, p. 36-56.

Hornibrook, N. de B., 1971. A revision of the Oligocene and Miocene foraminifera from New Zealand described by Karrer and Stache in the reports of the "Novara" Expedition (1864): Paleontol. Bull. New Zealand Geol. Surv., v. 43, p. 1-85.

Khalilov, D.M., 1967. Mikrofauna i stratigraphija paleogenovikh otlozhenij Aserbajdzhana: Akad. Nauk. Aserbajd. SSR, Inst. Geol., p. 1-286.

Olsson, R.K., 1969. Danian planktonic foraminifera from the Cannonball formation in North Dakota: J. Paleontol., v. 43, p. 1397-1404.

Premoli Silva, I., in press. The earliest Tertiary Globigerina eugubina zone: paleontological significance and geographical distribution: Contr. Woods Hole Oceanogr. Inst., no. 3227.

Renz, H.H., 1948. Stratigraphy and fauna of the Agua Salada Group, State of Falcon, Venezuela: Geol. Soc. Am. Mem., v. 32, p. 1-219.

Scott, G.H., 1961. Contribution to the knowledge of Rzehakina Cushman (Foraminifera) in New Zealand: New Zealand J. Geol. Geophys., v. 4, p. 3-43.

Webb, P.N., 1975. Paleocene foraminifera from DSDP Site 283, South Tasman Basin. *In* Kennett, J.P., Houtz, R.E., et al., Initial Reports of the Deep Sea Drilling Project, Volume 29: Washington (U.S. Government Printing Office), p. 833-843.

PLATE 1

Paleocene (Danian) planktonic foraminifera: *G. edita* Zone.

Figures 1, 2 *Globoconusa daubjergensis* (Brönnimann). Sample 323-16-1, 35-37 cm, ×298.

Figures 3-6 *Globigerina edita* Subbotina.
3. Sample 323-16-1, 35-37 cm, ×238.
4, 5. Sample 323-16-2, 77-79 cm, ×298.
6. Sample 323-16-1, 35-37 cm, ×298.

Figures 7-9 *Globigerina fringa* Subbotina. Sample 323-16-1, 35-37 cm, ×298.

Figures 10-12 *Globigerina* cf. *fringa*, high-spired. Sample 323-16-2, 77-79 cm, ×298.

Figures 13-14 *Globigerina* cf. *schachdagica* Khalilov. Sample 323-16-2, 77-79 cm, ×298.

Figures 15-16 *Globorotalia* cf. *inconstans* (Subbotina).
15. Sample 323-16-2, 77-79 cm, ×238.
16. Sample 323-16-1, 35-37 cm, ×298.

Figures 17-18 *Globigerina* cf. *triloculinoides nana* Khalilov. Sample 323-16-1, 35-37 cm, ×298.

Figures 19-23 *Globigerina triloculinoides triloculinoides* Plummer. Sample 323-15-6, 51-53 cm.
19, 20, 22. ×298.
21, 23. ×268.

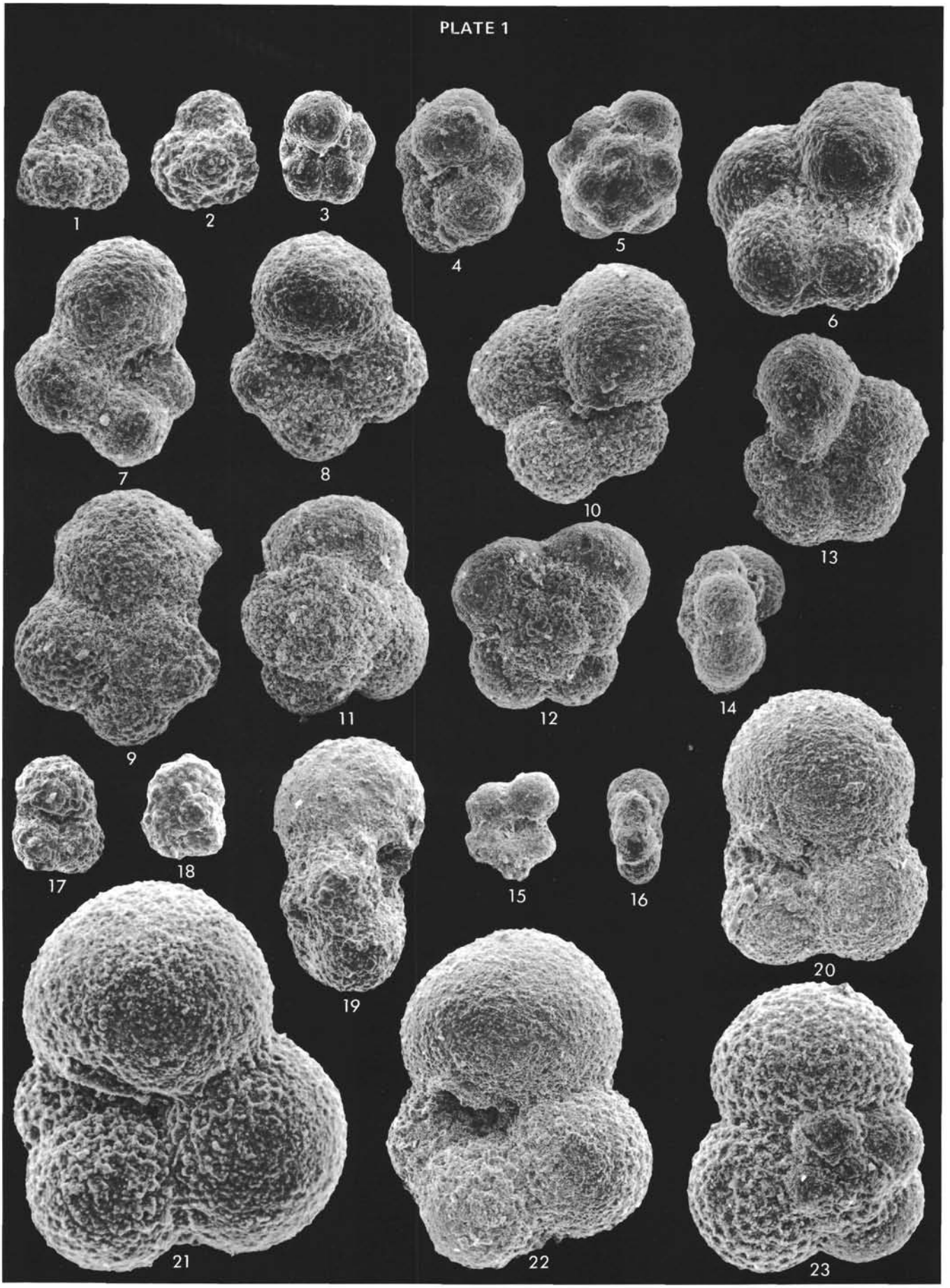
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PLATE 2

Figures 1-13: Paleocene (Danian) planktonic foraminifera *G. edita* Zone; Figures 14-17: Early Miocene planktonic foraminifera (Zones N6-N7); Figures 18-28: Late Cretaceous to early Paleocene arenaceous foraminifera.

Figures 1-5 — *Chiloguembelina crinita* (Glaessner).
1-4. Sample 323-16-2, 77-79 cm, ×298.
5. Sample 323-15-6, 51-53 cm, ×238.

Figures 6-8 — *Chiloguembelina* sp. 2. Sample 323-15-6, 51-53 cm, ×238.

Figure 9 — *Chiloguembelina* cf. *midwayensis strombiformis* Beckmann. Sample 323-15-6, 51-53 cm, ×238.

Figure 10 — *Chiloguembelina morsei* (Kline). Sample 323-15-6, 51-53 cm, ×238.

Figure 11 — *Chiloguembelina* sp. 1. Sample 323-15-6, 51-53 cm, ×238.

Figure 12 — *Chiloguembelina gradata* (Khalilov). Sample 323-15-6, 51-53 cm, ×238.

Figure 13 — *Chiloguembelina* cf. *subtriangularis* Beckmann. Sample 323-15-6, 51-53 cm, ×238.

Figures 14-17 — *Globorotalia zealandica incognita* Walters. Sample 325-10-1, 94-96 cm, ×119.

Figure 18 — *Rhabdammina* sp. Sample 323-18-2, 45-47 cm, ×60.

Figure 19 — *Bathysiphon* sp. Sample 323-18-2, 45-47 cm, ×60.

Figure 20 — *Hyperammina* sp. Sample 323-18-3, 144-150 cm, ×60.

Figure 21 — *Glomospira irregularis* (Grzybowski). Sample 323-18-5, 67-69 cm, ×60.

Figure 22 — *Ammodiscus cretaceus* (Reuss). Sample 323-18-5, 67-69 cm, ×47.

Figure 23 — *Ammodiscus peruvianus* Berry. Sample 323-18-5, 67-69 cm, ×47.

Figures 24, 25 — *Hormosina ovulum* (Grzybowski).
24. Sample 323-18-5, 67-69 cm, ×60.
25. Sample 323-18-2, 45-47 cm, ×60.

Figures 26, 27 — *Glomospira charoides* (Jones and Parker). Sample 323-18-4, 111-113 cm, ×60.

Figure 28 — *Glomospira gordialis* (Jones and Parker). Sample 323-18-2, 45-47 cm, ×60.

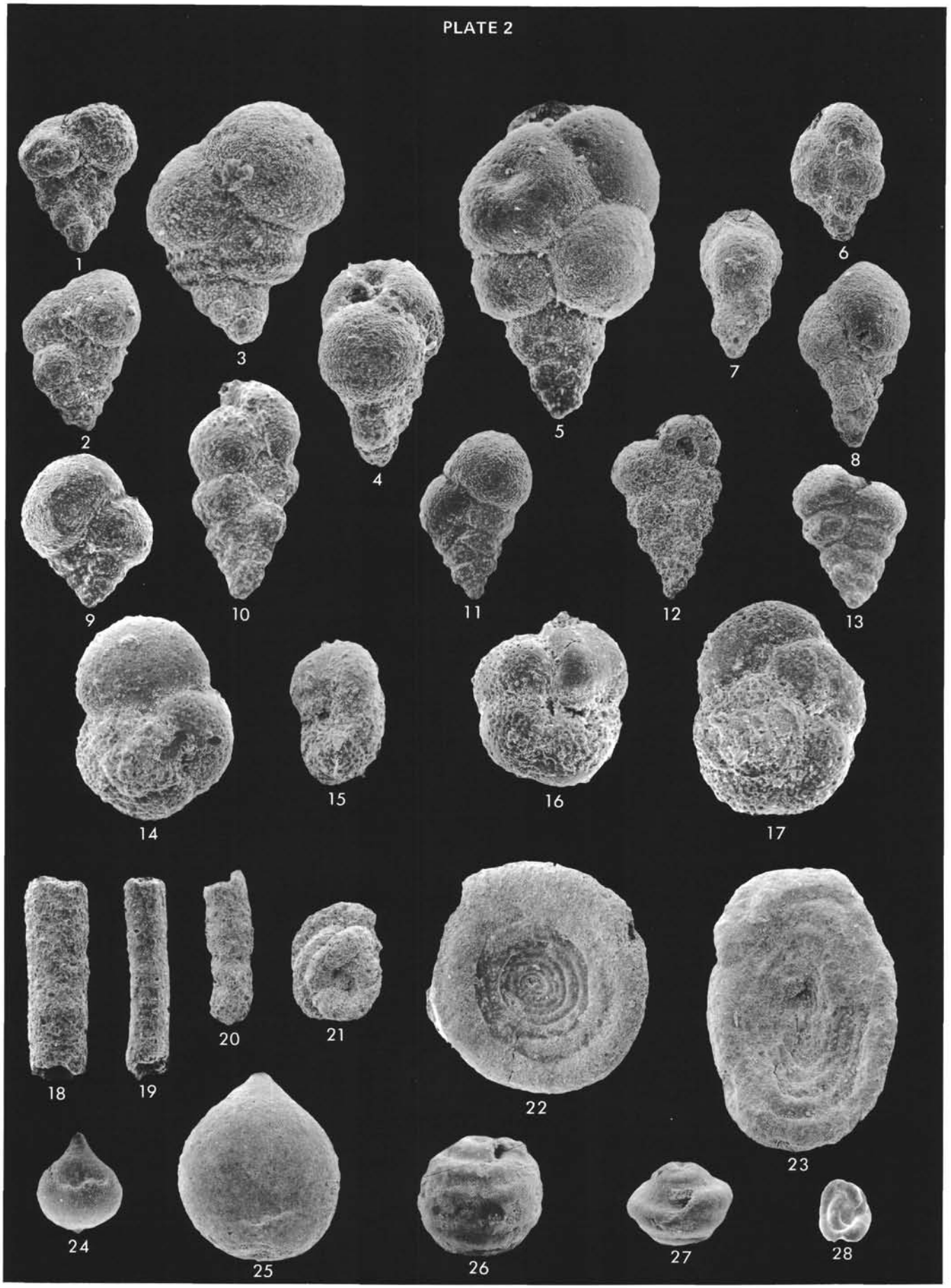
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PLATE 3

Figures 1-6: Late Cretaceous to early Paleocene arenaceous foraminifera; Figures 7-25: Paleocene (Danian) arenaceous foraminifera (*G. edita* Zone); Figures 26-40: Early Miocene arenaceous foraminifera (Zones N6-N7).

Figures 1, 2	*Paratrochamminoides* cf. *irregularis* (White). 1. Sample 323-18-4, 130-132 cm, ×60. 2. Sample 323-18-5, 67-69 cm, ×60.
Figure 3	*Rzehakina epigona fissistoma* (Grzybowski). Sample 323-18-5, 120-122 cm, ×60.
Figure 4	*Rzehakina epigona inclusa* (Grzybowski). Sample 323-18-3, 144-150 cm, ×60.
Figure 5	*Rzehakina epigona epigona* (Rzehak). Sample 323-18-2, 45-47 cm, ×60.
Figure 6	*Rzehakina* sp. Sample 323-18-2, 45-47 cm, ×60.
Figures 7, 8	*Saccammina complanata* (Franke). 7. Sample 323-16-1, 35-37 cm, ×60. 8. Sample 323-16-2, 77-79 cm, ×60.
Figures 9, 10	*Nodellum velascoense* (Cushman). Sample 323-16-2, 77-79 cm, ×60.
Figure 11	*Rzehakina epigona epigona* (Rzehak). Sample 323-16-1, 90-92 cm, ×60.
Figure 12	*Glomospira irregularis* (Grzybowski). Sample 323-16-1, 35-37 cm, ×60.
Figures 13, 14	*Paratrochamminoides* sp. Sample 323-15, CC, ×60.
Figures 15-17	*Dorothia* cf. *retusa* Cushman and Renz. Sample 323-15, CC, ×60.
Figure 18	*Dorothia oxycona* (Reuss). Sample 323-15, CC, ×60.
Figures 19, 20	*Tritaxia* cf. *jarvisi* Cushman. Sample 323-15, CC. 19. ×60. 20. ×54.
Figure 21	*Spiroplectammina dentata* (Alth). Sample 323-16-1, 35-37 cm, ×60.
Figure 22	*Spiroplectammina israelskyi* Hillebrandt. Sample 323-16-2, 77-79 cm, ×60.
Figures 23-25	*Bolivinopsis spectabilis* (Grzybowski). Sample 323-15, CC. 23, 25. ×54. 24. ×60.
Figure 26	*Bolivinopsis* sp. Sample 325-10-1, 94-96 cm, ×30.
Figure 27	*Psammosphaera fusca* Schulze, with *Ammolagena*. Sample 325-9-3, 141-143 cm, ×30.
Figure 28	*Saccammina* cf. *complanata* (Franke). Sample 325-9-3, 141-143 cm, ×60.
Figure 29	*Hormosina globulifera* Brady. Sample 325-7, CC, ×30.
Figure 30	*Rhabdammina abyssorum* Sars, with *Trochammina squammata* (see Plate 4, Figure 31). Sample 325-8-2, 11-13 cm, ×18.
Figure 31	*Rhabdammina abyssorum* Sars. Sample 325-9-3, 141-143 cm, ×18.
Figure 32	*Rhabdammina linearis* Brady. Sample 325-9-3, 58-60 cm, ×18.
Figure 33	*Bathysiphon nodosariaformis* Subbotina. Sample 325-8-2, 11-13 cm, ×18.
Figure 34	*Jaculella acuta* Brady. Sample 325-9-2, 50-52 cm, ×18.
Figure 35	*Tolypammina frigida* (Cushman). Sample 325-9-2, 50-52 cm, ×24.
Figure 36	*Hormosina ovulum* (Grzybowski). Sample 325-8-3, 139-141 cm, ×30.
Figure 37	*Nodellum velascoense* (Cushman). Sample 325-9-3, 141-143 cm, ×30.
Figures 38, 39	*Glomospira gordialis* (Jones and Parker). Sample 325-8, CC, ×60.
Figure 40	*Glomospira charoides* (Jones and Parker). Sample 325-10, CC, ×60.

PLATE 3

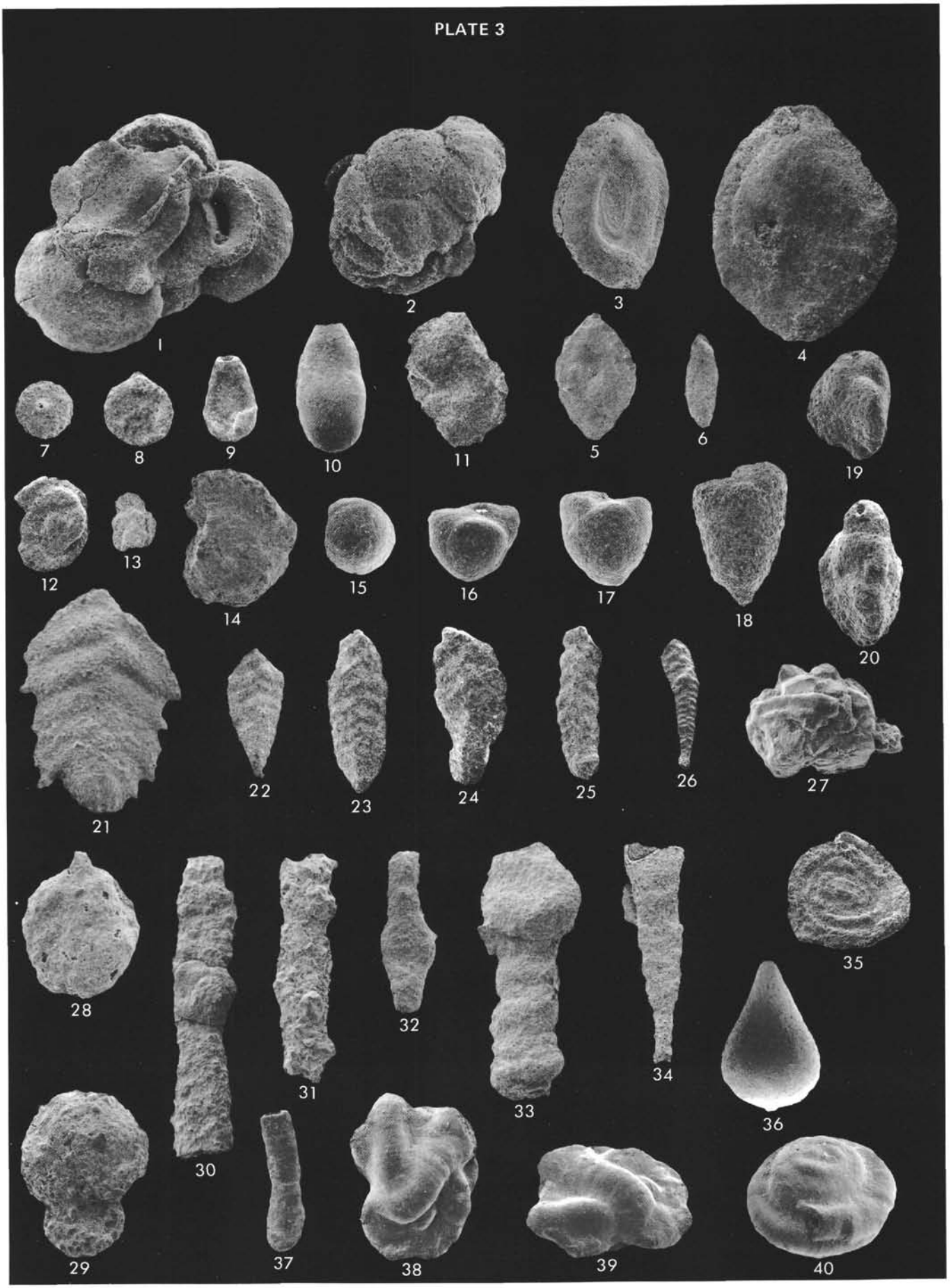
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PLATE 4

Early Miocene arenaceous foraminifera (Zones N6-N7).

Figure 1 — *Hyperammina friabilis* Brady. Sample 325-10-1, 94-96 cm, ×30.

Figure 2 — *?Reophax difflugiformis* (Brady). Sample 325-9-2, 50-52 cm, ×60.

Figure 3 — *Reophax* cf. *guttifer* Brady. Sample 325-8-2, 11-13 cm, ×30.

Figure 4 — *Hormosina glabra* Cushman and Stainforth. Sample 325-9-3, 141-143 cm, ×30.

Figure 5 — *Reophax distans* Brady. Sample 325-10-1, 94-96 cm, ×30.

Figure 6 — *Reophax nodulosus* Brady. Sample 325-9-2, 50-52 cm, ×30.

Figure 7 — *Reophax pilulifer* Brady. Sample 325-9-2, 50-52 cm, ×24.

Figure 8 — *Reophax trinitatensis* (Cushman and Renz). Sample 325-8-2, 133-135 cm, ×27.

Figure 9 — *Reophax sabulosus* Brady. Sample 325-9-3, 58-60 cm, ×27.

Figure 10 — *Psammosphaera fusca* (?), with *Tolypammina vagans* (see Plate 4, Figure 33). Sample 325-9-3, 141-143 cm, ×9.

Figure 11 — *Karreriella siphonella* (Reuss). Sample 325-9-2, 141-143 cm, ×30.

Figure 12 — *Pseudobolivina antarctica* Wiesner. Sample 325-9-3, 58-60 cm, ×30.

Figure 13 — *Martinotiella communis* (d'Orbigny). Sample 325-9-3, 141-143 cm, ×30.

Figure 14 — *Eggerella propinqua* (Brady). Sample 325-7, CC, ×60.

Figure 15 — *Eggerella bradyi* (Cushman). Sample 325-8-2, 133-135 cm, ×60.

Figure 16 — *Trochamminoides proteus* (Karrer). Sample 325-9-3, 141-143 cm, ×60.

Figure 17 — *Haplophragmoides carinatus* Cushman and Renz. Sample 325-9-3, 58-60 cm, ×30.

Figures 18, 19 — *Haplophragmoides indentatus* Voloshinova.
18. Sample 325-7, CC, ×24.
19. Sample 325-9-3, 141-143 cm, ×30.

Figure 20 — *Cribrostomoides crassimargo* (Norman). Sample 325-9-3, 141-143 cm, ×30.

Figure 21 — *Cribrostomoides subglobosus* (Sars). Sample 325-10-1, 94-96 cm, ×30.

Figure 22 — *Haplophragmoides* cf. *scitulum* (Brady). Sample 325-9-2, 50-52 cm, ×24.

Figures 23, 24 — *Recurvoides turbinatus* (Brady).
23. Sample 325-7-2, 6-8 cm, ×60.
24. Sample 325-7-2, 116-118 cm, ×60.

Figures 25, 26 — *Cribrostomoides arenaceus* (Heron-Allen and Earland). Sample 325-9-3, 141-143 cm, ×60.

Figures 27-29 — *Cyclammina japonica* Asano.
27. Sample 325-9-2, 50-52 cm, ×30.
28. Sample 325-8-2, 11-13 cm, ×27.
29. Sample 325-7, CC, ×30.

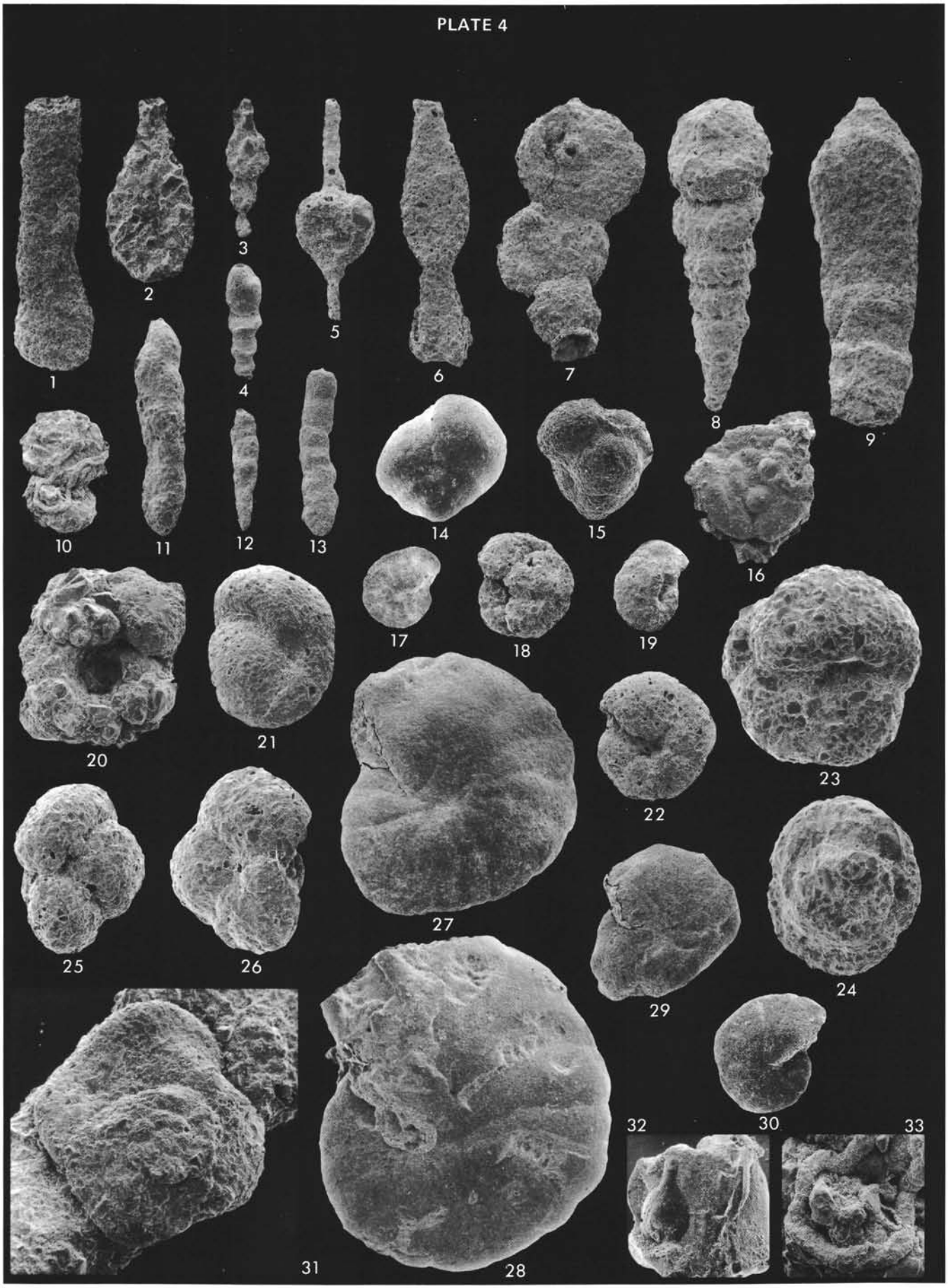
Figure 30 — *Cyclammina incisa* (Stache). Sample 325-10-3, 52-54 cm, ×30.

Figure 31 — *Trochammina squammata* Jones and Parker (see Plate 3, Figure 30). Sample 325-8-2, 11-13 cm, ×60.

Figure 32 — *Ammolagena clavata* (Jones and Parker). Sample 325-9-3, 141-143 cm, ×30.

Figure 33 — *Tolypammina vagans* (Brady) (see Plate 4, Figure 10). Sample 325-9-3, 141-143 cm, ×30.

PLATE 4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