7. CENOZOIC PLANKTONIC FORAMINIFERS, EQUATORIAL PACIFIC OCEAN, LEG 33, DSDP

Ansis G. Kaneps, Scripps Institution of Oceanography, La Jolla, California

INTRODUCTION

This chapter presents a preliminary summary of the Cenozoic planktonic foraminifers recovered in the equatorial Pacific Ocean during Leg 33 of the Deep Sea Drilling Project. Leg 33 was designed chiefly as a test of the "hot spot" hypothesis as it applies to the Line Islands and Tuamotus and involved drilling through thick sequences of calcareous ooze that cover the flanks of these volcanic chains. Owing to their topographic setting, these sequences are characterized by more-or-less contemporaneous redeposition of sediment from shallower areas, as well as stratigraphic hiatuses indicative of occasional sediment instability or current erosion. Drilling of an additional site aimed at coring the thick sedimentary cap of the Manihiki Plateau. This site was the prime biostratigraphic site for Leg 33 since, by analogy with other previously drilled sites on basement highs in the Pacific, it was expected to include a stratigraphic record within highly calcareous pelagic sediments not affected by synsedimentary dissolution of calcium carbonate. This site was largely a success except that technical malfunctions prematurely terminated operations, leaving an uncored gap between the lower Eocene and Maestrichtian.

In general, all Cenozoic sediments recovered during Leg 33 are highly calcareous; however, the average preservation of foraminifers can only be characterized as moderately good. The observed degree of preservation reflects varying amounts of carbonate dissolution on the sea floor and, in the deeper parts of the holes, the kinds of diagenetic dissolution, overgrowth, and eventual destruction of foraminifer tests described by Schlanger and Douglas (1974) that result from the reorganization of calcitic components under pressure of burial by a dissolution-diffusion-precipitation mechanism. Fortunately, only the middle Eocene and older sediments at Sites 316 and 318 have been so seriously affected by this process as to make zonal assignment doubtful; in the remaining sequences biostratigraphic information is relatively intact.

The location of Leg 33 sites is shown in Figure 1 and site data are given in Table 1. The present paper is based mainly on examination of core-catcher samples; additional intermediate samples were examined in intervals where the faunal distributions did not match those predicted by existing zonal schemes.

ZONATION

The foraminifer zonation employed during Leg 33 is in essence that of Bolli as it has been modified and amended since its initial publication in 1957. In addition, the letter-number designations for these zones proposed by Banner and Blow (1965) and Blow and Berggren (Berggren, 1972) were used. These are an effective shorthand representation of an often long and cumbersome (and to the nonspecialist, unfamiliar) zonal nomenclature. Onboard the *Challenger*, especially, the N and P zones have been commonly employed by specialist and nonspecialist alike. Part of the reason for this is that the absolute time scale currently in use, that of Berggren (1972, and subsequent modifications), has been closely related to the N-P zones. As a consequence, the N-P zonal sequence has through usage evolved into more of a chronostratigraphic scale than a strictly biostratigraphic one.

In two cases, however, the N-P designations were not used. For the Oligocene, application of Blow's (1969) zonal criteria at Site 317 led to an inversion of Zones P.18/19 and P.20, whereas the zones as defined by Bolli (1966) appeared in their normal order; the latter scheme was used. For the Pleistocene, the extinction level of *Globoquadrina pseudofoliata* was found to be a usable horizon to subdivide this series into two zones, as lower *G. pseudofoliata* Zone and an upper *G. conglomerata* Zone. The boundary between these two zones was shown by Thompson and Saito (1974) to have an age of about 220,000 yr. Zone N.23 of Blow (1969) has never been formally defined, but is simply characterized by an assemblage of forms that typically occurs in the upper Pleistocene of deep-sea sediments, but whose actual stratigraphic ranges are not fully known. Hence, the relationship between the zones used in the present report and Zones N.22 and N.23 of Blow is not known.

Oligocene

Based on the results of Leg 33, it is difficult to reconcile the Oligocene zonation of Blow (1969) with the distribution of foraminifers as seen at Site 317. The ranges of several key species and the resulting sequence of zones as defined by Blow (1969) and Bolli (1957, 1966) are shown in Figure 2. It can be seen that the distribution accords well with the zonal scheme of Bolli, but that applying Blow's criteria results in Zones P.18 and P.19 being largely the equivalent of Zones P.20 and P.21 (*Globigerina ampliapertura* and *Globorotalia opima opima* zones) and Zone P.20 preceding Zones P.18/19. The reason for this is that the *Globoquadrina tapuriensis*/*G. sellii* evolutionary lineage, which is well developed in the Oligocene at Site 317, is seen in what on other grounds would be called upper *Globigerina ampliapertura* Zone and lower *Globorotalia opima* Zone sediments. It should be recalled that according to the zonal scheme of Blow, this bioseries precedes the *G. ampliapertura* and *G. opima* zones and is not contained within them. The marker for Blow's lowest Oligocene zone, *Globerigerina gortanii*, was not seen in Leg 33 sediments; however, the *Cassigerinella chipolen-*

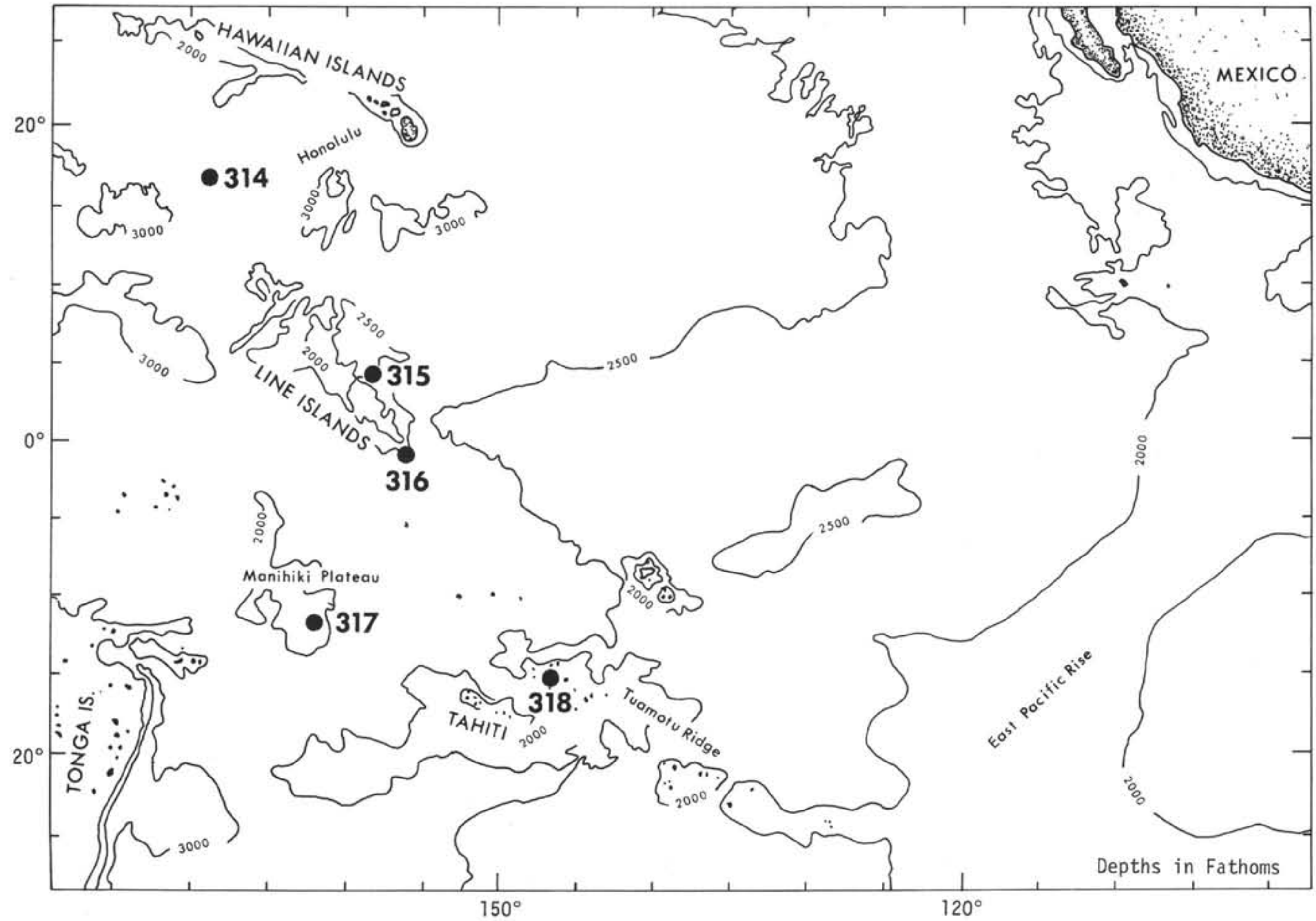

Figure 1. *Location of sites drilled during Leg 33.*

TABLE 1
Site Data

Site	Latitude	Longitude	Water Depth (m)
314	15°54.76′N	168°28.07′W	5214
315	4°10.26′N	158°31.54′W	4152
316	0°05.44′N	157°07.71′W	4451
317	11°00.09′S	162°15.78′W	2598
318	15°59.63′S	146°51.51′W	2641

sis/Pseudohatigerina micra Zone of Bolli, defined by the overlap of these two species, is present in Cores 33 through 35 at Site 317. It succeeds sediments with *Globorotalia cerroazulensis* and *Hantkenina* spines and thus seems to be in depositional continuity with the uppermost Eocene. The sequence of zones for the Oligocene would thus be:

1) *C. chipolensis/P. micra* Zone, defined as above;

2) *G. ampliapertura* Zone, from the last occurrence of *P. micra* to the last occurrence of *G. ampliapertura*;

3) *Globorotalia opima* Zone, from the last occurrence of *G. ampliapertura* to the last occurrence of *G. opima* (the undefined interval between the ranges of these two species observed by Bolli in Trinidad was not seen in Leg 33 materials where the first occurrence of *G. opima* immediately succeeds the last occurrence of *G. ampliapertura*:

4) "*Globigerina ciperoensis*" Zone, defined by the interval between the last *G. opima* and the first *Globorotalia kugleri*. This definition of the interval is necessary because *G. ciperoensis* was not observed in Leg 33 materials; neither was it possible to recognize a *G. angulisuturalis* interval as proposed by Jenkins and Orr (1972). This species is also absent from Leg 33 materials. These species may be absent because of dissolution, or paleoenvironment, or paleobiogeographic reasons.

SITE SUMMARIES

The distribution of Leg 33 cores with respect to the zonation used is shown in Figure 3. Owing to their location in the Pacific central water masses, Leg 33 foraminiferal assemblages are marked by generally low diversity as compared to coeval assemblages from lower latitudes and areas closer to regions of more nutrient-rich waters. Conspicuously absent or in very low numbers are members of the group of species that include such biostratigraphically significant species as *Globorotalia opima*, *G. acostaensis*, *G. humerosa*, and *G. pseudopima*. If the present-day distribution of *G. dutertrei* is indicative of the kind of environmental conditions

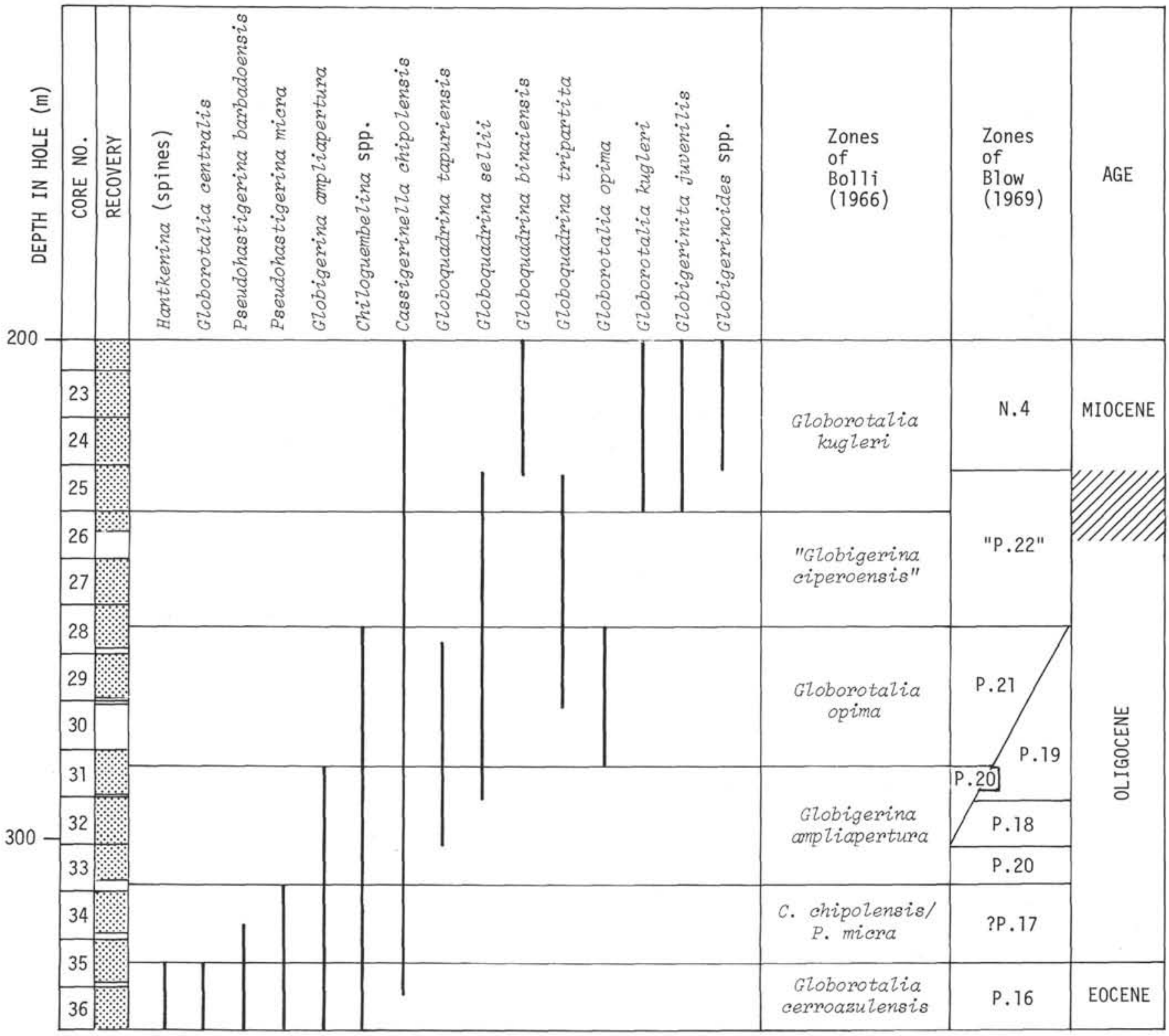

Figure 2. *Distribution of key species of planktonic foraminifers in the Oligocene of Site 317 and the relationship of the zonal schemes of Bolli (1966) and Blow (1969) to this distribution.*

preferred by this plexus, namely, areas of upwelling and high concentrations of nutrients, then the scarcity of these forms in Leg 33 cores is not surprising. Conversely, numerically dominant in Leg 33 assemblages are members of the genus *Globigernoides*, especially *G. trilobus* and related species; this would again be concordant with this species' present-day tolerance for relatively warm and infertile waters of the mid-latitude gyres. In addition to the above, the cosmopolitan species of the *Glorigerinita* group are common in the Leg 33 assemblages, and also appear to be comparatively solution-resistant.

Site 314

Abyssal brown clay and porcellanite were recovered in the three cores taken at this site. The sieved fractions from these cores were barren of foraminifers; however, smear slides made of the clays and thin sections of one of the silicified fragments revealed the presence of small specimens of bolivinid foraminifers (?*Chiloguembelina*) and unidentified throchoform species. A Paleogene age is indicated for Core 3 on this basis.

An additional sample of brown clay was obtained from the outside of the lower drill collar at the termination of the site. The provenance of this sample is not certain, but it probably came from the upper 35-meter interval of total penetration. The presence of a partial test of *Sphaeroidinella dehiscens* (Parker and Jones) indicates that Pliocene or younger materials are present. Also found in this material were additional specimens of ?*Chiloguembelina* sp., suggesting continued reworking of Paleogene material.

AGE		BLOW ZONE	ZONE NAME USED IN PRESENT STUDY	SITE 314	SITE 315 HOLE 315 HOLE 315A	SITE 316	SITE 317 HOLE 317 HOLE 317A HOLE 317B	SITE 318
PLEISTOCENE		NOT RECOGNIZED	*Globoquadrina conglomerata*	BROWN CLAY ON BIT: PLIOCENE-PLEISTOCENE	░	░	1B	CORE 1: MIXED PLIOCENE-PLEISTOCENE
			Globoquadrina preudofoliata		1	1	1, 1B-2B	
PLIOCENE		N21	*Globorotalia limbata*		4	░	2B	2
		N20	*Globoquadrina altispira*		▨	░	3B-5B	3
		N18/19	*Globorotalia tumida*		4	░	5B-7B	4
MIOCENE	UPPER	N17	*Pulleniatina primalis*	░	1A	░	8B	5
		N16	*Globorotalia acostaensis*	░	2A-3A	?2	9B-12B	6
	MIDDLE	N15	*Globorotalia menardii*	░	░	░	12B-14B	▨ 7-9
		N14	*Globorotalia mayeri*	░	░	3	14B	▨
		N13	*Sphaeroidinella subdehiscens*	░	░	▨	15B	▨
		N9-N12	*Globorotalia fohsi s. l.*	░	4A	▨	16B-17B	▨
	LOWER	N8	*Globigerinatella insueta/ Globigerinoides bisphericus*	░	5A	3	18B	▨
		N7	*Globigerinatella insueta/ Globigerinoides trilobus*	░	░		18B-19B	▨
		N6	*Catapsydrax dissimilis*	░	6A	░	20B	▨
		N5	*Globigerinoides trilobus*	░		░	2, 20B-21B	10
		N4	*Globorotalia kugleri*	░	6A-8A	░	22B-25B	10-12
OLIGOCENE	UPPER	NOT RECOGNIZED	*"Globigerina ciperoensis"*	CORE 3: PALEOGENE	░	4	26B-28B	13
			Globorotalia opima		9A		28B-31B	14
	MID.		*Globigerina ampliapertura*		IN CORES 10A-15A FORAMINIFERS ABSENT OR TOO POORLY PRESERVED FOR DETERMINATION		31B-33B	15
	LOWER		*Cassigerinella chipolensis/ Pseudohastigerina micra*			CORES 5-9 BARREN	33B-35B	16
EOCENE	UPPER	P16	*Globorotalia cerroazulensis*				35B-37B	16
		P15	*Globigerapsis mexicana*				3, 37B-38B	17-19
	MIDDLE	P14	*Truncorotaloides rohri*				▨	▨
		P13	*Orbulinoides beckmanni*				▨	▨
		P12	*Globorotalia lehneri*				39B-40B	20
		P11	*Globigerapsis kugleri*				40B-41B	22
		P10	*Hantkenina aragonensis*				1A	25-27
	LOWER	P9	*Acarinina densa*				IN CORES 42B-45B PRESERVATION TOO POOR FOR DETERMINATION	30-32
		P8	*Globorotalia aragonensis*					░
		P7	*Globorotalia formosa*				░	░
UPPER	PALEOCENE	P6	*Globorotalia subbotinae*			10	░	░
		P5	*Globorotalia velascoensis*			11-12	░	░
		P4	*Globorotalia pseudomenardii*		░	13-14	░	░

Figure 3. *Distribution of Leg 33 cores with respect to the zonation used in the present report. Numbers in columns are core numbers. Stippled areas represent stratigraphic intervals not cored; hachured areas represent biostratigraphically established hiatuses.*

Site 315

What appears to be a fairly standard Quaternary to upper Oligocene planktonic foraminiferal sequence was discontinuously cored at Site 315. Foraminifers are frequent to abundant in Cores 1 through 9A, though solution effects of moderate to large degree affect all assemblages, especially in the upper Miocene sections of Cores 2A and 3A. Below Core 9A, the sediments appear to be barren of in situ planktonic foraminifers.

A low-latitude Pleistocene assemblage including rare *Globorotalia truncatulinoides* and common *Globoquadrina pseudofoliata* was recovered in Core 1. Cores 2 and 3 did not contain sufficient sediment for a foraminiferal sample. Core 4 contains a good lower Pliocene assemblage, including well-developed specimens of *Pulleniatina spectabilis.*

Core 1A contains upper Miocene assemblages (Zone N.17) with *Pulleniatina primalis* but no *Globorotalia tumida*. Cores 2A and 3A are also upper Miocene (Zone N.16) and contain rare specimens of *Globorotalia acostaensis*; however, the assemblages are sparse, poorly preserved, and occur in a dominantly radiolarian facies.

Core 4A contains the upper two zones of the *Globorotalia fohsi* series. The base of the core is in the *G. fohsi lobata* zone while Section 1 contains well-developed, large specimens of *G. fohsi robusta*, as well as primitive *Globorotalia menardii*. A fairly high degree of dissolution is indicated in this core by the relatively monotonous fauna dominated by *Globorotalia siakensis*.

The *Globigerinoides bisphericus*/*Globigerinatella insueta* Zone (N.8) was recovered in Core 5A. Both nominate species are rare, and the scarcity of the genus *Globigerinoides* attests to impoverishment of the foraminiferal fauna by dissolution.

A hiatus in Core 6A separates highly corroded assemblages of the upper lower Miocene (with common *Globorotalia peripheroronda*) in Section 1 from *Globorotalia kugleri* Zone (N.4) assemblages in the core-catcher sample. The *G. kugleri* Zone was also found in Cores 7A and 8A.

Core 9A contains a *G. opima* Zone (upper Oligocene) assemblage, but also contains redeposited Upper Cretaceous (*Globotruncana* spp.) and lower middle Eocene (*Globigerina* cf. *G. frontosa*, *G.* cf. *G. soldadoensis*) forms.

Site 316

Foraminifers were recovered from all but five of the cores from the Cenozoic sequence cored at Site 316. Core 5 is in a radiolarian facies and barren of planktonic foraminifers, and Cores 6, 7, and 8 contain dolomitic sediments that were not sampled for foraminifers. The upper part of the sequence (Cores 1-4) comprises lower Oligocene to Quaternary calcareous oozes in which the foraminiferal fauna has generally undergone considerable dissolution. Foraminifers are abundant in the lower part of the sequence (Paleocene-lower Eocene), but preservation is poor owing to diagenetic effects.

Core 1 contains a typically equatorial Pacific Quaternary assemblage dominated by *Globorotalia tumida*, *Pulleniatina obliquiloculata*, *Globoquadrina pseudofoliata*, and *G. dutertrei*. Also present are frequent *Globorotalia truncatulinoides*.

Core 2 is of late Miocene age,belonging either in the *Globorotalia menardii* (N.15) or *G. acostaensis* (N.16) zones. The latter is more likely based on the overall aspect of the fauna. The marker for the zone is absent, but results at Site 315 indicate that it is extremely scarce in its zonal interval and may be missing as a result of dissolution, which is rather pronounced in Core 2. Reworked specimens of lower and middle Miocene species were also noted in the assemblage from Core 2 (*Globorotalia siakensis*, *G. fohsi robusta*, and *G. kugleri*).

The assemblage of Core 3 (upper lower to lowermost middle Miocene) shows a high degree of dissolution and is from a largely radiolarian facies. It consists dominantly of *Globorotalia mayeri* and *Globoquadrina zuelana* with rare specimens of *Globorotalia siakensis* and *Globoroquadrina dehiscens*, and trace specimens of *Sphaeroidinella seminulina* and *Globorotalia peripheroronda*. A firm zonal assignment cannot be made, but the sample probably belongs in the *Globigerinatella insueta* interval of the upper lower Miocene, or possibly in the lowermost middle Miocene.

Core 4 contains a seemingly fairly well preserved, but unusually limited fauna of lower Oligocene age. The fauna is of pre-*opima* and pre-*ciperoensis* age, but if this is true, the absence of *Globigerina ampliapertura* and members of the *G. tripartita-sellii* and *gortanii* groups is puzzling. The fauna consists of abundant to common *Globorotalia* cf. *G. opima*, *Globigerina galavisi*, and *Globigerina angustiumbilicata*, frequent *G. prasaepis* and *Catapsydrax dissimilis*, and rare *G. ouchitaensis*, *G. anguliofficinalis*, and *Cassigerinella chipolensis*.

Core 5 is in a radiolarian facies and is barren of planktonic foraminifers.

Cores 6, 7, and 8 contain dolomitic sediments that were not sampled for foraminifers.

The limestones or hard chalks of the lower part of the Cenozoic section, including Cores 9 through 17, in general contain abundant foraminifers of Paleocene to lower Eocene age, but preservation is extremely poor owing to recrystallization and overgrowth. Also, most foraminifer tests in these cores show extreme deformation as a result of compaction and/or diagenetic effects. Most assemblages are "dwarfed," but this is more likely a result of the disaggregation technique used to obtain specimens from the indurated sediments rather than ecological factors. Nonetheless, identification of some of the more distinctive marker species allowed the placement of these cores in the planktonic zonal sequence.

Core 9 contains an abundance of spiny globorotalliids of lower Eocene aspect. Core 10 contains specimens tentatively identified as *Globorotalia subbotinae* of the lowermost Eocene. Cores 11 and 12 yielded a number of specimens of *Globorotalia velascoensis* of the upper Paleocene *G. velascoensis* Zone. The assemblage of Core 13 was not identifiable; the assemblages of Cores 14 and 15 are similar, though Core 14 contains rare specimens of ?*Globorotalia pseudomenardii* Zone. Core 16 contains abundant foraminifer specimens, but without keeled globorotalliids, indicating placement in the lower Paleocene. The assemblage of Core 17 of lower

Paleocene age (as indicated by nannofossils) includes a considerable admixture of Cretaceous species.

Site 317

Foraminifers are abundant and generally well preserved in the Cenozoic sediments cored at Site 317 and provide an excellent section of continuous deposition of calcareous sediments in middle southern latitudes. The only intervals that are not well represented are the lower middle Eocene (Cores 42B-45B) where recovery was mainly of chert, and portions of the middle Miocene, where poor recovery obliterates the *Globorotalia fohsi* s.l. to *G. Mayeri* s.l. interval (Cores 14B, 15B, and 17B). In addition to the continuously cored Cenozoic interval of Hole 317B, additional Cenozoic samples were obtained in Cores 1 (Pleistocene) and 2 (lower Miocene) of Hole 317. Material in Cores 1 (upper Miocene or lower middle Eocene) and 2 (lower Eocene or Cretaceous) of Hole 317A is not representative of the age of the nominally cored intervals, but probably represents sediment unintentionally recovered from the overlying interval through which the bit was washed.

Foraminifer assemblages have, in general, all been affected by carbonate dissolution, but not seriously. Preservation is excellent in the lower middle and lower upper Eocene, then declines to very poor in the uppermost Eocene. Preservation is slightly better in the lowermost Oligocene, improves in the middle Oligocene, and remains good to the top of the section (with the exception of a slight decline in the upper lower Miocene).

Eocene

The upper Eocene (*Globigerapsis mexicana* and *Globorotalia cerroazulensis* zones) lies disconformably on the middle Eocene (*Globigerapsis kugleri* and *Globorotalia lehneri* zones) with the *Orbulinoides beckmanni* and *Truncorotaloides rohri* zones missing. Preservation becomes increasingly poor towards the Eocene/Oligocene boundary, until what remains in the uppermost Eocene is a dissolution residue of heavy walled forms and common *Hantkenina* spines.

Oligocene

A zonal sequence identical to that proposed by Bolli in 1957 and 1966 is seen in the Oligocene at Site 317. The lowest Oligocene is encompassed by the overlap in the ranges of *Pseudohastigerina micra* and *Cassigerinella chipolensis*. This is followed by a *Globigerina ampliapertura* interval, at the top of which the marker disappears (*G. ampliapertura* is generally very scarce and seems to be seriously affected by solution; only rare, partially fragmented specimens were seen). This is followed by the *Globorotalia opima*, "*Globigerina ciperoensis*," and lower *Globorotalia kugleri* zones.

Miocene-Pliocene

This part of the section is fairly orthodox and follows the Bolli and Blow zonations. The only problem lies in recognizing the upper Miocene *Globorotalia acostaensis* Zone owing to the extreme scarcity of the marker; the lower boundary, as presently drawn, is tentative. The scarcity of *G. acostaensis* is probably due to ecological reasons; the species, along with the related *G. humerosa* and *G. dutertrei*, seem to prefer highly productive areas and would not be expected to be common in the central water mass under which Site 317 is located.

Pleistocene

As previously (Kaneps, 1973), the base of the Pleistocene is drawn at the last occurrence of *Globorotalia limbata*, a horizon which approximates the last occurrence of discoaster. The Pleistocene is tentatively zoned by means of two species of *Globoquadrina*. Most of the lower part of the Pleistocene is characterized by common *G. pseudofoliata*, an interval in which *G. conglomerata* is absent. The latter species appears near the top of Core 1 of Hole 317 and continues to the top. There is a short overlap of the two species; the base of the *G. conglomerata* Zone is drawn at the last occurrence of the *G. pseudofoliata* and is roughly equivalent to the base of the *Gephyrocapsa oceanica* nannofossil zone.

Globigerinoides fistulosus is extremely abundant and well developed in the upper Pliocene and lower Pleistocene of Site 317, as has been previously noted by Kierstead et al. (1969). In addition, the small biserial (probably planktonic) *Streptochilus tokelauae* is common in middle Miocene to upper Pleistocene sediments at Site 317.

Site 318

A discontinuous and condensed, richly foraminiferal sequence spanning middle Eocene through Quaternary was cored at Site 318. Foraminifers are abundant and well preserved in middle Miocene to Quaternary sediments; with a few notable exceptions, they are poorly preserved in the Eocene to lower Miocene. In the upper Eocene through lower Miocene poor preservation is a result of solution, while in the middle Eocene preservation deteriorates downward with increasing lithification (though foraminifers remain common). The faunas throughout are very similar to those in rocks of similar age at Site 317.

Eocene

The upper Eocene *Globorotalia cerroazulensis* and *Globigerapsis mexicana* zones are contained in sediments of Cores 16-19. Preservation shows a pattern similar to that at Site 317 — that is, poor preservation (dissolution) in the uppermost Eocene, with improvement downward into the *G. mexicana* Zone. Also, as at Site 317, the upper Eocene disconformably overlies the middle Eocene *Globorotalia lehneri* Zone.

A remarkably well preserved fauna of the *Globigerapsis mexicana* Zone was found in a bioclastic bed in Sections 1 and 2 of Core 19. The upper portion of this bed contains commonly occurring specimens of, among others, *Hantkenina* cf. *H. alabamensis*, and specimens transitional between *Globorotalia centralis* and *G. cerroazulensis*. Test walls are often glassy and without the chalky surface of specimens from typically abyssal sequences. This, along with the presence of *Asterocyclina* in the coarser parts of the bed, indicates a relatively shallow source for the graded bed. Also, a penecontemporaneous origin is suggested by the lack of elements foreign to a *G. mexicana* Zone assemblage.

The uppermost *G. lehneri* Zone fauna of Core 20 is moderately well preserved, but below this level induration increasingly obliterates the foraminfer assemblages, which are apparently recrystallized, partially infilled, and deformed by compaction. The lowest, questionably identified assemblages are those of Core 25, which probably belong in the *Hantkenina aragonensis* Zone of the lower middle Eocene, and Cores 30 and 32, which probably are of upper lower Eocene age (*Acarinina densa* Zone).

Oligocene

The Oligocene faunas of Cores 13-15 are poorly preserved and apparently only the *Globorotalia opima* and "*Globigerina ciperoensis*" zones are represented. As at Site 317, *Globorotalia opima* is scarce, and *G. ciperoensis* is not present.

Miocene

The upper Miocene (Cores 5 and 6) is probably in depositional continuity with the overlying Pliocene, but a hiatus probably separates the *Globorotalia acostaensis* Zone sediments of Core 6 from the *G. menardii* Zone sediments of Core 7, which in turn probably disconformably overlies middle Miocene sediments of Cores 8 and 9, which contain *G. fohsi* s.l. Another (more pronounced) hiatus separates the latter from lower Miocene, *Globorotalia kugleri* Zone sediments of Cores 10-12 which are in depositional continuity with the underlying upper and middle Oligocene sediments of Cores 13-15.

The upper Miocene faunas are monotonous; *Globigerinoides* groups are dominant and *Globorotalia acostaensis* is very scarce. *G. kugleri* is dominant in its zone, along with common specimens of the early *Globigerinoides* lineage.

Pliocene

Cores 2, 3, and 4 are of Pliocene age and contain a typical Pliocene faunal sequence, including *Pulleniatina spectabilis*. The occurrence of this species at Site 318 is the southernmost yet reported for this areally restricted species.

Quaternary

Core 1 is of Quaternary age and contains a typical low-latitude planktonic fauna, dominated by the *Globigerinoides sacculifer* group. *Streptochilus tokelauae* is common and extends into the underlying Pliocene and upper Miocene sediments.

REFERENCES

Banner, F.T. and Blow, W.H., 1965. Progress in the planktonic foraminiferal biostratigraphy of the Neogene: Nature, v. 208, p. 1164-1166.

Berggren, W.A., 1972. A Cenozoic time scale — some implications for regional geology and paleobiogeography: Lethaia, v. 5, p. 195-215.

Blow, W.H., 1969. Late middle Eocene to Recent planktonic foraminiferal biostratigraphy. *In* Brönnimann, P. and Renz, H.H. (Eds.), Internatl. Conf. Plankt. Microfossils, 1st Proc.: Leiden (E.J. Brill), p. 199-421.

Bolli, H.M., 1957. Planktonic foraminifera from the Oligocene-Miocene Cipero and Lengua formations of Trinidad, B.W.I.: U.S. National Museum, Bull. 215, p. 97-123.

———, 1966. Zonation of Cretaceous to Pliocene marine sediments based on planktonic foraminifera: Assoc. Venezolano Geol., Min. Petrol., Bol. Inform., v. 9, p. 1-26.

Jenkins, D.G. and Orr, W.N., 1972. Planktonic foraminiferal biostratigraphy of the eastern equatorial Pacific — DSDP Leg 9. *In* Hays, J.D., et al., Initial Reports of the Deep Sea Drilling Project, Volume 9: Washington (U.S. Government Printing Office), p. 1059-1193.

Kaneps, A.G., 1973. Cenozoic planktonic foramifera from the Eastern Equatorial Pacific Ocean. *In* van Andel, T.H., Heath, G.R., et al., Initial Reports of the Deep Sea Drilling Project, Volume 16: Washington (U.S. Government Printing Office), p. 713-745.

Kierstead, C.H., Leidy, R.R.D., Fleisher, R.L., and Boersma, A., 1969. Neogene zonation of tropical Pacific cores. *In* Brönnimann, P. and Renz, H.H. (Eds.), Internatl. Conf. Plankt. Microfossils, 1st Proc.: Leiden (E.J. Brill), p. 328-338.

Schlanger, S.O. and Douglas, R.G., 1974. The pelagic ooze-chalk transition and its implications for marine stratigraphy. *In* Hsü, K.J. and Jenkyns, H. (Eds.), Pelagic sediments on land and under the sea: Int. Assoc. Sediment., Spec. Pub. 1, p. 117-148.

Thompson, P.R. and Saito, T., 1974. Pacific Pleistocene sediments: planktonic foraminifera dissolution cycles and geochronology: Geology, v. 2, p. 333-335.