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BIOSTRATIGRAPHIC CORRELATION IN THE AREA OF THE ONTONG JAVA PLATEAU

A THESIS SUBMITTED TO THE GRADUATE DIVISION OF THE UNIVERSITY OF HAWAII IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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By

Varunee Buyannanonth

Thesis Committee:

Johanna M. Resig, Chairman
James Andrews
Ralph M. Moberly

We certify that we have read this thesis and that in our opinion it is satisfactory in scope and quality as a thesis for the degree of Master of Science in Geosciences--Geology.

THESIS COMMITTEE

Johanna M. Resig

Johanna M. Resig, Chairman

James Andrews

James Andrews

Ralph M. Moberly

Ralph M. Moberly

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ABSTRACT

Seven cores from the Ontong Java Plateau and vicinity were studied. Fifteen biozones based upon planktonic foraminifera were recognized; Holocene horizons are suggested. Five benthic foraminiferal assemblages were represented. Most of the cores studied contained one or more hiatuses. Reworking of older sediments into the younger ones was prevalent, and discoasters are found throughout the cores. Severe solution of foraminiferal tests occurred only at the bottom of those cores taken in water depths of approximately 4,000 meters.

INTRODUCTION

Statement of the Problem

The purpose of this study is to correlate the biostratigraphy of Hawaii Institute of Geophysics deep sea cores from the Ontong Java Plateau and vicinity (see Table 1 for location) with the section penetrated during Leg 7 of the Deep Sea Drilling Project (Scientific Staff, 1969), and to derive information pertinent to the interpretation of the structure and history of that area. Foraminiferal, supplemented by radiolarian and nannofossil, studies are used in this investigation.

TABLE 1

LOCATIONS OF HAWAII INSTITUTE OF GEOPHYSICS CORES

Core No.	Core length (cm)	Position	Water Depth (m)
S67-FFC10	81	04°46.9'S, 162°19.5'E	2,535
S67-FFC11	40	05°20.5'S, 161°52.2'E	1,650
S68-PC7	222	06°59.2'S, 159°40.7'E	3,849
S68-PC10	502	06°27.3'S, 158°43.9'E	2,130
S68-PC11	1,174	01°00.9'S, 161°55.8'E	3,991
S68-PC21	788	04°19.3'S, 172°05.5'E	3,931
S68-PC23	729	04°31.0'S, 171°48.6'E	3,538

During the last decade many attempts have been made at the worldwide correlation of deep sea sediments by means of planktonic foraminifera. Banner and Blow's (1965a) and Blow's (1969) Neogene (N.) Zonation (Table 2) has attained wide usage and will be followed in this report. However, some additional data are still needed to confirm the zones that are weakly defined by non-restricted species. Zone N. 23 which is characterized by Sphaeroidinella dehiscens excavata Banner and Blow, and Globigerina calida calida Parker, is an example of one of these weakly defined zones. These two species are not restricted to the above mentioned zone (at least in the area under investigation), thus necessitating a revision of Zone N.23.

Laboratory Procedure

One hundred twenty-nine samples from Hawaii Institute of Geophysics free-fall cores (FFC) Nos. 10 and 11, taken in the year 1967, and piston cores (PC) Nos. 7, 10, 11, 21, and 23 of the year 1968 are used in this study. These cores were sampled at 10 centimeter intervals.

The samples were processed as follows:

1. To obtain clean microfossils, the sample was boiled in hydrogen peroxide and Calgon. This procedure was avoided if possible.

2. The sample was wet-sieved (0.062 mm sieve opening) to separate the sand-size particles (normally foraminifera

TABLE 2

CORRELATION CHART OF MALAITA GROUP, TRINIDAD, AND BLOW'S BIOZONES WITH ONTONG JAVA PLATEAU AND VICINITY

AGE	STAGE	MALAITA GROUP, SOLOMON ISLANDS' McTavish (1966)	TRINIDAD VENEZUELANA H. M. Bolli (1957) and W. H. Blow (1959)	W. H. Blow (1969)	Assemblages represented in cores studied, Ontong Java Plateau and vicinity
PLEISTOCENE - RECENT	CALABRIAN (and younger stages)	Globigerina dutertrei fauna	ABSENT OR REPRESENTED IN NON PLANKTONIC FORAMINIFERAL FACIES	Globigerina calida calida—Sphaeroidinella dehiscens excavata Zone (N. 23)	Hastigerinella (B.) digitata digitata—Hastigerina (B.) adamsi here proposed
				Globorotalia truncatulinoides truncatulinoides Zone (N. 22)	X
PLIOCENE	ZANCLEAN - ASTIAN			Globorotalia tosaensis tenuitheca Zone (N. 21)	X
				Globorotalia (G.) multicamerata—Pulleniatina obliquiloculata obliquiloculata Zone (N. 20)	?
				Sphaeroidinella dehiscens dehiscens—Globoquadrina altispira altispira Zone (N. 19)	X
				Globorotalia (G.) tumida tumida—Sphaeroidinellopsis subdehiscens paenedehiscens Zone (N. 18)	X
LATE MIOCENE	TORTONIAN - MESSINIAN	Sphaeroidinellopsis seminulina fauna	"Globigerina bulloides Zone"	Globorotalia (G.) tumida pleisiotumida Zone (N. 17)	X
			"Sphaeroidinella seminulina Zone"	Globorotalia (T.) acostaensis acostaensis—G. (G.) merotumida Zone (N. 16)	
		Globigerina nepenthes fauna	"Globorotalia menardii/ Globigerina nepenthes Zone"	Globorotalia continuosa Zone (N. 15)	
			Globorotalia mayeri/ Globigerina nepenthes Zone	Globigerina nepenthes/ Globorotalia (T.) siakensis Zone (N. 14)	
MIDDLE MIOCENE	LANGHIAN	not recognized	Globorotalia mayeri/Globorotalia lenguaensis Zone	Sphaeroidinellopsis subdehiscens subdehiscens—Globigerina druryi Zone (N. 13)	ZONE N. 13
			Globorotalia fohsi robusta Zone	Globorotalia (G.) fohsi Zone (N. 12)	ZONE N. 11
			Globorotalia fohsi lobata Zone	Globorotalia (G.) praefohsi Zone (N. 11)	
			Globorotalia fohsi fohsi Zone	Globorotalia (T.) peripheroacuta Zone (N. 10)	
		Globoquadrina altispira fauna	Globorotalia fohsi barisanensis Zone	Orbulina suturalis—Globorotalia (T.) peripheroronda Zone (N. 9)	
EARLY MIOCENE	BURDIGALIAN	Globigerinatella insueta fauna	Globigerinatella insueta Zone	Globigerinoides sicanus—Globigerinatella insueta Zone (N. 8)	ZONE N. 9
				Globigerinatella insueta--Globigerinoides quadrilobatus trilobus Zone (N. 7)	ZONE N. 6
	- AQUITANIAN	Globigerina (Globigerinita) dissimilis fauna	Catapsydrax stainforthi Zone	Globigerinatella insueta/Globigerinita dissimilis Zone (N. 6)	
			Catapsydrax dissimilis Zone	Globoquadrina dehiscens praedehiscens—(G.) dehiscens dehiscens Zone (N. 5)	
		Globorotalia kugleri fauna	Globorotalia kugleri Zone	Globigerinoides quadrilobatus primordius—Globorotalia (T.) kugleri Zone (N. 4)	X
OLIGOCENE	LATTORFIAN - BORMIDIAN	Globigerina ampliapertura/ Globigerina (Globigerinita) martini fauna	Globigerina ciperoensis ciperoensis Zone to Globigerina ampliapertura Zone	Globigerina angulisuturalis Zone (N. 3) to Globigerina gortani gortani/ Globorotalia (T.) centralis Zone (P. 17)	
U. EOCENE	PRIABONIAN	Globigerina ampliapertura/ Globigerina linaperta fauna	Globorotalia cocoaensis Zone	Cribrohantkenina inflata Zone (P. 16)	X
		Globigerina linaperta/ Gyroidina octocamerata fauna	Globigerapsis semiinvoluta Zone	Globigerapsis mexicana Zone (P. 15)	

and Radiolaria) from the fine fraction (nannofossils).

3. Both fractions were dried in an oven of moderate heat (approximately 60°C).

4. The coarse and fine fractions were weighed.

5. The coarse fraction (foraminiferal and radiolarian) was split with a modified Otto microsplitter to obtain approximately 1,000 tests.

6. Species or subspecies were picked for each sample, mounted on faunal slides, and identified.

7. Counts were made of the number of each species or subspecies of foraminifera, the number of Radiolaria, and the number of shell fragments present in particular samples representing faunal assemblages of different ages.

Most of the samples contained a very high percentage of small foraminifera, e.g. Globigerinita glutinata glutinata (Egger) and Turborotalita humilis (Brady). In order to avoid consuming time in counting these small tests, the larger foraminifera were first counted, and the sample was then split until there were approximately 200-300 specimens left, from which the tabulations of small tests were made.

Statistical Analysis

The proportion of foraminifera relative to Radiolaria in the coarse fraction is significant in determining the Pleistocene - Holocene boundary, and serves as a measure of the extent of selective solution of the foraminiferal

population. Both will be discussed later. Relative percentages of foraminifera, Radiolaria, and nannofossils (Table 3) are used in the classification of deep sea pelagic sediments (Olausson, 1960). The percentages of each species of foraminifera in one sample serves as a supplementary criterion in recognizing the age of the sediments. Therefore, the following calculations were utilized.

If

a = No. of foraminifera in coarse fraction

b = No. of Radiolaria in coarse fraction

A = Percentage of foraminifera in coarse fraction

B = Percentage of Radiolaria in coarse fraction

$$A = \left(\frac{a}{a + b}\right) 100 \quad \%$$

$$B = \left(\frac{b}{a + b}\right) 100 \quad \%$$

or

$$= 100 - \left[\left(\frac{a}{a + b}\right)\right] 100 \quad \%$$

Let

Y = Weight of fine fraction

Z = Weight of coarse fraction

S = Actual percentage of foraminifera and Radiolaria (Actual percentage denotes total percentage)

P = Actual percentage of nannofossils

Q = Actual percentage of foraminifera

R = Actual percentage of Radiolaria

TABLE 3

RELATIONSHIPS BETWEEN THE WEIGHT PERCENTAGES OF NANNOFOSSILS, FORAMINIFERA AND RADIOLARIA IN THE CORES STUDIED.

Core No.	Sample Depth (cm)	Weight (gr)		Total Weight (gr)	Percentages		
		Fine	Coarse		Nanno-fossils	Forami-nifera	Radiolaria
S67-FFC10	5	3.36	4.01	7.37	45.00	55.00	-
S67-FFC10	68	3.14	3.06	6.20	50.00	50.00	-
S67-FFC11	8	2.18	3.94	6.12	35.70	64.30	-
S67-FFC11	38	1.99	3.89	5.88	33.80	66.20	-
S68-PC7	15	2.63	0.17	2.80	94.00	2.00	4.00
S68-PC7	200	3.40	0.30	3.70	92.00	3.00	5.00
S68-PC10	69	0.64	0.34	0.98	65.00	35.00	-
S68-PC10	489	2.32	1.03	3.35	69.00	31.00	-
S68-PC11	58	0.36	1.18	1.54	77.00	13.10	9.90
S68-PC11	668	2.06	0.19	2.25	91.50	5.10	3.40
S68-PC11	978	2.74	0.12	2.86	96.00	0.04	3.96
S68-PC21	25	0.83	0.53	1.36	61.10	36.80	2.10
S68-PC21	215	0.50	0.19	0.69	72.00	28.00	-
S68-PC21	475	4.47	2.31	6.78	65.30	30.60	4.10
S68-PC21	565	1.22	0.67	1.89	64.70	28.20	7.10
S68-PC21	705	2.35	0.15	2.50	93.90	0.06	6.04
S68-PC23	12	2.30	1.73	4.03	57.10	40.30	2.60
S68-PC23	22	3.26	2.26	5.86	57.50	41.10	1.40
S68-PC23	32	2.46	2.34	4.80	51.30	47.20	1.50
S68-PC23	382	3.77	0.54	4.31	87.60	9.30	3.10
S68-PC23	472	4.30	0.35	4.65	92.60	4.90	2.50
S68-PC23	482	5.34	0.85	6.19	86.30	10.00	3.70
S68-PC23	550	2.73	0.62	3.35	81.00	16.00	3.00
S68-PC23	660	6.36	1.22	7.58	84.00	0.20	15.80

$$P = \left(\frac{Y}{Y + Z}\right) 100 \quad \%$$

$$S = \left(\frac{Z}{Y + Z}\right) 100 \quad \%$$

or

$$= 100 - \left[\left(\frac{Y}{Y + Z}\right)\right] 100 \quad \%$$

$$Q = \frac{A \times S}{100} \quad \%$$

$$R = \frac{B \times S}{100} \quad \%$$

Let

c = No. of specimens of a species in split examined

d = No. of specimens of a species in one sample/gr of original sediment

n = No. of times split

$$d = \frac{2^n \times c}{Y + Z}$$

e.g. 20 specimens of Globigerinoides ruber are found in a portion of a 2.00 gr sample that has been split 4 times (= 1/16 fraction).

No. of G. ruber/gr of sediment = $\frac{2^4 \times 20}{2} = 160$

Let

e = No. of benthic foraminifera

f = No. of planktonic foraminifera

benthic : planktonic = e : f

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RESULTS AND DISCUSSIONS

Effects of Solution on Foraminiferal Tests

According to Bramlette (1961) the critical level of 4,500 meters in the Pacific Ocean is called the "compensation depth", below which the calcium carbonate content of deep-sea sediments decreases rapidly with depth. However Peterson (1966) showed that in the central Pacific the rate of solution of calcium carbonate increases rapidly at 3,700 meters, however solution acts selectively on foraminiferal shells even above this depth (Berger, 1967). Phleger, Parker and Peirson (1953) found that species of Globigerinoides are attacked by solution before species of Globorotalia. Berger (1967) suspended foraminiferal specimens from deep-sea sediments of the East Pacific Rise at various depths for 4 months, and found that modern Globigerinoides species are selectively dissolved over thick shelled foraminifera, e.g. Globorotalia (G.) tumida and Globorotalia (G.) truncatulinoides.

All cores studied were obtained from depths between 1,600 and 4,000 meters (see Table 1). Thus effects of solution are more or less to be expected. Four of the cores studied closely approximated the calcium carbonate compensation depth. There are indications of severe solution at the bottom of the cores S68-PC11, S68-PC21, and S68-PC23, at the intervals of 918-111 cm, 665-715 cm, and 660-729 cm respectively. The percentage of foraminifera is markedly low,

approximately 1%, whereas siliceous microfossils constitute a major portion of the sediments. The calcareous zone indicators susceptible to solution are mostly missing, e.g. Globigerina linaperta in S68-PC21, and Globigerinoides quadrilobatus primordius in S68-PC23, giving rise to a distorted picture of the faunal assemblages. Additional evidence of solution is partially peeled-off foraminiferal walls. This exposes the smooth, second layer which may lead to a misidentification when species can be differentiated only by smooth or coarsely textured walls. Globigerina ampliapertura Bolli and Globigerina pseudoampliapertura Blow and Banner are good examples of such species. This factor requires special consideration when solution is suspected.

Sedimentation

Arrhenius (1952) stated that in the east equatorial Pacific during glacial periods the equatorial current system increased the intensity of upwelling in the region of divergence, giving rise to a high productivity of planktonic population in that area. Thus carbonate-rich sedimentary layers are found at these intervals. During warmer, interglacial periods the intensity of upwelling was decreased, inhibiting high productivity of planktonic organisms, and giving rise to lower contents of calcium carbonate in the marine sediments. Hays and others (1969) found eight

distinct carbonate cycles in the Brunhes series of sediments from the east equatorial Pacific, and suggests eight major glacial fluctuations during the last 700,000 years. However, Blair (1965) discovered that there are no differences in the carbonate percentages of both intervals in sediments of the southernmost Pacific. Moreover, some warm or interglacial layers have higher carbonate content than the sediments deposited during glacial time.

There are no pronounced changes in the carbonate content of the sediments under investigation through Pleistocene time. Moreover, during Miocene, Pliocene and Recent time the relative percentages of nannofossils and foraminifera to Radiolaria fluctuate without definite direction. All of the samples investigated contain very high percentages of nannofossils (33.8-96.0%) and the foraminiferal percentages range up to 66.2%. The percentage of Radiolaria is very low (1.4-15.8%) compared to the previously-mentioned microfossils (Table 3). The differences between the sediments investigated here and those examined by Arrhenius (1952) and Hays and others (1969) may be due to differences in locations of the cores. Their cores are located in the region of the equatorial upwelling, whereas the cores studied are located south of that region (Fig. 1), thus the latter are not effected by this current system. The percentage of diatoms, sponge spicules, and mineral grains is small and can be excluded.

Empty planktonic foraminiferal tests can be transported 117 nautical miles by surface current of one knot, while settling 2,000 fathoms (Blair, 1965). At the northern part of the Ontong Java Plateau, the flowing direction of the ocean current is more or less east to west, setting about 15-30 miles per day. At the eastern and southeastern margins of the plateau the current system has more or less the same trend, with occasional flows in the northeast to southwest direction (Hydrographic Office, 1959). Subsurface current data are not available. Thus, whereas the total assemblages in the bottom sediments might not originate in the surface water directly overhead, they probably reflect true paleotemperatures of the surface water, as most of the displacement during settling has been lateral.

The sediments of the cores are composed of sand, silt, and clay-size particles. Most of sand fraction is foraminifera and Radiolaria, and also includes diatoms, sponge spicules, and mineral grains. The foraminifera range in size from 0.125 to 0.500 mm and Radiolaria range from 0.062 to 0.125 mm. The silt and clay fractions are composed mainly of nannofossils. There are indications of other organic remains e.g. pollen and spores and minerals. In general, clay and silt predominates over the sand-size particles. Thus the sediments are dominantly nannofossil ooze, and only cores S67-FFC10 and S67-FFC11 are of nannofossil-foraminiferal ooze.

The foraminiferal assemblages of Pliocene to Recent sediments indicate the environment of deposition as tropical, with temperatures exceeding 18°C (Bandy, 1969), conforming to the Equatorial West Central Assemblage of Gradshaw (1959). The indicative species of foraminifera are:

Globorotalia cultrata menardii

Globorotalia tumida tumida

Globigerina conglomerata

Globigerina dutertrei

Globigerinoides quadrilobatus sacculifer

Candeina nitida nitida

Pulleniatina spp.

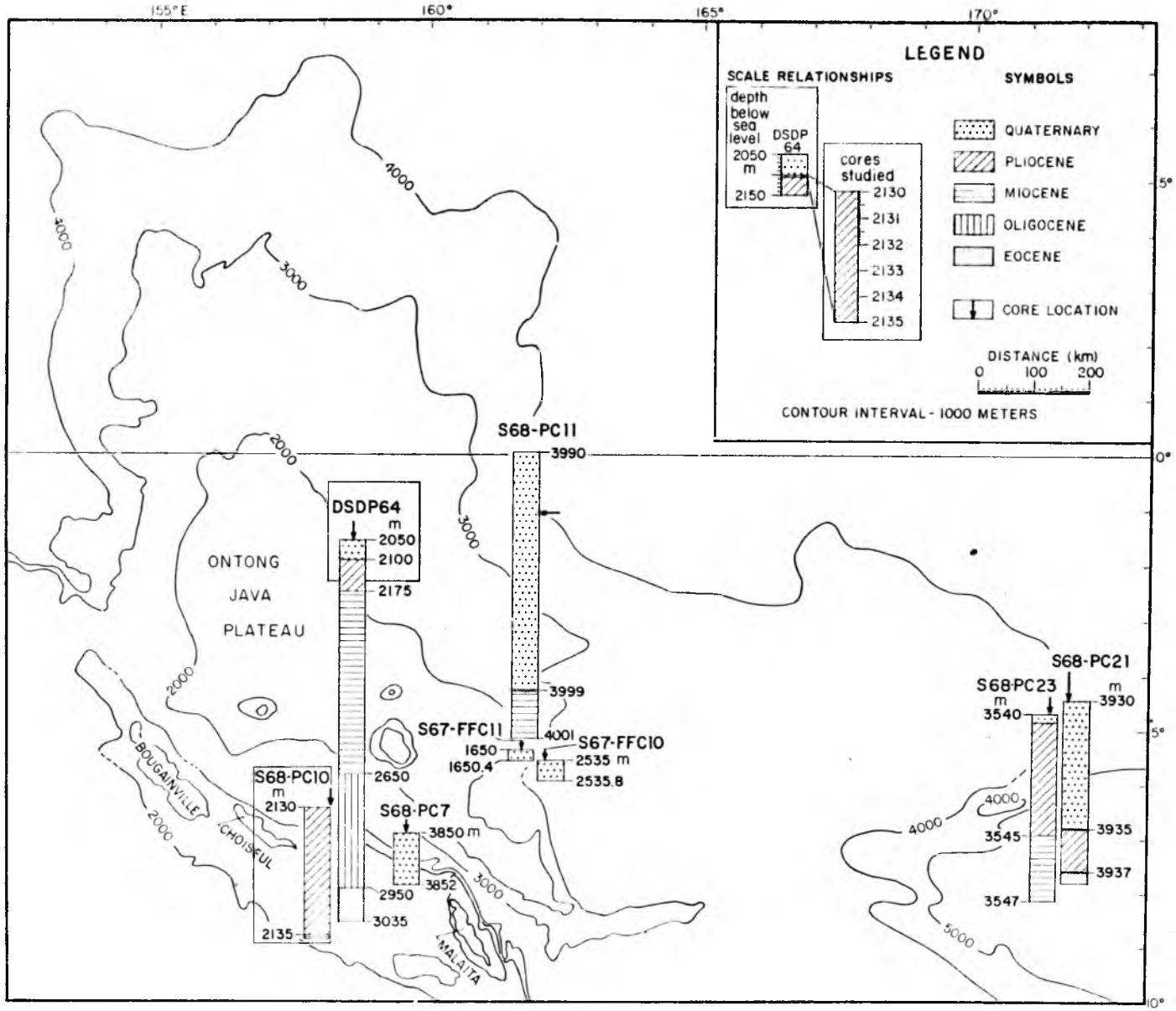
Sphaeroidinella spp.

The older assemblages, consisting of extinct species, are also tropical in character, as shown by their reported distribution in relation to the equator (Bolli, 1957a, 1957b, 1957c; McTavish, 1966; Todd, 1957;

Structural History

The Ontong Java Plateau is approximately 750 km wide and extends more than 1,500 km in a northwest-southeast direction parallel to the Solomon Islands in the southwestern Pacific Ocean (Fig. 1). The central portion of the plateau, at DSDP Site 64, is approximately 1,700 m below sea level. The section is composed of highly stratified, conformable

Fig. 1. Core Locations and their Relationships to the Stratigraphic Section at DSDP Site 64.


155°E
160°
165°
170°
LEGEND
SCALE RELATIONSHIPS
SYMBOLS
depth below sea level
DSDP 64
2050 m
2150
cores studied
2130
2131
2132
2133
2134
2135
QUATERNARY
PLIOCENE
MIOCENE
OLIGOCENE
EOCENE
CORE LOCATION
DISTANCE (km)
0 100 200
CONTOUR INTERVAL - 1000 METERS
5°
0°
5°
10°
4000
3000
2000
S68-PC11
3990
DSDP64
m
2050
2100
2175
ONTONG
JAVA
PLATEAU
3999
S67-FFC11
4001
S67-FFC10
1650
1650.4
2535 m
2535.8
2650
S68-PC10
m
2130
2135
S68-PC7
3850 m
3852
2950
3035
BOUGAINVILLE
CHOISEUL
MALAITA
S68-PC21
S68-PC23
m
3540
m
3930
3545
3935
3937
3547
5000

sediments. The margin of the plateau, where most of the Hawaii Institute of Geophysics cores were obtained has a complex physiographic pattern (L. Kroenke, personal communication). To date, the bathymetric data are inadequate to define the eastern and southern margin of the Ontong Java Plateau.

Woollard and others (1967) noted that active tectonic mobility characterizes the region of the Solomon Islands. The Ontong Java Plateau has been moderately deformed as indicated by horsts and grabens, and the en echelon pattern of folding along the southern margin. The eastern part is characterized by a steep escarpment and fractures suggestive of slumping and gravity sliding. An erosional en-entrant (submarine canyon) is predominant in the northeast (L. Kroenke, personal communication).

Paleontological evidence from cores studied conforms to the structure and historical events of this area. Seismic reflection records in the area of cores S68-PC21 and S68-PC23 beyond the eastern edge of the plateau, show erosional features which may have resulted from slumping or gravity-sliding events. Paleontological evidence shows many hiatuses present in both cores, and reworked sediments are prevalent. The area where cores S67-FFC10 and S67-FFC11 are located also shows erosional features, but there are no hiatuses represented in these short cores (Fig. 6).

However, S68-PC11 (Fig. 3), which is located in the channel of the northeastern submarine canyon of approximately 6.5 km width, shows a peculiarity. The late Miocene deposits from 918-111 cm contain a 10 cm thick layer (968-977) of early Pleistocene foraminiferal assemblages and Miocene-Pliocene nannofossils. This phenomenon may be expected in the channel of any submarine canyon that is a track for the transportation of turbidites from higher areas. The interbedding of Miocene and Pleistocene strata can be explained partly as follows: During early Pleistocene time, the area was subjected to a turbidity current which re-deposited there in mass sediments with late Miocene fossils. With the subsequent cessation of the current, a layer of early Pleistocene sediments was deposited. Erosion might have occurred afterward leaving only a very thin layer of early Pleistocene deposits. Then the area was subjected to slumping again and late Miocene sediments from the same source were again transported in the canyon and redeposited. Finally the area was calm, and the sequences of Pleistocene-Recent sediments were deposited. All of these events may have occurred in Pleistocene and Recent time.

S68-PC7 and S68-PC10 are located in the most folded and complicated area of the Ontong Java Plateau, its southern flexure north of the Malaita fold belt. Core S68-PC7 contains both faecal pellets and quartz. Nannofossils provide evidence of Pliocene or older material reworked into

Pleistocene sediments. There are two controversial proposals for the origin of quartz grains in this core. First, they may be derived from granodiorite bosses reported in andesitic and basaltic lava of Eocene-Oligocene age on Santa Ysabel Island or the western part of Guadalcanal (Coleman, 1963). The weathering products of the granodiorite bosses must have been transported to the area of deposition before late Miocene, which is the time of active folding in that area. Otherwise the folding systems would have been a trap for the sediments before they reached their present location. Second, they may have been transported to the place of deposition by wind. Revel and others (1955) and Arrhenius (1966) noted the presence of silt-size quartz in Pacific pelagic sediments, and suggested eolian transport as an explanation. Rex and Goldberg (1958) interpret the presence of well-sorted quartz concentrations of 1 to 20 microns size in the Eastern Pacific Ocean as of wind-borne origin. In addition, Heath (1969) observed quartz of windborne origin as prevalent in deep sea Quaternary sediments in the equatorial Pacific Ocean.

The presence of the faecal pellets may be explained in two ways as follows: First, they may have been deposited in Pleistocene time when slumping or gravity sliding was limited, leading to a quiet environment of deposition. The faecal pellets originated as the waste products of nectonic crustacea e.g. copepods and mysids, and worms

living on the sea floor. Second, they may have been transported by turbidity currents from a near shore area, however, this explanation seems to be hardly possible, since there is no tracks for the transportation of the sediments from the Solomon Islands to the location of S68-PC7, as previously described.

S68-PC10 is located in an area where the seismic profile shows features of erosion. Comparison of the seismic records with those of adjacent area suggests that approximately the upper 200 to 280 meters of the section is missing (L. Kroenke, personal communication). The paleontological evidence is in agreement, as the late Pliocene to Recent sections are absent, and only middle Pliocene to late Miocene fauna can be recognized.

In conclusion, the paleontological evidence and seismic reflection data both indicate that in general, the margins of the Ontong Java Plateau have experienced moderately active movements.

Correlation with Deep Sea Drilling Project Site 64

DSDP Site 64 is located near the central part of the Ontong Java Plateau (Fig. 1), a fairly stable area, characterized by thick, continuous and conformable strata. The thickness of the cored section is 985 meters, representing sediment accumulation from late Eocene to Recent. Basalt basement was not reached. The rate of sediment

accumulation at the site is approximately 2.5 cm/1,000 yr (Scientific Staff, 1969). The sediments are mainly calcareous ooze, indicating deposition under open sea conditions, above the depth of strong solution of calcium carbonate.

The Hawaii Institute of Geophysics cores are located mostly on the flanks of the plateau, where slumping and gravity sliding occurred during and after deposition (Fig. 1). Moreover, they are located in deeper water than the DSDP boring, giving rise to a slower rate of sediment accumulation and thinner strata. The rate of deposition of core S68-PC21 is approximately 0.27 cm/1,000 yr, about 10 times slower than the average rate at Site 64. The other cores, without continuous sections, are inadequate for calculating the rate of sediment accumulation. Because they are located in deeper water, where solution of foraminiferal tests generally is more than of nannofossils, all cores studied except S67-FFC10 and S67-FFC11 are of nannofossil ooze. The latter two are from approximately the same water depth as the DSDP Site 64 and thus contain similar sediments, nannofossil-foraminiferal ooze.

Apart from the differences mentioned above, the foraminiferal assemblages of the cores studied correlate very well with portions of the section at DSDP Site 64.

Pliocene - Pleistocene Boundary

Ericson and others (1963) reported the complete extinction of discoasters above the Pliocene - Pleistocene boundary, and used this criterion as a clue in determining the boundary. Wray and Ellis (1965), Akers (1965) and Bandy (1967a) observed the disappearance of discoasters within the lower part of the Pleistocene. However, McIntyre and others (1967) found the presence of all species of discoasters throughout the Pleistocene, though the numbers decrease drastically upward. The same is true for the cores studied, in which discoasters are present throughout, except for the upper 758 cm of core S68-PC11. Sediments representing Pleistocene deposits of all the cores studied except S68-PC21 contain Discoaster brouweri Tan Sin Hok, D. challengeri Bramlette and Riedel, D. variabilis Martini and Bramlette, and D. deflandrei Bramlette and Riedel. The ages of these species range from middle Miocene through Pliocene. S68-PC21 contains D. deflandrei throughout the Pleistocene section. D. deflandrei is abundant in the lower sections, whereas the other species are rare, thus it is preserved in the reworked Miocene - Pliocene sediments of the Pleistocene section. Most discoasters in all cores are broken and corroded. This might be due to reworking of the sediments by burrowing organisms, or slumping and gravity-sliding activities which prevailed in the area.

Benthic Foraminiferal Zonation

There are slight changes in deep bathyal and abyssal benthic faunas with time. Five benthic faunal assemblages were recorded for the following time intervals:

1. Pleistocene - Recent benthic fauna

   Alveolophragmium subglobosum (G. O. Sars)

   Cibicides pseudoungerianus (Cushman)

   Pyrgo murrhyna (Schwager)

   (Pyrgo murrhyna is reported in Miocene sediments of Buff Bay, Jamaica, by Cushman and Todd, 1945)

2. Pliocene - Recent benthic fauna

   Melonis pompilioides (Fichtel and Moll)

3. Late Miocene - Recent benthic fauna

   Ehrenbergina hystrix Brady

   Laticarinina pauperata (Parker and Jones)

   Planulina wuellerstorfi (Schwager)

   Quinqueloculina venusta Karrer

4. Early Miocene - Recent benthic fauna

   Cassidulina subglobosa Brady

   Eggerella bradyi (Cushman)

   Epistominella exigua (Brady)

   Eponides bradyi Earland

   Eponides umbonatus (Reuss)

   Favocassidulina favus (Brady)

   Fissurina spp.

   Pullenia bulloides (d'Orbigny)

Pullenia quinqueloba (Reuss)

5. Early Miocene - Late Miocene benthic fauna

Cibicides mundulus (Brady, Parker and Jones)

Gyroidina zealandica Finlay

(Gyroidina zealandica is found in New Zealand in Oligocene to Pliocene strata)

According to the lists above, many species endured through long periods of time, e.g. faunas 2, 3 and 4, which leads to a monotonous picture of the total benthic assemblages with time (Figs. 2 and 3).

In determining the age of deep sea sediments, benthic species are of little value, because of their much slower rate of evolution as compared to planktonic species. The latter reflect changes in the surface waters leading to rapid evolution, and because of their wide distribution, serve as a basis of worldwide correlation.

The ratio of benthic to planktonic foraminifera fluctuates in the cores (Table 4), as in the present environment of deposition.

Planktonic Foraminiferal Zonation

The rapid evolution, worldwide distribution, and adequate specimens of the planktonic foraminiferal species in the cores studied enable their identification with the biozones of Banner and Blow (1965) and of Blow (1969). However, the zonal sequences are discontinuous because of

Fig. 2. Ranges of the Biostratigraphically Important Benthonic Species of Core S68-PC23.

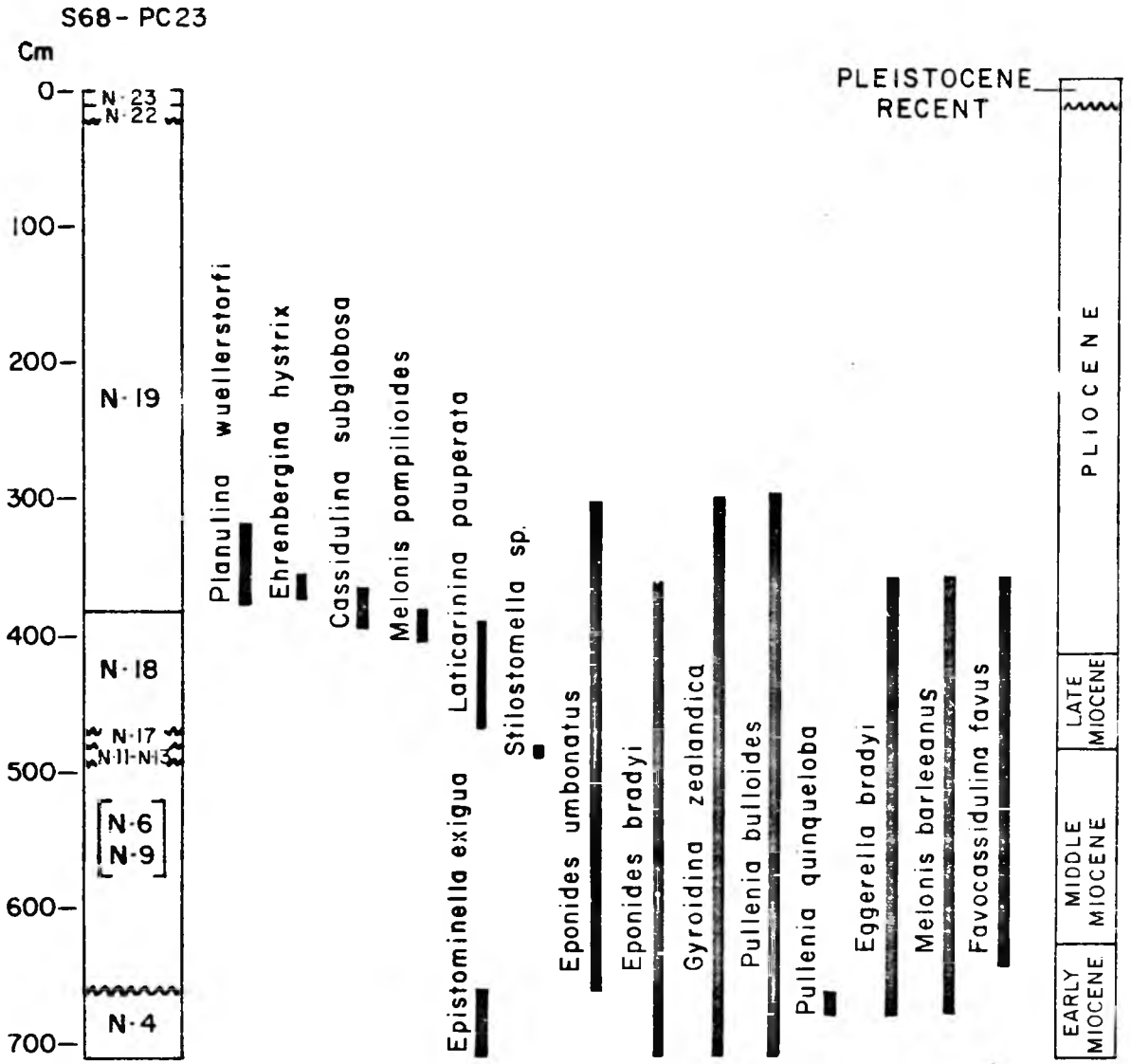

S68 - PC23
Cm
0
100
200
300
400
500
600
700
N·23
N·22
N·19
N·18
N·17
N·11-N·13
N·6
N·9
N·4
Planulina wuellerstorfi
Ehrenbergina hystrix
Cassidulina subglobosa
Melonis pompilioides
Laticarinina pauperata
Stilostomella sp.
Epistominella exigua
Eponides umbonatus
Eponides bradyi
Gyroidina zealandica
Pullenia bulloides
Pullenia quinqueloba
Eggerella bradyi
Melonis barleeanus
Favocassidulina favus
PLEISTOCENE
RECENT
PLIOCENE
LATE MIOCENE
MIDDLE MIOCENE
EARLY MIOCENE

Fig. 3. Ranges of the Biostratigraphically Important Benthonic Species of Core S68-PC11.

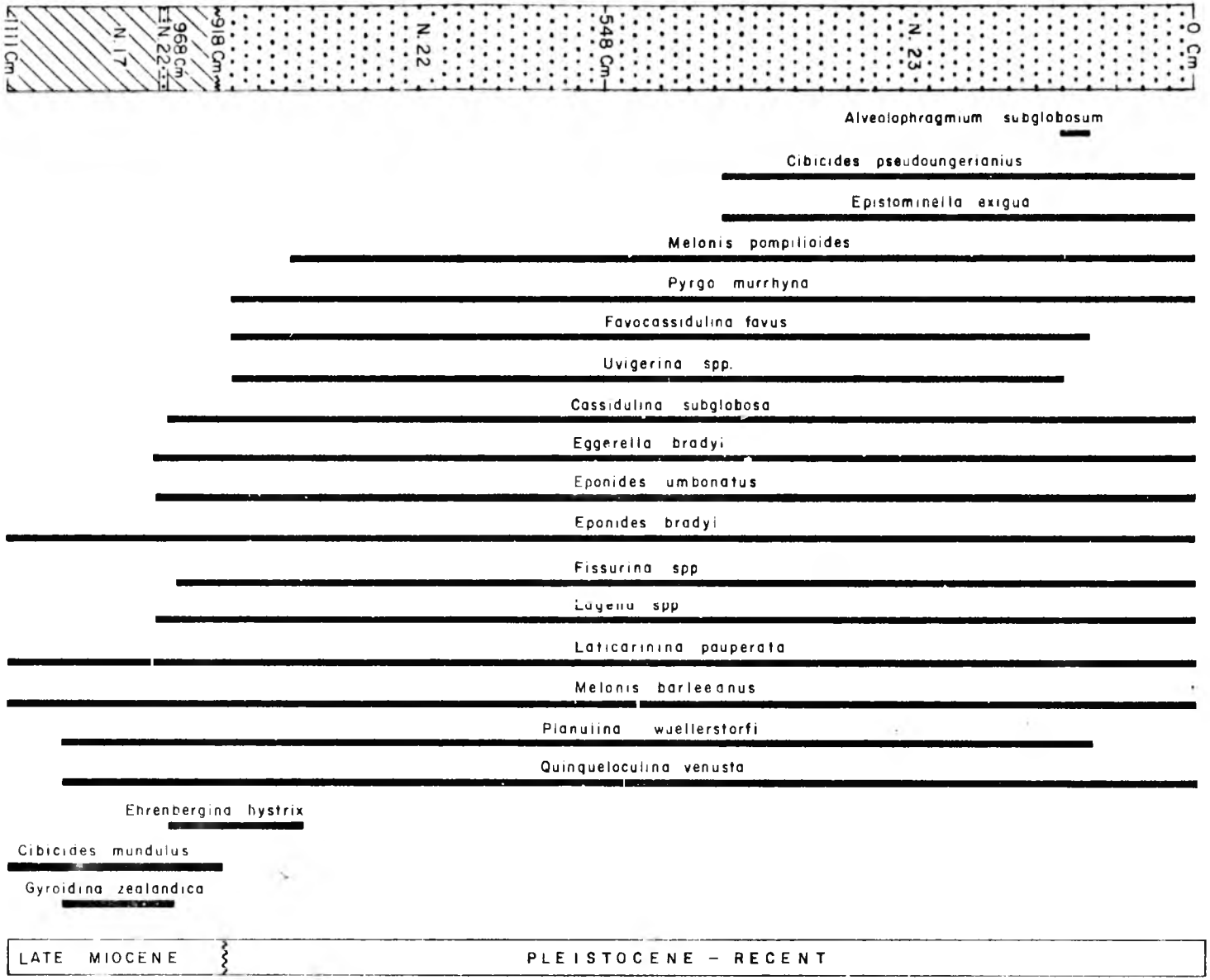

1111 Cm
N. 17
968 cm
N. 22
918 Cm
N. 22
548 Cm
N. 23
0 Cm
Alveolophragmium subglobosum
Cibicides pseudoungerianus
Epistominella exigua
Melonis pompilioides
Pyrgo murrhyna
Favocassidulina favus
Uvigerina spp.
Cassidulina subglobosa
Eggerella bradyi
Eponides umbonatus
Eponides bradyi
Fissurina spp
Lagena spp
Laticarinina pauperata
Melonis barleeanus
Pianulina wuellerstorfi
Quinqueloculina venusta
Ehrenbergina hystrix
Cibicides mundulus
Gyroidina zealandica
LATE MIOCENE
PLEISTOCENE – RECENT

TABLE 4

OCCURRENCE OF THE BIOSTRATIGRAPHICALLY IMPORTANT PLANKTONIC AND BENTHONIC FORAMINIFERAL SPECIES, AND BENTHONIC:PLANKTONIC RATIO OF THE CORES STUDIED.

STAGE	PLEISTOCENE-RECENT												PLIOCENE				MIOCENE						EO-CENE
ZONE	N. 23						N. 22					N. 21	N. 19			N. 18	N. 17		N.13 -11	N. 6-9	N. 4	P. 16	
CORE NO.	PFC 10	PFC 11	PC 7	PC 11	PC 21	PC 23	PFC 10	PFC 11	PC 7	PC 11	PC 21	PC 23	PC 21	PC 10	PC 21	PC 23	PC 10	PC 23	PC 11	PC 23	PC 23	PC 23	PC 23	PC 21
DEPTH IN CORE (cm)	5	8	15	58	25	12	68	38	200	668	215	22	475	69	565	32	489	382	978	472	482	550	660	705
PLANKTONIC SPECIES																								
GLOBIGERINA																								
angiporoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
calida calida	t	-	r	-	t	t	-	-	-	t	t	t	t	-	-	-	-	-	-	-	-	-	-	-
calida praecalida	r	-	-	-	r	-	s	-	-	-	c	-	r	r	-	s	-	-	-	-	-	-	-	-
conglomerata	f	-	r	-	c	t	-	-	-	r	f	c	-	s	-	f	-	-	-	-	-	-	-	-
decoraperta	t	a	r	-	-	-	-	a	-	-	-	-	-	t	-	-	a	p	-	f	-	-	-	-
dutertrei	t	-	s	p	f	f	a	-	f	c	f	p	-	-	c	f	-	-	-	-	-	-	-	-
galavisi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a
gortani gortani	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r
nepenthes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	f	f	r	s	-	-	-	-
praebulloides leroyi var.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a
prasaepis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	c
pseudoampliapertura	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a
pseudofoliata	s	t	-	-	-	-	-	-	-	-	-	-	s	-	-	a	r	-	-	-	-	-	-	-
rubescens (red)	t	f	r	a	c	a	-	-	r	-	-	p	-	-	-	-	-	-	-	-	-	-	-	-
tripartita	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	c
venezuelana	r	f	-	-	-	-	r	f	-	-	-	-	-	s	t	t	r	a	r	c	f	-	r	-
GLOBIGERINOIDES																								
bollii	f	f	-	-	-	-	s	a	-	-	r	-	-	p	-	-	p	s	-	f	r	-	-	-
conglobatus conglobatus	p	c	r	r	c	c	f	c	-	s	-	-	c	-	r	c	r	r	-	c	-	-	-	-
obliquus obliquus	-	-	-	-	-	-	s	a	-	-	-	-	-	p	-	f	f	a	-	r	-	-	-	-
obliquus extremus	-	-	-	-	-	-	a	p	-	-	-	-	-	f	-	s	c	c	-	r	-	-	-	-
quadrilobatus fistulosus	-	-	-	-	-	t	f	f	-	-	-	-	-	t	-	-	-	-	-	-	-	-	-	-
quadrilobatus immaturus	a	f	r	a	f	c	s	p	-	r	-	-	a	s	-	f	r	c	r	c	c	p	r	-
quadrilobatus sacculifer	a	f	r	f	p	f	p	p	-	a	-	-	f	p	c	a	p	c	r	c	c	c	-	-
quadrilobatus trilobus	f	c	r	r	c	c	s	p	c	r	f	r	s	f	-	s	p	a	r	c	c	p	r	-
ruber	a	a	c	p	a	a	a	a	c	r	p	a	c	a	c	a	f	-	r	r	-	-	-	-
sicanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-
subquadratus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	f	-	-	-
GLOBIGERINITA																								
dissimilis dissimilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	t	-	r
glutinata glutinata	a	a	f	a	a	a	a	a	c	a	-	-	a	a	-	a	a	c	r	f	c	a	-	-
glutinata parkerae	p	r	-	-	c	a	f	-	-	a	c	-	-	-	-	-	-	-	-	-	-	-	-	-
stainforthi stainforthi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	t	-	r
unicava primitiva	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	c
GLOBIGERINATELLA																								
insueta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	c
GLOBOQUADRINA																								
altispira altispira	-	-	-	-	-	-	a	p	-	-	-	-	-	c	-	-	c	c	r	c	f	-	r	-
altispira globosa	-	-	-	-	-	-	a	f	-	-	-	-	-	a	-	-	f	c	-	c	f	-	r	-

TABLE 4 -- Continued

STAGE	PLEISTOCENE-RECENT												PLIOCENE				MIOCENE						EO-CENE
ZONE	N. 23						N. 22						N. 21	N. 19		N. 18	N. 17		N. 14-11	N. 10-9	N. 8	E. 16
CORE NO.	PC 10	PC 11	PC 7	TC 11	PC 21	TC 21	PC 10	PC 11	PC 7	TC 11	TC 21	TC 24	TC 21	TC 10	TC 21	TC 24	TC 10	TC 24	TC 11	TC 23	TC 23	TC 23	TC 21
DEPTH IN CORE (cm)	5	8	15	58	25	12	68	48	200	168	215	22	575	60	580	32	680	382	978	473	483	550	660	705
dehiscens advena	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	a	-	-
dehiscens dehiscens	t	a	-	-	-	-	-	a	-	-	-	-	-	a	-	-	r	r	-	r	f	p	r	-
dehiscens praedehiscens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	t	-
GLOBOROTALIA (TURBOROTALIA)																								
acostaensis acostaensis	f	a	t	-	-	-	a	p	-	-	-	-	-	p	-	-	a	f	a	f	-	-	-	-
acostaensis humerosa	t	c	r	r	r	a	-	f	a	-	a	r	a	a	-	r	t	r	-	-	-	-	-	-
acostaensis pseudopima	t	-	r	r	-	-	-	-	-	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-
anfracta	-	-	-	-	-	t	t	-	r	a	-	-	-	c	-	-	-	-	-	-	-	-	-	-
centralis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	
cerroazulensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	
continuosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	f	r	-	
crassaformis crassaformis	-	t	-	-	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
crassaformis oceanica	r	t	-	-	-	-	-	-	-	t	r	t	-	-	a	-	-	-	-	-	-	-	-	
crassaformis ronda	-	-	-	-	-	-	r	r	-	-	-	-	t	-	a	-	-	-	-	-	-	-	-	
gemma	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	
increbescens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	
kuglerl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	
mendacis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	
obesa	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	-	-	-	-	-	-	-	
peripheroronda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	f	a	-	-	
scitula scitula	a	-	t	r	r	r	r	-	r	-	-	r	-	r	-	a	t	r	r	r	-	-	-	-
siakensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	a	r	-	
tosaensis tenuitheca	r	r	-	-	-	-	-	-	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-	
tosaensis tosaensis	a	-	-	-	-	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
GLOBOROTALIA (GLOBOROTALIA)																								
cultrata cultrata	a	f	r	f	f	a	t	a	-	r	f	r	a	a	a	a	r	r	r	t	t	-	-	-
cultrata limbata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	t	-	r	-	-	-	-	-	-
cultrata menardii	a	r	r	r	-	a	-	a	-	r	a	r	-	a	a	c	-	-	r	-	-	-	-	-
fohsi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-
margaritae	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	t	-	-	r	-	-	-	-
merotumida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	c	r	t	-	-	-	-
multicamerata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	-	-	-	-	-	-	-	-
praemenardii praemenardii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	c	-	-	-
praemenardii archaeomenardii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	-
truncatulinoides pachytheca	-	-	-	-	r	-	-	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
truncatulinoides truncatulinoides	-	-	-	c	-	-	-	-	a	a	a	-	-	-	-	-	-	-	-	-	-	-	-	-
tumida flexuosa	c	t	t	t	a	-	a	c	-	-	-	f	a	a	-	c	r	-	-	-	-	-	-	-
tumida pleistotumida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	r	t	-	-	-	-
tumida tumida	c	c	r	f	c	c	t	c	f	c	f	f	r	r	p	f	a	r	-	-	-	-	-	-
ungulata	a	f	r	r	-	-	f	c	-	-	a	r	r	-	-	c	t	-	-	-	-	-	-	-
GLOBOROTALOIDES																								
hexagona hexagona	a	-	t	r	r	a	a	-	-	-	-	r	-	r	-	f	r	-	-	-	-	-	-	-

TABLE 4 -- Continued

STAGE	PLEISTOCENE-RECENT												PLIOCENE				MIOCENE						EO-CENE
ZONE	N.23						N.22						N.21	N.19			N.18	N.17		N.14-11	N.8-9	N.4	F.16
CORE NO.	PFC 10	PFC 11	PC 7	PC 11	PC 21	PC 23	PFC 10	PFC 11	PC 7	PC 11	PC 21	PC 23	PC 21	PC 19	PC 21	PC 23	PC 10	PC 23	PC 11	PC 23	PC 23	PC 23	PC 21
DEPTH IN CORE (cm)	5	8	15	58	25	12	68	38	200	668	215	22	475	69	565	32	489	382	978	472	482	550	660	705
hexagona variabilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	t	-	-	-	r	-	-
HASTIGERINA																								
adamsi	t	t	-	t	-	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
siphonifera siphomifera	c	c	r	a	a	f	c	a	a	r	f	c	-	a	-	p	c	r	-	r	-	-	-	-
siphonifera involuta	-	-	-	-	-	-	-	f	-	-	-	-	-	c	-	r	r	-	-	-	-	-	-	-
HASTIGERINELLA																								
digitata digitata	-	-	t	t	t	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ORBULINA																								
suturalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-
universa	r	r	r	r	r	-	a	c	-	r	r	t	t	t	t	s	a	t	r	t	t	-	-	-
PULLENIATINA																								
obliquiloculata finalis	t	-	r	f	c	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
obliquiloculata obliquiloculata	t	s	s	a	p	r	a	a	c	c	f	f	a	t	a	f	-	-	-	-	-	-	-	-
obliquiloculata praecursor ..	-	t	-	-	-	-	c	-	-	-	-	-	r	-	r	-	-	-	-	-	-	-	-	-
primalis	p	p	r	-	-	-	f	f	-	-	-	-	c	a	a	p	-	-	-	-	-	-	-	-
spectabilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	f	r	-	-	-	-	-	-
SPHAEROIDINELLA																								
dehiscens dehiscens	a	a	r	r	t	t	c	t	t	r	r	r	r	t	-	s	-	-	-	-	-	-	-	-
dehiscens dehiscens forma immatura	a	a	r	-	-	-	r	r	-	-	-	-	r	-	t	r	-	-	-	-	-	-	-	-
dehiscens excavata	t	-	-	-	t	t	t	t	-	t	t	t	t	-	-	t	-	-	-	-	-	-	-	-
SPHAEROIDINELLOPSIS																								
seminulina kochi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	t	-	-	-	-
seminulina seminulina	-	r	t	-	-	-	-	r	-	-	-	-	-	t	c	-	r	c	r	s	r	-	-	-
subdehiscens paenedehiscens..	-	r	-	-	-	-	-	-	-	-	-	-	-	a	-	-	r	-	-	-	-	-	-	-
subdehiscens subdehiscens ...	-	-	-	-	-	-	-	-	-	-	-	-	-	t	s	-	r	c	r	s	r	-	-	-
TURBOROTALITA																								
humilis	a	a	-	p	a	a	a	p	-	s	f	-	-	a	a	a	a	-	-	-	r	-	-	-
iota	a	a	-	a	t	a	a	c	-	a	c	-	-	-	-	-	-	-	-	-	-	-	-	-
OTHER GENERA																								
Biorbulina bilobata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	s	r	t	-	-	-	-	-	-
Candeina nitida nitida	t	p	r	-	c	p	-	c	-	-	r	-	-	a	-	a	r	t	-	-	-	-	-	-
Chiloguembelina cubensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r
Cribrohantkenina inflata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r
Hantkenina alabamensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r
Pseudohastigerina barbadoensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r
BENTHONIC SPECIES																								
Bolivina sp.	a	a	-	-	-	-	-	-	-	r	-	f	-	-	-	f	a	-	-	c	f	f	-	-
Bolivina guadalupae	-	-	-	-	-	-	-	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-
Cassidulina subglobosa	-	r	-	r	-	-	r	s	-	r	-	r	-	-	-	r	-	r	-	r	r	s	-	t
Cibicides mundulus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	-	-	t
Cibicides pseudoungerianus ..	-	-	r	r	-	t	-	-	r	-	t	-	-	-	-	-	-	-	-	-	-	-	-	-
Dentalina communis	-	-	-	-	-	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eggerella bradyi	-	t	-	r	-	t	-	-	-	-	-	-	-	-	t	s	-	-	t	t	t	t	t	t

TABLE 4 -- Continued

STAGE	PLEISTOCENE-RECENT													PLIOCENE				MIOCENE						EO-CENE
ZONE	N. 23						N. 22						N. 21	N. 19			N. 18	N. 17		N. 13 -11	N. 6-9	N. 4		P. 16
CORE NO.	PFC 10	PFC 11	PC 7	PC 11	PC 21	PC 23	PFC 10	PFC 11	PC 7	PC 11	PC 21	PC 23	PC 21	PC 10	PC 21	PC 23	PC 10	PC 23	PC 11	PC 23	PC 13	PC 23	PC 21	
DEPTH IN CORE (cm)	5	8	15	58	25	12	68	38	200	668	215	22	475	69	565	32	489	382	978	472	482	550	660	705
Epistominella exigua	-	-	-	s	t	-	-	-	-	r	t	f	-	-	-	r	-	-	t	-	-	-	t	-
Eponides bradyi	-	-	r	s	t	s	-	f	s	s	t	c	t	f	t	s	r	-	r	-	-	-	-	t
Eponides umbonatus	-	-	r	r	t	t	-	-	r	s	s	-	-	-	t	r	-	-	t	-	-	-	r	-
Ehrenbergina hystrix	-	-	-	-	-	-	t	-	-	-	-	r	-	-	t	-	-	-	-	t	-	-	-	-
Favocassidulina favus	-	-	t	-	-	-	-	r	-	-	t	r	-	-	-	-	-	-	-	t	r	-	-	-
Fissurina fimbriata	-	-	-	-	-	-	-	-	-	-	-	r	-	-	-	r	t	-	-	-	-	-	-	-
Fissurina formosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	-	-	-	-	-	-
Fissurina laevigata	-	-	-	-	-	-	-	-	-	r	t	-	-	-	-	-	-	-	-	-	-	-	-	-
Fissurina marginata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	r	-	-	-	-	-
Fissurina spinosa	-	-	-	-	-	-	-	r	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gyroidina neosoldanii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	-
Gyroidina zealandica	-	-	-	-	-	-	-	-	-	-	-		-	-	-	t	-	t	-	t	t	t	r	t
Lagena sidebottomi	-	-	-	-	-	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lagena sulcata	-	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Laticarinina pauperata	-	t	-	-	-	-	t	-	-	-	-	-	-	-	-	-	-	t	-	c	-	-	-	-
Melonis barleeanus	-	-	t	-	r	t	t	t	r	r	-	-	-	-	-	r	t	-	r	-	-	-	-	-
Melonis pompilioides	-	-	t	-	-	t	-	-	r	-	-	-	-	-	t	-	-	-	-	-	-	-	-	-
Nonionella sp.	-	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oolina felsinia	-	-	-	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Planulina wuellerstorfi	r	t	-	-	r	t	-	-	r	-	t	-	t	-	t	-	c	-	-	-	-	-	-	-
Pullenia bulloides	-	-	-	r	-	-	-	-	-	s	t	r	-	-	t	s	-	-	r	-	-	-	-	-
Pullenia quinqueloba	-	f	t	-	-	-	-	-	-	r	-	s	-	-	-	-	r	r	-	-	-	-	r	t
Pyrgo murrhyna	-	t	r	r	-	-	-	-	-	-	-	r	-	-	-	-	r	-	-	r	-	-	-	-
Pyrulina angusta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	-	-	-
Pyrulina fusiformis	-	-	-	r	-	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quinqueloculina venusta	-	-	-	r	-	-	-	-	-	r	-	r	-	-	-	-	-	-	-	r	-	-	-	-
Stilostomella sp.	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stilostomella lepidula	-	-	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	s	-	-	-	-	-
Uvigerina sp.	r	s	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Uvigerina bradyana	-	-	-	-	-	-	-	-	r	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Uvigerina bruenensis	-	-	-	-	-	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bathysiphon discreta	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haplophragmoides sp.	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IMMATURE FORAMINIFERA	a	a	a	a	a	a	a	a	a	c	a	a	a	p	c	a	a	a	c	a	a	a	a	t
SHELL FRAGMENTS	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	c	a	a	a	a	r
RADIOLARIA	-	-	a	a	a	a	-	-	a	a	-	a	a	-	a	a	-	a	a	a	a	a	a	a
BENTHONIC:PLANKTONIC	1/8	1/60	1/58	1/34	1/99	1/99	1/77	1/65	1/60	1/5	1/85	1/20	1/45	1/46	1/35	1/90	1/12	1/15	1/13	1/99	1/25	1/30	1/24	1/45

r = rare (1-25 specimens/gram sediment)

s = seldom (26-75 specimens/gram sediment)

c = common (76-200 specimens/gram sediment)

t = trace

f = frequent (201-500 specimens/gram sediment)

p = prevalent (501-1000 specimens/gram sediment)

a = abundant (> 1000 specimens/gram sediment)

many hiatuses in the short cores. One new biozone is here proposed, and Holocene horizons are suggested.

Zones recognized in the Hawaii Institute of Geophysics cores are described below according to their faunal contents:

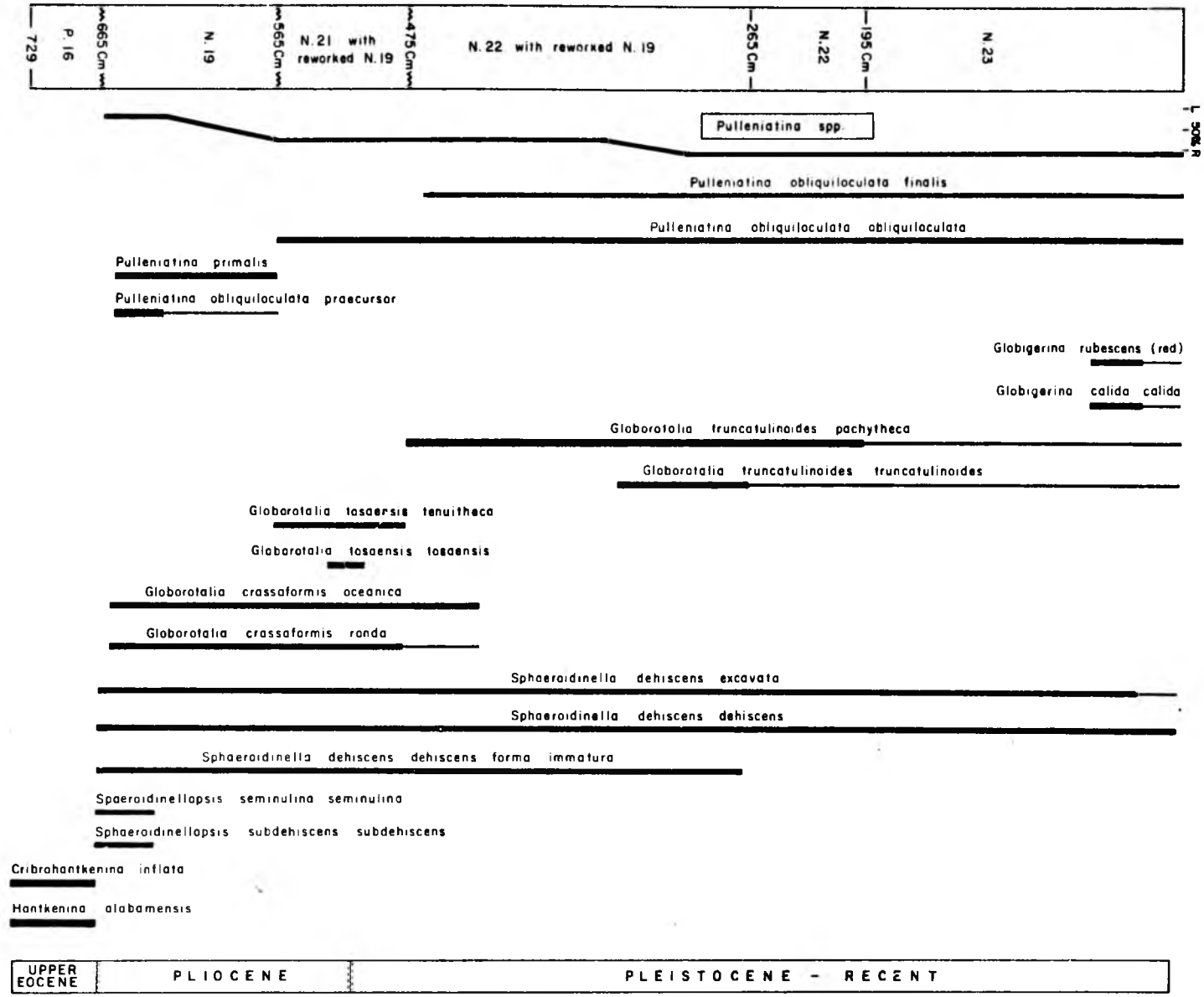
Zone P. 16 Cribrohantkenina inflata
(middle part of late Eocene)
S68-PC21, 665-71[illegible] cm (Fig. 4)

The fauna is characterized by Cribrohantkenina inflata (Howe), which is restricted to this zone. Globigerina pseudoampliapertura Blow and Banner and Globigerina galavisi Bermudez are abundant; Hantkenina alabamensis Cushman, Globigerina tripartita Koch, and Globigerinita unicava primitiva Blow and Banner are common. Globorotalia (T.) centralis Cushman and Bermudez, Globigerina aff. prasaepis Blow, and Pseudohastigerina barbadoensis Blow are rare. Globigerina praebulloides leroyi var. Blow and Banner is present, and there are traces of broken Globorotalia cerroazulensis (Cole).

Absence of Globigerina linaperta Finlay and the presence of only a small number of Globorotalia (T.) centralis are anomalous. This might be due to the effects of solution, as was previously mentioned.

This zone is partly comparable to the Globigerina ampliapertura/Globigerina linaperta fauna of McTavish (1966), from the Malaita Group, British Solomon Islands (Table 2), which is defined by the association of abundant Globigerina

Fig. 4. Ranges of the Biostratigraphically Important Planktonic Foraminifera of Core S68-PC21.


729
P. 16
665 Cm
N. 19
565 Cm
N. 21 with reworked N. 19
475 Cm
N. 22 with reworked N. 19
265 Cm
N. 22
195 Cm
N. 23
R 508
Pulleniatina spp.
Pulleniatina obliquiloculata finalis
Pulleniatina obliquiloculata obliquiloculata
Pulleniatina primalis
Pulleniatina obliquiloculata praecursor
Globigerina rubescens (red)
Globigerina calida calida
Globorotalia truncatulinoides pachytheca
Globorotalia truncatulinoides truncatulinoides
Globorotalia tosaensis tenuitheca
Globorotalia tosaensis tosaensis
Globorotalia crassaformis oceanica
Globorotalia crassaformis ronda
Sphaeroidinella dehiscens excavata
Sphaeroidinella dehiscens dehiscens
Sphaeroidinella dehiscens dehiscens forma immatura
Spaeroidinellopsis seminulina seminulina
Sphaeroidinellopsis subdehiscens subdehiscens
Cribrohantkenina inflata
Hantkenina alabamensis
UPPER EOCENE
PLIOCENE
PLEISTOCENE - RECENT

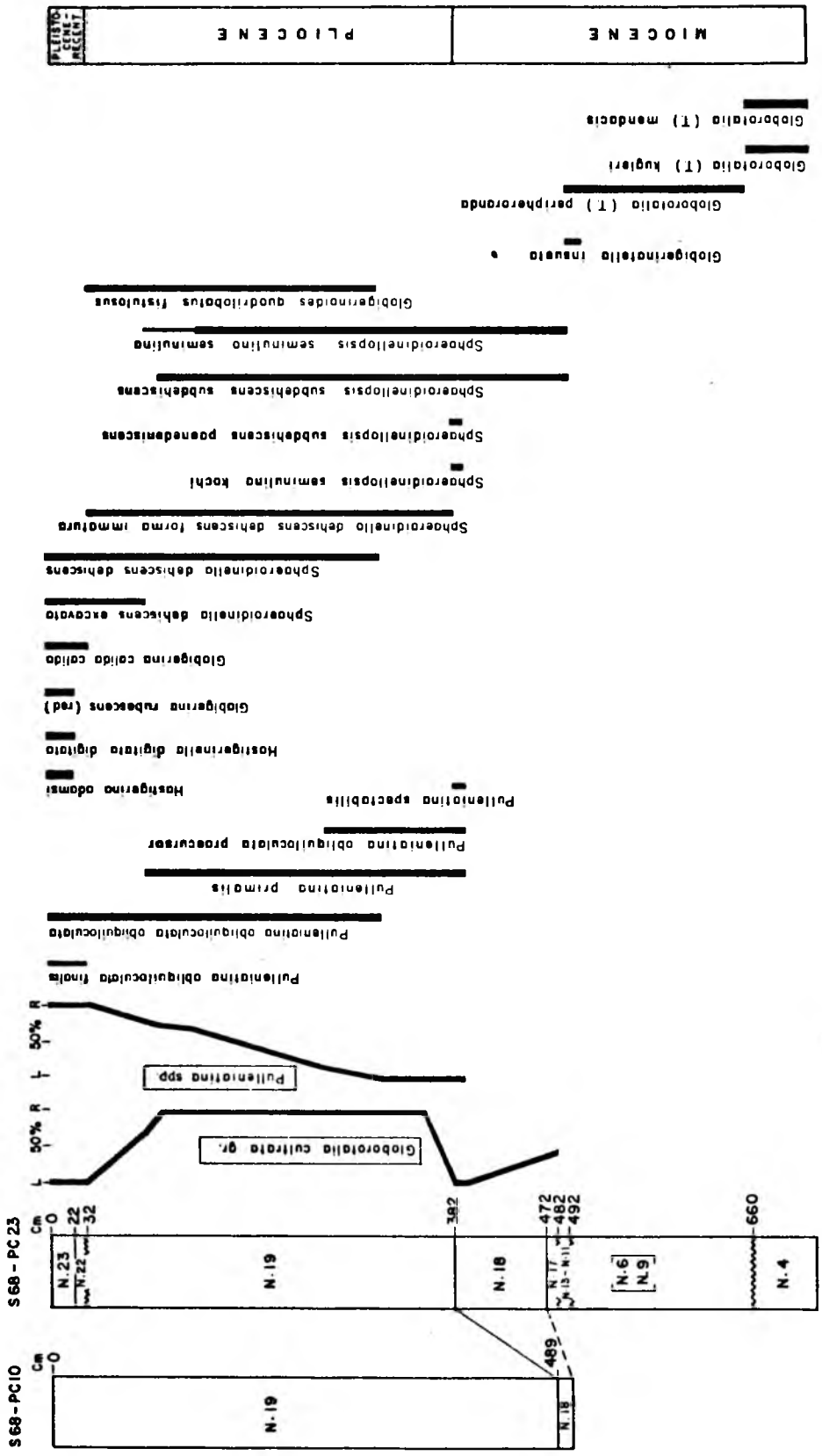
ampliapertura Bolli with frequent Globigerina linaperta. These species are absent from the fauna of the core studied, possibly due to the effects of solution, as previously mentioned. Moreover when the ranges of all species in the assemblage are examined, Zone P. 16 of the area studied lies slightly below McTavish's zone.

Zone N. 4 Globigerinoides quadrilobatus primordius/ Globorotalia (Turborotalia) kugleri (earliest Miocene, Aquitanian, part) S68-PC23, 660-729 (Fig. 5)

This faunal assemblage is characterized by Globorotalia (T.) kugleri Bolli, however, the more primitive form G. (T.) mendacis Blow which defines the previous Zone N. 3 is present here. There is no indication of Globigerinoides quadrilobatus primordius Banner and Blow, but the presence of G. quadrilobatus immaturus LeRoy indicates an age of at least the middle of Zone N. 4. The absence of the former species is probably the result of selective solution, since the tests of G. quadrilobatus immaturus are partially peeled off. Globorotalia (T.) siakensis LeRoy is abundant. Globigerina tripartita, Globoquadrina dehiscens dehiscens (Chapman, Parr and Collins), G. dehiscens praedehiscens Blow and Banner, G. altispira altispira (Cushman and Jarvis), and Globigerina venezuelana Hedberg are rare.

The fauna is partly comparable to the Globorotalia kugleri fauna (Table 2) of the Solomon Islands, which McTavish (1966) defines by the dominant species, Globorotalia

Fig. 5. Correlation of Core S68-PC10 with CoreS68-PC23, and Ranges of the Biostratigraphically Important Planktonic Foraminifera of Core S68-PC23.


PLEISTO-CENE-RECENT
PLIOCENE
MIOCENE
Globorotalia (T) mendacis
Globorotalia (T) kugleri
Globorotalia (T) peripheroranda
Globigerinatella insueta
Globigerinoides quadrilobatus fistulosus
Sphaeroidinellopsis seminulina seminulina
Sphaeroidinellopsis subdehiscens subdehiscens
Sphaeroidinellopsis subdehiscens paenedeniscens
Sphaeroidinellopsis seminulina kochi
Sphaeroidinella dehiscens dehiscens forma immatura
Sphaeroidinella dehiscens dehiscens
Sphaeroidinella dehiscens excavata
Globigerina calida calida
Globigerina rubescens (red)
Hastigerinella digitata digitata
Hastigerina adamsi
Pulleniatina spectabilis
Pulleniatina obliquiloculata praecursor
Pulleniatina primalis
Pulleniatina obliquiloculata obliquiloculata
Pulleniatina obliquiloculata finalis
Pulleniatina spp.
Globorotalia cultrata gr.
50% R
L
S68-PC23
Cm
0
22
32
382
472
482
492
660
N.23
N.22
N.19
N.18
N.17
N.13-N.11
N.6
N.9
N.4
S68-PC10
489

kugleri, and contains Globigerina ciperoensis angulisuturalis, G. ciperoensis ciperoensis, G. ampliapertura and Globorotalia opima nana.

Zone N. 9 — Orbulina suturalis - Globorotalia (Turborotalia) peripheroronda (middle Miocene, early Langhian)
to
Zone N. 6 — Globigerinatella insueta/Globigerinita dissimilis (early Miocene, late Aquitanian to early Burdigalian)
S68-PC23, 492-650 cm (Fig. 5)

This foraminiferal assemblage shows the characteristics of both Zone N. 6 and Zone N. 9. Globorotalia (T.) siakensis LeRoy and Globoquadrina dehiscens dehiscens, Globigerinoides quadrilobatus immaturus, G. quadrilobatus trilobus (Reuss), Globoquadrina altispira altispira and G. altispira globosa are common. There are traces of Globigerinita dissimilis dissimilis (Cushman and Bermudez), G. unicava unicava (Bolli, Loeblich, and Tappan), G. stainforthi stainforthi (Bolli, Loeblich, and Tappan), and Globigerinatella insueta Cushman and Stainforth. These species indicate an age as old as Zone N. 6, since Globigerinoides quadrilobatus trilobus first appears in the middle of this zone, and the other species range within the zone.

Rare specimens of Globigerinoides sicanus de Stefani, Globorotalia (G.) praemenardii praemenardii Cushman and Stainforth, Globorotaloides hexagona variabilis Bolli, and Orbulina suturalis Brönnimann are present. This faunal

assemblage indicates an age of Middle Miocene (Zone N. 9).

These zones can be compared to three faunal zones (Table 2) of the Malaita Group (McTavish, 1966).

1. The upper part of the Globigerina (Globigerinita) dissimilis fauna, characterized by the concurrence of G. (G.) dissimilis, G. (G.) unicava and Globigerinoides quadrilobatus.
2. Globigerinatella insueta fauna, which is defined by G. insueta and Globigerinoides sicanus.
3. The lower part of the Globoquadrina altispira fauna of which G. altispira is the most abundant species.

Zone N. 13 — Sphaeroidinellopsis subdehiscens subdehiscens - Globigerina druryi (Langhian part, Middle Miocene)

to

Zone N. 11 — Globorotalia (G.) praefohsi (Langhian part, middle Miocene) S68-PC23, 482-492 cm (Fig. 5)

The faunal assemblages are dominated by Globorotalia (T.) siakensis, Globoquadrina altispira subspp., G. dehiscens dehiscens, and Globigerinoides subquadratus Brönnimann. The common species are Globorotalia (T.) peripheroronda, Globigerinoides quadrilobatus immaturus, and G. quadrilobatus trilobus, whereas Globorotalia (G.) cultrata cultrata (d'Orbigny), G. (G.) praemenardii praemenardii Cushman and Stainforth, G. (G.) praemenardii archaeomenardii Bolli, Sphaeroidinellopsis subdehiscens subdehiscens Blow seminulina seminulina (Schwager) and Globorotalia (G.) fohsi Cushman and Ellisor are rare.

According to Blow (1969), G. (G.) fohsi ranges from the base of Zone N. 12 to within Zone N. 13, Sphaeroidinellopsis subdehiscens subdehiscens first occurs at the base of Zone N. 13, whereas Globorotalia (T.) peripheroronda ranges from within Zone N. 6 to within Zone N. 11 ? Zone N. 12. The ranges of these critical species indicate the ages of upper Zone N. 11 to the lower part of Zone N. 13. These biozones are not recognized in the Malaita Group, British Solomon Islands (Table 2).

Zone N. 17 Globorotalia tumida plesiotumida

(Messinian, part, late Miocene)

S68-PC11, 918-1111 cm (Fig. 3); S68-PC10, 472-482 cm (Fig. 5)

The foraminiferal assemblages at these intervals are characterized by dominant Miocene fauna, whereas the species which first occur in the Miocene, but are more abundant in the Pliocene to Recent, are comparatively rare. Globigerina nepenthes Todd, Globigerinoides bollii Blow, and Globorotalia (T.) acostaensis acostaensis Blow are abundant. Globoquadrina altispira altispira, G. altispira globosa, Globigerina venezuelana, Globigerinoides quadrilobatus immaturus, G. quadrilobatus trilobus, Sphaeroidinellopsis seminulina seminulina are very rare.

The absence of Globorotalia (G.) tumida tumida and the association of G. (G.) tumida plesiotumida and G. (G.) merotumida indicate Zone N. 17. A transition form between Globigerinoides obliquus obliquus Bolli, and G. conglobatus

conglobatus (Brady), which is very hard to place definitely in either species was found in the cores. This might be the primitive form of G. conglobatus conglobatus which first occurs in this zone.

This assemblage is comparable to the lower part of the Sphaeroidinellopsis seminulina fauna (Table 2), the Malaita Group, British Solomon Islands (McTavish, 1966), which is defined by the abundance of Sphaeroidinellopsis spp, of which s. seminulina seminulina is dominant. McTavish reported the extinction of several species at the top of this zone. These species are Globigerina apertura, Globoquadrina altispira globosa, G. dehiscens dehiscens, Globigerina venezuelana, Sphaeroidinellopsis seminulina, and S. subdehiscens. All of these species become extinct between lower Zone N. 19 and basal Zone N. 20. This suggests that McTavish's fauna extends to the base of Zone N. 20, thus is late Miocene to Pliocene rather than late Miocene as it was placed by him.

Zone N. 18 — Globorotalia tumida tumida - Sphaeroidinellopsis subdehiscens paenedehiscens

(Late Miocene - early Pliocene, late Messinian - early Zanclian)

S68-PC10, 479-489 cm; S68-PC23, 382-472 cm (Fig. 5)

The foraminiferal assemblages of this zone in core S68-PC10 from the southern margin of the Ontong Java Plateau are somewhat different in S68-PC23 from the eastern margin.

The faunal assemblage from S68-PC23 is composed of the dominant species Globigerina nepenthes and Globorotalia (T.) acostaensis acostaensis. Globoquadrina altispira altispira, G. altispira globosa, Globorotalia (G.) merotumida, Sphaeroidinellopsis subdehiscens subdehiscens, and S. seminulina seminulina occur frequently. Globorotalia (G.) tumida tumida, G. (G.) tumida plesiotumida and Globigerinoides quadrilobatus fistulosus (Schubert) are rare. The co-existence of Globorotalia (G.) tumida tumida and G. (G.) tumida plesiotumida defines this zone, and the determination is confirmed by the left coiling direction of Pulleniatina primalis Banner and Blow (Hays and others, 1969; Brönnimann and Resig, in press).

The faunal assemblage of the comparable zone on the southern margin of the Ontong Java Plateau (S68-PC10) is quite similar to the above mentioned fauna, but Globorotalia (G.) margaritae Bolli and Bermudez, indicating colder water (Blow, 1969), and Sphaeroidinellopsis subdehiscens paenedehiscens Blow, the immediate ancestor of Sphaeroidinella dehiscens dehiscens (Parker and Jones) are present. Globigerinoides quadrilobatus fistulosus is absent here. The coiling direction of Pulleniatina spectabilis and P. primalis are mostly to the left, thus confirming Zone N. 18. The absence of Globigerinoides quadrilobatus fistulosus might indicate selective solution occurring in this area, or perhaps a different horizon was sampled.

Zone N. 19 Sphaeroidinella dehiscens dehiscens - Globoquadrina altispira altispira

(Pliocene)

S68-PC10, 9-479 cm (Fig. 5); S68-PC21, 565-655 cm (Fig. 4); S68-PC23, 32-372 cm (Fig. 5)

There are slight differences in the faunal assemblages of this age in the cores studied. In core S68-PC21, the dominant species are Pulleniatina primalis, P. obliquiloculata praecursor Banner and Blow, P. obliquiloculata obliquiloculata (Parker and Jones), 70% of which coil to the left, and Globorotalia (G.) tumida tumida, Sphaeroidinellopsis subdehiscens subdehiscens and S. seminulina seminulina are found frequently. Sphaeroidinella dehiscens dehiscens forma immatura (Cushman), which is restricted to this zone, and S. dehiscens dehiscens occur rarely. There are traces of broken specimens of Globigerinoides fistulosus. The dominance of Sphaeroidinellopsis subdehiscens subdehiscens and the left coiling direction of the Pulleniatina spp. indicate the lower part of Zone N. 19 (Hays and others, 1969; Brönnimann and Resig, in press).

In S68-PC10 the foraminiferal assemblage is nearly the same as the above mentioned fauna. The assemblage from 9-479 cm is consistent throughout, except for an anomalous occurrence of what appears to be red Globigerina rubescens Parker at 319 cm. This is unexpected as red specimens of this species range from Pleistocene to Recent (Parker, 1967; Blow, 1969). A few specimens resemble

immature Globigerina conglomerata conglomerata Schwager, which may be pink in color (Resig, personal communication), but most of them are typical G. rubescens.

S68-PC23 contains the same species as S68-PC21, but 98% of the Pulleniatina spp. coil to the right. Globorotalia (T.) crassaformis oceanica Cushman and Bermudez and G. (T.) crassaformis ronda Blow are rare. Globigerina dutertrei d'Orbigny, Globorotalia (G.) tumida flexuosa (Koch), and Globigerina calida praecalida Blow are common. The coiling direction of Pulleniatina spp. and the occurrence of modern species, e.g. Pulleniatina obliquiloculata obliquiloculata and Globigerina dutertrei indicate that this assemblage lies within the upper part of Zone N. 19.

Blow (1969) defined Zone N. 20 by the partial ranges of Globorotalia (G.) multicamerata Cushman and Jarvis and Pulleniatina obliquiloculata obliquiloculata (Parker and Jones), and the species which characterize this zone such as Globorotalia (G.) miocenica Palmer, Globigerina borealis Brady, and Globorotalia (T.) acostaensis pseudopima Blow. Since the concurrence of Globorotalia (G.) multicamerta and Pulleniatina obliquiloculata obliquiloculata ranges from upper Zone N. 19 to within Zone N. 21, Globorotalia (G.) miocenica is not present in the sample studied, Globigerina borealis is a cold water species (Blow, 1969), and Globorotalia (T.) acostaensis pseudopima only sporadically occurs in the samples investigated, it is possible that Zone N. 20 has been overlooked.

Zone N. 21 Globorotalia (T.) tosaensis tenuitheca

(Pliocene to extreme basal Pleistocene)

S68-PC21, 475-555 cm (Fig. 4)

The following are two distinct faunal assemblages of this portion of the section, indicating specimens from Zone N. 19 (assemblage 2) have been reworked into Zone N. 21 (assemblage 1):

1. Globorotalia (Turborotalia) tosaensis tenuitheca Blow G. (T.) tosaensis tosaensis Takayanagi and Saito
   Pulleniatina obliquiloculata obliquiloculata
   Sphaeroidinella dehiscens excavata Banner and Blow
   Globorotalia acostaensis pseudopima Blow
2. Sphaeroidinella dehiscens forma immatura
   Pulleniatina obliquiloculata praecursor
   P. primalis
   Globorotalia (G.) ungulata Bermúdez

Seventy five percent of the Pulleniatina spp. coil to the right in both assemblages.

This zone can be compared to the lower part of the Globigerina dutertrei fauna of the Malaita Group (McTavish, 1966), which is characterized by large numbers of Globigerina dutertrei and the presence of the species Globorotalia truncatulinoides, (it is assumed here that G. (G.) truncatulinoides appears in the higher portion of this fauna), G. tumida tumida, G. puncticulata (Deshayes), G. cultrata multicamerata (Cushman and Jarvis), Pulleniatina obliquilo-

culata, and Sphaeroidinella dehiscens. By looking at the faunal assemblages it can be easily seen that this fauna should lie between the base of Zone N. 20 and the top of Zone N. 23 (Pliocene - Recent). It is impossible to place it in upper Miocene to Pliocene as stated by McTavish (1966).

Zone N. 22 Globorotalia truncatulinoides truncatulinoides

(Pleistocene)

S68-PC7, 45-200 cm (Fig. 6); S68-PC11, 548-908 cm (Fig. 3); S68-PC21, 265-475 cm (Fig. 4); S68-PC23, 22-32 cm (Fig. 5); S67-FFC10, 10-81 cm; S67-FFC11, 8-38 cm (Fig. 6)

Sediments from S68-PC11, S68-PC21 (195-265 cm) and S68-PC23 show no indication of reworked Pliocene foraminifera, but the rest show species reworked from Zone N. 19 into Zone N. 22.

One faunal assemblage contains mainly the common species of Pleistocene age as stated below:

Globorotalia truncatulinoides truncatulinoides

G. (G.) truncatulinoides pachytheca Blow

Globigerina rubescens (red)

G. calida calida

Pulleniatina obliquiloculata finalis Banner and Blow

P. obliquiloculata obliquiloculata

Sphaeroidinella dehiscens excavata

The dominant species are Globorotalia (G.) tumida tumida and Pulleniatina obliquiloculata obliquiloculata. Globorotalia (G.) cultrata menardii (Parker, Jones and Brady)

S67-FFC11
S67-FFC10
S68-PC7
Cm
N.23
N.22
-8
-38
-10
-80
-0
-45
-200
Pleistocene sediments
Reworked Pliocene sediments
H. digitata digitata
G. calida calida
P. obliquiloculata finalis
P. obliquiloculata obliquiloculata
G. rubescens (red)
G. truncatulinoides truncatulinoides
G. decoraperta
G. margaritae
G. cultrata cultrata
G. cultrata menardii
G. tumida tumida

and G. (G.) cultrata cultrata (d'Orbigny) are larger than the same species in the Pliocene. They predominantly coil to the left indicating a Pleistocene age, as stated by Ericson and others (1963) and Bandy (1967a).

Sediments of S68-PC11 (248-908 cm) are peculiar. The fauna in this interval shows a consistently Pleistocene age, but sporadically a few specimens of Sphaeroidinella dehiscens dehiscens forma immatura occur. There are no other indications of the presence of Pliocene fauna. This might suggest that S. dehiscens dehiscens forma immatura is not restricted to Zone N. 19.

The second faunal assemblage contains not only the species of the first, but also species from reworked Pliocene (N. 19) strata as listed below:

Sphaeroidinella dehiscens dehiscens forma immatura

Globigerinoides quadrilobatus fistulosus

Pulleniatina primalis

P. obliquiloculata praecursor

Globoquadrina altispira altispira

G. altispira globosa

This zone can be compared to the middle part of the Globigerina dutertrei fauna (Table 2), of the Malaita Group, British Solomon Islands (McTavish, 1966).

Zone N. 23 Hastigerinella digitata digitata/ Hastigerina adamsi

(Late Pleistocene-Holocene)

S68-PC7, 0-45 cm (Fig. 6); S68-PC11, 0-548 cm (Fig. 3); S68-PC21, 0-195 cm

(Fig. 4); S68-PC23, 0-22 cm (Fig. 5); S67-FFC10, 0-10 cm; S67-FFC11, 0-8 cm (Fig. 6)

The writer is reluctant to use the name Globigerina calida calida/Sphaeroidinella dehiscens excavata to define Zone N. 23 as both S. dehiscens excavata and G. calida calida were found to extend below Zone N. 23. Sphaeroidinella dehiscens excavata extended at least to Zone N. 21, and Globigerina calida calida at least to Zone N. 22. Thus it is impossible to use these species to distinguish this zone from the older zone N. 22. The writer found Hastigerinella digitata digitata and Hastigerina (B.) adamsi to be restricted to this interval, and thus they can be used as indices of Zone N. 23. In addition Brönnimann and Resig (in press) suggest the first occurrence of Hastigerina adamsi in defining the base of N. 23 and the top of N. 22.

Essentially the same foraminiferal assemblages continue from the underlying zone into this zone. Hastigerinella digitata digitata is found more frequently than Hastigerina (B.) adamsi. Globigerinoides ruber (d'Orbigny), which ranges back to late Miocene, reaches its acme in this zone.

Bandy (1967b) found in a study of deep basinal cores from off Southern California, a significant increase in the number of radiolarians per gram of sediment at and above the Pleistocene boundary. Frerichs (1968) also found the same trend in his study of the sediments from the Indian Ocean, and Duncan and others (1970) used the percentage of

planktonic foraminifera and radiolarians as the parameter for determining Holocene sediments off Oregon. He concluded that above this boundary the percentage of radiolarians to foraminifera is between 50-100%, whereas below the boundary the foraminifera constitute almost 100% of the faunal relationship.

The writer has perceived the same trend in the sediments of S68-PC23 (5 cm) and S68-PC21 (0-2 cm) which are characterized by 50-60% radiolarians, indicating warmer periods, whereas below these horizons, their numbers decrease to 0 to 5%, indicating glacial periods. The faunal boundary changes are abrupt, as indicated by Duncan and others (1970). Thus the Pleistocene - Holocene boundary can be placed at the level mentioned above. Even though these two cores are located near the compensation depth, severe solution fails to explain why there is a high foraminiferal content below the Pleistocene - Holocene boundary. If solution acted above the boundary, it should have acted more or less on the sediments below the boundary. The other cores show no remarkable change in the percentages of these two microfossils. They are mostly located at the flanks of the plateau, where slumping and gravity sliding is prevalent; thus the Holocene sediments may have been transported away.

This zone is comparable to the upper part of the Globigerina dutertrei fauna (Table 2), the Malaita Group, British Solomon Islands (McTavish, 1966).

Systematic Paleontology

Two species require further mention because of the particular variance of each with previously published information. The specimens designated Globorotalia (T.) obesa in this report are somewhat different than Bolli's (1957) holotype, but were considered to be within the range of variation of the species. In addition, specimens of Sphaeroidinella dehiscens dehiscens forma immatura in typical development occur in the core outside of the commonly accepted range of the species, and identification of this form therefore requires special confirmation. These species are discussed fully below:

Globorotalia (T.) obesa Bolli, Pl. III, fig. 10a-c.

Globorotalia obesa Bolli, 1957, U. S. Nat. Mus., Bull., No. 215, p. 119, pl. 29, figs. 2a-3.

Shape of the specimens in the Hawaii Institute of Geophysics core: Low trochospiral, containing 9-10 chambers arranged in 2 1/2 whorls, with 4 1/2 chambers in the final whorl. The chambers increase in size rapidly, but less so than in the holotype. The ventral cameral sutures are radial and shallow rather than deeply incised as in the holotype; dorsal cameral sutures radial and rather deep. Thus, the chambers are not as separated as in the holotype. The umbilicus is fairly wide and deep. The aperture is an interior marginal, umbilical - extraumbilical, moderately

high arch, bordered by a thin rim-like lip. The aperture is slightly lower than that of the holotype. Wall, calcareous, finely pitted with short spines.

Largest diameter: 0.5-0.6 mm

Occurrence: S68-PC10, 69-470 cm

Remarks: This species resembles Globorotalia (T.) acostaensis pseudopima, which first occurs in the middle Pliocene, but the species described contains a more highly arched aperture than Globorotalia (T.) acostaensis pseudopima.

Sphaeroidinella dehiscens dehiscens forma immatura (Cushman) Pl. III, fig. 15a-b.

Sphaeroidinella dehiscens forma immatura (Cushman), 1919, Carnegie Inst., Washington, Publ., Washington, no. 291, p. 40, pl. 14, fig. 2.

Sphaeroidinella dehiscens (Parker and Jones), Parker, 1967, Bull. Amer. Paleont., vol. 52, no. 235, p. 160, pl. 23, fig. 8a.

Sphaeroidinella dehiscens immatura (Cushman), Brönnimann and Resig, in press, from DSDP Site 64.

Test small, the largest specimen is approximately 0.5 mm in diameter. Chambers are not well separated. Primary aperture is a closed, elongated slit. The test is similar to Sphaeroidinellopsis subdehiscens subdehiscens in size and shape, but it possesses a small, circular or oval dorsal supplementary aperture.

S. dehiscens dehiscens forma immatura occurs mainly from the base to the upper part of Zone N. 19, but some are found sporadically in sediments of Pleistocene age in core S68-PC11

(248-908 cm).

CONCLUSION

The Ontong Java Plateau is an area of moderately complex physiographic patterns. A thick sedimentary column with a high rate of accumulation occurs at the central part, whereas thinner sedimentary layers that accumulated more slowly are at the margins. Hiatuses in the sedimentary column are common around the periphery. The sediments are composed mainly of calcareous microfossil skeletons, mainly foraminifera and nannofossils. The nannofossils predominate over foraminifera and radiolaria in the late Eocene to Pliocene sediments, but the Pleistocene sediments contain more foraminifera than nannofossils. Adequate, generally well-preserved foraminifera enable correlations to be made with Banner and Blow's (1965a) and Blow's (1969) Neogene (N. Zonation, although there is some indication of severe selective solution of sediments deposited at approximately 4,000 meters. Discoasters, which occurred throughout the core length of all the cores studied except core S68-PC11 (0-758 cm), assisted in determining the reworking of older sediments into the younger ones.

The foraminiferal biozones of the Ontong Java Plateau correlate well with the foraminiferal fauna of the Malaita Group, British Solomon Islands (McTavish, 1966). This

evidence can be used as one criterion for suggesting that the island of Malaita formed from a part of the Ontong Java Plateau.

The ranges of Globigerina calida calida and Sphaeroidinella dehiscens excavata in the plateau sediments extend at least to Zone N. 22, and thus the species cannot be used as the index fossils defining Zone N. 23. Hastigerinella digitata digitata and Hastigerina (B.) adamsi are proposed as the indices for recognizing Zone N. 23.

Sphaeroidinella dehiscens dehiscens forma immatura was found sporadically in Pleistocene sediments that contained no other foraminiferal indices of the Pliocene. Thus the previously accepted restriction of this species to Zone N. 19 should be reconsidered.

Explanation of Plate I

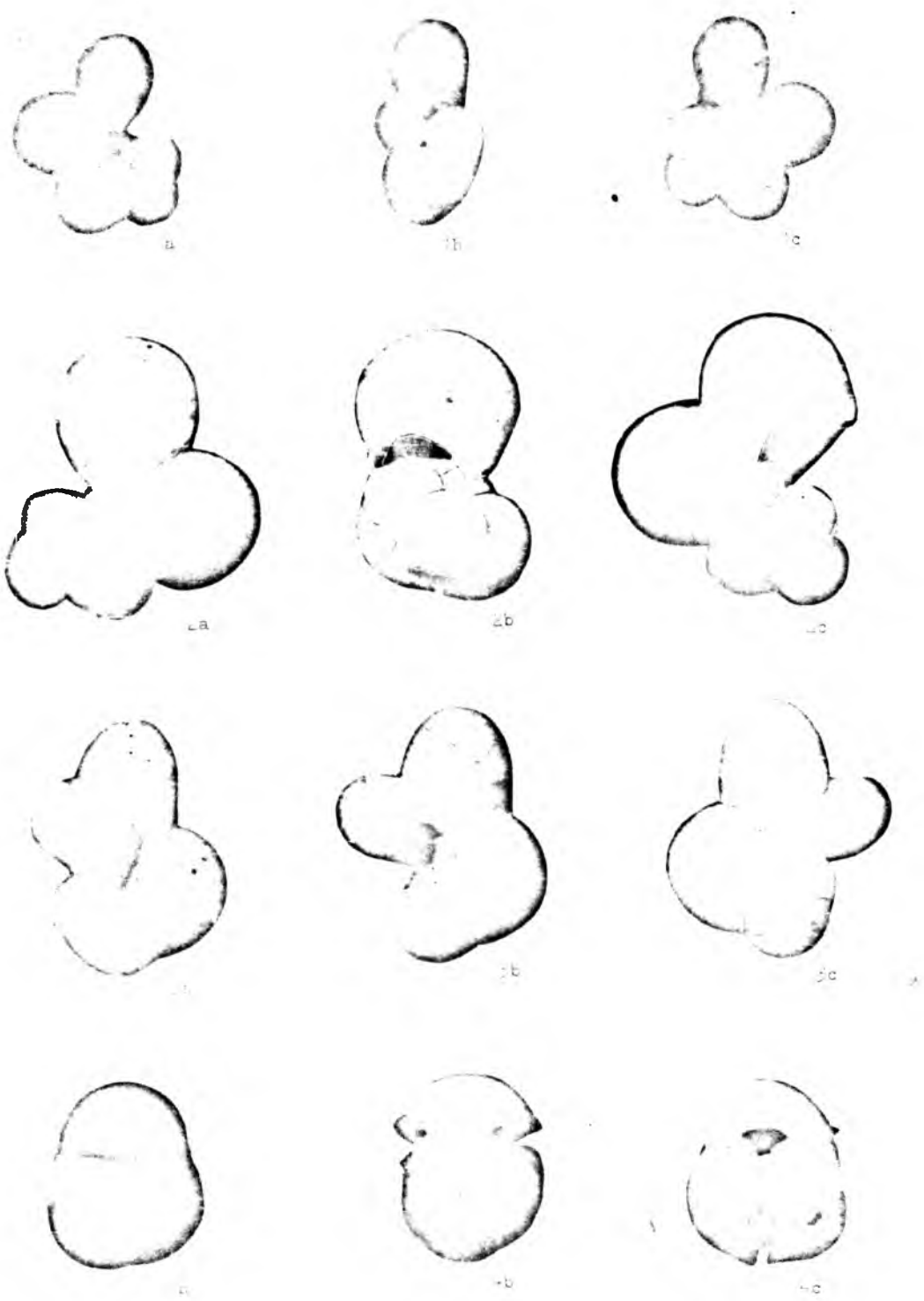
Figure

1a-c *Globigerina calida calida* Parker
X50, from Sample S68-PC7, 45 cm; fig. 1a, umbilical view; fig. 1b, side view; fig. 1c, spiral view.

2a-c *Hastigerina* (B.) *adamsi* Banner and Blow
X50, from Sample S68-PC23, 12 cm; fig. 2a, umbilical view; fig. 2b, side view; fig. 2c, spiral view.

3a-c *Hastigerinella digitata digitata* Brady
X50, from Sample S68-PC11, 8 cm; fig. 3a, umbilical view; fig. 3b, side view; fig. 3c, spiral view.

4a-c *Sphaeroidinella dehiscens excavata* Banner and Blow
X50, from Sample S68-PC21, 55 cm; fig. 4a, umbilical view; fig. 4b, side view; fig. 4c, spiral view.



Explanation of Plate II

Figure

5a-c *Globorotalia (G.) merotumida* Blow and Banner
X50, from Sample S68-PC11, 918 cm;
fig. 5a, umbilical view; fig. 5b,
side view; fig. 5c, spiral view.

6a-c *Globorotalia (G.) tumida plesiotumida* Blow and Banner
X50, from Sample S68-PC11, 918 cm;
fig. 6a, umbilical view; fig. 6b,
side view; fig. 6c, spiral view.

7a-c *Globorotalia (G.) tumida tumida* (Brady)
X50, from Sample S68-PC23, 382 cm;
fig. 7a, umbilical view; fig. 7b,
side view; fig. 7c, spiral view.

8a-c *Globorotalia (T.) tosaensis tosaensis*
Takayanagi and Saito
X50, from Sample S68-PC21, 465 cm;
fig. 8a, umbilical view; fig. 8b,
side view; fig. 8c, spiral view.

9a-c *Globorotalia (G.) truncatulinoides*
truncatulinoides (d'Orbigny)
X50, from Sample S68-PC21, 265 cm;
fig. 9a, umbilical view; fig. 9b,
side view; fig. 9c, spiral view.

PLATE II

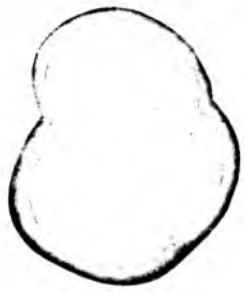
5a

5b

5c

6a

6b



6c

7a

7b

7c

8a

8b

8c

9a

9b

9c

Explanation of Plate III

Figure

10a-c *Globorotalia (T.) obesa* Bolli
X50, from Sample S68-PC10, 319 cm;
fig. 10a, umbilical view; fig. 10b,
side view of a specimen showing the aperture
which is comparatively more arched than in
Globorotalia (T.) acostaensis pseudopima
(fig. 11b); fig. 10c, spiral view.

11a-c *Globorotalia (T.) acostaensis pseudopima* Blow
X50, from Sample S68-PC11, 498 cm;
fig. 11a, umbilical view, test is comparatively
more compact than in G. (T.) obesa;
fig. 11b, side view; fig. 11c, spiral view.

12a-c *Globigerina rubescens* (red) Parker
X50, from Sample S67-FFC11, 8 cm;
fig. 12a, umbilical view; fig. 12b,
side view; fig. 12c, spiral view.

13 *Globigerina nepenthes* Todd
X50, from Sample S68-PC23, 382 cm;
umbilical view.

14 *Globigerinoides quadrilobatus fistulosus* (Schubert)
X25, from Sample S68-PC23, 102 cm;
umbilical view.

15a-b *Sphaeroidinella dehiscens forma immatura* (Cushman)
X50, from Sample S68-PC11, 258 cm;
fig. 15a, umbilical view showing small, sub-
sphaerical dorsal opening; fig. 15b, side view.

16a-b *Sphaeroidinellopsis subdehiscens subdehiscens* (Blow)
X50, from Sample S68-PC21, 565 cm; fig. 16a,
umbilical view showing an elongate, slit-
like aperture; fig. 16b, spiral view.

17a-c *Sphaeroidinellopsis seminulina seminulina* (Schwager)
X50, from Sample S68-PC10, 319 cm; fig. 17a,
umbilical view of a specimen containing four
chambers; fig. 17b, side view showing deep
and wide apertural opening; fig. 17c, spiral view.

18 *Pulleniatina obliquiloculata finalis* Banner and Blow
50X, from Sample S68-PC11, 350 cm;
side view.

PLATE III

10a

10b

10c

11a

11b

11c

12a

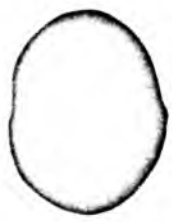
12b

12c

13

14

15a



15b

16a

16b

17a

17b

17c

18

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