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GULF OF MEXICO DEEP-WATER FORAMINIFERS

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PREFACE

In recent years the study of paleoenvironments has come to play an important role in exploration for petroleum deposits. This is especially true in offshore areas, where every available tool must be used to minimize the high cost of exploration in this highly competitive province. The evaluation and selection of the most favorable prospects depend on integrated results based on geophysical, geological, paleontological, and geochemical studies. The need for detailed knowledge of environments of deposition, sedimentation, and structural-growth history is critical.

The use of foraminifers is a proven and accepted method to interpret the depositional and environmental history of a basin. Foraminifers reflect environmental factors such as depth of water, salinity, sediment type, water temperature, and turbidity at the time of deposition and can, therefore, be used to distinguish paleoenvironments.

In 1966 Esso Production Research Company undertook a series of oceanographic surveys to supply specific information on sedimentologic and ecologic processes. Texas A & M University's R/V *Alaminos* surveyed and sampled along two selected profiles across the continental slope and abyssal plain of the Gulf of Mexico during September 1966. A third profile was sampled during September 1967 from the *Western Shoal,* a geophysical survey ship.

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GULF OF MEXICO DEEP-WATER FORAMINIFERS

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ABSTRACT

A new and more precise bathymetric zonation is proposed based on the distribution of benthic foraminifers primarily from the northern continental slope and abyssal plain of the Gulf of Mexico. Ninety-nine bathymetric indicator species selected from the 328 foraminiferal species identified in this study form the basis for the bathymetric subdivisions. Fourteen benthic species have upper depth limits within the neritic zone. Thirty-two species, including four rare auxiliary species, have upper depth limits within the upper bathyal zone. Twenty-eight species, including five rare auxiliary species, have upper depth limits within the middle bathyal zone, while 19 species are characteristic of the lower bathyal zone. Six species have upper depth limits within the abyssal zone, supplemented by abundance values from 4 additional species.

Twenty-six of the 99 bathymetric indicator species are considered to be isobathyal forms and form the framework for the bathymetric zonation. Fifty-seven species show varying upper depth limits associated with the Mississippi River deltaic area. Of these, 43 species show depressed upper depth limits, whereas 14 have elevated upper depth limits.

The bathymetric distribution of foraminifers from more than 20 genera representing either successions of valid taxonomic species or morphologic gradations of single species (clines) are used as auxiliary bathymetric indicators.

Six general faunal trends provide supplemental ecologic information. A dramatic increase occurs in foraminiferal/ostracode ratios with distance from shore and with increase in water depth. Radiolarians are of greatest abundance in bottom sediments from the lower bathyal and abyssal zones. Numbers of benthic species increase with increasing depth from shore into the bathyal zone; beyond this water depth the numbers decrease somewhat. Agglutinated foraminifers become more abundant with depth, increasing from about 5 percent of the benthic population in the upper bathyal zone to values of about 15 percent or more in many samples from the lower bathyal and abyssal zones. Planktonic foraminifers show a general increase in abundance to values of 50 percent of the foraminiferal assemblages in the lower neritic zone and to more than 90 percent in the lower bathyal and abyssal zones. Several planktonic species develop tests with a thick crystalline crust in upper bathyal and deeper water depths.

Benthic foraminiferal distribution in either clastic or carbonate environments also provides supplemental ecologic information. At least 20 species are more characteristic of clastic facies in the western Gulf of Mexico than in eastern carbonate facies, whereas four species are more characteristic of carbonate facies.

Several faunal-geochemical boundary associations were noted. Bathymetric faunal changes occur at a temperature boundary at a water depth of 3,000 feet in the Gulf of Mexico, a prominent oxygen-minimum zone within the upper bathyal zone, and an Eh gradient off the Mississippi delta. It is clear that any one geochemical factor does not control the bathymetric zonation observed in the Gulf of Mexico. Hydrostatic pressure is suggested to represent a primary limiting factor controlling benthic foraminifer bathymetric distribution in view of the similar depth zonations of benthic foraminifers in many different oceanic water masses.

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We wish to acknowledge the assistance given to us during the study by the late Dr. Orville L. Bandy. His knowledge of deep-water foraminifera, oceanographic techniques, and marine environments proved to be extremely useful. His help in the identification of species and environmental analyses was especially helpful and informative.

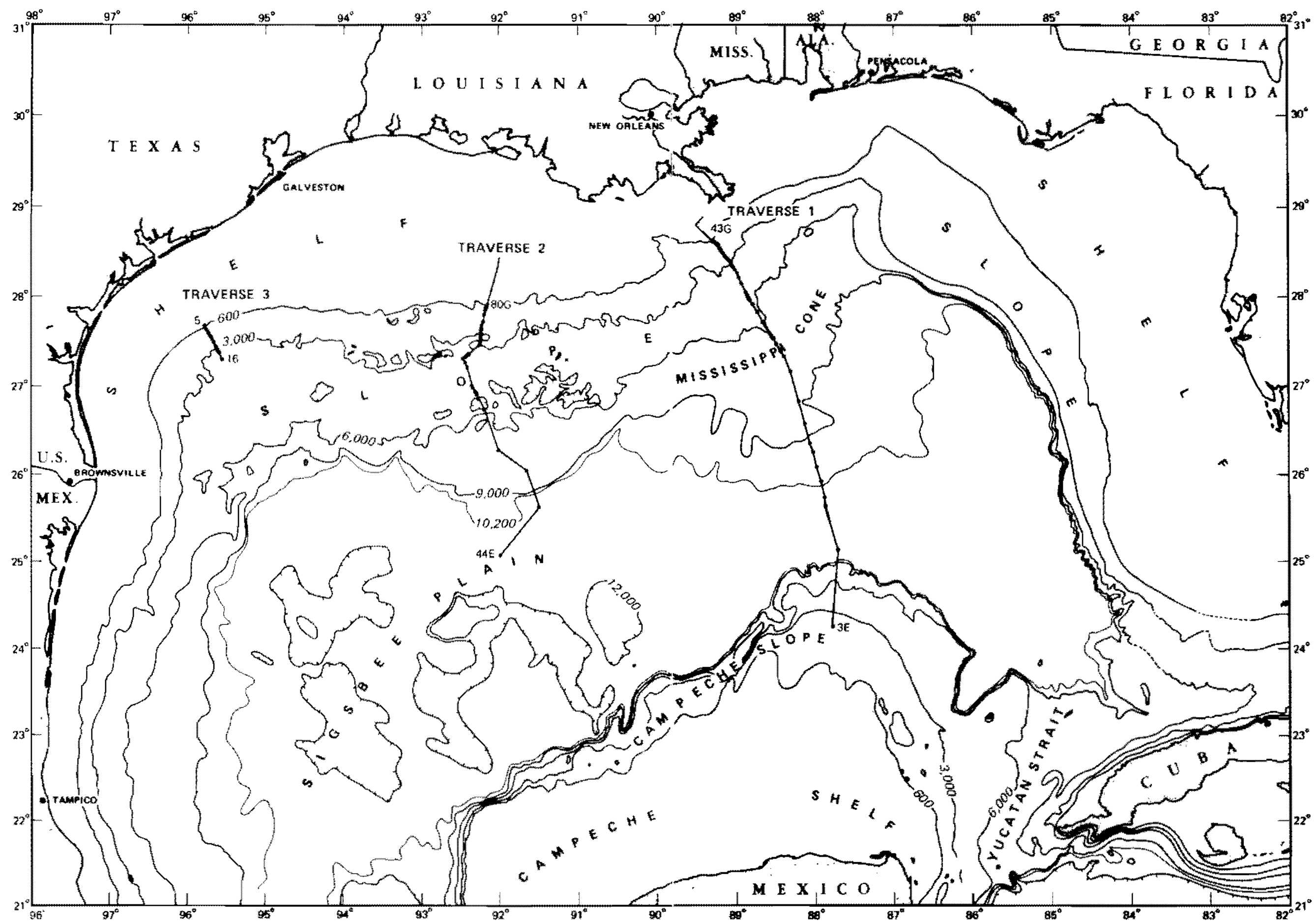

FIGURE 1

Location of deep-water ecology *Alaminos* and *Western Shoal* traverses in the Gulf of Mexico. Contours in feet.

INTRODUCTION

The deep-water ecology study along the northern continental slope and abyssal plain of the Gulf of Mexico (figs. 1, 2) has refined the bathymetric zonation used by most paleontologists along the Gulf Coast (fig. 3) and documented the distribution and abundance of 328 species of foraminifers. This documentation includes the identification of water-depth indicator species, water-depth variation of indicator species adjacent to a major depocenter (the Mississippi delta), morphologic gradations of species with increasing water depth, and the definition of several faunal trends.

The refined bathymetric zonation shown in figure 3 contains a series of bathymetric subdivisions based on the upper depth limits, abundance values, and morphologic gradations of water-depth indicator species. The major bathymetric boundaries, however, i.e., neritic-bathyal, upper-middle bathyal, etc., remain unchanged. Subdivisions from water depths from 600 to 7,000 feet are based primarily on the upper depth limits of indicator species, whereas those from water depths of 8,000 to 11,000 feet are based primarily on faunal abundance.

Upper depth limit verification, as a result of this study, was made for species such as *Cyclammina cancellata* Brady previously reported from water depths of 1,500 feet and that of *Melonis pompilioides* (Fichtel and Moll) thought to be 6,000 feet. On the other hand, *Pseudoclavulina mexicana* (Cushman) thought by some paleontologists to have upper depth limits below 3,000 feet was shown to range upward to a water depth of 762 feet in the Gulf of Mexico. In another case, *Pullenia bulloides* (d'Orbigny), previously interpreted to

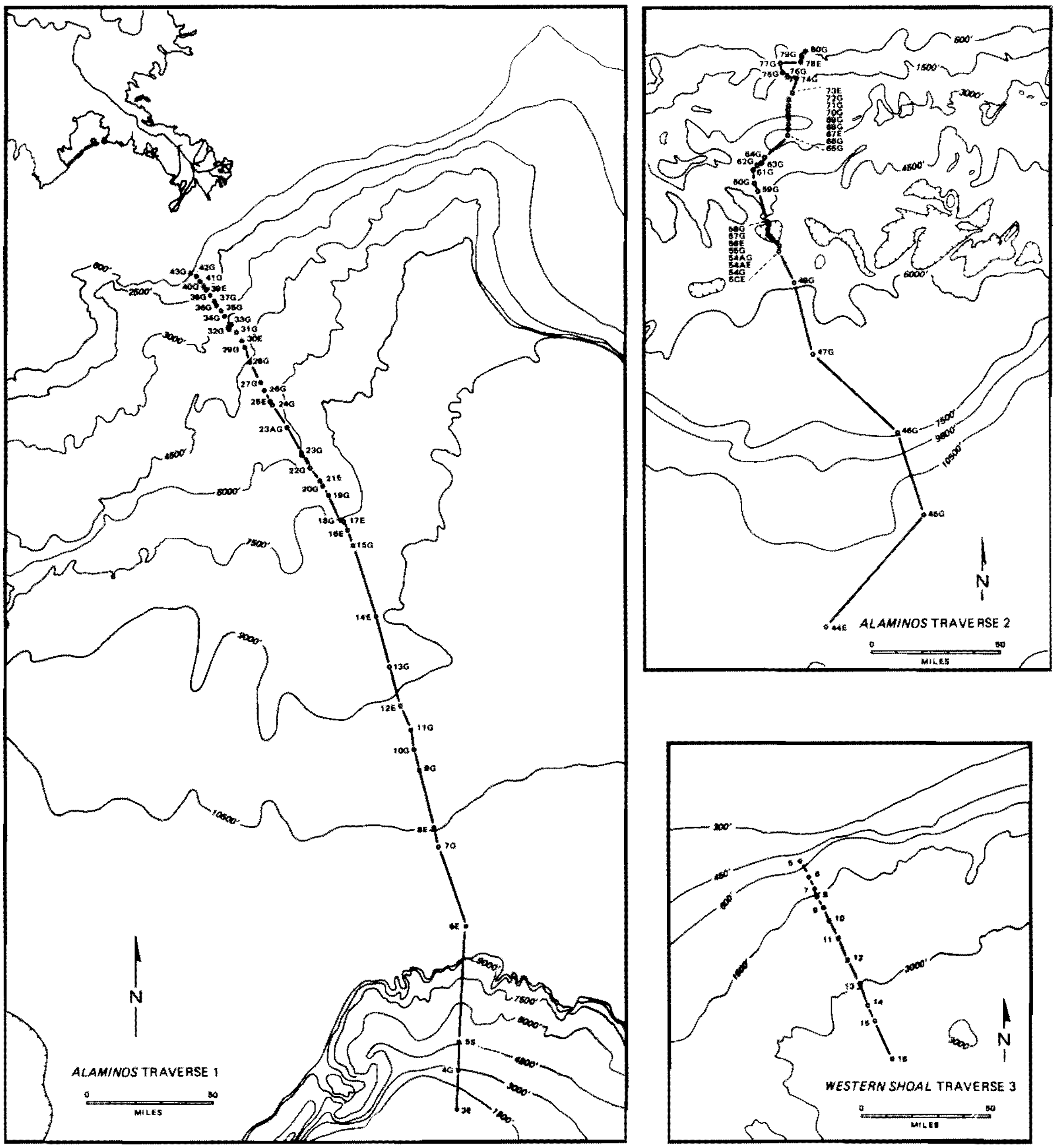

FIGURE 2

Deep-water ecology sample locations.

range bathymetrically no higher than 1,500 feet in fossil faunas, was found represented by small specimens in water depths as shallow as 500 feet.

The recognition of species with depressed or elevated upper depth limits adjacent to a major depocenter raises the intriguing possibility of recognizing and reconstructing ancient delta-influenced deep-water environments.

The morphologic variability of species related to water depth was examined in detail. Attempts were made to recognize as many morphovariants of a species as possible to determine which species are morphologically stable throughout their water-depth range and which species contain morphologic variations useful as bathymetric indicators. As a result, the ornamentational, or test length/width, and size varia-

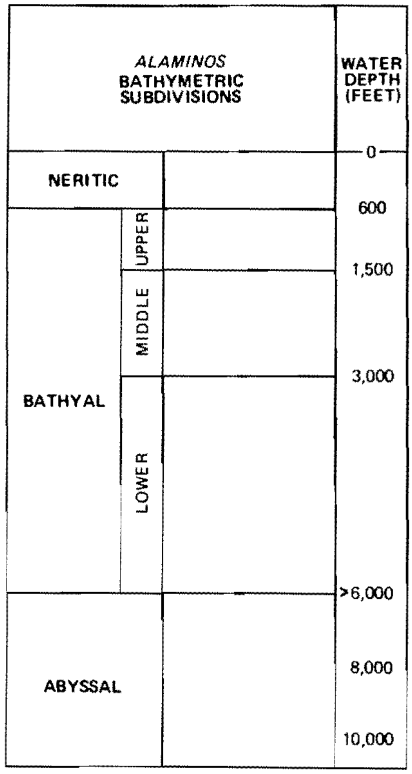

FIGURE 3

General bathymetric zonation (adapted from Tipsword, Setzer and Smith, 1966).

tions noted in this study should be useful in making paleoenvironmental interpretations.

The need to more precisely define foraminiferal depth ranges involves coordinated faunal-geochemical studies. The geochemical data in this study represent the first attempt toward these goals, and the data are impressive. A number of geochemical boundaries were found to be likewise faunal boundaries, although specific faunal-geochemical relationships are difficult to assess. Examination of the geochemical changes taking place at depth in the sediment cores points to the need to understand more completely the effects of postdepositional geochemical alteration on the fauna, i.e., which species are destroyed first and which fossil assemblages represent chemical artifacts.

Paleoenvironmental-foraminiferal interpretation is based primarily on as complete an understanding as possible of present foraminiferal distribution. Prior to this study Gulf of Mexico paleontologists were severely limited by the lack of observational data. Even now a review of existing foraminiferal depth zonations from any worldwide location shows depth zones closely spaced in shallow water and progressively wider spaced in bathyal and abyssal water depths. It was to improve our understanding of deep-water foraminiferal ecology that the present comprehensive study of Recent Gulf of Mexico foraminifers was initiated.

Three traverses were made along the northern slope of the Gulf of Mexico (fig. 1). Traverses 1 and 2 were run in September 1966, using the Texas A&M R/V *Alaminos*, whereas traverse 3 was made in September 1967, using Western Geophysical's M/V *Western Shoal.* Traverse 1, as shown in figure 2, is approximately 320 nautical miles in length and extends south-southeast from water depths of 498 feet off the Mississippi delta down the smooth slope of the Mississippi cone to 11,442 feet on the abyssal plain; one sample was obtained in 1,164 feet of water on the Campeche slope at the extreme south end of the traverse. Traverse 2 (fig. 2) is approximately 210 nautical miles in length and extends south from water depths of 594 feet south of Vermilion Bay, Lousiana, across the basin and knoll topography of the central slope down the Sigsbee escarpment to water depths of 11,532 feet. Traverse 3 (fig. 2) is approximately 20 nautical miles in length and begins south of Matagorda Bay in 534 feet of water and crosses the relatively smooth northwest slope to water depths of 3,864 feet.

Eighty-seven cores, 6 to 40 feet long, were taken along the three traverses (see table A-1). These include 72 six-foot gravity cores and 15 Ewing piston cores. In addition, a Shipek sediment sampler was used at one station, and a single dredge sample was taken in the Mississippi trough. Generally, samples were collected at about 300-foot intervals to a water depth of 8,000 feet and at 600-foot intervals at greater water depths. The three traverses were made along tracks of previously run seismic (arcer) lines.

Geochemical analyses were made of the sediment cores to determine the chemical controls on the microfaunal distribution. These included determinations for Eh (oxidation-reduction potential), pH, oxygen content, temperature, chlorinity, nitrate content, phosphate content, organic carbon, and carbon isotope ratios (C^{13}/C^{12}) (see appendices A, B). Water samples were collected at 11 stations using Nansen bottles attached to the line about 75 feet above the core barrel; additional water samples were taken in various water depths at two deep-water stations.

Detailed comparisons of the results of the Foraminiferal Ecology study were made with the earlier studies of Phleger (1951) in the northwestern Gulf of Mexico and Parker (1954) in the northeastern Gulf of Mexico. Walton (1964) more recently completed an extensive report of modern facies in the Gulf of Mexico while Phleger (1960) gives a good summary of earlier studies.

BATHYMETRIC ZONATION

Eighteen bathymetric subdivisions are proposed for bathyal and abyssal water depths along the northern slope of the Gulf of Mexico as shown in table 1. These subdivisions are defined by the upper depth limits or abundance of foraminiferal indicator species chosen from the total foraminiferal fauna for the following reasons: (1) they are common or abundant forms, (2) they are members of clines or morphologic gradients, (3) they are identical or similar to important fossil indicators, or (4) they appear to be unique forms that are useful in depth zonation. The indicator species include both isobathyal forms, or those with essentially similar worldwide upper depth limits, and heterobathyal forms, or species with varying upper depth limits.

Upper depth limits of indicator species in the three traverses of this study (western and north-central Gulf slope clastic facies) are compared with data from Phleger (1951) for the same area and from Parker (1954) for the eastern carbonate facies of the Gulf and listed on the right-hand side of table 1. The absolute upper depth limit of most of the species is represented by one or two rare occurrences or questionable occurrences; the number of individuals per sample for many species increases greatly with increasing water depth. Therefore, rare occurrences of a species above its typical depth zone are indicated by a footnote.

The foraminiferal depth subdivisions are, for the most part, correlated with the general bathymetric classification used by many Gulf of Mexico geologists and published in G.C.A.G.S. Transactions, 1966, p. 119, i.e., inner neritic (0–60 feet), middle neritic (60–300 feet), outer neritic (300–600 feet), upper bathyal (600–1,500 feet), middle bathyal (1,500–3,000 feet), lower bathyal (3,000–6,000 feet), and abyssal (6,000 feet). This major water depth zonation and its subdivisions are indicated in table 1.

There are essentially no faunal data from the neritic zone in this study; however, the published upper depth limits of bathyal species that range into the neritic zone are shown on table 1. In addition, water depth ranges of the species listed in table 1 are limited to an accuracy of ±300 feet as most of the sampling was spaced at about 300-foot water depth increments.

Rare auxiliary species listed in table 1 provide supplementary bathymetric information but are not regarded as indicator species owing to their rare or sporadic occurrence. In addition, several species are listed that also occur in many Neogene deposits, as their distribution characteristics may prove to be useful in applied studies. These species include *Alveovalvulinella pozonensis* (Cushman and Renz), a species previously thought to be extinct, and *Amphicoryna hispida* (d'Orbigny).

Auxiliary data provide abundance or size data for the indicator species. It is clear, however, that abundance values as such may not apply to many fossil studies for several reasons: faunas from well cuttings often represent mixtures of biofacies; postdepositional selective solution of species may alter abundance values; and variations in the character of environment, such as changes in the temperature gradient, may influence faunal abundance. Increases in the size of individuals with depth are noted as size trends, and these may vary geographically. Auxiliary data are therefore not to be used as absolute values. Instead, they represent trends that are shown to vary with environmental factors and thus represent additional tools to use in the interpretation of fossil assemblages.

ISOBATHYAL SPECIES

Twenty-seven isobathyal species, or those having more or less consistent upper depth limits, in samples from various traverses and in different water masses are shown in table 2. These include seven species with an upper depth limit at about 600 feet, five with upper depth limits at about 900 feet, three species with upper depth limits at about 1,200 feet, one with an upper depth limit at 1,500 feet, five with upper limits at about 2,000 feet, and then single representatives at each of six additional deeper water depths. Thus, groups of isobathyal species provide depth control for water depths in the upper and middle bathyal zones whereas single species only are available for control at lower bathyal and abyssal water depths. The decline in species available for control in deeper water is due in part to the decline in the number of species and to the lack of detailed study of deeper water biofacies.

Isobathyal species form the basic framework for the bathymetric subdivisions as they appear to be little affected by environmental conditions such as what has been termed the "delta effect." There are good arguments against the very concept of isobathyal species; however, the validity of this concept is dependent in large part upon the degree of precision involved. Variations of upper depth limits are related to factors such as sampling interval, method of sampling, and variations in species concept from one investigator to

TABLE 1

Bathymetric indicator species.

UPPER DEPTH LIMIT (FEET)	SPECIES	UPPER DEPTH LIMITS (FEET) *WESTERN GULF	DEEP-WATER ECOLOGY TRAVERSES 3	2	1	EASTERN** GULF
	NERITIC ZONE, BATHYAL SPECIES WITH UPPER DEPTH LIMITS IN THE NERITIC ZONE					
100	*Eponides turgidus*	100				100
150	*Planulina ariminensis*	150		1,146	984 (498)[1]	600
150	*Pullenia quinqueloba*	150			762 (498)[1]	300
200	*Melonis barleeanus*	200 ?			762	200 ?
200	*Oridorsalis tener stellatus*	200			498[1]	200
300	*Anomalina corpulenta*	300			762	300
300	*Glomospira charoides*	300			1,230	600
300	*Hoeglundina elegans*	300			498[1]	300
300	*Planulina foveolata*	275			498[1]	260
300	*Pullenia bulloides*	300			762 (498)[1]	600
300	*Sphaeroidina bulloides*	300			498[1]	300
300	*Uvigerina flintii*	328			762	250 ?
	UPPER BATHYAL ZONE					
600	*Bolivina albatrossi*	600	906	594[1]	762	600
	Bulimina striata mexicana	600	534[1]	594[1]	498[1]	600
	Chilostomella oolina	600	906	594[1]	498[1]	600
	Epistominella exigua		1,506	1,146	1,962	600
	Eponides regularis	600	534[1]	594[1]	498[1]	600
	Gyroidina altiformis cushmani	600	534[1]	594[1]	762	600
	Haplophragmoides bradyi	600	534[1]	1,146	1,230	600
	Rotorbinella translucens	600	906	594 ?	984	600
	Uvigerina peregrina	600	534[1]	594[1]	498[1]	600
	Valvulineria complanata		906	1,212	498[1]	
900	*Bathysiphon filiformis*		1,224	918 ?	3,270	
	Bulimina aculeata	900	1,224	1,146	1,230	900
	Bulimina rostrata alazanensis	900	1,506	1,146	1,230	1,500
	Haplophragmoides sphaeriloculus		1,224	1,536	762	
	Osangularia rugosa	900	1,224	1,146	1,410	900
	Uvigerina peregrina dirupta		1,224	918	984	
	Uvigerina peregrina mediterranea		1,224	918	762	
	RARE AUXILIARY SPECIES					
	Alveovalvulinella pozonensis				762	
	Amphicoryna hispida		1,224	918	1,410	
	Cassidulinoides tenuis			1,230	2,640	840
	Ehrenbergina trigona		1,224	918		
1,200	*Ammodiscoides turbinatus*		1,224	1,536	2,964	
	Ammodiscus planorbis		1,824	1,572	1,230	
	Cibicides bantamensis		1,224	1,230	1,230	
	Cibicides robertsonianus	1,500	1,506	1,572	2,358	1,200
	Cribrostomoides scitulus ?		2,730	1,536	1,230	
	Cribrostomoides wiesneri		1,506	1,212	1,230	

NOTE: Parentheses indicate occurrence at depth in core samples.

*Phleger (1951).

**Parker (1954), Bandy (1956).

[1] Shallowest sample taken on traverse.

TABLE 1. (continued)

UPPER DEPTH LIMIT (FEET)	SPECIES	WESTERN GULF	DEEP-WATER ECOLOGY TRAVERSES 3	2	1	EASTERN GULF
		UPPER DEPTH LIMITS (FEET)				
1,200	*Eggerella propinqua*		1,824	1,212	1,722	
	Gyroidina orbicularis	1,200	1,224	1,212	1,410	1,200
	Karreriella apicularis	1,200	1,224	918 ?	4,092[A]	1,200
	Laticarinina pauperata	1,200	1,224	1,146	2,178	1,200
	Reophax dentaliniformis		1,224	1,836	2,178	
	Reticulophragmium venezuelanum		1,224	1,536	1,230	
	Tosaia weaveri		1,506	1,146	2,178	
	MIDDLE BATHYAL ZONE					
1,500	*Ammolagena clavata*		2,496	1,572	3,636	
	Cibicides bradyi		1,506	1,536	3,270 (2,178)	
	Cribrostomoides subglobosus		2,148	1,572	1,722[B]	
	Cyclammina cancellata	1,500	1,506	1,536	1,410	2,000
	Cystammina pauciloculata		1,506	1,536	2,640	
	Globocassidulina murrhyna		1,506	2,118	1,722	
	Hormosina carpenteri		2,496	1,536		
	Hormosina globulifera		1,506 ?	2,118	2,178	
	Reophax pilulifer			1,572	1,722	
	Trochammina globulosa		3,324	2,118	1,410 ?	3,500
	Valvulineria "opima"		1,506	2,448	2,640	
	AUXILIARY DATA					
	2% values, *Chilostomella oolina*					
	2% values, *Epistominella exigua*					
	10% values, *Sphaeroidina bulloides* (0.7 mm diameter)					
	Base of 10% values for *Uvigerina peregrina*					
2,000	*Cibicides kullenbergi*			1,836	4,092 (2,178)	2,000
	Cibicides rugosus	3,000	2,148	2,448	2,178	2,000
	Cibicides wuellerstorfi	2,000 ?	3,324	2,328*	3,270	1,500 ?
	Cribrostomoides umbilicatus			2,118	4,338	
	Eponides polius	2,000	1,824	2,328	4,778[1] (2,358)	2,000
	Oridorsalis tener umbonatus		2,148	2,118	2,964 (2,640)	
	Osangularia culter	2,000	1,824	1,836	2,178	2,000
	Uvigerina spinicostata		1,824	2,118	2,964	
	RARE AUXILIARY SPECIES					
	Ammodiscus tenuis		2,730	2,448	1,722	
	Gaudryina minuta		2,730	2,118	1,722 ?	
	Recurvoides contortus (subglobosus)			1,836	1,722	
	Oolina longispina			5,622	2,178	
	Tolypammina schaudinni		2,148	3,030	2,964	1,800
	AUXILIARY DATA					
	10% values for *Bulimina rostrata alazanensis*					
	2% values for *Cibicides bradyi* and *C. robertsonianus*					
	4% values for *Eponides turgidus*					
	1% values for *Uvigerina peregrina dirupta*					

[A]One occurrence at 1,230 feet water depth.

[B]One occurrence at 498 feet water depth.

*One occurrence at 1,572 feet water depth.

[1]One occurrence at 2,640 feet water depth.

TABLE 1. (continued)

UPPER DEPTH LIMIT (FEET)	SPECIES	UPPER DEPTH LIMITS (FEET) WESTERN GULF	DEEP-WATER ECOLOGY TRAVERSES 3	2	1	EASTERN GULF
2,500	*Martinottiella* (Initial portion)		2,496	3,102		
	Pleurostomella bolivinoides			2,328	5,130 (2,178)	
	Pullenia subsphaerica		3,324	2,688	2,964	
	Pullenia trinitatensis		3,324	2,328	5,514 (2,178)	
	AUXILIARY DATA					
	Length/width 2, *Bolivina albatrossi*					
	3.7 mm diameter, *Cyclammina cancellata*					
	LOWER BATHYAL ZONE					
3,000	*Alabamina decorata*	3,500		3,816	4,778	2,700
	Allomorphina trigona var.			3,078		
	Anomalina globulosa		3,864	3,030	3,270	
	Eponides tumidulus	4,000		3,816	4,778	2,700
	Florilus clavatus		3,006	2,688	5,130	
	Gyroidina altiformis acuta		3,630	3,078	4,338	
	Oridorsalis sidebottomi		3,864	3,078		
	Siphotextularia curta			4,920	4,092	3,000
	Uvigerina hispida		3,864	3,078	5,880	
	AUXILIARY DATA					
	5% values, *Gyroidina orbicularis*					
	1% values, *Oridorsalis tener umbonatus* (0.7 mm diameter)					
4,000	*Heronallenia gemmata*		3,864	4,506	6,174	
	Siphotextularia rolshauseni			4,218*	4,092	4,000
	AUXILIARY DATA					
	5% values, *Eponides tumidulus*					
	10% values, *Glomospira charoides*					
	1.7 mm diameter, *Hoeglundina elegans*					
	0.9 mm diameter, *Sphaeroidina bulloides*					
4,500	*Cassidulinoides parkerianus*			4,506	6,174	
	Globocassidulina moluccensis			4,506	5,880	
	Pseudotrochammina triloba			4,218[1]	4,778	
	Pyrgo lucernula			4,506	5,514	
	Quinqueloculina venusta			4,506**	8,874	6,000 ?
	AUXILIARY DATA					
	10% values, *Alabamina decorata*					
	5% values, *Hoeglundina elegans*					
	1.7 mm diameter, *Laticarinina pauperata*					
	5% values, *Pullenia quinqueloba*					

*One occurrence at 2,328 feet water depth.

**One occurrence at 2,688 feet water depth.

[1]One occurrence at 2,448 feet water depth.

TABLE 1. (continued)

UPPER DEPTH LIMIT (FEET)	SPECIES	UPPER DEPTH LIMITS (FEET) WESTERN GULF	DEEP-WATER ECOLOGY TRAVERSES 3	2	1	EASTERN GULF
5,000	*Bolivina pusilla*			5,136*	5,130	5,638*
	Uvigerina ampullacea			5,136[1]	5,514	
	AUXILIARY DATA					
	3.0 mm diameter, *Laticarinina pauperata*					
	4% values, *Pullenia subsphaerica*					
5,500	*Francesita advena*			7,482	5,436	5,674
	AUXILIARY DATA					
	0.3 mm diameter, *Haplophragmoides bradyi*					
	ABYSSAL ZONE					
6,000	*Apiopterina angusta*			5,994	8,328	
	Apiopterina extensa			11,532	5,880	
	Uvigerina senticosa			6,234	6,174	
	AUXILIARY DATA					
	10% values, *Hoeglundina elegans***					
6,500	*Melonis pompilioides* (Rare)			6,624	6,726	7,439
7,000	*Bolivinita quadrilatera*				6,864	
	5% values, *Oridorsalis tener umbonatus*					
8,000	*Trochammina subturbinata*				8,328	
	20% values, *Cibicides wuellerstorfi*					
	5% values, *Eponides polius*					
9,000	10% values, *Eponides tumidulus*					
10,000	5% values, *Melonis pompilioides*					
11,000	10% values, *Eponides tumidulus*					

*Rare occurrences shallower than this.

[1] One occurrence at 2,688 feet water depth.

**High values are sometimes noted in fossil assemblages that are rather clearly upper bathyal.

Question marks beside water depths indicate questionable upper depth limits. This uncertainty is due to scattered occurrences and/or whether the upper depth limit is due to modern or fossil occurrences. Additional footnotes indicate the shallowest samples taken in the traverses and published upper depth limits.

another. For instance, the sampling interval in this study is at about 300-foot increments; thus, a given water depth is only accurate to ±300 feet. Errors due to species concept are clearly demonstrated in comparing the present data to the report by Phleger (1951); for example, *Melonis pompilioides* of Phleger includes both the typical abyssal forms as well as highly compressed specimens that range widely in water depth and are now generally referred to as *M. barleeanus* (Williamson).

HETEROBATHYAL SPECIES (DELTA EFFECT)

Heterobathyal species are those having variable upper depth limits. In samples from the present traverses depth variation in a number of species was noted off the major deltaic areas. Two groups of heterobathyal species were recognized: (1) species with depressed upper depth limits and (2) species with elevated upper depth limits.

DELTA-DEPRESSED SPECIES

Neritic and bathyal species with upper depth limits that appear to be considerably depressed off the Mississippi River and other deltaic areas are shown in table 3. These data are summarized as follows:

At least four species with reported general upper depth limits at water depths of 150 or 200 feet (Phleger, 1951; Parker, 1954) have upper depth limits depressed into the lowermost neritic or upper bathyal zones off the Mississippi River. These include *Planulina ariminensis* d'Orbigny, *Pullenia quinqueloba* (Reuss), *Melonis barleeanus*, and *Oridorsalis tener stellatus* (Silvestri). At least six species, which have upper depth limits at water depths of about 300 feet, show upper depth limits in the lowermost neritic or upper bathyal zone as exemplified by *Anomalina corpulenta* (Phleger and Parker). Three bathyal species with upper depth limits at water depths of 600 feet, i.e., *Anomalina mexicana* (Parker), *Eggerella bradyi* (Cushman), and *Epistominella exigua* (Brady), show a marked depression of upper depth limits into the middle bathyal zone off the delta. Two other species, *Haplophragmoides bradyi* (Robertson) and *Karreriella bradyi* (Cushman), show some depression. Nine additional species with upper depth limits at water depths between 900 and 1,200 feet show depressed upper depth limits to within the middle bathyal zone off the delta. *Karreriella apicularis* (Cushman) has its first continuous occurrences in water depths below 4,092 feet off the delta, with the exception of one specimen which occurred at a water depth of 1,230 feet. Five species with upper depth limits within the middle bathyal zone, i.e., *Ammolagena clavata* (Parker and Jones), *Cibicides robertsonianus* (Brady), *Cibicides bradyi* (Trauth), *Cibicides wuellerstorfi* (Schwager), and *Cribrostomoides umbilicatus* (Pearcey), show greatly depressed upper depth limits to levels well within the lower bathyal zone off the delta. Four additional species of the middle zone also show some depression of their upper depth limits off the delta. At least ten species which have upper depth limits within the lower bathyal zone show some evidence of delta depression. However, additional corroboration is needed to evaluate the magnitude of the observed upper depth limit depressions as lower bathyal zone species are represented by relatively few specimens.

Some delta depressed species such as *Eponides turgidus* Phleger and Parker, *Bulimina aculeata* d'Orbigny, *Hoeglundina elegans* (d'Orbigny), and *Epistominella exigua* show asymmetric distributions of their upper depth limits on the slope with regard to the position on the delta. In these cases the delta depression is offset to the west, which would appear to be an apparent reflection of prevailing westward flowing currents (Leipper, 1967) entraining the delta discharge with their suspended loads and depositing them to the west. This current-modified distributional pattern is interesting in that its effect extends well into the upper bathyal zone. There is some degree of correlation between the volume of discharge of a river system and the magnitude of a "delta effect." Delta depression of upper depth limits off the Mississippi, Rio Grande, and other smaller rivers is shown by *Eponides turgidus,* perhaps one of the most environmentally sensitive benthic species. Most species, however, are apparently less sensitive, and their distributions reflect mostly Mississippi River influence.

The position of a river mouth should affect the magnitude of the "delta effect" in slope species; the "delta effect" of a river discharging directly on the slope should be greater than that of a river discharging its water across a broad shelf. During most of the Tertiary, larger river systems discharged their loads directly into the Gulf (D. E. Frazier, Exxon Production Research Co., personal communication); hence, the "delta effect" would have been much greater in Tertiary depositional centers.

The effects of delta depression on fossil foraminifers

TABLE 2

Isobathyal species.

UPPER DEPTH LIMIT (FEET)	SPECIES	UPPER DEPTH LIMITS (FEET) *WESTERN GULF	DEEP-WATER ECOLOGY TRAVERSES 3	2	1	EASTERN** GULF
	UPPER BATHYAL ZONE					
600	*Bolivina albatrossi*	600	906	594[(1)]	762	600
	Bulimina striata mexicana	600	534[(1)]	594[(1)]	498[(1)]	600
	Chilostomella oolina	600	906	594[(1)]	498[(1)]	600
	Eponides regularis	600	534[(1)]	594[(1)]	498[(1)]	600
	Gyroidina altiformis cushmani	600	534[(1)]	594[(1)]	762	600
	Rotorbinella translucens	600	906	594 ?	984	600
	Uvigerina peregrina	600	534[(1)]	594[(1)]	498[(1)]	600
900	*Bulimina aculeata*	900	1,224	1,146	1,230	900
	Bulimina rostrata alazanensis	900	1,506	1,146	1,230	1,500
	Osangularia rugosa	900	1,224	1,146	1,410	900
	Uvigerina peregrina dirupta		1,224	918	984	
	Uvigerina peregrina mediterranea		1,224	918	762	
1,200	*Cibicides bantamensis*		1,224	1,230	1,230	
	Gyroidina orbicularis	1,200	1,224	1,212	1,410	1,200
	Reticulophragmium venezuelanum		1,224	1,536	1,230	
	MIDDLE BATHYAL ZONE					
1,500	*Cyclammina cancellata*	1,500	1,506	1,536	1,410	2,000
2,000	*Cibicides kullenbergi*			1,836	4,092(2,178)	2,000
	Cibicides rugosus	3,000	2,148	2,448	2,178	2,000
	Eponides polius	2,000	1,824	2,328	4,778[A](2,358)	2,000
	Oridorsalis tener umbonatus		2,148	2,118	2,640	
	Osangularia culter	2,000	1,824	1,836	2,178	2,000
2,500	*Pleurostomella bolivinoides*			2,328	2,178	
	LOWER BATHYAL ZONE					
3,000	*Anomalina globulosa*		3,864	3,030	3,270	
4,000	*Siphotextularia rolshauseni*			4,218[B]	4,092	4,000
5,000	*Uvigerina ampullacea*			5,136[1]	5,514	
	ABYSSAL ZONE					
6,000	*Uvigerina senticosa*			6,234	6,174	
6,500	*Melonis pompilioides*			6,624	6,726	7,439

*Phleger (1951)

**Parker (1954)

(1) Shallowest sample taken on traverse.

A One occurrence at 2,640 feet water depth.

NOTE: Parentheses indicate occurrence at depth in core samples.

B One occurrence at 2,328 feet water depth.

1 One occurrence at 2,688 feet water depth.

TABLE 3

Delta-depressed species.

UPPER DEPTH LIMIT (FEET)	SPECIES	*WESTERN GULF	UPPER DEPTH LIMITS (FEET) DEEP-WATER ECOLOGY TRAVERSES 3	2	1	EASTERN** GULF
	NERITIC ZONE					
100	*Eponides turgidus*	100			3,636(498)	100
150	*Planulina ariminensis*	150			984(498)	600
150	*Pullenia quinqueloba*	150			762(498)	300
200	*Melonis barleeanus*	200			762	200 ?
200	*Oridorsalis tener stellatus*	200			498	200
300	*Anomalina corpulenta*	300			762	300
	Glomospira charoides	300			1,230	600
	Hoeglundina elegans	300			498	300
	Planulina foveolata	275			498	260
	Sphaeroidina bulloides	300			498	300
	Uvigerina flintii	328			762	250 ?
	UPPER BATHYAL ZONE					
600	*Anomalina mexicana*		1,224	594	2,964	731
	Eggerella bradyi	623	1,506	594	1,962	508
	Epistominella exigua		1,506	1,146	1,962	600
	Haplophragmoides bradyi	600	534	1,146	1,230	600
	Karreriella bradyi	508	1,224	594	762	456
900	*Bathysiphon filiformis*		1,224	918	3,270	
	Cassidulinoides tenuis			1,230	2,640	840
	Stainforthia companata			918	2,178	
1,200	*Ammodiscoides turbinatus*		1,224	1,536	2,964	
	Karreriella apicularis	1,200	1,224	918 ?	4,092[1]	1,200
	Laticarinina pauperata	1,200	1,224	1,146	2,178	1,200
	Reophax dentaliniformis		1,224	1,836	2,178	
	Tosaia weaveri		1,506	1,146	2,178	
	MIDDLE BATHYAL ZONE					
1,500	*Ammolagena clavata*		2,496	1,572	3,636	
	Cibicides robertsonianus	1,500	1,506	1,572	2,358	1,200 ?
	Cibicides bradyi		1,506	1,536	3,270	
	Cystammina pauciloculata		1,506	1,536	2,640	
	Valvulineria opima		1,506	2,448	2,640	
2,000	*Cibicides wuellerstorfi*	2,000 ?	3,324	2,328[A]	3,270	1,500 ?
	Cribrostomoides umbilicatus			2,118	4,338	
	Oridorsalis tener umbonatus		2,148	2,118	2,964(2,640)	
	Uvigerina spinicostata		1,824	2,118	2,964	

*Phleger (1951)

**Parker (1954)

[1] One occurrence at 1,230 feet water depth.

[A] One occurrence at 1,572 feet water depth.

NOTE: Parentheses indicate occurrence at depth in core samples.

TABLE 3. (continued)

UPPER DEPTH LIMIT (FEET)	SPECIES	UPPER DEPTH LIMITS (FEET) WESTERN GULF	DEEP-WATER ECOLOGY TRAVERSES 3	2	1	EASTERN GULF
	LOWER BATHYAL ZONE					
3,000	*Alabamina decorata*	3,500		3,816	4,778	2,700
	Eponides tumidulus	4,000		3,816	4,778	2,700
	Florilus clavatus		3,006	2,688	5,130	
	Gyroidina altiformis acuta		3,630	3,078	4,338	
	Uvigerina hispida		3,864	3,078	5,880	
4,000	*Heronallenia gemmata*		3,864	4,506	6,174	
4,500	*Fissurina formosa* (1.0 mm long)			4,2 8	5,130	
	Globocassidulina moluccensis			4,506	5,880	
	Pyrgo lucernula			4,506	5,514	
	Quinqueloculina venusta			4,506[8]	8,874	6,000 ?

[8]One occurrence at 2,688 feet water depth.

were examined and a few subsurface samples taken from the present cores (table 7). The study showed that the upper depth limits of the fossil species were at shallower depths in the recent past than now, or that the modern faunal patterns were not sampled with sufficient density to show the correct upper depth limits. For example, *Pullenia quinqueloba, Planulina ariminensis, Cibicides bradyi, Cibicides kullenbergi* Parker, *Eponides polius* Phleger and Parker, *Oridorsalis tener umbonatus* (Reuss), *Pleurostomella bolivinoides* Schubert, and *Pullenia trinitatensis* (Cushman and Stainforth) have shallower upper depth limits immediately beneath the surface than in the surface sample. Examination of additional samples from slope cores representing many years of deposition may show whether the depressed zones are only brief or temporary relationships or if these are indeed reflected over a considerable period of time.

Delta-Elevated Species

Species with shallower upper depth limits in the area off the Missipi River are shown in table 4. Seven bathyal species are elevated into the neritic zone. For instance, *Martinottiella occidentalis* (Cushman) and *Sigmoilopsis schlumbergeri* (Silvestri) show this effect off the delta. Phleger (1951) reported occurrences of both species, however, in the middle neritic zone in the northwestern Gulf. *Cribrostomoides scitulus* (Brady) shows a change in upper depth limits from the lower part of the middle bathyal zone in areas away from the delta to 1,230 feet near the delta. This species has been reported, however, from the lower neritic zone in carbonate areas off Florida (Parker, 1954). Of the four additional species with upper depth limits at 600 feet or shallower, *Valvulineria complanata* (d'Orbigny) is the most striking, with upper depth limits greater than 900 feet in the northwestern Gulf, 498 feet off the Mississippi River delta, and deeper than 3,000 feet in the eastern Gulf of Mexico.

Upper depth limits of seven bathyal species exhibit some degree of shoaling. *Trochammina globulosa* (Cushman) shows the most spectacular depth decrease from more than 3,300 feet away from the delta to about 1,400 feet off the delta. *Oolina longispina* (Brady) also seems to show a spectacular decrease, but this observation needs further corroboration.

Stratigraphic Significance of Upper-Depth-Limit Variation

The effect of upper depth limit variation, or the "delta effect," upon biofacies is of considerable stratigraphic significance. It offers at least one fundamental explanation of the faunal diversity encountered in fossil assemblages from wells and surface sections. For instance, consider the facies relationships of three species, one from each depth group, i.e., isobathyal, delta-depressed, delta-elevated, that have uppermost depth limits at or near the upper bathyal boundary at 600 feet, as shown in figure 4. An isobathyal species "A" is exemplified by *Uvigerina peregrina* Cushman, a delta-depressed species "B" is illustrated by *Epistominella exigua,* and a delta-elevated species "C" is represented by *Valvulineria complanata.*

In a normal sequence away from a delta, species

TABLE 4

Delta-elevated species.

UPPER DEPTH LIMIT (FEET)	SPECIES	UPPER DEPTH LIMITS (FEET) *WESTERN GULF	DEEP-WATER ECOLOGY TRAVERSES 3	2	1	EASTERN** GULF
150	*Martinottiella occidentalis*	150 ?	906	594	498	
150	*Sigmoilopsis schlumbergeri*	150	906	594	498	600 ?
300	*Cribrostomoides scitulus*		2,730	1,536	1,230	300
600	*Cassidulinoides bradyi*		906		498	
600	*Globobulimina affinis* s. l.		906	594	498	541
600	*Lenticulina orbicularis*		906	594	498	
600	*Valvulineria complanata*		906	1,212	498	3,000 ?
900	*Alveovalvulinella pozonensis*				762	
	Haplophragmoides sphaeriloculus		1,224	1,536	762	
	Uvigerina peregrina mediterranea		1,224	918	762	
1,200	*Ammodiscus planorbis*		1,824	1,572	1,230	
1,500	*Trochammina globulosa*		3,324	2,118	1,410	3,500
2,000	*Ammodiscus tenuis*		2,730	2,448	1,722	
	Oolina longispina			5,622	2,178	

* Phleger (1951)

** Parker (1954)

"A" plus "B" would occur together at 600 feet along with the associated species listed for the two depth groups, i.e., isobathyal species and delta-depressed species would appear in bathymetric sequence as deeper water facies are encountered. Conversely, delta-elevated species would appear initially in deeper water, or in this case, at 3,000 feet. Thus, normal sequences away from deltaic areas would be represented by a combination of species "A" plus "B" but without "C." In an area representing deltaic deposition as shown in figure 4, the upper depth limit of the delta-depressed and delta-elevated species would be reversed. In this case, species "A" plus "C" would occur together, whereas species "B" would be indicative of deeper water facies.

Several additional guidelines are useful in supporting the interpretation of deltaic influence on the upper depth limits of certain species; these include the presence of indicator species, size trends, planktonic abundance, and benthic specimens-per-species trends. Several species such as *Buliminella bassendorfensis* Cushman and Parker and *Eponides regularis* Phleger and Parker are unusually dominant off the Mississippi River. In addition, size trends of several species are associated with deltaic influence; *Cyclammina cancellata* has diameters between 1 and 2 mm within the middle bathyal and uppermost lower bathyal facies off the Mississippi River. Conversely, populations of *C. cancellata* attain average diameters in excess of 3 mm within the middle bathyal zone in profiles away from the delta. Both planktonic abundance and benthic specimens-per-species trends show lower values in traverse 1 (see Faunal Trends) and are attributed to the environmental influence of the Mississippi River.

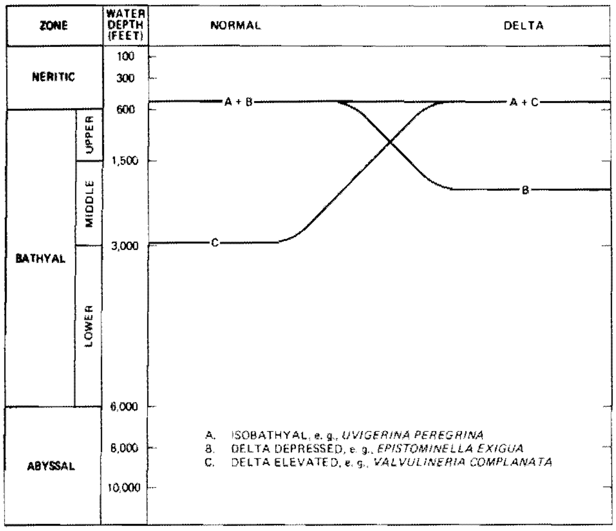

FIGURE 4

Example of the "delta effect" involving isobathyal, delta-depressed, and delta-elevated species. All have absolute upper depth limits at or near 600 feet.

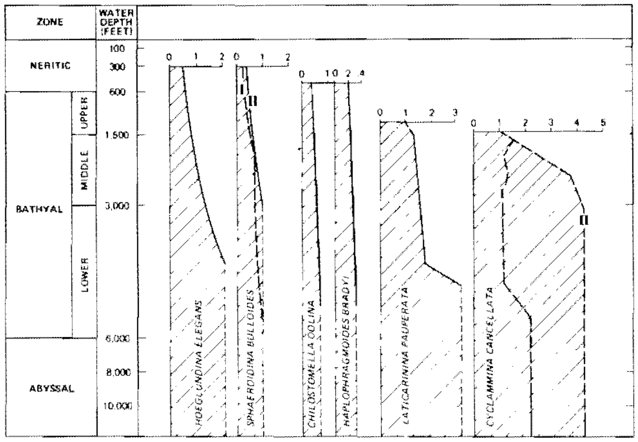

FIGURE 5

Size increase of selected benthic species with increasing water depth. Roman numerals indicate traverses 1 and 2. Maximum test diameters shown in millimeters.

BATHYMETRIC AND PROVINCIAL FAUNAL VARIATION

Foraminifers are known to vary in size, form, and ornamentation because of water depth variation and sediment type, i.e., clastic versus carbonate facies. Morphologic variation related to variation in water depth represents either (1) bathymetric successions of valid taxonomic species or (2) clines, here regarded as transitional forms of a single species varying morphologically in response to environmental change. An example of clinal variation was documented by Lutze (1964) in populations of *Bolivina argentea* (Cushman) from Santa Barbara and Santa Monica basins off southern California. Lutze showed that the test width/length ratios, length of costae, and length of the basal spine in this species increased progressively in specimens from basin environments to those from slope environments.

The following section describes the taxonomic succession or morphologic variation of selected diagnostic species from samples of the present study and compares these trends with those of related taxa in other geographic areas.

Size Variation

Size increase with increasing depth of water was noted in six species as shown in figure 5. *Hoeglundina elegans* has an average diameter of about 0.5 mm in the lower neritic zone in the shallowest stations sampled. It attains a diameter, however, of about 1.0 mm in the middle bathyal zone and about 2.0 mm in the lower bathyal and abyssal zones. The size of individuals in the lower bathyal and abyssal zones of the Gulf of Mexico are similar to those recorded in the eastern Pacific at like water depths but different water masses in terms of temperature and oxygen gradients (Bandy, 1963a).

In the Gulf of Mexico, a remarkable size increase occurs in *Laticarinina pauperata* (Parker and Jones). Its diameter is only slightly greater than 1 mm near its upper depth limits in the upper bathyal zone; however, it attains diameters of more than 3 mm in the middle and lower bathyal zones and below. In the eastern Pacific its upper depth limits appear to be in the lower part of the lower bathyal zone where the size is about 2 mm; the shallower populations of smaller individuals are as yet unrecorded in the Pacific.

Minor size increases with increasing water depths were noted in the tests of *Sphaeroidina bulloides* d'Orbigny, *Chilostomella oolina* (Schwager), and *Haplophragmoides bradyi*. *Sphaeroidina bulloides* increases in size from less than 0.5 mm in the lower neritic zone to about 1 mm in the lower bathyal and abyssal zones; a varying rate of increase was noted between traverses 1 and 2. *Chilostomella oolina* increases in size from about 0.4 mm near its upper depth limits in the lower neritic zone to approximately 0.6 mm in the lower bathyal and abyssal zones. *Haplophragmoides bradyi* shows a small size increase from

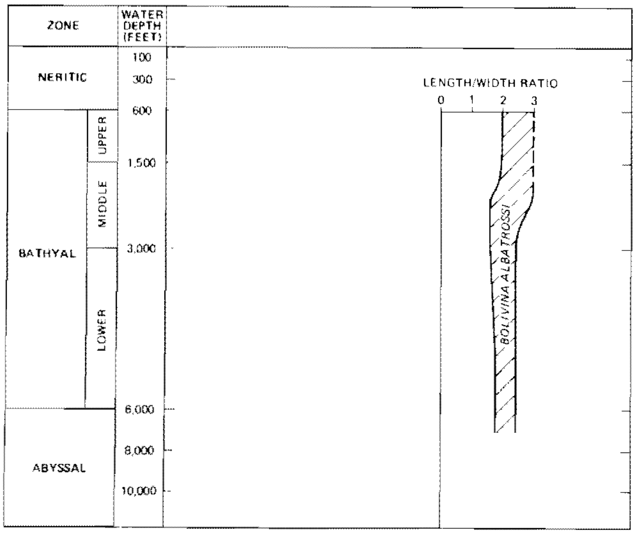

FIGURE 6

Test length/width ratio of *Bolivina albatrossi* Cushman with increasing water depth.

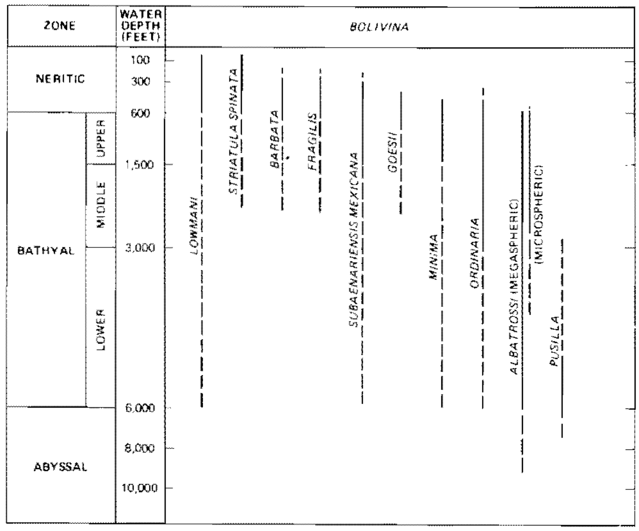

FIGURE 7

Water-depth distribution of species of *Bolivina*.

about 0.2 mm in the lowermost neritic zone to slightly more than 0.3 mm in the lower bathyal and abyssal zones.

The greatest variation in size increase between traverses is that of *Cyclammina cancellata* as shown in figure 5. Off the Mississippi River in samples from traverse 1 the test diameters vary between 1 and 2 mm throughout the middle bathyal zone, whereas in traverse 2 the maximum diameters increase abruptly to about 4 mm within the middle bathyal zone. Specimens in traverse 1 increase in size to more than 2 mm in the lowermost lower bathyal and abyssal zones whereas in traverse 2 the size remains about the same (slightly over 4 mm) throughout the lower bathyal and abyssal zones.

It is important to note that the rate of size increase in both *Cyclammina cancellata* and *Sphaeroidina bulloides* is much greater in nondeltaic areas than in deltaic areas. This size variation may be related to nutrient abundance off the Mississippi River that produces a more optimum environment at greater water depths. In this case, reproduction would occur earlier in the organisms' life cycles than in an adverse environment and would result in populations made up of smaller individuals (Phleger, 1960).

Temperature is known to significantly affect foraminiferal growth and reproduction rates (Bradshaw, 1957). In colder waters reproduction is delayed and, although growth may be slower than normal, the size of the individual becomes much greater. In this study there is a general correspondence between the zones of most rapid size increase and temperature decrease. Thus, different temperature gradients should correspond to different patterns of foraminiferal size increase.

Form-Ratio

A significant change in form-ratio with increasing depth was noted in one species. Specimens of *Bolivina albatrossi* Cushman in the upper bathyal zone exhibited a length/width ratio generally between 2 and 3 as shown in figure 6. This ratio changes to a range of from less than 2 to about 2.5 in the middle bathyal zone and remains approximately the same at greater depths. The megalospheric generation has a lower ratio than the microspheric generation, which suggests that the type of reproduction contributes in large part to the variation in form-ratio with increasing depth. Myers (1943) demonstrated that temperature, food, substrate, and perhaps other factors play an important part in modifying the form of foraminiferal species.

Morphometric Variation of Diagnostic Water-Depth-Indicator Species

Bolivina

The genus *Bolivina* includes an important group of species shown in figure 7. These species represent a succession of valid taxonomic species and not a cline; however, it is important to compare related species

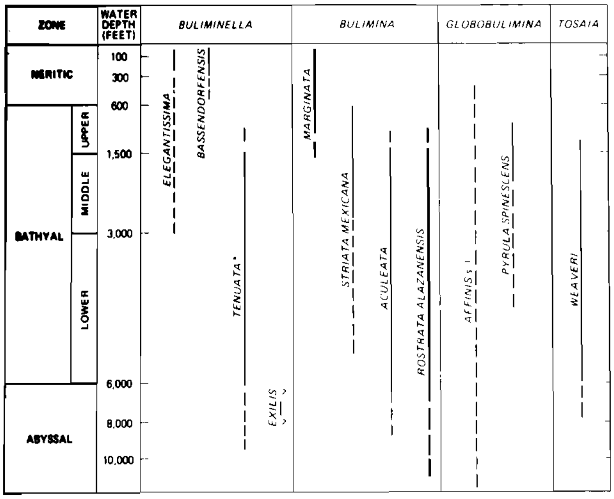

FIGURE 8

Water-depth distribution of selected buliminids. Asterisk indicates **species** not reported in the Gulf of Mexico. Heavy line indicates **cline.**

with bathymetry to show the type of test morphology characteristic of various water-depth zones. *Bolivina lowmani* Phleger and Parker, a small (less than 0.3 mm in length) and unornamented species, is most characteristic of the neritic zone, although it is also recorded as living throughout most of the bathyal zone (Parker, 1954). Along the Pacific coast of North America similar forms such as *Bolivina quadrata* Cushman and McCulloch occur in the neritic zone and apparently range into the bathyal zone.

Bolivina striatula spinata Cushman is a second species that is characteristic of the neritic zone, especially the middle and lower neritic zones (fig. 7). Rare occurrences in the upper and middle bathyal zones may be due to downward displacement. This species, with longitudinal striae and an apical spine, is more restricted than the unornamented *B. lowmani*. Three additional species, *B. barbata* Phleger and Parker, *B. fragilis* Phleger and Parker, and *B. subaenariensis mexicana* Cushman are most characteristic of the lower neritic zone, spreading up into the lowermost part of the middle neritic zone and down into the upper bathyal zone. There is a general similarity between the latter two species, both of which have longitudinal costae; *B. barbata* is distinctive, with downward directed projections on many of the chambers, and its counterpart in the eastern Pacific, *B. acuminata* Natland, also has projections on the basal portions of the chambers.

Bolivina goesii Cushman, *B. minima* Phleger and Parker, and *B. ordinaria* Phleger and Parker are three bolivinid species with upper depth limits within the lower neritic zone (fig. 7). *Bolivina goesii* has the most distinctive surface sculpture, is the most restricted in depth, and appears to have no similar counterpart in the eastern Pacific. *Bolivina minima*, although most characteristic of the lowermost neritic and upper bathyal zones, has scattered occurrences throughout the middle and lower bathyal zones. It is somewhat like *B. spathulata* Williamson which is reported through much of the same depth range, and the two species may represent a cline. *Bolivina ordinaria*, another species that is similar to *B. spathulata* but differs in having thickened sutures, is characteristic of the lowermost neritic, upper and middle bathyal zones.

Bolivina albatrossi Cushman is essentially a bathyal index species, with both megalospheric and microspheric tests in the upper and middle bathyal zones and mostly megalospheric tests in deeper waters (fig. 7). The test wall is thickened, being much heavier in construction than other bolivinid species. *Bolivina pusilla* Schwager is the deepest bolivinid index of importance in this study, being most characteristic of the lowermost bathyal and abyssal zones. The wall of *B. pusilla* is not as heavy as that of *B. albatrossi*, and it has somewhat irregular longitudinal striae or low costae over much of the test. Both *B. albatrossi* and *B. pusilla* are cosmopolitan, being almost worldwide in distribution in deeper oceanic waters.

Buliminids

The distribution of four species of *Buliminella* is shown in figure 8. These species, although either rare or absent in the present study, illustrate the bathymetric variation between shallow- and deep-water buliminellids. Again, these forms represent a taxonomic succession and not a cline. *Buliminella elegantissima* (d'Orbigny) was previously reported as occurring rarely in the neritic and upper bathyal zones of the Gulf of Mexico (Phleger, 1951). In the present study, rare nonstained specimens were noted in the bathyal zone. Along the coast of southern California this species is a dominant upper neritic form (Bandy, Ingle, and Resig, 1964) where the salinity is about 34 ‰ (parts per thousand) and the substrate is silty sand and sandy silt. Occasional live specimens, however, have been noted in water depths as great as 300 feet. Thus, in the northern and western Gulf of Mexico salinity variations in upper neritic environments perhaps exclude this stenohaline species.

Buliminella bassendorfensis Cushman and Parker, in contrast with *B. elegantissima*, is a dominant form in the deltaic marine fauna off the Mississippi River (Lankford, 1959). It is thus an emportant upper neritic euryhaline index species.

Buliminella tenuata Cushman and *B. exilis* (Brady) are characteristic of bathyal and abyssal zones (fig. 8). *Buliminella tenuata* is included, even though it was not found in the Gulf of Mexico, as it is an important bathyal form in the eastern Pacific (Crouch, 1952; Bandy, 1961). Its general depth distribution is intermediate between *B. bassendorfensis* and *B. exilis. Buliminella exilis* does occur in the abyssal zone of the Gulf of Mexico and many other worldwide areas (Brady, 1884).

Bulimina marginata d'Orbigny and its morphovariants shown in figure 8 represent a cline. These morphologic forms range from water depths of less than 100 feet downward to the upper bathyal zone (Phleger, 1951; Parker, 1954). In coastal waters off California this species and its morphovariants occur on silty clay or clayey silt substrates in lagoonal areas as well as in the lower neritic and upper bathyal zones (Bandy, Ingle, and Resig, 1964). It appears to be restricted to stenohaline conditions and to a fine-grained substrate within the indicated depth range. In temperate regions the spinose fringes at the base of the chambers are reduced, and these specimens are referred to *B. marginata denudata* Cushman and Parker.

Bulimina striata mexicana Cushman is characteristic of the bathyal zone, especially the upper and middle bathyal zones of this study. The species is similar to forms in the eastern Pacific that are generally restricted to water depths greater than about 2,000 feet (Crouch, 1952; Bandy, 1961). A different species, *Bulimina costata* d'Orbigny of the Mediterranean and Atlantic is somewhat similar to *B. striata mexicana* and has about the same depth range in the Mediterranean as does the latter in the Gulf of Mexico (Bandy and Chierici, 1966).

Bulimina aculeata d'Orbigny is a distinctive spinose isobathyal species, not closely related to the preceding species. It has upper depth limits within the upper bathyal zone and ranges down to the abyssal zone (fig. 8). Spinosity appears to increase with increasing water depth in samples from traverse 1; however, this trend was not clearly defined by populations obtained from traverse 2. *Bulimina aculeata* occurs in the Antarctic, Mediterranean, and Atlantic regions and always with an upper depth limit approximating that found in the Gulf of Mexico (Bandy and Chierici, 1966). Many morphovariants of this species are reported in the Neogene of Italy (AGIP Mineraria, 1957).

A morphologic gradation exists between *Bulimina alazanensis* Cushman and *B. rostrata* Brady; hence, these species are here referred to as *B. rostrata alazanensis* Cushman (fig. 8). *Bulimina rostrata* is typically an abyssal species with heavy continuous costae that terminate in a strong apical spine. *Bulimina alazanensis* typically has notches on the lower portions of the costae and the costae are commonly slightly irregular. Both species intergrade in deeper bathyal water. In the Gulf of Mexico, *B. rostrata alazanensis* ranges from within the upper bathyal zone down into the abyssal zone. Conversely, in the eastern Pacific the more typical *B. rostrata* occurs generally in the abyssal zone (Crouch, 1952; Bandy, 1961).

Smooth forms of *Globobulimina* such as *G. affinis* (d'Orbigny) have a depth range from the lower neritic zone to abyssal water depths (fig. 8); however, spinose forms such as *G. pyrula spinescens* (Brady) are restricted to the bathyal zone of the Gulf of Mexico, Mediterranean, and California (Bandy and Chierici, 1966). A small buliminid, *Tosaia weaveri* Seigle and Bermúdez, occurs mostly in the middle and lower bathyal zones (fig. 8). It ranges between 0.10 and 0.20 mm in test length and has a variable aperture consisting of a narrow slit along the base of the apertural face in some specimens and a somewhat diagonal slit in others; in both cases the aperture has a narrow lip.

SELECTED TRISERIAL-BISERIAL AND BISERIAL CALCAREOUS SPECIES

Three species of *Coryphostoma*, *C. zanzibarica* (Cushman), *C. subspinescens* (Cushman) and *C. spinescens* (Cushman), probably represent a cline (fig. 9). The first species, *C. zanzibarica*, ranges from middle neritic to upper bathyal water depths and is characterized by the raised limbate sutures on the early portion of the test and spinose areas on the lower part of the otherwise smooth chambers. The second form, *C. subspinescens*, ranges from upper to lower bathyal water depths and, although similar to the above species, lacks the raised sutures. The deepest water form of the series, *C. spinescens*, ranges from middle bathyal water depths down into the abyssal zone and has much reduced areas of spines on the lower part of the chambers and correspondingly enlarged clear areas on the upper half of the chambers. There appears to be a morphologic gradation between these three species; therefore, they are thought to represent a cline.

Sagrina pulchella primitiva (Cushman), a triserial to biserial form with longitudinal striae or fine costae, is most characteristic of the middle neritic zone (Phleger, 1951; Parker, 1954; Bandy, 1956), but rare specimens

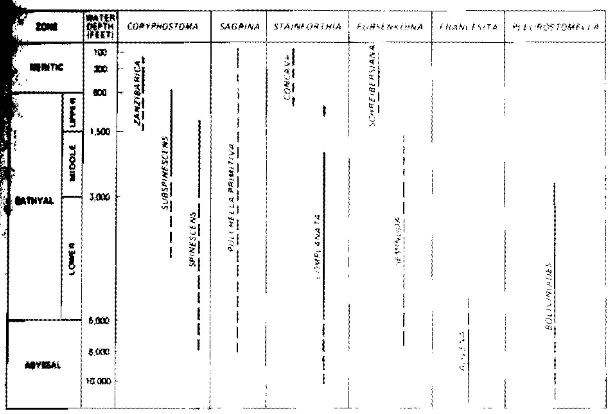

FIGURE 9

Water-depth distribution of selected triserial-biserial and biserial **calcareous** species. Heavy line indicates cline.

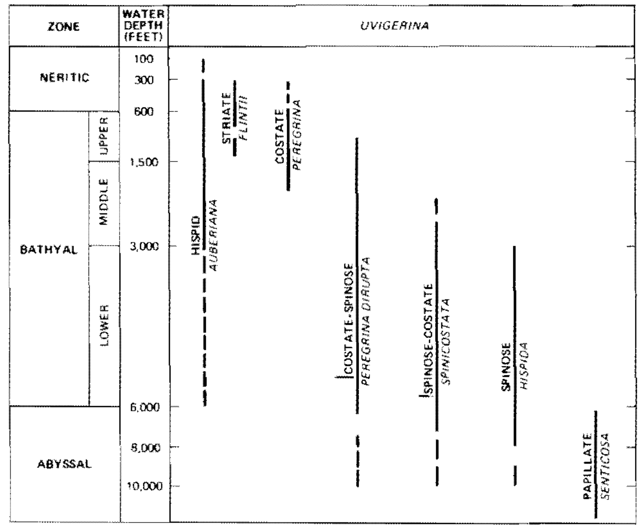

FIGURE 10

Water-depth distribution of species of *Uvigerina*. Heavy line indicates cline.

occur in the lower neritic, bathyal, and abyssal zones (**fig.** 9), probably due in large part to downward displacement.

Species of *Stainforthia*, such as *S. concava* (Höglund) and *S. complanata* (Egger), most probably represent a cline (fig. 9). Forms reported from the neritic zone have tests with a greater triserial stage of development whereas those of the middle and lower bathyal zones and deeper have tests that are almost entirely biserial; transitional forms occur in the upper bathyal zone. The neritic form illustrated as *Virgulina complanata* Egger by Phleger and Parker (1951, pl. 9, figs. 1–3, Sta. 9, 31 meters) is better referred to *Stainforthia concava* whereas the essentially biserial lower bathyal specimen of *Virgulina complanata* figured by Parker (1954, pl. 7, fig. 6, Sta. 36, 1719 meters) resembles specimens of *S. complanata* found in bathyal and abyssal facies of this study.

Twisted biserial and regular biserial forms, such as *Fursenkoina schreibersiana* (Czjzek) and *F. seminuda* (Natland), are distinct species lacking any suggestion of intergradation in form and structure (fig. 9). On the other hand, several species such as *F. punctata* (d'Orbigny), *F. pontoni* (Cushman), and *F. schreibersiana* are apparently closely related forms which represent a cline rather than distinct species. Specimens resembling *F. schreibersiana* are mostly middle to lower neritic in water depth distribution, whereas those with translucent areas in the upper portions of the chambers such as *F. seminuda* are middle and lower bathyal and even abyssal in distribution. The species described by Phleger and Parker (1951) as *F. tesselata* is considered to be conspecific with the eastern Pacific species *F. seminuda*.

Francesita advena (Cushman) has been found to be almost exclusively an abyssal species (fig. 9). This species is the deepest water "virgulinid" index known.

Although most modern forms of *Pleurostomella* are abyssal in distribution, *P. bolivinoides* was found to range from the basal part of the middle bathyal zone to the abyssal zone in the Gulf of Mexico (fig. 9).

Uvigerina

Uvigerinids represent a closely related group of excellent depth indicator species (fig. 10). The morphologic succession of species represents, in part, one or more clines. The shallowest forms are represented by *Uvigerina parvula* Cushman, a finely striate-hispid form, less than 0.5 mm in length, and variations of *Uvigerina auberiana* d'Orbigny, characterized by small specimens less than 0.5 mm in length, with very fine spines or a hispid wall. *Uvigerina parvula* ranges into the upper neritic zone, and the upper depth limits of *U. auberiana* are within the middle neritic zone; however, the most characteristic range of the latter species is from the lower neritic to middle bathyal zones. *Uvigerina flintii* Cushman is a striate species that is characteristic of the lower neritic and uppermost bathyal zones. Costate species, represented by *Uvigerina peregrina* Cushman and its variations are

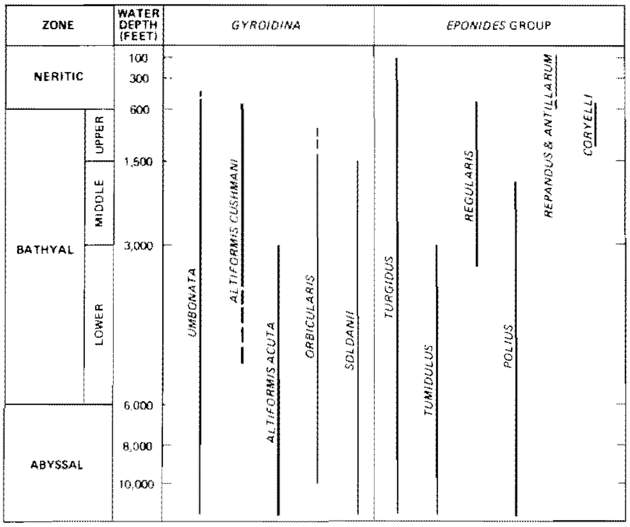

FIGURE 11

Water-depth distribution of species of *Gyroidina* and *Eponides* group. Heavy line indicates cline.

mostly upper bathyal in range with occurrences in the lower neritic and uppermost part of the middle bathyal zones. The length of the costate species varies from less than 0.5 mm in some areas in the Gulf of Mexico to perhaps 0.7 mm off California.

Costate-spinose forms, represented by *U. peregrina dirupta* Todd with surface sculpture consisting of costae on the lower portion of the test and spines on the upper portion, have upper depth limits within the upper bathyal zone. *Uvigerina peregrina dirupta* averages about 0.7 mm in length. Morphologically between costate-spinose and totally spinose forms is a transitional group exemplified by *Uvigerina spinicostata* Cushman and Jarvis, another large species that has spines that are slightly flattened and aligned somewhat parallel with the axis of the test; upper depth limits of this group are within the middle bathyal zone.

Uvigerina hispida Schwager, a totally spinose, cosmopolitan, large (about 0.75 mm in length) species has a depth range from the abyssal zone to the top of the lower bathyal zone (fig. 10). In the Gulf of Mexico this species, although present, is very rare whereas in the eastern Pacific it is a dominant form within the lower part of the lower bathyal zone. *Uvigerina ampullacea* Brady, a form that resembles *U. hispida* in its initial portion but which tends to become uniserial with elongated chambers, appears to have upper depth limits within the lowermost bathyal zone. The deepest uvigerinid index known is *U. senticosa* Cushman, which was described from abyssal depths of the eastern Pacific; in the Gulf of Mexico rare occurrences were noted at water depths of 6,174 feet in traverse 1 and 6,234 feet in traverse 2. In the eastern Pacific, *U. senticosa* is the dominant uvigerinid at depths of 8,000 feet and greater; its surface sculpture varies from almost smooth to papillate and sometimes slightly spinose. Transitional forms occur between *U. hispida* and *U. senticosa* in the upper abyssal zone.

Gyroidina and *Eponides* Group

Gyroidina umbonata (Silvestri) represents the simplest morphologic form of *Gyroidina* and the species with the greatest depth range encountered in this study with upper depth limits within the lower neritic zone and a lower range extending into the deepest abyssal zone sample (fig. 11). No change in size or ornamentation was noted with increasing depth of water.

Subspecies of *G. altiformis* Stewart and Stewart (fig. 11) most likely represent a cline. *Gyroidina altiformis cushmani* Boomgaart, ranging from bathyal depths up into the lower neritic zone, has thickened shell deposits on the umbilical shoulders of the chambers. With increasing depth, in the lower bathyal and abyssal zones, the umbilicus becomes much reduced and the thickened areas on the umbilical shoulders disappear; this latter form is referred to *G. altiformis acuta* Boomgaart.

Gyroidina orbicularis d'Orbigny and *G. soldanii* d'Orbigny are distinct species with upper depth limits within the upper and middle bathyal zones, respectively (fig. 11). No evidence was found of a cline existing between these two species.

The *Eponides* group includes several forms that may belong to separate genera (fig. 11). Neritic zone species include *Eponides repandus* (Fichtel and Moll) and *Eponides antillarum* (d'Orbigny) which are large robust species occurring commonly in many tropical to warm temperate shelf areas. *Eponides turgidus* Phleger and Parker, conversely, is a very small species that may belong in the genus *Eilohedra*. It ranges from the middle neritic zone into the abyssal zone in the Gulf of Mexico, whereas a similar form off California, *Eilohedra levicula* (Resig), may prove to be the same species, and it too ranges from the neritic zone into abyssal waters.

Species of the *Eponides* group that have upper depth limits in the lower part of the lower neritic zone include *Neoeponides coryelli* (Palmer) and *Eponides regularis* (Phleger and Parker). *Neoeponides coryelli* ranges from the lowermost neritic zone into the upper bathyal zone and is similar to many species in the Neogene and Paleogene. *Eponides regularis*, with upper depth limits within the lower neritic zone, ranges down through the upper and middle bathyal zones and is similar to "*Eponides*" *condoni* of the Paleogene in California. *Eponides polius* (Phleger and Parker) has upper depth limits at the upper boundary of the middle bathyal zone and ranges down into the abyssal zone. This species somewhat resembles *Gyroidina gemma* (Bandy) which occurs in the abyssal zone of the eastern Pacific. The deepest water index of the *Eponides* group is *E. tumidulus* (Brady) that occurs in the lower bathyal and abyssal zones and is quite cosmopolitan in deeper waters of the world's oceans. There is little evidence of morphologic gradation between the species of this *Eponides* group.

Rotorbinella, Valvulineria, and *Oridorsalis*

Forms referred to *Rotorbinella,* with its characteristic ventral umbilical plug, include a very useful group of species that may in part represent a cline (fig. 12). Other studies have shown that coarsely perforate foraminifers with a strongly convex dorsal spire are characteristic of relatively high energy environments of the intertidal zone especially in the tropics and in warm temperature areas (Cushman and Valentine, 1930; Bandy, 1953, 1956, 1964a). *Rotorbinella rosea* (d'Orbigny) is red in color, coarsely perforate, and most characteristic of tropical reefs and similar high energy environments. *Rotorbinella turbinata* (Cushman and Valentine) is coarsely perforate and characteristic of the warm temperate intertidal environments of islands off southern California but lacks the red color. These two species are perhaps synonymous, and the difference in color may be due to an environmental effect such as that producing the red and white color variations in the planktonic species *Globigerinoides ruber* (d'Orbigny).

Off southern California the more finely perforate forms of *Rotorbinella* include *R. lomaensis* (Bandy) and *R. versiformis* (Bandy) (Bandy, 1953). *Rotorbinella lomaensis* has a shape similar to *R. rosea,* but lacks the red color. It is brown, very finely perforate, and occurs from the beach areas out to the middle neritic zone. *Rotorbinella versiformis* has a less conical dorsal spire and appears to be characteristic of the upper to middle neritic zones exclusive of the beach areas. *Rotorbinella basilica* Bandy, a middle to lower neritic form of *Rotorbinella,* has slightly inflated chambers and a more nearly equally biconvex test than the above two shallower water species.

Rotorbinella translucens (Phleger and Parker) is a good bathyal index that appears to have upper depth limits approximating the upper limit of the bathyal zone. It occurs throughout the bathyal zone and

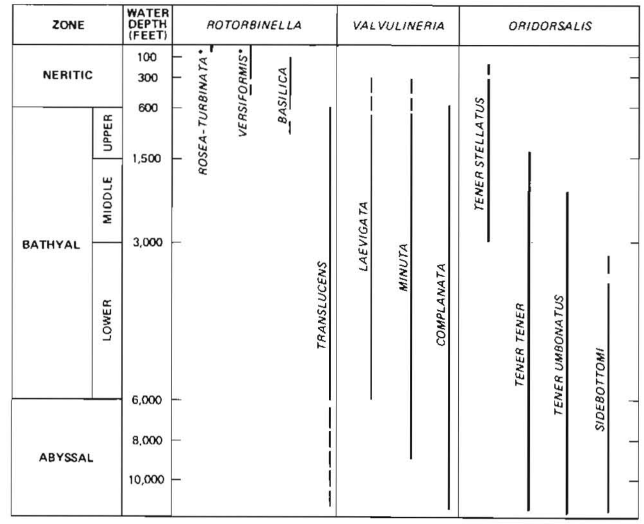

FIGURE 12

Water-depth distribution of species of *Rotorbinella, Valvulineria,* and *Oridorsalis.* Asterisk indicates species not reported in Gulf of Mexico. Heavy line indicates cline.

sporadically in the abyssal zone. This species has a smooth and almost flat dorsal side and is commonly light brown in color. Reports of its occurrence in the neritic zone should probably be referred to *R. basilica.*

Species referred to *Valvulineria* include *V. laevigata* Phleger and Parker, *V. minuta* (Parker), and *V. complanata* (d'Orbigny) (fig. 12). The latter species has also been identified as *V. mexicana* by Parker (1954) and *V.* sp. cf. *V. arauncana* (d'Orbigny) by Phleger and Parker (1951); however, it is identical to specimens of *V. complanata* of the Mediterranean and Atlantic figured by Parker (1958).

Valvulineria laevigata and *V. minuta* are both small forms that have upper depth limits in the lower neritic zone and show a slight size increase in the bathyal zone with increasing water depth. *Valvulineria complanata,* a larger and more characteristic species of *Valvulineria,* has upper depth limits near the upper boundary of the bathyal zone and ranges down into the abyssal zone. It is a more cosmopolitan deep-water species, being reported from the Atlantic, Mediterranean, and Gulf of Mexico.

Species of *Oridorsalis* probably represent a cline in part (fig. 12). *Oridorsalis tener stellatus* (Silvestri), a small form (0.3 mm in diameter) with highly reflected ventral sutures, ranges from the middle neritic zone down through the middle bathyal zone. *Oridorsalis tener tener* (Brady), about the same size as the preceding form or slightly larger, has slightly curved ventral

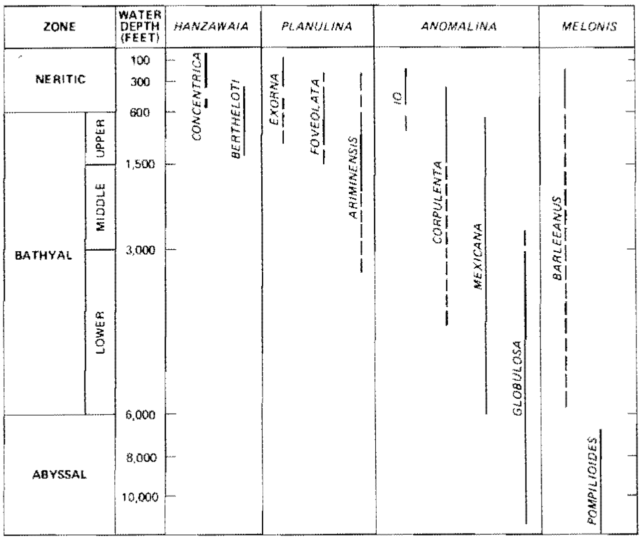

FIGURE 13

Water-depth distribution of species of *Hanzawaia*, *Planulina*, *Anomalina* and *Melonis*. Heavy line indicates cline.

sutures and apparently ranges from the lower upper bathyal zone into the abyssal zone. *Oridorsalis tener umbonatus* (Reuss), about 0.75 mm in diameter, is distinctly larger than the two shallower species. It has somewhat reflected ventral sutures, and its upper limits in the middle bathyal zone coincide approximately with the upper limits of the colder isothermal waters of the Gulf of Mexico.

Oridorsalis sidebottomi (Earland), a small (about 0.20 mm in diameter), rounded form, is restricted to the lower bathyal and abyssal zones in the Gulf. It appears to be a morphologically distinct species unlike those in the above cline.

Hanzawaia, *Planulina*, *Anomalina*, and *Melonis*

Hanzawaia strattoni (Applin), a form with a somewhat rounded edge, is perhaps most characteristic of the lower part of the upper neritic zone; *Hanzawaia concentrica* s.s. with its sharp edge is most characteristic of the middle neritic zone (Bandy, 1956), and *H. bertheloti* (d'Orbigny), a thin-walled delicate species, is more or less confined to the lower neritic and upper bathyal zones (fig. 13). The two shallower species, *H. concentrica* and *H. strattoni*, may represent a cline.

Planulina exorna (Phleger and Parker) is the most shallow occurring species of *Planulina* in the Gulf of Mexico, being most characteristic of the middle neritic zone but extending slightly up into the upper neritic zone and down into the upper bathyal zone (fig. 13). It is very similar to *P. ornata* (d'Orbigny) in the eastern Pacific, and both have approximately the same upper depth ranges. [Compare with Gulf of California (Bandy, 1961).] *Planulina foveolata* (Brady) is primarily a lower neritic and upper bathyal index, with only rare occurrences in the middle neritic zone and in water depths greater than about 1,500 feet. *Planulina ariminensis* d'Orbigny has about the same upper depth limits as *P. foveolata*; however, it is more characteristic of the upper and middle bathyal zones. No evidence of a cline was noted in these species of *Planulina*.

Anomalina io (Cushman), which is commonly referred to the genus *Cibicides*, represents the most shallow occurring species of this genus with upper depth limits within the middle neritic zone (fig. 13). Its lowest occurrence is in the upper bathyal zone. *Anomalina corpulenta* (Phleger and Parker) is a large robust species with upper depth limits in the lower neritic zone; it ranges down through the upper bathyal zone and occurs sporadically in deeper water. *Anomalina mexicana* (Parker) is generally a good bathyal index; it appears to be unique to the Gulf of Mexico and the tropical Atlantic area. *Anomalina globulosa* (Chapman and Parr) is similar to many anomalinids of the Tertiary and Upper Cretaceous. It is restricted for the most part to lower bathyal and abyssal water depths and occurs in most of the world's oceans. Species of *Anomalina* in the Gulf of Mexico show a general morphologic change corresponding to increasing water depth. Species from shallow water have a more sharply rounded edge and a compressed form, whereas those in deeper water have a more broadly rounded edge. For example, *A. corpulenta* shows this trend of increasing roundness of the edge with increasing water depth.

Species of *Melonis*, as distinct from *Nonion*, are biumbilicate and appear to be restricted mainly to middle neritic and deeper zones (fig. 13). *Melonis barleeanus* (Williamson) and *M. affine* (Reuss) have compressed tests, are rather finely perforate, and range in depth from the middle neritic zone down into the lower part of the bathyal zone. *Melonis pompilioides* (Fichtel and Moll), on the other hand, is restricted to the abyssal zone. Reports of *M. pompilioides* in shallower water are incorrect; the shallow-water forms that have the general form of *M. pompilioides* are better referred to *M. soldanii* (d'Orbigny) which differs in having a smoother surface and finer perforations (Frerichs, 1969). It may be possible that populations of *M. soldanii* and *M. pompilioides* intergrade in some deep-water areas and thus represent a cline. However, *M. soldanii* was not found in the Gulf of Mexico.

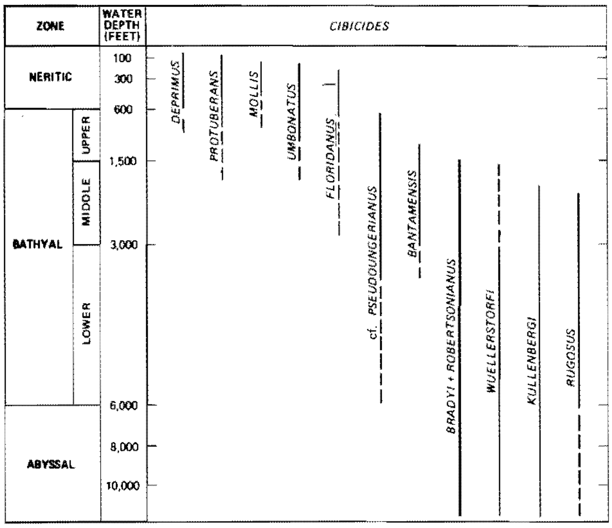

FIGURE 14

Water-depth distribution of species of *Cibicides*. Heavy line indicates cline.

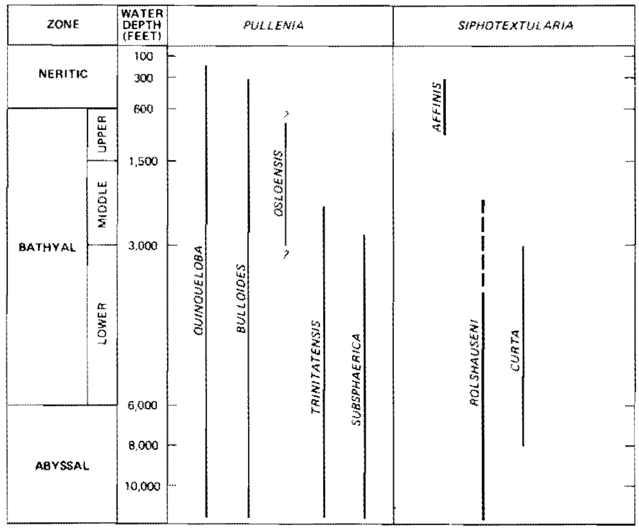

FIGURE 15

Water-depth distribution of species of *Pullenia* and *Siphotextularia*. Heavy line indicates cline.

Cibicides

Cibicides lobatulus (Walker and Jacob) occurs in the intertidal zones of many areas including the Gulf of Mexico; in California, *C. fletcheri* (Galloway and Wissler) occupies this environmental niche. *Cibicides deprimus* (Phleger and Parker) and *C. protuberans* (Parker) have upper depth limits near the base of the upper neritic zone and both occur in the upper bathyal zone (fig. 14). *Cibicides deprimus* somewhat resembles *C. lobatulus*, whereas *C. protuberans* is similar to *C. fletcheri*. These species may intergrade morphologically; however, this has yet to be documented.

Cibicides mollis (Phleger and Parker), *C. umbonatus* (Phleger and Parker), and *C. pseudoungerianus* (Cushman) all have upper depth limits within the middle neritic zone, and extend down into the upper bathyal zone with sporadic occurrences in deeper water (fig. 14).

Cibicides floridanus has upper depth limits near the upper boundary of the upper bathyal zone (fig. 14). *Cibicides bantamensis* (LeRoy) may be restricted to the middle bathyal zone. *Cibicides bradyi* (Trauth) intergrades with *C. robertsonianus* (Brady), and in this study both appear to have upper depth limits near the upper boundary of the middle bathyal zone; some reports in the literature record shallower occurrences, but these are regarded as misidentifications. *Cibicides wuellerstorfi* (Schwager), although it is most characteristic of depths greater than 3,000 feet, has scattered occurrences in the middle bathyal zone. *Cibicides rugosus* (Phleger and Parker), with upper depth limits within the middle bathyal zone, is an excellent deeper water index and, because of its thickened wall, is not easily dissolved in deep water. *Cibicides kullenbergi* (Parker) also has upper depth limits within the middle bathyal zone; shallower occurrences noted in the literature may represent misidentifications.

Pullenia and *Siphotextularia*

Forms of *Pullenia* occurring in shallow water are referred to *P. quinqueloba* (Reuss), which ranges in water depth from the middle neritic zone into the abyssal zone (fig. 15). In the original *Alaminos* sample counts, specimens of *Pullenia* with four chambers in the final whorl were referred to *P. quadriloba* (Cushman and Todd); however, these appear to have about the same distribution as those with five chambers in the final whorl, and the two forms are now regarded as morphovariants of *P. quinqueloba*. *Pullenia bulloides* (d'Orbigny) includes forms that are spherical and have about four to five chambers in the final whorl; these specimens range from the lower neritic zone into the abyssal zone. Specimens of *Pullenia* that resemble *P. bulloides* but differ in being slightly compressed laterally are referred to *P. osloensis* (Feyling-Hansen); they appear in the upper and middle bathyal zones of this study.

Pullenia trinitatensis (Cushman and Stainforth) and *P. subsphaerica* (Parr) have upper depth limits within the middle bathyal zone. *Pullenia trinitatensis*, a rela-

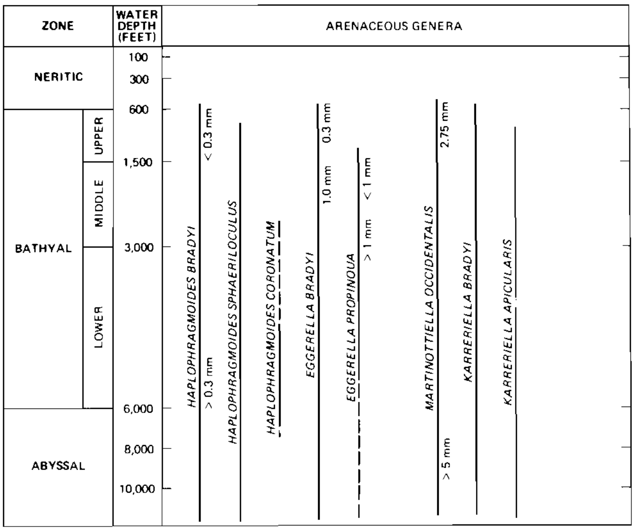

FIGURE 16

Water-depth distribution of selected agglutinated species. Maximum test-size trends are shown in millimeters.

tively small species, is highly compressed laterally with from six to seven chambers in the final whorl, is biumbilicate, and ranges in diameter from about 0.2 to 0.3 mm in the Gulf of Mexico. *Pullenia subsphaerica*, another small species ranging from 0.2 to 0.25 mm in diameter, has been erroneously identified as *P. bulloides* in many deep-sea reports; it is characterized by the four chambers in the final whorl, curved sutures, and a curved and slightly oblique apertural face. There are no intergradational forms between *P. trinitatensis* and *P. subsphaerica*.

Siphotextularia affinis (Fornasini), with its aperture aligned more or less parallel with the plane of test compression, appears to be restricted to the lower neritic and upper bathyal zones (fig. 15). *Siphotextularia rolshauseni* (Phleger and Parker), with the long axis of its oval aperture aligned generally at right angles to the plane of test compression, has upper depth limits in the middle bathyal zone and ranges into abyssal water depths. *Siphotextularia curta* (Cushman) is characteristic of the lower bathyal and abyssal zones. *Siphotextularia affinis* and *S. rolshauseni* are perhaps related, whereas *S. curta* is morphologically distinct.

Selected Agglutinated Genera

Haplophragmoides bradyi (Robertson) generally has upper depth limits near the upper limit of the bathyal zone (fig. 16); it attains abundances of from 2 to 10 percent in the middle bathyal, lower bathyal, and abyssal zones, except in the eastern carbonate area off Florida. There is a slight size increase from a diameter of less than 0.3 mm in the upper and middle bathyal zones to about 0.3 or larger at greater depths. *Haplophragmoides sphaeriloculus* (Cushman) has rather consistent upper depth limits at a water depth of about 1,200 feet with the exception of one specimen collected at 762 feet along traverse 1. *Haplophragmoides coronatum* (Brady), a large species, has its most characteristic occurrence in the lower bathyal zone of the Gulf of Mexico but also occurs occasionally in the middle bathyal zone. These three species are quite distinct and do not intergrade morphologically.

Eggerella bradyi (Cushman), a cosmopolitan form with a smooth wall, occurs in upper bathyal water depths with a maximum length of about 0.3 mm (fig. 16); its size in middle bathyal and abyssal water depths is about 1.0 mm. On the other hand, *Eggerella propinqua* (Brady), with somewhat coarser wall texture, has upper depth limits in the lower part of the upper bathyal zone where its length is less than 1 mm; in the middle bathyal water depths and deeper its size is generally greater than 1 mm. These two species are unrelated and not morphologically gradational.

Martinottiella occidentalis (Cushman) occurs generally in bathyal and abyssal water depths (fig. 16) in the Gulf of Mexico with only rare occurrences in the middle and lower neritic zones; its maximum length is at least 2.75 mm in the upper bathyal zone. In the eastern Pacific, this species and related forms seem to be restricted to water depths greater than 3,000 feet where they attain lengths of more than 4 mm in the lower bathyal zone and more than 5 mm in the abyssal zone (Bandy, 1963a).

Karreriella bradyi (Cushman) has a distribution similar to that of *Eggerella bradyi*, with upper depth limits in the lowermost neritic zone and occurrences throughout the bathyal and abyssal zones (fig. 16). *Karreriella apicularis* (Cushman) has upper depth limits in the upper bathyal zone and ranges throughout all the deeper water zones; off the Mississippi River its continuous occurrences are in the lower bathyal and abyssal zones and thus show evidence of delta depressed upper depth limits. There may be an intergradational series between *Karreriella bradyi* and *Eggerella bradyi*; however, none exists between these two species and *Karreriella apicularis*.

Cribrostomoides Group and Agglutinated Alveolar Species

Cribrostomoides subglobosus (Sars) is generally a good depth index for the middle bathyal and deeper zones (fig. 17). Occasional specimens have been reported in the upper bathyal zone and one occurrence

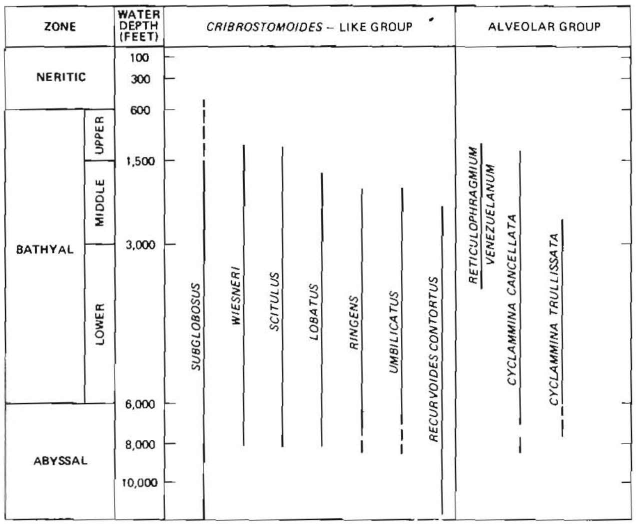

FIGURE 17

Water-depth distribution of *Cribrostomoides* group and selected agglutinated alveolar species.

was noted from traverse 1 of this study at a water depth of 498 feet. Specimens in abyssal water depths intergrade with forms showing the development of multiple apertures; this trend from simple to cribrate apertures represents a cline and is thus not used as a generic characteristic. Specimens in this study generally have areal apertures that occasionally develop incipient constrictions regarded as the first step toward the formation of cribrate multiple apertures.

Cribrostomoides wiesneri (Parr), a rare species in the Gulf of Mexico, has upper depth limits in the lower part of the upper bathyal zone and ranges into the abyssal zone (fig. 17). *Cribrostomoides scitulus* (Brady) has the same depth range as *C. wiesneri. Cribrostomoides lobatus* (Saidova), reported at great depths in the Pacific Ocean, is characteristic of middle bathyal to abyssal water depths in the Gulf of Mexico. *Cribrostomoides ringens* (Brady) is also characteristic of middle bathyal to abyssal water depths; this latter species, *C. weisneri*, and *Haplophragmoides bradyi* all have very similar wall texture. *Cribrostomoides umbilicatus* (Pearcey) is quite rare and sporadic in distribution and occurs in the middle bathyal and deeper zones (fig. 17).

Planispiral forms that tend to become streptospiral or trochospiral in later growth stages are referred to *Recurvoides*; however, this genus may represent simply a variation of *Cribrostomoides*. *Recurvoides contortus* Earland occurs in the middle bathyal zone and deeper; some of the specimens referred to this species may be irregular forms of *Cribrostomoides subglobosus*.

Alveolar agglutinated forms include *Alveovalvulinella pozonensis* (Cushman and Renz) which is represented by a few scattered specimens at a water depth of 762 feet and deeper; however, with the exception of one questionable occurrence, no living specimens were found. Prior to this study this species was previously restricted to the middle Tertiary of the West Indies. *Reticulophragmium venezuelanum* (Maync) has a water depth range from about 1,200 feet to 4,000 feet (fig. 17).

Perhaps one of the best isobathyal indicator species among the arenaceous foraminifers is *Cyclammina cancellata* (Brady), which has an upper depth limit of about 1,500 feet and a lower limit within the abyssal zone (fig. 17). *Cyclammina trullissata* (Brady), reported originally at water depths of 2,340 feet (Brady, 1884), has upper depth limits deeper than 2,600 feet in this study (fig. 17).

FAUNAL TRENDS

FAUNAL-DEPTH TRENDS

Six general faunal-water depth trends noted in this study provide auxiliary data for paleoenvironmental interpretation, i.e., total foraminifer- and benthic foraminifer-ostracode ratios, percent radiolarians in both the total and benthic foraminifer populations, benthic specimens per species, percent agglutinated foraminifers in the benthic foraminiferal population, and the planktonic foraminiferal abundance and wall type. These trends observed in modern marine microorganisms are strikingly similar to many microfossil trends (Bandy and Arnal, 1960, 1969; Phleger, 1960).

Foraminifer/ostracode ratios shown in figure 18 are drawn as the abundance of both total and benthic foraminifers with respect to ostracodes (Bandy, 1963b, 1964a). In the present study, the mean ratio values for benthic plus planktonic foraminifers to ostracodes in the samples of each major water-depth zone reflect a dramatic increase from about 400 in the upper bathyal zone to more than 2,300 in the abyssal zone (see table 5). Eliminating the planktonic foraminifers, the mean values for benthic foraminifers to ostracodes range from 78 to 219; the lower values of 76 and 105 occur in the lower part in the lower bathyal and abyssal zones, respectively. Along the California coast, in the Gulf of California, and in Batabano Bay, Cuba, foraminifers commonly are only 1 to 10 times as abundant as ostracodes in lagoon and inshore paralic euryhaline environments, whereas in open marine environments,

TABLE 5

Foraminifer/ostracode ratios listed according to increasing water depth. Traverse 3 sample numbers 5–16 and traverse 2 sample numbers 44–80.

BATHYMETRIC ZONATION	SAMPLE	WATER DEPTH (FEET)	BENTHIC FORAMINIFER/ OSTRACODE RATIO		TOTAL FORAMINIFER/ OSTRACODE RATIO	
Upper Bathyal	5	534	425		525	
	80	624	33		135	
	6	906	88	(Mean 168)	144	(Mean 408)
	7	1,224	269		700	
	73	1,176	120		582	
	77	1,212	73		364	
Middle Bathyal	8	1,506	265		750 +	
	74	1,572	100		469	
	9	1,824	376		1,454 +	
	72	1,836	282		1,496	
	10	2,148	166		620	
	65	2,328	200	(Mean 198)	3,521	(Mean 1,153)
	11	2,496	313		1,965	
	70	2,448	117		626	
	12	2,730	156		739	
	62	2,688	50		563	
	69	2,724	150		477	
Lower Bathyal	13	3,006	119		543	
	68	3,030	280		1,120	
	66	3,078	83		465	
	63	3,078	250		2,831	
	61	3,078	200		3,076	
	64	3,102	200		2,345	
	14	3,324	316	(Mean 219)	1,092	(Mean 1,924)
	67	3,318	120		977	
	15	3,630	333		1,966	
	16	3,864	288		2,563	
	60	3,816	410		5,350	
	59	4,218	31		757	
Lower Bathyal	53	4,506	125		2,718	
	58	4,524	33		1,058	
	52	4,920	44		1,131	
	54	5,010	45		755	
	51A	5,136	67	(Mean 76)	1,442	(Mean 1,717)
	57	5,268	25		390	
	54B	5,394	50		1,182	
	51	5,622	63		1,836	
	54A	5,994	233		4,944	
Abyssal	49	6,054	30		971	
	55	6,234	200		3,333	
	56	6,492	112		3,453	
	47	6,624	150	(Mean 105)	6,587	(Mean 2,305)
	46	7,482	22		764	
	44	11,532	117		653	

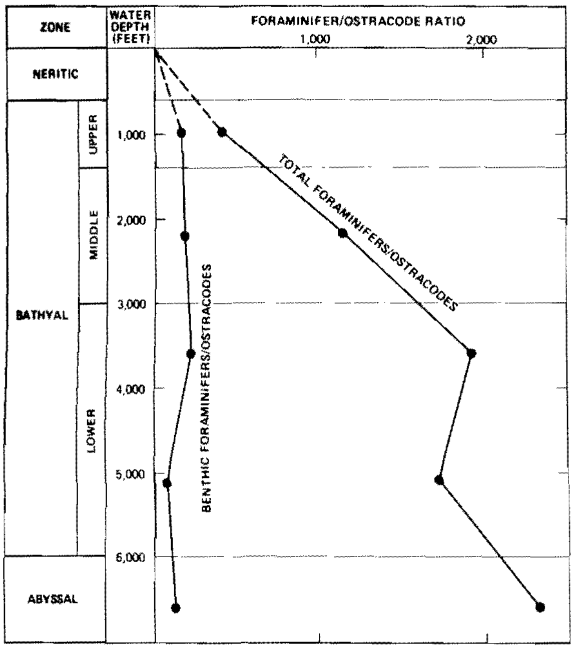

FIGURE 18

Foraminifer/ostracode ratio mean values with increasing water depth for samples from traverses 2 and 3.

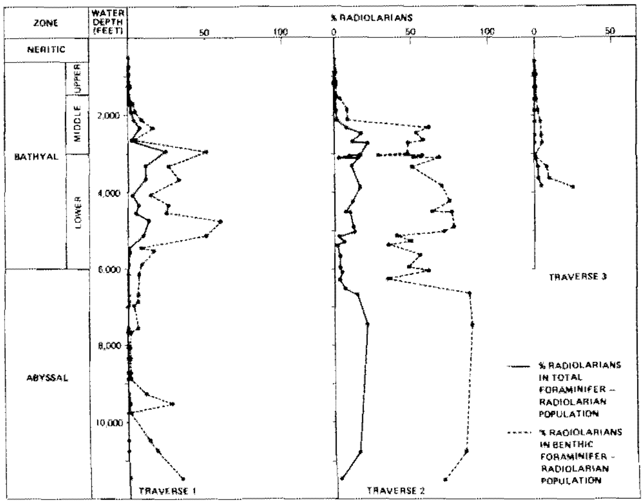

FIGURE 19

Percent radiolarians in total foraminifer- and benthic foraminifer-radiolarian populations with increasing water depth.

foraminifers are generally 100 to 200 times as abundant as ostracodes.

Radiolarian abundance measured against both the total and benthic foraminifer populations is shown in figure 19. Radiolarians occur in samples from all three traverses but are generally not abundant in the Gulf of Mexico. An irregular increase in abundance of radiolarians with water depth is noted, agreeing with the trend previously reported in the Pacific Ocean (Bandy and Arnal, 1960; Bandy, 1961, 1964b; Bandy and Rodolfo, 1964); however, percentage values differ between the three traverses. In general, radiolarians are absent in sediments on the shelf and in the upper portion of the bathyal zone. They become consistent components of the benthic assemblages, however, in the deeper portions of the upper bathyal zone and show a marked increase in abundance in the middle bathyal zone of traverses 1 and 2. Along traverse 3, their first significant increase is in samples from the lower bathyal zone. Maximum percentages of radiolarians, 10 to 15 percent of the benthic population, occur in the lower bathyal zone of samples from traverses 1 and 2. In summary, abundant radiolarians occur in Gulf of Mexico sediments where (1) bottom temperatures are less than 6°C, (2) water depths are well below the oxygen minimum zone (fig. B-3), and (3) Eh values of expressed water are less than 100 millivolts; this correlation is especially notable in traverse 1 (figs. 19, B-1). The difference in Eh values between direct or slurry readings and those from expressed waters suggests a variation due to postdepositional change. Direct Eh readings reflect conditions in the upper 8 cm of the cored sediment, whereas expressed water values represent conditions at a core depth of 8 to 16 cm. Thus, an implied postdepositional selective elimination of the siliceous remains of radiolarians occurs in cores with high Eh values from expressed water; preservation occurs with low Eh values. Correspondingly, the apparent increase in radiolarian abundance with these lower Eh values may be related to the solution of foraminifers.

A specimen-per-species trend is shown in figure 20. Species number alone reflects the change in populations with depth; however, these values are dependent on a uniform sample size. The error introduced by unequal sample size is minimized by relating the total benthic population of each sample to the number of species or, in other words, the specimens per species. For example, with a population of 1,000 specimens and 1,000 species, the index would be 1, representing a very diverse population. On the other hand, a population of 1,000 specimens and 1 species would have an index of 1,000, which would represent the least possible diversity. Thus, along the traverses of this study the greatest benthic diversity is indicated in samples from the deepest zones studied. The least diversity or the most specimens per species in samples from the

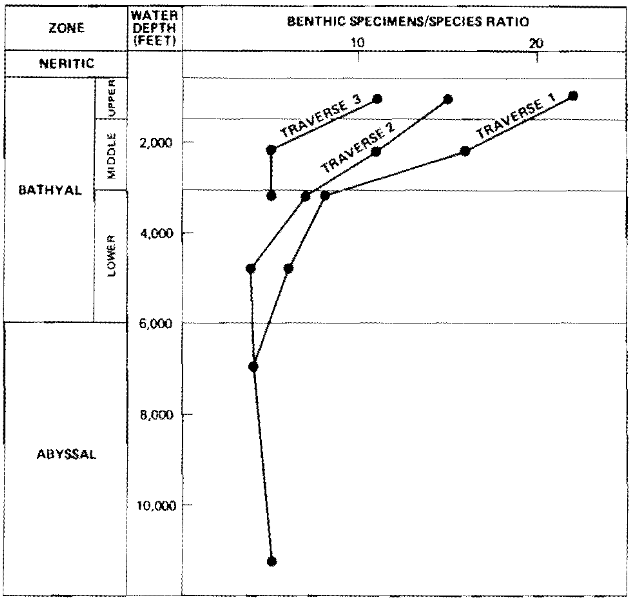

FIGURE 20

Benthic foraminifer specimens/species trend with increasing water depth.

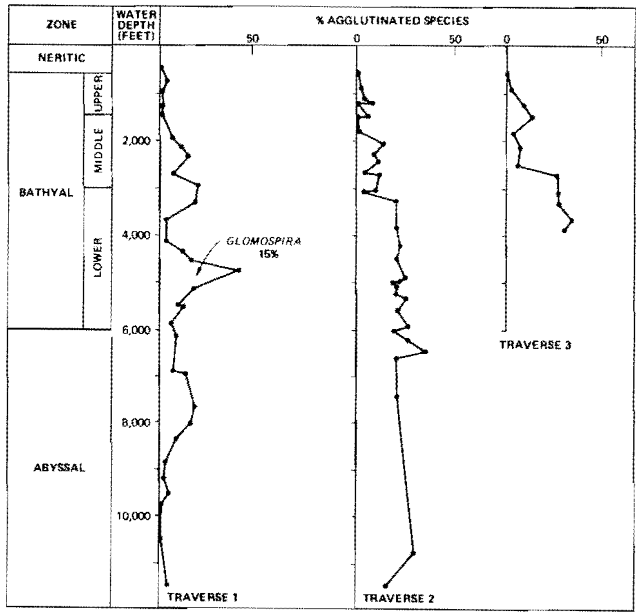

FIGURE 21

Percent agglutinated foraminifers in the benthic population with increasing water depth.

three profiles is in samples off the Mississippi River (traverse 1), which may reflect an unfavorable environment or more rapid sedimentation rates. In oceanic areas previously studied, the number of benthic foraminiferal species increases with increasing water depth from the inner neritic zone to the bathyal zone and then may decrease with increased water depth (Bandy, 1956, 1960; Bandy and Arnal, 1957, 1960). In the present study, a total of 60 species or more are representative of all samples in the middle and lower bathyal zones, whereas fewer than 60 characterize most samples deeper than 7,000 feet (see appendix C). This trend is observed in figure 20 where the upper bathyal zone is characterized by specimen-per-species values from 11 to 22, followed by an abrupt decline of values in the lower bathyal zone of from 4 to 8 and from 4 to 5 in the abyssal zone. A slight increase in the abyssal zone from a low of 4 at upper abyssal depths to 5 at lower abyssal depths is significant compared to the very high values in the upper bathyal zone. Thus, in the upper bathyal zone there are more species represented by unusually large populations of specimens; in the lower bathyal zone there are fewer species and smaller populations producing a greater faunal diversity or lower numerical value represented by the specimens per species. In summary, a decrease in specimens-per-species values for open marine foraminifers may reflect (1) a shoreward trend, or (2) a deepening trend from upper bathyal to abyssal depositional environment. These two trends in fossil assemblages could be distinguished easily by changes in depth indices and faunal composition.

The relationship between calcareous and agglutinated (arenaceous) foraminifers and water depth is shown in figure 21. Species with porcelaneous or calcareous imperforate walls, a subdivision of the calcareous group, occur rarely in samples from the deeper water facies of the Gulf of Mexico (appendix C). Hence, the percentage of agglutinated foraminifers in benthic populations is essentially the complement of the percentage of specimens with calcareous perforate or hyaline walls. The percentage of agglutinated foraminifers increases with increasing water depth in all three traverses from less than 5 percent in the upper bathyal and the upper part of the middle bathyal zones to 15 percent or more in the lower bathyal and abyssal zones. In water depths of about 3,000 feet in the Pacific Ocean there is appreciable solution of foraminiferal tests (Berger, 1967). Below depths of about 9,000 feet Berger showed that tests dissolved differentially; thus, solution selectively changes faunal composition and size distribution by first dissolving thin-walled forms and then thicker-walled forms. In the present study, Eh values in the upper 12 inches of

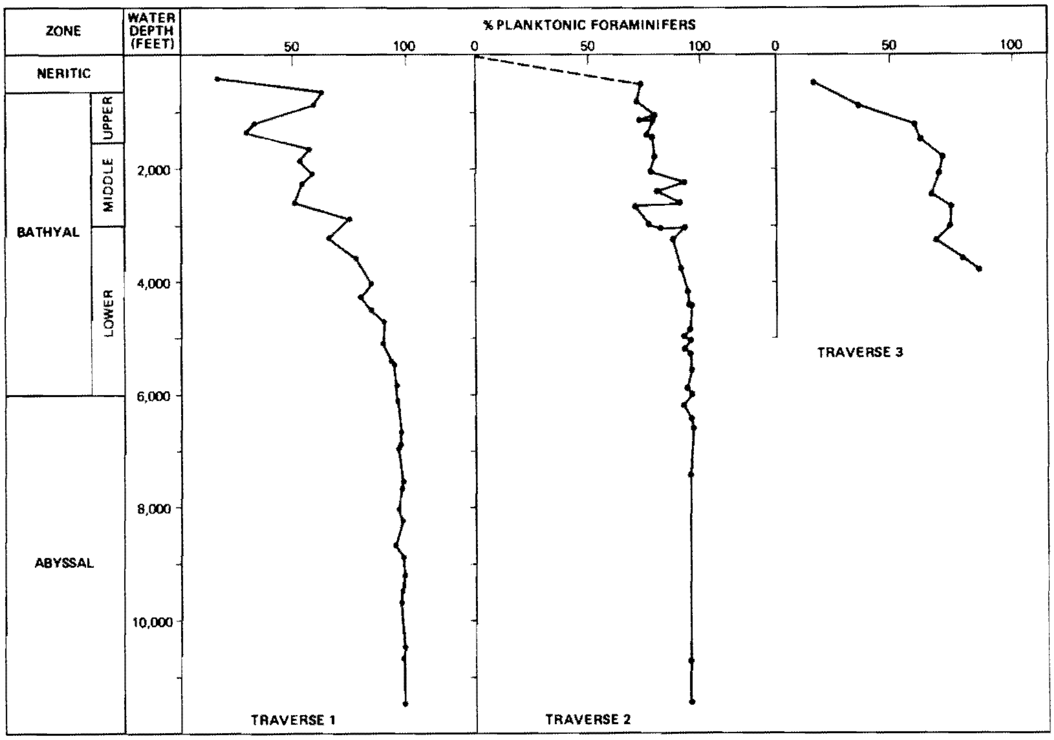

FIGURE 22

Percent planktonic foraminifers in the benthic population with increasing water depth.

cores from traverse 3 showed a rapid change to an anaerobic (H_2S) system with core depth (table A-3; fig. B-2). This postdepositional change could result in the solution of fragile tests, leaving only calcareous forms with thick walls or agglutinated species. For instance, in the Andaman Sea, Frerichs (1970) found an exclusively agglutinated foraminiferal fauna in a silled basin (sill depth 5,900 feet), whereas at similar depths in the open ocean the fauna is dominantly calcareous. Consequently, a fossil assemblage composed of agglutinated foraminifers and radiolarians might result from similar geochemical conditions.

Planktonic-benthic foraminiferal relationships found in samples from the three traverses of this study are shown in figure 22. Planktonic foraminifers are generally very rare or absent in inshore waters and become progressively more abundant with increasing distance from shore and increasing water depth (appendix E of this report; Grimsdale and Morkhoven, 1955; Bandy, 1956). In addition, the environmental effect of a major fresh-water inflow, such as the Mississippi River system, also affects planktonic species abundance. This effect is illustrated by the pronounced decline of *Globigerinoides ruber* (d'Orbigny) off the Mississippi River as shown by Phleger (1960, fig. 79).

The quantitative abundance of planktonic foraminiferal species in the benthic population according to water depth and geographic distribution in the Gulf of Mexico is shown in figure 23. This figure is based on data from the present study and those of Phleger (1951) and Parker (1954). Shallow-water samples in the present study were limited to the lowermost neritic zone; however, the resultant distributional data are consistent with those of the previous authors. Planktonic species become common in sediments from the middle neritic zone, are of about equal abundance with benthic species near the neritic-bathyal zone boundary or somewhat below it, and comprise more than 90 percent of the total foraminiferal population in the lower bathyal and abyssal zones. Exceptions to this general trend are shown off the Mississippi River where planktonic abundance values are displaced into lower depth zones. Off the Rio Grande, Trinity River, and the Galveston areas the 50 percent isopleth is depressed into middle and upper bathyal water depths. The displaced values off rivers are due no doubt to the influx of fresh water and perhaps to the downward displacement of slope sediment.

Wall structure of planktonic species also shows a relationship to water depth. For instance, Bé and Eric-

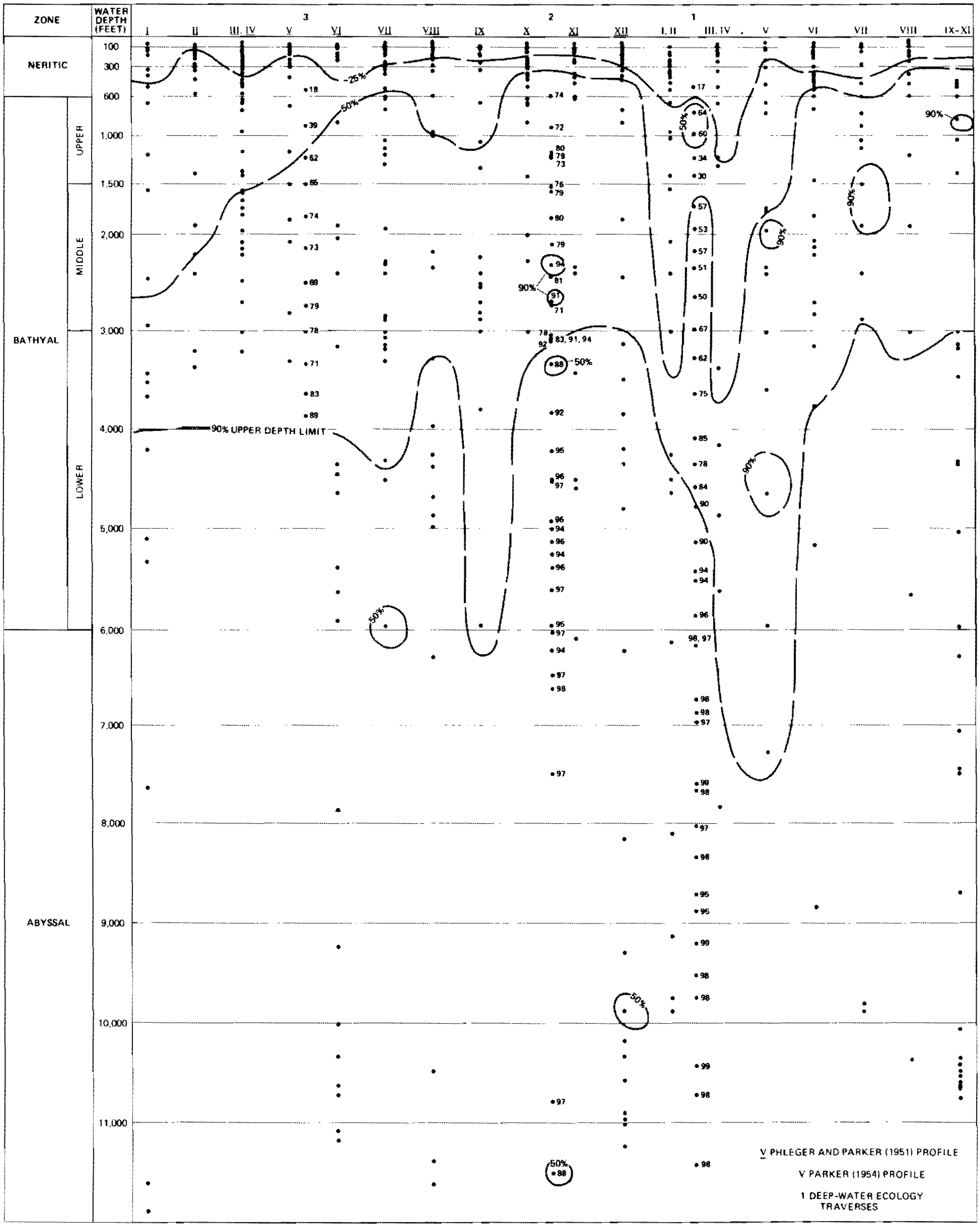

FIGURE 23

Planktonic foraminifer abundance in the benthic population with increasing water depth. Data from the present traverses and from published reports.

son (1963) showed that a thick, coarsely crystalline crust with a sugary texture develops on certain planktonic species at mesopelagic water depths between 1,000 and 3,000 feet. In the present study significant numbers of *Globorotalia menardii* (Parker, Jones, and Brady) developed a crystalline crust in water depths deeper than about 762 feet; 77 percent of the specimens of this species have a crust at this depth in samples from traverse 1, 85 percent have a crust at 918 feet in traverse 2, and 50 percent have a crust at 906 feet in traverse 3. In shallower water depths only a few individuals exhibited some crustal development. *Globorotalia truncatulinoides* (d'Orbigny) showed significant numbers (80 percent) of specimens with crustal thickening at water depths of 1,230 feet along traverse 1, 1,176 feet along traverse 2, and 1,224 feet along traverse 3; the first observed appearance of crustal thickening in this species was at a water depth of 762 feet. Secondary crustal thickening in *Globorotalia crassaformis* Galloway and Wissler appeared at water depths of about 1,200 feet. Thus, significant crustal thickening of these three planktonic species was found in upper bathyal water depths.

These data differ from those of Orr (1967), who evaluated the upper depth limits of secondary calcification in four Holocene species of *Globorotalia* from the Gulf of Mexico. He reported that crustal thickening appears at neritic water depths of about 360 feet in *Globorotalia menardii* (given as *G. cultrata*), at upper bathyal water depths of 600 feet in *Globorotalia tumida* (Brady), and at 900 feet in *Globorotalia truncatulinoides*, and at middle bathyal water depths of 2,000 feet in *Globorotalia crassaformis*.

In addition to wall structure variation in the more ubiquitous planktonic species, it is clear that some species live at greater depths than others. Thick-walled species such as *Globorotalia tumida* and *Sphaeroidinella dehiscens* (Parker and Jones) occur mainly in the bathyal and abyssal zones although the upper depth limits of these species are generally within the lower neritic zone. This depth preference was observed in Atlantic Ocean plankton tows discussed by Bé (1960) who found *G. tumida* and *S. dehiscens* in water deeper than 500 feet, although maximum planktonic populations of other species occurred at shallower water depths.

Faunal Provinces—Clastic vs Carbonate Facies

Many foraminiferal species exhibit varying degrees of specificity for one or more kinds of lithologic facies (appendix C; see Part II). The following examples illustrate this effect. *Martinottiella occidentalis* (table 4) occurs in the neritic and bathyal zones of the western Gulf in clastic substrates but is not reported in the carbonate facies of the eastern Gulf (Parker, 1954). *Glomospira charoides* (Jones and Parker) is rare in bathyal carbonate facies, comprising less than 2 percent of the benthic population; however, it is abundant in clastic substrates of the bathyal zone of the western Gulf, making up from 2 percent to more than 10 percent of the benthic population. *Sphaeroidina bulloides* attains its maximum abundances of from 5 to nearly 10 percent in clastic bathyal deposits. On the other hand, *Uvigerina flintii* is much more widespread in lower neritic and upper bathyal carbonate facies than in clastic facies; *Bolivina goesii* is also more characteristic of the lower neritic carbonate facies off western Florida (Parker, 1954) than the clastic facies of the western Gulf.

Several species with upper depth limits between water depths of 600 and 900 feet, within the upper part of the upper bathyal zone, exhibit marked facies preferences. Species that are generally twice to several times as abundant in clastic substrates than in carbonate substrates include *Bolivina albatrossi, Bulimina aculeata, Bulimina striata mexicana, Chilostomella oolina, Gyroidina altiformis cushmani, Haplophragmoides bradyi, Haplophragmoides sphaeriloculus, Uvigerina peregrina,* and *Valvulineria complanata. Valvulineria complanata* is especially restricted to the delta area in the upper part of its depth range. Two species that show the reversed preference, from twice to several times as abundant in carbonate substrates than in clastic substrates, are *Epistominella exigua* and *Rotorbinella translucens*.

Three species, *Gyroidina orbicularis, Karreriella apicularis,* and *Laticarinina pauperata*, with upper depth limits at about 1,200 feet, are about twice as abundant in the lower bathyal zone of the western Gulf as in the eastern area. Two species with upper depth limits at about 2,000 feet, *Eponides polius* and *Osangularia culter*, are somewhat more abundant in the lower bathyal zone of the western area of the Gulf; *Alabamina decorata* and *Eponides tumidulus*, with upper depth limits at about 3,000 feet, are also more abundant in deeper waters of the western Gulf than off Florida.

Discussion—Bathymetric Distribution of Benthic Foraminifers

The major changes in bathyal and abyssal benthic foraminiferal faunas in the Gulf of Mexico are those that occur with increasing depth of water in contrast to

TABLE 6

Fossil planktonic foraminifers found in deep-water ecology samples. Numbers indicate number of specimens.

TRAVERSE 1

	42	37	34	22	21	17	16	15	12	10
I. EXTINCT PLANKTONIC SPECIES										
1. *GLOBIGERINA DRURYI* AKERS										
2. *GLOBOROTALIA MENARDII* (PARKER, JONES AND BRADY) DEXTRAL POPULATIONS			1							
3. *GLOBOROTALIA PUNCTICULATA* (D'ORBIGNY)										
4. *NEOGLOBOQUADRINA DUTERTREI* (D'ORBIGNY) SINISTRAL POPULATIONS										
5. *PULLENIATINA OBLIQUILOCULATA PRIMALIS* BANNER AND BLOW, SINISTRAL POPULATIONS										
II. PLANKTONIC SPECIES INDICATIVE OF WATERS COOLER THAN THOSE TODAY										
1. *NEOGLOBOQUADRINA PACHYDERMA* (EHRENBERG) DEXTRAL FORMS	2					11	2	15	2	19
2. *GLOBOROTALIA INFLATA* (D'ORBIGNY) SINISTRAL POPULATIONS										
3. *GLOBOROTALIA TRUNCATULINOIDES* (D'ORBIGNY) SINISTRAL POPULATIONS		17	4	12	10	8	7	B	25	

TRAVERSE 2

	80	78	77	74	73	72	68	65	61	55	54	52	51	49
I. EXTINCT PLANKTONIC SPECIES														
1. *GLOBIGERINA DRURYI* AKERS											1			
2. *GLOBOROTALIA MENARDII* (PARKER, JONES AND BRADY) DEXTRAL POPULATIONS					2	1					30			3
3. *GLOBOROTALIA PUNCTICULATA* (D'ORBIGNY)			X		?				?		?			
4. *NEOGLOBOQUADRINA DUTERTREI* (D'ORBIGNY) SINISTRAL POPULATIONS			20										6	
5. *PULLENIATINA OBLIQUILOCULATA PRIMALIS* BANNER AND BLOW, SINISTRAL POPULATIONS											12	1		
II. PLANKTONIC SPECIES INDICATIVE OF WATERS COOLER THAN THOSE TODAY														
1. *NEOGLOBOQUADRINA PACHYDERMA* (EHRENBERG) DEXTRAL FORMS														
2. *GLOBOROTALIA INFLATA* (D'ORBIGNY) SINISTRAL POPULATIONS			30		1				3		11			
3. *GLOBOROTALIA TRUNCATULINOIDES* (D'ORBIGNY) SINISTRAL POPULATIONS	25	5		3	2	2	6	40	30	5		5		

TRAVERSE 3

	5	6	8	9	11	13	14	15
I. EXTINCT PLANKTONIC SPECIES								
1. *GLOBIGERINA DRURYI* AKERS								
2. *GLOBOROTALIA MENARDII* (PARKER, JONES AND BRADY) DEXTRAL POPULATIONS				1				
3. *GLOBOROTALIA PUNCTICULATA* (D'ORBIGNY)								
4. *NEOGLOBOQUADRINA DUTERTREI* (D'ORBIGNY) SINISTRAL POPULATIONS		2	4	1	4			
5. *PULLENIATINA OBLIQUILOCULATA PRIMALIS* BANNER AND BLOW, SINISTRAL POPULATIONS								
II. PLANKTONIC SPECIES INDICATIVE OF WATERS COOLER THAN THOSE TODAY								
1. *NEOGLOBOQUADRINA PACHYDERMA* (EHRENBERG) DEXTRAL FORMS								
2. *GLOBOROTALIA INFLATA* (D'ORBIGNY) SINISTRAL POPULATIONS								
3. *GLOBOROTALIA TRUNCATULINOIDES* (D'ORBIGNY) SINISTRAL POPULATIONS	2		4	3		4	3	2

lateral geographic location. Bathymetric faunal changes correspond to a number of environmental boundaries. It is difficult to determine at present, however, which environmental factor or factors limit faunal distribution. For example, a temperature boundary occurs in the Gulf of Mexico at water depths slightly greater than 3,000 feet (table A-2); if this were the primary limiting factor, there should be little faunal zonation recorded below this depth; however, this is not the case. In addition, species such as *Bulimina aculeata* and others with upper depth limits at various water depths within the lower neritic and upper bathyal zones have similar upper depth limits in different oceanic water masses characterized by different temperature gradients and oxygen values (Bandy and Echols, 1964; Bandy and Chierici, 1966).

A prominent oxygen minimum zone correlates with the upper bathyal zone in the Gulf of Mexico (fig. B-3). If oxygen depletion is responsible for the upper depth limits of certain species, those upper depth limits should vary from one water mass to the next depending on the water depth of the oxygen minimum zone in each location. However, as noted above, a number of benthic species with upper depth limits within the upper bathyal zone show similar depth limits in different water masses with different oxygen values. Nevertheless, increasing oxygen values and decreasing temperature values with increasing water depths probably affect the mode of foraminiferal reproduction, i.e., sexual or asexual, and/or size characteristics of some benthic species as noted in the distribution characteristics for *Bolivina albatrossi, Hoeglundina elegans, Cyclammina cancellata,* and others. Abundances of radiolarians may likewise be related to oxygen-temperature variations; the upper limit of significant numbers of radiolarians in the Gulf of Mexico is just below the oxygen minimum zone (figs. 19, B-3). Planktonic foraminifers, on the other hand, are very abundant from lower neritic to abyssal depths and thus show little or no effect to the location of the oxygen minimum zone.

The upper depth limit of delta-depressed species along traverse 1 may be limited by an environmental factor or combination of factors related to negative Eh. Negative or significantly smaller positive direct Eh values were recorded from all sediment samples of traverse 1 between water depths of 984 and 4,338 feet. Many of the upper depth limits of delta-depressed species were observed within this depth range (table 3). Negative Eh readings were not recorded from samples in traverse 2, although there are some lower positive values in samples from the upper bathyal zone (table A-2). Some samples from traverse 3 contain negative Eh readings; however, these readings were obtained with a different instrument and under different conditions than those from samples from traverses 1 and 2 (fig. B-2).

The delta-elevated group of species, though small

TABLE 7

Core samples examined for (1) fossil foraminifers and (2) evidence of "delta effect" in fossil benthic foraminifers.

	STATION NUMBER	PURPOSE	NUMBER OF SAMPLES	CORE INTERVAL SAMPLED
TRAVERSE 1	10	Fossil check	2	98-100 cm, 195-197 cm
	15		1	98-100 cm
	17		2	98-100 cm, 128-130 cm
	30		4	10-20 cm, 30-40 cm, 60-70 cm, 90-100 cm
	31	Evidence of "delta effect" in fossil	2	38-100 cm, 144-146 cm
	32	benthic foraminifers	2	98-100 cm, 166-168 cm
	33		2	98-100 cm, 170-172 cm
	34		2	98-100 cm, 128-130 cm
	35		2	98-100 cm, 144-146 cm
	36		2	98-100 cm, 169-171 cm
	37		2	98-100 cm, 160-162 cm
	39		4	20-30 cm, 30-40 cm, 60-70 cm, 90-100 cm
	40		1	96-98 cm
	41		2	98-100 cm, 148-150 cm
	42		1	36-38 cm
	43		2	98-100 cm, 158-160 cm
TRAVERSE 2	51	Fossil check	2	98-100 cm, 198-200 cm
	54		2	98-100 cm, 188-190 cm
	61		2	80-90 cm, 150-164 cm
	73		2	90-100 cm, 190-200 cm
	77		1	18-20 cm
TRAVERSE 3	8	Fossil check	2	30-35 cm, 100-105 cm
	9		2	30-35 cm, 80-90 cm
	11		2	30-35 cm, 100-105 cm

(table 4), appears to thrive in the anomalous chemical environment of the delta area. It is probable that the large discharge of fresh water and sediment from the Mississippi River results in a correspondingly greater concentration of organic material in the area of traverse 1 producing the reducing conditions. However, data for organic content in carbon isotopes do not appear to provide values or trends in values that relate to faunal changes (see appendix B).

In view of the similar upper depth limits for a number of benthic foraminiferal species that occur in highly disparate water masses, faunal depth limitations expressed in terms of water pressure may be more important than the other environmental factors here considered. Hydrostatic pressure varies directly with water depth and it has been shown that the pressure tolerance of marine bacteria is related to their depth habitat (ZoBell and Johnson, 1949). It appears that a similar case may be made for depth limitations of benthic foraminifers.

FOSSIL OCCURRENCE

Fossil planktonic foraminifers are defined as (1) extinct species, or (2) species indicative of climatic conditions differing from those in Holocene water masses in a given basin or area. In the Gulf of Mexico at least five extinct planktonic foraminiferal species were noted in the deep-water ecology samples and at least three other planktonic species were found to be indicative of cooler waters than those existing today (table 6). Samples taken at depth in cores at several of the stations (table 7) show the presence of corroborating fossil or relic species for the stations listed in table 6. Species indicating cooler water masses are thought to be relic forms occurring at sample locations receiving little sedimentation during most of the Holocene; those stations with extinct later Neogene species are areas of Holocene and at least in part Pleistocene nondeposition. For example, bottom photographs at station 12 (water depth of 9,204 feet) from traverse 1 show evidence of bottom currents. Correspondingly, the sample from this station contained dextrally coiled specimens of *Globigerina pachyderma* (Ehrenberg) and an abundance of sinistrally coiled specimens of *Globorotalia truncatulinoides*, neither of which live in the waters of the Gulf of Mexico today.

Generally the nonliving planktonic populations from samples along traverse 1 are characteristic of cooler waters and are not extinct forms. Traverse 2 has several stations that contain significant numbers of extinct forms and others with species indicative of cooler water masses; traverse 3 stations also show some mixture of the two groups. The greater prevalence of older fossil faunas in the rugged slope topography of the western Gulf region indicates that the rate of tectonism in this region is greater than the rate of sedimentation. In addition, some of the irregular distributions of planktonic foraminifers in the Gulf of Mexico reported by Parker (1954) are due to the occurrences of relic populations. Parker later reported (Parker, 1965) that *Globorotalia inflata* (d'Orbigny), *G. hirsuta* (d'Orbigny), *G. crassaformis*, and *G. scitula* (Brady) occur in the eastern, but not the western, Gulf of Mexico. In this study, all of these species occur in the western Gulf (appendix C). However, *G. inflata* is not living there today and is probably not living in the eastern Gulf. In addition, *G. hirsuta* is rare in the western Gulf and was not reported living in tows from the eastern Gulf by Parker (1954). The other two species, *G. crassaformis* and *G. scitula*, are common in the western Gulf in contrast to the data by Parker.

Some benthic foraminiferal species occurring at stations where fossil planktonic species are recorded may likewise be fossil forms. It should be noted, however, that the fossil planktonic species represent very minor faunal elements in the respective samples. Similarly, it is probable that fossil occurrences of benthic species are also minor faunal components. Nevertheless, the benthic species used in the bathymetric zonation are forms that generally occur in continuous sample sequences, and many of these were also living at the time of collection (appendix D).

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APPENDIX A
BIOLOGICAL AND GEOCHEMICAL PROCEDURES

BIOLOGICAL PROCEDURES

Shipboard procedures, established by C. E. Pflum and G. A. Morales on the *Alaminos* cruise and C. E. Pflum on the *Western Shoal* cruise, consisted of sampling the uppermost five centimeters of each core (table A-1); this sample was then washed on a 200-mesh screen (0.074 mm), stained in rose bengal for ten minutes, rinsed, and stored in seawater. Upon return to the laboratory the samples were dried and split with a microsplitter; one fraction was sent to O. L. Bandy at the University of Southern California for frequency counts; the remaining sample was analyzed both quantitatively and taxonomically at EPR by W. E. Frerichs and C. E. Pflum.

Frequency counts of 300 benthic specimens were made by O. L. Bandy for most aliquots, unless the total sample size was too small. Generally, all benthic specimens were counted in each aliquot. Planktonic specimens were counted in selected grids on the counting slide and this number was then divided by the proportion of the grids counted to estimate the total number of planktonic specimens. In this way the planktonic/benthic foraminiferal ratio of each sample was estimated.

An independent qualitative study of the assemblages was made at EPR by C. E. Pflum and W. E. Frerichs. Their study was then combined with those from O. L. Bandy to produce the final frequency tables. Rare species not occurring in the frequency counts of the aliquots were added to the frequency tables. These added species were considered to be represented by a single specimen and hence were plotted with the frequency value of less than 1 percent of the population. The number of these added species ranged from 0 to as many as 10 to 12 in individual traverses.

Live specimens, or those with protoplasm stained red by rose bengal (Walton, 1952), were picked from each sample of traverses 1 and 2 by a technician at EPR. These specimens were identified and recorded by O. L. Bandy. Live counts were made directly from the samples of traverse 3. Living specimens were considered to be those that took a red stain in at least part of one chamber. The accuracy of this method of determining living specimens is highly subjective and hence influences the data for live counts. In future studies of living foraminiferal populations, it is suggested that a box corer be employed and the populations then stained, preserved, and studied wet.

GEOCHEMICAL PROCEDURES

Alaminos cruise geochemical analyses were established by C. B. Koons and included shipboard measurements for pH, Eh, and oxygen content, and laboratory measurements for chlorinity, nitrate, and inorganic phosphate content, organic carbon content and carbon isotope ratios (table A-2). Core samples were selected just below the biologic sample or from approximately 5 to 10 cm below the top of the cores.

Western Shoal cruise geochemical analyses, established by D. Perry, included shipboard measurements for pH and Eh in the sediment cores (at the water-sediment interface, three inches beneath the core top, one foot below the top and at the core bottom) and core sediment temperature (table A-3).

Alaminos cruise pH and Eh measurements were made with a Beckman model M pH meter. For pH measurements, the calomel and glass electrodes were standardized with a pH 7 buffer. The electrodes were then used to measure the pH of the Nansen bottle water samples, the direct sediment pH, a 50:50 percent slurry of the sediment sample and distilled water, and the pH of water samples were made on 50:50 percent slurries of the sediment samples and distilled water. Probing the intact sediment sample with the dual electrode system did not give reproducible Eh readings; hence, the slurry method was adopted. Expressed waters were obtained with the use of a standard API mud filter press. About 100 grams of core sediment was placed in the press and, with as low nitrogen pressure as possible to drive the system, sample water was expressed.

Western Shoal cruise pH and Eh measurements were made with a Beckman model N pH meter. Measurements of pH were taken with a single, combination electrode. This electrode has the advantage over calomel and glass electrodes in that the calomel junction is located only a few millimeters from the glass element. Thus, the instrument is more sensitive and provides a more stable reading. The electrode was washed with distilled water between readings and standardized frequently with a pH 7 buffer. Eh measurements were made with a single, combination platinum-calomel electrode. The platinum surface was frequently burnished with a mild abrasive soap, cleaned with distilled water between readings, and standardized with freshly aerated sea water.

A Sargent polarographic oxygen analyzer was used to determine the oxygen content of the *Alaminos* Nan-

TABLE A-1

Deep-water ecology project core data.

SAMPLE NUMBER	DEPTH (FEET)	LOCATION (LAT.	LONG.)	TYPE OF SAMPLE	SAMPLE NUMBER	DEPTH (FEET)	LOCATION (LAT.	LONG.)	TYPE OF SAMPLE
TRAVERSE 1									
2	810	28° 39′ N.	89° 58′ W.	Dredge	24	5,514	27° 48′ N.	88° 44′ W.	Gravity
43	498	28° 39′ N.	89° 20′ W.	Gravity	23A	5,880	27° 42′ N.	88° 39′ W.	Gravity
42	762	28° 35′ N.	89° 16′ W.	Gravity	23	6,176	27° 42′ N.	88° 41′ W.	Gravity
41	984	28° 34′ N.	89° 15′ W.	Gravity	22	6,174	27° 36′ N.	88° 37′ W.	Gravity
40	1,230	28° 33′ N.	89° 13′ W.	Gravity	21	6,726	27° 32′ N.	88° 32′ W.	Ewing
39	1,410	28° 32′ N.	89° 12′ W.	Ewing	20	6,864	27° 27′ N.	88° 30′ W.	Gravity
38	1,722	28° 31′ N.	89° 10′ W.	Gravity	19	6,972	27° 24′ N.	88° 30′ W.	Gravity
37	1,962	28° 30′ N.	89° 08′ W.	Gravity	18	7,590	27° 20′ N.	88° 24′ W.	Gravity
36	2,178	28° 29′ N.	89° 07′ W.	Gravity	17	7,650	27° 20′ N.	88° 26′ W.	Gravity
35	2,358	28° 26′ N.	89° 06′ W.	Gravity	16	8,010	27° 14′ N.	88° 20′ W.	Ewing
34	2,640	28° 25′ N.	89° 05′ W.	Gravity	15	8,328	27° 11′ N.	88° 18′ W.	Gravity
33	2,964	28° 22′ N.	89° 04′ W.	Gravity	14	8,874	26° 45′ N.	88° 11′ W.	Ewing
32	3,270	28° 19′ N.	89° 02′ W.	Gravity	13	8,712	26° 29′ N.	88° 05′ W.	Gravity
31	3,636	28° 16′ N.	89° 01′ W.	Gravity	12	9,204	26° 17′ N.	88° 03′ W.	Ewing
30	4,092	28° 14′ N.	88° 59′ W.	Ewing	11	9,510	26° 09′ N.	88° 02′ W.	Gravity
29	4,338	28° 12′ N.	88° 58′ W.	Gravity	10	9,762	26° 03′ N.	88° 01′ W.	Gravity
28	4,584	28° 10′ N.	88° 57′ W.	Gravity	9	10,122	25° 51′ N.	87° 57′ W.	Gravity
27	4,778	28° 04′ N.	88° 52′ W.	Gravity	8	10,446	25° 41′ N.	87° 55′ W.	Ewing
26	5,130	28° 03′ N.	88° 52′ W.	Gravity	7	10,728	25° 29′ N.	87° 52′ W.	Gravity
25	5,436	27° 55′ N.	88° 50′ W.	Ewing	6	11,442	25° 07′ N.	87° 38′ W.	Ewing
TRAVERSE 2									
80	594	27° 52′ N.	92° 10′ W.	Chmelik	61	3,078	27° 18′ N.	92° 26′ W.	Gravity
80	624	27° 52′ N.	92° 10′ W.	Gravity	60	3,816	27° 16′ N.	92° 26′ W.	Gravity
79	918	27° 52.5′ N.	92° 10′ W.	Gravity	59	4,218	27° 14′ N.	92° 25′ W.	Gravity
78	1,230	27° 50′ N.	92° 11′ W.	Ewing	58	4,524	26° 58′ N.	92° 19′ W.	Gravity
77	1,212	27° 48′ N.	92° 19′ W.	Gravity	57	5,268	26° 54′ N.	92° 17.5′ W.	Gravity
76	1,536	27° 47′ N.	92° 15′ W.	Gravity	56	6,492	26° 57′ N.	92° 20′ W.	Ewing
75	1,842	27° 45′ N.	92° 14′ W.	Gravity	55	6,234	26° 56′ N.	92° 20′ W.	Gravity
74	1,572	27° 44′ N.	92° 13′ W.	Gravity	54	5,010	26° 54.5′ N.	92° 17′ W.	Gravity
73	1,176	27° 41′ N.	92° 12′ W.	Ewing	54A	5,994	26° 55′ N.	92° 20′ W.	Gravity
72	1,836	27° 37′ N.	92° 13′ W.	Gravity	54B	5,394	26° 54′ N.	92° 20′ W.	Gravity
71	2,118	27° 37′ N.	92° 13′ W.	Gravity	53	4,506	26° 53′ N.	92° 17′ W.	Ewing
70	2,448	27° 36′ N.	92° 13′ W.	Gravity	52	4,920	26° 52′ N.	92° 17′ W.	Gravity
69	2,724	27° 34.5′ N.	92° 13′ W.	Gravity	51	5,622	26° 51′ N.	92° 16′ W.	Gravity
68	3,030	27° 34′ N.	92° 14′ W.	Gravity	51A	5,136	26° 51′ N.	92° 16′ W.	Gravity
67	3,318	27° 34′ N.	92° 13′ W.	Ewing	49	6,054	26° 42′ N.	92° 14′ W.	Gravity
66	3,078	27° 31′ N.	92° 13.5′ W.	Gravity	47	6,624	26° 13′ N.	92° 00′ W.	Gravity
65	2,328	27° 28′ N.	92° 13′ W.	Gravity	46	7,482	26° 00′ N.	91° 38′ W.	Gravity
64	3,102	27° 20.5′ N.	92° 25′ W.	Gravity	45	10,800	25° 35′ N.	91° 30′ W.	Gravity
63	3,078	27° 19′ N.	92° 27′ W.	Gravity	44	11,532	25° 00′ N.	92° 00′ W.	Ewing
62	2,688	27° 19′ N.	92° 27′ W.	Gravity					
TRAVERSE 3									
5	534	27° 39.0′	95° 46.5′	Gravity					
6	906	27° 37.5′	95° 45.0′	Gravity					
7	1,224	27° 36.5′	95° 44.0′	Gravity					
8	1,506	27° 35.0′	95° 43.5′	Gravity					
9	1,824	27° 34.8′	95° 42.5′	Gravity					
10	2,148	27° 31.5′	95° 41.0′	Gravity					
11	2,496	27° 30.0′	95° 39.8′	Gravity					
12	2,730	27° 27.5′	95° 38.5′	Gravity					
13	3,006	27° 24.5′	95° 36.0′	Gravity					
14	3,324	27° 22.5′	95° 35.0′	Gravity					
15	3,630	27° 20.5′	95° 34.0′	Gravity					
16	3,864	27° 16.5′	95° 31.2′	Gravity					

TABLE A-2

Geochemical data of samples from traverses 1 and 2 (*Alaminos*).

CORE SAMPLES

SAMPLE NO.	WATER DEPTH (FEET)	LOCATION LAT.	LOCATION LONG.	Eh-CORE (MV)	pH-CORE	Eh-EXPRESSED WATER (MV)	pH-EXPRESSED WATER	OXYGEN CONTENT (% SAT.)	CHLORINITY (MG/L)	NITRATE NITROGEN (μ G/L)	SAMPLE SIZE (ML)	ORGANIC CARBON CONTENT (%)	C^{13}/C^{12} RATIO	PHOSPHATE PHOSPHORUS (ML)	SAMPLE SIZE (ML)
66 A 13 6	11,442	22° 07′ N	87° 38′ W	+ 114	7.4	+ 186	7.9	82	19,300	497	5		- 26.7	0.0	5
7	10,728	25° 29′ N.	87° 52′ W	+ 300	7.1	+ 218	7.5	82	19,300	181	5	0.52	- 23.1	3.6	5
8	10,446	25° 41′ N	87° 55′ W	+ 246	7.0	+ 198	7.8	75	19,100	254	4		- 23.3	0.0	5
9	10,122	25° 51′ N	87° 57′ W	+ 204	7.2	+ 156	7.4	82		407	5			0.0	6
10	9,762	26° 03′ N.	88° 01′ W.	+ 210		+ 80	7.9	82	18,700	339	5			0.0	5
11	9,510	26° 09′ N	88° 02′ W	+ 192		+ 126	8.2	82	19,300	531	2	0.23	- 24.2	12.0	2
12	9,204	26° 17′ N.	88° 03′ W.	+ 18	8.0	+ 162	7.8	82		226	4			0.0	5
14	8,874	26° 45′ N	88° 11′ W	+ 120	7.3	+ 126	8.0	89	19,800	142	10			0.0	10
15	8,328	27° 11′ N.	88° 18′ W.	+ 156	7.8	+ 162	7.8	89	18,800	288	5	1.07	- 26.8	0.0	6
16	8,010	27° 14′ N	88° 20′ W	+ 108	7.8	+ 144	7.7	89	19,000	181	6			0.0	5
17	7,650	27° 20′ N	88° 26′ W.	+ 102	7.7	+ 144	7.7	86	18,500	113	10			1.2	5
18	7,590	27° 20′ N.	88° 24′ W	+ 86	7.4	+ 174	7.4	89	17,900	113	5	1.21	- 26.3	0.0	5
20	6,864	27° 27′ N.	88° 30′ W.	+ 144	7.7	+ 204	7.2	89	16,400	904	2			0.0	2
21	6,726	27° 32′ N	88° 32′ W									0.94	- 26.9		
22	6,174	27° 36′ N.	88° 37′ W.	+ 144	7.6	+ 150	7.3	81	19,000	248	10			0.6	10
23	6,174	27° 42′ N	88° 41′ W	+ 132	7.9	+ 198	7.5	89	18,900	271	5	0.90	- 25.8	1.2	10
24	5,514	27° 46′ N	88° 44′ W	+ 180	7.3	+ 114	7.4	86	18,100	136	5			2.4	5
25	5,436	27° 55′ N	88° 50′ W	+ 150	7.5	+ 186	7.6	91	19,000	142	10			0.0	10
26	5,130	28° 03′ N	88° 52′ W	+ 240	7.4	+ 78	7.3	86	19,000	113	10			0.6	10
27	4,278	28° 04′ N	88° 52′ W	+ 174	7.5	+ 66		84	18,900	181	5			2.4	10
28	4,584	28° 10′ N	88° 57′ W	+ 210	7.8	+ 66	7.3	87	18,900	113	5	1.05	- 25.9	4.8	5
29	4,338	28° 12′ N	88° 56′ W	+ 126	7.5	+ 48	7.8	87	19,100	84	10			10.0	5
30	4,092	28° 14′ N	88° 59′ W	+ 90	7.7	+ 48	8.0	87	19,300	90	5			0.0	5
31	3,636	28° 16′ N	89° 01′ W	+ 72	7.9	+ 48	8.0	93	19,400	45	10			0.0	5
32	3,270	28° 19′ N	89° 02′ W	+ 48	7.8	+ 48	8.3	96	19,800	113	5			2.4	5
33	2,964	28° 22′ N	89° 04′ W	+ 36	7.5	+ 54	8.3	87	19,400	81	5	0.87	- 21.7	0.0	5
34	2,640	28° 25′ N	89° 05′ W	+ 12	7.9	+ 102	7.8	93	18,500	41	10			2.4	10
35	2,358	28° 26′ N	89° 06′ W	- 12	7.6	+ 132	7.4	86	18,600	102	10			0.0	10
36	2,178	28° 29′ N	89° 07′ W	- 108	7.2	+ 78	7.4	87	19,200	57	10			0.3	10
37	1,962	28° 30′ N	89° 08′ W	- 120	7.4	+ 84	7.8	89	19,000	45	10	0.81	- 21.8	0.6	10
38	1,722	28° 31′ N	89° 10′ W	- 186	7.4	+ 120	7.4	87	18,900	90	5	1.34	- 21.8	1.2	5
39	1,410	28° 32′ N	89° 12′ W	- 150	7.6	+ 126	7.1	93	19,200	45	10			0.0	10
40	1,230	28° 33′ N	89° 13′ W	- 132	7.2	+ 132	7.3	87	19,100	90	5			0.6	10
41	984	28° 34′ N	89° 15′ W	- 186	7.1	+ 11A	7.5	90	19,300	81	5	0.77	- 21.9	0.0	5
42	762	28° 35′ N	89° 16′ W	- 36	7.4			90	19,800	108	5			0.0	5
43												0.79			
44	11,532	25° 00′ N	92° 00′ W	+ 126	7.8	+ 132	7.3	93	18,800	362	5	1.04	- 22.3	0.0	5
45	10,800	25° 35′ N	91° 30′ W	+ 150	7.9			94	19,000						
46	7,482	26° 00′ N	91° 38′ W	+ 192	7.4	+ 192	7.9	90	18,500	233	10	0.86		0.6	10
47	6,624	26° 13′ N	92° 00′ W	+ 252	7.4	+ 168	8.1	94	19,300	34	10			2.4	10
49	6,054	26° 42′ N	92° 14′ W	+ 168	8.1	+ 156	7.7	94	19,200	346	10			1.2	10
51A	5,136	28° 51′ N	92° 16′ W	+ 186	7.4	+ 174	7.6	98	19,000	339	10			0.0	5
51	5,622	26° 51′ N	92° 16′ W	+ 180	7.8	+ 174	7.3	96	19,400	271	10		- 21.6	0.6	10
52	4,920	26° 52′ N	92° 17′ W	+ 180	7.7	+ 168		94	18,900	373	10			1.7	10
53	4,506	26° 53′ N	92° 27′ W	+ 168	7.8	+ 186	7.4	94	18,800	163	10			0.0	10
54	5,010	26° 54′ N	92° 17′ W	+ 186	7.6	+ 168	7.6	99	18,900	316	10		- 22.0	1.0	10
55	6,234	26° 56′ N	92° 20′ W	+ 216	7.8	+ 174	7.4	94		129	10	0.53	- 23.5	0.0	10
56	6,492	26° 57′ N	92° 20′ W	+ 252	7.2	+ 186	7.3	89	19,500	260	10	0.78	- 22.8	0.0	10
57	5,268	26° 54′ N	92° 18′ W	+ 245	7.3	+ 228	7.5	94	19,100	106	10			0.0	10
58	4,524	26° 58′ N	92° 19′ W	+ 186	7.4	+ 210		97	19,600	849	5			1.2	5
59	4,218	27° 14′ N	92° 25′ W	+ 245	7.7	+ 252	7.7	94	18,900	90	10			1.2	5
60	3,816	27° 16′ N	92° 26′ W										- 21.1		
61	3,078	27° 18′ N	92° 26′ W	+ 198		+ 198		94	19,700	362	5	0.88	- 22.9	1.2	5
62	2,688	27° 19′ N	92° 27′ W					91					- 21.7		
64	3,102	27° 21′ N	92° 25′ W	+ 216		+ 204		89	19,200	438	5			0.6	5
65	2,328	27° 28′ N	92° 13′ W	+ 180		+ 210		91	18,800	362	10			0.6	10
66	3,078	27° 31′ N	92° 14′ W										21.2		
67	3,318	27° 34′ N	92° 13′ W	+ 204		+ 188		84	19,400	106	10			0.0	10
68	3,030	27° 34′ N	92° 14′ W	+ 162	7.7	+ 198	7.3	96	18,700	84	10			2.4	5
69	2,724	27° 35′ N	92° 13′ W	+ 198	7.2	+ 216		94	18,900	167	5			2.0	10
70	2,448	27° 36′ N	92° 13′ W	+ 258		+ 240		96	19,200	68	10			3.2	10
71	2,118	27° 37′ N	92° 13′ W										- 21.4		
72	1,836	27° 37′ N	92° 13′ W	+ 156		+ 156		93	19,200	90	10			0.3	10
73	1,176	27° 41′ N	92° 12′ W	+ 168				91	19,700	362	2			0.0	2
75	1,842	27° 45′ N	92° 14′ W	+ 114		+ 132		89	18,900	45	10			4.8	5
76	1,536	27° 47′ N	92° 15′ W	+ 72				91	18,800	68	10		- 21.4	2.4	5
77	1,212	27° 48′ N	92° 19′ W	+ 72				93		158	5		- 24.0		
78	1,230	27° 50′ N	92° 11′ W	+ 54		+ 120	7.0	91	19,000	113	5			5.5	10
79	918	27° 53′ N	92° 10′ W	+ 66		+ 132		91	19,700	145	5	1.05		0.0	5
80	624	27° 52′ N	92° 10′ W	+ 72		+ 138		91	19,600	68	10	1.12		0.0	10

NANSEN WATER SAMPLES

SAMPLE NO.	WATER DEPTH (FEET)	LOCATION LAT.	LOCATION LONG.	TEMPERATURE (°C)	Eh (MV)	pH	OXYGEN CONTENT (% SAT.)	NITRATE NITROGEN (μ G/L)	SAMPLE SIZE (ML)	CHLORINITY (MG/L)	PHOSPHITE PHOSPHORUS (μ G/L)	SAMPLE SIZE (ML)
66 A 13 6	Surface	26° 07′ N	87° 38′ W		+ 84	7.8	82	324	20	20,000	2.4	5
9	9,870	25° 51′ N	87° 57′ W	4.70	+ 186	7.6	75	396	5	19,400	0.0	5
13	8,520	26° 29′ N	88° 05′ W	4.66	+ 144	7.7	82	371	5	19,400	0.0	5
17	7,500	27° 20′ N	88° 26′ W	4.62	+ 168	7.7	90	311	20	19,400	0.0	20
22	6,060	27° 36′ N	88° 37′ W	4.65	+ 144	7.4	87	407	5	19,400	0.0	10
26	4,990	28° 08′ N	88° 52′ W		+ 180	7.3	86	306	20		0.0	20
31	3,564	28° 16′ N	89° 01′ W	5.15	+ 80	7.7	82	360	20	19,400	0.0	20
40	1,188	28° 33′ N	89° 13′ W	9.72	+ 80	7.5	70	367	20	19,500	0.0	10
45	10,468	25° 36′ N	91° 30′ W	4.29	+ 168	7.5	93	384	5	19,400	0.0	5
46	7,270	26° 00′ N	91° 38′ W	4.19	+ 264	7.5	93	384	5	19,400	0.0	5
56	3,928	26° 57′ N	92° 20′ W	4.25	+ 162	7.8	93			19,400		
	4,587			4.26	+ 168	7.6	94			19,400		
	5,079			4.24	+ 174	7.6	96			19,400		
	5,407			4.24	+ 174	7.6	96			19,400		
	5,731			4.21	+ 168	7.6	91			19,400		
	6,060			4.21	+ 174	7.7	97			19,400		
	6,388			4.22	+ 188	7.7	93	332	10	19,400	0.0	10
67	1,303	27° 34′ N	92° 13′ W.	10.54	+ 162		75			19,500		
	2,287			6.26	+ 162		75			19,300		
	2,615			5.73	+ 162		76			19,300		
	2,943			5.38	+ 166		81			19,300		
	3,271			4.90	+ 162		86	381	10	19,400	0.0	10
78	1,150	27° 50′ N	92° 11′ W				80	384	10	19,600	0.0	10

sen bottle water samples and the water samples expressed from the sediment cores. This water was conducted by tubing directly to the oxygen analyzer to minimize contact with atmospheric oxygen.

Chlorinity was determined volumetrically by titration with silver nitrate (chromate indicator). Nitrate in the *Alaminos* samples was estimated by (1) reducing the nitrate in the sample to nitrite with hydrazine-copper reagent, (2) diazotization of sulfanilic acid with the produced nitrite and coupling with 1-naphthylamine and (3) determining spectrophotometrically the concentration of the red azo compound which is proportional to the nitrate concentration in the original sample (see Mullin and Riley, 1955).

Inorganic phosphate of the *Alaminos* samples was estimated by the molybdenum blue method (see Harvey, 1955). This method consists of (1) converting the inorganic orthophosphate ion in the sample to phosphomolybdic acid and (2) reducing this intermediate to molybdenum blue. The intensity of the blue color produced is a measure of the inorganic phosphate in the original sample and was determined spectrophotometrically.

Organic carbon content was measured by a combustion method, after the inorganic carbon was leached from the sample with acid solution.

The experimental procedures used in determining the C^{13}/C^{12} ratios are described by Rogers and Koons (1969). The sediment samples were acidified to eliminate carbonate CO_2, dried and combusted over copper oxide at approximately 800°C. The CO_2 produced was purified by passing it over dry ice to remove water and over copper metal and manganese dioxide of 500°C to remove nitrogen oxides and sulfur dioxide.

The purified CO_2 samples were analyzed in a 60° sector-type mass spectrometer. The mass spectrometric analyses are reported as per mil deviations (δ) from the C^{13}/C^{12} ratio of the Cretaceous belemnite *Belemnitella americana* from the Peedee Formation of South Carolina. In practice, a commercial lubricating oil with the assigned value of −29.4 per mil relative to the Peedee belemnite is used as a laboratory standard. The results are reported thus:

$$\delta C^{13} \text{ (in per mil)} = \frac{C^{13}/C^{12}\text{ (sample)} - C^{13}/C^{12}\text{ (standard)}}{C^{13}/C^{12}\text{ (standard)}} \times 1000$$

TABLE A-3

Geochemical data of samples from traverse 3 (*Western Shoal*).

CORE NO.	WATER DEPTH (UNCORRECTED) (FEET)	TEMPERATURE AT TOP OF CORE (°C)	CORE RECOVERY (INCHES)		pH	Eh
OG 1-5	534	19	48	Top	7.28	+ 10
				3 in.	7.31	0
				12 in.	7.45	+ 80
				Bottom	7.53	+ 20
6	906	16	44	Top	7.45	- 10
				3 in.	7.38	- 30
				12 in	7.41	+ 12
				Bottom	7.15	0
7	1,224	14	47	Top	7 30	+ 6
				3 in.	7.28	+ 18
				12 in.	7 88	- 100
				Bottom	7.30	- 114
8	1,506	17	56	Top	7.20	+ 228
				3 in.	7.21	- 24
				12 in	7.42	- 24
				Bottom	7 32	- 108
9	1,824	–	51	Top	7 30	+ 258
				3 in	7 38	- 23
				12 in	7.45	- 36
				Bottom	7 23	- 90
10	2,148	10	43	Top	7 08	+ 216
				3 in	7 28	- 54
				12 in	7 45	- 72
				Bottom	7.50	- 108
11	2,496	10.5	58	Top	7 39	+ 276
				3 in.	7.45	+ 6
				12 in.	7.30	+ 18
				Bottom	7.20	- 114
12	2,730	12 5	37	Top	7.15	+ 120
				3 in	7 20	- 12
				12 in	7 25	- 30
				Bottom	7 35	- 108
13	3,006	–	48	Top	7 50	+ 72
				3 in	7.38	- 90
				12 in	7.58	- 75
				Bottom	7.30	- 108
14	3,324	13.5	48	Top	7 35	+ 252
				3 in.	7.21	0
				12 in	7.50	- 30
				Bottom	7.35	- 114
15	3,630	12	63	Top	7.29	+ 132
				3 in	7.40	- 24
				12 in	7 34	- 36
				Bottom	7.32	- 96
16	3,864	–	62	Top	7 26	+ 132
				3 in	7.60	+ 150
				12 in	7.25	- 15
				Bottom	7.20	- 114

Appropriate corrections for CO_2 background in the mass spectrometer source, mixing of sample and standard due to leakage, and tailing under the mass 45 peak were made. The precision for the complete analysis is ±0.2 parts per thousand (‰). The conclusions of this study are based on differences greater than ±1.0 ‰ (5 times precision).

APPENDIX B

GEOCHEMICAL INTERPRETATION OF *ALAMINOS* AND *WESTERN SHOAL* CRUISE DATA

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EH MEASUREMENTS

The Eh of an individual chemical system is a measure of the tendency of that system to accept electrons (reducing environment) or give up electrons (oxidizing environment) relative to the standard hydrogen electrode. In sediment samples the Eh depends on the ratios of the concentration of the oxidized and reduced components of many chemical systems. For this reason, interpretation of sediment Eh values is difficult and quite debatable.

A decrease in sediment Eh probably reflects oxidation of organic matter by the easiest available oxidizing agent present, i.e., the free oxygen dissolved in the interstitial water. Upon utilization of this oxygen source, the chief remaining source is the oxygen in sulfate ions. Sulfate-reducing bacteria can use this oxygen to mineralize the remaining organic matter and release hydrogen sulfide to the sediments. In most sediments H_2S first appears at the same approximate depth as the first negative values of Eh.

Along traverse 1, direct Eh values, or those from sediment slurries, stay positive with no apparent trend between station 6 (water depth 11,442 feet) and 28 (water depth 4,584 feet), as shown in figure B-1. A decreasing Eh trend begins at station 29 (water depth 4,338 feet) and continues to station 41 (water depth 984 feet). The Eh becomes negative between stations 34 and 35 at an approximate water depth of 2,500 feet.

On traverse 2, the Eh change is not so pronounced. It seems to begin between stations 70 and 72 (water depth approximately 2,100 feet) and continues through 78 (water depth 1,230 feet). The Eh never becomes negative along this traverse.

One possible interpretation of these data on the Eh of the cores is that the oxygen content in the interstitial water of the sediment samples from the upper continental slope is quite low, and essentially reducing conditions exist very near the water-sediment interface, especially along traverse 1. During sampling it was noted that a color change in the sediment samples coincided with the change in Eh, particularly along traverse 1. The deeper water sediments were tannish-brown in color and graded toward a medium gray color with decreasing water depth.

The Eh measurements on the expressed water from the sediments show the same general trend of decreasing Eh values with decreasing water depth, but it is much less pronounced. It seems reasonable that in measuring the Eh, the entire system (gas-liquid-solid phases) should be used rather than using just one phase, the liquid.

The Eh measurements on the water samples taken just above the water-sediment interface show less positive Eh values at stations 31 and 40, which correspond to the position of negative Eh values in the sediments along traverse 1 (table A-2). Along traverse 2, the water samples show no trend in Eh.

In summary, the Eh data from the *Alaminos* cruise suggest that a reducing environment exists in the shallow sediment samples (about 15–20 centimeters below the sediment-water interface) from the upper part of the continental slope, in particular along traverse 1. This reducing environment is much less apparent along traverse 2.

Eh measurements from the *Western Shoal* cores likewise show the correlation between increasing positive values of Eh with increasing depths of water; that is, the ratio of the oxidized components to the reduced components of the sediment at the sediment-water interface becomes greater with depths of water (fig. B-2).

A second correlation is noted between core sediment temperature (table A-3) and the Eh trend. The temperature at the tops of the cores measured on shipboard as soon as the cores were brought aboard varied from 19°C at a water depth of 84 fathoms to 10°C at 347 fathoms. These values represent maximum temperatures since the cores undoubtedly warmed during their recovery.

Eh and pH of sediments are known to be influenced by temperature, bacterial action, the presence of oxygen in interstitial water, organic matter in sediments,

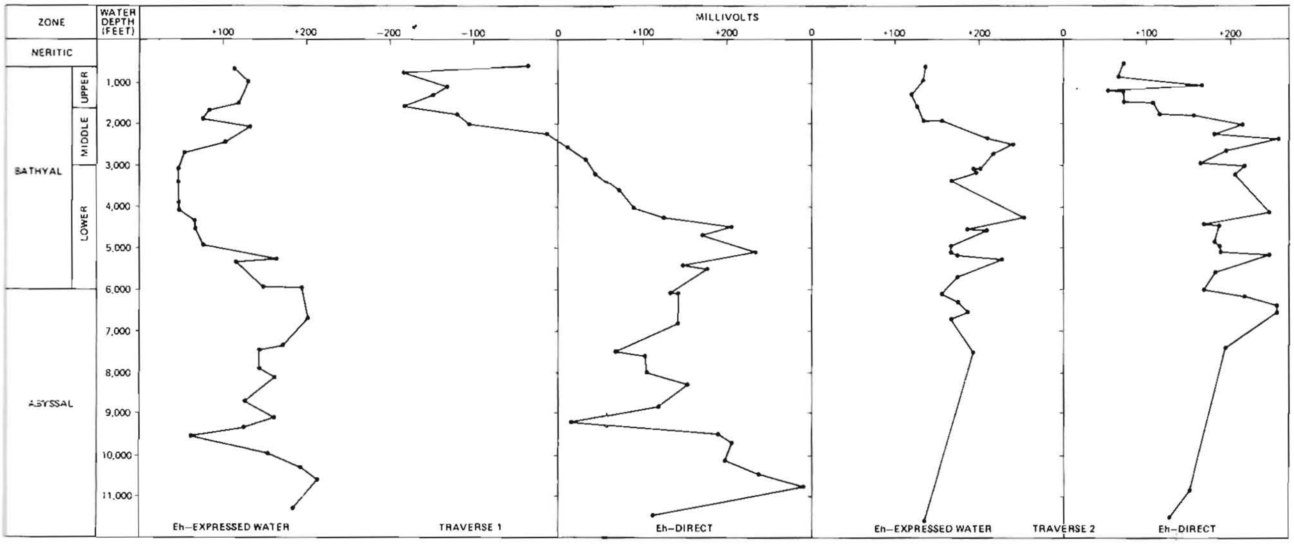


FIGURE B-1

Eh measurements of samples from traverses 1 and 2 with increasing water depth. Values are shown for both direct (slurry) and expressed waters.

and the rates of sedimentation. The positive correlation of temperature and Eh is suggested to have resulted from a combination of these factors. For instance, the growth of bacteria which bring about reducing conditions, as well as rates of oxidation of organic matter would proceed more slowly where temperatures are lower. Thus, oxidizing conditions would persist at the sediment-water interface for longer periods of time in cold, deep water than in warm, shallow water.

Older sediments were encountered in the *Western Shoal* cores at core depths of 3 inches, 1 foot, and the core bottom. Eh measurements at these core depths represent zones where there has been reduction of the many chemical components which make up the sediments due to the utilization of dissolved oxygen and the bacterial action in the sediments.

pH MEASUREMENTS

The pH of a system is a measure of the abundance of hydrogen ions. In sediment samples, low pH values (more hydrogen ions) can be produced by CO_2 liberated during the oxidation of carbohydrates and fats, whereas high pH values (less hydrogen ions) can result from the oxidation of proteins to form ammonia (NH_3) and hydrogen sulfide (H_2S). The NH_3 and H_2S can be further oxidized to nitrate (NO_3^-) ions and sulfate ($SO_4^=$) ions, which lowers the pH again.

The pH values for the *Alaminos* core samples (50:50 slurries with distilled water), the expressed waters from the cores, and the *Alaminos* water samples show slight local variation but no recognizable trends among the two traverses (table A-2). All values are slightly outlined (>7.0). There seems to be little difference in the pH for the core samples or the water expressed from the cores. These data seem to suggest that large amounts of CO_2 are not being generated in these sediments by oxidation of carbohydrates and fat, and similarly, the NH_3 and H_2S being produced are not being rapidly oxidized to nitrate and sulfate ions.

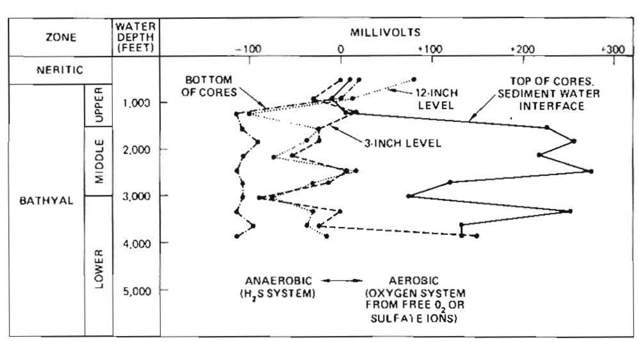


FIGURE B-2

Eh measurements of samples from traverse 3 with increasing water depth. Curves show measurements taken at the sediment-water interface, at a core depth of 3 inches and 12 inches, and at the core bottom.

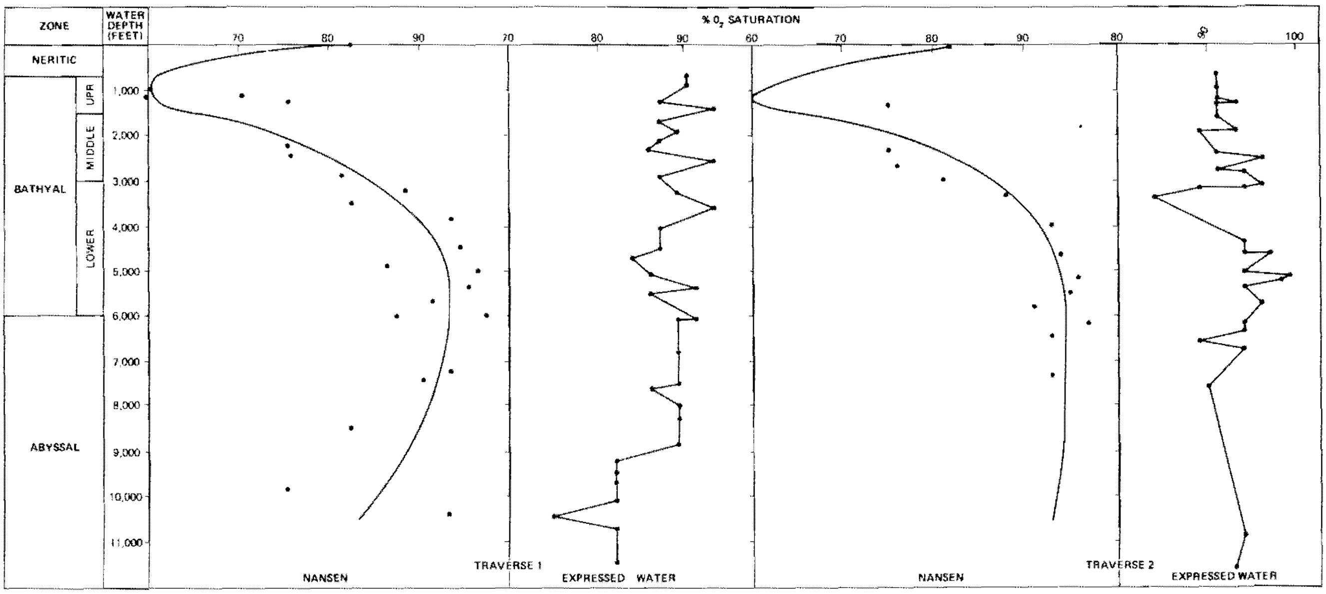


FIGURE B-3

Oxygen content in Nansen bottle samples and expressed waters of samples from traverses 1 and 2. Curves are shown with increasing water depth.

Western Shoal sediment samples, however, show a general increase of pH with core depth (table A-3). This trend suggests the presence of a greater concentration of dissolved CO_2 near the sediment surface at these localities due to the oxidation of organic matter and the subsequent lower pH values.

Oxygen-Content Measurements

The oxygen content of the expressed waters from the *Alaminos* core samples shows no recognizable trends along traverses 1 and 2 (fig. B-3). However, there does seem to be a slightly lower oxygen level in the samples from traverse 1; the difference, however, is slight. The oxygen contents of the Nansen bottle water samples shows a definite decrease with decreasing water depth starting at 6,000 to 7,000 feet along both traverses. This decrease seems to coincide with decreasing Eh values in the sediments.

Chlorinity Measurements

The chlorinities of the expressed waters from the *Alaminos* sediment samples show some variability, ranging from 17,900 to 19,800 mg/liter (table A-2). However, the changes appear local in nature and no trends are evident along *Alaminos* traverses 1 and 2 or between traverses. Certainly no anomalously high or low chlorinity values were encountered in these sediment samples. Complex water-sediment interface interactions probably account for the local variations. The chlorinities of the Nansen bottle water samples are much more constant, ranging from 19,300 to 20,000 mg/liter with an average of about 19,400. One water sample taken just below the atmosphere-water interface was anomalously high (20,000 mg/liter), but this can probably be explained by the concentration of inorganics by evaporation. No significant trends were noted along the traverses or at different water depths at the same location (stations 56 and 67, table A-2).

Nitrate Measurements

Nitrates are essential plant nutrients, chemical compounds that are needed for plant growth, but are sometimes present in such small concentrations at sea that phytoplankton growth is limited. Other essential plant nutrients are phosphates and silica. The ultimate source of nutrients is the land, but plants each year use more nutrients than are contributed to the oceans. A balance is provided, however, as most nutrients are returned to the sea upon the death of the organism.

Deep waters are thus much richer in both nitrates and phosphates than surface waters because of the nutritional requirements of phytoplankton. As a result, concentrations of both nitrates and phosphates tend to be higher near river mouths and in areas of prominent upwelling.

As soon as organic matter is deposited in the sedi-

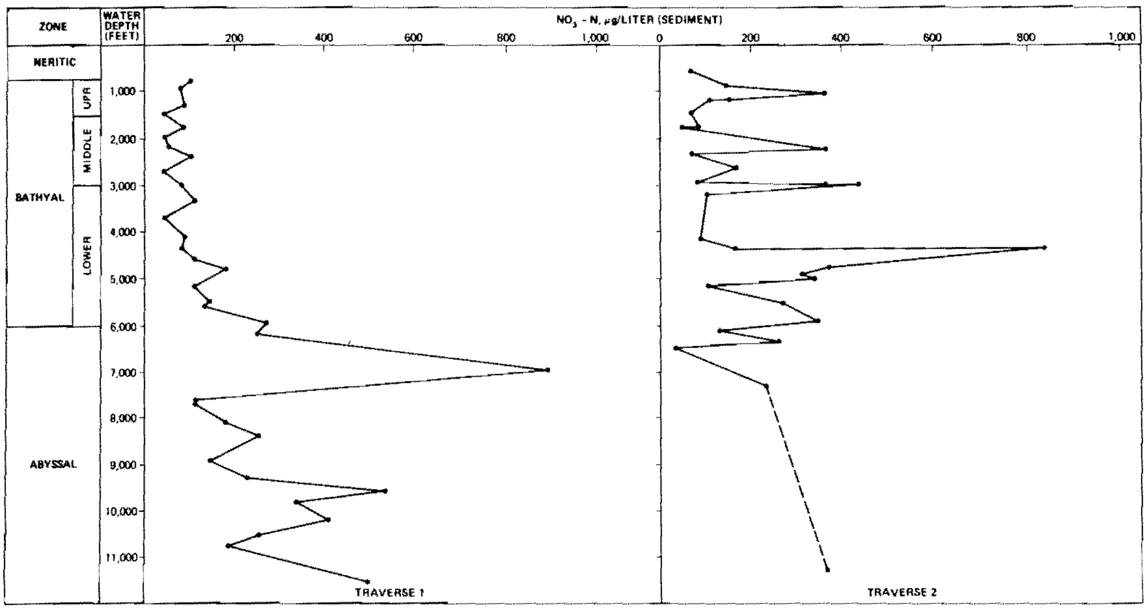


FIGURE B-4

Nitrate measurements of expressed water of samples from traverses 1 and 2. Values shown with increasing water depth.

ment and oxidation of nitrogeneous matter begins, ammonia (NH_3) forms as the first product. Under aerobic or oxidative conditions, the ammonia is further oxidized to nitrite (NO_2^-) and nitrate (NO_3^-) by bacteria (nitrobacteria). If conditions change to anaerobic or reducing, the reverse will occur. In addition, the nitrate present in sea water above the sediment will gradually diffuse into the interstices between sediment grains and also be reduced to nitrite and eventually ammonia. In summary, positive Eh and pH greater than 8 favor a movement of nitrate ions from the sediment into the water, whereas negative Eh and a pH less than 8 favor the reverse movement.

Nitrate values generally increase with increasing water depth along traverse 1 (fig. B-4). Sediment samples from stations 41 through 28 average about 80 µg/liter of nitrate-nitrogen in the expressed waters. From stations 27 through 6 a significant increase in nitrate values is observed, averaging about 230 µg/liter, although the nitrate values themselves increase and decrease irregularly. Nitrate values in samples from traverse 2 show a similar change in value, although the individual nitrate values are more irregular. For example, the nitrate values average 90 µg/liter for stations 78 through 70 and about 270 µg/liter for stations 69 through 44. The basin and knoll topography of traverse 2 no doubt contributes to the irregularity of the nitrate and phosphate values in these samples.

The nitrate/nitrogen data on the Nansen bottle water samples do not show the wide variability noted in the expressed water samples (table A-2). The overall range is rather narrow, 305 to 407 µg/liter with an average of about 360 µg/liter. No significant trends with regard to station location are evident.

Phosphate Measurements

The cycle of phosphate in the interstitial waters is less complex than the cycle for nitrogen because there are no intermediate forms between the organic matter phosphorus and the inorganic orthophosphate dissolved in the water. As with nitrates, deep waters are much richer than surface waters because of the nutritional requirements of phytoplankton. Phosphate concentrations also will tend to be higher near river mouths and in areas of prominent upwelling. Variations of total phosphorus with increasing water depth probably are related more to grain size than to solution or deposition of phosphate because the content of phosphorus in detrital sediments far exceeds the amount present in organic matter deposited in the sediments. Unlike that for nitrogen components, the concentration of dissolved phosphate is controlled by solubility equilibria rather than by bacterial oxidation of organic matter. The Eh and pH of the sediments thus will influence the movement of phosphate ions across the sediment-water interface. Positive Eh and pH less

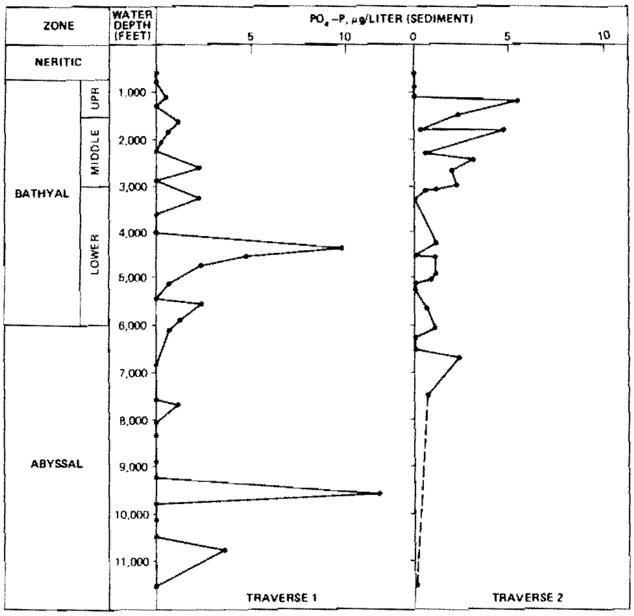


FIGURE B-5

Phosphate measurements of expressed waters of samples from traverses 1 and 2.

than 8 favor movement of phosphate ions from the water into the sediment, whereas negative Eh and pH greater than 8 favor the reverse movement.

Phosphate values from samples along both traverses 1 and 2 are irregular (fig. B-5); nevertheless, greater values are noted in samples from traverse 1. Phosphate values in samples from both traverses show a tendency to decrease with increasing water depth.

Organic-Carbon Measurements

Organic carbon determinations were run on 19 *Alaminos* sediment samples (table A-2). The range of organic carbon for all the samples was 0.23 percent to 1.34 percent and the average 0.88 percent. No extremes in organic carbon content, either low or high, were found, and there did not appear to be trend with water depth or geographic position. If reducing conditions do exist on the upper part of the continental slope, it is not reflected in the organic carbon content of the samples analyzed.

C^{13}/C^{12} Ratios

Studies by Rogers and Koons (1969) have shown that the δC^{13} values for the organic matter in marine sediments depend on two factors: (1) the marine versus terrestrial origin of the deposited organic matter and (2) the water temperature of the overlying photosynthetic zone during deposition. Values of δ from –16 ‰ to –24 ‰ would represent predominantly marine organic matter deposited below a relatively warm water photosynthetic zone (~25°C), whereas values of δ from –24 ‰ to –28 ‰ would represent either terrestrially derived organic matter of marine organic matter deposited in relatively cold water (5° to 20°C).

The δC^{13} values in samples from traverses 1 and 2 range from –21.1 to –25.9, with the values averaging –24.1 along traverse 1 and –22.2 along traverse 2 (table A-2). The more negative values in the samples from traverse 1, located off the Mississippi River, thus indicate either deposition in colder waters (relict cold fauna were found in many of these samples) or a greater contribution of terrestrially derived organic matter.

APPENDIX C
BENTHIC FORAMINIFERS FROM TRAVERSES 1, 2, AND 3

BENTHONIC SPECIES OF TRAVERSE I LISTED ALPHABETICALLY WITHIN DEPTH INCREMENTS*

Depth - feet	498	762	984	1,230	1,410	1,722	1,962	2,178	2,358	2,640	2,964	3,270	3,636	4,092	4,338	4,584	4,778
Station	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27
498 FEET																	
Ammobaculites americanus	X	X	X		X												
Bolivina barbata	7	3	2	X	X			X	X		X		X				
Bolivina subaenariensis mexicana	51	11	23	3	1	X	X	X	X								
Bulimina marginata	17	4	4	X	X	X		X									
Bulimina striata mexicana	X	6	5	4	4	11	3	6	3	11	5		X	3	3	2	X
Cancris auricula	X	X															
Cassidulina curvata	X	17	6	1	X												
Cassidulina neocarinata	2	2	10	17	52	43	18	16	10	4	9	2	2				X
Cassidulinoides bradyi	X	1	1	1	X												
Chilostomella oolina	X	X	X	X	X	X	X	1	3	1	2	6	3	X	2	X	2
Cibicides mollis	X																
Cibicides floridanus	3																
Cibicides umbonatus	X	4	X	X	X	X	X				X						
Coryphostoma subspinescens	X	X															
Cribrostomoides subglobosus	X					X	X		X		1	X					
Dentalina communis	X	X		X	X	X	X			X	X	X		X	X	X	
Eponides regularis	4	3	2	1	X	4	X		X	X	X						
Globobulimina affinis	X	X		X	X	X	5	6	2	3	5	2	2	2	4	3	X
Globobulimina ovula	1	X		X	X		X	X		2					1	X	
Gyroidina umbonata	1	X	X		X	X											X
Hanzawaia bertheloti	X	X	X														
Hanzawaia concentrica	X	1															
Hoeglundina elegans	X	X	1	X	X	X	2	X	3	1	X		X	2	1	2	1
Lagenammina difflugiformis	X	X				X				X	X	X			X	X	
Lenticulina calcar	X	4	X	X	X	X	X										
Lenticulina gibba	X	X		X	X				X	X					X	X	
Lenticulina orbicularis	X	4	X		X	X	X										
Lenticulina peregrina	X				X	X	X		X	X	X	X	X	X	X	X	1
Marginulinopsis marginulinoides	X	X					X										
Marginulinopsis subaculeata glabrata	X	X	X	X	X	X	X	X									
Martinottiella occidentalis	X	X	X	X	X	1	X	X	X	X	X		X	1	X		X
Neoeponides coryelli	X	X															
Nonionella opima	1	X	X	2	1	X	X										
Oridorsalis tener stellatus	X	X	X	X	X	X	1	1					X				
Planulina foveolata	X	3	X														
Rotorbinella basilica	X	X															

NTS*

4,584	4,778	5,130	5,436	5,514	5,880	6,174	6,174	6,726	6,864	6,972	7,590	7,650	8,010	8,328	8,721	8,874	9,204	9,501	9,762	10,446	10,662	11,442
28	27	26	25	24	23A	23	22	21	20	19	18**	17**	16**	15**	13**	14	12**	11	10	8	7	6
																		X				
									X					X								
																	1			X		
										X								X				
2	X	2	7	X	X	X	X	X	X	3		X	X	X	X	X		X				
	X		X		X	X								1		X						
X	[illegible]									X								X	X			
																					X	
					X	X														1		1
			X	X			X		X	3	6			X	X		X	X	X		X	X
X						X			X									X				X
						X						1	X									
3	X	X			X	X	X	X		X	X	6	3	4	20	4	5	5	6	X	1	X
X		X					1			X												
	X					X			2				X		X	X		X		X	2	1
2	[illegible]	2	5	2	X	8	6	22	10	7	6	28	24	10		20	10	17	6	X	X	9
X																					X	
X		X	X		X	X	X		X		X		X									
X	[illegible]	X	X	X	X	X	X		X													
	X	X	X	X		X	X	X	X			X		X		X					X	
																				X		

Depth - feet	498	762	984	1,230	1,410	1,722	1,962	2,178	2,358	2,640	2,964	3,270	3,636	4,092	4,338	4,584
Station	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28
Sigmoilopsis schlumbergeri	X	X	X			X		X		X	X	1	X	X	X	
Siphonina bradyana	X	X	X													
Siphotextularia affinis	X	X	X													
Sphaeroidina bulloides	X	2	1	13	1	7	14	9	5	7	13	18	15	X	X	X
Spirosigmoilina distorta	X	X	X	X	X	X		X	X					X		
Triloculina tricarinata	X										X	X	X	X	X	
Triloculina trigonula	X															
Uvigerina auberiana	X	1	X													
Uvigerina peregrina (<0.45 mm)	X	4	26	22	23	1										
Valvulineria complanata	X	X	1	10	5	X	X	X	X	X						
<u>762 FEET</u>																
Alveovalvulinella pozonensis		X		X		X										
Ammonia beccarii		X								X						
Amphicoryna sublineata		X	X	X												
Anomalina corpulenta		X											X	X	X	
Bolivina alata		X	X	X				X	X			X				
Bolvina albatrossi		9	13	4	2	1	1	3	1	12	2	4	7	6	2	3
Bolivina lanceolata		X	X													
Bulimina spicata		X						X	X	X	X	X	X	X	2	X
Cassidulinoides mexicanus		X	1	1	X	1	5	3	3	1	2		X			
Cibicides deprimus		X														
Cibicides cf. pseudoungerianus		X	X	7	1	1	1	1	3	1	5	1	7	6	3	7
Cribroelphidium discoidale		X														
Dentalina cuvieri		X	X	X												
Florilus atlanticus		X		X			X			X						
Fursenkoina schreibersiana		X	X	X	X											
Gaudryina flintii		X		X												
Globobulimina pyrula spinescens		X	X	X												
Globocassidulina crassa		X	X	X		X							X	X	X	
Globocassidulina subglobosa		X							X		X	5	11	X	X	X
Gyroidina altiformis cushmani		3	X	X	X	3	X	1	3	2	X	1	X	1	X	
Haplophragmoides sphaeriloculus		X			X		X	X	X	X	X	X				X
Karreriella bradyi		X	X	X						X	X	X	X	X	X	X
Melonis barleeanus		X														
Nodosaria lamnulifera		X														

[illegible]	5,130	5,436	5,514	5,880	6,174	6,174	6,726	6,864	6,972	7,590	7,650	8,010	8,328	8,721	8,874	9,204	9,501	9,762	10,446	10,662	11,442
27	26	25	24	23A	23	22	21	20	19	18**	17**	16**	15**	13**	14	12**	11	10	8	7	6
X	X	4	5	X	1	2	X	X	X		5	2	2		2	X	2	X	X	X	X
X	X	4	X	X	X	X	X	X													
X				X	X	X	X				X		X								X
								X	X			2	1		X		1	X	X	X	
																			X	X	
									X										X		
							X		8			X	X	X	X	X	3	1			
X		1	X																		
				X					X									X			
[illegible]	4	3	11	X	X	X	X	X													1
									X										X	X	
X	X			1		X		X	X									X			
X	2	X	X	X	X	X				X	X										
		X			X			X			X		X							X	
	X															1				X	
			X	X								X		2				1	2	1	1
X	6	8	X	19	12	12	12	11	3	X	5	1	7	X	3		2	2		X	1
[illegible]	X	X		X		X					X										
[illegible]	X		2	X																	

Depth - feet	498	762	984	1,230	1,410	1,722	1,962	2,178	2,358	2,640	2,964	3,270	3,636	4,092	4,338	4,584	4,778
Station	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27
Pseudoclavulina mexicana		X	X		X	X											
Pseudonodosaria comatula		4															
Pullenia bulloides		1	X	X	X	1	1	1	1	1	1	1	1	3	2	X	1
Pullenia quinqueloba		X	X	X			X	X	X	X	1		1	2	2	X	1
Pyrgo elongata		X		X		X	X	X	X	X		X	X	X	X		
Pyrgo sarsii		X													X		
Pyrgo serrata		X	X	X	X	X	1	1	X		X	X					
Reophax scorpiurus		X	X	X	X	X	1	X	2	X		X		X	X	X	X
Rosalina suezensis		X	X														
Textularia foliacea occidentalis		X															
Textularia mexicana		3															
Thurammina papillata		X													X		
Uvigerina flintii		1															
Uvigerina peregrina mediterranea		X	X		X	X					X						
Valvulineria laevigata		X	X					X	1		X	X	X	X	4		X
<u>984 FEET</u>																	
Bulimina barbata			X	X													
Planulina ariminensis			X	1	X	1	X	X									
Pyrgo murrhina (broad aperture)			X										X				13
Rotorbinella translucens			X	10	5	9	11	7	3	1	X		1	X	X	X	
Uvigerina peregrina dirupta (0.67 mm)			1	X	X	X	1	3	7	25	13	11	7	9	12	9	3
<u>1230 FEET</u>																	
Adercotryma glomerata				X			X	X		X	X	X	X	X	X	X	2
Ammobaculites agglutinans				X						X	X	X	X	X		1	X
Ammodiscus planorbis				X	X					X	X	X	X	X	X		X
Bolivina minima				X		1											
Bolivina ordinaria				X	X	X	2	2	1	1	X	X					
Bolivina quadrata				X													
Bulimina aculeata				X	1	7	20	18	20	8	8	9	7	31	29	29	19
Bulimina rostrata alazanensis				X	X	X	1	1	3	2	2	9	7	4	1	X	13
Cibicides bantamensis				X	X	X	X	X	X		X						
Coryphostoma spinescens				X		X			X								
Cribrostomoides scitulus				X		X	X	X	X	X	1	X			X		X
Cribrostomoides wiesneri				X	X	X	X	1	2	1	2	3	X	X	2	1	1
Eggerella scabra				X		X											
Glomospira charoides				X	X			X				X			3	2	15
Glomospira gordialis				X	X			X	X	X	X	X			X	X	X

	4,778	5,130	5,436	5,514	5,880	6,174	6,174	6,726	6,864	6,972	7,590	7,650	8,010	8,328	8,721	8,874	9,204	9,501	9,762	10,446	10,662	11,442
	27	26	25	24	23A	23	22	21	20	19	18	17	16	15	13	14	12	11	10	8	7	6
	1	6	3	2	5	5	4	6	3	X			3					X	1	3	X	X
	1	2	X		1		X		X			2	2	8				X	4		1	1
	X	X	X	X			X		X	X	X			X				X			X	X
									X													1
	X	1	X	X		X																1
	13	4	1	8	4	X	X	X	X					1		X			1			1
			X	X	X	X																
	3	4	10	6	2	5	4	2	2	5	X	2	6	2		X	X	X	X			
	2	1	X	X	X	X	X				X	X	X	1				2	X	2	3	2
	X	X					X	X														
	X	1								X	6											
				X	X	X																
	19	15	13	13	4	4	2	2	2	X	6	X		1								
	13	4	1	8	4	X	X	X	X					1		X			1			1
			X	X	X	X	X	X														
	X		X			X	X				X											
	1	3				X	X	X		X		2		X								
	15	X	X	3	1	2	2						1									
	X	X	X	X	X	X	X	X					X	X								X

Depth - feet	498	762	984	1,230	1,410	1,722	1,962	2,178	2,358	2,640	2,964	3,270	3,636	4,092	4,338	4,584	4,778	5,130
Station	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26
Haplophragmoides bradyi				X	X	X		X	3	1	5	7			X	1	X	X
Karreriella apicularis				X										X	X	X	X	1
Pyrgo depressa				X	X	X						X		1		X		
Reophax distans delicatulus				X					X						X			
Reticulophragmium venezuelanum				X	X	X	X	3	1	X	1	X	X		X			
Trochammina japonica				X	X	X	X	X	3	2	5	3	X		1	X	2	1
Trochammina tasmanica				X	X	X	X								1			
Valvulineria minuta				X			X	X			X	X	X	X				1
1410 FEET																		
Amphicoryna hispida					X													
Cyclammina cancellata					X	X	1	2	1	X	X	X	X	X	X	X	2	1
Gyroidina orbicularis					X	X	X	X	X	X	1	1	4	6	3	3	3	6
Osangularia rugosa					1	1	1	2	1	X	X	X	X					X
Pyrgoella sphaera					X	X	X	X	X				X		X	X		
Quinqueloculina cf. Q. vulgaris					X	X	X		X			X	X	X	X	X	X	
Trifarina bradyi					X	X											X	
Tritaxis conica					X										X			
Tritaxis fusca					X												X	
Trochammina globulosa					X				X	X	1	1	1		1	2	8	3
1722 FEET																		
Ammodiscus tenuis						X	X	X	1	1	1	X	X	X	X	X	X	X
Eggerella propinqua						X	X					X	X	X		X		
Globocassidulina murrhyna						X					X		X					
Pyrgo murrhina (circular aperture)						X						X	X	X	X	1	X	
Recurvoides contortus (forma subglobosa)						X		X									X	
Reophax pilulifer						X	X	X	X		X	X			X		X	
Textularia earlandi						2	2	1	2	X	1	X	1					
1962 FEET																		
Eggerella bradyi							X				X				X		X	3
Epistominella exigua							4	3	2	1	2	2	9	5	6	4	X	X
Glandulina laevigata							X											
Hormosina ovicula							1	2				X	X					1
2178 FEET																		
Cibicides rugosus								X			X	X	X	X	1	X	X	X
Florilus scaphus								X	X									
Hormosina globulifera								X	X	X	X	X						
Laticarinina pauperata								X	X		X	X	X	1	1	X	3	6

4,77[illegible]	5,130	5,436	5,514	5,880	6,174	6,174	6,726	6,864	6,972	7,590	7,650	8,010	8,328	8,721	8,874	9,204	9,501	9,762	10,446	10,662	11,442
27	26	25	24	23A	23	22	21	20	19	18	17	16	15	13	14	12	11	10	8	7	6
X	X	X	X	X	X	X	2	X	X		2	4	X	20	X						
X	1	X	X	1	X	X	2	2	X			2	2		2		X	X		1	X
							X				X	X		X	X			X			X
1	1																				
			X																		
	1	X		X																	
1	1	2	X	X	X	X		X					X								
3	6	4	12	4	6	8	3	5	1		2	X				2	2	1			X
	X	X	2	X																	
									X												
X		X	X					X									1				
X			X																		
X																					
8	3	2	X	1	X	1	X	X	2		3	4									
X	X	X																			
		X																			
		X						X													
X		X	X				X					X					X	2	X	X	2
X			X					X					1			X					1
X																					
X	3	X	X	X	X	2	X	X	2	6	3	X	X		X	1	X	1	X	X	1
X	X		X	1	3	2	X	X	X				1								
	1				X			X					X				X	X			
X	X	X	X	X	X	X	X													1	
									X												
[illegible]	6	7	4	13	9	5	X	X	2	X	3	2	X		3	7	X	1	X	X	1

Depth - feet	498	762	984	1,230	1,410	1,722	1,962	2,178	2,358	2,640	2,964	3,270	3,636	4,092	4,338	4,584	4,778	5,130
Station	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26
Oolina longispina								X	X									
Osangularia cultur								X	3	8	6	6	6	4	4	12	2	9
Reophax dentaliniformis								X	X	X	X					X	X	X
Stainforthia complanata								X					X	X				X
Tosaia weaveri								X					X					
2358 FEET																		
Buliminella bassendorfensis									X									
Cibicides robertsonianus									X		X	X	X	X	X	X	X	X
Rhabdammina abyssorum									X	X	X	2	X	X	1	X	X	1
Rhabdammina linearis									X	X	X	X	X	X	X	X	X	X
Robertinoides bradyi									X				X					
Saccorhiza ramosa									X	X	X	X	X	X	X	3	3	1
2640 FEET																		
Ammoglobigerinoides dehiscens										X	X	X						
Astrononion tumidum										X	X							
Cassidulinoides tenuis										X			X					
Cystammina pauciloculata										X	X	X	X		1	X		
Eponides polius										X							X	X
Valvulineria "opima"										X								
2964 FEET																		
Ammodiscoides turbinatus											X				X	X	1	X
Anomalina mexicana											X		X					
Bolivina translucens											X					X	X	
Cribrostomoides ringens											X			X	1	X	X	X
Cyclammina trullissata											X							
Dorothia pseudoturris											X				X			
Fursenkoina seminuda											X	X	1					
Marsipella elongata											X						X	X
Oridorsalis tener umbonatus											X	1	X	X	X	1	1	1
Pullenia subsphaerica											X			X			X	X
Tolypammina schaudinni											X	X					X	X
Uvigerina spinicostata											1	X	1	1				
3270 FEET																		
Bathysiphon filiformis												X			X	X	X	
Cibicides bradyi												1	2	3	1	1	X	X
Cibicides wuellerstorfi												X	X	X	1	6	4	7

4,778	5,130	5,436	5,514	5,880	6,174	6,174	6,726	6,864	6,972	7,590	7,650	8,010	8,328	8,721	8,874	9,204	9,501	9,762	10,446	10,662	11,442
27	26	25	24	23A	23	22	21	20	19	18	17	16	15	13	14	12	11	10	8	7	6
2	9	3	4	3	3	2	2	3		13	2	X	X								
X	X	X								X											
	X			1	X			X										X	1		
X	X	X	X	X	X	X	2	2	X			1	X				X			X	
X	1	X			X	X		X			X	1	X		X		X		X	X	X
X	X	X			X			X					X				X			X	X
									X			1						X	1	X	
3	1	X	X	X	X	X		X	1	6	1	X	1				X	X			
								X			X	X	X								
				X					1			1								X	
X	X	X	X	X	X	X	X	X	X	X	2	X	X		6		4	X	9	4	6
1	X	X	X	X	X			X	1				1		X	X					
X		X				X										X					
X	X	X									2										
				X					X												
X	X	X		X		X			X												
1	1	1	X	X	X	1	2	2	5	X	5	4	3	20	3	3	6	X	X		
X	X	X	X	X	X	X	X	X	X		1	X	1			4	1	1			X
X	X		X																		
		X		X				X													
X					X	X						X									
X	X	4	4	3	3	6	5	6	2	19	3	8	6		4	4	1	10	X		1
4	7	11	9	15	13	9	16	3	9	6	14	16	25	X	35	44	28	28	24	31	29

Depth - feet	498	762	984	1,230	1,410	1,722	1,962	2,178	2,358	2,640	2,964	3,270	3,636	4,092	4,338	4,584	4,778
Station	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27
Miliolinella subrotunda												X					
Saccammina socialis												X					X
<u>3636 FEET</u>																	
Ammolagena clavata													X				X
Angulogerina angulosa													X				
Eponides turgidus													X			X	X
Hyperammina friabilis													X				
<u>4092 FEET</u>																	
Aschemonella ramuliformis														X	X	1	
Cibicides kullenbergi														X			
Robertina oceanica														X			
Siphotextularia curta														X			
Siphotextularia rolshauseni														X			X
<u>4338 FEET</u>																	
Cribrostomoides lobatus															X		X
Cribrostomoides umbilicatus															X		
Gyroidina altiformis acuta															X		X
Lituotuba lituiformis															X		X
<u>4584 FEET</u>																	
Reophax nodulosa																X	
Siphotrochammina squamata																X	X
<u>4778 FEET</u>																	
Alabamina decorata																	X
Eponides tumidulus																	X
Nodellum membranaceum																	X
Parafissurina lateralis																	X
Pseudotrochammina mexicana																	X
Pseudotrochammina triloba																	X
<u>5130 FEET</u>																	
Ammobaculoides cylindroides																	
Bolivina pusilla																	
Dentalina intorta																	
Fissurina formosa (length 1.0 mm)																	
Florilus clavatus																	
Hyperammina laevigata																	

4,778	5,130	5,436	5,514	5,880	6,174	6,174	6,726	6,864	6,972	7,590	7,650	8,010	8,328	8,721	8,874	9,204	9,501	9,762	10,446	10,662	11,442
27	26	25	24	23A	23	22	21	20	19	18	17	16	15	13	14	12	11	10	8	7	6
									X												
X	X																				
X	X	X	X	X	X			2						X							
		X																			1
X	1	2	X	3	2	X		5					1				3	11	17	6	2
			X	X	X	X	X	2	2	X	X	4	6		2	X	X	X	1	3	1
																	X				
X		X	X	X		X		X					X			1		X	X		X
X	X		X		X		X	X					X								
								X													
X	X	X	X	X	1	2	4	X			1				3	4	X				1
X																					
																				X	
X									X												
X	X	2	X	5	9	15	9	20		6		X	1		2	1	4	7	13	20	22
X		X	X			X		X					1			2	X	1	7	3	1
X	X	X																			
X	1		X	1		X		X												X	
X	X																				
X									X		X										
	X																				
	1		X	1	X	2		4										X	X	X	
	X						X				1		X		X	X					X
	X		X	X																X	
	X	X	X	X	X	X		X					X								
	X																				

Depth - feet	498	762	984	1,230	1,410	1,722	1,962	2,178	2,358	2,640	2,964	3,270	3,636	4,092	4,338	4,584	4,778
Station	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27
Lagena laevis																	
Pleurostomella bolivinoides																	
5436 FEET																	
Coryphostoma abrupta																	
Francesita advena																	
Oridorsalis tener tener																	
5514 FEET																	
Pullenia trinitatensis																	
Pyrgo lucernula																	
Uvigerina ampullacae																	
5880 FEET																	
Apiopterina extensa																	
Globocassidulina moluccensis																	
Uvigerina hispida																	
6174 FEET																	
Cassidulinoides parkerianus																	
Heronallenia gemmata																	
Uvigerina senticosa																	
6726-6972 FEET																	
Ammomarginulina foliacea																	
Bolivinita quadrilatera																	
Buliminella exilis																	
Gyroidina soldanii																	
Lagenammina atlantica																	
Melonis pompilioides																	
Rhizammina sp.																	
Uvigerina auberiana var.																	
7590 FEET OR DEEPER																	
Apiopterina angusta																	
Bolivina pseudoplicata																	
Conorbina orbicularis																	
Quinqueloculina venusta																	
Trochammina subturbinata																	

4,778	5,130	5,436	5,514	5,880	6,174	6,174	6,726	6,864	6,972	7,590	7,650	8,010	8,328	8,721	8,874	9,204	9,501	9,762	10,466	10,662	11,442
27	26	25	24	23A	23	22	21	20	19	18	17	16	15	13	14	12	11	10	8	7	6
	X				X															X	
	X			X						X		1	X								
		X		X	X		X														
		X		X	X	X		X	X			X			X		X	X			X
		X							3		2	2	3		2		1	3			
			X	X	X	X	X	X	X						X				X		
			X		X	X			X				X			X	X	X			X
			X	X	X	X	5	6				X									
				X						X	X	X	X	X	X	X	X	X	X	X	X
				X			X		X				X			X		X			
				X	X	X	X	X		X	1		X								
						X												X			
					X																
						X		1			X	2	1	X	X		1	X	X	X	X
									X			X									
								X													
							X		10												
									X									X			
									X			2	1		X		1	X			
							X	X	13		X	X	6	20	2	8	6	1	8	4	8
								X			X	X	X		X						
								X		6											X
													X					X		X	
																	X	1	2		
																				2	
															X		X				X
													X	X	X	X	X				

Depth - feet	498	762	984	1,230	1,410	1,722	1,962	2,178	2,358	2,640	2,964	3,270	3,636	4,092	4,338	4,584	4,778
Station	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27
Total Benthonic Specimens	324	589	878	1279	2683	790	1102	870	664	839	458	600	510	193	322	282	390
Percent Arenaceous	X	4	X	1	1	5	6	11	15	7	20	18	4	4	12	16	41
Percent Porcelaneous	X	0	X	X	X	1	1	1	1	0	X	X	X	2	1	1	X
Percent Hyaline	99	96	99	98	98	94	93	88	84	93	79	81	95	94	87	83	58
Total Planktonic Foraminifera	66	1047	1324	646	1140	1091	1275	1240	824	865	1412	1204	1802	1112	1282	1582	3869
Percent Planktonic Foraminifera	17	64	60	34	30	58	54	59	55	51	76	67	78	85	80	85	91
Total Foraminifera	390	1636	2202	1925	3823	1881	2377	2110	1488	1704	1870	1804	2312	1305	1604	1864	3259

* Occurrences cited as percent of total benthonic foraminifera. X denotes occurrences less than 1 percent.

4,778	5,130	5,436	5,514	5,880	6,174	6,174	6,726	6,864	6,972	7,590	7,650	8,010	8,328	8,721	8,874	9,204	9,501	9,762	10,466	10,662	11,442
27	26	25	24	23A	23	22	21	20	19	18**	17**	16**	15**	13**	14	12**	11	10	8	7	6
390	333	255	127	214	149	180	125	126	176	27	64	98	91	16	127	75	149	191	103	138	105
41	18	10	13	6	9	9	6	7	14	24	19	16	10	20	4	3	7	2	2	6	5
X	X	0	2	X	0	1	0	0	3	0	0	2	1	0	0	0	1	4	0	0	3
58	81	90	85	93	91	90	94	93	83	76	81	82	89	80	96	97	92	94	98	94	92
3869	3133	4274	2085	5040	5591	6597	6058	6488	5463	2355	2985	3272	5416	96	5767	5269	8686	7810	9151	6694	4437
91	90	94	95	96	97	97	98	98	97	99	98	97	98	86	98	99	98	98	99	98	98
3259	3466	4529	2185	5254	5740	6777	6183	6614	5639	2382	3049	3370	5510	112	5894	5344	8835	8001	9254	6832	4542

BENTHONIC SPECIES OF TRAVERSE II ARRANGED ALPHABETICALLY WITHIN DEPTH INCREMENTS*

Depth - feet	594	918	1,146	1,212	1,230	1,536	1,572	1,836	2,118	2,328	2,448	2,688	2,724	3,030	3,078	3,078
Station	80	79	73	77	78	76	74	72	71	65	70	62	69	68	66	63
594 FEET																
Amphicoryna sublineata	1	X		X	1	X	X			X						
Angulogerina bella	X	X														
Anomalina corpulenta	X	X		1	X	X	X	X	X	X	X	X	X	X	X	X
Anomalina mexicana	X	X	X	X	X	X	X	X	X	X	X		X	X	X	
Bolivina albatrossi	1	9	6	5	10	7	11	12	15	3	8	19	25	6	12	16
Bolivina goesii	11	X			X			X								
Bolivina lanceolata	1	X			X		X					X				
Bolivina minima	X	1	X	X	X	2	X	1						X		
Bolivina quadrata	X	X					X				X					
Bolivina subaenariensis mexicana	18	18	14	5	4	3	1	1		X	X		X	X	X	
Bulimina marginata	1	X	2	2	X		X									
Bulimina spicata	X	X	X		X	X	X	X	X	1	1	X	3	3	2	X
Bulimina striata mexicana	X	4	3	1	3	1	3	2	1	1	2	1	1	X	3	5
Cancris auricula	X	X														
Cassidulina curvata	15	2	1	3	1	1	X	2	1	X						
Cassidulina neocarinata	9	2	7	4	2	3	2	2	2	1	1	2	X		X	
Cassidulinoides mexicanus	X	X	X	1	X	X	1	X	X	X	1		X		X	
Chilostomella oolina	X		X		1	1	3	1	1	1	3	1	1	2	1	X
Cibicides cf. pseudoungerianus	X	X	2	5	2	2	2	1	4	1	2	3	2	4	X	3
Cibicides lobatulus	X	X														
Cibicides umbonatus	X	1	6	9	1	3	1	X	X				X			
Coryphostoma subspinescens	X	X	X		X	X	X	1	X	X	X	X				
Cribroelphidium poeyanum	X															
Dentalina communis	X	X			X	X	X	X	X	X				X	X	X
Dentalina cuvieri	X	X		X	X	X		X		X						
Eggerella bradyi	X		X		X	X			X	X	X	X	1	X	X	X
Ehrenbergina spinea	X	X														
Eponides regularis	X	X	X	1	X	1			X		1	X				
Frondicularia sagittula	X															
Fursenkoina schreibersiana	X	X	1		X											
Gaudryina atlantica	X	X	X	5	X											
Globobulimina affinis	X	X					X	X	X	X	X	X		X		
Globocassidulina crassa	1	X	7	1	2	5	3	14	3	9	7	4	4	1	2	2
Globocassidulina subglobosa vars.	X			X	2	6	2	1	4	5	4	1	5	3	3	4
Gyroidina altiformis cushmani	X	X	X	4	X	1	2	X	1		1	X	X	X	X	X
Gyroidina umbonata	1	X	X	X	X	X				1	1	X	1	X	X	X
Hanzawaia bertheloti	1	X		1	X											

3,078	3,102	3,318	3,816	4,218	4,506	4,524	4,920	5,010	5,136	5,268	5,394	5,622	5,994	6,054	6,234	6,492	6,624	7,482	10,800	11,532
61	64	67	60	59	53	58	52	54	51A	57	54B	51	54A	49	55	56	47	46	45	44
X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X				
X		X																		
10	13	14	13	8	5	4	2	2	2	2	X	1	5		2	2	X			X
			X	X				X					X		X					
X																				
3	1	2	3	3	X	3	X	X	X	1	X	X	X	X	X	1				
2	X	1	X	1	X		X		2	X	X	1	2	3	2	X	X			
	X																			
1		X											X		X					
X	X	X						X					X			X		X		
1	X	3									X			X	1			X	3	
1	2	1	2	X	X	X	X	X	1		X		X		X					X
															1	X				
X	X			X	X	X	X	X		X		X	X							
				X		X				X										
X	X	X	1	1	1	1	1	X	3	X	1	1	1	X	1	X	1	2	X	2
		X																		
X	X	1						1		1	1		X		X			1		
6	1	3	1		2	X	1		1	1	X	X		1	1	2		1		X
3	4	1	1	X	1	2	1		X	X	2	1	4	1	2	X	X			X
X	X	X	X	X	X	X	X				X									
X		X	1			X	X		X			X	X	X	X		X	1	4	3

Depth - feet	594	918	1,146	1,212	1,230	1,536	1,572	1,836	2,118	2,328	2,448	2,688	2,724	3,030	3,078	3,078
Station	80	79	73	77	78	76	74	72	71	65	70	62	69	68	66	63
Hanzawaia strattoni	X															
Hoeglundina elegans	X	1	X	1	X		X	X	X	X	X	X	X	1	X	
Karreriella bradyi	X	X	X	1	X	1	X	X	X	X	X	X	X	X	X	X
Lagenammina difflugiformis	X	X	X	X	X	X	X					X	X	X	X	X
Lenticulina calcar	X	1		3	2	X	X	X								
Lenticulina gibba	X	X			X	X	X	X				X				X
Lenticulina orbicularis	X			X	X								X			
Lenticulina peregrina	X	X	X	X	X	1	X	X	X	1	1	X	X	X	1	2
Liebusella soldanii	X															
Marginulina tenuis	X	X		X	X	X										
Marginulinopsis marginulinoides	X					X										
Marginulinopsis subaculeata glabrata	X		X	2	X	X		X								
Martinottiella occidentalis	X	X	X	1	X	X	X	X	X							
Melonis barleeanus	X		X	X	X			X								
Neoeponides coryelli	X	X	X	X	X											
Nonionella opima	X					X										X
Oridorsalis tener stellatus	X	X	1	X	X	3	X	X	1							
Orthomorphina guttifera	X	X		X	X	X			X							
Pavonina atlantica	X															
Planulina foveolata	2	1	2	4												
Pseudoclavulina mexicana	X	X		X	X	X	X	X	X							
Pseudonodosaria comatula	X	X														
Pullenia bulloides	X	X	1	2	1	2	1	X		X						
Pullenia osloensis	X	X	X				X			X	X	X	X		X	X
Pullenia quinqueloba	1	1	X	X	1	1	1	X	X	1	X	X	X	1	1	X
Pyrgo elongata	X													X		
Pyrgo murrhina (broad aperture)	X	X		X	X					X	X	X	X	X		
Pyrgo sarsii	2	X			X	X		X								
Pyrgo serrata	X				X											
Quinqueloculina polygona	X															
Quinqueloculina seminulum	X	X														
Ramulina globulifera	X															
Reussella atlantica	1	X														
Robertinoides bradyi	X	X							X		X					
Rosalina suezensis	2	X														
Rotorbinella translucens	X	7	12	5	10	13	7	6	3	4	6	3	X	2	3	2
Sigmoilopsis schlumbergeri	X	X	2	X	X	1	X		3	X	1		1	1	X	1

3,078	3,102	3,318	3,816	4,218	4,506	4,524	4,920	5,010	5,136	5,268	5,394	5,622	5,994	6,054	6,234	6,492	6,624	7,482	10,800	11,532
61	64	67	60	59	53	58	52	54	51A	57	54B	51	54A	49	55	56	47	46	45	44
	X		X	1	1	5	5	2	3	1	1	6	3	5	3	4	13	11	7	X
X	X	X		X	X	X		X	X						X					X
X		X		X		X		X	1	1	1	2	1	1	X	1	1	4	3	X
							X					X								
					X						X		X					X		
X	1	2	X	X	2	1	X	1	X	1	X	X	1	X	X	X	X			
												X	X							
	X																			
																			1	1
X																				
		X																		
	X		X		X	X	X	X	X				X	X		X			X	X
X	X	X	2	X		4	X	X	X		X	X	X	X	1		X	X	X	X
X	X	X	X		X	1	1	X	X	X	X	X	X	X	X	X	X	X	X	X
																		X		
																				X
		X			X	1	X	X		X		1	X	X		X		1		
1	X	1	X	1	X		2	X	1	1	X	1	1	X	X	X				
X	1	X	1	X	X	X	X	1	X	X	1	X	2	X	1		X	X	X	X

Depth - feet	594	918	1,146	1,212	1,230	1,536	1,572	1,836	2,118	2,328	2,448	2,688	2,724	3,030	3,078	3,078
Station	80	79	73	77	78	76	74	72	71	65	70	62	69	68	66	63
Siphonina bradyana	3	2	1	X	X	1	3	2	2	X						
Siphonina pulchra	X	X		X					2							
Siphotextularia affinis	X	X														
Sphaeroidina bulloides	X	3	5	3	9	14	10	3	2	1	4	1	2	2		X
Spirillina vivipara	X								1							
Spiroloculina antillarum	X															
Spirosigmoilina distorta	X	1	1	X	X	X	2	2	X	1	X	X	X	X	X	1
Stomatorbina concentrica	X															
Technitella legumen	X															
Textularia candeiana	X															
Textularia foliacea occidentalis	X															
Textularia mexicana	X	X	2	1												
Textulariella barretti	X															
Triloculina trigonula	X															
Uvigerina auberiana	2	1	X	1	2	1	X									
Uvigerina peregrina (<0.45 mm)	22	30	13	15	32	4	9	X	X							
Valvulineria laevigata	1	1	X		X			X	X	1	3	X	1	1	X	X
Valvulineria minuta	1	1		X	1	1	1	X	X	X	1		X	X	X	X
918 FEET																
Adercotryma glomeratum		X	X			X	X	X	X				1	X		
Ammobaculites americanus		X						X		X						
Amphicoryna hispida		X			X	X		X	X	X	X	X				
Bathysiphon filiformis		X				X	X	X	X				X			
Bolivina barbata		X	X		X	1										
Bolivina translucens		X	X		1	1	X	X	X	X	X		X		X	X
Cibicides deprimus		X		X	X	X										
Dentalina intorta		X		X	X	X							X			
Ehrenbergina trigona		X	1	1	1	1	1									
Globobulimina ovula		X	X						X	X						
Globocassidulina pacifica var.		X				X	X	X	X	1	X	X	X	X	X	2
Glomospira charoides		X	X				X		3	1	X	1	X		1	X
Hyperammina laevigata		X								X	X	X	X		X	
Karreriella apicularis		X				X	X	X	X		1	1	1	X	1	2
Reophax distans delicatulus		X			X	X		X			X	X	X	X		X
Reophax scorpiurus		X		1	X	X			X		X					X
Stainforthia complanata		X				X		X	X	1	X	X	1	X	X	X
Trifarina bradyi		X	3	1	X	1	2	3	1	X	1	X	X	X	X	X
Tritaxis conica		X						X			X					

3,078	3,102	3,318	3,816	4,218	4,506	4,524	4,920	5,010	5,136	5,268	5,394	5,622	5,994	6,054	6,234	6,492	6,624	7,482	10,800	11,532
61	64	67	60	59	53	58	52	54	51A	57	54B	51	54A	49	55	56	47	46	45	44
					X															
3	1	2	X	X	X	1	1	1	X			1		X	1	X	X			
X	1	X	X	X		X		1		X	2	1	X	X	X		X			
					X		X	X			X			X			X	1		
														X						
X	X	2	X		X															
1	X		1		1		X			X		X	X	X	X					
		X	1	X	1	X	X		X	1	X	X	2	X		X	X	X	7	3
									X	X										
X			X		X			X	X					X				2	X	
						X				X	X			X	1	X				
															X					
	X	X	1	1	3	1	3	1	3	6	2	5	1	3	4	1	1		X	
X	X	X	2	1	5		1	5	1	1	6	4	3	2	2	5	4	1	X	2
X			X	X			X			X		X	X		X	X				
1	X	1	4	1	1	X	1	1	1	3	X	1	3	1	1	3	1	1	3	4
	X	X		X	X	1	X	X	X		X	X	X	X		X	X	1	3	1
				X	X	1	X	2		1	X	1	X	1	X	1			X	
X		X	X							X	1		1		1	1		X	X	
X	X	X																		

Depth - feet	534	918	1,146	1,212	1,230	1,536	1,572	1,836	2,118	2,328	2,448	2,688	2,724	3,030	3,078	3,078
Station	80	79	73	77	78	76	74	72	71	65	70	62	69	68	66	63
Trochammina japonica		X				1		X	X	X	1	X	2	3	1	3
Uvigerina peregrina dirupta		X	X		X	X	X	1	2	8	6	6	5	6	7	5
Uvigerina peregrina mediterranea		1	1	3	X	1	1	X				X				
<u>1146-1212-1230 FEET</u>																
Ammosphaeroidina sphaeroidiniformis				X												
Angulogerina angulosa			X	X		1	X					X				X
Bolivina alata			X													
Bolivina ordinaria				1		1	6	4	2	7	3	2	1	1	X	X
Bulimina aculeata			X	2		2		2	2	3	3	3	9	6	2	4
Bulimina rostrata alazanensis			2		X	2	3	7	14	13	6	11	7	32	12	21
Cassidulinoides tenuis					X		X		X	X						
Cibicides bantamensis					X	X	X	X	X		X					X
Coryphostoma spinescens				X								X		X		X
Cribrostomoides wiesneri				X		X			X	X	1	X	1	X	X	X
Eggerella propinqua				X		1	X	X	X	X	X		X	X	X	X
Epistominella exigua			X			3	12	16	8	10	7	6	5	3	21	6
Eponides turgidus			X			1	1	X	X	2	X	2	1		X	
Fursenkoina seminuda					X		X		X	X	X	X	X	X		
Globobulimina pyrula spinescens					X	X										
Gyroidina orbicularis				X		X		X	X		X	1	2	3	3	3
Haplophragmoides bradyi			X		1	X	X	X	3	1	2	2	7	1	2	3
Laticarinina pauperata			X	X	X		X	1	2	X	3	1	X	X	1	3
Lingulina seminuda				X												
Oridorsalis tener tener				X							X					
Osangularia rugosa			1		X	X		2	2	X	X	X	2	2	X	1
Planulina ariminensis			X		X	X	1	1	1	1		X				
Rectobolivina dimorpha			X				X	X	X		X	X				X
Tosaia weaveri			X		X		X	4	4	5	2	5	2		6	X
Valvulineria complanata				X	X			1								
<u>1536-1572 FEET</u>																
Ammodiscoides turbinatus						X				X		X	X		X	X
Ammodiscus planorbis							X	X	X	X	X	X	1	X	X	X
Ammolagena clavata							X		X	X	X	X	X	X	X	X
Cibicides bradyi						X	X	X	1	1	1	1	4	X	X	X
Cibicides robertsonianus							X	X	X	X		X	X	X	X	X
Cibicides wuellerstorfi							X			X	X	X	1	X	X	X
Cribrostomoides scitulus						X		X		X	X			X	X	X
Cribrostomoides subglobosus							X	X	X		X		X		X	X

3,078	3,102	3,318	3,816	4,218	4,506	4,524	4,920	5,010	5,136	5,268	5,394	5,622	5,994	6,054	6,234	6,492	6,624	7,482	10,800	11,532
61	64	67	60	59	53	58	52	54	51A	57	54B	51	54A	49	55	56	47	46	45	44
X	1	2	1	2	X	5	1	X	X	X	1	X	3	X	1	3	X	1		
7	8	5	3	5	1	X	1	1	1	3	3	1	3	2	3	1	1	X		
		X																		
								X												
1		1	X																	
9	7	11	9	18	10	5	2	6	7	8	3	3	2	2	5	4	X			
14	12	12	4	4	5	3	1	2	1	1	2		2	X	X	1			X	
X			X			X									1			X		
X																				
X						X	X		1		X	1	X		X	X	X	1		
	X	1	1	1	1		1	X	1	X	X	1	X	1			X	1		
X		X					X	X												
8	10	3	2	3	3	X	3	1	1	1	1	X	1		1	1	1			
1	X	X	2	2	5	1	2	X	5	2	3	2	3	2	2	3	3	3	4	3
X		X							X		1									
2	1	X	6	5	2	5	4	3	6	5	4	4	4	7	4	3	3	2	X	1
2	1	X	2	X	1	X		1	1	2	3	X	2	X	X	3	1	1	3	1
1	7	1	4	1	3	6	2	1	2	5	2	3	X	2	2	3	1			
						2	X	1	1	X							1			
2	1	1	1	1	X	X											X			
		X																		
X	X			X	X		X	X								X			X	
1	5	X	1	X		1				X				X						
	1	X		1			X		X				X				X			
	X	X	X	X																
		X	X	1	X	1		1	1	1	X	1	X	X	X	1	X	X	X	
1	X	1	3	3	1	2	2	2	3	4	3	2	4	1	2	5	2	5	X	1
X	X	X	1	X	X	X	X	X	X	X	X	X	X		X			X	X	X
2	1	X	X	1	2	3	2	5	1	2	2	1	1	3	3	2	1	1	8	12
X		X		X						X			X		X					
X	X	X		X	X		X	X	X		X	X	X	X	X	X	X	X	X	X

Depth - feet	594	918	1,146	1,212	1,230	1,536	1,572	1,836	2,118	2,328	2,448	2,688	2,724	3,030	3,078	3,078
Station	80	79	73	77	78	76	74	72	71	65	70	62	69	68	66	63
Cyclammina cancellata						X	X	X	X	X	X	X	1	X	X	X
Cystammina pauciloculata						1			X	X	X					
Glandulina laevigata						X		X							X	
Glomospira gordialis						X			X	X			X	X		
Gyroidina soldanii						X										
Haplophragmoides sphaeriloculus						X	X	X	X	X	X		X		X	X
Hormosina carpenteri						X		X	X		X		X			
Nodosaria lamnulifera						X			X							
Reophax pilulifer							X		X	X	X	X	X	X	X	X
Reticulophragmium venezuelanum						X		X		X	X					X
Rhabdammina linearis						X	X	X		X	X		X	X	X	X
Saccorhiza ramosa						X	X	X	1	1	2	X	1	X	1	1
Thurammina papillata						X		X			X			X	X	
<u>1836 FEET</u>																
Cibicides kullenbergi								X	1	X	1		X		X	X
Cribrostomoides lobatus								X	X	X	X	X		X	X	
Lituotuba lituiformis								X	X	X		X	X	X	X	X
Martinottiella communis								X								
Osangularia cultur								X	4	1	4	6	3	1	2	1
Recurvoides contortus (subglobosus)								X	X	X		X	X	X	X	X
Reophax dentaliniformis								X	X	X	X	X	X	X	X	X
Rhabdammina abyssorum								X	X	X		X	X	X		
<u>2118 FEET</u>																
Cribrostomoides ringens									X					X		
Cribrostomoides umbilicatus									X				X			X
Dorothia pseudoturris									X	X	X	X	X	X	X	X
Gaudryina minuta									X		1	X	X	X	X	X
Globocassidulina murrhyna									X	1		2		X		
Hormosina globulifera									X	X	X	X	X	X	X	
Hyperammina friabilis									X	X						X
Oridorsalis tener umbonatus									X	X	X			X	X	X
Pseudotrochammina mexicana									X						X	
Textularia earlandi									X							
Tritaxis fusca									X							
Trochammina globulosa									X	X		X	X	X	X	X
Uvigerina spinicostata									X			X	X	X	X	
<u>2328-2448 FEET</u>																
Ammodiscus tenuis											X					

3,078	3,102	3,318	3,816	4,218	4,506	4,524	4,920	5,010	5,136	5,268	5,394	5,622	5,994	6,054	6,234	6,492	6,624	7,482	10,800	11,532
61	64	67	60	59	53	58	52	54	51A	57	54B	51	54A	49	55	56	47	46	45	44
1	X	1	X	X	X	X	X	X	X	X	X	X	X		X	X	X			
		X				X														
X	X																			
		X	1	1	1	X	1	X	1	X	1	1	1	X	1	X	X	1	1	1
						X														
X	X	X	2		X	1	1	1	1	2	X	1	X	X	X	1	X	X	X	1
	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X		1	X	X
	X	X	X		X		X	X	X	X	X	X	X			X				
				X												X				
X		X	X				X	X		X	X	X	X			X			X	
X	X	X	2	1	2	2	1	2	1	1	2	1	1	X	1	1	X	2	1	X
							2	1		X	X	2	X	X	1	X	1	1	2	
			X			1	X	1	X	X	X	X	X	X			X	X	X	X
X	X	X	X			X	X	X	1	1	X	X	X	X	X	2	X	X		
X	X	X	X	X	X	X	X	X		X	X		X		X	X		X		
								X				X								
2	1	2	2	1	4	1	5	1	4	3	3	5	2	3	2	4	3	1		
					X					X	X	X				X	X	X	X	X
		X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X			
X				X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	
	X	X			X		X	X	X		X	X	X		X					
X	X					X	X			X		X	X		X					
															X	1				
		X					X					X					X			
X			1									X								
X		X				1					X					X	X	1	3	1
X	X	X	X		X		X	X	X	X	X		X	X		X	X			X
X		2		1		1	X	1	1	X	X	X	X		1	X			X	2
							X		X											
	X	X			1	1	1	1	2	1	2	2	1	1	2	4	1	X		
X	X		X		X		X	X				X			X					
			X							X						1				

Depth - feet	594	918	1,146	1,212	1,230	1,536	1,572	1,836	2,118	2,328	2,448	2,688	2,724	3,030	3,078	3,078
Station	80	79	73	77	78	76	74	72	71	65	70	62	69	68	66	63
Ammoglobigerinoides dehiscens											X	X			X	
Astrononion tumidum										X	X	X	X	X		X
Cibicides rugosus											X	X	X	X	X	X
Coryphostoma abrupta											X	X				X
Ehrenbergina pupa										X		1	2			3
Eponides polius										3	X	1	1	X	X	X
Nodellum membranaceum										X					X	X
Pleurostomella bolivinoides										X	X					X
Pseudotrochammina triloba											X					
Pullenia trinitatensis										1	X	X		1	1	X
Pyrgo murrhina (oval aperture)											X					
Recurvoides contortus (scitulus)										X					X	
Reophax distans										X	X		1	1		X
Siphotextularia rolshauseni										1						
Valvulineria "opima"											X	1	X	X	X	2
<u>2688-2724 FEET</u>																
Ammobaculites agglutinans												X			X	X
Ammobaculites filiformis													X			
Bolivina pusilla												X				
Cyclammina trullissata												X				X
Fissurina tenuissima												X				
Florilus clavatus												X				
Pullenia subsphaerica												2		1		2
Quinqueloculina venusta												X				
Rhizammina algaeformis												X		X	X	1
Saccammina socialis												X				
<u>3030-3102 FEET</u>																
Allomorphina trigona																
Anomalina globulosa														X	X	
Gyroidina altiformis acuta															X	X
Lagena laevis														X		
Martinottiella (initial portion)																
Oridorsalis sidebottomi															X	
Pyrgo depressa														X		X
Pyrgoella sphaera ?														X		
Siphotrochmmina cf. s. squamata														X		X
Tolypammina schaudinni														X	X	
Triloculina tricarinata (displaced)														X		

3,078	3,102	3,318	3,816	4,218	4,506	4,524	4,920	5,010	5,136	5,268	5,394	5,622	5,994	6,054	6,234	6,492	6,624	7,482	10,800	11,532
61	64	67	60	59	53	58	52	54	51A	57	54B	51	54A	49	55	56	47	46	45	44
	X	X			X		X	X			X	X	X			X		X		
X	X					1														
X	X	2	X	X	1	1		X	X	X	X	X	X		X	X				
									X											
4	2		2	3	4	2	6	10	6	2		5	1	4	2	5	2	1		
1	X	X	3	1	1	3	X	3	2	1	2	3	3	4	X	X	3	1	8	13
				X	X	X		X	X	X	X	X	X	X	X	X	X	X		X
				X			X		X		X		X		2			1		X
				1	X	X	X	1	X	X	X	X	X	1	1	X	X	X	X	
	1	1		1	2	X	1	2	2	X	2	2	1	X	1	X	X	1	X	2
X					X		1			X	X			X	X				X	
X	X		X		1		X	X		X		X	X	X			X	1	X	X
	X			X									X				X	X		
				1	X		X		X	X	X	1		X	1	X	X	X	1	X
	5	X	3			3									1					
		X	X				X	X		X	X		X	X	1	X				
			X	X	X	X											X			
X			X						2	X	2	X	1	2	X	1	1	X		
X					X	X		X			X		X							
			1		X					1		X				1			X	X
			X	X		X	1		1	X	2	X	3	X	X	1	2	1	X	
1	X	2	2	3	3	3	5	6	4	3	6	7	4	3	8	4	7	7	X	5
					X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	1	5	1	4	2	2	2	2	1	X	1	1	3	2	2	X		
X																				
X																				
X	X																			
				X	X	X		X	X	X	X	X		X	1		X			X
	X	X	1	1	1			1		X	1			1			X	X	4	1
	X		X	X		X		X	X	X	X	X				X				
	2		1							X		X		X			1	1	X	
		X			X	X								X						X
													X							
		1		1	X	1	X	X		X		X	X	X	X	X	X	X		
X	X	X			X		X	X	X	X	X	X		2		X	X			
								X			X						X	X		

Depth - feet	594	918	1,146	1,212	1,230	1,536	1,572	1,836	2,118	2,328	2,448	2,688	2,724	3,030	3,078	3,078
Station	80	79	73	77	78	76	74	72	71	65	70	62	69	68	66	63
Trochammina tasmanica														X		
Uvigerina hispida																X
3318 FEET																
No new species																
3816 FEET																
Alabamina decorata																
Astrononion sp.																
Coryphostoma mayori																
Eponides tumidulus																
4218 FEET																
Aschemonella scabra																
Fissurina formosa (>1.0 mm long)																
Gaudryina flintii																
Hormosina ovicula																
4506-4524 FEET																
Ammomarginulina foliacea																
Bolivina seminuda var.																
Cassidulinoides parkerianus																
Fissurina aradasii																
Globocassidulina moluccensis																
Haplophragmoides coronatus																
Heronallenia gemmata																
Hyperammina cylindrica																
Pyrgo lucernula																
Pyrgo murrhina																
Quinqueloculina weaveri																
Reophax nodulosa																
Sigmoilina sigmoidea																
4920-5010 FEET																
Cribrostomoides canariensis																
Parafissurina sp.																
Quinqueloculina vulgaris																
Siphotextularia curta																
Trochammina subglabra																

3,078	3,102	3,318	3,816	4,218	4,506	4,524	4,920	5,010	5,136	5,268	5,394	5,622	5,994	6,054	6,234	6,492	6,624	7,482	10,800	11,532
61	64	67	60	59	53	58	52	54	51A	57	54B	51	54A	49	55	56	47	46	45	44
		X	X	1	2		3	4	2	X	X	2	!	X	2	X	X	1		
			X	X				1		X	X									
			X	X	5	2	6	11	17	19	14	13	11	24	11	8	22	19	6	23
			X																	
			X																	
			X	3	5	1	2	1	1	1	1	1	X	X	1	X	1	2	X	5
				X																
				X	X	X	X	X		X	X				X	X				
				X	X						X									
				X				X								X				
						X		X	1							X			X	
					X				X											
					X								X	1	2		X			
					X		1	X			1	X					X			
					X		X		1					X	X					
					X	X	X					X			X	X	X	X		
					X				X						X					
					X		X	1	2	1	1		3	1	3	3			X	
					X	X			X	X		X			X		X	X		
					X			X		X			X				X	X		
					X		X	X	X		X	X	X	X		X	X			
					X					X					X					
					1						1	X								
								X			X		X						X	
							X							X				2	X	
							X		X									X		
							X		X		X	X	X	X						
							X				X		X		X					

Depth - feet	594	918	1,146	1,212	1,230	1,536	1,572	1,936	2,118	2,328	2,448	2,688	2,724	3,030	3,078	3,078
Station	80	79	73	77	78	76	74	72	71	65	70	62	69	68	66	63
5136-5268 FEET																
Trochammina conglobata																
Uvigerina ampullacea																
Uvigerina auberiana var.																
5622 FEET																
Martinottiella occidentalis																
Oolina longispina																
5994-6492 FEET																
Apiopterina angusta																
Uvigerina sentisoca																
Nodosaria calomorpha																
6624 FEET																
Melonis pompilioides																
7482 FEET																
Cassidulinoides tenuis var.																
Francesita advena																
Globotextularia anceps																
11,532 FEET																
Apiopterina extensa																
Total Benthonic Specimens	1614	678	1151	1057	925	565	1007	1230	705	529	704	573	1022	757	656	459
Percent Agglutinated	1	3	5	9	1	6	2	2	15	10	11	5	13	11	10	8
Percent Porcelaneous	2	1	1	X	X	1	2	2	X	1	0	1	0	X	0	X
Percent Hyaline	97	96	94	91	99	93	96	96	85	89	89	94	87	89	90	92
Total Planktonic Foraminifera	4483	1704	4673	4046	2501	1756	3684	4742	2587	8802	3052	5927	2555	2604	3125	4688
Percent Planktonic Foraminifera	74	72	80	79	73	76	79	80	79	94	81	91	71	78	83	91
Total Foraminifera	6097	2382	5824	5103	3426	2321	4691	5972	3292	9331	3756	6500	3577	3361	3781	5147
Benthonic Foraminifera/Ostracode	33		120	73			100	282		200	117	50	150	280	83	250
Total Foraminifera/Ostracode	135		582	364			469	1496		3521	626	563	477	1120	465	2831

*Occurrences cited as percent of total benthonic Foraminifera. X denotes occurrences less than 1 percent.

3,078	3,102	3,318	3,816	4,218	4,506	4,524	4,920	5,010	5,136	5,268	5,394	5,622	5,994	6,054	6,234	6,492	6,624	7,482	10,800	11,532
61	64	67	60	59	53	58	52	54	51A	57	54B	51	54A	49	55	56	47	46	45	44
									X					X						
									X			X				X		X	X	
									X			X								
												X	X							
												X								
													X		X	X	X			X
															X					
																X				
																	X	X	10	6
																		X		
																		1	X	X
																		X		
																				X
481	221	482	433	277	343	276	283	380	356	399	256	382	284	251	333	314	215	279	155	262
4	10	21	2	4	20	22	26	23	22	21	26	22	28	20	27	37	21	21	30	15
0	1	X	0	0	2	2	2	1	X	1	4	1	X	2	X	0	1	2	X	1
96	89	79	78	76	78	76	72	76	78	78	70	77	72	78	73	63	78	77	70	84
6757	2385	3427	4917	5780	7811	8727	6990	5966	7508	5862	5807	10918	5649	7842	4870	9385	9195	8890	4608	12801
94	92	88	92	95	96	97	96	94	96	94	96	97	95	97	94	97	98	97	97	98
7238	2606	3909	5350	6057	8154	9003	7273	6346	7864	6261	6063	11300	5933	8093	5203	9699	9410	9169	4763	13063
200	200	120	410	31	125	33	44	45	67	25	50	63	233	30	200	112	150	22		117
3076	2345	977	5350	757	2718	1058	1131	755	1442	390	1182	1836	4944	971	3333	3453	6587	764		653

BENTHIC SPECIES OF TRAVERSE III LISTED ALPHABETICALLY WITHIN DEPTH INCREMENTS OF ABOUT 300 FEET

Depth - feet	534	906	1224	1506	1824	2148	2496	2730	3006	3324	3630	3864
Station	5	6	7	8	9	10	11	12	13	14	15	16
% Benthic Species												
534 FEET												
Ammobaculites americanus	X	X	X	X								
Ammonia beccarii tepida	1	X										
Amphicoryna sublineata	X	X	X	2	1	1	X					
Angulogerina bella	22	18	X			X						
Anomalina corpulenta	X	X	X	X	X	X	X			X		X
Bolivina barbata	1	X	X									
Bolivina fragilis	8	X	X									
Bolivina striatula spinata	3	X										
Bolivina subaenariensis mexicana	9	16	4	X	X		X		X	X		
Buccella hannai	X											
Bulimina marginata	X	1	X	X						X		
Bulimina spicata	X	X	1	1	1	2	4	4	2	9	5	5
Bulimina striata mexicana	X	3	5	9	6	5	1	X		1	1	X
Cancris auricula	1	1										
Cassidulina curvata	1	2	2	2	1		X		X	X		
Cassidulina neocarinata	4	X	2	3	4	4	X		X	1	X	
Cassidulinoides mexicanus	X	X	X	X	X	X	X				X	
Cibicides cf. pseudungerianus	X	2	5	3	4	2	X	1	1	2	1	2
Cibicides mollis	X											
Cibicides floridanus	1	8										
Cibicides umbonatus	X	X	X	X		X		X				
Coryphostoma zanzibarica	X	X		X								
Cribroelphidium discoidale	2											
Cribroelphidium gunteri galvestonense	X											
Dentalina inornata bradyensis	X	X	X	X		X	X					
Eponides regularis	X	3	1	X		X		X	X			
Florilus atlanticus	X	X		X								
Florilus scaphus	X											
Frondicularia sagittula	X											
Fursenkoina schreibersiana	3	X	X									

Depth - feet	534	906	1224	1506	1824	2148	2496	2730	3006	3324	3630	3864
Station	5	6	7	8	9	10	11	12	13	14	15	16
% Benthic Species												
Gyroidina altiformis cushmani	X	1	X	X	1	X	X	X	X	X		X
Gyroidina umbonata	1	X	X		1	X	1	X			X	
Hanzawaia bertheloti	X	X										
Hanzawaia concentrica	8	X										
Haplophragmoides bradyi	X	X	X	X	X	1	X	3	3	3	4	3
Hoeglundina elegans	X	X					1	X	X	X	X	1
Lagena sulcata var.	X					X	X					
Lenticulina calcar	X	X	X	X		X						
Lenticulina peregrina	X	X	X	1	1	2	1	1	X	1	X	1
Marginulinopsis subaculeata glabrata	X	X	X	X	X							
Melonis barleeanus	X	X										
Neoeponides coryelli	X	X	X									
Nonionella opima	X	X							X			
Oridorsalis tener stellatus	X	X	X	X	1	1		X	X			
Planulina foveolata	X	2	X									
Pseudoclavulina mexicana	X	X	1	X						1	X	X
Pullenia osloensis	X		X			X			1			X
Pullenia quinqueloba	1	X	X	1	1	1	1	X	X	1	X	2
Pyrgo sarsii	X	X					X		X			
Rectobolivina advena	X											
Reussella atlantica	X	X										
Rotorbinella basilica	X	X										
Scutuloris sp.	X	X										
Siphonina bradyana	X	X	X	1	2	1	X					
Siphonina pulchra	X		1	X								
Siphotextularia affinis	X	X										
Sphaeroidina bulloides	X	X	5	8	11	5	9	4	X	1	1	1
Spirosigmoilina distorta	X		X	X			X	X	X		X	X
Trifarina bradyi	X		X	1	1	X		X				X
Uvigerina auberiana	9	13	X									
Uvigerina peregrina parvula (<0.45 mm)	18	9										

Depth - feet	534	906	1224	1506	1824	2148	2496	2730	3006	3324	3630	3864
Station	5	6	7	8	9	10	11	12	13	14	15	16
% Benthic Species												
Uvigerina peregrina peregrina (< 0.45 mm)	X	6	30	11	1							
Valvulineria laevigata	X	X	X	X	X	1	X		X	X	X	X
Valvulineria minuta	X	X	X	2	X		X	X			X	X
906 FEET												
Bolivina albatrossi		1	5	4	11	6	5	11	7	7	8	7
Bolivina minima		X		X								
Cassidulinoides bradyi		X	1									
Chilostomella oolina		X	1	1	1	1	1	1	1	1	1	1
Cibicides deprimus		X	X		X							
Fissurina tenuissima		X	1	X								
Fursenkoina pontoni		X	1									
Gaudryina atlantica		X	X	X								
Globobulimina affinis		X			1	1	1	1	1	2	1	X
Globobulimina pyrula spinescens		X	X	1			X					
Globocassidulina crassa		1	2	5	4	2	1	1				
Lagenammina difflugiformis		X	X									
Lenticulina orbicularis		X		X		X						
Martinottiella occidentalis		X	X	2	X	X	X	X	X	X	X	
Pullenia bulloides		X	1	3	1	1	2	1	X	1		X
Pyrgoella sphaera		X										
Quinqueloculina bosciana (displaced)		X										
Reophax scorpiurus		X	X	X	X				X			
Rotorbinella translucens		X	1	4	5	3	2	1	X	1		
Sigmoilopsis schlumbergeri		X	X	1	X	X	X	X	X		1	X
Textularia candeiana		X										
Textularia mexicana		X	X									
Triloculina trigonula (displaced)		X										
Trochammina advena		X	X	1	1	X	X	4	1	3	2	
Valvulineria complanata		X										

% Benthic Species / Depth - feet	534	906	1224	1506	1824	2148	2496	2730	3006	3324	3630	3864
Station	5	6	7	8	9	10	11	12	13	14	15	16
1224 FEET												
Ammodiscoides turbinatus			X						X	1		1
Amphicoryna hispida			X	X	1	X						
Anomalina mexicana			X	1	1	X	X	X		X	X	
Astrononion tumidum			X				X					X
Bathysiphon filiformis			X	X	X	X		1	1		X	
Bolivina ordinaria			1	X	X	X						
Bolivina quadrata			X									
Bulimina aculeata			X	1	2	5	9	8	16	13	15	18
Cibicides bantamensis			X	X	X	X		X				
Dentalina cuvieri			X	X								
Ehrenbergina trigona			X									
Fissurina orbignyana vars.			X									
Glomospira charoides			X	1	1	X	X	1	4	3	1	3
Glomospira gordialis			X	X				X				
Gyroidina orbicularis s.l.			X	1	X	X	2	2	1	3	3	2
Haplophragmoides sphaeriloculus			X	X		X	X	3	1	X	1	2
Hormosina distans delicatula			1	1		X		X	X	X	1	X
Karreriella apicularis			X	1	X	X	X	1	1	2	5	5
Karreriella bradyi			1	1	X	X	X				1	X
Lagena laevis			X					X		X		X
Laticarinina pauperata			X	1	1	1	1	2	1	2	1	2
Marginulina hantkeni			X									
Marginulina tenuis			X	X								
Oridorsalis tener tener			X	1	1	X	X	X	X	X	X	X
Osangularia rugosa			X	X	1	1	2	1	X			
Planulina ariminensis			X	1	2	X				X		
Pseudonodosaria comatula			X									
Pseudotrochammina mexicana			X	X								X
Pyrgo murrhina (oval aperture)			X		X			X		X		
Reophax dentaliniformis			X	X								

Depth - feet	534	906	1224	1506	1824	2148	2496	2730	3006	3324	3630	3864
Station	5	6	7	8	9	10	11	12	13	14	15	16
% Benthic Species												
Reophax guttifer			X	1	X	X				X		
Reticulophragmium venezuelanum			X	X		X		X	1		X	
Saccorhiza ramosa			1	2	1	1	1	4	3	3	2	3
Saracenaria italica var.			X									
Uvigerina peregrina dirupta			X		4	12	16	9	12	13	9	7
Uvigerina peregrina mediterranea			2	3	3	2	X					
1506 FEET												
Adercotryma glomeratum				X		1	X	X	1	1	3	1
Bulimina rostrata alazanensis				1	6	14	10	8	11	9	6	3
Cibicides bradyi				X	1	1	3	1		X	2	3
Cibicides robertsonianus				X		X		X	X	X	X	X
Cribrostomoides wiesneri				X				X		X	1	X
Cyclammina cancellata				X		X	X	1	1	X	X	1
Cystammina pauciloculata				1		X		1	4	3	2	X
Eggerella bradyi				X	X	1	2	1	2	2	3	1
Epistominella exigua				1	6	5	1	1	X	X	1	X
Globocassidulina murrhyna				1	X	3	2	1	2	1	X	1
Globocassidulina pacifica var.				X	1	1	1				X	1
Hormosina globulifera				X				X			X	X
Islandiella norcrossi australis				1	1							
Tosaia weaveri				X	1	X						
Trochammina sp.				X	X			X	1	X		X
Valvulineria "opima"				X	X	X	X	X			1	X
1824 FEET												
Ammodiscus planorbis					X	X	X	2		1	2	X
Coryphostoma spinescens					X							
Eggerella propinqua					X		X	X	X		X	
Eponides polius					1	X	X	X	X	X	X	X
Eponides turgidus					X	1		X		X		X
Fissurina formosa (<0.5 mm)					X	X	X	X				

Depth - feet	534	906	1224	1506	1824	2148	2496	2730	3006	3324	3630	3864
Station	5	6	7	8	9	10	11	12	13	14	15	16
% Benthic Species												
Globocassidulina subglobosa					X	X	X		X	X		X
Gyroidina soldanii					X	X	X		X		X	X
Orthomorphina guttifera					X							
Osangularia cultur					1	5	6	9	5	2	2	2
Parafissurina lateralis					X							
Rhabdammina linearis					X	X		X	X	X	X	X
Uvigerina spinicostata					X	X	X	X	X	X	1	X
2148 FEET												
Bolivina translucens						X	X				X	
Cibicides rugosus						X	1	1	1	2	1	1
Cribrostomoides subglobosus						1		X	X	1	1	1
Fursenkoina seminuda						X		X		X		
Oridorsalis tener umbonatus						X	X			1		
Rectobolivina dimorpha						X						
Reophax distans						X	X					
Tolypammina schaudinni						X		X	X	X	X	X
2496 FEET												
Ammolagena clavata							X	1	X	X	1	1
Hormosina carpenteri							X	X	X			X
Martinottiella (initial portion)							X		X			X
Trochammina tasmanica							X	X	X	1	1	X
2730 FEET												
Ammodiscus tenuis								X		1		
Ammoglobigerinoides dehiscens								X			X	X
Cribrostomoides lobatus								X	X	X	X	
Cribrostomoides scitulus								X	X		X	X
Ehrenbergina pupa								1				X
Fissurina orbignyana								X				1
Gaudryina minuta								1		X		
Hormosina ovicula								X	X	X		

Depth - feet	534	906	1224	1506	1824	2148	2496	2730	3006	3324	3630	3864
Station	5	6	7	8	9	10	11	12	13	14	15	16
% Benthic Species												
Nodellum membranaceum								X				
Reophax bacillaris								X				
Siphotrochammina squamata								X	1	X	X	1
Tritaxis fusca								1	1			
3006 FEET												
Dorothia pseudoturris									X	X		
Florilus clavatus									X	1	X	
Robertina oceanica									X			
Thurammina papillata									X	X		
3324 FEET												
Cibicides wuellerstorfi										X	X	1
Cribrostomoides ringens										X		X
Pullenia subsphaerica										X	1	1
Pullenia trinitatensis										X	X	1
Rhizammina algaeformis										X	1	1
Trochammina globulosa										1	2	1
3630 FEET												
Fissurina tenuissima											X	
Gyroidina altiformis acuta											X	X
3864 FEET												
Anomalina globulosa												X
Heronallenia gemmata												X
Oridorsalis sidebottomi												X
Uvigerina hispida												X
Total Benthonic Foraminifera	1702	881	269	265	376	333	317	311	237	318	333	294
Percent Agglutinated	X	2	10	14	4	7	6	27	28	28	35	31
Percent Porcelaneous	X	1	X	X	0	0	X	0	X	0	0	0
Percent Hyaline	99	97	90	86	96	93	94	73	72	72	65	69
Total Planktonic Foraminifera	376	555	431	485	1078	907	1348	1166	848	774	1633	2269
Percent Planktonic Foraminifera	18	39	62	65	74	73	69	79	78	71	83	89
Total Foraminifera	2078	1436	700	750	1454	1240	1965	1477	1085	1092	1966	2563
Benthonic Foraminifera/Ostracode	425	88	269	+265	376	166	313	156	119	+316	333	288
Total Foraminifera/Ostracode	525	144	700	750+	1454	620	1965	739	543	1092	1966	2563

APPENDIX D
LIVE BENTHIC FORAMINIFERS FROM TRAVERSES 1, 2, AND 3

TRAVERSE 1

Water depth	498'	762'	984'	1230'	1410'	1722'	1962'	2178'	2358'	2640'	2964'	3300'	3636'	4092'	4338'	4584'	4778'	5730'	5436'	5514'	5880'	6174'	6174'	6726'	6864'	6972'	7590'	7650'	8010'	8328'	8874'	8712'	9204'	9510'	9762'	10446'	10728'	11442'
Stations	43G	42G	41G	40G	39E	38G	37G	36G	35G	34G	33G	32G	31G	30E	29G	28G	27G	26G	25E	24G	23A,G	23G	22G	21E	20G	19G	18G	17G	16E	15G	14E	13G	12E	11G	10G	8G	7G	6G
498 FEET																																						
Bolivina barbata	2																																					
Bolivina subaenariensis mexicana	6		1																																			
Bulimina marginata	9			1																																		
Cassidulina neocarinata	1			1	14	8		2	1		1																											
Chilostomella oolina	2			1							7	13	2				1	1																				
Cibicides pseudoungerianus	1																																					
Dentalina filiformis	1																																					
Dentalina inornata bradyensis	1		1																																			
Eponides (neoeponides) regularis	1				1					1																												
Florilus atlanticus	1																																					
Glandulina laevigata	1													1																								
Globobulimina ovula	1		1					2	4	3	3	6	4	1																								
Lagena sulcata	1																																					
Lenticulina calcar	1	3	3	1	1																																	
Lenticulina cultrata	1								1	1																												
Nonionella opima	2																																					
Sphaeroidina bulloides	1		3	5		4	2	3	2	1	2	5	5				1	1																				
Uvigerina peregrina (<0.5 MM)	2		5	4			1	1	1	2	2																											
Vaginulina subaculeata glabrata	1		2																																			
762 FEET																																						
Bulimina striata mexicana		2	1	3	1	1	1	3																														
Cibicides umbonatus		1																																				
Hoeglundina elegans		1	1		1			1							1		1		2			1	1				1			1	3						1	1
Karreriella bradyi		1										1			1																							
Paradentalina sp.		1																																				
Pullenia bulloides		1	1			1			1	1	1	2																										
984 FEET																																						
Anomalina mexicana			1																																			
Bolivina alata			1																																			
Bolivina albatrossi			1	2		2		2					2	4																								
Cassidulina curvata			1			1																																
Cassidulinoides mexicanus			1			2		1	2																													
Cibicides aff. floridanus			1	1			1		1		1	1	3						1																			
Fissurina			1	1																																		
Lenticulina sp.			1						1																													
1230 FEET																																						
Astacolus				1																																		
Bulimina aculeata				1	1	8	8	10	4	2	2	4	5	1	4		1	1	4																			
Fursenkoina pontoni				1																																		
Rotorbinella translucens				2	6	4	3	1							1																							
Tosaia weaveri				1																																		
1410 FEET																																						
Amphicoryna hispida					1																																	
Reophax scorpiurus					1				2				1												2					1								

Water depth	498'	762'	984'	1230'	1410'	1722'	1962'	2178'	2358'	2640'	2964'	3300'	3636'	4092'	4338'	4584'	4778'	5730'	5436'	5514'	5880'	6174'	6174'	6726'	6864'	6972'	7590'	7650'	8010'	8328'	8874'	8712'	9204'	9510'	9762'	10446'	10728'	11442'
Stations	43G	42G	41G	40G	39E	38G	37G	36G	35G	34G	33G	32G	31G	30E	29G	28G	27G	26G	25E	24G	23A,G	23G	22G	21E	20G	19G	18G	17G	16E	15G	14E	13G	12E	11G	10G	8G	7G	6G
1722 FEET																																						
Cyclammina cancellata						1	1	1	1		1											1																
Globobulimina affinis						1			4		5	4	4	2	5	1	1	2																			1	
Globocassidulina crassa						1																																
Gyroidina altiformis cushmani						1		2																														
Haplophragmoides canariensis						1	1	1	1																													
Martinottiella occidentalis						1																																
Oridorsalis tener stellatus						1																																
Osangularia rugosa						1																																
Planulina ariminensis						1																																1
Reticulophragmium venezuelanum						1	1	2		1		1																										
1962 FEET																																						
Lagena gracillima							1		1																													
Lenticulina orbicularis							1																															
Pullenia quinqueloba							1										1	1																				
Pyrgo serrata							2																															
Reophax dentaliniformis							2	4																														
Valvulineria complanata							1	1																														
2178 FEET																																						
Ammodiscus tenuis								2	1	1		1																										
Bulimina spicata								1				1			1																							
Epistominella exigua								1			1		1																									
2358 FEET																																						
Fissurina tenuissima									1			2																										
Lagena acuticosta var.									1																													
Lagenammina difflugiformis									3			1	1																				1					
Lenticulina peregrina									2		1	2																										
2640 FEET																																						
Bulimina rostrata alazanensis										1	1		1																									
Cribrostomoides scitulus										1							1																					
Gyroidina orbicularis										2		3	1		1		1	2																				
Hormosina globulifera										1	2				1			1																				
Oridorsalis umbonata										1																												
2964 FEET																																						
Adercotryma glomeratum											1																											
Astrononion tumidum											2																											
Cibicides bantamensis											1																											
Cibicides kullenbergi											1						1																					
Cibicides robertsonianus											1	1		1	1		1		4		2	1	4		1				1	1			2				1	
Cribrostomoides ringens											1				1	1																						
Hormosina ovicula											1	1																										
Lagena distoma											1																											
Uvigerina peregrina dirupta											1	6	1			2		1						1														

Water depth	498'	762'	984'	1230'	1410'	1722'	1962'	2178'	2358'	2640'	2964'	3300'	3636'	4092'	4338'	4584'	4778'	5730'	5436'	5514'	5880'	6174'	6174'	6726'	6864'	6972'	7590'	7650'	8010'	8328'	8874'	8712'	9204'	9510'	9762'	10446'	10728'	11442'
Stations	43G	42G	41G	40G	39E	38G	37G	36G	35G	34G	33G	32G	31G	30E	29G	28G	27G	26G	25E	24G	23A,G	23G	22G	21E	20G	19G	18G	17G	16E	15G	14E	13G	12E	11G	10G	8G	7G	6G
<u>3300 FEET</u>																																						
Anomalina corpulenta												1						1							1													
Anomalina globulosa												1													1													
Cribrostomoides subelobosus												3			1							1		1										1			1	
Eggerella propinqua												1																										
Hyperammina subnodosa												4						1																				
Lituola lituolinoidea												2																										
Oolina longispina												1																										
Osangularia culter												1	1	1		1	2		1			1			1													
Pyrgo depressa												1																										
Sigmoilopsis schlumbergeri												1							1																			
Trochammina globulosa												1																										
<u>3636 FEET</u>																																						
Cibicides wuellerstorfi													1																				1					4
Laticarinina pauperata													1		1				1																			
Rhizammina algaeformis													1	2	2																							
<u>4092 FEET</u>																																						
Saccorhiza ramosa														1	1																							
<u>4338 FEET</u>																																						
Cribrostomoides "profundus"															1																							
<u>4584 FEET</u>																																						
Dorothia pseudoturris																1																						
<u>5730 FEET</u>																																						
Cibicides bradyi																		1			1			1									2		2			
Hyperammina friabilis																		1																				
Rhabdammina linearis																		1																				
<u>5436 FEET</u>																																						
Ammodiscus planorbis																			1																			
Ehrenbergina pupa																			1																			
Globocassidulina subglobosa																			1																			
<u>5880 FEET</u>																																						
Apiopterina sp.																					1				1													
<u>6174 FEET</u>																																						
Pyrgo lucernula																						1																
<u>6726 FEET</u>																																						
Haplophragmoides bradyi																								1											1			
Uvigerina cf hispida																								1														

Water depth	498'	762'	984'	1230'	1410'	1722'	1962'	2178'	2358'	2640'	2964'	3300'	3636'	4092'	4338'	4584'	4778'	5730'	5436'	5514'	5880'	6174'	6174'	6726'	6864'	6972'	7590'	7650'	8010'	8328'	8874'	8712'	9204'	9510'	9762'	10446'	10728'	11442'
Stations	43G	42G	41G	40G	39E	38G	37G	36G	35G	34G	33G	32G	31G	30E	29G	28G	27G	26G	25E	24G	23A,G	23G	22G	21E	20G	19G	18G	17G	16E	15G	14E	13G	12E	11G	10G	8G	7G	6G
6864 FEET																																						
Bolivinita quadrilatera																									1													
Eponides polius																									1									1				
Fissurina																									1													
Pleurostomella bolivinoides																									1													
8010 FEET																																						
Gyroidina lamarckiana																													1									
8874 FEET																																						
Eggerella bradyi																															1							
9204 FEET																																						
Parafissurina lateralis																																	1					
Hormosina distans delicatula																																	3					
10446 FEET																																						
Reophax spiculifer																																				1	1	
10728 FEET																																						
Melonis pompilioides																																					1	1
Raphanulina "gibba"																																					1	
11442 FEET																																						
Dentalina intorta																																						1

TRAVERSE 2

Water depth	594'	918'	1176'	1212'	1230'	1536'	1572'	1836'	2118'	2328'	2448'	2698'	2724'	3030'	3078'	3078'	3078'	3102'	3318'	3816'	4218'	4506'	4524'	4920'	5010'	5136'	5268'	5394'	5622'	5994'	6054'	6234'	6492'	6624'	7482'	10800'	11532'
Stations	80G	79G	73E	77G	78E,G	76G	74G	72G	71G	65G	70G	62G	69G	68G	61G	63G	66G	64G	67E	60G	59G	53E	58G	52G	54G	51A,G	57G	54B,G	51G	54A,G	49G	55G	56E	47G	46G	45G	44E
594 FEET																																					
Anomalina corpulenta	2										1							2																			
Bolivina subaenariensis mexicana	8			1																																1	
Cancris auriculus	3																																				
Cassidulina curvata	15	1																																			
Cassidulinoides mexicanus	1																																				
Chilostomella oolina	1			1										6																						1	
Cibicides umbonatus	1	1																																			
Dentalina cuvieri	1																								1												
Dentalina inornata bradyensis	1												1					1																			
Globobulimina affinis	3			1							1			1																							
Hanzawaia bertheloti	1																																				
Hoeglundina elegans	6	3				1								1										4		3		1	1		2			5	8	1	
Lagena sp.	1																																				
Lenticulina calcar	4	1			2																																
Lenticulina cultrata	1			1	4																							1									
Lenticulina orbicularis	3			1			1																														
Lingulina seminuda	1			1																																	
Oridorsalis tener stellatus	1																																				
Pseudoglandulina comatula	1																																				
Pullenia bulloides	3	2																																			
Saracenaria sp.	1									1																											
Siphonina bradyana	8			1	2	3	1	1			1																										
Siphonina pulchra	4			1																																	
Sphaeroidina bulloides	2				2	1	2	3		1			3						1																		
Uvigerina flintii	3																																				
Valvulineria laevigata	1																																				
918 FEET																																					
Bulimina spicata		1						1	1									1		1																	
Gyroidina altiformis cushmani		1											1					1																			
Uvigerina peregrina mediterranea		1		1	1	2	3																														
Vaginulina subaculeata glabrata		1	1	1	1																																
1212 FEET																																					
Bolivina albatrossi				1					2				2				1			2			1														
Ehrenbergina trigona				1																																	
Gaudryina atlantica				1																																	
Orthomorphina guttifer				1																																	
Trifarina bradyi				1			1						1																								
1230 FEET																																					
Cibicides aff. floridanus					1		1				1		1	1		1	2	1			1																
Globobulimina ovula					1																																
Globocassidulina crassa					2			1																													
Uvigerina peregrina (0.4 MM)					1																																
1536 FEET																																					
Bulimina aculeata						1	2		1	1			4					2	1	1	1	1	2		2	1	3	1	1								

Water depth	594'	918'	1176'	1212'	1230'	1536'	1572'	1836'	2118'	2328'	2448'	2698'	2724'	3030'	3078'	3078'	3078'	3102'	3318'	3816'	4218'	4506'	4524'	4920'	5010'	5136'	5268'	5394'	5622'	5994'	6054'	6234'	6492'	6624'	7482'	10800'	11532'
Stations	80G	79G	73E	77G	78E,G	76G	74G	72G	71G	65G	70G	62G	69G	68G	61G	63G	66G	64G	67E	60G	59G	53E	58G	52G	54G	51A,G	57G	54B,G	51G	54A,G	49G	55G	56E	47G	46G	45G	44E
1572 FEET																																					
Ammodiscus planorbis							1													1																	
Cassidulina neocarinata							1																														
Cibicides bradyi							1						2								2					5	1		1								
Cibicides robertsonianus							1						1	1						1	1	2	4	5	6	3	2	3	6	1	5	2		4	1		
Glandulina laevigata							1			1																											
Laticarinina pauperata							1						1	2						4	2		2	1		2	2				2		2				
1836 FEET																																					
Bulimina striata mexicana								1	1																												
Cribrostomoides subglobosus								1		2		1	1			1	1										1						1				
2118 FEET																																					
Fissurina sp.									3				1																								
Osangularia culter									4		1			1						5	1	1	1	1	1		4	2			1		2				
Reophax dentaliniformis									1					1						1	2						1		1	1							
Reophax scorpiurus									1		2			1												3				3				1			
Robertinoides bradyi									1																												
Uvigerina peregrina dirupta									4	2	2	2	3		2	1		3	2	1	2	1	1	1					2	1		1	1		1		
2328 FEET																																					
Bathysiphon filiformis										1																											
Rotorbinella translucens										1																									1		
2448 FEET																																					
Cribrostomoides sp.											1																										
Cribrostomoides "profundus"										1	1		1					1															1				
Cribrostomoides umbilicatulus											1	1																									
Cribrostomoides wiesneri											1																										
Cyclammina cancellata var.											1	1						1		1																	
Eggerella propinqua										1	1								1																		
Haplophragmoides sphaeriloculus											1																										
Hormosina carpenteri											1																										
Hormosina globulifera										1	2						1																				
Lenticulina peregrina										1	2					1	1	1	2		2		1		1		1							1			
Parafissurina											1																										
Reophax pilulifer											1						1																				1
Sigmoilopsis schlumbergeri											1																										
2724 FEET																																					
Lituola lituolinoidea													1						1																		
Martinottiella occidentalis var.													1																								
Trochammina tasmanica													1																								
3030 FEET																																					
Cibicides kullenbergi										1				1				1			1				4										2		
Haplophragmoides bradyi														1																						1	

Water depth	594'	918'	1176'	1212'	1230'	1536'	1572'	1836'	2118'	2328'	2448'	2698'	2724'	3030'	3078'	3078'	3078'	3102'	3318'	3816'	4218'	4506'	4524'	4920'	5010'	5136'	5268'	5394'	5622'	5994'	6054'	6234'	6492'	6624'	7482'	10800'	11532'
Stations	80G	79G	73E	77G	78E,G	76G	74G	72G	71G	65G	70G	62G	69G	68G	61G	63G	66G	64G	67E	60G	59G	53E	58G	52G	54G	51A,G	57G	54B,G	51G	54A,G	49G	55G	56E	47G	46G	45G	44E
3078 FEET																																					
Bathysiphon sp																	1																				
Cibicides rugosus																	1	1																			
Alveolovalvulinella pozonensis																1																					
Globocassidulina murrhyna																1																					
3102 FEET																																					
Ammodiscoides turbinatus																		1								1											
Cornuspira																		1																			
Eggerella bradyi																		1																			
Epistominella exigua																		1																			
Fissurina																		1						1	1				1								
Gyroidina altiformis acuta																		1																			
Lagenammina difflugiformis																		1																1	2		
Lenticulina sp.																		1																			
Pullenia quinqueloba																		1											1	1							
3318 FEET																																					
Gyroidina orbicularis										1								2	2				1						1	1				2	1		
Hyperammina friabilis																			1																		
Oridorsalis umbonatus (0.7 MM)																			1															1	1		
3816 FEET																																					
Karreriella apicularis																				1																	
Karreriella bradyi																				1																	
Pullenia subsphaerica																				1															1		
4218 FEET																																					
Ammobaculites agglutinans																					1																
Rhabdammina cornuta																					8		2	1	1		2				1				1	1	
Rhizammina algaeformis																					1													1			
4524 FEET																																					
Cibicides wuellerstorfi																							1		1		1			1							
5010 FEET																																					
Lagena laevis																									1												
Oolina longispina																									1												
Pyrgo murrhina																						1			1										1	1	
5622 FEET																																					
Parafissurina lateralis																													1								
5994 FEET																																					
Gyroidina lamarckiana																														1							
Pullenia subsphaerica (5 chambers)																														1						2	
6054 FEET																																					
Cribrostomoides ringens																															1						
Hyperammina cylindrica																																				1	
6492 FEET																																					
Apiopterina																																	1	1			
Aschemonella catenata																												2	1				1	3	1	1	2
Trochammina globulosa																																	1				
10800 FEET																																					
Melonis pompilioides																																				1	1
Eponides (neoeponides) polius																																				1	

TRAVERSE 3

Depth - feet	534	906	1224	1506	1824	2148	2496	2730	3006	3324	3630	3864
Station	5	6	7	8	9	10	11	12	13	14	15	16
534 FEET												
Amphicoryna sublineata	1				1		1					
Angulogerina bella	2	3										
Anomalina corpulenta	1											
Bolivina fragilis	1											
Bolivina striatula spinata	1											
Bolivina subaenariensis mexicana	2	3	3									
Cancris auricula	2											
Cassidulina curvata	1	4	3							1?		
Cassidulina neocarinata	1											
Cassidulinoides mexicanus	1											
Cibicides floridanus	3	2		3								
Cibicides mollis	1											
Cibicides pseudoungerianus	4	14										
Coryphostoma zanzibarica	1											
Eponides regularis	1	3										
Neoeponides coryelli	1	1										
Planulina foveolata	1	7	1									
Pullenia osloensis	1		1									
Reussella atlantica	1											
Siphonina bradyana	6	3	5	3	2							
Uvigerina auberiana	1	3										
Uvigerina peregrina parvula (<0.45 mm)	1?	1										
Uvigerina peregrina peregrina (<0.45 mm)	1	4	3	3		1						
906 FEET												
Bolivina albatrossi		3	5	2	3	1	12	6	3	4	2	5
Bolivina barbata		1										
Bulimina spicata		1				2	4	1			1	2
Bulimina striata mexicana		4	2	2	2	2	1					
Chilostomella oolina		2	2			3	1				2	
Cibicides umbonatus		7										
Lenticulina peregrina		1										
Pullenia bulloides		1		1			2	2	1			
Rosalina suezensis		1										
Sphaeroidina bulloides		3	2	1	2		6	3		2	1	3
1224 FEET												
Bulimina marginata			1									
Cassidulinoides bradyi			1									
Globocassidulina crassa			2									
Reophax scorpiurus			1									
Rotorbinella translucens			1	2		1	2					
Uvigerina peregrina mediterranea			2	1	1							
1506 FEET												
Cibicides robertsonianus				1		1	3	1				
Dentalina inornata bradyensis				1	1							

Depth - feet	534	906	1224	1506	1824	2148	2496	2730	3006	3324	3630	3864
Station	5	6	7	8	9	10	11	12	13	14	15	16
Ehrenbergina trigona				1		1						
Florilus scaphus				1								
Globobulimina pyrula spinescens				1			1					1
Gyroidina orbicularis s. l.				1	1							
Lagenammina difflugiformis				1								
Marginulina tenuis				1								
Tosaia weaveri				1	1							
Trifarina bradyi				1	1							
1824 FEET												
Globobulimina affinis					2		1	1	1	3		
Orthomorphina guttifera					1							
Uvigerina peregrina dirupta					2	1	2	5	1	1	1	4
2148 FEET												
Bulimina aculeata						1		3		2	2	5
Oridorsalis tener umbonatus						1	2			1		
Osangularia culter						3	3	3	3		2	2
Trochammina globulosa						1						
2496 FEET												
Adercotryma glomeratum							1				1	
Bulimina rostrata alazanensis							6					1
Eggerella bradyi							2			1	1	2
Epistominella exigua							1					
Gyroidina umbonata							1					
Karreriella bradyi							2					1
Laticarinina pauperata							1		1			1
Trochammina advena							1					
2730 FEET												
Osangularia rugosa								1				
Recurvoides contortus (subglobosus)								1				
Saccorhiza ramosa								1				
3324 FEET												
Planulina ariminensis										1		
3630 FEET												
Pullenia quinqueloba											1	1
3864 FEET												
Cibicides rugosus												1
Cibicides wuellerstorfi												1
Cyclammina cancellata												1
Hoeglundina elegans												1
Spirosigmoilina distorta												1

APPENDIX E
PLANKTONIC FORAMINIFERS FROM TRAVERSES 1, 2, AND 3

PLANKTONIC SPECIES, TRAVERSE I

Depth - feet	498	762	984	1230	1410	1722	1962	2178	2358	2640	2964	3270	3636	4092	4338	4584	4778	5130
Station	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26
% Planktonic Species																		
Candeina nitida																		
Globigerina bulloides (Fossil ?)	8	1	1	5	1	1	3	X	1	1	2	1	X	X	X	X	X	X
Globigerina calida		1	X	X	2	X	X	1	X	X	X	1	1	2	X	X	X	3
Globigerina digitata															X	X	X	X
Globigerina falconensis	1	1	1	5	7	9	8	10	4	6	9	5	8	6	5	2	23	5
Globigerina quinqueloba		X	X	1	X	X	X		X				X	2	X	X	2	X
Globigerina rubescens		15	18	11	10	15	11	10	9	5	13	10	8	6	6	5	9	14
Globigerinella siphonifera	5	6	2	X	X	1	3	X	2	1	1	1	4	2	1	3	2	2
Globigerinita glutinata	5	2	2	5	4	4	2	1	4	4	2	3	6	3	6	2	9	X
Globigerinita uvula		X	X	X	X	X	X	1	3	X	X	X	X	X	X	X	X	X
Globigerinoides conglobatus	1	3	1	X	3	X	1	X	X	1	2	1	1	2	2	2	1	X
Globigerinoides ruber	21	34	34	30	31	34	26	22	35	22	34	24	24	31	27	24	23	17
Globigerinoides sacculifer	18	8	13	7	2	9	3	13	7	4	5	10	16	10	14	13	6	16
Globorotalia crassaformis	1	1	2	1	3	2	1	3	1	1	1	5	X	X	2	X	X	X
Globorotalia menardii	1	6	7	5	4	1	2	1	2	4	5	8	6	6	7	10	3	7
Globorotalia scitula						X			X	X	X	X	3	1	1	X	1	5
Globorotalia truncatulinoides	21	7	4	14	13	9	19	11	16	11	6	11	10	8	13	14	7	8
Globorotalia tumida	1	X	2	X	X			X	X	5	X	3	X	1	X	3	1	2
Globorotaloides hexagonus ?		X	X	X	X							X					X	
Hastigerina pelagica																		
Neogloboquadrina dutertrei	5	10	8	7	7	5	8	13	5	13	10	5	6	11	8	10	6	9
Orbulina universa	3	1	1	1	1	1	1	2	3	1	1	4	3	3	1	1	2	1
Pulleniatina obliquiloculata	8	3	2	8	12	8	11	10	6	16	5	7	3	5	6	10	4	7
Sphaeroidinella dehiscens			X	X				X	X	X	X	X	X	X	X	X	X	X
Neogloboquadrina pachyderma (Fossil)		X												X		X		
Turborotalita humilis		X	1	X	X	X	X		X		X	X	X	X	X	X	X	X
Planktonic Foraminifera	66	1046	1323	638	1133	1066	1225	1155	699	826	937	994	1537	1077	1167	1485	3269	2791
Radiolaria		1	1	8	7	25	50	85	125	39	475	210	265	35	115	95	600	342
Total Planktonic	66	1047	1324	646	1140	1091	1275	1240	824	865	1412	1204	1802	1112	1282	1580	3869	3133

5130	5436	5514	5880	6174	6194	5726	6864	6972	7590	7650	8010	8328	8874	8712	9204	9510	9762	10446	10662	11442
26	25	24	23A	23	22	21	20	19	18	17	16	15	14	13	12	11	10	8	7	6
				X	X	X	X	X	X		X	X	X		X	X	X	X	X	X
X	X	X	X				X			X	X	X								
3	X	2	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
X	X	X	X	X	X	X	X	X							X		X	X	X	X
5	2	12	2	8	18	5	8	6	1	2	1	5	21	14	6	6	3	13	8	8
X	X	X	X	X	1	X	1	X	X	X	X	X	X	2	3	2	4	9	6	4
14	15	6	16	16	11	8	13	11	12	4	4	22	26	9	23	23	28	30	23	25
2	2	5	1	X	2	1	2	2	X	1	1	2	X		2	2	1	1	1	4
X	1	6	2	6	2	1	3	X	X	X	X	2	3		5	5	4	13	28	11
X	X	X	X	X	X	X	X	X		X		X	X		X	2	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X
17	28	27	40	33	31	58	48	42	21	31	25	28	17	11	17	21	31	15	11	15
16	17	12	19	14	12	11	8	8	24	23	28	16	12	15	14	19	6	7	7	16
X	X	2	1	3	2	1	1	X	3	3	2	1	X	2	X	1	2	X	X	X
7	9	5	4	4	3	3	4	3	13	6	10	7	6	20	6	4	X	7	5	8
5	1	X	X	X	X	X	X	X			X	X	X		1	X	9	5	4	X
8	8	6	2	3	3	1	2	5	6	5	2	3	2	7	2	3	2	X	1	X
2	3	2	X	X	2	X	X	X	2	2	2	1	1	6	2	X	X	X	X	X
		X	X	X	X															
															X	X	X	X	X	X
9	5	5	6	5	5	3	5	9	11	9	11	7	5	3	6	4	2	2	3	2
1	2	2	X	1	X	1	1	2	1	1	3	2	X		2	2	1	1	2	1
7	5	6	2	3	4	3	2	6	6	8	8	3	5	8	3	4	2	X	X	2
X	X	X	X	X	X	X	X	X		X	X	X	X	1	X	X	X	X	X	X
			X	X	X	X	X		X	X	X	X			X		X			
X	X	X	X	X	X	X	X	X				X			X	X	X	X	X	X
2791	4249	2059	5019	5580	6584	6049	6478	5455	2354	2984	3270	5413	5766	96	5260	8626	7808	9136	6654	4384
342	25	26	21	11	13	9	10	8	1	1	1	1	1	0	9	60	2	15	30	33
3133	4274	2085	5040	5591	6597	6058	6488	5463	2355	2985	3271	5414	5767	96	5269	8686	7810	9151	6684	4417

PLANKTONIC SPECIES, TRAVERSE II

Depth - feet	594	918	1,230	1,212	1,536	1,572	1,176	1,836	2,118	2,448	2,724	3,030	3,318	3,078	2,328	3,102	3,078
Station	80	79	78	77	76	74	73	72	71	70	69	68	67	66	65	64	63
Candeina nitida	X			X				X					X				
Globigerina bulloides (Fossil?)	3	1	X	X	1	1	1	X	2	1	X	1	X	X	1	X	X
Globigerina calida	X	X				X	X	X	X	X	X	X	X	X	X	X	X
Globigerina digitata											X	X	X				X
Globigerina falconensis	11	11	6	5	16	4	4	19	22	9	13	6	9	6	28	10	14
Globigerina quinqueloba		X	X	X	X	6	X	5	4	4	3	3	3	2	3	7	2
Globigerina rubescens	22	19	34	13	18	19	7	17	9	33	15	16	13	22	17	18	15
Globigerinella siphonifera	4	3	2	X	X	X	2	X	2	2	2	5	2	1	1	1	2
Globigerinita glutinata	1	13	10	10	13	18	13	21	8	10	14	10	13	11	23	21	18
Globigerinita uvula									X	X	X	X		X		X	X
Globigerinoides conglobatus	X	X	X	1	X	X	X	X	X	X	X	2	1	X	X	1	X
Globigerinoides ruber	40	23	17	35	17	17	51	16	19	21	19	14	20	16	11	17	26
Globigerinoides sacculifer	2	4	3	7	5	6	6	5	6	4	4	4	5	9	1	5	3
Globorotalia crassaformis	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Globorotalia hirsuta	X																
Globorotalia inflata (Fossil ?)				X			X										
Globorotalia menardii	3	3	3	5	2	4	5	3	5	1	6	7	4	4	4	4	6
Globorotalia menardii fimbriata								X	X	X	X	X	X	X	X		
Globorotalia scitula	X	1	1	X	X	1	X	X	1	2	2	3	3	4	4	1	2
Globorotalia truncatulinoides	5	8	7	5	6	7	4	3	7	4	9	11	11	6	1	4	4
Globorotalia tumida			X	X	X	X	X	X	X	X	1	X	X	X	X	1	1
Globorotaloides hexagonus (?)								X					X				X
Hastigerina pelagica						X				X				X			
Neogloboquadrina dutertrei	1	3	8	9	8	3	2	3	3	2	3	2	2	4	1	2	3
Orbulina universa	X	X	1	1	1	1	X	1	1	X	1	2	1	X	1	X	X
Pulleniatina obliquiloculata	7	10	6	6	11	11	2	4	7	5	7	12	12	11	3	6	3
Sphaeroidinella dehiscens					X		X	X	X		X	X	X		X		X
Neogloboquadrina pachyderma (Fossil ?)																	
Turborotalita humilis																	

2,688	3,078	3,816	4,218	4,524	5,268	6,492	6,234	5,010	5,994	5,394	4,506	4,920	5,622	5,136	6,054	6,624	7,482	10,800	11,532
62	61	60	59	58	57	56	55	54	54A	54B	53	52	51	51A	49	47	46	45	44
X				X	X			X	X	X	X				X	X	X	X	X
X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X
X	X	X	X	1	X	X	X	1	1	X	X	1	1	1	1	1	X	X	X
	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11	4	12	9	6	7	21	5	12	12	7	17	11	9	9	7	9	16	8	23
2	2	3	6	3	3	1	X	4	1	3	3	3	3	X	3	2	8	12	3
8	33	18	17	14	22	12	25	13	11	17	20	10	29	27	19	22	18	13	14
1	1	1	1	2	5	3	1	4	1	3	3	5	6	3	3	2	3	3	1
18	13	17	16	11	11	23	11	8	18	10	11	18	11	13	14	11	8	22	27
			X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
1	X	1	X	X	1	X	X	X	X	X	X	1	X	X	X	1	X	X	X
30	18	19	18	32	17	12	16	12	25	21	10	21	9	12	13	16	14	13	7
7	8	3	4	2	3	3	8	8	6	7	10	3	5	5	5	4	4	7	6
1	1	1	X	X	1	X	X	X	2	1	X	X	X	X	X	X	X	X	X
	X								X										
5	6	6	6	6	7	4	6	6	5	6	6	5	6	7	6	7	6	5	5
X	X				X	X									X	X	X	X	X
1	1	2	3	3	3	2	X	2	1	2	4	4	4	2	4	5	4	3	1
5	3	4	7	4	6	4	8	8	3	4	4	4	4	6	5	4	4	4	3
1	X	1	X	1	1	X	1	1	1	1	1	1	1	2	X	X	1	1	X
X			X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3	3	3	2	3	2	2	6	6	3	4	3	1	2	2	5	3	2	4	2
1	1	X	2	3	2	2	1	4	1	3	1	2	2	3	3	2	2	1	1
4	3	7	6	8	8	10	10	10	6	8	5	9	7	7	10	10	9	3	5
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
									X										
						X	X	X	X	X			X			X	X		X

Depth - feet	594	918	1,230	1,212	1,536	1,572	1,176	1,836	2,118	2,448	2,724	3,030	3,318	3,078	2,328	3,102	3,078
Station	80	79	78	77	76	74	73	72	71	70	69	68	67	66	65	64	63
Globorotalia menardii (% Crystalline crust)	4	85	50	90	87	67	91	54	78	91	93	79	87	63	70	93	92
Pteropods												2					
Radiolarians (% in total Foram.-Radiolarian Complex)	0	X	X	X	1	1	X	2	3	21	21	17	11	15	8	16	10
Planktonic Foraminifera	4483	1704	2501	4046	1756	3684	4673	4742	2587	3052	2555	2604	3427	3125	8802	2385	4688
Radiolaria	0	5	8	11	12	41	15	120	70	800	950	700	475	680	850	500	600
Total Planktonics (Foram. + Rad.)	4483	1709	2509	4057	1768	3725	4688	4862	2657	3852	3505	3304	3902	3805	9652	2885	5288

2,688	3,078	3,816	4,218	4,524	5,268	6,492	6,234	5,010	5,994	5,394	4,506	4,920	5,622	5,136	6,054	6,624	7,482	10,800	11,532
62	61	60	59	58	57	56	55	54	54A	54B	53	52	51	51A	49	47	46	45	44
75	38	76	60	45	41	47	70	50	37	85	43	42	53	57	42	27	29	64	50
11	3	16	12	10	6	6	3	14	4	2	7	12	4	3	5	15	21	16	3
5927	6757	4917	5780	8727	5862	9385	4870	5966	5649	5807	7811	6990	10918	7508	7842	9195	8890	4608	12801
775	200	1000	850	950	400	650	180	1000	250	140	600	1000	500	240	400	1600	2400	900	600
6702	6957	5917	6630	9677	6262	10035	5050	6966	5899	5947	8411	7990	11418	7748	8242	10795	11290	5508	13401

PLANKTONIC SPECIES, TRAVERSE III

Depth - feet	504	864	1170	1446	1758	2082	2412	2640	2910	3228	3528	3762
Station	5	6	7	8	9	10	11	12	13	14	15	16
% Planktonic Species												
Globigerina bulloides	X	1	X	X	X	X	X	X	3	4	3	2
Globigerina calida		X		X	X	X	X	X	1	X	X	X
Globigerina digitata			X	X	X	X	X	X	X	X	X	X
Globigerina falconensis	16	20	10	9	9	5	10	5	19	10	6	13
Globigerina quinqueloba	2	1	X	2	X	2	X	1	2	1	X	X
Globigerina rubescens	13	14	13	9	26	28	15	15	17	10	15	16
Globigerinella siphonifera	1	X	2	3	1	3	3	4	1	X	1	4
Globigerinita glutinata	9	5	6	7	18	8	9	9	11	15	16	7
Globigerinita uvula	8	X	X	X	X	X	X	X	2	1	X	X
Globigerinoides conglobatus	X	X	X	2	2	1	X	1	X	X	1	2
Globigerinoides ruber	19	42	29	12	14	12	23	20	10	14	19	15
Globigerinoides sacculifer		1	4	2	2	2	2	3	1	2	3	3
Globorotalia crassaformis (L)	1	1	X	X	1	X	X	X	X	X	X	X
Globorotalia menardii (L)	4	X	4	5	7	3	5	3	4	2	2	3
Globorotalia scitula			X	X	X	2	2	X	1	X	X	1
Globorotalia truncatulinoides (R)	3	5	6	14	7	9	10	12	7	9	12	11
Globorotalia tumida (L)						X	1	X	1	4	X	2
Neogloboquadrina dutertrei (R)	3	2	5	7	5	8	4	4	3	12	4	4
Orbulina universa	X	X	3	1	X	2	1	1	1	2	1	1
Pulleniatina obliquiloculata (R)	19	7	15	24	6	14	13	17	12	13	14	15
Sphaeroidinella dehiscens					X							X
Globorotalia menardii (% with crystalline crust) (L)	0	50	89	99	99	70	60	90	78	94	30	74
Planktonic Foraminifera	376	555	431	485	1078	907	1348	1166	848	774	1633	2269
Radiolaria	10	8	1	3	7	15	12	16	2	25	31	100
% Radiolarians in total Foram.-Radiolarian complex	X	1	X	X	X	1	1	1	X	2	2	4
Total Planktonic	386	563	432	488	1085	922	1360	1182	850	799	1664	2369

APPENDIX F
FORAMINIFERAL SPECIES FOUND IN THE DEEP-WATER-ECOLOGY STUDY

Adercotryma glomeratum
Alabamina decorata
Allomorphina trigona
Alveovalvulinella pozonesis
Ammobaculities agglutinans
Ammobaculities americanus
Ammobaculities filiformis
Ammobaculoides cylindroides
Ammodiscoides turbinatus
Ammodiscus planorbis
Ammodiscus tenuis
Ammoglobigerinoides dehiscens
Ammolagena clavata
Ammomarginulina foliacea
Ammonia beccarii
Ammosphaeroidina sphaeroidiniformis
Amphicoryna hispida
Amphicoryna sublineata
Angulogerina angulosa
Angulogerina bella
Anomalina corpulenta
Anomalina globulosa
Anomalina mexicana
Apiopterina angusta
Apiopterina extensa
Aschemonella ramuliformis
Aschemonella scabra
Astrononion tumidum
Astrononion sp.
Bathysiphon filiformis
Bolivina alata
Bolivina albatrossi
Bolivina barbata
Bolivina fragilis
Bolivina goesii
Bolivina lanceolata
Bolivina minima
Bolivina ordinaria
Bolivina pseudoplicata
Bolivina pusilla
Bolivina quadrata
Bolivina seminuda s. l.
Bolivina subaenariensis mexicana
Bolivina translucens
Bolivinita quadrilatera
Bucella hannai
Bulimina aculeata
Bulimina barbata
Bulimina marginata
Bulimina rostrata alazanensis
Bulimina spicata
Bulimina striata mexicana
Buliminella bassendorfensis
Buliminella exilis
Cancris auricula
Candeina nitida
Cassidulina curvata
Cassidulina neocarinata
Cassidulinoides bradyi
Cassidulinoides mexicanus
Cassidulinoides parkerianus
Cassidulinoides tenuis
Chilostomella oolina
Cibicides bantamensis
Cibicides bradyi
Cibicides deprimus
Cibicides floridanus
Cibicides kullenbergi
Cibicides lobatulus
Cibicides mollis
Cibicides pseudoungerianus
Cibicides robertsonianus
Cibicides rugosus
Cibicides umbonatus
Cibicides wuellerstorfi
Conorbina orbicularis
Coryphostoma abruptam
Coryphostoma mayori
Coryphostoma spinescens
Coryphostoma subspinescens
Coryphostoma zanzibarica
Cribroelphidium discoidale
Cribroelphidium galvestonense
Cribroelphidium poeyanum
Cribrostomoides canariensis
Cribrostomoides lobatus
Cribrostomoides ringens
Cribrostomoides scitulus
Cribrostomoides subglobosus
Cribrostomoides umbilicatus
Cribrostomoides wiesneri
Cyclammina cancellata
Cyclammina trullissata
Cystammina pauciloculata
Dentalina communis
Dentalina cuvieri
Dentalina inornata bradyensis
Dentalina intorta
Dentalina orthomorphina guttifera
Dorothia pseudoturris
Eggerella bradyi
Eggerella propinqua
Eggerella scabra
Ehrenbergina pupa
Ehrenbergina spinea
Ehrenbergina trigona
Epistominella exigua
Eponides polius
Eponides regularis
Eponides tumidulus
Eponides turgidus
Florilus atlanticus
Florilus clavatus
Florilus scaphus
Fissurina aradasii
Fissurina formosa
Fissurina orbignyana s. l.
Fissurina tenuissima
Frondicularia sagittula
Fursenkoina pontoni
Fursenkoina schreibersiana
Fursenkoina seminuda
Francesita advena
Gaudryina atlantica
Gaudryina flintii
Gaudryina minuta
Glandulina laevigata
Globigerina bulloides
Globigerina calida
Globigerina digitata
Globigerina falconensis
Globigerina quinqueloba
Globigerina rubescens
Globigerinella siphonifera
Globigerinita glutinata
Globigerinita uvula
Globigerinoides conglobatus
Globigerinoides ruber
Globigerinoides sacculifera
Globobulimina affinis
Globobulimina ovula
Globobulimina pyrula spinescens
Globocassidulina crassa
Globocassidulina moluccensis
Globocassidulina murrhyna
Globocassidulina pacifica s. l.
Globocassidulina subglobosa
Globorotalia crassaformis
Globorotalia hirsuta
Globorotalia inflata
Globorotalia menardii
Globorotalia menardii fimbriata
Globorotalia scitula
Globorotalia truncatulinoides
Globorotalia tumida
Globorotaloides hexagonus
Globotextularia anceps
Glomospira charoides
Glomospira gordialis
Gyroidina altiformis acuta
Gyroidina altiformis cushmani
Gyroidina orbicularis
Gyroidina soldanii
Gyroidina umbonata
Hanazawaia berthelott
Hanazawaia concentrica
Hanazawaia strattoni
Haplophragmoides bradyi
Haplophragmoides coronatus
Haplophragmoides sphaeriloculus
Hastigerina pelagica
Heronallenia gemmata
Hoeglundina elegans
Hormosina carpenteri
Hormosina distans delicatula
Hormosina globulifera
Hormosina ovicula

Hyperammina cylindrica
Hyperammina friabilis
Hyperammina laevigata
Islandiella norcrossi australis
Karreriella apicularis
Karreriella bradyi
Lagena laevis
Lagena sulcata s. l.
Lagenammina atlantica
Lagenammina difflugiformis
Laticarinina pauperata
Lenticulina calcar
Lenticulina gibba
Lenticulina orbicularis
Lenticulina peregrina
Liebusella soldanii
Lingulina seminuda
Lituotuba lituiformis
Marginulina hantkeni
Marginulina tenuis
Marginulinopsis marginulinoides
Marginulinopsis subaculeata glabrata
Marsipella elongata
Martinottiella communis
Martinottiella occidentalis
Melonis barleeanus
Melonis pompilioides
Miliolinella subrotunda
Neoeponides coryelli
Neogloboquadrina dutertrei
Neogloboquadrina pachyderma
Nodellum membranaceum
Nodosaria calomorpha
Nodosaria lamnulifera
Nonionella opima
Oolina longispina
Orbulina universa
Oridorsalis sidebottomi
Oridorsalis tener tener
Oridorsalis tener stellatus
Oridorsalis tener umbonatus
Orthomorphina guttifera
Osangularia cultur
Osangularia rugosa
Parafissurina lateralis
Parafissurina sp.
Pavonina atlantica
Planulina ariminensis
Planulina foveolata
Pleurostomella bolivinoides
Pseudoclaulina mexicana
Pseudonodosaria comatula
Pseudotrochammina mexicana
Pseudotrochammina triloba
Pullenia bulloides
Pullenia osloensis
Pullenia quinqueloba
Pullenia subsphaerica
Pullenia trinitatensis
Pulleniatina obliquiloculata
Pyrgo depressa
Pyrgo elongata
Pyrgo lucernula
Pyrgo murrhina s. l.
Pyrgo sarsii
Pyrgo serrata
Pyrgoella sphaera
Quinqueloculina bosciana
Quinqueloculina polygona
Quinqueloculina seminula
Quinqueloculina venusta
Quinqueloculina vulgaris
Quinqueloculina weaveri
Ramulina globulifera
Rectobolivina advena
Rectobolivina dimorpha
Recurvoides contortus s. l.
Reophax bacillaris
Reophax dentaliniformis
Reophax distans
Reophax distans delicatulus
Reophax guttifer
Reophax nodulosa
Reophax pilulifer
Reophax scorpiurus
Reticulophragmium venezuelanum
Reussella atlantica
Rhabdammina abyssorum
Rhabdammina linearis
Rhizammina algaeformis
Rhizammina sp.
Robertina oceanica
Robertinoides bradyi
Rosalina suezensis
Rotorbinella basilica
Rotorbinella translucens
Saccammina socialis
Saccorhiza ramosa
Saracenaria italica s. l.
Scutuloris sp.
Sigmoilopsis schlumbergeri
Sigmoilina sigmoides
Siphonina bradyana
Siphonina pulchra
Siphotextularia affinis
Siphotextularia curta
Siphotextularia rolshauseni
Siphotrochammia squamata
Sphaeroidina bulloides
Sphaeroidinella dehiscens
Spirillina vivipara
Spiroloculina antillarum
Spirosigmoilina distorta
Stainforthia complanata
Stomatorbina concentrica
Technitella legumen
Textularia candeiana
Textularia earlandi
Textularia foliacea occidentalis
Textularia mexicana
Textulariella barretti
Thurammina papillata
Tolypammina schaudinni
Tosaia weaveri
Trifarina bradyi
Triloculina tricarinata
Triloculina trigonula
Tritaxis conica
Tritaxis fusca
Trochammina advena
Trochammina conglobata
Trochammina globulosa
Trochammina japonica
Trochammina subglabra
Trochammina subturbinata
Trochammina tasmanica
Turborotalita humilis
Uvigerina ampullacea
Uvigerina auberiana
Uvigerina flintii
Uvigerina hispida
Uvigerina peregrina
Uvigerina peregrina dirupta
Uvigerina peregrina mediterranea
Uvigerina peregrina parvula
Uvigerina senticosa
Uvigerina spinicostata
Valvulineria complanta
Valvulineria laevigata
Valvulineria minuta
Valvulineria opima

PLATES

PLATE 1

1 *Cyclammina cancellata* Brady. Traverse 1, station 37, 1,962 feet.

2 *Karreriella apicularis* (Cushman). Traverse 2, station 69, 2,724 feet.

3, 4 *Pyrgo lucernula* (Schwager). Traverse 1, station 23, 6,174 station 19, 6,972 feet.

5 *Bolivina albatrossi* Cushman. Megaspheric form, traverse 1, station 34, 2,640 feet.

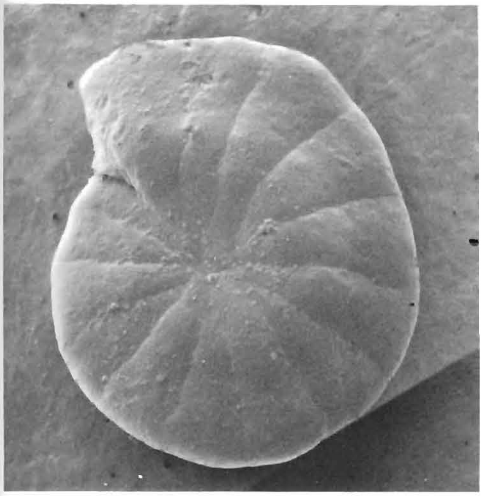
6 *Bolivina albatrossi* Cushman. Microspheric form, traverse 1, station 40, 1,230 feet.

7 *Bolivina pusilla* Schwager. Traverse 1, station 26, 5,130 feet.

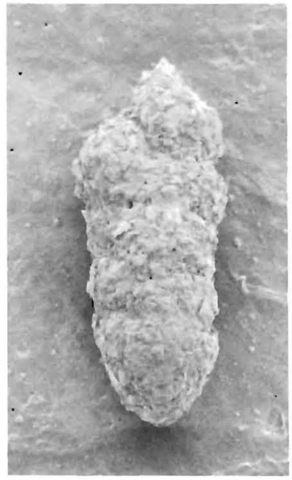
8 *Bulimina aculeata* d'Orbigny. Traverse 3, station 7, 1,224 feet.

9 *Bulimina rostrata alazanensis* Cushman. Traverse 2, station 72, 1,836 feet.

10 *Laticarinina pauperata* (Parker and Jones). Traverse 1, station 30, 4,092 feet.

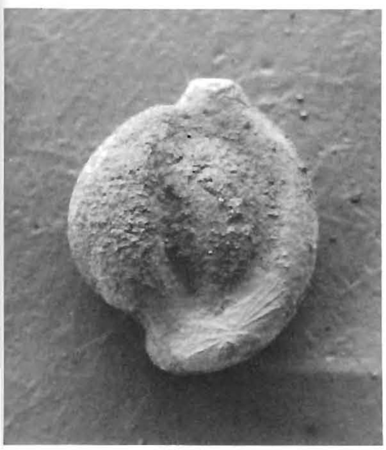


1 ×45 300μ



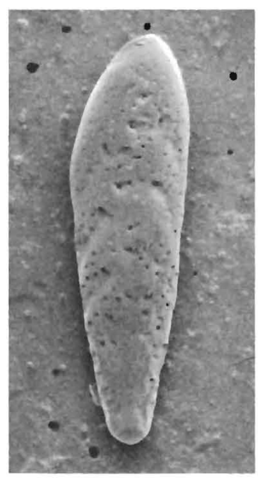
2 ×60 200μ

3 ×40 250μ



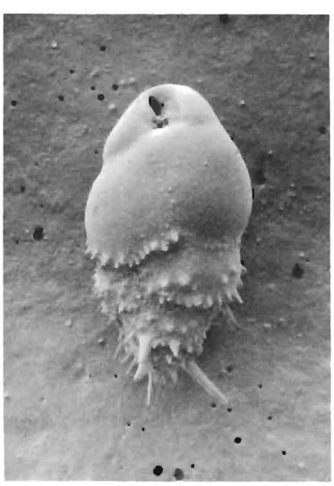
4 ×40 250μ

5 ×120 100μ

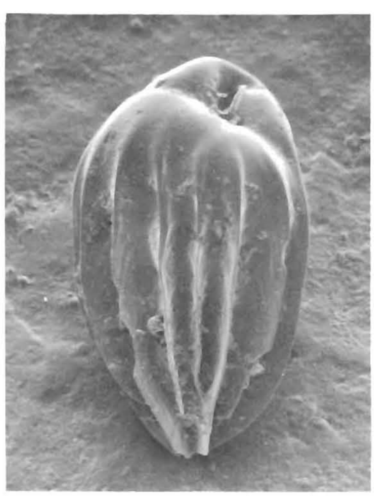


6 ×85 100μ

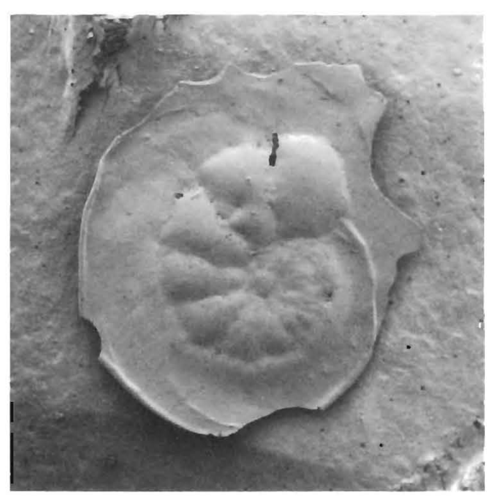
7 ×130 100μ



8 ×67 150μ



9 ×475 20μ



10 ×24 500μ

PLATE 2

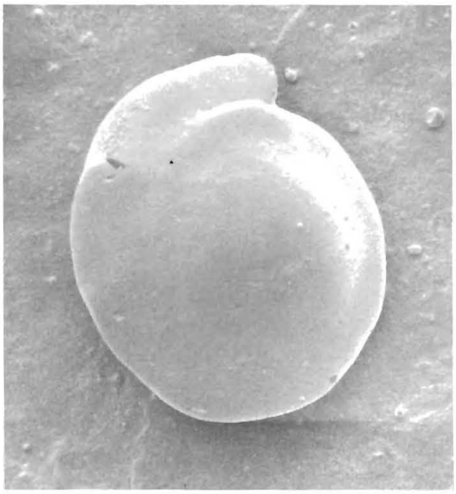
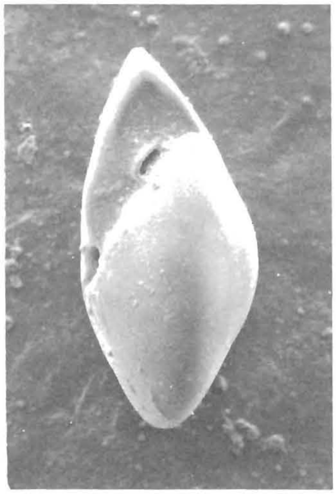
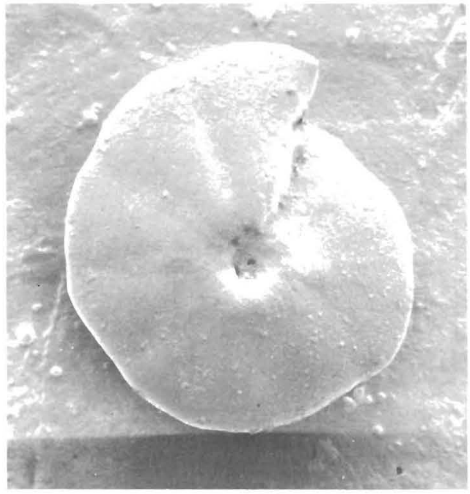
→

1, 2, 3 *Eponides regularis* Phleger and Parker. Traverse 1, station 43, 498 feet.

4, 5 *Eponides tumidulus* (Brady). Traverse 2, station 59, 4,218 feet.

6, 7, 8 *Cibicides kullenbergi* Parker. Traverse 2, station 70, 2,448 feet.

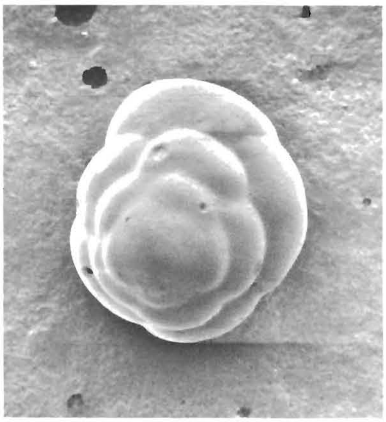
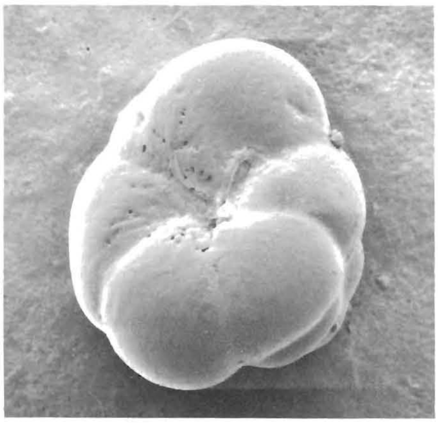
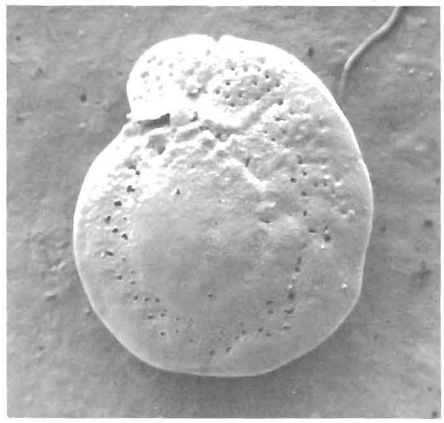
9 *Cibicides* cf. *pseudoungerianus* (Cushman). Traverse 1, station 40, 1,722 feet.

1 ×180 50μ

2 ×175 50μ

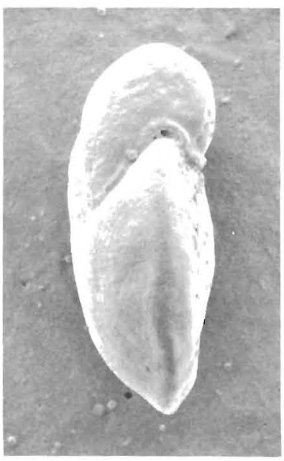
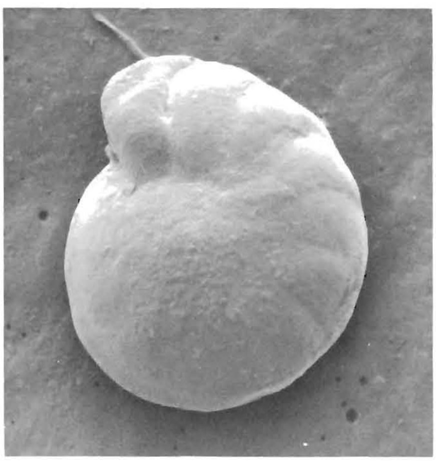
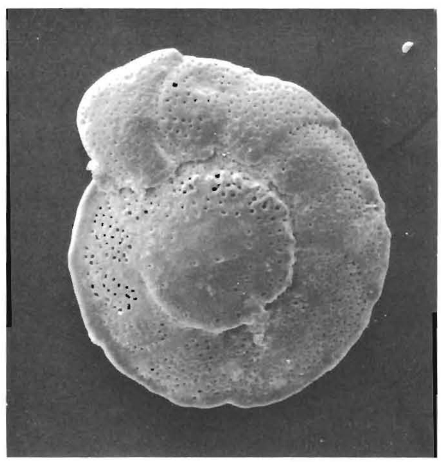
3 ×160 50μ

4 ×215 50μ

5 ×215 50μ

6 ×65 200μ

7 ×100 100μ

8 ×50 200μ

9 ×50 200μ

PLATE 3

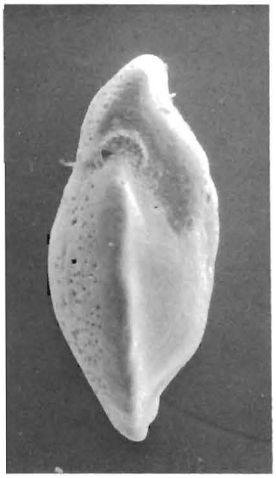
→

1, 2 *Cibicides* cf. *pseudoungerianus* (Cushman). Traverse 1, station 40, 1,722 feet.

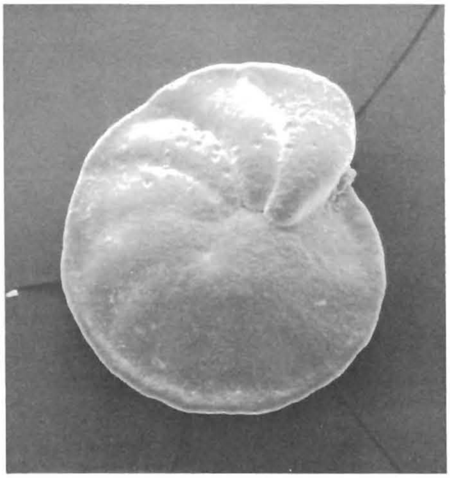
3, 4, 5 *Cibicides robertsonianus* (Brady). Traverse 2, station 66, 3,078 feet.

6, 7 *Cibicides bradyi* (Trauth). Traverse 2, station 66, 3,078 feet.

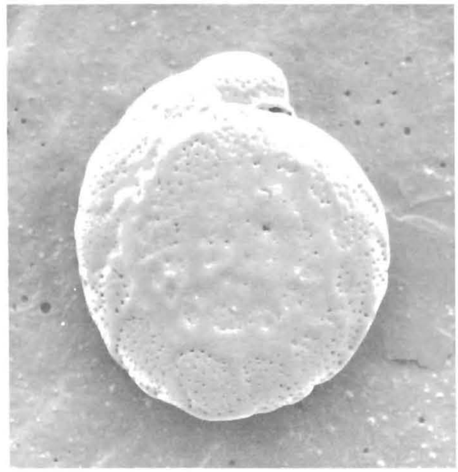
8, 9 *Cibicides rugosus* Phleger and Parker. Traverse 1, station 29, 4,338 feet.



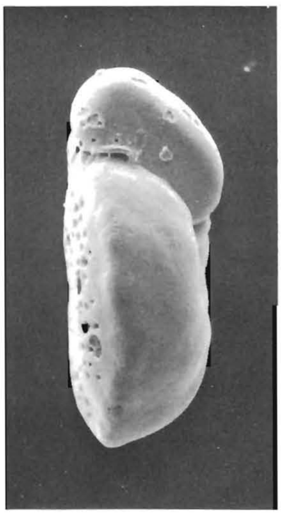
1 ×60 200μ



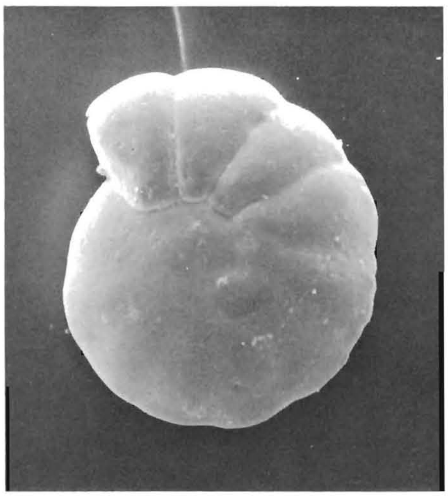
2 ×60 200μ



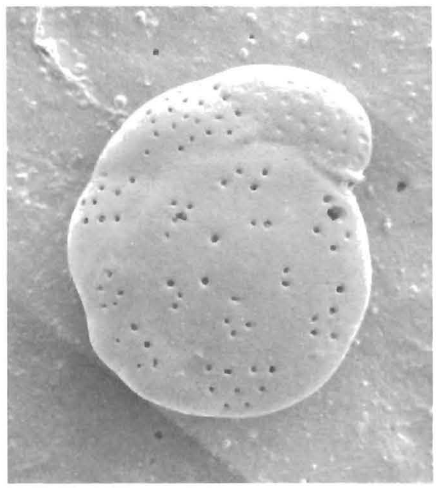
3 ×48 200μ



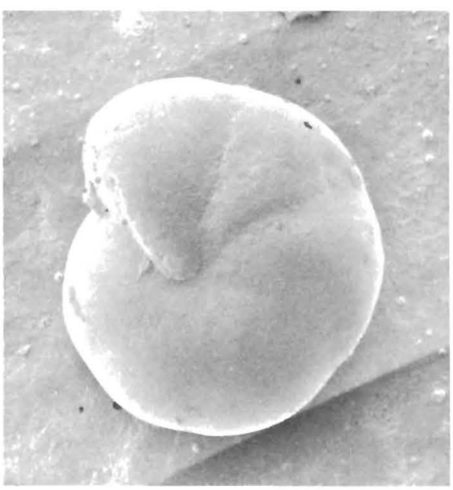
4 ×65 200μ



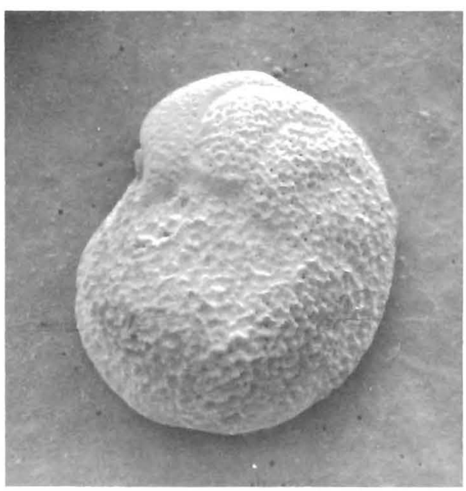
5 ×48 200μ



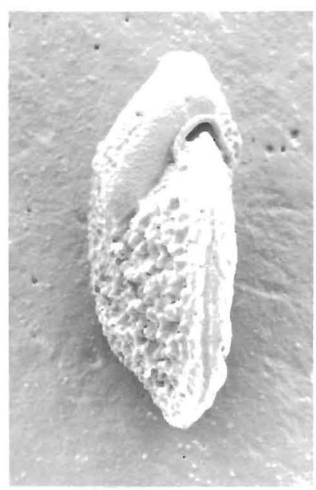
6 ×125 100μ



7 ×120 100μ



8 ×45 300 μ



9 ×35 300μ

→

PLATE 4

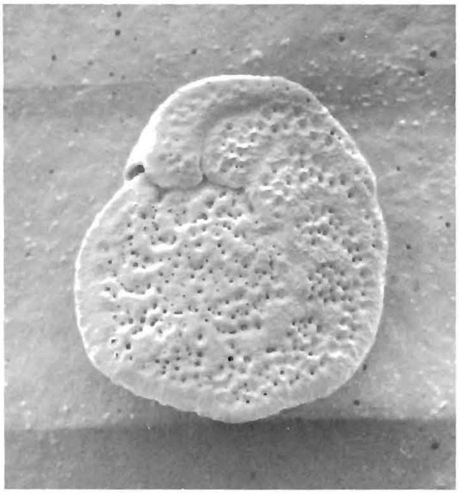
1 *Cibicides rugosus* Phleger and Parker. Traverse 1, station 29, 4,338 feet.

2, 3, 4 *Cibicides wuellerstorfi* (Schwager). Traverse 1, station 28, 4,584 feet.

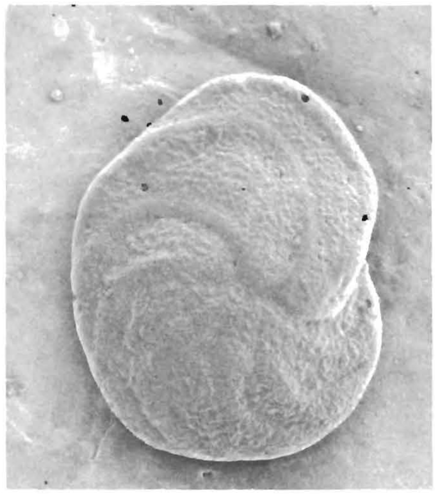
5 *Globocassidulina mollucensis* (Germeraad). Traverse 1, station 19 6,972 feet.

6, 7 *Francesita advena* (Cushman). Traverse 1, station 16, 8,010 feet.

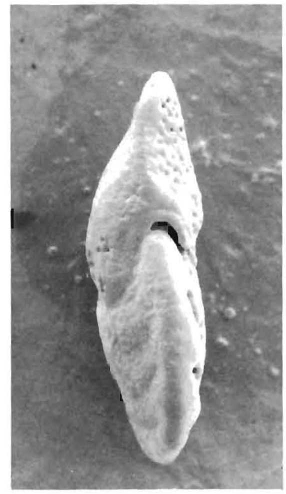
8, 9 *Gyroidina altiformis acuta* Boomgaart. Traverse 2, station 59, 4,218 feet.



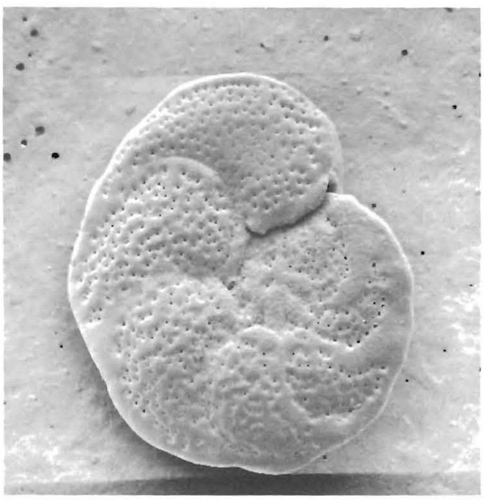
1 ×55 200μ



2 ×75 150μ

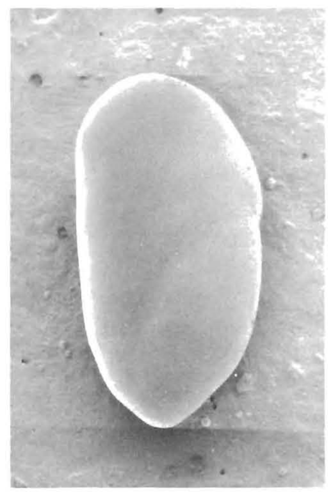


3 ×60 200μ

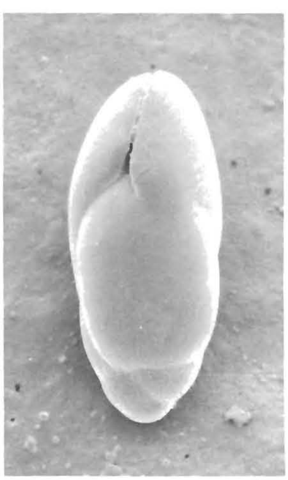


4 ×60 200μ

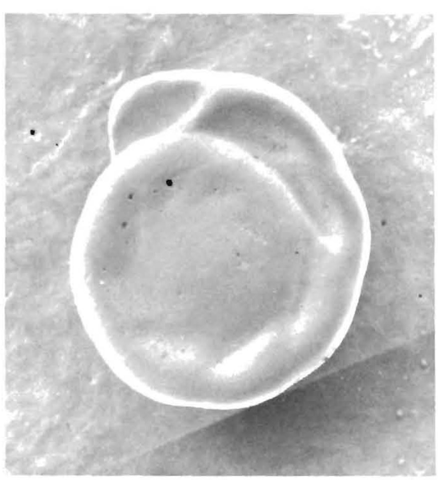
5 ×105 100μ



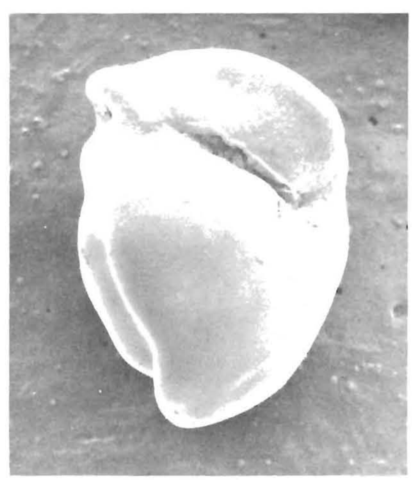
6 ×105 100μ



7 ×105 100μ



8 ×95 100μ



9 ×85 100μ

PLATE 5

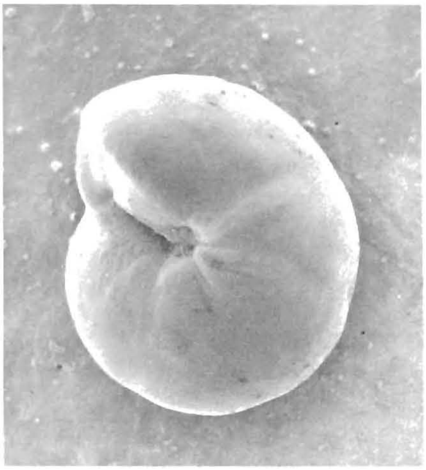
→

1 *Gyroidina altiformis acuta* Boomgaart. Traverse 2, station 59, 4,218 feet.

2, 3, 4 *Gyroidina altiformis cushmani* Boomgaart. Traverse 2, station 73, 1,146 feet.

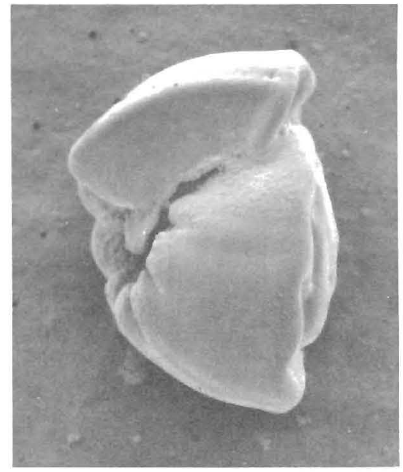
5, 6, 7 *Gyroidina orbicularis* d'Orbigny. Traverse 1, station 38, 1,722 feet.

8, 9 *Oridorsalis tener stellatus* (Silvestri). Traverse 1, station 43, 498 feet.

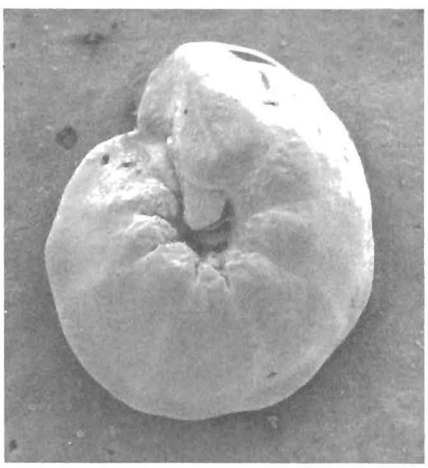


1 ×90 100μ

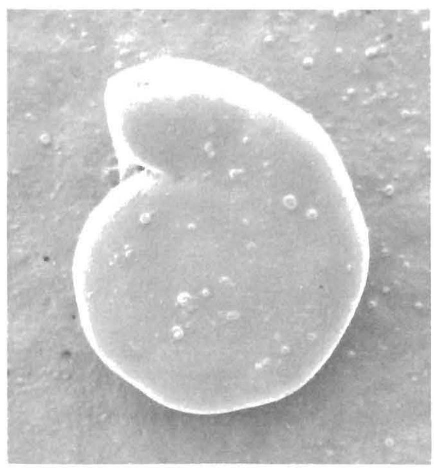
2 ×95 100μ



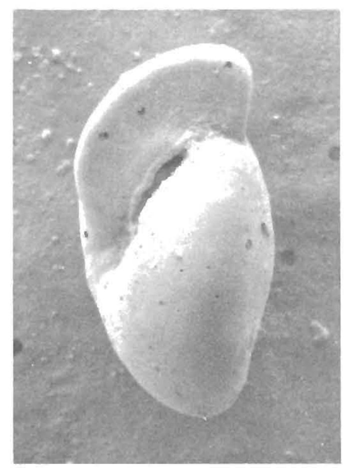
3 ×95 100μ



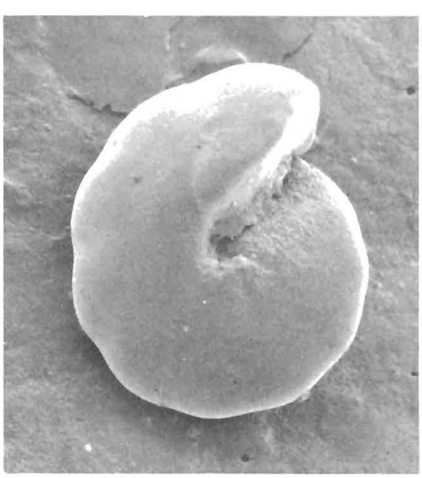
4 ×95 100μ



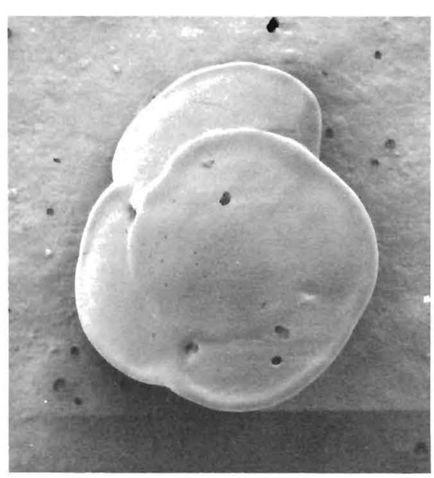
5 ×105 100μ



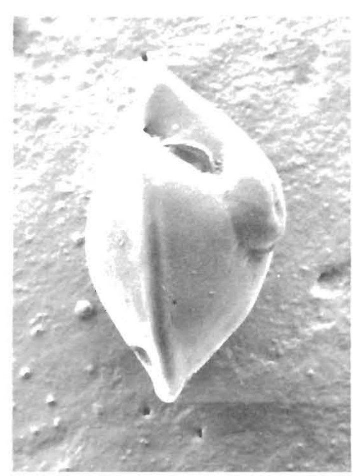
6 ×130 100μ



7 ×125 100μ



8 ×120 100μ



9 ×135 100μ

→

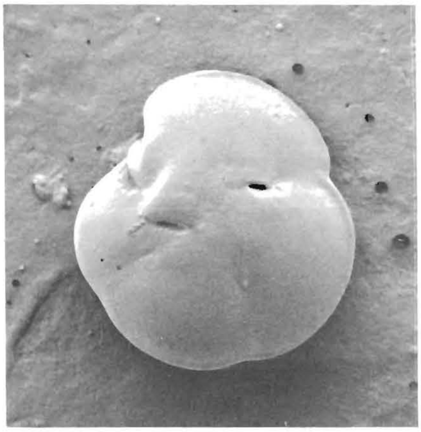
PLATE 6

1 *Oridorsalis tener stellatus* (Silvestri). Traverse 1, station 43, 498 feet.

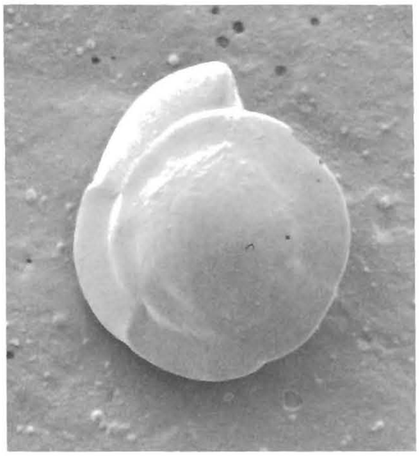
2, 3, 4 *Oridorsalis tener tener* (Bradyi). Traverse 3, station 9, 1,824 feet.

5, 6, 7 *Oridorsalis tener umbonatus* (Reuss). Traverse 1, station 26, 5,130 feet.

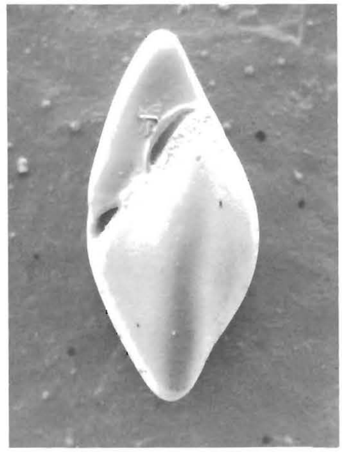
8, 9 *Alabamina decorata* (Phleger and Parker). Traverse 1, station 25, 5,436 feet.



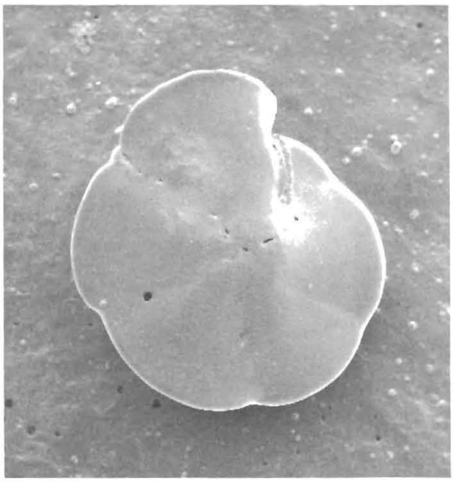
1 X125 100μ



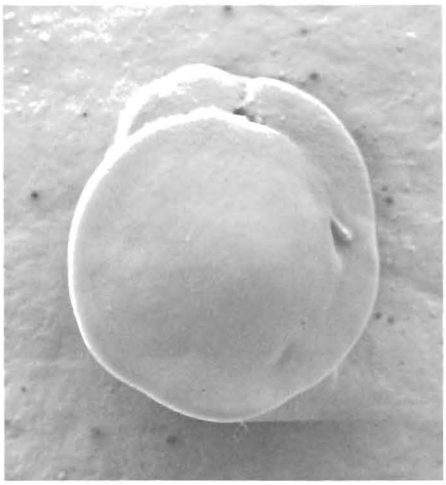
2 X130 100μ



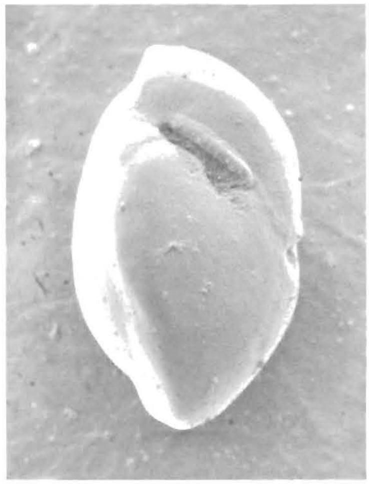
3 X110 100μ



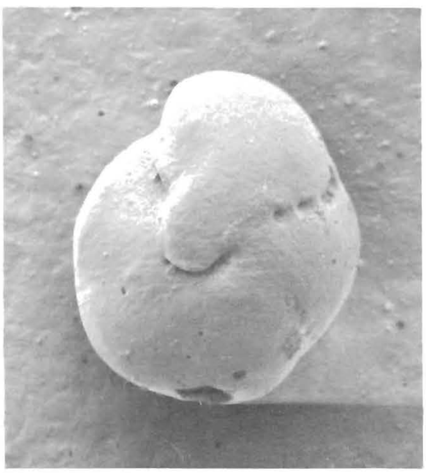
4 X90 100μ



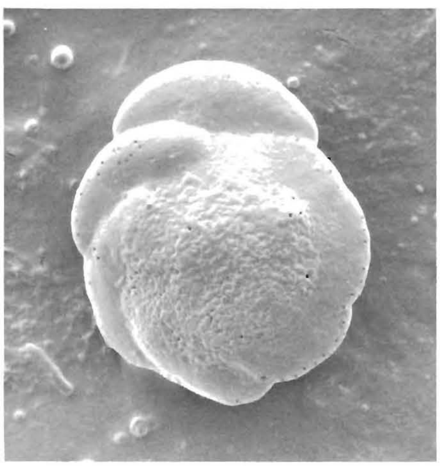
5 X63 200 μ



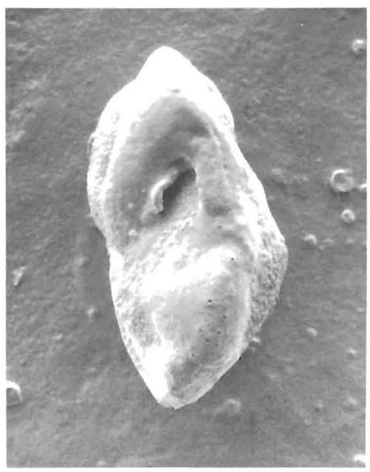
6 X63 200 μ



7 X63 200μ



8 X220 50μ



9 X230 50μ

→

PLATE 7

1 *Alabamina decorata* (Phleger and Parker). Traverse 1, station 25, 5,436 feet.

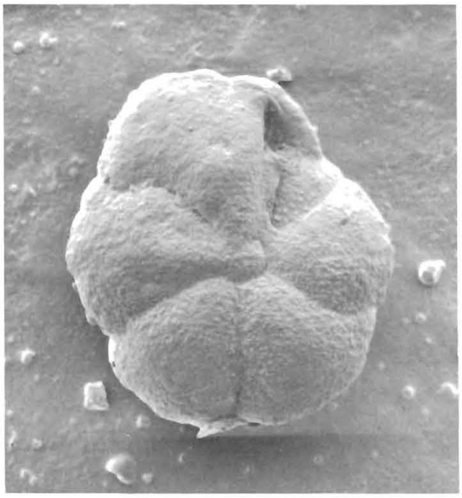
2, 3, 4 *Osangularia rugosa* (Phleger and Parker). Traverse 2, station 71, 2,118 feet. 3, aperture highlighted.

5 *Melonis barleeanus* (Williamson). Traverse 2, station 72, 1,836 feet.

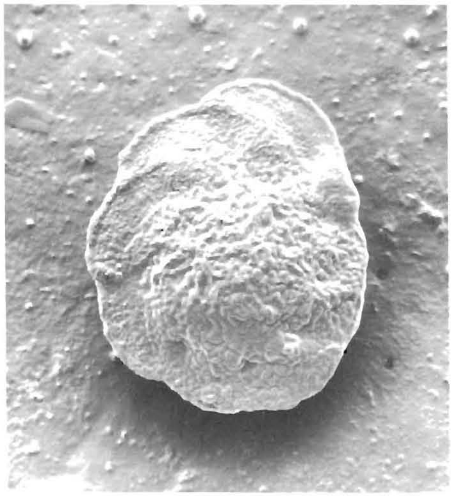
6 *Melonis barleeanus* (Williamson). Traverse 3, station 5, 534 feet.

7, 8 *Melonis pompilioides* (Fichtel and Moll). Traverse 1, station 19, 6,972 feet.

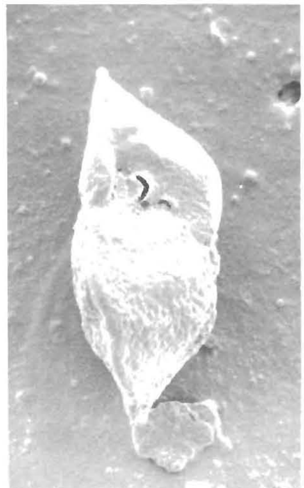
9 *Uvigerina flintii* Cushman. Traverse 1, station 42, 762 feet.



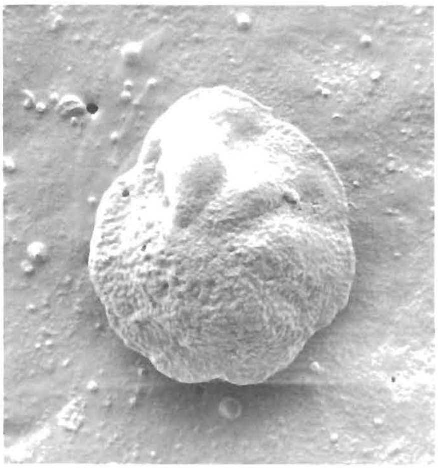
1 ×220 50μ



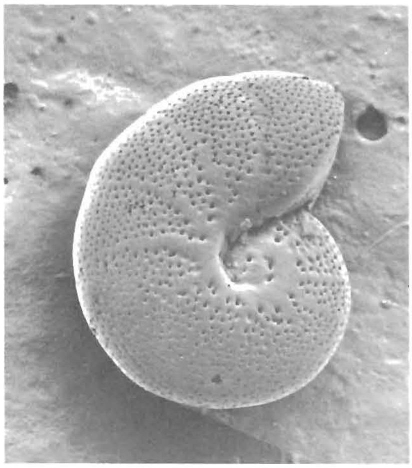
2 ×130 100μ



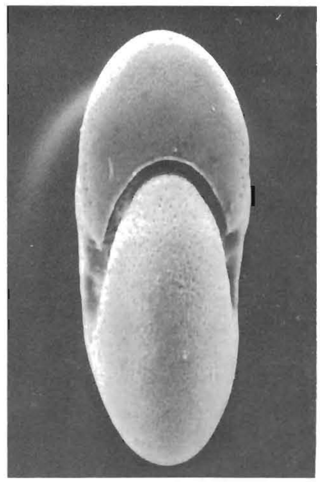
3 ×180 50μ



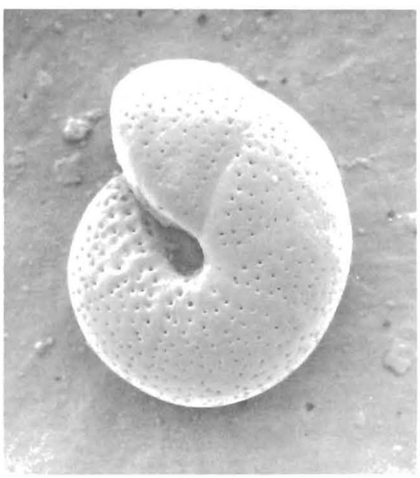
4 ×130 100μ



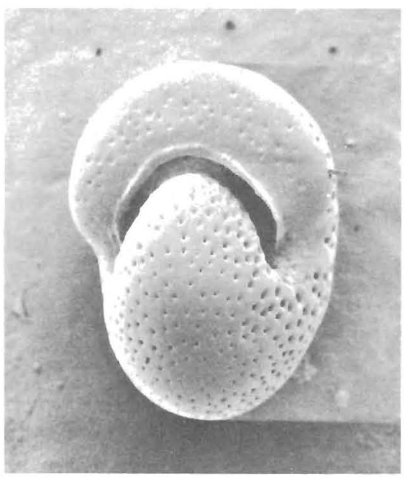
5 ×125 100μ



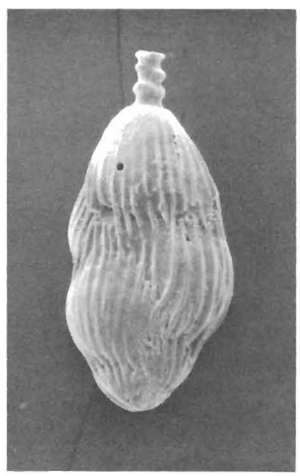
6 ×140 80μ



7 ×105 100μ



8 ×120 100μ



9 ×60 200μ

PLATE 8

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1 *Uvigerina peregrina mediterranea* Hofker. Traverse 1, station 41, 984 feet.

2, 3 *Uvigerina peregrina peregrina* Cushman. 2. Traverse 1, station 43, 498 feet. 3. Traverse 1, station 41, 984 feet. Spines located on apertural neck.

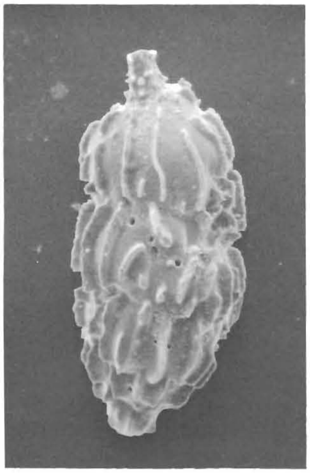
4, 5 *Uvigerina peregrina dirupta* Todd. 4. Traverse 1, station 40, 1,230 feet. 5. Traverse 1, station 35, 2,358 feet. Costae on last two chambers broken into spines.

6, 7 *Uvigerina spinicostata* Cushman and Jarvis. 6. Traverse 1, station 33, 2,964 feet. 7. Traverse 1, station 25, 5,436 feet. All costae broken into spines but are still aligned.

8, 9, 10 *Uvigerina hispida* Schwager. 8. Traverse 1, station 23A, 5,880 feet. 9. Traverse 1, station 21, 6,726 feet. 10. Traverse 1, station 17, 7,650 feet. Costae broken into random spines over whole test.

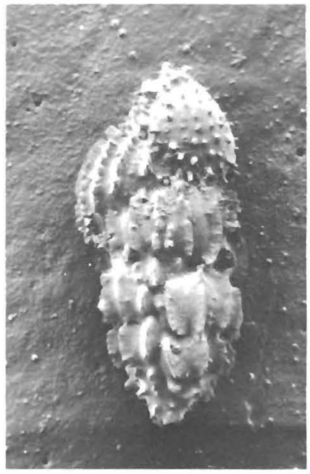
11, 12 *Uvigerina senticosa* Cushman. 11. Traverse 1, station 20, 6,864 feet. 12. Traverse 1, station 11, 9,501 feet.

1 ×70 145μ

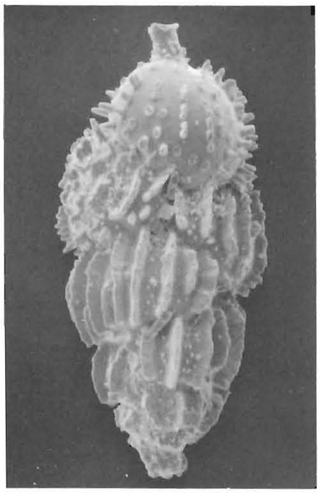


2 ×80 125μ

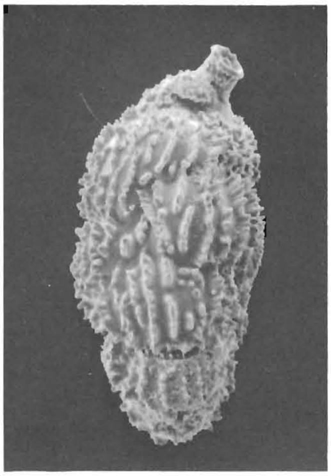
3 ×100 100μ



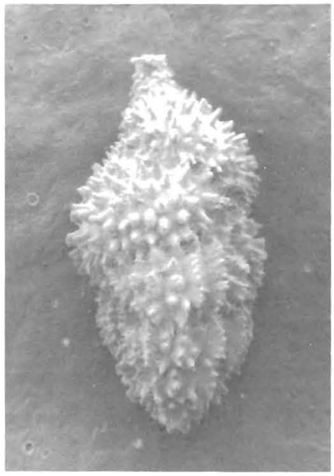
4 ×64 200μ



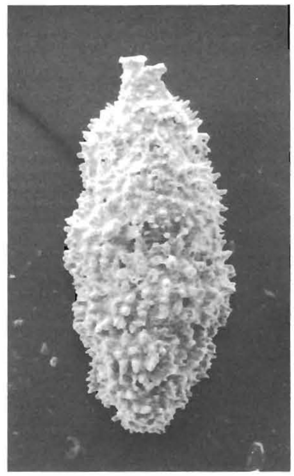
5 ×60 200μ



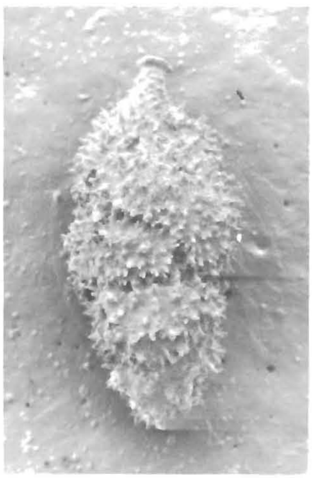
6 ×60 200μ



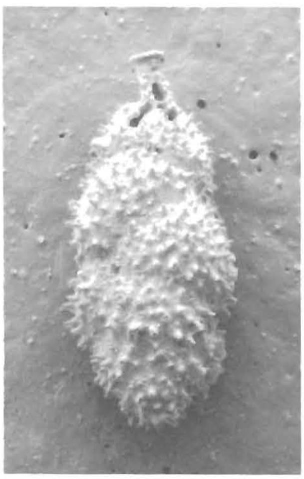
7 ×58 200μ



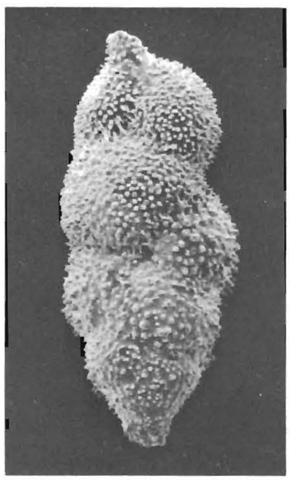
8 ×55 200μ



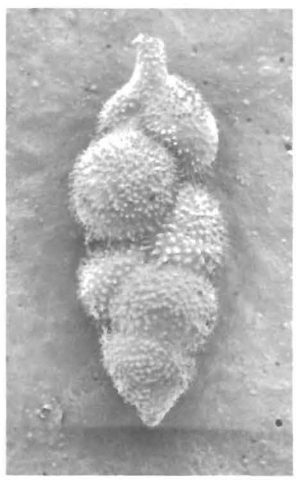
9 ×65 200μ



10 ×60 200μ



11 ×50 200μ



12 ×45 300μ