

6. SITE 215

The Shipboard Scientific Party¹

ABSTRACT

Site 215 was drilled west of Ninetyeast Ridge in 5309 meters of water. The stratigraphic column in the area is 155.5 meters in thickness and is divided into four units, an upper radiolarian diatom ooze of Quaternary to upper Miocene age, two thin terrigenous silty clay layers of upper Miocene age, a 7-meter-thick brown clay which corresponds with a 40-m.y. time interval, and a calcareous nannofossil ooze ranging from lower Eocene to mid-Paleocene in age which includes an iron-oxide-rich zone at the base. These are underlain by a fresh pillow basalt with intercalated baked calcareous ooze. Lithology and biostratigraphy of Site 215 closely resemble Site 213 which is on the opposite side of Ninetyeast Ridge and suggest synchronous subsidence of both sites since the mid-Paleocene.

SITE DATA

Date Occupied: 13 Feb 72 (0334)
Date Departed: 15 Feb 72 (2018)
Time on Site: 64 hours 44 minutes
Position:
lat 8°07.30'S
long 86°47.50'E
Water Depth (to rig floor):
5321 meters (Echo sounding)
5319 meters (Drill pipe)
Penetration: 175 meters
Number of Holes: 1
Number of Cores: 20
Total Length of Cored Section: 175 meters
Total Core Recovered: 113.3 meters
Acoustic Basement:
Depth: 155.5 meters
Nature: Basalt
Age of Oldest Sediment: Mid-Paleocene
Basement: Basalt

BACKGROUND AND OBJECTIVES

To complete the trio of sites on and either side of the Ninetyeast Ridge, Site 215 was placed in the central Indian Basin at 8°12'S, 86°50'E. The original site was picked further to the south. However, because of the thin sediment cover and the unclear nature of the magnetic anomalies, the site was moved further north. Another factor involved in the move north was the hope that some of the distal sediments from the Bengal Fan could be sampled.

The site was selected on the basis of Scripps Institution of Oceanography CIRCE V airgun profile run from the R/V *Argo*. The region chosen was to the east of an area of prominent east-west magnetic lineations identified by McKenzie and Sclater (1971) as anomalies 28 through 33. By extrapolating these anomalies eastward, it was anticipated that the site was close to anomaly 29 and would yield a basement age of 68 to 70 m.y. Due to the poor character of the magnetic anomalies in the area selected, we considered moving the site to the well-identified anomalies further east. However, as this involved extra steaming, we decided not to change the site.

The surface sediments in this slightly elevated area to the south of the fan are predominantly siliceous, though in more elevated regions isolated calcareous Eocene sediments have been recovered. With this rather scattered preliminary evidence, it was anticipated that Site 215 would be stratigraphically very similar to Site 213 and yield a basement age of some 7 to 12 m.y. older.

The actual site was selected at a depth of 5300 meters in ponded sediments at the southernmost extremity of the Bengal Fan (Figure 1). The CIRCE V airgun profile showed three horizons, an uppermost transparent layer over an acoustically opaque layer with many internal reflectors on top of another transparent layer which appeared to drape over what was thought to be basement. The incoming and outgoing airgun records show these layers very clearly. The sediment thickness of the top two units was close to 0.15

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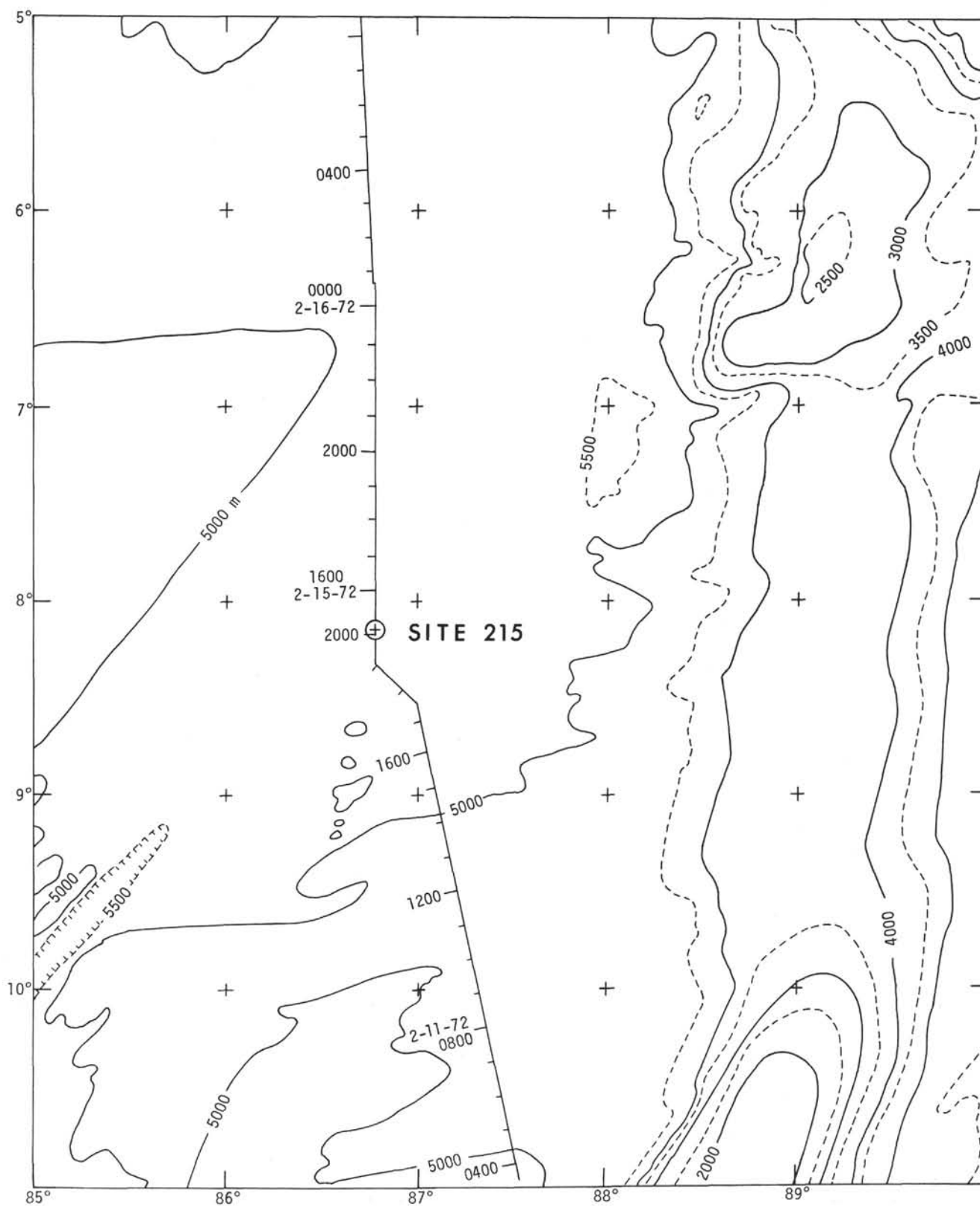


Figure 1. Bathymetry in vicinity of Site 215.

to 0.20 sec with 0.05 sec of draped sediment overlying acoustic basement.

The objectives of this site were (a) to obtain a continuous core for stratigraphic and biostratigraphic purposes, (b) to sample some of the distal fan sediments, and (c) to date the age of the basement for comparison with the magnetically determined age.

OPERATIONS

The approach to Site 215 was made in an approximately northward direction along the seismic reflection line run by R/V *Argo* (CIRCE Expedition, Leg V). The site was chosen in what appears as a basin of ponded and draped sediments just beyond the distal end of the Bengal Abyssal Fan.

After the final choice of site was made, *Glomar Challenger* reversed course and steamed back to the chosen area at 5 knots. A lighted spar buoy was dropped and the seismic gear secured, after which the vessel returned to the buoy. The beacon was dropped in 5309 meters of water.

A Smith 93 CJS, 4-cone chizzel-point bit was used and no drilling difficulties were encountered. Sediments drilled comprise 155.5 meters of soft siliceous ooze, brown clay, calcareous ooze, and chalk overlying basalt. The basalt was drilled for 19.5 meters. A total of 175 meters of coring was carried out resulting in 133.3 meters of sediment and rock, a recovery of 64.7% (see Table 1).

LITHOLOGIC SUMMARY

Introduction

Quaternary to mid-Paleocene sediment (151 meters) was continuously cored from the sea floor down to acoustic basement where a penetration of 24 meters into basaltic pillow lava was accomplished (Figure 2).

The following lithologic units can be recognized:

Unit	Depth Below Sea Floor (m)	Lithology	Age	Cores
1	0 to 64.5	Rad, diatom ooze, clay-rich in places	Quaternary to late Miocene	1-7
2	47.5 to 48.0 and 72.0 to 74.0	Silty clay and clayey silt	Late Miocene	6, 8
3	65.0 to 82.0	Clay—zeolitic in part	Late Miocene to early Eocene	8, 9
4	82.0 to 151.0	Nanno ooze	Paleocene	9-17
4b	149.0 to 151.0	Iron-oxide-rich nanno ooze		16,17
5	151.0 to 175+	Basalt	Mid-Paleocene	17-20

TABLE 1
Coring Summary, Site 215

Core	Date (Feb)	Time	Depth from Drill Floor (m)	Depth Below Sea Floor (m)	Cored (m)	Recovered (m)	Recovery (%)
1	13	1445	5319.0-5328.5	0-9.5	9.5	8.5	89
2	13	1618	5328.5-5336.0	9.5-17.0	7.5	1.5	20
3	13	1737	5336.0-5345.5	17.0-26.5	9.5	9.5	100
4	13	1900	5345.5-5355.0	26.5-36.0	9.5	9.5	100
5	13	2020	5355.0-5364.5	36.0-45.5	9.5	5.0	52
6	13	2142	5364.5-5374.0	45.5-55.0	9.5	3.3	35
7	13	2300	5374.0-5383.5	55.0-64.5	9.5	2.0	21
8	14	0035	5383.5-5393.0	64.5-74.0	9.5	8.2	87
9	14	0235	5393.0-5402.5	74.0-83.5	9.5	4.2	44
10	14	0430	5402.5-5412.0	83.5-93.0	9.5	3.6	40
11	14	0620	5412.0-5421.5	93.0-102.5	9.5	9.0	95
12	14	0755	5421.5-5431.0	102.5-112.0	9.5	9.0	95
13	14	0935	5431.0-5440.5	112.0-121.5	9.5	4.8	52
14	14	1115	5440.5-5450.0	121.5-131.0	9.5	9.0	95
15	15	1305	5450.0-5459.5	131.0-140.5	9.5	6.4	67
16	14	1425	5459.5-5469.0	140.5-150.0	9.5	6.8	74
17	14	1600	5469.0-5474.5	150.0-155.5	5.5	0.8	14
18	14	2006	5474.5-5481.0	155.5-162.0	6.5	4.5	69
19	14	2255	5481.0-5484.5	162.0-165.5	3.5	2.5	71
20	15	0255	5484.5-5494.0	165.5-175.0	9.5	5.2	55
Total					175.0	113.3	64.7

Note: Sounding depth (to drill floor) = 5321 meters; drill pipe length to bottom = 5319 meters.

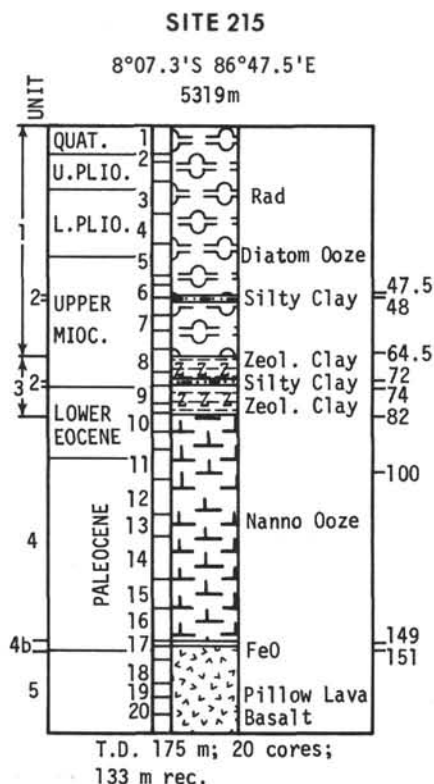


Figure 2. Lithologic units at Site 215.

Unit 1—Radiolarian Diatom Ooze (Cores 1-7)

This unit is predominantly light yellowish brown radiolarian-diatom ooze with varying amounts of clay and sponge spicules. The only trend seen in this unit is an increase in clay content with depth to reach 30% to 40% near the base, with a corresponding decrease in siliceous fossils. Abundant black streaking and mottling is due to drilling deformation of manganese-rich layers. Silicoflagellates and iron-oxide granules are always present in small amounts (<2%). In Core 4 at a depth of 34 meters small amounts (3%) of volcanic glass, mostly rhyolitic with some basalts, were seen through a 30-cm interval.

Unit 2—Silty Clay to Clayey Silt (Cores 6-8)

This unit forms two distinct beds of grayish brown to gray sediment in Cores 6 and 8. The beds are estimated as 60-cm thick in Core 6 and 200-cm thick in Core 8. The base of the beds is clearly defined as a sharp contact of gray silty clay resting on light yellowish brown material from Unit 1. The upper parts of the beds appear finer grained with a predominance of clay-size material and show a gradational color change of grayish brown upwards into Unit 1 sediment. The composition of the silt sized fraction as deduced from smear slides is predominantly (65%) feldspar (Refractive Index <1.55 i.e., sodic) with moderate (25%) clay aggregates. The minor constituents include pale green basic volcanic glass, hornblende, tourmaline, zircon, epidote, calcite, and garnet.

Unit 3—Clay (Cores 8, 9)

This unit comprises light brown spicule radiolarian bearing clay in Core 8 and dark brown zeolite-rich clay in Core 9. The nonclay fraction (<20%) is biogenous (Radiolaria and sponge spicules) in Core 8 and iron-oxide-manganese(?) and phillipsite in Core 9.

Unit 4—Nannofossil Ooze (Cores 9-17)

This unit is pale brown to yellowish brown nannofossil ooze with a clay content ranging from 5% to 20%. Foraminifera are rare, and dolomite and authigenic carbonate only occur in trace amounts. In Cores 13 (114 meters) and 14 (122 meters) yellowish brown porcellaneous chert nodules up to 5 cm across were recovered. The chert is slightly calcareous and foraminiferal ghosts are visible in thin section. On polished surfaces burrow structures and chemical haloes (?) are visible.

Subunit 4b is identified on the basis of an abundance (~12%) of iron-oxide micronodules in the 1 meter of sediment above the basalt. The sediment here is a dark brown color and above this is transitional into a brown color for 1 meter and then up into the typical light yellowish brown of Unit 4. The sediment in the subunit contains about 30% clay, but only a trace of authigenic carbonate.

The basal contact zone with basalt was cored and consists from top to bottom of about 1 to 2 cm of dark grayish brown nannofossil chalk, a 1-mm-thick layer of pure white chalk, a 1 to 2-mm thick yellow palagonite layer, a dark brown fresh glass layer about 3 mm thick, and finally fresh black volcanic glass in a 4 to 10-mm skin resting on the basalt of Unit 5. Neither of the chalks show recrystallization of the nannofossils.

Unit 5—Basalt (Cores 17-20)

Unit 5 consists of a succession of about 14 basalt pillows. The total amount of rocks recovered is 13.3 meters. These basaltic rocks have undergone various degrees of seawater weathering effects. The pillowed structure of the basaltic rocks is characterized by the occurrence of (1) glassy margins, (2) a less glassy variolitic transitional zone, and (3) an innermost crystalline zone.

1) The glassy margin consists of basaltic glass criss-crossed with veins of palagonite. Sometimes indurated carbonate material (limestone <5 cm thick) occurs at contact or intermixed with the basaltic glass. The limestone contains mostly nannofossils, calcite, and traces of brown glass.

2) The less glassy variolitic margin is the transitional zone between the glassy margin and the innermost crystalline zone. This transitional zone is made up of sheaf-like microlites and radiating plagioclase laths and an abundantly weathered matrix consisting of a reddish brown dark mesostasis comprising iron-ore-rich brown glass and palagonite.

3) The crystalline rock is always found in the innermost zone of the pillow lava; it is either partially weathered or moderately fresh. These rocks are usually holocrystalline or hypocrySTALLINE, and their general texture varies between subophitic and pilotaxitic, respectively.

CHEMICAL PROPERTIES

Nine pairs of contiguous 10-cm minicores and one "piece of sediment" were obtained from the first 17 cores recovered at this site. Slope determinations were made on all nine minicore samples, and one sample (215-1-5) was used for temperature cycling experiments.

Data on slopes and the pH values obtained with the punch-in (sediments) and flow-through (pore waters) electrodes are given below:

Sample	pH (punch-in)	pH (flow-through)	Temperature
215-1-5	7.21	7.30	25.0
215-3-5	7.16	7.13	26.0
215-5-2	7.18	7.29	25.9
215-8-3	7.17	7.46	26.0
215-9-2	7.34	7.26	26.0
215-10-2	7.40	7.23	26.2
215-11-5	7.24	7.01	26.1
215-13-3	7.36	7.19	26.2
215-15-4	7.40	7.32	26.2
215-17-1	—	7.12	26.0

BIOSTRATIGRAPHIC SUMMARY

General

Datable fossil assemblages were recovered throughout the sedimentary section cored at Site 215. Cores 1 through 8 yielded siliceous microfossils including radiolarians of Neogene age, and which indicate a more or less complete section from the late Miocene through the Quaternary. Calcareous fossils are lacking in the above cores, although some agglutinated benthonic foraminifera were recovered in Cores 1 to 7. Core 9 is barren of fossils except at its base where it penetrated the top of a calcareous interval. The calcareous section continues to the top of Core 17 and ranges in age from the early Eocene at the base of Core 9 to the mid-Paleocene in Core 17. This section contains both planktonic foraminifera and nannofossils, though somewhat sparse near the base, in a more or less normal succession.

The unfossiliferous portion of Core 9 separates two intervals which differ in age by 40 m.y. As Core 9 consists of less than 5 meters of sediment, a considerable hiatus must be inferred even if a very low rate of brown clay accumulation is assumed.

Foraminifera

Cores 1 to 7 contain sporadic occurrences of deep-water agglutinated benthonics. One planktonic in Core 4 indicates an age of Pliocene (Zone N.19) or younger.

A lower Tertiary planktonic foraminiferal section was encountered fading out fast in Core 9. Cores 10 and 11 contain rich and well-preserved assemblages identified throughout (10-1 to 11, CC) as Zone P.6b (lowest lower Eocene). It would seem from the poor material of Core 9 that the record ends within Zone P.7.

Core 12, Section 1 differs markedly from Cores 11 and 10 in having a quite diverse benthonic assemblage (see below) but poor planktonics. These are sufficient to indicate a late Paleocene age (Zones P.5 to P.6a). A top to *Planorotalites pseudomenardii* in Core 13, Section 1 marks the top of Zone P.4, and the rest of the assemblage supports this identification. Zone P.4 continues down to the top of the basalt in Core 17, Section 1. The most important change in the interval from Core 13 to Core 17, Section 1 occurs within Core 16, where a relatively good assemblage (in terms of specimen numbers and lack of corrosion) dominated by abundant *Subbotina* spp. appears somewhat suddenly in the core catcher and continues into Core 17, Section 1. This matches well the downward increase in iron-rich clay.

The pelagic limestone in Core 17, CC contains a poor assemblage, but indicates clearly the mid-Paleocene (Zone P.3) age.

From Core 9 to Core 17, Section 1 there are marked variations in content and preservation. These variations range from (1) abundant, well-preserved planktonics, few and small benthonics, little clay or fish remain to (2) few or very few and corroded to fragmented planktonics, robust, often strongly calcified (in growth), and common benthonics variable in preservation, substantial clay, and fish remains. The former is exemplified by Cores 10 and 11, the latter by Cores 9, CC and Core 15; Core 16, CC and Core 17, Section 1 contain both benthonics and good planktonics. The explanation for the inverse relationship between the calcareous planktonics and benthonics appears to lie in the composition and age indications of the latter: species of *Nuttallinella*, *Gyroidinoides*, *Anomalinoides*, *Cibicides*, *Oridorsalis*, *Marssonella*, etc. are of Senonian-Maastrichtian aspect rather than Paleocene and are known from carbonate shelf facies. Other benthonics (e.g., *Nuttallides*) are lower Tertiary. Since no Cretaceous planktonics have been found and the Paleocene biostratigraphic record in Core 12 to Section 17-1, though it could be better, shows no evidence of mixing or inversion, it might be concluded that some part of this section (also Core 9) is material stripped from a high on which normal marine benthonics flourished, but planktonics did not accumulate (in the Upper Cretaceous at any rate they may well have in the Paleocene). If the estimated 2-m.y. interval of Zone P.4 extends from Core 13, Section 4 to Core 17, Section 1 (a minimum), then the accumulation rate is of the order of 20 m/m.y.—rather high, particularly in a calcareous section showing so much corrosion and fragmentation of foraminiferal tests. A tentative figure of 12 m/m.y. for Cores 9, CC to 11, CC puts the lower Eocene clayey material in the same class, since Cores 10 and 11 contain relatively little clay. It would seem that these figures support the foraminiferal evidence for redeposition, and it could be inferred that some nearby part of the Ninetyeast Ridge was topographically very shallow during the Late Cretaceous. Finally, the great dominance of subbotinids over acariniids and globorotalids in Core 16, CC and Core 17, Section 1 may indicate an "extratropical" environment at about 58 m.y. In any case, the gross composition contrasts sharply with that in Cores 10 and 11 (lower Eocene).

Nannofossils

Calcareous nannofossils were recovered at Site 215 from near the base of Core 9 through Core 17. The preservation is variable, but datable assemblages are present throughout the interval. The bottom of Core 9 is assignable to the *Tribachiatulus orthostylus* Zone of early Eocene age. Core 10 and Sections 1 and 2 of Core 11 also are of early Eocene age, probably assignable to the *Discoaster diastypus* Zone. From Section 3, Core 11 through the top of Section 2, Core 13, the late Paleocene *Discoaster multiradiatus* Zone is represented. Additional Paleocene zones are present as follows: Core 10, Section 2 to Core 14, Section 4—*Discoaster mohleri* Zone; Core 14, Section 4 to Core 17, Section 1, ~90 cm—*Heliolithus kleinpellii* Zone; basal part of Core 17—*Fasciculithus tympaniformis* Zone.

The nannofossil assemblages in the calcareous interval from Cores 9 through 17 are for the most part of normal diversity with fair to good preservation except at the top and bottom of the calcareous interval where solution effects are strongly manifested. Only the most solution-resistant species remain at the top where the calcareous section grades into the barren deep-sea clays above. Similarly poor preservation and low diversity characterize the calcareous nannofossil assemblage immediately above basement.

Radiolaria

At Site 215 Radiolaria are common and well-preserved in Cores 1 through 7. In Core 8 Radiolaria are few to rare and moderately to poorly preserved. No identifiable Radiolaria were encountered between the bottom of Core 8 and the base of the sediment at the basalt contact, although trace amounts of siliceous debris were observed in a few samples.

The Radiolaria in Cores 1 through 8 range in age from Quaternary through upper Miocene. The following zonal boundaries can be recognized: The base of the Quaternary lies within Core 1, between Samples 215-1-4, 130-132 cm and 215-1-5, 70-72 cm. The base of the *Pterocanium prismatium* Zone is between Samples 215-2-1, 53-55 cm and 215-2, CC. The base of the *Spongaster pentas* Zone is between Sample 215-5-3, 70-72 cm and 215-5, CC. The base of the *Stichocorys peregrina* Zone lies between Samples 215-7, CC and 215-8-1, 90-92 cm. The *Ommatartus penultimus* Zone appears to be missing at this site, since the base of this zone occurs at approximately the same level as the base of the *Stichocorys peregrina* Zone. The base of the *Ommatartus antepenultimus* Zone occurs in the interval below Core 8 in which radiolaria are absent or unidentifiable. The earliest identifiable radiolarian assemblage at Site 215 is at Sample 215-8-5, 78-80 cm and appears to be in the upper *Ommatartus antepenultimus* Zone.

CORRELATION OF REFLECTION PROFILE AND STRATIGRAPHIC COLUMN

Site 215 is near the distal portion of the Bengal Fan. The seismic profile approaching the site from the south shows irregular outcropping acoustic basement with small basins of ponded sediment. Immediately north of the site the

smooth, graded surface of the Bengal Fan begins, rising steadily to the north. Site 215 is situated in what appears on the single available crossing to be a basin approximately 4 nautical miles in length, containing up to 0.25 sec of sediment. Surface sediment at the site is at a slightly higher level than the surface of obvious Bengal Fan sediments to the north. However, deeper layers within the "basin" may be continuous with fan sediments.

Details of the seismic reflection record at Site 215 (Figure 3) show an upper, acoustically transparent zone of ponded sediments 0.06 sec in thickness. This is underlain by a zone of ponded sediments characterized by a succession of well-defined reflectors which resemble the Bengal Fan turbidites. At the drill site, this zone is only about 0.005 sec thick, over a basement high, but nearby it reaches a thickness of 0.1 sec. Lowermost zone on the seismic profile consists of an acoustically transparent layer 0.1 sec in thickness which is draped over the irregular acoustic basement (3).

The upper acoustically transparent zone on the record represents a 46-meter-thick Radiolaria diatom ooze unit, with an interval velocity of 1.5 km/sec. The underlying thin zone of acoustically layered sediment may represent a 28-meter section which is bounded at the top and bottom by thin terrigenous silty clays and clayey silts, separated by clayey Radiolaria diatom ooze. This unit is tentatively considered to be distal Bengal Fan sediments, possibly of turbidite origin. The basal acoustically transparent draped zone correlates with the thick nannofossil ooze to chalk unit which overlies basalt.

Overall sediment thickness at the drilling site is 155.5 meters, represented by 0.18 sec on the seismic profile. From these observations, the overall interval velocity of Site 214 is 1.7 km/sec.

Depth of reflections and interval velocities are as follows:

Reflector	2-Way Time (sec)	Depth (m)	Interval Velocity (km/sec)	
0	0	0	1.5	1.7
1	0.06	46	1.8	
3	0.18	151		

SUMMARY AND CONCLUSIONS

Site 215 is situated in the central Indian Ocean Basin in a water depth of 5309 meters, approximately 240 km west of the median line of Ninetyeast Ridge. The hole was drilled in what appears on one crossing to be an 18-km-long basin of ponded and draped sediments up to 0.25 sec thick. The basin is separated by basement highs from the distal portion of the Bengal Fan to the north.

The 175 meters of sediment and rock drilled at Site 215 is divisible into five lithologic units. The lowermost unit consists of a succession of pillow basalts with mid-Indian Ocean Ridge affinities. This typical sea-floor basalt is overlain by 1 meter of mid-Paleocene iron-oxide-rich nannofossil ooze which is in turn overlain by a 70-meter unit of nannofossil ooze and thin cherts of mid-Paleocene

SITE 215

SECS 6

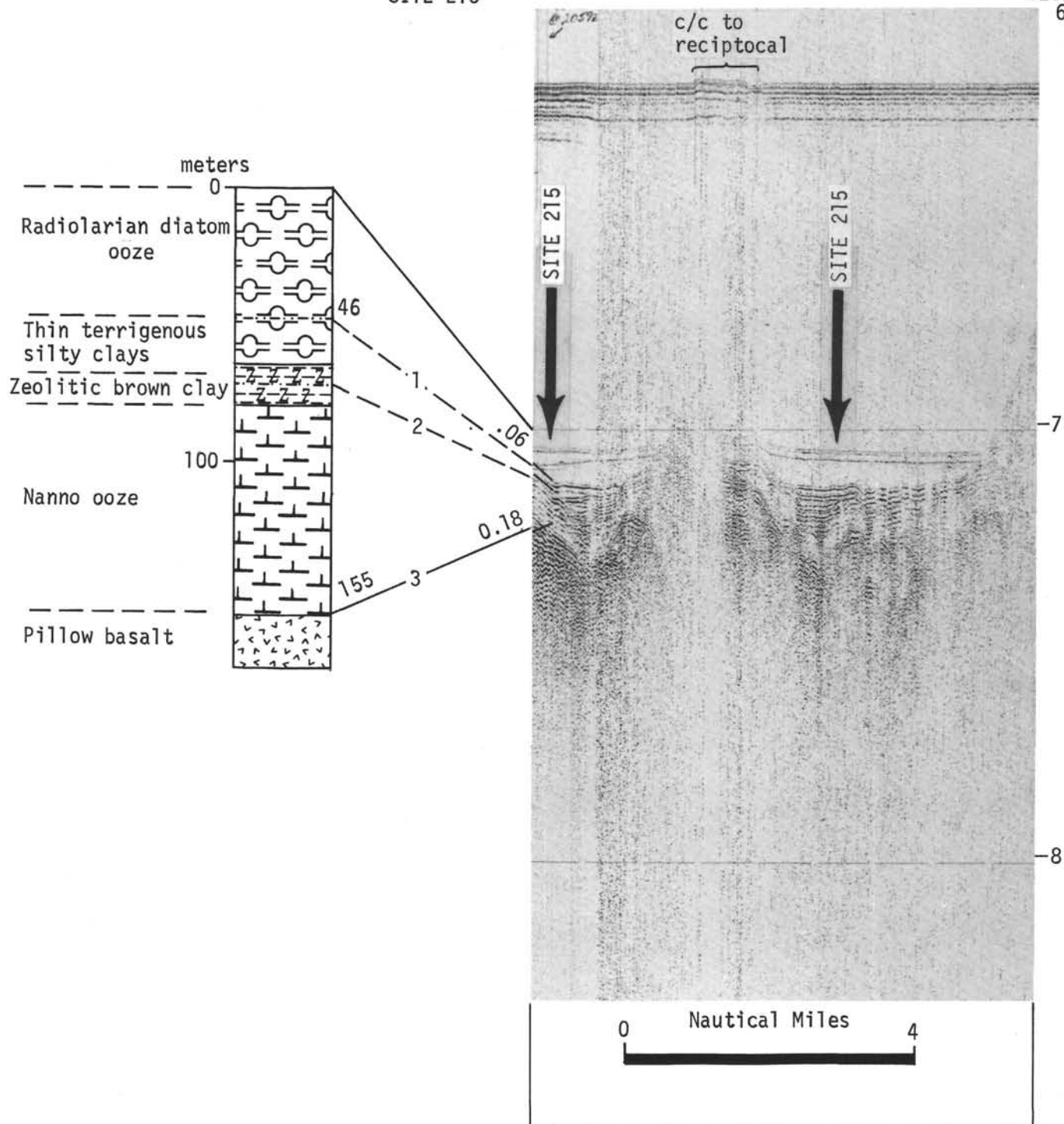


Figure 3. Correlation of reflection profile and stratigraphic column at Site 215.

to early Eocene age. Seven meters of barren zeolitic brown clay, corresponding to a 40-m.y. time interval, lies above the nannofossil ooze and is succeeded by upper Miocene terrigenous silts and clays. The uppermost unit at Site 215 is a 70-meter-thick radiolarian-diatom ooze of upper Miocene to Quaternary age.

The stratigraphy and biostratigraphy of Site 215 imply subsidence accompanying sea-floor spreading in a fashion

very similar to Site 213 which is situated on the opposite side of the Ninetyeast Ridge. The major difference between these two sites is the occurrence of upper Miocene terrigenous silts and clays at Site 215 which probably represent distal turbidites of the Bengal Fan.

The oldest nannofossils and foraminifera, which were found with the basalts at the base of Core 17, give an age between 58 and 60 m.y. for the crust at this site. They are

significantly younger than the age of the crust of 72 m.y. given by the beginning of magnetic anomaly 31 to the west (McKenzie and Sclater, 1971) which is at the same latitude. Apparently the oceanic crust just to the west of the Ninetyeast Ridge is younger than the crust west of 86°E. Thus, there must be a major fracture zone unidentified from topography running parallel to the Ninetyeast Ridge along 86°E offsetting the oceanic crust of the same age some 6° to 8° to the south. Though some 350 km to the north of Site 214, Site 215 has a basement age of 58 to 60

m.y. which, though probably slightly older, is still close to the Paleocene age of the basal sediments at Site 214. This similarity and the possible existence of the fracture zone at 86°E are discussed further in the regional synthesis chapter.

REFERENCE

- McKenzie, D. P. and Sclater, J. G., 1971. The evolution of the Indian Ocean since the Late Cretaceous: *Geophys. J. Roy. Astro. Soc.*, v. 25, p. 439-528.

Site 215 Hole Core 1 Cored Interval: 0-9.5 m

AGE	ZONE	FOSSIL CHARACTER		SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL ABUND.	PRES.						
QUATERNARY	(Unzoned)	R	C	G	0.5				RAD DIATOM OOZE dark yellowish brown 10YR4/4 - soupy Diatoms 50% Rads 25% Clay and Spicules 25%
		R	C	G					
				1	1.0				RAD DIATOM OOZE light yellowish brown 10YR6/4 to yellowish brown 10YR5/4 Diatoms 50% Rads 30% Spicules 10% Silicoflag. 2% FeO grains 2% Opagues 1% Clay 5%
				2					
				3					with abundant streaks and mottles of very dark grayish brown 10YR3/2 to black 10YR2.5/1 - Mn rich
				4					
		R	C	G					X-ray at 6.40 m Quar 24, Plag 9, Kaol 17, Mica 35, Mont 15
		R	C	G					
				5					Diatom ooze 0.5 cm thick Diatoms 73% Clay 20% Other silic. foss. 7% pronounced black layers - somewhat distorted at 25-29, 35-38, 47-52, and 91-125 cm.
		R	C	G					
UPPER PLIOCENE	Pterocanium prismatium	R	C	G					RAD DIATOM OOZE yellow brown 10YR5/4 Diatoms 50% Rads 30% Clay 10% Spicules 6% Silicoflag. 2% Opagues and FeO 2%
		R	C	G					
		R	C	G					
		R	C	G					Core Catcher

Explanatory notes in Chapter 1

Site 215 Hole Core 2 Cored Interval: 9.5-17 m

AGE	ZONE	FOSSIL CHARACTER		SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL ABUND.	PRES.						
UPPER PLIOCENE	Pterocanium prismatium Zone (R)	R	C	M	0.5				RAD DIATOM OOZE yellowish brown 10YR5/4 with abundant streaks and mottles of black 10YR2.5/1 - Mn rich
		R	C	M					
LOWER PLIOCENE	Spongaster pentas Zone (R)	R	C	G	1.0				
		R	C	G					
						Core Catcher			

Explanatory notes in Chapter 1

Site 215 Hole Core 3 Cored Interval: 17-26.5 m

AGE	ZONE	FOSSIL CHARACTER		SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL	ABUND.						
LOWER PLIOCENE	Spongaster pentas Zone (r)	R	C	G	1	0.5 1.0	?	-30	RAD CLAY RICH DIATOM OOZE brown 10YR5/3 Diatoms 60% Clay 25% Rads 10% Spicules 5%
		R	C	G	2		?	-90	CLAY RAD RICH DIATOM OOZE moderately firm, light yellowish brown 10YR6/4 with traces of brown 10YR5/3 Diatoms 60% Rads 20% Clay 16% Spicules 2% Silicoflag. 2%
		R	F	M	3				Sections 3, 4, 5, 6 light yellowish brown with abundant black streaks and patches of brown
					4				
		R	C	G	5				
		R	C	G	6				
		R	C	G	Core Catcher				

Explanatory notes in Chapter 1

Site 215 Hole Core 4 Cored Interval: 26.5-36 m

AGE	ZONE	FOSSIL CHARACTER		SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL	ABUND.						
LOWER PLIOCENE	Spongaster pentas Zone (r)	R	C	G	1	0.5 1.0		-84	light yellowish brown 10YR6/4 RAD CLAY RICH DIATOM OOZE pale brown 10YR6/3 Diatoms 60% Rads 15% Clay 20% Spicules 5% some black streaking e.g. 17-24 cm, 40-50 cm and patches of darker color 10YR6/2 e.g. 84 cm which is RAD RICH DIATOM CLAY
		R	C	G	2			140	Clay 45% Diatoms 35% Rads 20% light brownish gray 2.5Y6/4 with few smears of grayish brown 2.5Y5/2
		R	C	G	3				light yellowish brown 10YR6/4 with dark smears at 74-85, 95- 102, 120-122, and 142 cm.
		R	C	G	4			-45	SPONGE SPIGULE RAD RICH CLAY DIATOM OOZE Diatoms 40% Clay 35% Rads 15% Spicules 10%
		R	C	G	5			-80	ASH BEARING RAD RICH CLAY DIATOM OOZE light brownish gray 2.5Y6/2 Diatoms 40% Clay 32% Rads 20% Volcanic glass (mostly rhyolitic, some basaltic) 3% Spicules 5%
		R	C	G	6				10YR6/4 with streaking of 2.5Y6/2 between 60 and 90 cm patches of brown 10YR5/3 from 90-130 cm
		R	F	G	Core Catcher				X-ray at 27.00 m Quar 27, Plag 6, Kaol 19, Mica 24, Mont 24

Explanatory notes in Chapter 1

Site 215 Hole Core 5 Cored Interval: 36-45.5 m

AGE	ZONE	FOSSIL CHARACTER			SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL	ABUND.	PRES.						
UPPER MIOCENE	Spongaster pentas Zone (R)	R	C	G	1	0.5 1.0				light yellowish brown 10YR6/4 mixed with brown 10YR5/3, few black specks from 0-30 cm
					2		GEO CHEM VOID			pale brown 10YR6/3 with few patches of 10YR6/4
		R	C	G	3		VOID			pale brown 10YR6/3 10YR6/4
					4		VOID			
	Stichocorys peregrina Zone (R)	R	C	G	Core Catcher					RAD RICH DIATOM CLAY Clay 40% Diatoms 35% Rads 20% Spicules 2% Silicoflag. 1% FeO 1% Phillipsite 1%

Explanatory notes in Chapter 1

Site 215 Hole Core 6 Cored Interval: 45.5-55 m

AGE	ZONE	FOSSIL CHARACTER			SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL	ABUND.	PRES.						
UPPER MIOCENE	Stichocorys peregrina Zone (R)	R	C	G	1	0.5 1.0	VOID			light yellowish brown 10YR6/4 down to brown 10YR5/3, 10Y-110 cm very dark gray 10YR3/1 pocket
					2					SILTY CLAY grayish brown 10YR5/4, silt fraction mainly carbonate with feldspar and hornblende Clay 70% Silt 30%
		R	F	M	3		VOID			light yellowish brown 10YR6/4 CLAY gray 10YR5/1, silt fraction mainly feldspar, rare quartz (?) and basic glass. Clay 80% Silt 20%
		R	C	G	Core Catcher					10YR6/4 with streaks of gray 10YR5/1 105-150 very watery X-ray at 47.80 m Quar 20, Feld 2, Plag 4, Mica 61, Chlo 6, Mont 7

Site 215 Hole Core 7 Cored Interval: 55-64.5 m

AGE	ZONE	FOSSIL CHARACTER			SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL	ABUND.	PRES.						
UPPER MIOCENE	Stichocorys peregrina Zone (R)	R	C	G	1	0.5 1.0	VOID			light yellowish brown 10YR6/4
		R	F	P	2					CLAY DIATOM RAD OOZE pale brown 10YR6/3 Rads 40% Diatoms 30% Clay 28% Spicules 1% Silicoflag. 1% Basic volcanic glass - pale green Tr.
		R	C	G	Core Catcher					97-105 patches of light gray 5Y7/2 10YR6/4 X-ray at 57.10 m Quar 28, Plag 8, Kaol 16, Mica 28, Mont 20

Explanatory notes in Chapter 1

Site 215 Hole Core 8 Cored Interval: 64.5-74 m

AGE	ZONE	FOSSIL CHARACTER			SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL	ABUND.	PRES.						
UPPER MIOCENE	Omatartus antepenultimus Zone (R)					0.5	VOID			
		R	F	M	1	1.0				CLAY mostly light brown 7.5YR6/4 with mixed very pale brown 10YR7/3 yellow brown 10YR5/4 Clay 90% Rads 5% Spicules 3% Feldspar, volcanic glass, FeO, silico- flag. 2%
		R	F	M						
		R	C	M	2					
		R	F	P			GEO CHEM			
		R	F	M	3		VOID			
		R	+	P			VOID			grayish brown 10YR5/2 and gray 2.5Y5 some drilling contamination of light brown clasts from above.
		R	R	P	4		VOID			
		R	+	P			VOID			
		R	+	P	5					CLAYEY SILT AND CLAY Feldspar 65% Clay minerals 25% Pale green basic volcanic glass 5% FeO, quartz(?), horn- blende, tourmaline, zircon, epidote(?) 5%
		R	+	P			VOID			X-ray at 66.60 m Quar 19, Plag, 9, Kaol 7, Mica 15, Mont 50 X-ray at 69.20 m Quar 25, Feld 3, Plag 6, Kaol 1, Mica 52, Chlo 5, Mont 7
							Core Catcher			

Explanatory notes in Chapter 1

Site 215 Hole Core 9 Cored Interval: 74-83.5 m

AGE	ZONE	FOSSIL CHARACTER			SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL	ABUND.	PRES.						
EARLY EOCENE	Tribrachiatulus orthostylus					0.5	VOID			
					1	1.0				very dark gray 10YR3/1 grading down to dark brown 10YR3/3
							GEO CHEM			ZEOLITE RICH CLAY and FeO/Mn(?) rich in places, smear pale brown 10YR6/3 77-85 cm Clay 80% FeO/Mn(?) 10% Phillipsite 10% Nannos Tr.
					2					mottled brown 10YR5/3
					3					dark brown 7.5YR4/2 changing from 70 to 90 cm to brown 10YR5/3 with blotches of very pale brown 10YR7/3 near base Section 3. CLAY RICH NANNO OOZE
		N	C	F						Nannos 70% Clay 20% Calcite fragments 9% FeO 1%
		R	F	P						
		R	+	P						
		R	+	P						
							Core Catcher			
										X-ray at 74.40 m Quar 10, Feld 8, Mica 6, Mont 13, Paly 36, Phil 27 X-ray at 76.10 m Quar 8, Paly 91 X-ray at 77.40 m Quar 7, Paly 89, Hal 5

Site 215 Hole Core 10 Cored Interval: 83.5-93.0 m

AGE	ZONE	FOSSIL CHARACTER			SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL	ABUND.	PRES.						
EARLY EOCENE	Discoaster diabyus Zone (N)					0.5	VOID			
					1	1.0				pale yellow 2.5Y7/4
							GEO CHEM			CLAY RICH NANNO OOZE 2.5Y7/4
					2		VOID			Nannos 80% Clay 15% Calcite fragments - mostly rectangular 5% FeO Tr.
					3					white 2.5Y8/2, firm and soft alternations
							Core Catcher			
										CLAY BEARING NANNO OOZE Nannos 84% Clay 10% Calcite fragments 5% Foram 1% Carbonate rhombs Tr. FeO Tr.

Explanatory notes in Chapter 1

Site 215 Hole Core 11 Cored Interval: 93-102.5 m

AGE	ZONE	FOSSIL CHARACTER			SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL	ABUND.	PRES.						
Eocene	Discoaster dyastypus Zone	N	A	F	1	0.5	VOID			18-22 cm white 10YR8/1
		F	A	G	1	1.0				
PALEOCENE TO EOCENE	Discoaster multiradiatus Zone	N	A	P	2		NANNO OOZE very pale brown 16YR8/4 with smears and pockets of white Nannos 92% Clay 5% Foram 3% Dolomite Tr. Authigenic carbonate Tr. Rads Tr.		-90	
		F	C	G	3					
					4					
					5					
		F	C	G	6					
		R A N	A A	G F	Core Catcher					

Explanatory notes in Chapter 1

Site 215 Hole Core 12 Cored Interval: 102.5-112 m

AGE	ZONE	FOSSIL CHARACTER			SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL	ABUND.	PRES.						
PALEOCENE	Discoaster multiradiatus Zone (N) Morozovella velascoensis (P5) to Morozovella velascoensis/M. subbotinae (P6a) (F)	N	A	F	1	0.5		?	-43	
		F	R	P	1	1.0				
					2					
		F	R	P	3					
					4					
		F	R	P	5					
		F	R	P	6				-68	
		R A N	A A	P P	Core Catcher					

Explanatory notes in Chapter 1

CLAY RICH NANNO OOZE
very pale brown 10YR7/3
with few pockets of white
10YR8/2. At approx. 20 cm
intervals are firmer zones
2-3 cm thick

Nannos 79%
Clay 20%
Foram 1%

Site 215 Hole Core 13 Cored Interval: 112-121.5 m

AGE	ZONE	FOSSIL CHARACTER			SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL	ABUND.	PRES.						
PALEOCENE	Discoaster multiradiatus Zone	Morozovella velascoensis (P5) (F)	N	A	G	0.5	VOID			
						1				
	Discoaster mohleri Zone	Planorotalites pseudonardii (P4) (F)	N	A	F	1.0		?	130	
						2				
	Discoaster mohleri Zone	Planorotalites pseudonardii (P4) (F)	F	C	M	3				
						4				
	Discoaster mohleri Zone	Planorotalites pseudonardii (P4) (F)	R	F	N	Core Catcher				
	Discoaster mohleri Zone	Planorotalites pseudonardii (P4) (F)	R	F	N					

CLAY RICH NANNO OOZE
 Very pale brown 10YR7/4
 Nannos 85%
 Clay 15%
 few white blebs throughout
 Chert nodule yellowish brown
 10YR5/4 porcellaneous shows
 burrows and chemical alteration
 fragment 5 cm across.

Explanatory notes in Chapter 1

Site 215 Hole Core 14 Cored Interval: 121.5-131 m

AGE	ZONE	FOSSIL CHARACTER			SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL	ABUND.	PRES.						
PALEOCENE	Discoaster mohleri Zone	Planorotalites pseudonardii (P4) (F)	N	A	F	0.5				
						1				
	Discoaster mohleri Zone	Planorotalites pseudonardii (P4) (F)	F	R	P	2				
						3				
	Discoaster mohleri Zone	Planorotalites pseudonardii (P4) (F)	F	R	P	4				
						5				
	Discoaster mohleri Zone	Planorotalites pseudonardii (P4) (F)	N	A	F	6				
						Core Catcher				
	Discoaster mohleri Zone	Planorotalites pseudonardii (P4) (F)	R	F	N					

105-107
 117-120

Chert nodules brown 10YR5/3 and
 very dark gray 10YR3/1 with white
 chalky rind in places.

95-105 to 130-135 zones
 of white mottles

CLAY RICH NANNO OOZE
 very pale brown 10YR7/3 with
 few scattered white pockets up
 to 1 cm across, every 10-50 cm
 get 5 cm thick more lithified
 zone

45
 white 10YR8/1
 chalk zone

CLAY RICH NANNO CHALK

Explanatory notes in Chapter 1

Site 215 Hole Core 15 Cored Interval: 131-140.5 m





AGE	ZONE	FOSSIL CHARACTER			SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL	ABUND.	PRES.						
PALEOCENE	Helioithus kleinpellii Zone	Planorbulites pseudonardii (p4) (F)	F	R	P	0.5	VOID			
						1				
						1.0				
						2				
						3				
						4				
PALEOCENE	Helioithus kleinpellii Zone	Planorbulites pseudonardii (p4) (F)	F	R	P	5				
						6				
						Core Catcher				

Explanatory notes in Chapter 1

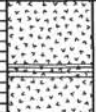


Site 215 Hole Core 16 Cored Interval: 140.5-150 m

AGE	ZONE	FOSSIL CHARACTER			SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL	ABUND.	PRES.						
PALEOCENE	Helioithus kleinpellii Zone (N)	Planorbulites pseudonardii (p4) (F)	F	R	P	0.5	VOID			
						1				
						2				
						3				
						4				
						5				
PALEOCENE	Helioithus kleinpellii Zone (N)	Planorbulites pseudonardii (p4) (F)	F	R	P	6				
						Core Catcher				
						149				

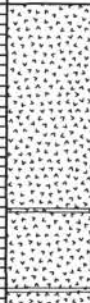
Explanatory notes in Chapter 1

Site 215		Hole		Core 17		Cored Interval: 150-155.5 m				
AGE	ZONE	FOSSIL CHARACTER			SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL	ABUND.	PRES.						
PALEOCENE	Fasciculithus tympaiformis Zone Morozovella pusilla/M. angulata (P3)(F) Planorotalites pseudonardii (P4) (F)	N	A	G	1	0.5	VOID			
					1	1.0		100		
		N	C	F	2			110		
					3			-22		
					Core Catcher					
										

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Site 215		Hole		Core 18		Cored Interval: 155.5-162 m				
AGE	ZONE	FOSSIL CHARACTER			SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL	ABUND.	PRES.						
						0.5				limestone bordered by basaltic glass then chilled margin of glassy basalt
					1	1.0				BASALT partially weathered olive gray 5Y4/1
					2					glassy zone Plagioclase in matrix 55% Dark brown mesostasis 35% Olivine ? 3% Calcite 3% Pyroxene 1% Plag. micro. phenocrysts 1% Palagonite 1%
					3					glassy zone
					Core Catcher					15 cm

Explanatory notes in Chapter 1

Site 215		Hole		Core 19		Cored Interval: 162-165.5 m				
AGE	ZONE	FOSSIL CHARACTER			SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL	ABUND.	PRES.						
					1	0.5 1.0				BASALT Holocrystalline unweathered coarse grained rock, medium dark gray N4. Subophitic texture no phenocrysts. Plagioclase 40% Clinopyroxene 40% Iron 10% Chloritic material 10%
					2					glassy zone bordered by weathered basalt
										70-110 cm calcite veins
					Core Catcher					

Site 215		Hole		Core 20		Cored Interval: 165.5-175 m			
AGE	ZONE	FOSSIL CHARACTER		SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		FOSSIL ABUND.	PRES.						
					0.5	VOID			BASALT
				1	1.0				100-120 cm calcite veining 100-130 cm basalt is moderately fresh
				2					glassy zone with weathered finer basalt on each side
				3					120-150 cm one side of core comprises basaltic glass glassy limestone and palagonite
									glass with weathered borders of fine basalt
									glass with weathered borders of fine basalt
				4					glass with weathered borders of fine basalt small edge of glass at 35 cm glass with weathered borders of fine basalt
				Core Catcher					

Explanatory notes in Chapter 1

