4. SITE 213

The Shipboard Scientific Party

ABSTRACT

The stratigraphic column at Site 213 is 154 meters in thickness and contains four stratigraphic units with gradational contacts. These units comprise an uppermost radiolarian-diatom ooze of Quaternary to middle Miocene age, a nonfossiliferous zeolitic brown clay, a nannofossil ooze of lower Eocene to upper Paleocene age, and a basal iron-manganese oxide sediment overlying weathered pillow basalt. Stratigraphic evidence is consistent with a gradual deepening of the oceanic crustal plate since its formation. The nonfossiliferous brown clay interval midway down the hole may represent normal deep-basin sedimentation subsequent to the plate sinking below the carbonate compensation level. The uppermost radiolarian diatom ooze suggests the onset of high productivity, with only the siliceous component being preserved below the carbonate compensation level and may reflect northward migration of the site into the equatorial productive zone. The oldest sediment age of 55 to 57 m.y. places an upper limit on the age of the beginning of magnetic anomaly 26.

SITE DATA

Date Occupied:
213: 4 Feb 72 (1800)
213A: 6 Feb 72 (1800)

Date Departed:
213: 6 Feb 72 (1800)
213A: 6 Feb 72 (1520)

Time on Site:
213: 48 hours
213A: 21 hours 20 minutes

Position:
lat 10°12.71'S
long 93°53.77'E

Water Depth (to rig floor):
5609 meters (Echo sounding)
5611 meters (Drill pipe)

Penetration:
213: 172.5 meters
213A: 130.5 meters

Number of Holes: 2

Number of Cores:
213: 19
213A: 3

Total Length of Cored Section:
213: 172.5 meters
213A: 24.5 meters

Total Core Recovered:
213: 145.5 meters
213A: 24.5 meters

Acoustic Basement:
Depth: 154.0 meters
Nature: Basalt

Age of Oldest Sediment: Upper Paleocene
Basement: Basalt

BACKGROUND AND OBJECTIVES

The major piece of information governing the selection of all three sites in the Wharton Basin was the identification by Sclater and Fisher (in preparation) of lineated east-west trending magnetic anomalies to the east of the Ninetyeast Ridge. On the basis of this identification these authors suggested that the Wharton Basin was formed from an east-west spreading center which is either against the Java Trench or has descended down the trench after the cessation of spreading. The general topography of the basin is accounted for by having large north-south trending fracture zones offsetting the spreading axis progressively northwards to the east of the Ninetyeast Ridge. This
interpration of the age and tectonics of the basin is totally dependent on the correct identification of the anomalies east of the Ninetyeast Ridge as 23 through 33 getting older to the south.

Initially it was planned to drill close to anomaly 27 in a site surveyed during Scripps Institution of Oceanography Cruise ANTIPODE XII. However, the sediment in the area was too thin, and the site was moved further north to an alternate site at 10°00'S, 93°57'E. This site is located in the middle of a slight trough south of a 500-meter ridge which stops the distal Nicobar Fan sediments on the eastern side of the Ninetyeast Ridge from penetrating further south (Figure 1). The ANTIPODE XII airgun record was of poor quality, but was good enough to show that the trough consists of a series of small basins 3 to 5 kilometers long covered with flat-lying sediments of 0.1 to 0.2 sec thickness. The incoming and outgoing airgun records (Chapter 10) are typical of the area.

The principal objective of the site was to date the age of basement and to help identify the magnetic anomalies. A secondary objective was to obtain a stratigraphic and biostratigraphic sequence east of the Ninetyeast Ridge. The data from this site are to be compared with sections recovered from sites on and to the west of the ridge. If the tectonic history as illustrated by the magnetics is correct, then before the Eocene the oceanic crust on either side of the ridge moved in opposite directions, and this difference in motion may be reflected in the biostratigraphic, biogeochemical, and paleomagnetic record.

OPERATIONS

Site 213 was approached in a northward direction along the seismic reflection profile of ANTIPODE XII. Sediments in the area occur in what appear to be isolated basins, a few kilometers in cross-section, within basement. The site was selected in what appears to be a typical basin, containing 0.1 to 0.15 sec of acoustically transparent sediment overlying a strong irregular basement reflector.

Due to the small size of the basin, the acoustic beacon and a spar buoy were dropped underway at 5 knots, after which the seismic gear and magnetometer were secured in the normal way and the Challenger reversed course back to the site. In order to drill in the deepest portion of the basin, the drilling vessel was offset 1500 ft to the north of the beacon. The chosen site is situated in 5611 meters of water (drill pipe to rig floor) at 10°12.75'S, 93°53.77'E. The site was occupied on 4 Feb 72 at 1800 hours.

Soft siliceous ooze, red clays, and stiff chalks of Site 213 presented no drilling difficulties. The Smith 10, 1/8-inch bit from Site 212 was rerun. Basalt was reached at a sediment depth of 154 meters and was drilled for 18.5 meters with a recovery of 45.4%. The hole was terminated at a total depth of 172.5 meters. A total of 145.5 meters of sediment and basalt was recovered, giving an overall recovery of 84% (Table 1).

A second hole, 213A, was subsequently drilled offset approximately 40 ft from the first. This hole was designed to test the mechanical latching and electronic operation of the temperature probe. Three mechanically successful lowerings were made of the downhole instrument package.

and temperature data were successfully gathered on the last two. Three cores were taken from Hole 213A. A total of 24.5 meters of sediment was cored with 100% recovery (Table 2). Discussion of the heat flow results is given in Chapter 14.

LITHOLOGIC SUMMARY

The total sediment section of about 150 meters was continuously cored and ranged in age from Quaternary to late Paleocene. About 8 meters of weathered basalt were also recovered from a penetration of 18 meters. The cored sequences have been divided into five lithologic units (Figure 2) as follows:

<table>
<thead>
<tr>
<th>Unit</th>
<th>Depth Below Sea Floor (m)</th>
<th>Lithology</th>
<th>Age</th>
<th>Cores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 to 75</td>
<td>Rad-diatom ooze with varying clay</td>
<td>Quaternary</td>
<td>1-8</td>
</tr>
<tr>
<td>2</td>
<td>~70.5 to 135</td>
<td>Zeolitic clay grading towards nano-bearining manganese iron-oxide-rich clay</td>
<td>Middle Miocene</td>
<td>8-15</td>
</tr>
<tr>
<td>3</td>
<td>~135 to 147</td>
<td>Nanno ooze</td>
<td>Early Eocene</td>
<td>15,16</td>
</tr>
<tr>
<td>4</td>
<td>~147 to 152</td>
<td>Iron-oxide-manganese facies</td>
<td>late Paleocene</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>~154 to 172</td>
<td>Weathered basalt</td>
<td></td>
<td>17-19</td>
</tr>
</tbody>
</table>

Unit 1 – Radiolarian-Diatom Ooze (Cores 1-8)

Unit 1 consists of reddish yellow radiolarian-diatom ooze. The diatoms and Radiolaria make up 50% to 75% and 12% to 40%, respectively, of the unit. The minor constituent is a clay fraction averaging 7%. However, the clay content increases considerably near the top (35%) and bottom (70%) of this unit. Among the other minor constituents, iron-oxide minerals associated with manganese micronodules are concentrated in thin layers and laminae in the middle portion of the unit (Cores 3 and 6). Here the iron-oxide minerals are minute crystals with an oolitic shape, reddish yellow color, with high relief and often associated with purple red hematitic material. Volcanic ash of probably rhyolitic composition is also scattered throughout the unit with major concentrations (about 25%) and pumice being noted in Core 2 (upper Pliocene) and in Core 5 (late lower Pliocene).

Unit 2 – Zeolitic Clay, Mn Iron-Rich at Base (Cores 8-15)

Unit 2 consists of zeolitic, brown clay. Well-crystallized phillipsite is the main type of zeolite found. The zeolite content varies from 1% to 7% in Cores 8, 9, and 13 and is higher elsewhere in the unit reaching a maximum of 20% in Cores 11 and 12. Iron-oxide minerals and manganese micronodules are concentrated in the lower part (Cores 12 through 15) of the unit where they make up about 15% of the sediment. One concentration of volcanic ash of rhyolitic composition was noted at the top of this unit. The base of Unit 2 grades into Unit 3 and consists of interbedded nanofossil ooze and clay, the latter containing
Figure 1. Bathymetry in vicinity of Site 213.
less iron-oxide-manganese constituents than above and no zeolite.

Unit 3—Nannofossil Ooze (Cores 15, 16)

Unit 3 is defined as the sediment section consisting only of pure nannofossil ooze (<10% clay only). The minor constituents are authigenic carbonate (3%) and foraminifera (2%). Iron-oxide-manganese minerals only occur in trace amounts.

Unit 4—Iron-Oxide-Manganese Facies (Core 16)

This unit comprising the lower part of Core 16 consists entirely of iron-oxide-manganese facies. The iron-oxide material is made up of oolitic-like crystals (geothite?) associated with red scales of hematitic and less crystalline masses of limonitic material. Micronodules and aggregates of manganese were also seen. The only other mineral occurring in significant amounts in this facies is palygorskite (detected by X-ray diffraction).

Unit 5—Basalt (Cores 17-19)

Unit 5 consists of a succession of at least 11 basaltic flows. Each flow is a pillow-lava with chilled margins. Within each flow three different zones are identified: (1) a glassy palagonitized margin, (2) a weathered porphyritic basaltic zone, and (3) a more crystalline and less weathered basaltic zone. A thin film of manganese was noticed in some fragments near the top of Unit 5. The general mineralogy consists of plagioclase, clinopyroxene, palagonite, iron-oxide minerals, calcite, silica aggregate, and a dark mesostasis. The texture varies from variolitic to subophitic.

Note: Echo sounding depth (to drill floor) = 5609 meters; drill pipe length to bottom = 5611 meters.
CHEMICAL PROPERTIES

Ten samples were collected from the 16 cores which contained sediments. Two contiguous 10-cm minicores were taken from the top of the selected core section in all cases excepting Samples 213-2-5 and 213-16-4 when only one was removed. Samples were held at 4°C until processing. One minicore was used for resistivity measurements, then removed from the liner, scraped to remove contamination, and loaded into the squeezer. Sufficient time was allowed for the sediment to reach ambient room temperature before extraction of the pore fluids. The other minicore was used for punch-in pH measurements, then preserved for shore-laboratory studies. Complete shipboard results are given in Table 3.

BIOSTRATIGRAPHIC SUMMARY

General

Site 213 was cored continuously from the sea floor to the acoustic basement, which was encountered at a depth of approximately 152 meters. The sequence can conveniently be divided into three lithologic units. Transitions between these major units occur over intervals of several meters.

The upper unit (Cores 1 through 8) is a siliceous ooze with abundant diatoms and common radiolarians. Diatoms are in greatest abundance near the top of the unit and decrease in abundance downward. This unit contains an apparently uninterrupted sequence from the Recent into the late Miocene. At the lower part of the unit (Cores 9 and 10) the radiolarian specimens become increasingly more corroded. Below Core 10 radiolarians are absent entirely.

Underlying the siliceous ooze is an unfossiliferous zeolitic clay, which represents much of the depositional history of the area (from early Eocene to middle Miocene).

The lowermost unit consists of interbedded nannofossil ooze and iron-rich clay of early Eocene and late Paleocene age. Approximately 5 to 10 meters of unfossiliferous clay overlies the acoustic basement. There is one recognizable unconformity within the cores obtained; the *Cannartus petterssoni* (radiolarian) Zone (within the middle Miocene) may be missing.

**Foraminifera**

Cores 4 to 6 contain sporadic deep-water benthonic assemblages. Single specimens of *Morozovella aff. spinulosa*, *Acarinina aff. primitiva*, "*Globorotalia aff. pseudomayeri*, and one fragment of *Globigeropsis* or *Globigerinoides higginsi* are sufficient to indicate a middle Eocene age for the clays of the Core 11 CC to Core 13 CC interval.
There is a downward increase in total assemblage in Core 14 from fish teeth and agglutinated benthonics (Sections 1, 2) through very rare planktonics (Sections 3, 4) and calcareous benthonics (Sections 5 and upper part of 6) to a planktonic assemblage (lower part of Sections 6 and CC). In the latter, specimens are corroded, fragmented, and recrystalized.

This planktonic assemblage is richer in specimens and more diverse in Core 15 (Sections 1 to 3) where the "Globorotalia" formosa Zone (P.7) is recognizable.

There is a change within Core 15, Section 4: a distinctly different, better preserved and even richer assemblage from Section 5 to CC is identified as the Morozovella subbotinai/ Pseudohastigerina wilcoexensis Subzone (P.6b).

There is another change between Sections 15, CC and 16-1. Core 16 contains a rich, excellently preserved assemblage with abundant Morozovella velascoensis and very few of the M. subbotinai/gracilis/marginodentata/ pasionensis group, in both respects being in sharp contrast with Core 15. Core 16 is identified as the Morozovella velascoensis Zone (P.5) and, on negative evidence, is assigned to the upper part of that zone. Core 16, CC contains a mixed Paleocene and Eocene assemblage due to contamination.

The limits of this three-part calcareous section are estimated to be approximately 51 and 55 m.y.

Material removed ultrasonically from the surface of the top four pieces of basalt in Core 17 yielded small benthonics and small planktonics in two distinct preservation. All of the planktonics could be downhole contaminants; if they were in situ, they would give a maximum age of 57 to 58 m.y.

Nannofossils

Calcareous nannofossils of early Tertiary age were recovered in Cores 14, 15, and 16. In addition, nannofossils were also recovered from the surfaces of basalt fragments near the top of Core 17. The highest occurrence of nannofossils is in Core 14, Section 5, which contains a sparse assemblage consisting primarily of Discoaster lodoensis and Tribrichiaus orthostylus. The cooccurrence of these two species indicates an early Eocene age (Tribrachiatus orthostylus Zone = ~52 m.y.) for this interval. This same assemblage, with progressively more species added, continues to Core 15, Section 4. Discoaster lodoensis is not present below this level, but Tribrichiaus orthostylus and Discoaster diastypus cooccur as far as the bottom of Core 15. The interval from the middle of Section 6, Core 14 to the bottom of Core 15 is assignable to the early Eocene as well (Discoaster diastypus Zone of Bukry, 1971).

All of Core 16 is assignable to the late Paleocene Discoaster multiradiatus Zone. The core-catcher sample for Core 16 is contaminated as it contains a mixture of late Paleocene and early Eocene elements.

One additional age assignment can be made—and that is for the calcareous material scraped from basalt fragments from near the top of Core 17. The assemblage from this material contains, among others, Cyclcoccolithina robusta and Sphenolithus anarrhopus with few asterololiths of the Discoaster ornatus type. Only one specimen of Discoaster multiradiatus was encountered, and this is probably a contaminant. Only a relative age assignment can be made for this sample. It is slightly, but distinctly, older than the oldest material recovered in Core 16. The nannofossil assemblage has an oceanic aspect with normal diversity except at the top and bottom of the calcareous interval, where the number of species is much reduced and the remaining specimens show strong evidence of solution/corrosion.

Radiolaria

Radiolaria ranging in age from Quaternary to middle Miocene are present in Cores 1 through 10 at Site 213. In Cores 1 through 8 Radiolaria are common and well preserved. In Cores 9 and 10 Radiolaria are increasingly more corroded downward, and the orosphaerids and collophanes are the predominant forms present.

The following faunal boundaries can be recognized within the siliceous ooze section of the cores:

The base of the Quaternary is between Samples 213-2-3, 100-102 cm and 213-2-4, 90-92 cm. The base of the Pterocanium prismatum Zone is between Samples 213-3, CC and 213-4-2, 105-107 cm. The base of the Spongaster penultimus Zone is between Samples 213-7-4, 60-62 cm and 213-7, CC. The base of the Stichocorys peregrina Zone is between Samples 213-8-6, 100-102 cm and 213-8-8, CC. The Ommatartus penultimus Zone is represented at Sample 213-8, CC. Material between Samples 213-9-1, 140-142 cm and 213-9-6, 73-75 cm is within the Ommatartus antepenultimus Zone. The material in Sample 213-9, CC lies within the lower Carnarvus petterssoni Zone or upper Dorcasopyris alata Zone. Radiolaria are absent below Sample 213-10-1, 70-72 cm.

**CORRELATION OF REFLECTION PROFILE AND STRATIGRAPHIC COLUMN**

Sediment cover in the region of Site 213 is sparse, with sediment mainly occurring in small "basins" a few miles in length within rugged basin topography. The actual drill site was chosen in a typical basin which contains a maximum of 0.14 to 0.16 sec of sediment over basement.

The seismic profile of the site (Figure 3) shows the sediment to be acoustically highly transparent throughout the entire section. Acoustic basement is topographically rough, and from the figure it is apparent that the drill site was chosen in a basin "valley" over which about 0.16 sec of sediment occurs.

The only positive correlation possible in this area is that of acoustic basement, depth 0.16 sec, and basalt, at a drilled depth of 154 meters. This correlation gives an interval velocity to the sediment of 1.9 km/sec. From the stratigraphic column it is evident that the acoustically transparent sediment corresponds with monotonous massively bedded units of siliceous ooze, zeolitic brown clay, and stiff calcareous ooze.

Depths of reflectors and interval velocities are as follows.
Figure 3. Correlation of reflection profile and stratigraphic column at Site 213.

<table>
<thead>
<tr>
<th>Reflectors</th>
<th>2-Way Time (sec)</th>
<th>Depth (m)</th>
<th>Interval Velocity (km/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.16</td>
<td>154</td>
<td>1.9</td>
</tr>
</tbody>
</table>

SUMMARY AND CONCLUSIONS

Site 213 was chosen at a point approximately 500 km east of the Ninetyeast Ridge. It was drilled close to the beginning of anomaly 26 identified by Sclater and Fisher (in preparation).
The site was drilled in a small basin approximately 6 miles in length which contains a maximum of 0.14 sec of acoustically transparent, apparently ponded sediment. Water depth is 5601 meters. The site typifies the region, so far as can be deduced from the seismic profile. To the north and south the basement is rugged and includes several similar basins.

The basal unit is a weathered pillow-basalt with distinct mid-Indian Ocean ridge affinities. Approximately 2.5 meters of section, possibly calcareous ooze, is missing from just above the basalt, but upper Paleocene calcareous ooze adheres to the uppermost basalt fragments. Above the zone of missing basal sediment lies an iron-oxide-rich clay which is overlain by and partly interbedded with a calcareous nannofossil ooze unit of late Paleocene to early Eocene age. The main unit at this site is a zeolitic clay and the upper lithologic unit is a Quarternary to upper Miocene radiolarian-diatom ooze.

Foraminiferal and nannofossil assemblages in the calcareous section near the bottom of the hole have a low latitude oceanic aspect. Towards the top of the calcareous unit where it grades into overlying red clay, a residual flora and fauna composed only of the most resistant forms is present, indicating the onset of dissolution.

At the time of the formation of oceanic crust at Site 213, the area was situated above the regional carbonate compensation depth as a sea-floor spreading center and remained so until early Eocene as evidenced by accumulation of biogenic carbonates. The ridge then slowly subsided below the carbonate compensation level during spreading, resulting in a gradual diminution of the carbonate supply to the sea floor. The resulting lack of diluting biogenic material would then favor the accumulation of nonfossiliferous zeolitic brown clay facies. During late Miocene, the plate moved northwards into equatorial high productivity regions so that brown clay sediments became swamped with biogenous material. Because the plate has subsided below the carbonate compensation depth, noncalcareous radiolarian diatom ooze began to accumulate and has persisted to the present.

The weathered basalts below the sediments are similar in composition to those from the active mid-Indian Ocean ridges. The presumed basement contact was continuously cored, and nannofossils were recovered in Core 17 adhering to the basalt which gave an age of 55 to 57 m.y. Foraminifera were recovered to the bottom of Core 16 and were located in the P.6a (54 m.y.) Zone of Berggren (1971). However, material removed ultrasonically from the basalt in Core 17 gave a maximum downward age of Zone P4 or 57 to 58 m.y. The magnetic anomaly identification is clear and is the beginning of 26 giving a magnetic age from Heirtzler et al. (1968) of 64 m.y. This is 6 to 7 m.y. more than the oldest sediment, and together with the results from Legs 3 and 5, is evidence that the magnetic and biostratigraphic scales are significantly different. As a result, a special chapter (Chapter 13) has been devoted in this report to the correlation between the two time scales.

REFERENCES
**Site 213 Hole Core 1 Cored Interval: 0-9 m**

**LITHOLOGIC DESCRIPTION**

- **Soft, DIATOM RICH RAD CLAY**
  - Matrix brown (7.5YR4/4)
  - Clay 35%
  - Rads 34%
  - Silicoflag. 15%
  - Manganese 15%
  - Fe oxide minerals 15%
  - Spicules 15%
  - Volcanic glass 15%
  - Manganese micromdules 15%

- Abundantly mottled with light brown (7.5YR4/4) clay rich rad diatom ooze. The diatom content increases with depth (up to 52%) diatom.
  - Fe oxide minerals in streaks and patches occur throughout.
  - Bottom contact transitional towards a diatom rich zone.

- Firmer reddish yellow (7.5YR6/0)
  - Diatoms 47-49%
  - Rads 36-40%
  - Clay 5-10%
  - Spicules 1-5%
  - Silicoflag. 1%
  - Glass 1%
  - Feldspar 1%

- Abundantly mottled with medium brown (7.5YR4/4) clay rich rad diatom ooze and with light brown (7.5YR3/2) manganese rich rad diatom ooze.

- **LAMINÆ-like zone, of MANGANESE**

- LAMINÆ-like zone, of MANGANESE
  - Occur throughout.
  - Manganese micromdules 15%
  - Diatoms 60%
  - Rads 10%
  - Clay 16%

- These laminæ occur at Section 3 (50-65 cm), Section 4 (60-80 cm), and Section 5 (60-80 cm).

- **INTERLAMINÆ of RED CLAY BEARING RAD VOLCANIC ASH RICH DIATOM OOZE (ash 10-25%).**

- The volcanics are mainly glass shards of rhyolitic composition, laminations disappear with depth and disappear in Section 3 below 80 cm.

- Mottling occurs throughout the core.

**Explanatory notes in Chapter 1**

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**Site 213 Hole Core 2 Cored Interval: 9-18 m**

**LITHOLOGIC DESCRIPTION**

- **Light brown reddish yellow**
  - Diatoms 1%
  - Rads 10%
  - Clay 5%
  - Volcanic glass 2%
  - Silicoflag. 1%
  - Spicules 1%

- Commonly laminated in Sections 1 and 2 with dark brown (7.5YR4/3)
  - Diatoms 49-79%
  - Rads 7-10%
  - Clay 16%
  - Volcanic glass 2%
  - Silicoflag. 1%

- Commonly mottled with dark brown (7.5YR4/3)
  - Diatoms 49-79%
  - Rads 7-10%
  - Clay 16%
  - Volcanic glass 2%
  - Silicoflag. 1%

**Explanatory notes in Chapter 1**
**Site 213 Hole**

<table>
<thead>
<tr>
<th>Cored Interval</th>
<th>Site 213 Hole</th>
<th>Core 2</th>
<th>Cored Interval: 10.5-20 m</th>
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</thead>
<tbody>
<tr>
<td><strong>FOSSIL CHARACTER</strong></td>
<td><strong>LITHOLOGY</strong></td>
<td><strong>DETRITUS</strong></td>
<td><strong>LITHOLOGIC DESCRIPTION</strong></td>
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<td><strong>AGE</strong></td>
<td><strong>ZONE</strong></td>
<td><strong>FOSSIL</strong></td>
<td><strong>FOSSIL</strong></td>
</tr>
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<td>0.5</td>
<td>1</td>
<td>Fe&gt;•Mn</td>
<td><strong>Reddish yellow (7.5YR8/6) RAD RICH DIATOM Ooze.</strong></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>Fe&gt;•Mn</td>
<td><strong>Reddish yellow (7.5YR8/6) RAD RICH DIATOM Ooze.</strong></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Fe&gt;•Mn</td>
<td><strong>Reddish yellow (7.5YR8/6) RAD RICH DIATOM Ooze.</strong></td>
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<td>3</td>
<td>Fe&gt;•Mn</td>
<td><strong>Reddish yellow (7.5YR8/6) RAD RICH DIATOM Ooze.</strong></td>
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<td>5</td>
<td>Fe&gt;•Mn</td>
<td><strong>Reddish yellow (7.5YR8/6) RAD RICH DIATOM Ooze.</strong></td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>Fe&gt;•Mn</td>
<td><strong>Reddish yellow (7.5YR8/6) RAD RICH DIATOM Ooze.</strong></td>
</tr>
</tbody>
</table>

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**Explanatory notes in Chapter 1**
### Site 213 Hole Core 5 Cored Interval 37.5-47 m

**Lithologic Description**

- Reddish yellow (7.5YR7/5) RICH DIATOM OOZE, similar to core number 4, mottled with brown (7.5YR3/2) manganese Fe-oxide aggregate clay bearing rad rich diatom ooze.
- Most of the core is moderately disturbed and intermixing of sediment occur.
- The silicoflag. are more abundant than in previous cores (=5%).

### Site 213 Hole Core 6 Cored Interval 47-56.5 m

**Lithologic Description**

- Reddish yellow (7.5YR7/7) RICH DIATOM OOZE
- Diatoms 70%
- Rads 15-20%
- Clay 5%
- Spicules 2-5%
- Silicoflag. 2%
- Ash 1%
- Mottled with grayish brown MANGANESE BEARING CLAY RAD RICH DIATOM OOZE
- Diatoms 51%
- Rads 25%
- Clay 15%
- Mn°x 3%
- Glass 2%
- Others (Fe-oxide minerals) 4%
- Caused by disturbance (due to corer) most of the core is intermixed with reddish yellow and grayish brown sediment similar to above.
### Site 213 Hole Core 7

**Cored Interval:** 56.5-66 m

**Lithologic Description:**
- Reddish yellow (7.5YR7/7)
  - Diatoms: 51-56%
  - Clay: 15%
  - Silicoflag.: 2%
  - Spicules: 1%
  - Fe-oxide minerals: 2%
  - Feldspar: 1%
  - Glass: 1-3%
- Mottled with light olive brown (2.5Y5/4) ash-bearing clay rich diatom ooze.
  - Small patches enriched in manganese aggregates scattered throughout the core.
- A small pocket of white volcanic ash occur in Section 3 at 70 cm.

### Site 213 Hole Core 8

**Cored Interval:** 66-75.5 m

**Lithologic Description:**
- Medium dark brown (7.5YR4/2)
  - Sponge spicule rich diatom ooze.
  - Clay: 67%
  - Diatoms: 10%
  - Spicules: 10%
  - Glass: 2%
  - Zeolite: Tr.
- Mottled with light olive brown (2.5Y5/4) ash-bearing clay rich diatom ooze.
  - Small patches enriched in manganese aggregates scattered throughout the core.
  - A small pocket of white volcanic ash occur in Section 3 at 70 cm.
- This medium dark brown layer grades into a darker brown layer. The contact appears to be gradational.
  - Dark brown (7.5YR3/2) clay
    - Clay: 92%
    - Diatoms: 3%
    - Spicules: 2%
    - Glass: 1%
    - Zeolite: 1%
    - Mn oxn.
- Black streaks of manganese aggregate occur throughout Section 4.

### Explanatory Notes

- A patchy white peto of manganite ash
- X-ray at 64.10 m: Quartz 29, Plagioclase 19, K-feldspar 16, Mont 24
- X-ray at 74.20 m: Quartz 14, Feldspar 12, Plagioclase 11, K-feldspar 14, Mont 50

---

Explanatory notes in Chapter 1
Site 213 Hole Core 9 Cored Interval: 75.5-85 m

LITHOLOGIC DESCRIPTION

Dark brown (7.5YR3/2) CLAY
similar to the lower half of Core 8, grades towards a dark brown (7.5YR3/2) zeolite rich clay.

Dark brown (7.5YR3/2) ZEOLITE
Clay 82-84%
Rads 1-3%
Zeolite (Phillipsite) 3-10%
MnOx 1-2%
Fe-oxide minerals 1-3%
Glass 1%
Fe-oxide mineral shows oolitic shape (may be goethite ?)
The manganese aggregate content increase slightly with depth up to about 3%.

X-ray at 83.80 m Quar 13, Feld 11, Plag 6, Kaol 11, Mica 13, Mont 36, Phil 10

MANGANESE FE-OXIDE AGGREGATE
BEARING ZEOLITE CLAY
Clay 65-77%
Zeolite (Phillipsite) 1-3%
MnOx 1-3%
Fe-oxide minerals 3-10%
Rads 1-15%
Spinites 1%

There is a slight increase in Fe-oxide minerals with depth. These minerals are reddish yellow and have an oolitic shape (goethite ?).

X-ray at 88.70 m Quar 14, Plag 9, Kaol 14, Mica 5, Mont 37, Phil 10

Explanatory notes in Chapter 1
Site 213

Hole Corel2 Cored Interval: 94.5-104 m

LITHOLOGIC DESCRIPTION

Dusky yellow brown (10YR2/2) MANGANFSF BFARTNG ZEOLITE RICH CLAY
Clay 67-79%
Zeolite 15-25%
Mn°x aggregates 3-6%
Fe-oxide minerals 2%
Feldspar

The content of zeolite seems to be constant throughout the core.

X-ray at 99.70 m Quar 9, Feld 5, Plag 6, Kaol 4, Mica 7, Mont 15, Paly 14, Phil 38, Amph 1

Site 213

Hole Corel2 Cored Interval: 104-113.5 m

LITHOLOGIC DESCRIPTION

Dusky brown (5YR2/2) MANGANESE BEARING FE-OXIDE MINERAL and ZEOLITE RICH CLAY
Clay 59%
Zeolite 20%
Fe-oxide mineral (goethite ?) 15%
Feldspar

The content of zeolite seems to be constant throughout the core.

X-ray at 107.70 m Quar 9, Feld 5, Plag 6, Kaol 4, Mica 7, Mont 15, Paly 14, Phil 38, Amph 1
### Site 213 Hole Core 12 Cored Interval: 113.5-123 m

<table>
<thead>
<tr>
<th>Layer</th>
<th>Fossil</th>
<th>Character</th>
<th>Age</th>
<th>Sector</th>
<th>Lithology</th>
<th>LITHOLOGIC DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>1.0</td>
<td></td>
<td>Clay: 51-54%</td>
<td>Dusky brown (5YR3/2) MANGANESE FE-oxIDE MINERALS and ANGLIADENITE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Zeolite: 1-3%</td>
<td>Clay 73-84%, Zeolite 3-10%, Fe-oxide minerals (goethite?) 13-20%</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Glass Tr.</td>
<td>The iron oxide minerals are reddish yellow, with high relief, opaque and oolitic shaped (goethite?).</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>The main type of zeolite is philipsite.</td>
</tr>
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<td></td>
<td>The zeolite content decreases with depth in the core. In Section 6 there is only about 3-4% zeolite.</td>
</tr>
</tbody>
</table>

X-ray at 117.20 m: Quar 10, Feld 20, Mica 7, Mont 5, Paly 20, Phil 47

### Site 213 Hole Core 14 Cored Interval: 123-132.5 m

<table>
<thead>
<tr>
<th>Layer</th>
<th>Fossil</th>
<th>Character</th>
<th>Age</th>
<th>Sector</th>
<th>Lithology</th>
<th>LITHOLOGIC DESCRIPTION</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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<td>1.0</td>
<td></td>
<td>Clay: 62%</td>
<td>Light brown (5YR3/6) FE-oxide mineral rich clay</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>Zeolite: 30%</td>
<td>Clay 70%, Fe-oxide minerals 30%, Name 10%, Rads 3%</td>
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<td>Transitional contact.</td>
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<td>Moderate brown (5YR3/4) MANGANESE BEARING FE-oxide mineral clay</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Clay 70%, Fe-oxide: 35%, Name: 3%, Rads: 12</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Interbedded with moderate yellowish brown (10YR5/4) CLAY BEARING NANNO Ooze and becoming less clayey with depth.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Name: 70-85%, Clay: 10-25%, Rads: 12, Name: 2-15, Fe-oxide &lt;2%, Mica &lt;2%, Calcite: 1-3%</td>
</tr>
</tbody>
</table>

X-ray at 125.20 m: Quar 13, Feld 25, Mica 13, Mont 10, Paly 35

### Explanatory Notes

Explanatory notes in Chapter 1
**Cored Interval:** 132.5-142 m

**Site 213**

**LITHOLOGIC DESCRIPTION**

**FOSSIL CHARACTER**

**1.0 -**

**LITHOLOGIC DESCRIPTION**

Moderate brown (5YR3/4) NANN Videos containing Fe-oxide mineral rich clay similar to Core number 14.

In Section 2 this sediment is intermixed (due to coring process) with moderate yellowish brown (10YR5/4) clay bearing nanno ooze.

Yellow (2.5Y7/6) CLAY BEARING NANN Videos

Nanno 85%
Foraminifera 10%  
Rods 5%  
Foraminifera 5%  
Calcite 2%

Interbedded with moderate brown (5YR3/4) nanno bearing Fe-oxide mineral rich clay similar to Core number 14.

Burrow mottled.

Yellow (2.5Y7/6) CLAY BEARING NANN Videos

Nanno 98%
Foraminifera 2%  
Authentic carbon 3%
Clay 10%

**Interbedded with moderate brown (5YR3/4) nanno bearing Fe-oxide mineral rich clay similar to Core number 14. Burrow mottled.**

**Grayish brown (5YR3/2) CLAY RICH IRON OXIDE SEDIMENT**

Clay 9%
Iron ore 80-85%
Nanno 1-3%
Authentic carbon 0-2%

X-ray at 144.60 m Calc 100  
Calc 12, Quar 11, Feld 16, Kaol 4,  
Mont 3, Paly 64

**Grayish brown (5YR3/2) CLAY BEARING NANN Videos”**

Limonitic aggregates and manganese comprise about 40%, oolitic Fe-oxide 45%, clay 9%, and nanno 3%.

Explanatory notes in Chapter 1
**FOSSIL CHARACTER**

**Core Catcher**

**LITHOLOGIC DESCRIPTION**

- 2.5 m gap between the basalt and the above cored sediment.
- The first rock fragments near the top were coated with nanno ooze. (a) light brown (5YR5/6)
- WEATHERED BASALT, phenocrysts of Plagioclase are set into a fine grained weathered matrix. This zone grades into a more glassy area.
- (b) BASALTIC GLASS rimed with a palagonite crust
- (c) light olive gray (5Y6/1) partially WEATHERED PORPHYRITIC BASALT.

**General mineralogy:**
- Dark mesostones 40%
- Plag. phen. 1%
- Plag. microphen. 2%
- Plag. laths (intermediate size)

**Thin sect, at Section 2, 80 cm:**
- Plag. microHtes
- Skeletal pyrox.
- Palagonite
- Olivine outlined phenocrysts
- Calcite

**Cored Interval: 159.5-163 m**

- (a) Light brown (5YR5/6)
- WEATHERED BASALT.
- (b) BASALTIC GLASS partially PALAGONITIZED.
- (c) Light olive gray (5Y6/1) coarse grained BASALT.

**General texture:** subophitic. The interstices of Plagioclase are filled with granules of pyroxene, silicoflag. aggregates and iron oxide minerals.

**This zone appears to be coarser grained and more crystalline than Core number 17 Section 2.**

Explanatory notes in Chapter 1