3. SITE 587: LANSDOWNE BANK, SOUTHWEST PACIFIC

Shipboard Scientific Party

HOLE 587

Date occupied: 3 December 1982
Date departed: 5 December 1982
Time on hole: 40 hr.
Position: 21°11.087'S; 161°19.99'E
Water depth (sea level; corrected m, echo-sounding): 1101
Water depth (rig floor; corrected m, echo-sounding): 1111
Bottom felt (m, drill pipe): 1115
Penetration (m): 147
Numbers of cores: 17
Total length of cored section (m): 147 (89.5 in Pliocene)
Total core recovered (m): 88.81 (80.95 in Pliocene)
Core recovery (%): 60.4 (59.4 in Pliocene)
Oldest sediment cored:
Depth sub-bottom (m): 115
Nature: Calcareous sandstone
Age: Probably late Miocene
Basement: Not reached

Principal results: Site 587 is located on the southern slope of Lansdowne Bank in the southwest Pacific at 21° S, 161° E. At this site the hydraulic piston corer penetrated 147 m into the upper Miocene, with good recovery only in the Pliocene. The section consists of one major lithofacies, a foraminifer-bearing nannofossil ooze to foraminifer-nannofossil ooze, interbedded with minor lithofacies of coarse-grained sediment consisting of skeletal silty sands to skeletal sandy gravels. The coarse sediment facies consists of redeposited sediments of shallow-water origin, especially corals, calcareous algae, bryozoan, and shallow-water foraminifers from the photic zone. These sediments were probably deposited during low stands of sea level.

Three successful in situ temperature measurements provide a linear temperature profile with depth, details of which are provided in Morin (this volume).

BACKGROUND AND OBJECTIVES:
LANSDOWNE BANK, SOUTHWEST PACIFIC

Site 587 is located on the southern slope of the Lansdowne Bank (Fig. 1) which represents the most northern part of Lord Howe Rise. Lansdowne Bank lies between Lord Howe Basin to the west and New Caledonia Basin to the east. The bank rises to a present-day water depth of only 100 m and the crest lies within the photic zone (Launay et al., 1977; Ravenne et al., 1977).

Site 587 was selected in order to obtain an uncomplicated, high-resolution calcium carbonate sedimentary record of Neogene and late Paleogene age in an area between the warm subtropics and the equator. This location was chosen because it lies close to the edge of the true tropics at 21°S, is in shallow depths (1100 m) to guarantee a calcareous pelagic sedimentary section and should provide an apparently uncomplicated stratigraphic sequence with no major terrigenous sedimentary input. However, during the selection process for Site 587, it was discovered that few shallow-water features exist at about 20°S in the southwest Pacific that might provide the kind of sequence of interest. The flanks of Lansdowne Bank exhibit a source of high-amplitude reflections in the upper part (0.4 s) of the section (Fig. 2) which, it was thought, might represent calcareous sediments transported from the shallow waters at the crest of the bank. Because of this, the site was considered to

Figure 1. Regional bathymetry (fathoms) around Site 587, after Mannerick et al. (1974) Glomar Challenger Leg 90 track shown; heavy portion locates water gun seismic profile illustrated in Fig. 2.
be suboptimal, but other areas at these latitudes seemed to be no less complicated.

The specific objectives at Site 587 were to obtain a continuous section through calcareous oozes of late Oligocene and Neogene age near the edge of the tropics. A stratigraphic linkage section was required between two previously drilled sites of high biostratigraphic quality, Site 289 (and 586) on the equator and Site 208 (and 588) at 26°S in warm subtropics. There was particular interest in establishing a biostratigraphic sequence at about 20°S to assist with stratigraphic correlations between the equator and the warm subtropics and to monitor paleo-oceanographic oscillations of the tropical and warm subtropical surface water masses over the region. Approaches to be employed included stable isotope analysis (δ¹⁸O and δ¹³C), qualitative and quantitative biostratigraphy, sedimentology, and magnetostratigraphy.

To meet these objectives the plan was to recover two hydraulic piston core (HPC) sections and a rotary-drilled section below the point at which the HPC became unusable.

**OPERATIONS**

**Noumea to Site 587**

The last mooring line was cast off from the Passenger Terminal in Noumea, New Caledonia at 1620 hr. on 2 December 1982, and the *Glomar Challenger* cleared the barrier reef bordering New Caledonia's southwest coast at 2042 hr. after having tested thrusters. Aboard were the normal complement of 45 Global Marine, Inc., personnel plus 28 technical staff and scientists.

Routine geophysical data were collected under way to Site 587 (SW-8), using a 12-kHz echo sounder, a 3.5-kHz reflection profiler, a magnetometer, and a water gun seismic profiling system. The water gun system, incorporating a MICA T model water gun of Seismic Systems, Inc. (80 cu. in. air requirement per shot) was a relatively new addition to *Glomar Challenger*'s suite of underway geophysical equipment, and was used in place of the standard 60 and 120 cu. in. air guns. Records obtained by the water gun appeared superior to those obtained using the air guns, with excellent penetration (in excess of 1 s two-way traveltime), a subdued bubble-pulse, and resolution of fine sub-bottom reflectors.

The few seismic profiles which were available for site selection at Site 587 indicated simple Neogene stratigraphy and sub-bottom structure over a relatively broad area around the proposed location. Because of this, and because the major objective of drilling this site was to core the Neogene section, a presite survey was considered unnecessary. Consequently, the Elf-Aquitaine multichannel seismic Line WNC 109 (used for initial site selection) was intersected by the track of *Glomar Challenger* some 14 n. mi. southeast of the proposed drill site. Seismic Line WNC 109 then was followed to the site.

The ship averaged 10.6 knots for the 170.2 mi. transit, aided by favorable weather and currents.

The first of two positioning beacons was launched on the first pass at 2243 hr., 3 December 1982. A second beacon was required when the first proved to be too erratic for automatic positioning.

**Site 587 (SW-8); South of Lansdowne Bank, Northern Lord Howe Rise**

A special bottom-hole assembly (BHA) was assembled and checked for spacing to accommodate the latest version of the extended core barrel (XCB), a through-the-bit rotary coring tool, which was being deployed for the first time since Leg 84. The BHA was also configured to accommodate the conventional variable length HPC (VLHPC). By this means, piston coring to refusal could be followed immediately by rotary (XCB) coring to the objective without a pipe round trip to change bits. Hole 587 was spudded at 1355 hr., 4 December 1982 with a mud line VLHPC core containing 3.1 m of calcareous ooze (Table 1). Drill pipe measured (DPM) depth of 1115 m from the rig floor reference elevation proved to be 4 m greater than the depth measured by the precision depth recorder (PDR).

All appeared well until Core 2 came up empty, apparently because the core catcher failed. Because the BHA was so near the mud line, a second shot was taken at Core 2, but very little core was recovered because of a mechanical failure in the VLHPC. This was quickly rec-
The pipe was tripped and the vessel got under way that only minimal scientific data were likely to be acquired. The hydraulic piston corer to a total sub-bottom depth for Site 588 at 1505 hr., 6 December 1982. Returns, especially in view of higher priorities at future sequence experienced severe coring disturbance. The recovery of good cores. The ooze is soft at the top of the sequence, becomes stiff by about 50 m sub-bottom, and by 90 m sub-bottom clasts of chalk occur. The major lithofacies a is interbedded with a coarse-grained lithofacies b which consists of skeletal silty sands to skeletal sandy gravels. These interbeds are yellow gray and, less commonly, pinkish gray. The yellow gray color is distinctive and is principally derived from coarser silt, sand, and gravel-sized skeletal tests and fragments of planktonic and benthic foraminifers, calcareous red and green algae (including Halimeda), corals, bryozoans, and echinoid spines, as well as abundant, fine, indeterminate biogenic detritus and common skeletal carbonate lithoclasts (Fig. 4). The interbeds are massive or normally graded, subtly in the finer-grained deposits, and are typically less than 1 to 2 m thick. Clasts and irregular or disrupted layers of the foraminifer-bearing nannofossil ooze (or chalk) occur sporadically throughout the interbeds.

The occurrence of normal grading and shallow-marine biogenic detritus in the interbeds indicates that they are reworked beds. However, interpretation is complicated by the fact that most of the skeletal debris occurs at or near the tops of cores, which may mean that some of these interbeds represent contamination from wash and cave-in during coring. Presumably, this material could be from the topmost 6 m of seabed, because Cores 587-1 and 587-2 are dominated by a disturbed sequence of coarse skeletal hashes of Pleistocene age (nannofossil Zone NN21).

Late Miocene chalk clasts and layers in Core 587-11 (89.5 to 99.1 m sub-bottom) appear to be stratigraphically in situ and represent episodes of sediment redeposition. The clasts are nannofossil-bearing chalks and include longer-ranging Neogene nannofossils and poorly preserved Cretaceous and Paleogene specimens (Table 2). The paleontologic evidence suggests reworking of the pre-Neogene nannofossils into an earlier Miocene ooze that subsequently became partially lithified, eroded, and redeposited into the late Miocene sequence. The chalk clast

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Table 1. Coring Summary, Site 587.

<table>
<thead>
<tr>
<th>Core no.</th>
<th>Date (Dec. 1982)</th>
<th>Time</th>
<th>Depth from drill floor (m)</th>
<th>Depth below seafloor (m)</th>
<th>Length recovered (m)</th>
<th>Percentage recovered</th>
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<td>1</td>
<td>1445</td>
<td>1151.1</td>
<td>0.0-3.1</td>
<td>3.1</td>
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<td>100</td>
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<td>2</td>
<td>1800</td>
<td>1182.7</td>
<td>1.1-12.7</td>
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<td>9.6</td>
<td>95</td>
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<td>3</td>
<td>1850</td>
<td>1138.7</td>
<td>12.7-23.2</td>
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<td>91</td>
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<td>31.9-41.5</td>
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<td>9.8</td>
<td>95</td>
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<td>41.5-51.1</td>
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<td>91</td>
</tr>
<tr>
<td>7</td>
<td>2225</td>
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<td>92</td>
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<td>2305</td>
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<td>92</td>
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<tr>
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<td>80.9-90.6</td>
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<td>92</td>
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<td>2424</td>
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<td>90.6-100.0</td>
<td>100.0</td>
<td>9.6</td>
<td>92</td>
</tr>
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<td>100.0-110.5</td>
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<td>2451</td>
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<td>110.5-120.4</td>
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<td>9.6</td>
<td>92</td>
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<td>2554</td>
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<td>92</td>
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<td>150.5-160.1</td>
<td>160.1</td>
<td>9.6</td>
<td>92</td>
</tr>
</tbody>
</table>

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Neogene nannofossils into an earlier Miocene ooze that are interbedded throughout the length of the section.
layers may, in fact, be the coarse basal portion of proximal turbidites in which the finer portions are the skeletal, muddy, fine sands.

PHYSICAL PROPERTIES

The physical properties program for Site 587 consisted of employing gravimetric and gamma-ray attenuation techniques (Boyce, 1976) to determine wet-bulk density, porosity, and grain density throughout the sediment column. Carbonate content and thermal conductivity were also measured as functions of depth (see Explanatory Notes for details of methods). Plans to measure sonic velocity and to obtain specimens for shore-based permeability tests from a second hole were abandoned since coring of the adjacent hole was cancelled.

The GRAPE provides measurements of wet-bulk density versus depth. The distinct values (points) are averaged across each meter and plotted as a solid line (Fig. 5A). A grain density estimate of 2.691 g/cm$^3$ is used to convert sediment wet-bulk density to porosity. Since the carbonate content at this site is very high, never dropping below 90% (Fig. 5B), this conversion factor provides a reasonable estimation of porosity profile (Fig. 5C). A gradual decrease in porosity with depth and corresponding lithostatic load is evident. A transition from ooze to chalk was not reached, however, over the 89 m of core recovered. The physical properties for Site 587 are reported in detail by Morin (this volume).

SEISMIC STRATIGRAPHY

Figure 6 illustrates a portion of the shipboard water gun seismic profile collected during the approach to Site 587. Three acoustic units have been identified (A, B, C).
Figure 4. Photomicrographs of typical shallow-marine carbonate components in the redeposited coarse-grained sediment facies at Site 587. Plane polarized light, bar scale 1 mm. A. Dark *Halimeda* grains, lighter coral fragments, and large benthic foraminifers in Sample 587-1-2, 65-67 cm. B. Abraded grains of calcareous red and green algae, and bryozoan, coral, benthic foraminiferal, and irregular carbonate lithoclast material in 587-13,CC. C. Large bryozoan and dark *Halimeda*, coral, and benthic foraminiferal material in 587-13,CC. D. Irregular carbonate lithoclasts of skeletal packstone and wackestone in 587-13,CC.

Table 2. Some nannofossil species associated with chalk chunks from Section 587-11-1.

<table>
<thead>
<tr>
<th>Species</th>
<th>Abundance</th>
<th>Preservation</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coccolith sp. (small)</td>
<td>Common</td>
<td>Fair</td>
<td>Cenozoic</td>
</tr>
<tr>
<td>Coccolithus pelagicus</td>
<td>Few</td>
<td>Fair-poor</td>
<td>Neogene</td>
</tr>
<tr>
<td>Reticulofenestra pseudoumbilica</td>
<td>Rare</td>
<td>Fair</td>
<td>Neogene</td>
</tr>
<tr>
<td>Pentacolpites sp.</td>
<td>Rare</td>
<td>Poor</td>
<td>Cenozoic</td>
</tr>
<tr>
<td>Discocystis brouweri</td>
<td>Rare</td>
<td>Poor</td>
<td>Neogene</td>
</tr>
<tr>
<td>Helicosphaera carteri</td>
<td>Rare</td>
<td>Poor</td>
<td>Neogene</td>
</tr>
<tr>
<td>Sphenolithus abies</td>
<td>Rare</td>
<td>Fair</td>
<td>Neogene</td>
</tr>
<tr>
<td>Dictyococcites sp. cf. D. scrippsi</td>
<td>Few</td>
<td>Fair-poor</td>
<td>Paleogene</td>
</tr>
<tr>
<td>Scyphosphaera intermedia</td>
<td>Rare</td>
<td>Very poor</td>
<td>Cenozoic</td>
</tr>
<tr>
<td>Eiffelliithus turrisseiffi</td>
<td>Rare</td>
<td>Very poor</td>
<td>Cretaceous</td>
</tr>
<tr>
<td>Watznaueria barnesae</td>
<td>Rare</td>
<td>Very poor</td>
<td>Cretaceous</td>
</tr>
<tr>
<td>Arkhangelskiiella cymbiformis</td>
<td>Rare</td>
<td>Very poor</td>
<td>Cretaceous</td>
</tr>
</tbody>
</table>

and C). These are compared in part with the lithology of the site (Lithostratigraphic Unit I).

Acoustic Unit A is acoustically well stratified, characterized by relatively high amplitude and locally relatively coherent reflectors. The uppermost zone, in the region below the reflected wave-form down to 0.1 s, is slightly more transparent than the underlying portion of Unit A. This upper zone also exhibits a possible buried channel adjacent to the drill site, and the sediment surface is dissected by an unfilled channel several miles to the east (Fig. 6). A diffuse zone of greater transparency is evident between 0.2 and 0.26 s sub-bottom. The lower boundary of Unit A grades down into Unit B.

Acoustic Unit B is more transparent than Unit A. The upper zone (0.325–0.45 s) is characterized by diffuse, noncoherent reflectors. Between 0.45 and 0.55 s sub-bottom, a well-defined transparent zone is evident.

Acoustic Unit C is separated from B by the uppermost of a series of strong, coherent reflectors which con-

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3 Depths quoted in text as seconds below seafloor have been measured below Site 587.
Figure 5. Physical properties versus sub-bottom depth for Site 587. A. GRAPE wet-bulk density. B. Carbonate content. C. GRAPE porosity.

constitute Unit C. Unit C at Site 587 continues below the limit of the figure.

Site 587 was drilled to a total depth of 147 m, within the uppermost portion of seismic Unit A. It comprises a single lithological unit (Unit I) of late Miocene to recent age, characterized by interbedded foraminifer-bearing to foraminifer-nannofossil ooze and skeletal sands to skeletal sandy gravels. The skeletal sands and gravels are re-worked, perhaps as debris flows or turbidites from neighboring shallow banks. This coarse-grained facies appears to dominate the section in Cores 587-1 and 587-2 (Pleistocene) and from the lower portion of Core 587-10 at least through Core 587-11 (NN11, late Miocene). Below Core 587-12 to the bottom of the hole at Core 587-17 recovery was essentially zero, suggesting the presence of additional sand- and gravel-rich sections.

Correlation of the seismic and lithologic data suggests that the upper bioclastic sections (Cores 587-1 and 587-2) are genetically associated with the surficial and buried channels shown on Figure 6. These channels are probably Pleistocene features caused by episodes of re-deposition during periods of low sea level. The zone of almost 100% core recovery in the calcareous-ooze-rich sequence (Cores 587-3 through 587-10, with the exception of 587-9) may correlate with the relatively transparent upper zone of seismic Unit A. The lower portion of the sequence (lowermost Core 587-10, possibly through 587-17) may correlate with the uppermost acoustically stratified portion of seismic Unit A, approximately 0.1 s sub-bottom.

**BIOSTRATIGRAPHY**

The preservation of planktonic foraminifers is reasonably good in the Pliocene-Pleistocene but deteriorates rapidly in the late Miocene; the faunal yield is disappointing, especially in the Pliocene and late Miocene, where zonal indicators are either absent or present only in low numbers. Benthic foraminiferal faunas are found to be mixtures of allochthonous and autochthonous species.

The sedimentation rate of sediments in the Pliocene and late Miocene was 24.5 m/m.y., decreasing up-section to 16.6 m/m.y. in the Quaternary.

The calcareous nannoplankton are abundant and moderately well preserved in the Quaternary through to the upper part of the late Miocene, but preservation and numbers deteriorate throughout the remainder of the late Miocene. No radiolarians, diatoms, or silicoflagellates were found in the smear slides.

Fish otoliths were recovered in Cores 1 to 3. Microfossil preservation was very poor in Core 3.

Calcareous nannoplankton zones and planktonic foraminiferal zones are correlated in Figure 7.

Foraminifers

**Planktonic Foraminifers**

The planktonic foraminifers from the 13 sediment cores containing material at this site represent a section from Pleistocene to upper Miocene. Only the fossils in the Pleistocene and Pliocene sediments are well preserved. Numbers and preservation of the planktonic foraminifers both deteriorate downward in the upper Miocene. The Neogene sequence at this site contains a mixture of tropical and temperate planktonic foraminiferal elements, providing a link between those of the tropical Site 586 (289) and the cooler water faunas of the sites drilled further south (Site 588, 590, 591, 592, 593, and 594).

A detailed analysis of the faunas reveals that Blow's (1969) zonal scheme cannot be used for the site because of the scarcity of index planktonic foraminifers in the
Pleistocene and Pliocene sequence. Tropical elements dominate in the late Miocene, whereas temperate elements dominate in the Pliocene–Pleistocene sequence, although many tropical elements persist. Thus, biostratigraphic subdivision of the late Miocene requires use of the tropical zones (Srinivasan and Kennett, 1981a), whereas the Pliocene–Pleistocene sequence requires the use of the temperate zones of Kennett (1973). The zonal scheme employed at the site is shown in Figure 7. The *Globorotalia truncatulinoides* Zone in Sample 587-1-1, 5–6 cm through 587-3-2, 19–20 cm yielded a well-preserved, highly diverse fauna which includes the zone fossil, *G. truncatulinoides*, *Pulvinatina obliquiloculata*, *G. tumida*, and *G. inflata*. Reworked Pliocene foraminifers are detectable in 587-1,CC and in other samples.

Samples 587-3-3, 19–20 cm through 587-4,CC yielded faunas of *Globorotalia truncatulinoides*–*G. tosaensis* overlap Zone, which yielded the zone fossils, *G. truncatulinoides*, *G. tosaensis*, *G. menardii*, and *Sphaeroidinella dehiscens*. In the lower part of the zone *Globigerinoides fistulosus*, a late Pliocene index form, occurs in association with *Globorotalia truncatulinoides*.

The *G. tosaensis* Zone in Sample 587-5-1, 114–115 cm through 587-5-4, 90–91 cm yielded the zone fossil in a highly diverse fauna, which also includes *P. obliquiloculata*, *G. menardii*, *G. inflata*, *G. puncuticulata*, *G. crassafornis*, and rare *Globigerinoides fistulosus*.

Planktonic foraminiferal determinations place the Pleistocene/Pliocene boundary between Samples 587-4,CC and 587-5-1, 114–115 cm. The boundary is drawn at the first evolutionary appearance of *Globorotalia truncatulinoides*.

The *G. inflata* Zone, from Sample 587-5-5, 80–81 cm through 587-5,CC, yielded a nicely preserved, well-diversified fauna, which includes the zone fossil, *G. menardii*, *G. multicamerata*, *G. crassafornis*, *G. tumida*, and *P. obliquiloculata*.

The *G. crassafornis* Zone, which was identified in Sample 587-6-1, 85–86 cm through 587-6-3, 89–90 cm, yielded a rich fauna. *Globigerina nepenthes* and *Globorotalia* cf. *miotumida* make their last appearance in the lower part, and *G. margaritae* is present in the upper part of the zone. The first appearance of *S. dehiscens* is in the upper part of the zone, and is much later than at the tropical Site 289 (Kennett, 1973; Srinivasan and Kennett, 1981a,b).

Samples 587-6-4, 85–86 cm through 587-6-5, 85–86 cm yielded faunas of the *Globorotalia puncuticulata* Zone, which include the zone fossil, *P. primalis*, *G. cf. miotumida*, *G. tumida tumida*, *G. menardii*, and *G. multica merata*. The base of the zone is marked by the first appearance of *G. puncuticulata*. As was true for the warm subtropical sites, the evolutionary bioseries is not represented.
The Globorotalia marginata Zone was identified in Sample 587-6-6, 53-56 cm and 587-6-6, 124-125 cm; it yields the zone fossil in association with G. cf. miotumida, G. tumida tumida, and P. primalis.

The Globorotalia tumida Zone (= N18) is represented in Samples 587-6-7, 11-12 cm through 587-6-CC, which yielded an excellent fauna including the zone fossil, Globigerina nepenthes, Globorotalia menardii, Dentoglobigerina altispira, and P. primalis.

The Miocene/Pliocene boundary is placed between Samples 587-6-CC and 587-7-1, 59-60 cm; it is drawn at the first evolutionary appearance of Globorotalia tumida tumida.

The Pulletiina primalis Zone (= N17B) is recorded from Sample 587-7-1, 59-60 cm through 587-8-4, 70-71 cm which again yielded reasonable faunas, including the zone fossil, G. miotumida, Orbulina bilobata, G. plesirotumida, Neogloboquadrina acostaensis, and G. cibaoensis.

G. plesirotumida Zone (= N17a) is represented in the interval from Samples 587-8-5, 70-71 cm through 587-13,CC. The faunas in these samples besides the zone fossil, include G. miotumida, G. multicornata, Globigerina nepenthes, and N. acostaensis. Candeina nitida makes its first appearance in Sample 587-10-6, 17-18 cm, and Globorhopalina gehirsens makes its last appearance within the zone (Sample 587-10-5, 17-18 cm).

**Benthic Foraminifers**

Benthic foraminifers were examined in core-catcher Samples 587-1-9,CC and 587-10-13,CC from the fraction of the sediment greater than 63 µm. Each fauna contains an allochthonous and an autochthonous element; the allochthonous benthics are considered to be derived from a carbonate platform back-reef to beach environment.

Allochthonous benthic foraminifers and some other invertebrates are most common in Cores 587-1 through 587-3 and 587-10 through 587-13, in which few if any bathyal species are present. Typical constituents of this element are bryozoa, heavily spinose ostracodes, numerous miliolids including ornamented quinqueloculinds, and Articulina scrobiculata, Tretomphalus pacificus, Uvigerina porrecta, Elphidium macellum, E. crispum, and E. cf. advenum, Amphistegina sp., Cymbaloporella sp., and several larger benthic genera. Considering the amount of carbonate debris in each core-catcher sample, it appears that the depositional mode changed from the Miocene (Cores 587-10 through 587-13), characterized by large, pure shallow-water deposits, to the upper Pliocene-Pleistocene (Cores 587-5 through 587-1), which is characterized by redeposited shallow-water elements within marl deposit.

Miocene faunas (Cores 587-7 through 587-9) include Laticarinina bullbrooki, Uvigerina auberiana, Cibicidoides bradyi, Osangularia culter, Gyroidinoides nitidula, Buliminina alazanensis, and Robulus nicobarenensis, as well as many long-ranging species listed below in the discussion about the Quaternary.

Within the Pliocene (Cores 587-5 and 587-6), faunas can be differentiated into glacial (Core 587-5) and preglacial (Core 587-6). Faunas of Core 587-5 resemble those of the Pleistocene, except that they are rarer and more difficult to separate from the chalky matrix. The preglacial faunas of Core 587-6 contain taxa typical of the Miocene at this site; several of them, such as Rectuvigerina multispira, Bolivina subaenariensis, C. cucumisus, and Heterolepa kullenbergi, do not range above Core 587-6.

Quaternary autochthonous faunas (Core 587-1 through Sample 587-4,CC) contain many long-ranging, cosmopolitan species such as Karreriella bradyi, Globocassidulina subglobosa, Cibicides wuellerstorfi, Cassidulina crassa, Sigmoilopsis schuhmbergeri, Stilostomella lepidula, U. hispida, Bulliminina striata, and Ehrenbergina pacifica. Species are considered to be autochthonous if they are common in Cores 587-7 through 587-9, which contain much less evidence of redeposited carbonates, if they appear consistently in sediments from the deeper Site 586, and if they are known from the bathyal zone in others areas.

Comparison of the faunas at Site 586 (closer to 2200 m) and Site 587 (1101 m) indicate that the following species are restricted to the shallower site: R. multispira, Robulus nicobarenensis, E. pacifica, S. raphanus, U. nitidu-
la, and O. culter, Osangularia bengalensis, B. pusilla, Sphaeroidina bulloides, Pollenia quinquelsoba, among others, were found at the deeper Site 586, but not at Site 587.

Calcareous Nannoplankton

Samples from Cores 1 through 9 contain abundant moderately to well-preserved nannoplankton. Samples below 587-10,CC contain rare to few poorly preserved nannoplankton. The boundary between NN21 and NN20 was not observed, but all other zones down to NN11a are present.

Pliocene

The presence of Emiliania huxleyi in Samples 587-1-1, 4-5 cm to 587-3-3, 20-21 cm places these samples in the late Pliocene Emiliania huxleyi Zone (NN21). The rare occurrence of Discoaster brouweri, D. pentaradiatus, and Ceratolithus rugosus in Sample 587-1,CC is interpreted as reworked late Pliocene. The presence of E. ovata and the absence of Calcidiscus macintyrei in Samples 587-3-4, 20-21 cm to 587-4-4, 4-5 cm places these samples in the upper subzone of the early Pliocene Emiliania ovata Zone (NN19b). The absence of Gephyrocapsa oceanica Zone (NN20) may be present between Samples 587-3-3, 20-21 cm and 587-3-4, 20-21 cm. The presence of E. ovata and C. macintyrei in Sample 587-4-5, 4-5 cm places this sample in the lower subzone in the E. ovata Zone (NN19a).

Pliocene

The presence of Discoaster brouweri and absence of D. pentaradiatus in Sample 587-4-6, 4-5 cm place this sample in the late Pliocene Discoaster brouweri Zone (NN18). Sample 587-4,CC contains D. pentaradiatus with D. brouweri, placing it in the late Pliocene D. pentaradiatus Zone (NN17). The last occurrence of D. surculus in Sample 587-5-1, 106-107 cm places Samples 587-5-1, 106-107 cm to 587-5-5, 4-5 cm in the late Pliocene D. surculus Zone (NN16).

The presence of Reticulofenestra pseudoumbilica and the absence of Amaurolithus tricorniculatus in Samples 587-5-6, 4-5 cm to 587-6-4, 4-5 cm place these samples in the early Pliocene Reticulofenestra pseudoumbilica Zone (NN15). Samples 587-6-5, 4-5 cm to 587-7-1, 4-5 cm contain A. tricorniculatus together with D. asymmetricus, which places these samples in the early Pliocene D. asymmetricus Zone (NN14). The presence of Ceratolithus rugosus and the absence of D. asymmetricus in Samples 587-7-2, 4-5 cm to 587-7-3, 4-5 cm place this interval in the early Pliocene Ceratolithus rugosus Zone (NN13). The absence of C. rugosus in Sample 587-7-4, 4-5 cm places this sample in the early Pliocene Amaurolithus tricorniculatus Zone (NN12).

Mioocene

Samples 587-7-5, 4-5 cm to 587-10-1, 12-13 cm contain Discoaster quinquergamus along with A. primus, which places the samples in the upper subzone of the late Miocene Discoaster quinquergamus Zone (NN11b).

Samples 587-10,CC and 587-11,CC are recrystallized and cannot be assigned an age. Sample 587-16,CC is composed of a yellow and a gray fraction. The gray fraction is interpreted as downhole caving from lower Pleis-
Calcareous nannofossils nearly always make up more than 50% of the pelagic facies, whereas foraminifers mostly vary between 5 and 50%. Detrital minerals are almost completely lacking. The ooze is soft at the top of the sequence and becomes stiff by about 50 m sub-bottom; by 90 m there occur clasts of indurated chalk.

The coarse sediment facies is formed of redeposited sediments of shallow-water origin, especially corals, calcareous algae, bryozoans, and shallow-water foraminifers from the photic zone of nearby banks. A majority of these particles exhibit surface wear, which probably occurred in shallow water and before redeposition. The interbeds are massive or normally graded and are typically less than 1 to 2 m thick. A few of these layers are found at the tops of cores and thus may represent contamination from wash and caving during coring, presumably from the Quaternary sands. The upper Miocene coarse layers appear to be in place.

Because the coarser redeposited facies occurs in the late Quaternary and probably the late Miocene, which are times of sea level regression, it is suggested that sediment gravity flows or turbidity currents were locally stimulated at times of low sea level stands. The sedimentation rate for the Pliocene was 10.4 m/m.y., increasing to 16.6 m/m.y. during the Quaternary. The relatively low rate during the Quaternary is surprising considering the coarser biologic sediment facies. One possible explanation for this could be channeling and localized erosion of sediments by turbidity currents, as suggested by nearby channel structures observed on the seismic profile (see Seismic Stratigraphy). The zone of almost 100% core recovery in the carbonate-ooze-rich sequence is inferred to correlate with an upper, relatively transparent zone of seismic Unit A. The lower sand-rich part of the sequence may correlate with a further acoustically stratified section of Unit A.

Three successful heat flow measurements provide a linear temperature profile of 5.47°C/100 m.

REFERENCES


Date of Acceptance: 1 December 1983

Figure 9. Summary lithology, biostratigraphy, and calcium carbonate percentages for Site 587.
LITHOLOGIC DESCRIPTION

SKELETAL SANDY FORAMINIFER NANNOFOSSIL OOZE, pinkish gray (5YR 8/1), soft to waxy, matrix with reddish shallow marine skeletal fragments. Disturbed by coring.

SKELETAL SILTY SAND TO SKELETAL SANDY GRAVEL, yellowish gray (5YR 8/1) to pinkish gray (5YR 8/1), soft to firm, massive to graded. Normal grading may be from core disturbance. Shallow marine skeletal fragments include coral, green algal, and large foraminifers.

FORAMINIFER-BEARING NANNOFOSSIL OOZE TO FORAMINIFER NANNOFOSSIL OOZE, very light gray (N8) to white (N9), soft, with disrupted pyritized laminae and blebs, rare burrows and chemical diffusion bands.

SMEAR SLIDE SUMMARY:

<table>
<thead>
<tr>
<th>Section</th>
<th>Clay</th>
<th>Composito</th>
<th>FAC</th>
<th>ROC</th>
<th>JNIT</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core 1</td>
<td>1.0</td>
<td>3.0</td>
<td>0.5</td>
<td>1.0</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>Core 2</td>
<td>1.0</td>
<td>3.0</td>
<td>0.5</td>
<td>1.0</td>
<td>0.5</td>
<td>1</td>
</tr>
</tbody>
</table>

TEXT:

- Text:
  - Sand
  - Clay
  - Carbonate ooze
  - Foraminifers
  - Calc. nannofossils

- Composition:
  - Calcite
  - Clay
  - Carbonate ooze
  - Foraminifers
  - Calc. nannofossils

- Section:
  - Core 1
  - Core 2

GRAPHIC LITHOLOGY:

- Core 1
- Core 2

LITHOLOGIC DESCRIPTION

SKELETAL SILTY SAND TO SKELETAL SANDY GRAVEL, yellowish gray (5YR 8/1), soft to firm, massive to graded. Better may be from core disturbance. Includes shallow marine skeletal fragments.

FORAMINIFER-BEARING NANNOFOSSIL OOZE TO FORAMINIFER NANNOFOSSIL OOZE, very light gray (N8) to white (N9), soft, with disrupted pyritized laminae and blebs, rare burrows and chemical diffusion bands.

NANNOFOSSIL BEARING FORAMINIFER OOZE, yellowish gray (5YR 8/1), soft, matrix includes chunks of light gray (N8) foraminifer nannofossil ooze with blurred contacts with sandstone. Significant core disturbance down to Section 6.

SMEAR SLIDE SUMMARY:

<table>
<thead>
<tr>
<th>Section</th>
<th>Clay</th>
<th>Composito</th>
<th>FAC</th>
<th>ROC</th>
<th>JNIT</th>
<th>2</th>
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</thead>
<tbody>
<tr>
<td>Core 1</td>
<td>1.0</td>
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<td>0.5</td>
<td>1.0</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>Core 2</td>
<td>1.0</td>
<td>3.0</td>
<td>0.5</td>
<td>1.0</td>
<td>0.5</td>
<td>1</td>
</tr>
</tbody>
</table>

TEXT:

- Text:
  - Sand
  - Clay
  - Carbonate ooze
  - Foraminifers
  - Calc. nannofossils

- Composition:
  - Calcite
  - Clay
  - Carbonate ooze
  - Foraminifers
  - Calc. nannofossils

- Section:
  - Core 1
  - Core 2

GRAPHIC LITHOLOGY:

- Core 1
- Core 2
### Lithologic Description

**SITE 587 HOLE 3 CORED INTERVAL 12.7–22.3 m**

**Lithologic Description**

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Sedimentary Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>Skeletal Silty Sand to Skeletal Sandy Gravel, yellowish gray (5Y 8/1), firm, massive, with very light gray (IN 8/) lumps and laminae. Appears normally graded but may be all disturbed by coring.</td>
</tr>
<tr>
<td>1.0</td>
<td>Foraminifer-bearing Nanofossil Ooze to Foraminifer Nanofossil Ooze, very light gray (IN 8/), soft, massive, with disrupted, pyritized laminae and blebs, rare burrows and chemical diffusion bands.</td>
</tr>
</tbody>
</table>

**Smear Slide Summary**

- **Texture:** Silt
- **Composition:** Foraminifers, Calc. nanofossils, Other

**SITE 587 HOLE 4 CORED INTERVAL 22.3–31.9 m**

**Lithologic Description**

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Sedimentary Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>Skeletal Medium to Coarse Sand, yellowish gray (5Y 8/1), very disturbed by coring.</td>
</tr>
<tr>
<td>1.0</td>
<td>Foraminifer-bearing Nanofossil Ooze, white (NE) to bluish white (SB 9/1), greenish gray laminae at 49 cm may be altered volcanic ash. Pyrite (?) occurs in disrupted pods throughout core. Interbeds may be present but very disturbed. Entire core has appearance of severe coring disturbance.</td>
</tr>
</tbody>
</table>

**Smear Slide Summary**

- **Composition:** Foraminifers, Calc. nanofossils

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**Notes**

- Graphic representation of core sections with descriptive lithologic units.
- Various columns indicating sedimentary succession, textural characteristics, and fossil content.
- Diagrams for each interval showing stratigraphic positions and core recovery.
SKELETAL CHALK SAND, yellowish gray (5Y 8/1), hard breccia created by coring. Homogeneous, with a few scattered pods of medium bluish gray (5B 5/1).

FORAMINIFER-BEARING NANNOFossil Ooze, with the light bluish gray (5B 7/1) by Section 6. Homogeneous except for a few scattered bands and laminae. Soft in Section 1 but stiff from Sections 2 through 7. Sections 2 and 3 show inner laminae. Red of core washed away at Section 6. 48 cm.

Artificial gap due to core handling.

**SMEAR SLIDE SUMMARY:**

<table>
<thead>
<tr>
<th>2, 90</th>
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<th>7, 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>M</td>
<td>M</td>
</tr>
</tbody>
</table>

**Composition:**

- Foraminifers: C - C
- Calc. nannofossils: D - D
- Sponge spicules: R - R

FORAMINIFER-BEARING NANNOFossil Ooze TO NANNOFOSSIL Ooze, yellow (5Y 9/1), stiff, with interbeds of very light gray (5B 7/1) and light bluish gray (5B 7/1) occurring. Contacts are gradational. Specimen (part of purple) in Section 7 and Core Catcher.

**SMEAR SLIDE SUMMARY:**

<table>
<thead>
<tr>
<th>3, 68</th>
<th>6, 137</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>

**Composition:**

- Foraminifers: A - C
- Calc. nannofossils: D - D
LITHOLOGIC DESCRIPTION

SITE 587 HOLE 5B 7/1-CORED INTERVAL 51.1-60.7 m

Foraminifer-bearing Nanofossil Ooze, white (N9) to light greenish gray (5G 9/1) in top of Section 2 back to white (N9), soft, homogeneous but with faint laminae and streaks of light gray (N7) color of same lithology. Some faint burrowing in Sections 2 and 4. Streaks of pyrite (N6) common. Small amount of diatomaceous matter present.

SMEAR SLIDE SUMMARY:
1.66 2.25 4.61 6.70

CORED INTERVAL 60.7-70.3 m

LITHOLOGIC DESCRIPTION

Skeletal Chalk Sand, white (N9) drilling breccia. Foraminifer-bearing Nanofossil Ooze, white (N9) to very light gray (N8), soft to stiff, homogeneous, with zones of color laminations of white (N9) and very light gray (N8). Pyrite (N6) scattered as blebs throughout but only common. Artifactual gap due to handling — sediment has been compacted.

SMEAR SLIDE SUMMARY:
1.16 2.69 4.61 6.70

Composition: D D M M

1

Phylum

1

Order

1

Family

1

Genus

1

Species

1

Calciredonella

1

Calc. nanobech

1

Calc. tyrrhanus

1

Nautilus

1

Nanofossil Ooze

1

Pyrite

1

Musselshell

1

Trematosuchus

1

Gastropod

1

Foraminifer

1

Shell Debris

1

Skeletal Chalk

1

Foraminifer-bearing Nanofossil Ooze

1
SITE 587 HOLE
CORE 10 CORED INTERVAL 79.9-89.6 m

LITHOLOGIC DESCRIPTION

FORAMINIFER-BEARING NANNOFOSSIL OOZE, white (N9), stiff, massive with rare very light gray (N8) diffuse
FORAMINIFER-BEARING SILTY SKELETAL NANNO-
FOSSIL OOZE, yellowish gray (5Y 8/1), soft, massive but
with chunks and disrupted laminae of white (N9) ooze,
possible normally graded beds in Section 6 and inter-
mixed skeletal sandy gravel in Core Catcher.

SMEAR SLIDE SUMMARY

Texture:
Sand
Silt
Clay
Composition:
Carbonate un
2.75
D
C
D
soec. —
5.33
D
C
A
A
CC, 5
M
C
D
Artificial gap due to

SITE 587 HOLE
CORE 9 CORED INTERVAL 79.9-89.6 m

LITHOLOGIC DESCRIPTION

NANNOFOSSIL OOZE, bluish white (5B 9/11, stiff, color
laminations and swirls of very light gray (N8I. Pyritel?)
concentration at Section 2, 2 to 3 cm.

SMEAR SLIDE SUMMARY

Clay
Composition:
Pyrite
Foraminifers
Calc. nannofossils
Sponge spicules
1.59
D
D
R
D
_
### LITHOLOGIC DESCRIPTION

**SITE 587 HOLE 11 CORED INTERVAL 89.5–99.1 m**

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th></th>
<th>GRAPHIC LITHOLOGY</th>
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</thead>
<tbody>
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<tr>
<td>10</td>
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</tbody>
</table>

**LITHOLOGIC DESCRIPTION**

- **SKELETAL MUDDY FINE SAND**, yellowish gray (5Y 8/1), soft, massive to subtly normally graded, includes rare chunks of very light gray (N8) nanofossil-bearing ooze or chalk.
- **NANOFOSIL-BEARING SKELETAL Ooze OR CHALK**, very light gray (N8), soft to more commonly hard, crudely laminated to chunky, interbedded with above skeletal sands.

**SMEAR SLIDE SUMMARY**

- **1,60 4,10 1,100**
- **Clay A**
- **Composition:**
  - **Carbonate:** D
  - **Calcite:** C
  - **Ferrous:** C
  - **Calsparite:** C

**SITE 587 HOLE 13 CORED INTERVAL 103.6–108.6 m**

<table>
<thead>
<tr>
<th>SAMPLE</th>
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<th>GRAPHIC LITHOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
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<td>10</td>
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</tbody>
</table>

**LITHOLOGIC DESCRIPTION**

- **SKELETAL SANDY GRAVEL**, yellowish gray (5Y 8/1), soft, normally graded (possibly due to core disturbance). Core Catcher sample only.