OCEAN DRILLING PROGRAM

LEG 119 PRELIMINARY REPORT

KERGUELEN PLATEAU - PRYDZ BAY

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D I S C L A I M E R

SCIENTIFIC REPORT

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ABSTRACT

Ocean Drilling Program Leg 119 completed a latitudinal transect of 11 sites in the Southern Ocean from the Kerguelen Plateau to Prydz Bay, Antarctica. Sediments recovered from Sites 736-738 and 744-746 on the Kerguelen Plateau provide insight into the Tertiary tectonic and oceanographic development of the Kerguelen Plateau region. Of particular importance is the recovery of (1) an undisturbed Cretaceous/Tertiary boundary which occurs in laminated calcareous claystone, (2) a deep-water sedimentary record of glacial-interglacial fluctuations during the last 10 m.y., (3) fossiliferous sediments which allow documenting latitudinal fluctuations in surface watermasses as well as the overall oceanographic setting during the Tertiary, and (4) basalt from the southern Kerguelen Plateau that has an age older than the overlying Turonian (90 Ma) limestone.

A variety of glacial sediment types, including lodgement till and glaciomarine sediments, were recovered from Sites 739-743 located in Prydz Bay. Most of the sediments are mixtures of clay, silt, sand, and gravel--diamictites. Repeated loading of these sediments, possible by ice, is indicated by their partially overconsolidated nature. Diamictites rich in metamorphic gravel and pebbles, derived from basement source areas, are present in thick prograding sequences extending for over 30 km on the Prydz Bay shelf. The drilling results from Prydz Bay provide evidence that ice has been grounded on the continental shelf in Prydz Bay intermittently since earliest Oligocene and possible since late middle Eocene times. Two sedimentary sequences below the glacial sequence were recovered and consist of "red bed" type sediments of continental origin, and laminated silty claystone and sandstone of fluvial and lacustrine origin.

INTRODUCTION

The Indian Ocean sector of the Southern Ocean is a region critical to the understanding of late Tertiary climatic and oceanographic development, specifically, the development of thermal gradients and climatic isolation of Antarctica, the timing of glaciation in eastern Antarctica, and the paleoceanographic history of the southern Indian Ocean. Both the Kerguelen Plateau and Prydz Bay are strategically positioned for such high-latitude paleoceanographic and climatic studies.

Kerguelen Plateau

The Kerguelen Plateau stretches approximately 2500 km between 46°S and 64°S latitude in a northwest-southeast direction on the Antarctic Plate (Figure 1). The feature is between 200 and 600 km wide, and stands 2 to 4 km above the adjacent ocean basins. Surface currents in latitudes of the plateau are dominated by the Antarctic Convergence or Polar Front, which separates subantarctic waters to the north from antarctic waters to the south. Although the Antarctic Convergence fluctuates seasonally, it is situated at approximately 48°S. Thus, a principal objective of drilling in this region during Leg 119 was to provide evidence of the development of the Antarctic Convergence and the response of this oceanographic boundary to climatic change.

A second major objective of Leg 119 drilling was to investigate the origin and tectonic history of the Kerguelen Plateau, and the breakup history of the Kerguelen Plateau from Broken Ridge. Figure 2 shows the two major seismic sequences (S and I) identified by Munschy and Schlich (1987), which are separated by a discordance "A". Discordance "A" is a major event in the sedimentary section, marking a hiatus from the middle Eocene to early Miocene according to Munschy and Schlich (1987). The event may also separate pre-rifting from breakup and post breakup sequences.

Prydz Bay

Prydz Bay is situated on the shelf of East Antarctica and at the oceanward end of the graben occupied by the Lambert Glacier and Amery Ice Shelf (Figure 1). The Lambert Glacier drains a large part of the East Antarctic ice sheet, including the 3000-m-high subglacial Gamburtsev Mountains. The glacier follows the line of the Lambert Graben, which extends 700 km or more inland and is of Permian or Early Cretaceous age. The present ice drainage basin is believed to be long-lived because of this structural control, and Prydz Bay sediments should reflect all stages of Antarctic glaciation and the pre-glacial continental climate.

Today, the icebergs calving from the Amery Ice Shelf cross western Prydz Bay and then turn westward along the margin, drifting with the coastal current. Eastern Prydz Bay, where the drilling sites lie, is therefore not in the main iceberg path at present. During glacial maxima, however, ice appears to have grounded right across Prydz Bay, as demonstrated by the eroded, over-deepened shelf topography. This inshore deepening is typical of Antarctic shelves. A 100-m-thick prograding sequence of sediments at the shelf edge, identified on the seismic sections at the outlet of a channel that traverses the shelf in front of the Amery ice shelf, provides confidence that the younger eastern Prydz Bay sediments would accurately reflect the glacial processes of the East Antarctic margin.

Seismic data from Prydz Bay were interpreted by Stagg (1985) in terms of several sedimentary packages, separated by seismic reflectors, on both the shelf and slope (Figures 3 and 4). On the shelf an older sequence showing minor folding and faulting, is interpreted as a continental to possibly shallow marine sequence that predates breakup. The younger sequence is interpreted as a post-breakup sequence of shallow marine sediments. A thin sequence at the seafloor is clearly disconformable on older strata and suggests that ice advance has removed parts of the underlying sequences. Stagg (1985) tentatively assigned ages to these sequences: acoustic basement in southeastern Prydz Bay, adjacent to the Vestfold Hills, is Cambrian and older; pre-breakup strata (seismic units PS 3, 4, and 5) are continental clastic sediments and coal; post-breakup strata (seismic unit PS 2) are Early Cretaceous to ?Miocene, whereas the thin veneer at the seafloor (seismic unit PS 1) is post-middle Miocene.

The Leg 119 scientific objectives in the Kerguelen Plateau and Prydz Bay regions were the following:

-to investigate the Mesozoic through Holocene climatic and glacial history of East Antarctica as recorded in the sediments of the broad and deep continental shelf.

- to understand the role of changing climates in the meridional and vertical evolution of water masses and their associated biota in the Southern Ocean.

- to determine the growth of the East Antarctic ice sheet through the Oligocene and early Neogene.

- to investigate the history of glacial erosion of the shelf, which is itself an indication of ice sheet volume changes and has implications for bottom-water formation.

- to document other changes in the shelf environment (depth, temperature, and sea ice cover) before and during glaciation, providing secondary indications of climatic change.

- to determine the timing of East Antarctica-India rifting and the subsidence history of the plateau.

- to document the nature and age of basement in the southern Kerguelen Plateau region.

- to document the geological development of the northern Kerguelen Plateau.

DRILLING RESULTS

Leg 119 of the Ocean Drilling Program completed a latitudinal transect of 11 sites (Table 1; Figure 1) in the Southern Ocean from the Kerguelen Plateau (49°S) to Prydz Bay, Antarctica (68°S) to complete the scientific objectives discussed above.

Northern Kerguelen Plateau (Sites 736-737)

Site 736

Site 736 (proposed Site KHP-1) is located on the northern part of the Kerguelen Plateau (Table 1; Figure 1). A 371-m-thick, continuous section of upper Pliocene and Quaternary diatomaceous ooze with a varying component of volcanic ice-rafted and/or detrital material was cored in three holes at the site (Figure 5).

Two lithologic units are recognized in the sediments recovered from Site 736. The upper 257 m (Unit I) consists of diatomaceous ooze containing basaltic volcanic debris, and the lower 114 m (257-371 mbsf; Unit II) is diatom ooze, that includes very little feldspathic detritus, pumice, and a thin layer of nannofossil ooze. These two units are also distinguishable on seismic profiles. The upper seismic unit is characterized by tightly spaced reflections, while the lower unit displays more diffuse reflections. These seismic units are traceable regionally, and they probably correspond with seismic unit S1 and the upper part of unit S2 of Munschy and Schlich (1987), respectively. The upper unit shows considerable thickening and thinning in the nearby area, and it fills in hollows and covers the topography of the lower unit.

The age of the base of Unit I is approximately 2.6 Ma according to diatom biostratigraphy, so the unit corresponds to the latest Cenozoic time of increased intensity of Antarctic glaciation. This age, the dispersed nature of pebble-sized clasts in the sediments, the predominance of mafic volcanics, and the presence of faceting, striations, and a bullet-nosed shape of some of the pebbles argue for emplacement by ice rafting, possibly from glaciers on nearby Kerguelen Island.

Alternatively, portions of the diatom ooze with incorporated volcanic detritus in Unit I may have been deposited by debris flows. Features supporting this mode of deposition include (1) sharp contacts with underlying purer diatom oozes showing basal size grading; (2) incorporation of isolated bodies of volcanic-bearing ooze in other intervals, including in relatively pure ooze; (3) apparent post-depositional disturbance of bedding relations with locally sub-vertical boundaries; and (4) partial destruction of lithologic boundaries, many of which are diffuse or wispy (cuspate). The good quality of preservation of both the diatoms and the radiolarians, and the scarcity of reworking argue against redeposition and transport by bottom currents over long distances. It is entirely possible that debris flows have redeposited glacially derived sediments that had accumulated higher on the plateau and closer to emergent areas. However, the upper unit displays a general pelagic, draping relationship over underlying Unit II.

All of the cores taken at Site 736 contain common to abundant diatoms and standard Antarctic zonations can be applied. Diatoms and radiolarians are generally well preserved, and little if any reworking of older species was observed. Deposition appears to have been continuous, and no hiatuses were observed. The majority of diatom species are typical of the Southern Ocean, but species more typical of middle latitudes are occasionally present, especially in the pre-uppermost Pliocene. Further study is required in order to determine times of movement of the Antarctic Convergence back and forth across the site. The radiolarian assemblage is notable because of the relatively few species (15-20) present compared with Southern Ocean assemblages of equivalent age. This low diversity is probably due to the relatively shallow depositional depth of the site and the high amount of upwelling and surface water productivity present.

The scarcity and low diversity of the calcareous nannofossil and foraminiferal assemblages in Site 736 sediments prevent establishing refined calcareous biostratigraphic zonations. The magnetic signal of the sediments is weak, so a magnetic reversal stratigraphy could not be established.

Phosphate, silica, and ammonia are the only chemical species that show significant variations in their interstitial water concentrations downhole at Site 736. Phosphate and ammonia decrease downhole, whereas silica concentrations increase and suggest the onset of silica diagenesis in the lower portions cored. While much higher than values found in typical sediment columns, phosphate and ammonia concentrations are considerably lower than values found in sediments beneath highly productive surface waters typified by upwelling (e.g., Peru; Suess, von Huene, et al., in press).

The absence of hydrocarbon gases and the presence of sulfate in sediment pore waters indicate that methanogenic bacteria have been inactive. Organic carbon is high to moderate for diatomaceous sediments (1% in the upper 200 m of sediments), but the organic matter present is immature.

The upper 235 m of sediment shows an overall decrease in water content, while porosity, bulk density, and grain density stay relatively constant. This is most likely a consequence of the fact that the sediment is predominately a diatom ooze, which tends to maintain a relatively open structure with depth. Measurements of shear strength and P-wave velocity are affected by Extended Core Barrel and Rotary Core Barrel coring disturbance below about 110 mbsf, but they show an increase with depth above that horizon.

The heat flow at Site 736 is estimated as 46 W/m^2 (1.1 HFU) based on measured downhole temperatures which suggest a temperature gradient of 78^o/km and average thermal conductivities of 0.59 $W/m^2/^oC$. The estimated temperature at the bottom of Hole 736C (371 mbsf) is 29^oC.

Site 737

Site 737 (proposed site KHP-3) is located on the northern Kerguelen Plateau about 100 km southeast of Site 736 (Table 1; Figure 1). The 715.5-m-thick middle Eocene through lower Pliocene-Quaternary section cored in two holes at Site 737 (Figure 5) begins stratigraphically almost exactly (3.4 Ma) where coring was terminated at Site 736, so together, the two sites form a very valuable reference section for the late Paleogene and Neogene at about 50^{o}S.

Six lithologic units are recognized at Site 737: (Unit I) a 1.5-m-thick layer of Quaternary black calcareous and pumaceous sand mixed with diatom ooze (0-1.5 mbsf); (Unit II) lower Pliocene and upper Miocene olive to olive gray diatom ooze (1.5-244.1 mbsf); (Unit III) upper and middle Miocene diatom-nannofossil ooze (244.1-306.6 mbsf); (Unit IV) middle Miocene sandy porcellaneous siltstone with mixed volcanic sand and diatom-nannofossil ooze (306.6-312.8 mbsf); (Unit V) lowermost Miocene to upper Eocene calcareous claystone, which contains clayey limestone at its base (312.8-677.6 mbsf); and (Unit VI) upper middle Eocene clayey limestone, which contains some thin chert layers (677.6-715.5 mbsf). Unconformities occur between Units I and II, Units IV and V, and Units V and VI (Figure 5).

The sedimentary record at Site 737 is characterized by an early phase of carbonate-clay deposition (Units V-VI; late middle Eocene to lowermost Miocene), a middle phase of mixed diatom and nannofossil ooze deposition with significant volcanic sand input (Units III-IV; middle Miocene to late Miocene), a late phase of diatom ooze sedimentation (Unit II; late Miocene to early Pliocene), and a final phase (Unit I; Quaternary) of either very slow sedimentation combined with bypassing of sediments by bottom currents or, less likely, uplift and removal of sediments. Disseminated volcanic glass and/or minerals occur in uppermost Eocene sediments and reach their peak in middle to upper Miocene sediments (13.8-7.8 Ma). These ages are significant, because Nougier (1972) dates two extrusive basalts on Kerguelen Island at 13.3 and 11.5 Ma and dates phonolitic extrusions in the southeastern part of the island at 8-9 Ma.

The middle Eocene to lower Miocene discordance "A" as proposed by Munschy and Schlich (1987) based on seismic interpretations of the northern Kerguelen Plateau, was not recognized at Site 737. An unconformity, however, is present between the middle Eocene and upper Eocene, where nannofossil Subzones CP14b and CP15a are missing. This unconformity separates Unit V from underlying Unit VI. It is also recognized as a seismic reflector by Leg 119 sonobuoy studies, and it corresponds to a downhole increase in sonic velocities measured by physical properties and by logging, but is placed much deeper in the section than discordance "A".

A second unconformity at about 312.8 mbsf, separating lowermost Miocene calcareous claystone (Unit V) from middle Miocene diatom-nannofossil ooze containing siltstone and volcanic sandstone (Unit IV), may correspond to seismic discordance "A" of Munschy and Schlich (1987). A seismic reflector corresponding to this unconformity is traceable regionally by seismic stratigraphy and also coincides with a seismic velocity peak measured in a calcareous siltstone at 310 mbsf. The seismic unit overlying this reflector (unit S2 of Munschy and Schlich, 1987) progrades regionally onto this reflector, and it is possible that units older than middle Miocene may also prograde onto it east of the site. Thus, locally, sediment was deposited onto the surface corresponding to this reflector prior to the middle Miocene.

Calcareous microfossils are present and generally abundant from the upper middle Eocene to the middle upper Miocene. A complete Eocene/Oligocene boundary appears to be present at about 606 mbsf, and no abrupt environmental change is evident in nannofossil assemblages across the boundary. A good magnetostratigraphic record was obtained for the Eocene and Oligocene, which supports biostratigraphic evidence that the section is complete from the lower upper Eocene to the lowermost Miocene. Calcareous nannofossil diversity and abundances in the Eocene and Oligocene are similar to those in assemblages studied from Maud Rise (Barker, Kennett et al., in press) and the Falkland Plateau (Ciesielski, Kristoffersen et al., in press).

Diatoms and radiolarians are present and generally abundant and well preserved from the uppermost Oligocene to the Quaternary surficial lag sand. Diatom assemblages are dominated by Southern Ocean species in sediments less than 4.5 Ma, but temperate species make up an important component of middle Miocene through lowermost Pliocene assemblages. Indeed, low-latitude diatoms are consistently present in the upper Miocene (5.1 to 8.2 Ma) interval. Radiolarian assemblages show no low-latitude affinities, but they are low in diversity, probably reflecting the shallow water depth of Site 737.

In addition to unconformities detected between the middle Eocene and upper Eocene and between the lowermost Miocene and the middle Miocene, an unconformity spanning the interval between 10 and 8.2 Ma is recognized by diatom and radiolarian biostratigraphy at 263 mbsf. This unconformity coincides with combined widespread Neogene deep-sea hiatuses NH5 and NH4 of Barron and Keller (1982).

A low organic carbon content (0.5-0.3% total organic carbon (TOC)) in the upper 225 mbsf, decreasing to <0.1% TOC below that level characterizes the sediments. Combined with relatively inactive methanogenic bacteria, this low organic-carbon content has a major effect on the chemistry of Site 737 sediments. Sulfate concentrations in the interstitial waters decrease with depth, but they do not reach low enough levels to indicate significant sulfate reduction. Sharp discontinuities of calcium, magnesium, silica, and pH occur in pore water profiles at about 400 mbsf, corresponding with the uppermost Oligocene transition from nannofossil-rich clay and ooze below to mixed diatom and nannofossil ooze and clay above. Calcium and pH values increase with depth to 380-400 mbsf and remain high below that level. Magnesium and silica values show opposite trends, although silica values are variable between 285 and 380 mbsf.

Southern Kerguelen Plateau Region (Sites 738, 744-746)

Site 738

Site 738 (proposed site SKP-6A) is situated on the southern Kerguelen Plateau (Table 1; Figure 1). A 490-m-thick lower Turonian through Quaternary sediment section overlying 43 m of basaltic breccia and altered basalt was cored at Site 738 (Figure 6). The sediment section records shallow deposition on the inner shelf during the early Turonian, followed by deepening to depths equivalent to near the shelf break by the end of the Cretaceous, and continued deepening and deposition at depths at or below the present-day water depth (2252.5 m) throughout most of the Cenozoic. Biogenic carbonates (nannofossil ooze, chalk, and limestone) dominates the Cretaceous and Paleogene section, while biogenic silica (diatoms and radiolarians) is more evident in the abbreviated section of Neogene sediments recovered at the site. Seismic stratigraphic studies by Leclaire et al. (in press) and our site survey both indicate that the seismic unit overlying the top of the main body of the lowermost Oligocene to Cretaceous section varies in thickness regionally on the southern Kerguelen Plateau and displays scouring and fill relationships on the older unit.

Seven lithologic units are recognized at Site 738 (Figure 6): Unit I is upper Miocene to Quaternary diatom ooze with minor proportions of foraminifers, calcareous nannofossils, radiolarians, and clay (0-16.8 mbsf); Unit II is upper Miocene nannofossil ooze with minor diatoms (16.8-17.7 mbsf); Unit III is middle Eocene to lower Oligocene homogeneous nannofossil ooze (17.7-120.8 mbsf); Unit IV is early-middle Eocene nannofossil ooze and chalk, with chert layers and concretions (120.8-254.4 mbsf); Unit V is Campanian to lower Eocene calcareous chalk with chert nodules and fragments (254.4-418.6 mbsf), which is moderately to intensively bioturbated and includes trace fossils in the Cretaceous section; Unit VI is lower Turonian to Campanian partially silicified limestone (418.6-479.7 mbsf), containing burrowing trace fossils, *Inoceramus* fragments, and an algal calcarenite with basaltic pebbles near its base; and Unit VII consists of alternating volcaniclastics and massive aphyric basalt, which are moderately to highly fractured and altered (479.7-533.8 mbsf). The occurrence of dull red volcaniclastics in four intervals, the abundance of vesicles, and the lack of typical submarine flow features suggest that these basalts erupted in shallow water or a subaerial environment.

The Turonian to Quaternary sediment section cored at Site 738 can be readily correlated to existing microfossil zonations. In general, Southern Ocean or middle-latitude zonations are most applicable, however; low-latitude biostratigraphy can be applied to parts of the Cretaceous and Paleogene sections. The abbreviated Neogene section (0-17.7 mbsf) contains a consistent reworked component from the Paleogene and parts of the Neogene, whereas reworking is rare in the Paleogene and Cretaceous sections.

At least five unconformities are recognized in the sediment section: (1) the late Miocene interval between 8.4 and 6.1 Ma is missing at 16.75 mbsf; (2) a unconformity at 17.7 mbsf separates lower upper Miocene sediments from lower Oligocene sediments; (3) nannofossil subzone CP15b is missing at the Eocene/Oligocene boundary (32.5-41.5 mbsf); (4) nannofossil subzone CP14b is missing at the middle Eocene/upper Eocene boundary (61-70 mbsf); and (5) a Campanian to upper Maestrichtian hiatus (408.9 mbsf) has a duration of 6-8 m.y. Leclaire et al. (in press) suggest that another, possibly subaerial, unconformity separates the basalt and basalt breccia from the marine sediment section, because they date dredged basalt in the southern Kerguelen Plateau area at 114 $\pm$ 1 Ma (Barremian) or at least 20 m.y. older than early Turonian.

The Cretaceous/Tertiary boundary at Site 738 is complete and occurs in a 15-cm-thick laminated claystone at 377.1 mbsf. The fine fraction of the laminated claystone consists of 95% micrite particles and few to rare nannofossils. Magnetostratigraphy identifies lowermost Tertiary magnetic anomalies 27 and 28 from 341.3-350.9 mbsf to 350.9-360.9 mbsf, respectively, further arguing for the completeness of the lowermost Tertiary at the site. Between 377.05 and 377.00 mbsf, Danian taxa increase from less than 1% to 50% of the assemblage, the remainder being Cretaceous taxa. Since this gradual replacement of Cretaceous by Early Tertiary nannofossils occur in this laminated claystone, the transition cannot be explained by bioturbation processes, but must be truly gradational or due to lateral influx of older Cretaceous material.

Another significant paleontological finding at Site 738 is the occurrence of the low-latitude diatoms *Thalassiosira convexa aspinosa*, *T. miocenica*, and *T. praeconvexa* at 16.48 and 17.12 mbsf, coinciding with a latest Miocene warm interval between 5.8 and 6.1 Ma.

The geotechnically properties of the sediment can be divided into six units. The first geotechnical unit (0-17.7 mbsf), which corresponds to lithologic Units I and II, is characterized by high water content and low bulk density, which seem typical of diatom oozes. A second geotechnical unit (17.7 and 135 mbsf) corresponds to lithologic Unit III and the uppermost part of Unit IV, and its bulk density, water content, and porosity show little scatter and normal depth-related trends (i.e., increasing bulk density and decreasing porosity and water content with depth). The third geotechnical unit (135-210 mbsf) corresponds to an interval characterized by a distinct change of gradient in porosity and water content with depth, which may indicate an increase in diagenesis, not apparent in the lithostratigraphy. Interstitial water chemistry shows a slight increase in dissolved silica in this middle middle Eocene interval, and radiolarians are relatively common, through very sporadic. A fourth geotechnical unit (210-410 mbsf) corresponds to lithologic Units IV and V and is marked by a new downhole gradient in index property depth profiles. The base of the fourth geotechnical unit and the top of the fifth geotechnical unit (410 mbsf) corresponds with an unconformity between the upper Maestrichtian and the Campanian. This horizon is marked by an abrupt downhole increase in wet bulk density and a decrease in water content and porosity, which typifies lithologic Unit IV, the bioturbated limestone. A final geotechnical unit (485-533 mbsf) is composed of basaltic breccia and basalt and is marked by large variations in density and velocity, probably reflecting different degrees of alteration.

Logging was completed between 97 and 455 mbsf at Site 738, and four logging units are recognized: unit I, 97-250 mbsf; unit II, 250-344 mbsf; unit III, 344-405 mbsf; and unit IV, 405-455 mbsf. The upper three logging units correspond to intervals that display the same general downhole trends in resistivity, density, sonic velocity, and porosity, whether those parameters are uniform, increasing, or decreasing within the interval. The top of the fourth logging unit is marked by an abrupt increase in sonic velocity, resistivity, density, and radioactivity, and an abrupt decrease in porosity. The boundaries between logging units I and II and units III and IV correspond respectively to the boundary between lithologic Units IV and V and to the Campanian/upper Maestrichtian unconformity. The II/III logging unit boundary at 344 mbsf occurs in lower Paleocene sediments and does not correspond to either lithological or geotechnical changes.

The upper seismic unit at Site 738 consists of the abbreviated Neogene biosiliceous sequence (0-17.7 mbsf), and it appears to be an age equivalent of Colwell et al.'s (in press) seismic units A and B. A second seismic unit at Site 738 consists of middle Eocene to lower Oligocene nannofossil ooze (17.7-210 mbsf). This seismic unit is correlative by age, at least in part, with Colwell et al.'s (in press) seismic unit C. Between 210 and 410 mbsf, a third seismic unit, corresponds to the upper Maestrichtian to middle Eocene chalk. The upper boundary of this seismic unit appears to be a diagenetic boundary, and it is unclear whether this unit has a correlative equivalent in the Raggatt Basin. A fourth seismic unit (410-480 mbsf) is Turonian to Campanian limestone, This seismic unit may be equivalent to parts of either or both of Leclaire et al.'s (in press) units E and F.

Leclaire et al. (in press) suggest that arching of the Kerguelen Plateau occurred at the top of their seismic unit E, which they date as Latest Cretaceous. It is possible that the unconformity between upper Maestrichtian chalk and Campanian limestone (410 mbsf), which also marks seismic, geotechnical, and logging unit boundaries at Site 738, resulted from this tectonic event. A final seismic unit recognized at Site 738 is the volcaniclastics and altered basalt flows encountered between 480 and 533.8 mbsf (sixth geotechnical unit).

The Cretaceous and Paleogene geologic history of Site 738 resembles the geologic history proposed by Leclaire et al. (in press) and Colwell et al. (in press) for the southern Kerguelen Plateau. Nearshore to subaerial volcanism in the pre-Turonian was interbedded and followed by deposition of basaltic breccias. Subsidence during the Turonian to Maestrichtian coincided with deposition of limestone in a shelf environment. During the earliest Paleocene to the earliest Oligocene, Site 738 underwent subsidence to water depths at or near the present depth (2252 m). Unlike the central parts of the Kerguelen Plateau, however, there is no evidence that Site 738 was uplifted and/or subaerially eroded after the Eocene. Rather, deposition of the abbreviated Oligocene and Neogene section of the site was influenced by strong bottom currents, which caused erosion and/or nondeposition.

If the Turonian limestone at Site 738 was deposited near sea level, the surface of the basaltic basement has subsided 2742 m in approximately 90 m.y. Roughly 150 m of this subsidence is probably due to isostatic compensation of the 500-m-thick pile of sediments, estimated at one third of the sediment thickness (van Andel et al., 1977). The present depth of the basement at Site 738 and its minimum age of 90 Ma agrees well with the subsidence curve for aseismic ridges published by Detrick et al. (1977). This suggests that the subsidence of Site 738 may be due mainly to thermal contraction of a cooling lithosphere, at the same rate as that of oceanic crust of aseismic ridges or other volcanic ridges. Assuming the site was near sea level at 90 Ma, and discounting eustatic changes in sea level, one would expect water depths at Site 738 at the end of the Campanian to be about 1200 m. However, upper Maestrichtian benthic foraminifers suggest a considerably shallower paleodepth near the outer shelf (400-600 m), arguing that additional tectonic factors may also be responsible for Site 738's subsidence history.

Site 744

Site 744 (proposed site SKP-6B) was cored to obtain a thicker Neogene section than previously recovered at Site 738. A 176.1-m-thick uppermost Eocene to Quaternary section, which contains carbonate throughout, was cored with a composite recovery of over 95% in three holes (Figure 6). The uppermost Miocene to Quaternary in the upper 23 m of the section (lithologic Unit I) is dominantly diatomaceous ooze with a variable carbonate content. This lithologic unit is separated from Unit II by a hiatus (6.1 to 7.6 Ma) at 23 mbsf. Unit II consists of 153 m of uppermost Eocene to upper Miocene nannofossil ooze. The biosiliceous content of this nannofossil ooze shows considerable variation in abundance, but it essentially disappears below the Eocene/Oligocene boundary. The detrital component at Site 744 is almost negligible.

Biostratigraphy and magnetostratigraphy indicate that the Eocene/Oligocene, Oligocene/Miocene, and possibly the Miocene/Pliocene boundaries are complete at Site 744. Hiatuses or compressed intervals occur in the middle part of the Oligocene (~32-28 Ma), the lower Miocene (~23-20 Ma), and in the upper Miocene (~7.6-6.1 Ma). Southern Ocean microfossil zonations can be applied to the assemblages, but low- to middle-latitude diatom zonations can also be recognized in the upper lower Miocene and uppermost Miocene.

Site 744 lies at an intermediate water depth (2307.8 m) within present-day Circumpolar Deep Water. It is likely that the site remained above the Carbonate Compensation Depth (CCD) since the late Eocene, and that fluctuations in the percentage of carbonate versus biosiliceous microfossil components reflect variations in surface water fertility. The transition from nannofossil ooze to diatom ooze that occurs at the contact between lithologic Units I and II (~23 mbsf) probably coincides with an increase in diatom productivity in the late Miocene between 6.1 and 7.6 Ma. At Site 744 this interval is marked by an unconformity, but at Site 737 on the northern Kerguelen Plateau, it is represented by diatom ooze.

Lithologic unit I (0-23 mbsf) is a soft diatomaceous ooze with fluctuating amounts of biogenic and calcareous sediment components. Diatoms compose 50-80% of this section. Coarse sand grains, granules, and small pebbles up to 5 cm in diameter are disseminated throughout the unit, ranging from <1% to 2% in some intervals. Clasts consist of quartz, granite, quartz-feldspar-biotite, gneiss, and amphibolite. They resemble clasts found in the diamictites of Prydz Bay. Most of the larger clasts are subrounded to subangular and are coated with black manganese oxide, commonly only on one side. These clasts are most certainly ice-rafted, and their occurrence in uppermost Miocene to Quaternary sediments at Site 744 mirrors their occurrence at Site 738 and probably reflects enhanced glaciation in East Antarctica.

Calcareous nannofossils compose >70% and mostly >80% of lithologic Unit II, the upper Eocene to upper Miocene nannofossil ooze. Below 147 mbsf, the carbonate component is partly disaggregated to micrite. Scattered coarse sand grains, which are probably ice-rafted, are present in the uppermost part of lithologic Unit II down to 30.8 mbsf. This lower upper Miocene interval (~7.6-9 Ma) is represented at Prydz Bay Site 739 by diamictite.

In the lower part of lithologic Unit II (146.3-146.7 mbsf), black, manganese oxide-coated, coarse sand grains (1-4 mm in diameter) are again disseminated throughout the sediment. This lower Oligocene interval is assigned to the base of magnetic polarity anomaly 13 and is, therefore, about 35.8 Ma in age, closely corresponding to the age estimate of Shackleton (1986) for the major earliest Oliogocene benthic foraminiferal $\delta^{18}O$ isotope increase (+1.0 o/oo), which is identified globally in deep waters.

Organic matter is very low throughout the Site 744 sediment column, and inorganic chemistry data indicate that any organic matter settling through the water column was thoroughly oxidized before it was incorporated into the sediments.

The carbonate content of Unit II is variable; intervals of lower carbonate values (60-70%) occur in the lower Oligocene (143.15 and 137.4 mbsf or ~35.5-34.5 Ma), middle Miocene (59.74 mbsf or ~14 Ma), upper middle Miocene (48.12 mbsf or ~11 Ma), and lower upper Miocene (37.66-37.41 mbsf or ~9 Ma). Interestingly, with the exception of the 11 Ma interval, these intervals coincide with times of major benthic foraminiferal $\delta^{18}O$ isotope increases, signalling cooling of Southern Ocean waters. Such cooling would have likely caused increased biosiliceous fertility.

Physical properties measurements at Site 744 reflect the biosiliceous nature of lithologic Unit I and the nannofossil character of lithologic Unit II. Lithologic Unit I is characterized by water content, porosity, and bulk density data that remain fairly constant with depth, as is typical of diatomaceous sediment. There is a slight decrease of sound velocity and a slight increase of shear strength with depth Lithologic Unit II exhibits slight depth trends in response to increasing burial diagensis; namely, water content and porosity decrease slightly with depth, while density and thermal conductivity increase slightly with depth.

Site 745

Site 745 (proposed site SKP-8A) is located near the crest of a large sedimentary ridge, the East Kerguelen Sedimentary Ridge of Houtz et al. (1977), which extends for more than 600 km toward the northeast along the steep eastern slope of the southern Kerguelen Plateau. This site lies beneath present-day Antarctic Bottom Water, and seismic stratigraphy indicates that currents have influenced sediment distribution.

The 215-m-thick section of silty diatom ooze and diatom clay cored at Site 745 is of mixed biosiliceous pelagic-terrigenous character, with practically no carbonate accumulation (Figure 6). Foraminifers and calcareous nannofossils occur in only a few samples and are strongly etched because of deposition near the carbonate compensation depth (CCD). Abundant to common, well-preserved diatom and radiolarian assemblages are present throughout the section. Together with an excellent magnetostratigraphy, they indicate that a complete uppermost Miocene to Quaternary section was recovered at the site. The Pliocene/Quaternary boundary lies at about 85 mbsf, the lower/upper Pliocene boundary at about 135 mbsf, and the Miocene/Pliocene boundary at about 202 mbsf. Within the Quaternary section, abundance fluctuations of the radiolarian Theocalyptra davisiana and the diatom Eucampia antarctica give promise that glacial-interglacial cycles can be recognized.

A single lithologic unit with two subunits is recognized at Site 745. Subunit IA (0-37 mbsf) is dominated by diatom ooze and occasional minor amounts of quartz-feldspar silt, radiolarians, or clay. Subunit IB (37-215 mbsf) is characterized by more clearly alternating diatom ooze and diatomaceous clay intervals on a scale of decimeters to a few meters. The clay-rich intervals of this subunit contain <50% diatoms, and the silt content of the subunit is also significant, reaching a maximum of 35%. Minor thin claystone, silt, and volcanic ash layers are also present in Subunit IB. The origin of the clay fraction is uncertain, but some of it is likely ice-rafted, especially in the upper 70 m of Hole 745A where a more obviously ice-rafted quartz-silt component follows a roughly similar trend of alternation with the diatom ooze. Although bioturbation is evident in parts of the section cored at Site 745, it is generally diffuse, except in the upper cores where some distinct burrows are present.

A significant feature of Site 745 is the presence throughout most of the section of dispersed lonestones, granules, and small pebbles from a metamorphic basement source area. Small pebbles of quartz-feldspar biotite gneiss, amphibolite, and granite, some of which resemble the clasts found in Prydz Bay glacial sediments, are clearly ice-rafted. There is no continental basement that could supply such clasts nearer than the Antarctic margin. Similarly, the freshness of the grains and their angular to subangular shapes suggest that much of the quartz-feldspar silt fraction present in Site 745 sediments is also ice-rafted. Broad, complex peaks of ice-rafted material occur between 0 and 70 mbsf (0-1.2 Ma) and between 145 and 195 mbsf (4.0-~5.0 Ma), suggesting enhanced glaciation during the late Quaternary and early Pliocene. However, at least some ice rafting continued throughout the remainder of the Quaternary, Pliocene, and latest Miocene.

Seismic stratigraphy reveals that the upper Miocene and younger sediments cored at Site 745 are truncated to the southeast by a channel, indicating the influence of bottom currents on erosion and preferential sedimentation. It is possible that bottom currents originating below the slope of the Antarctic margin may carry fine-grained terrigenous materials that have been swept off the Antarctic shelf, northward to Site 745. Such transport may have been increased during glacial periods when melting of ice at the Antarctic shelf break supplied fine glacial debris directly onto the continental slope. Thus, enhanced terrigenous transport to Site 745 would occur during maximal glacial intervals. Alternatively, some of the non ice-rafted detrital clay at Site 745 may have been supplied from the shallow northern Kerguelen Plateau, because reworked radiolarians and diatoms of various ages occur throughout the Hole 745A sediments, as do benthic diatoms derived from environments within the photic zone (~0-100 m).

Site 746

Site 746 is located 3 nmi north of Site 745, near the crest of the East Kerguelen Sedimentary Ridge. Site 746 was occupied after an approaching iceberg terminated drilling operations at Site 745. Seismic stratigraphy, biostratigraphy, and geotechnical stratigraphy established that stratigraphic horizons at Site 746 lay about 23 m deeper than equivalent horizons at Site 745. Consequently, continuous coring, which began at 164.8 mbsf in Hole 746A, duplicated about the lower 30 m of Hole 745B. Coring was then continued in Hole 746A to 280.8 mbsf where lower upper Miocene diatomaceous sediment was cored.

The lithologic and geotechnical units encountered at Site 746 closely resemble those of Site 745. The sequence cored at Site 746 consists of mixed biosiliceous and terrigenous sediments, and is assigned to two lithologic units. In the upper part of the recovered section clayey diatom ooze alternates with diatomaceous clay and silty clay in crude cycles, which are 6 to 73 cm thick. The boundaries between these cycles are mostly gradational, and only occasionally do they display sharp contacts. This relationship persists downhole until about 217.8 mbsf, where there is a gradational change to sediment which is more lithified, more pervasively bioturbated, contains less distinct cycles, but is more fractured. This gradational change separates two lithologic subunits, IA and IB. Lithologic Unit II consists of a 58-cm-thick layer of nannofossil ooze from 246.7 to 247.28 mbsf.

Coarse grains, granules, and minor small pebbles are uniformly disseminated throughout Subunit IA. These appear to be mostly ice-rafted, as most clasts are fresh, subrounded to subangular and are composed predominantly of quartz. The larger clasts, however, display a wider range of lithologies including granite, amphibolite, and various types of gneiss. Similar grains and granules are found in Subunit IB, but they are less common.

Diverse, well preserved diatom assemblages are present in all of the core-catcher samples from Hole 746A. Radiolarians are abundant and well preserved in the upper part of the sequence recovered, but they become less common below 227.3 mbsf. Biosiliceous biostratigraphy indicates that sediment cored at the bottom of Hole 746A is lower upper Miocene and younger than 10 Ma. As at Site 745, calcareous microfossils are absent for most of the recovered sequence. The nannofossil ooze of Unit II contains a strongly etched, low diversity assemblage, which is of little use for biostratigraphy.

Diatom stratigraphy suggest that a hiatus spanning the interval between 7.6 and 6.1 Ma may be present at about 200 mbsf, but there is no lithologic evidence for such an unconformity, and physical properties do not reveal any abrupt downhole changes at that level. It is possible that if such an unconformity exists, it represents an interval of nondeposition.

Magnetostratigraphy identifies a series of reversed and normally polarized intervals that should be correlatable to the magnetic polarity time scale after further study onshore and refined biostratigraphic study. Preliminary study indicates that magnetic polarity Chron C5 may be represented below 240 mbsf.

Carbonate content is >1% throughout Hole 746A, except in the 58-cm-thick Unit II, where it increases to 4.6%. Sediments recovered from Hole 746A contain low organic carbon ranging from 0.09% to 0.16%. It is clear that bacterial sulfate reduction is taking place at depths greater than 248 mbsf, but low ammonium and phosphate concentrations indicate that the amount of organic matter being consumed at that depth is very small.

As at Site 745, the sediments recovered at Site 746 most likely record glacial-interglacial fluctuations in the sedimentation of biogenic and detrital components. The randomly dispersed coarse sand grains and gravel present in the sediment are probably ice-rafted. The composition of some of the clasts clearly points to Antarctic basement as the source area, although some glacial input from Kerguelen Island cannot be ruled out. A broad channel separates the sediment ridge containing Sites 745 and 746 from the southern Kerguelen Plateau, most likely preventing deposition at those sites of detrital material transported along the bottom from the southern Kerguelen Plateau. However, transport in suspension is possible. It is unclear whether this depression persists to the north, and transport of detrital material from the more elevated northern portion of Kerguelen Plateau is a possibility. In fact, the occurrence of reworked diatoms and radiolarians of various ages throughout Hole 746A, and the presence of benthic diatoms that lived within the photic zone (above 100 m) support this area as a source of some of the transported sediment. Another important source for detrital material might also have been the Antarctic shelf, as Antarctic Bottom Water originating on the Antarctic slope might transport sediment supplied by melting of ice sheets grounded at the shelf break during times of maximum glaciation. Whatever the source of bottom current-transported detrital material, a larger volume of that material was probably transported during glacial times, when Antarctic Bottom Water flow was increased and currents sweeping over the Kerguelen Plateau were probably stronger because of shallower water and increased temperature gradients. Consequently, one might expect increased detrital sediment input at Sites 745 and 746 during glacial times owing to increased ice rafting and/or increased bottom-current transport.

Prydz Bay (Sites 739-743)

Site 739

Site 739 (proposed site PB-6) is located 30 km from the shelf edge, and represents the most seaward of the sites drilled on the Prydz Bay shelf (Table 1; Figure 1). The water depth is 412.3 m, and the distance from land near Davis Station and the Amery Ice Shelf is 140 km. Since the Lambert Graben drains 22% of the East Antarctic Ice Sheet, and has probably existed since Permian or Early Cretaceous time, it was expected that sites in Prydz Bay would provide a record of the initiation of the ice sheet and its long-term development.

Seismic data of Stagg (1985) suggested that beneath ~100-m-cover of presumed Plio-Pleistocene glacial sediments lies a seaward-dipping prograding sequence at the mouth of the broad Prydz channel, and it was inferred that the oldest part of the prograding sequence would mark the time when grounded glaciers reached the shelf edge. Drilling at Site 739 was expected to pass through this prograding sequence into more shallowly dipping strata, which may date from pre-glacial time. However, the less inclined strata also proved to be glacigenic. Although a depth of only 486 mbsf was reached (Figure 7), the base of the glacial sequence was not cored at this site.

The sequence has been divided into five lithologic units. Unit I (0-24.1 mbsf) is Quaternary normally consolidated massive diamicton where recovered. Unit II (24.1-173.6 mbsf) is upper Miocene to lower Pliocene massive diamictite (indurated diamicton). However, in the unrecovered upper part (38-106 mbsf), it is probably bouldery diamictite with sand layers, according to downhole logging results and drilling characteristics. Unit III (173.6-267.2 mbsf) contains two stratified diamictite zones with diatoms, separated by a thin diatomaceous sandy silty claystone of early Oligocene age. Unit IV (267.2-315.7 mbsf) is massive, slightly indurated but friable diamictite, of ages similar to Unit III. Unit V (315.7-486.8 mbsf) is lithologically similar to Unit IV, but is mainly unfossiliferous and of uncertain age.

The sedimentary sequence can be considered principally in terms of deposition close to and immediately seaward of the grounding line of an extended Lambert Glacier, probably close to the paleo-shelf edge. Probably little or no land was exposed during periods of till deposition over the site, and the bulk of the sediment was derived subglacially, modified by transport at the base of the sliding ice mass. Overall, there appears to have been little if any reworking by fluvial processes, but unrecovered intervals of sand could have been formed by such processes. Clast composition indicates that the bulk of the detritus was derived from the granite-gneiss basement, with only minor contributions from sedimentary cover sequences. However, the high content of terrigenous type III organic matter in the lower part of lithologic Unit II indicates a substantial amount of erosion of carbonaceous sediments of a type similar to those near the base of Site 741.

The sequence is remarkable for its apparent uniformity, especially the homogeneity of the hundreds of meters of massive diamictite. This can be explained only if the grounding line was in a relatively stable position, or alternatively interbedded lodgment tills and glaciomarine sediments were removed by subsequent glacier advances, or they were not recovered. The loading history of the sediment and the long period of time involved suggest a more complex history of glacial advances and retreats than that indicated by the recovered facies.

In general, tidewater glaciers are characterized by rapid fluctuations in grounding line and snout positions, and they are very sensitive to climatic change. However, stable grounding line positions may arise if there is a sharp break in the submarine slope, such as a shelf edge, beyond which grounding would require a vastly increased supply of ice. This situation may have prevailed at Site 739 for much of the time represented by the recovered section below 175 m, while each massive diamictite unit accumulated, a view supported by the nature of seaward-dipping seismic reflectors suggesting an old shelf break near this point. Landward of the grounding line lodgment tills would have been deposited, but they are not represented at Site 739 below 175 mbsf. Above this level, although mainly unrecovered, they may form the bulk of the sequence, built up on the shelf after the prograding wedge had extended beyond Site 739. More distal glaciomarine facies are evident only in lithologic Unit III, and the greater part of the non-glacial history is missing.

Biostratigraphic age constraints on these sediments are generally poor. Factors contributing to the poor stratigraphic resolution include several broad intervals lacking microfossils, poor core recovery, absence of zonal marker species, and the occurrence of reworked specimens. Of the fossil groups examined, diatoms are the most abundant and persistent. They provide most of the age estimates, and suggest that the upper two-thirds of the recovered sequence is early Oligocene to Quaternary, with a hiatus representing much of late Oligocene and early and middle Miocene time. Sparse calcareous nannofossils suggest a Eocene-Oligocene age for the lower lithologic Unit V. Planktonic foraminifers were not observed below 38 mbsf, and benthic foraminifers are very sparse throughout. Radiolarians were observed only in the upper 5 mbsf, and no palynomorphs were observed.

It was not possible to achieve magnetostratigraphic determinations for this site, because the random orientation of the gravelly and sandy units that dominate the succession are unsuitable for establishing a reversal stratigraphy. However, long-term oscillations in natural remanent magnetic intensity were found to follow the same trend as magnetic susceptibility, providing strong evidence that the magnetic intensity fluctuates according to the abundance of magnetic minerals in the rock, rather than changes in the earth's magnetic field. The amount of magnetite might be a reasonable tracer for a basement source for the material in the tills.

Measurements of physical properties (index properties, undrained shear strength, and compressive wave velocity) provide constraints on the main events recorded by the core, and in particular the nature of the complex loading history to which the sediments were subjected at different times. Eight geotechnical units were recognized: Unit 1 (0-9 mbsf) has characteristics typical of normally consolidated ice-proximal glacial diamictons and is partly equivalent to lithologic Unit I. Unit 2 (9-167 mbsf) is characterized by overconsolidated diamictites typical of sediments loaded by ice or sediment, approximately equivalent to lithologic Unit II. Units 3 through 6 (167-310 mbsf) show alternations of increasing and decreasing trends in compaction on stratified and massive diamictites, possibly representing the effects of several fluctuations of the grounding line of a glacier back and forth over the site, or sediment loading, or a combination of both; these units equate with lithologic Units III and IV approximately. Units 7-8 (310-486 mbsf) lack any evidence of major ice-loading events, as the diamictites apparently have not been overconsolidated. These units correspond approximately to lithologic Unit V.

On the basis of downhole logging, four units were defined according to major fluctuations in porosity, velocity, resistivity, and spontaneous potential. These changes reflect differences in the degree of compaction. These parameters have been used to infer the lithologic characteristics of the unrecovered intervals. In particular logging Units I and II correspond to lithologic Unit II, logging unit III approximates lithologic unit III, and logging unit IV corresponds to lithologic Units IV and V. The nonrecovered intervals in these lower units are probably sand layers.

Seismic data obtained near the site during Leg 119 have been processed and are part of a continuous transect from inner Prydz Bay to the shelf edge. These data will be helpful in making correlations between the sites, especially between Sites 739 and 742. Three acoustic units have been distinguished at Site 739 (Figure 8). Acoustic unit 1 (0-175 mbsf) shows flat-lying, high amplitude reflections. This great variability in reflection character results from large fluctuations of in situ velocity and density, as measured by downhole logging. Two high-amplitude reflections at 120 and 175 mbsf coincide with the top and bottom of a massive diamictite (the main recovered part of lithologic Unit II), respectively; the lower boundary also corresponds with the paleontologically determined early Oligocene-late Miocene hiatus. Acoustic unit 2 (175-310 mbsf) is characterized by a seaward-dipping sequence of high variability, reflecting marked changes in the continuity, uniformity and inferred degree of lithification of the sedimentary facies. This unit is equivalent to the mixed massive and stratified diamictites of lithologic Units III and IV. Acoustic unit 3 (310-467 mbsf) shows near continuous, gently seaward-dipping, low amplitude reflections. These reflections show a relatively uniform increase in velocity with depth, characteristic of burial compaction. Relatively low-velocity layers match with the sands inferred from the downhole logging, but not recovered by drilling.

Site 740

Site 740 (proposed site PB-1) is situated in the inner part of Prydz Bay on the East Antarctic continental shelf (Table 1; Figure 1). The main objectives of this site were to sample and date the lower portion of the basinal sediments of Prydz Bay in order to provide information on the pre-glacial depositional environments and climate in East Antarctica, and the age of graben formation or the separation of East Antarctica from India. A further objective was to study the younger sequence of glacial/pre-glacial sediments as a means of developing a generalized model for sedimentation on glacially dominated shelves.

The sedimentary succession recovered at this site was incomplete because of poor core recovery. It can be divided into three units. However, the contacts between units can not be accurately defined as they lie within zones of no recovery. Nevertheless, the units coincide with significant changes in the physical properties of the sediments. Unit I (0-15 mbsf) is soft diatomaceous ooze containing 10-20% terrigenous clastic grains, 15-95% diatoms, and 0-5% radiolarians and silicoflagellates most probably of late Pliocene to Holocene age, extending from the seafloor to approximately 15 mbsf. This unit is deposited in small sediment ponds in the deeper parts of the inner shelf. The sediments in these ponds are draped over existing topography. Unit II (15-60 mbsf) is silty clay with about 1% gravel and coarse sand in those parts recovered. The gravel component consists predominantly of granules and small pebbles of quartz, granite and gneiss, with scattered boulders of gneiss. Minor amounts of diatoms of late Pliocene to Holocene age are present in the uppermost part of the unit. Unit III (60-225.5 mbsf) consists of greenish gray and red poorly sorted immature sandstone interbedded with reddish and mottled siltstone and claystone. The ratio of sandstone to siltstone and claystone decreases markedly toward the top of the unit, thereby imparting a gross fining-upward trend to the succession. Compositionally, the sandstones range from feldspathic arenite and quartz arenite to feldspathic wacke and quartz wacke. No fossils were observed in this unit apart from undatable algal spores.

Internally, the section contains vertically stacked, pedogenically influenced fining- and rare coarsening-upward sequences up to 2 m thick. Individual fining-upward sequences, where fully developed, comprise a scour surface overlain successively by conglomerate, coarse- to medium-grained cross-bedded sandstone, and locally rippled and laminated siltstone and claystone. In some cases the conglomerate is missing and the scour surface is directly overlain by sandstone. Rare coarsening-upward sequences typically comprise locally rippled fine-grained sandstone or siltstone, sharply or gradationally underlain by claystone or silty claystone.

The sedimentary succession at this site records major changes in depositional environments. The older sediments of Unit III, located some 300 m above the basement, are a "red bed" type sequence deposited within a fluvially influenced continental environment. Thus, the major sandstones are interpreted as channel sand bodies, and the finer siltstones and claystones represent low-energy flood basin and overbank deposits. The fining- and rare coarsening-upward trends recorded in the vertical changes in lithology, texture, and sedimentary structures are attributed to channel shifting (avulsion) and fluctuating discharge related to decelerating and accelerating flood flows. The presence of pedogenic carbonate (calcrete) deposits provides useful evidence of the climatic conditions prevailing at this time. Comparison with Holocene and older equivalent pedogenic deposits shows that pedogenesis normally requires a warm dry climate with a seasonal but not excessively peaked rainfall. The mineral composition of the sediments shows that they are immature first cycle sediments. The red and green color of the sediments is determined primarily by their residence time in the oxygenated vadose zone and the degree of diagenetic alteration of iron-bearing minerals such as mica. The overall upward-fining trend of this unit can be explained by a gradual decrease in paleoslope in response to weathering and the gradual reduction in source area relief, or to decreased levels of tectonic activity. Unit II, which rests unconformably on Unit III, is probably indicative of cold water glaciomarine conditions, whereas the overlying diatom ooze (Unit I) represents present day conditions of sedimentation.

The occurrence of well-preserved diatoms allows the interval from 0.0 to 13.7 mbsf (Unit I) to be assigned to the Quaternary with a probable age of less than 0.62 Ma. Below this interval diatoms are sparse, poorly preserved, and lack zonal taxa. Nevertheless, the species indicate a late Pliocene or younger age for the upper part of Unit II. Because of the lack of fossils in Unit III its age is uncertain, but it may correlate with parts of the Permian Amery Group sediments in the Lambert Graben, some 360 km to the southwest. Alternatively, it may form part of the ?Mesozoic-Cenozoic "molasse and/or riftogenic" complex, which is thought to represent pre-glacial sediments in Prydz Bay.

Paleomagnetic studies demonstrate that two polarities are present in the "red beds" of Unit III, and that the primary magnetization is of reversed rather than normal polarity. These results are incompatible with a Permian age for these sediments, and more detailed land-based paleomagnetic and paleontological (palynological) studies are required in order to more accurately characterize the age and magnetic history of the sediments. However, the existence of multiple components of magnetization in these rocks is an indication that they must have undergone a complex geological history, possibly related to the development of the Lambert Graben.

Alkalinity and sulfate analyses of interstitial waters from this site indicate high levels of microbial activity in the uppermost sediment layers which emit a strong smell of hydrogen sulfide. Oxidation of organics is responsible for the significant enrichment of the interstitial waters in the uppermost sediments in ammonium and phosphate. High values for ammonium and phosphate suggest that most bacterial catabolism occurs near the sediment/water interface. Both organic carbon and carbonate are low, except for the interval 0-17 mbsf, where up to 1.4% TOC was recorded. However, these levels drop off downhole. The reason for this is not clear because of poor core recovery between 17 and 59 mbsf. Below 59 mbsf the depletion in TOC probably reflects the dry, oxidizing nature of the original depositional environment.

Preliminary study of the marine ecosystem in Prydz Bay shows that few species in the plankton at this site are not associated with ice. Furthermore, no single species is restricted to the ice, although those species adapted to growth in brine pockets in the ice seem to flourish best.

Abrupt changes in the physical properties profiles enable us to divide the sediments into four geotechnical units. The upper two units, G1 and G2, are equivalent to lithologic Units I and II. Geotechnical units G3 and G4 lie within lithologic Unit III. Although there is no evidence from the appearance of the sediments to warrant any further subdivision of this unit, the geotechnical properties indicate a slight but significant change at 190 mbsf where a slight reversal from normal to anomalous depth trends on index property and velocity profiles occurs. In addition, bulk density and velocity show decreasing trends below this boundary while water content and porosity increase. This manifests itself in the occurrence of relatively thick, coarser, poorly consolidated, more porous and permeable sand bodies.

Site 741

Site 741 (proposed site PB-3) is situated in the inner part of Prydz Bay on the East Antarctic continental shelf (Table 1; Figure 1). Drilling at this site penetrated a 24-m-thick sediment cover probably of glacial origin underlain by about 100 m of older continental clastics (Figure 7). Seismic data indicate that these sediments form part of a 2-to 3-km-thick, subhorizontal sedimentary sequence that probably rests on basement. Stratigraphically the sampled interval lies about 2000 m above the top of the pre-glacial sediments encountered at Site 740, which lie, in turn, some 600 m above basement. The main objectives at Site 741 were to recover the nonmarine to marine transition and the pre-glacial to glacial transition in order to date the onset of glaciation in Prydz Bay and to determine the pre-glacial environment of Prydz Bay.

The sediments at Site 741 have been divided into four lithologic units. Unit I (0.00-0.66 mbsf) is soft, soupy diatom ooze containing about 20% terrigenous quartz silt. In addition to diatoms, the sediment contains rare radiolarians, silicoflagellates, and sponge spicules. Small, mainly subangular metamorphic pebbles up to 4 cm long are randomly scattered throughout the unit. Coarse sand grains and granules of quartz concentrate near the base of the unit. Unit II (0.66-4.1 mbsf) is soft, homogeneous clayey silt with up to 20% diatoms; the proportion of diatoms decreases toward the base of the unit, concomitant with a change in color from greenish gray to gray. The nonclay fraction of the sediment is predominantly quartz silt. Unit III (4.1-24.05 mbsf) lies within an interval of poor core recovery, and comprises broken fragments of metamorphic rocks, some of which are hole cave-in contamination. As a result the thickness, age and overall composition of this unit is unknown. Unit IV (24.05-128.1 mbsf) is the dominant lithologic unit at this site. It consists predominantly of fine- to medium-grained, poorly sorted sandstone, with siltstone, containing various amounts of finely disseminated organic matter and carbonized plant fragments. Coarse sandstone, conglomerate, and claystone are also represented but make up only a small part of the succession. Fining-upward and rare coarsening-upward sequences occur in places. The more common fining-upward sequences consist of an erosively based coarse sandstone that grades up into finer grained sandstone, siltstone, and claystone. The scour surface in some sequences is overlain by a clast-supported conglomerate composed of intra- and extraformational clasts up to 5 cm long. The sandstone is structureless, vaguely laminated or less commonly cross-bedded on a small to medium scale. Locally the sandstone is cemented by carbonate (Core 119-741A-7R), but most is relatively immature and composed of quartz, feldspar, garnet, biotite, and pyrite. The finer grained lithologies in the upper part of these sequences are laminated, ripple cross-laminated, and weakly bioturbated. Coarse sand grains and granules of quartz are scattered throughout most of the coarser sandstone in these sequences. Some of the more elongate plant material is imbricated, consistent with transport by unidirectional currents.

The absence of fossils other than plant fragments and pollen, and the presence of erosively based fining-upward sequences suggest that Unit IV was deposited by river channels. The precise location of this fluvial depositional system is difficult to assess because of the shallow depth of the hole and poor core recovery, but it may have originated on the intermediate to distal reaches of an alluvial plain. There is no evidence of any marine influence on sedimentation. The general environmental setting was conducive to growth of extensive vegetation along channel banks and low lying areas of the alluvial plain. As the channels shifted as a result of gradient advantages, vegetation became incorporated into the sediment and subsequently carbonized under reducing conditions. This is consistent with the reduced character of the host sediments and the presence of pyrite. The internal character of the channel sand bodies suggests that the channels were probably of a perennial nature. This and the abundance of vegetation argue for a wet climatic regime.

Lithologic Unit III is poorly preserved. It may, however, represent the remnants of a gravel-bearing diamicton. The fine-grained diatomaceous clayey silt of Unit II may have been deposited in a distal glaciomarine setting, in a location sufficiently distant from the active ice margin to allow for biogenic productivity. The increase in diatoms toward the top of the unit may indicate a phase of glacial recession and climatic amelioration. The uppermost portion of Unit I records present-day conditions of sedimentation.

Poor to moderately well-preserved diatoms recovered from the uppermost portion of the sequence indicate a Quaternary and late Pliocene age. A diverse, poor to moderately preserved, possibly Eocene pollen and spore assemblage, including reworked Late and Early Cretaceous forms, was found at about 50 mbsf. A diverse benthic-dominated foraminiferal assemblage was recovered from the mud line, but these did not persist downcore. Paleontological data indicate the presence of a significant hiatus between 33.5 and 43.2 mbsf separating the upper Pliocene from the ?Eocene.

Paleomagnetic studies reveal a predominantly negative inclination indicative of normal polarization in the southern hemisphere. Field demagnetization experiments demonstrate a wide swing in demagnetization as a result of unstable magnetization. Because of this no age has been assigned to these rocks.

Geochemical analyses of sulfate, phosphate, and ammonium in the interstitial waters at this site indicate that the abundance of reactive organic matter is limiting microbial activity. The downhole decrease in sulfate values is low and implies (1) that the supply of reactable organic matter to the sediment is low (low surface water productivity) and (2) that sedimentation rates are too low to prevent diffusion of oxygen into the sediment column. The carbonate content at this site is generally low (<3%). However, there is a high terrestrial (type III kerogen) organic content below 27 mbsf. Much of the material appears to have been reworked, as indicated by the sedimentology and palynology, and it is unlikely to have a hydrocarbon producing potential. Based on the chemical character of the organic matter the environment may have been partly oxidizing.

Interpretation of the physical properties data at this site is difficult owing to poor core recovery, and only a very broad subdivision into geotechnical units is possible. The upper thin layer of soft superficial sediments is divided into two geotechnical units, which correspond to lithologic Units I and II. The remainder of the sedimentary succession is considered one geotechnical unit. Unit 1 is diatom ooze identified on the basis of its high water content and porosity and low bulk density. Unit 2 is a normally consolidated gravel-bearing diamicton, but because of poor recovery few physical properties were measured. Unit 3 is approximately equivalent to lithologic Unit IV. It shows no significant changes in physical properties with depth. The slight changes that can be detected are due largely to the influence of texture and variations in carbon content.

Two acoustically defined units are recognized at this site; acoustic unit 1 (0-25 mbsf) and Acoustic unit 2 (25->128.1 mbsf). Acoustic unit 2 is characterized by low amplitude discontinuous reflections. The acoustic character and gentle dip of the reflectors are consistent with relatively uniform sandstone and claystone lithologies. The total thickness of the sedimentary section beneath Site 741 is not known. The unit drilled at 190 mbsf near the bottom of Hole 740B is approximately 2 km below the bottom of Hole 741A. However, the uniform acoustic character of acoustic 2 two and the occurrence of nonmarine sediments at Sites 740 and 741 suggest that the sedimentary section below Site 741 may also be nonmarine and that acoustically it can be traced to the northwest of Site 741 where it becomes downbowed into a mid-shelf trough. The lack of deformation features implies that, apart from general subsidence, the area has remained relatively stable since deposition of unit 2.

Site 742

Site 742 is located 60 km from the shelf break, 170 km from Antarctica, approximately midway along the Leg 119 Prydz Bay drilling transect (Table 1; Figure 1). This site and Site 739 provide the principal deep penetrations of the Prydz Bay glaciogenic stratigraphy. The main objective was to sample and date the sediment section that lies between the marine

Paleogene glacial units recovered farther north at Site 739, and the nonmarine ?Paleogene sequence cored at landward Site 741.

A seismic survey was run from Site 741 to determine the geometric structure of the sediment units involved and to pass over Site 742. The underlying seismic stratigraphic structure consists of a sequence of nearly flat to gently seaward-dipping reflections, representing parts of the prograding sediment wedge of the Prydz Bay outer shelf.

The site was cored to 316 mbsf, before being abandoned because of the detection of very low gas levels (methane 35 ppm or less); detections of higher weight molecules (ethane and propane; 2-6 ppm and 5-12 ppm, respectively) proved to be very irregular. Nevertheless, proximity of the site to seismic fault structures warranted abandonment of the hole.

Although diamictite and diamicton composed the bulk of recovery, six lithologic units were recognized, based on some significant minor lithologies (e.g., diatomite, sorted sand) or on differences in the diamictite (e.g., layering, calcareous content; Figure 7).

Surficial Unit I (0-5.4 mbsf) is a Quaternary soft, uncompacted, pebbly diamicton and olive diatomaceous silt-clay. Gravel content is 5-10%. No oriented fabrics were detected for the gravel clasts, implying that the diamicton originated as proximal marine waterlaid till. Grounding icebergs appear to have played a role in the disruption of the unit, as grounding scars are visible in 3.5-kHz records over the site. Fossil remains include benthic foraminifers, diatoms, and (Pleistocene) radiolarians.

Unit II (5.4-115.2 mbsf) consists of a considerable thickness of compacted, massive, dark gray diamictite. Some intervals of exceptionally low recovery may mark levels with a high content of pebbles and boulders. Gravel content is high (up to 15% in recovered intervals), but varies considerably. Depositional conditions were probably diverse, and the nonrecovered intervals may conceal a complex advance-retreat glacial sequence. Random grain fabric and massive character at the base suggest waterlaid till deposition. Parts of the unit bear rare, poorly preserved marine diatom remains of late Pliocene-Quaternary age, and also specimens of reworked nannofossil and diatom taxa from a range of early Eocene to Quaternary.

Unit III (115.2-134.4 mbsf) is a thin comparatively well-stratified, lithologically diverse unit. An 80-cm-thick diatomite of early late Pliocene age lies between poorly consolidated diamictites that show evidence for discrete episodes of soft-sediment deformation and intraclast erosion/redeposition. Proximal glaciomarine deposition on an unstable slope is envisaged.

Crudely layered diamictites composing Unit IV (134.4-172.5 mbsf) lie below. Gravel content increases steadily upsequence and reaches 10-15% adjacent to the bouldery interval from 133.7 to 134.4 mbsf. Grain orientations are random throughout, suggesting waterlaid till deposition. The content of redeposited organic matter is very high compared to surrounding units (1-2%). A very sharp lower boundary is presented to Unit V (below), and there is evidence for reworking from the lower unit in the basal few meters. Thus, the lower boundary, which corresponds with important levels in the seismic stratigraphy, physical properties and downhole log data, is probably erosional. No biostratigraphic control exists for Unit IV.

Unit V (172.5-304.3 mbsf) consists of diamictite, characterized by relatively pale tones, a minor calcareous component, and low percentages (1-5%) of gravel. The massive, homogeneous character and random grain orientations suggest that it was deposited as a waterlaid till or proximal glaciomarine till. The carbonate content is due to detrital micrite, and is comparable to that in Subunit IVB of Site 739. A lithologic correlation of those units is thereby suggested, supported by the fact that both bear ?Eocene-Oligocene fossils. In this unit those fossils consist of rare diatom fragments at 170-174 mbsf and nannofossils (associated with ?bivalve remains) at 245 mbsf, each occurrence suggesting a middle Eocene to Oligocene age.

Finally, Unit VI shows diamictite interstratified with laminated claystone and (at the base) texturally sorted sandstone and carbonaceous siltstone. These levels are apparently of fluvial-lacustrine origin and probably indicate periglacial environments associated with standing and flowing water, perhaps meltwater. The laminated silty claystone shows no graded bedding and no evidence of bottom-current scouring, but gravel dropstones and the interbedded sand-silt-clay beds attest to synchronous ice-rafted deposition. The thicker sand-silt-clay and diamictite accumulations of Unit VI contain 1-5% gravel for which no preferred orientation is found. At the very base of the unit lies a thickness of interbedded sorted sandstone, carbonaceous siltstone, and sand-silt-clay. The entire subunit underwent soft-sediment deformation (folding), apparently before deposition of overlying strata. Different explanations for the emplacement of these beds are possible: (1) that they were deposited as part of Unit VI, but underwent glaciotectonic deformation; or (2) that they were glaciotectonically transported to the site, perhaps from a great distance and probably fromanother (?lower) unit. In any case, they indicate some period of simultaneous fluvial/lacustrine and glacial nonmarine deposition. The clastic supply was identical to that throughout Unit VI but has undergone greatly improved textural sorting without the rounding of grains. The inferred depositional environment tallies with that of the lacustrine silty claystones above. Abundant spore-pollen and dinoflagellate remains occur throughout Unit VI, but most appear to be reworked and most coal in the unit occurs as pebbles. A small number of dinoflagellate cysts were observed, which were indicative of an early Eocene-Oligocene age or younger (if reworked).

No definitive correlations between the paleomagnetic reversal sequence found at this site can be made with reference to paleomagnetic time scales. Natural remanent magnetization values for upper parts of the hole were very large, perhaps reflecting relatively high contents of heavy minerals in the sediments. Magnetic inclinations shallow downhole from 180 mbsf, and this is interpreted as a decrease in the paleolatitude with increasing time. Below 172 mbsf the diamictite of lithologic Unit V displays a dominant normal polarity which is interrupted by six brief reversals (cryogenic data). Within the middle Eocene to earliest Oligocene age constrained for this interval by in situ calcareous nannofossils and diatom assemblages overlying this interval in strata at Site 739, this magnetostratigraphy most closely resembles that of magnetic polarity Chrons 18-16 (late middle to late Eocene).

The physical properties program was aimed particularly at investigating the effects of variable glacial cover in terms of sediment consolidation. Six geotechnical units were distinguished and show a generally good correspondence with the lithostratigraphic divisions. The upper unit (1; 0-5.4 mbsf) is normally (weakly) consolidated diamicton covered with a thin veneer of diatomaceous silt-clay. The transition into unit 2 clearly represents a transition into overconsolidated sediment. The abrupt change in all physical properties is evidence that 2 sediments have experienced a considerably higher load than their present overburden. Grounded ice is a likely explanation, either through direct loading or glacial removal of a former sediment load. Units 2 (5.4-114 mbsf), 4 (135.5-172.6 mbsf) and 5 (172.6-195.4 mbsf) have essentially the same physical properties characteristics: low water content and porosity, and higher bulk density, P-wave velocity, and shear strength. This implies the existence of grounded ice at the tops of units 2, 4 and 5 (lithologic Units II and V to 195.4 mbsf) at stages in the Cenozoic. Unit 3 (lithologic Unit III) on the other hand causes a distinct velocity reversal that is likely to give rise to a strong seismic reflector, and is characterized by relatively higher water content and porosity than surrounding sediments, and also decreased bulk density and undrained shear strength.

Downhole logging results were obtained from 30.8 to 283.8 mbsf. Changes of velocity and porosity correspond well with the boundaries of geotechnical units based on laboratory measurements, and appear to outline several units of overcompaction. A synthetic seismogram computed from the downhole log indicated that the largest velocity and density variations occur at unconformities and low-velocity layers in the lithostratigraphy and that these are the principal cause of seismic reflections.

On closer inspection, and with the benefit of the lithostratigraphic and downhole logging results after drilling, the seismic stratigraphy yielded information of the larger-scale internal structure and broader geometry of facies in the Site 742 area. The acoustic units are mostly undeformed, other than by erosion and slight downwarping in the central part of the shelf, indicating long-term tectonic stability in the region. Acoustic unit 1 (0-175 mbsf) is nearly flat and contains high-amplitude reflections, discontinuous owing to glacially compacted (high velocity) and underconsolidated (low velocity) layers. It is without apparent internal stratification in the upper 120 mbsf (equaling lithologic Units I and II), but is more continuous below (lithologic Unit III).

The in situ velocity-depth profile for acoustic units 2 and 3 shows that velocity increases with depth, indicating that reflections at these deeper levels are not caused by velocity inversions from to compaction by glacial loading. Combined, the two represent lithologic Unit V, composed of diamictite. Acoustic unit 2 (175-220 mbsf) is characterized by weak but continuous reflections that broaden seaward. The entire unit also thickens seaward, reaching maximum thickness between Sites 742 and 739. Unit 3 (220-304 mbsf) is characterized by high amplitude, laterally variable reflections of complex shape. It can be traced over a 25-30 km distance in the region of Sites 742 and 739. Between the two sites, the upper surface dips gently seaward, but the bottom is irregular because of the infilling of an eroded substrate. The high amplitude reflections in unit 3 are probably due to low-velocity, unlithified sand layers such as those identified by downhole logging. Their acoustic characteristics, including varying waveform shapes, terminal diffractions, and wavy underlying reflectors, are strong indicators of areally restricted, low-velocity sand bodies with variable thickness that may compose channel, deltaic, or meltwater sand bodies. Continuous high amplitude reflections farther seaward may represent a more distal facies.

Acoustic unit 4 (304-415 mbsf) is represented by the probably periglacial fluvial/lacustrine facies of lithologic Unit VI. The semi-continuous and wavy reflections are often weak, discordant with overlying strata, and associated with diffractions. The unit is identifiable over 75 km in the ODP seismic lines and filled pre-existing or slowly subsiding depressions seaward and landward of Site 742. The reflection character and style of truncations suggest that unit 4 is a mostly nonmarine sequence of possible lacustrine/fluvial origin that was eroded in the initial period of glacial advance.

Acoustic unit 5 (415-675 mbsf), between unit 4 and the seafloor multiple beneath Site 742, was not sampled by drilling. It consists of well-layered, continuous to semi-continuous reflections with variable amplitudes in both depth and distance. It is traceable over 90 km, from Site 739 (where disappears into the seafloor multiple) to a point 35 km seaward of Site 741 (eroded near the seafloor). Seaward it becomes more strongly reflective and continuous. The relatively uniform thickness, continuity and absence of major deformation suggest that the unit was deposited on a relatively stable platform, possibly as shallow marine and alluvial plain deposits and possibly non-glacial.

Correlations of the seismic units indicates that the thickness between Sites 741 and 742 is about 3 km, and that if reflections from the lowermost beds drilled at Site 742 are traced, they lie approximately 750 m below the bottom of Hole 742A.

In brief summary of the total stratigraphic results, Site 742 appears to have been a location of fluvial/lacustrine deposition at those times corresponding with the base of the hole (?Eocene), though glacial/pre-glacial deposition was also clearly already in operation. Distinct erosional surfaces and glaciotectonic deformations in the stratigraphy at about this level show that bodies of ice were present and in motion on the landscape, in addition to ice-rafting of debris into lake deposits. Younger diamictite of probable Oligocene age continues the glacial record. Fossil remains in Unit V (245 mbsf) seem to indicate the level at which glacial-marine conditions began. The earliest evidence of grounded ice based on oriented grain fabrics, is in Unit IV (140-150 mbsf), which displays coarsening-upward in gravel and is overcompacted from the grounding of ice (i.e., ice loading and/or sediment load removal) at Site 742. This level (173 mbsf) is an especially significant one in the seismic stratigraphy, being the initiation of the horizontal "shelf" accumulations at this particular location in the Prydz Bay continental progradation; underlying units have the form of gently sloping, progradational deposits.

Thus, this transformation and first ice-grounding predate the early late Pliocene and postdate Oligocene beds. Sediments representing open marine conditions where diatom accumulation was not overwhelmed with glaciomarine clastics may have accumulated on several occasions at Site 742, but are preserved only for the early late Pliocene (Unit III). However, two different time intervals of similar deposition are preserved at Site 739. Thick accumulations of coarse diamictite followed, but were perhaps a result of more than one depositional phase. No detailed history of this interval is available because of poor core recovery, but downhole logging suggests that it underwent overconsolidation as one unit. That event probably coincided in its final stages with the Quaternary surface between Units I and II, at 5.4 mbsf (Unit I/II boundary) since clast orientation fabrics below that level indicate a considerable thickness of lodgment tills. Subsequent deposition has been of proximal glaciomarine clastics and in very recent times, diatomaceous silt-clay.

Site 743

Site 743 is situated on the upper continental slope of Prydz Bay (Table 1; Figure 1). The site was situated on seismic Line 21 of Stagg (1985; see Figures 3 and 4) on the upper slope as far seaward as possible in order to maximize the marine influence of the sediments and minimize the amount of boulders dropped from grounded ice. However, the seismic line measured by JOIDES Resolution while approaching the site showed that the continental slope, below a water depth of 1000 m, is characterized by many small steps, probably indicating slump scarps. In order to optimize the chance for an undisturbed datable stratigraphic sequence, the drilling site was selected at a depth of about 1000 m.

Three lithologic units were identified in the recovered sequence. Unit I (0-0.46 mbsf) is moderately well-sorted sand, the upper part of which is mixed with diatom ooze. It contains beds with size-graded foraminifers. Unit II (0.46-15.8 mbsf) is rather stiff and sticky clayey silt with mostly less than 1% gravel, interbedded with 1- to 132-cm-thick layers of sorted sand and gravel. The clayey silt is homogeneous, showing no sign of sedimentary structures. Contacts between sand and the clayey silt are sharp. The sand and gravel layers rank from well-sorted, clearly current-transported sands with size-graded foraminifers to poorly sorted gravelly sands, which may represent erosional lags or grain flow deposits. The description of Unit III (15.8-98.1 mbsf) is hampered by very low core recovery in this interval; it exceeded 10% in 2 of 10 cores. Although represented by little more than an assemblage of stones in several cores, this unit appears to be diamicton, dark gray, massive clayey silt with 5-25% sand and gravel.

The carbonate content is generally less than 0.5% throughout the sequence, except for two sand layers that contain 2.4 and 4.2% $CaCO_3$. The organic carbon content is in the range 0.2 to 0.6%, mostly reworked type III kerogen with minor type II. The organic content is thus chiefly detrital; a contribution from the marine environment was not recognized. Microbial catabolism is limited by the low abundance of organic matter. Silicate concentrations in the pore water are well above seawater concentrations, showing that dissolution of biogenic(?) silica takes place in the sediment. No concentrations of methane significantly above background levels were detected.

The stratigraphic sections previously recovered from the prograding unit (Site 739, 170-313 mbsf) were clearly overconsolidated, possibly by ice-loading, so comparing the physical properties of the corresponding sediment types on the slope, which have not been covered by grounded ice, with those of Site 739 may provide critical information regarding the compaction of the diamictons. From the physical properties (water content, porosity, bulk density, sound velocity, etc.) at Site 743, the sequence is divided into three geotechnical units, 1 (0-9.9 mbsf), 2 (9.9-11.4 mbsf) and 3 (11.4-98.1 mbsf, total depth). Of these, unit 2 is most distinct, and most likely reflects a higher proportion of fine-grained fraction relative to the adjacent units. All geotechnical parameters show relatively constant values in the upper unit, while there is a gradual downhole effect of increased overburden in unit 3. The average water content of the units are 16.8%, 32.9%, and 15.5%, which indicate rather low ercentages of clay in the sediment. At the present stage of investigation, the sparse data indicate no overconsolidation indicative of ice loading, or large scale erosion or slumps removing extensive sediment masses in the cored sequence.

The samples examined from the site are barren of calcareous nannofossils, radiolarians, and dinoflagellates. Diatoms are rare and poorly preserved in the upper 12 m, but appear to be absent below. They indicate that the upper 12 m is late Pliocene-Quaternary in age. Foraminifers occur in several sandy intervals, down to 69 mbsf. The age of the foraminifer-bearing intervals is late Miocene to Holocene based on the presence of the planktonic foraminifer Neogloboquadrina pachyderma. It was not possible to achieve a magnetostratigraphic determination for this site.

The seismic pattern at Site 743 is in general similar to that seen in the prograding sequence elsewhere on the seismic transect. Consequently it is likely that the sediment sequence encountered at this site is reasonably representative of the types of sediments elsewhere in the prograding sequence, but not necessarily in similar proportion. At Site 743, two acoustic units are identified as being the youngest two of the seaward prograding sequence of the upper continental slope. Unit I (0-500 mbsf) is characterized by variable amplitude and continuity reflections from interbedded diamicton and sand layers of Quaternary age, at least in the uppermost 60 meters. Unit II (500-900 mbsf) consists of continuous to semi-continuous reflections that are characterized commonly by very high amplitudes. Reflections at the top of Unit II can be traced updip to a paleo-shelf edge and "topset" beds beneath the continental shelf. The age of this paleo-shelf edge is younger than late Miocene, based on seismic tracing from dated sequences at Site 739.

The recovered sediment sequences at Sites 743 and 739 prove that diamicton (unsorted clayey silt with gravel and stones) is a very important constituent of the sediments of the continental slope and thus of the prograding unit. The supply and deposition of this unsorted sediment, including boulders, indicate melting of huge amounts of debris-laden ice, presumably from the basal part of a floating glacier that probably was grounded very near to the shelf edge. Direct sedimentation (rain-out) from the floating ice shelf in front of the grounded ice in combination with various mass flows on the slope is presumably the main depositional processes on the slope. A grounded ice edge will act as a linear sediment source, which explains the extension of the prograding unit along the shelf. The muddy waters and lack of light under the floating ice shelf (proximal glaciomarine environment) offer an explanation for the scarcity or lack of marine fossils in the diamicton. The lack of glacial loading on the slopes glacial sediments is also consistent with the model. This mode of sedimentation is only effective on the slope during near maximum extent of ice cover, while current-sorted sediments or distal glaciomarine sediments may be deposited in the intervening periods.

The other facies of the slope sediment are sand and gravel layers. The well-sorted sand layers containing size-graded foraminifers are clearly transported and deposited by currents. The highly variable, poorly sorted sand with gravel and scattered clay may be lag sediments, indicative of occasional erosion of the slope. It is uncertain whether the sand units represent sedimentation on the slope in "interglacial" periods like the present day, or intermittent variations in the currents that sweep the slopes without close relation to glaciations.

The diamicton on the slope is thus indicative of an extensive ice sheet. This, combined with the dating of sand layers in the upper part of Hole 743, indicates that the ice sheet extended to the shelf edge at least once during Quaternary.

SUMMARY

Ocean Drilling Program Leg 119 departed Port Louis, Mauritius, on 18 December 1987 and arrived Fremantle, Australia, on 21 February 1988, completing a 66-day scientific expedition to the Kerguelen Plateau in the southern Indian Ocean and to Prydz Bay, East Antarctica. Scientific objectives addressed the paleoceanographic history of the southern Indian Ocean, the geologic development of the Kerguelen Plateau, and the onset and development of glaciation in East Antarctica.

Six drill sites (736-738, 744-746) were occupied on the northern and southern Kerguelen Plateau (Figures 1, 5, and 6). Sediments recovered from the northern sites (736 and 737) consist of middle Eocene to lowermost Miocene (57-23 Ma) calcareous claystones overlain by middle Miocene to Quaternary (15.0-0 Ma) diatom and calcareous oozes. The abrupt transition between these sediment sequences, clearly visible on seismic profiles, thus represents a major hiatus having a duration of about 8 m.y. Superimposed on the general pelagic biogenic character of the sediments is a component of volcanic glass and minerals present throughout the sequence, but distinct ash layers are few.

The northern Kerguelen Plateau sites are situated directly below a major surface-water boundary, the Antarctic Convergence, which separates more temperate surface waters from polar waters. Examination of the recovered sediments allows monitoring of the latitudinal fluctuation of this surface water-mass boundary over time. An abrupt change in the diatom assemblage from species typical of temperate regions to species endemic to the Southern Ocean suggests that present-day oceanographic circulation patterns were established during the late Miocene or early Pliocene (4.5-5.5 Ma), probably as a result of a climatic cooling.

Drill sites situated on the southern Kerguelen Plateau (738, 744) and just to the east of that structure (745, 746) recovered Cretaceous through Quaternary sediments and 37 m of basalt breccia and altered basalt (Figure 6). The basement, which was encountered at Site 738, is older than the overlying Turonian limestone (90 Ma) and consists of alternating volcaniclastics and massive, aphyric basalt. The presence of oxidized red volcaniclastics, the abundance of vesicles, and the lack of typical submarine flows suggest that these basalts erupted in shallow water or above sea level. The present depth to the surface of the basement (2742 mbsf) combined with a minimum age of 90 Ma agrees well with the subsidence curve for other aseismic ridges. The sediment sequence recovered at Site 738 documents a series of paleoceanographic and geologic changes caused in part by subsidence of the southern Kerguelen Plateau. This shows up as a progression from inner shelf (<100 m water depth) deposition during the Late Cretaceous (65 to 89 Ma) to pelagic ooze deposited at water depths comparable to those of the present day (2252 m). Of special interest is a complete, undisturbed Cretaceous/Tertiary boundary which occurs within a 15-cm-thick sequence of laminated calcareous claystone. The truncated and compressed Oligocene and Neogene section at Site 738 is represented by over 160 m of well-preserved, mixed nannofossil and diatom ooze at Site 744, extending from the lower Oligocene through the Quaternary. A transition from calcareous to siliceous deposition occurred during the late Miocene (7.6 Ma), and increased deposition of gneissic/granitic ice-rafted debris

of probable Antarctic derivation has taken place during the late Pliocene to Holocene, signaling intensification of glaciation in Antarctica.

Deep-water Sites 745 and 746 lie on a sediment ridge (4100 m water depth) off the steep southeast flank of the Kerguelen Plateau. Sediments recovered at these sites record glacial-interglacial fluctuations during the last 10 million years. Biosiliceous-rich sediment alternates with clay-rich sediment in cycles. The biosiliceous-rich sediment contains diatom and radiolarian species typical of interglacial periods; the clay-rich sediment contains diatom and radiolarian species characteristic of glacial periods in the upper Pliocene and Quaternary and may represent increased transport of detrital material by bottom currents and/or increased ice-rafted deposition during glacial periods.

Coring at the five Prydz Bay drill sites (739-743; Figures 1, and 7), was an attempt to drill through the glacial sequence in East Antarctica and the first attempt by the Ocean Drilling Program to document the Cenozoic history of ice cover on the Eastern Antarctic continental shelf (Sites 739, 742, and 743). Two sedimentary successions below the glacial deposits were recovered consisting of "red bed" type sediments of continental origin (Site 740), and laminated silty claystone, poorly sorted sandstone and siltstone of fluvial and lacustrine origin (Site 741).

The Prydz Bay sequence records major changes in the depositional environment. The oldest succession above acoustic basement, the "red bed" type sediments, suggests deposition within the proximal reaches of a river system. Climatic conditions at the time probably were warm and characterized by seasonal rainfall. Although the paucity of microfossils inhibits age determinations, these sediments may be equivalent to the Amery Group sequence in the Lambert Graben, suggesting a possible Permian age, but a later age is also possible. The overlying thin units of laminated silty claystone, poorly sorted sandstone, and carbonaceous siltstone at Site 741 lie below the Prydz Bay glacial sequence and are of Eocene age, on the basis of spore and pollen detritus present in the sediment.

The sequence recovered at Sites 739 and 742 consists of unsorted mixtures of clay, silt, sand, gravel, and occasional stones (diamictites). They represent various facies of glaciogenic deposition, from lodgment till, deposited beneath grounded ice, through waterlaid till, deposited off but near the grounding line, to glacial marine sediments of a more distal facies. The waterlaid till may have been deposited beneath floating ice shelves and down the upper part of the continental slope during periods when the grounding line was at or near the shelf break. The more distal glacial marine facies are rather poorly represented in the cored sequence, an observation that may be explained by erosion of this facies by subsequent advances of grounded ice. The latter is indicated by various degrees of apparent compaction through the sequence, pointing toward several major glacial oscillations across the shelf. Overcompaction of the sequence seems clear in the upper half of the cored sequence, whereas the loading history in the lower part may be obscured by diagenetic effects. Distinct overcompaction is observed below a thin cover of normally consolidated diamictites, indicating that the last major glacial expansion in East Antarctica reached the shelf edge. This may explain the interbedding of soft waterlaid till and sand of Pliocene-Quaternary age present just a few meters below the seafloor on the continental slope.

Thus, the sediments recovered from Prydz Bay demonstrate that the glaciation proceeded in phases. The deepest glacial levels sampled (Site 742) are nonmarine (early Eocene-earliest Oligocene time), and marine conditions are evident only sometime later (earliest Oligocene time). Glacial sediment fabrics and overconsolidation features indicate that grounded ice occupied Prydz Bay during Eocene-Oligocene and younger time, though these features probably represent a complex series of ice advances and retreats. During the Miocene-Quaternary glacial maximum the ice front extended 170 km beyond the present location.

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Table 1. Latitude, longitude, and water depth of sites drilled during Leg 119.

Site	Latitude	Longitude	Water Depth (m)
736	49°24.121'S	71°39.611'E	629.0
737	50°13.660'S	73°01.950'E	564.0
738	62°42.543'S	82°47.245'E	2252.5
739	67°16.570'S	75°04.914'E	412.3
740	68°41.220'S	76°43.246'E	816.0
741	68°23.160'S	76°23.020'E	561.4
742	67°32.982'S	75°24.270'E	410.0
743	66°54.994'S	74°41.423'E	987.0
744	61°34.656'S	80°35.463'E	2307.8
745	59°35.710'S	85°51.600'E	4082.0
746	59°32.823'S	85°51.780'E	4059.0

FIGURE CAPTIONS

Figure 1. Geographic location of the ODP drill sites occupied during Leg 119 in the Kerguelen Plateau and Prydz Bay regions. Bathymetry (in meters) is from GEBCO (Hayes and Vogel, 1981; Fisher et al., 1982).

Figure 2. Chronology of seismic units as identified by Munschy and Schlich (1987) for the Kerguelen Plateau region.

Figure 3. Seismic survey track-lines from cruise Nella Dan (1982) in Prydz Bay. Proposed Prydz Bay sites were located on line PB/021 (From Stagg, 1985).

Figure 4. Line drawings of seismic sections along lines PB/013, PB/019, and PB/021 (from Stagg, 1985).

Figure 5. Core recovery, age, lithology, lithologic units, and percentage of carbonate of the sediment recovered from northern Kerguelen Plateau Sites 736 and 737 (See Table 1 and Figure 1 for site locations).

Figure 6. Core recovery, age, lithology, lithologic units, and percentage of carbonate of the sediment recovered from Sites 738 and 744-746 in the southern Kerguelen Plateau region (see Table 1 and Figure 1 for site locations). Because of the low percentage of carbonate content (generally <5%) at Sites 745 and 746, carbonate values are presented only for Sites 738 and 744.

Figure 7. Core recovery, age, lithology and lithologic units of the sediment recovered from Sites 739-743 in Prydz Bay (see Table 1 and Figure 1 for site locations).

Figure 8. Seismic reflection profile (ODP line 119-08) across Site 739. A. Analog, B. Digital.

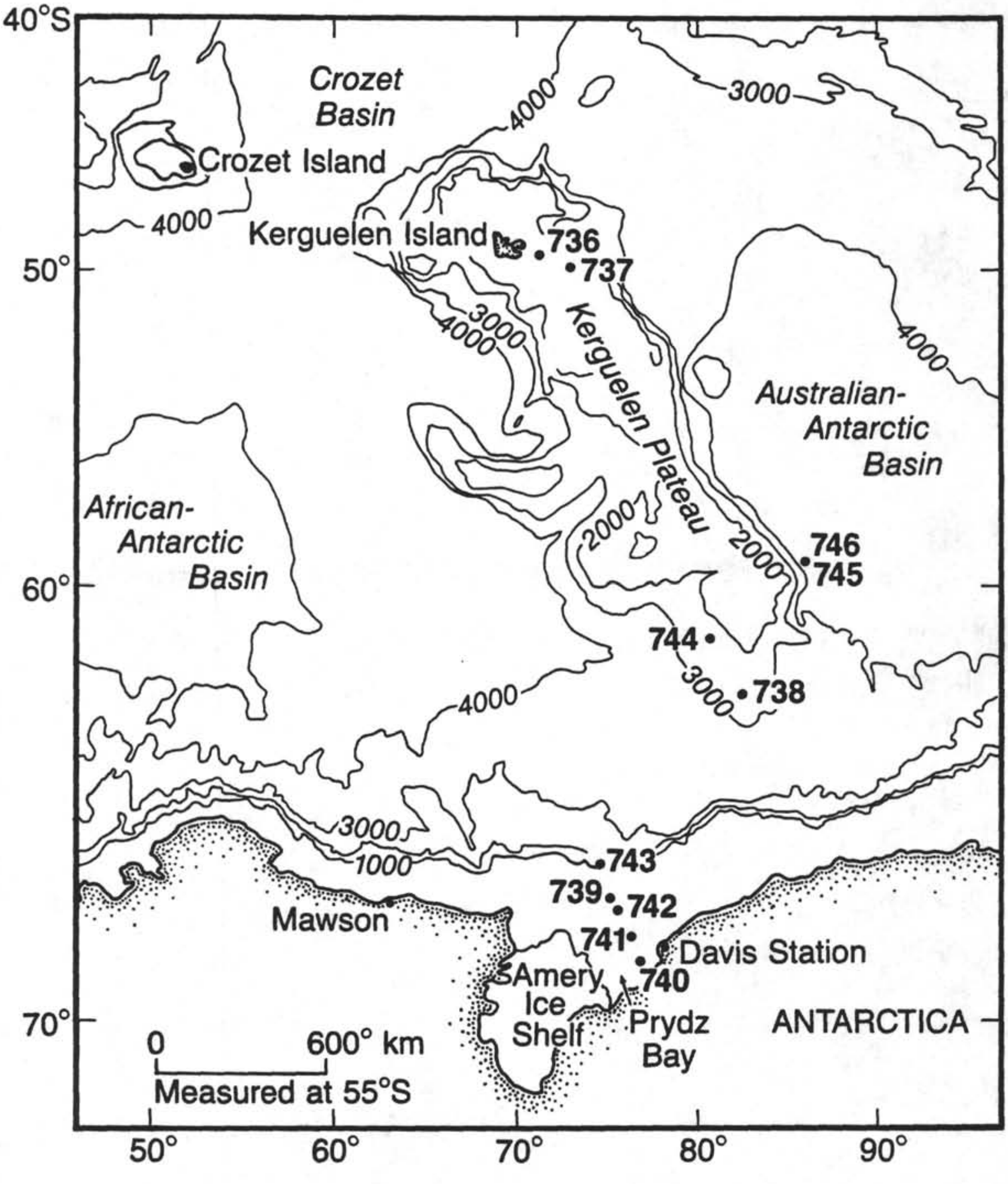

40°S
50°
60°
70°
50°
60°
70°
80°
90°
Crozet
Basin
Crozet Island
4000
3000
Kerguelen Island
736
737
Kerguelen Plateau
Australian-
Antarctic
Basin
African-
Antarctic
Basin
2000
746
745
744
738
743
739
742
741
740
1000
Mawson
Davis Station
Amery
Ice
Shelf
Prydz
Bay
ANTARCTICA
0
600° km
Measured at 55°S

Figure 1.

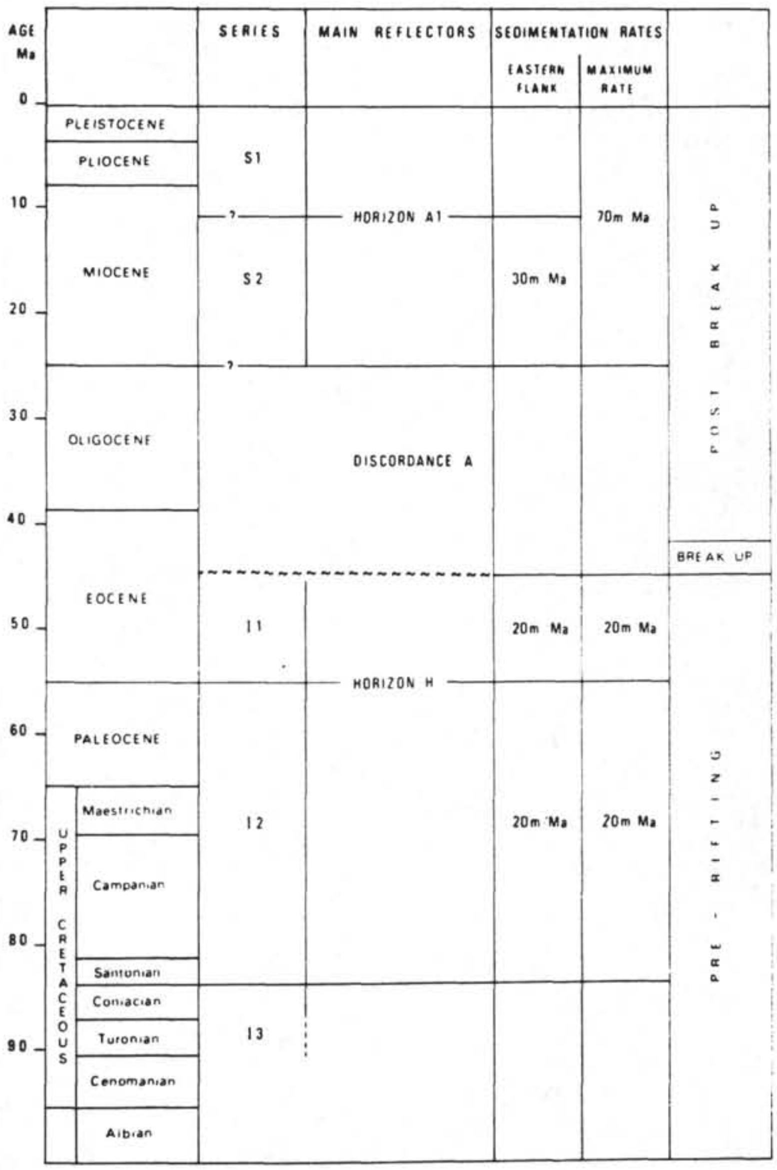

AGE Ma
SERIES
MAIN REFLECTORS
SEDIMENTATION RATES
EASTERN FLANK
MAXIMUM RATE
0
10
20
30
40
50
60
70
80
90
PLEISTOCENE
PLIOCENE
MIOCENE
OLIGOCENE
EOCENE
PALEOCENE
UPPER CRETACEOUS
Maestrichian
Campanian
Santonian
Coniacian
Turonian
Cenomanian
Albian
S1
S2
I1
I2
I3
?
HORIZON A1
DISCORDANCE A
HORIZON H
70m Ma
30m Ma
20m Ma
20m Ma
20m Ma
20m Ma
POST BREAK UP
BREAK UP
PRE - RIFTING

Figure 2.

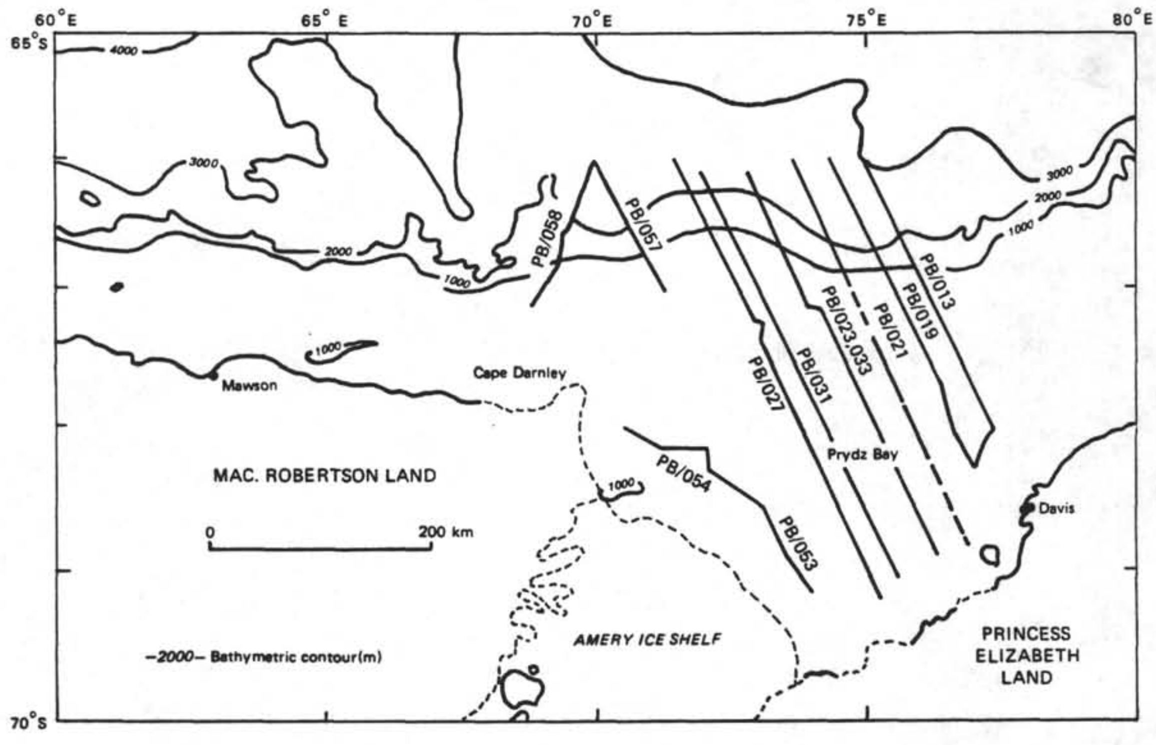

60° E
65° E
70° E
75° E
80° E
65° S
70° S
4000
3000
2000
1000
PB/058
PB/057
PB/013
PB/019
PB/021
PB/023,033
PB/031
PB/027
PB/054
PB/053
Mawson
Cape Darnley
Prydz Bay
Davis
MAC. ROBERTSON LAND
0
200 km
AMERY ICE SHELF
PRINCESS
ELIZABETH
LAND
-2000- Bathymetric contour(m)

Figure 3.

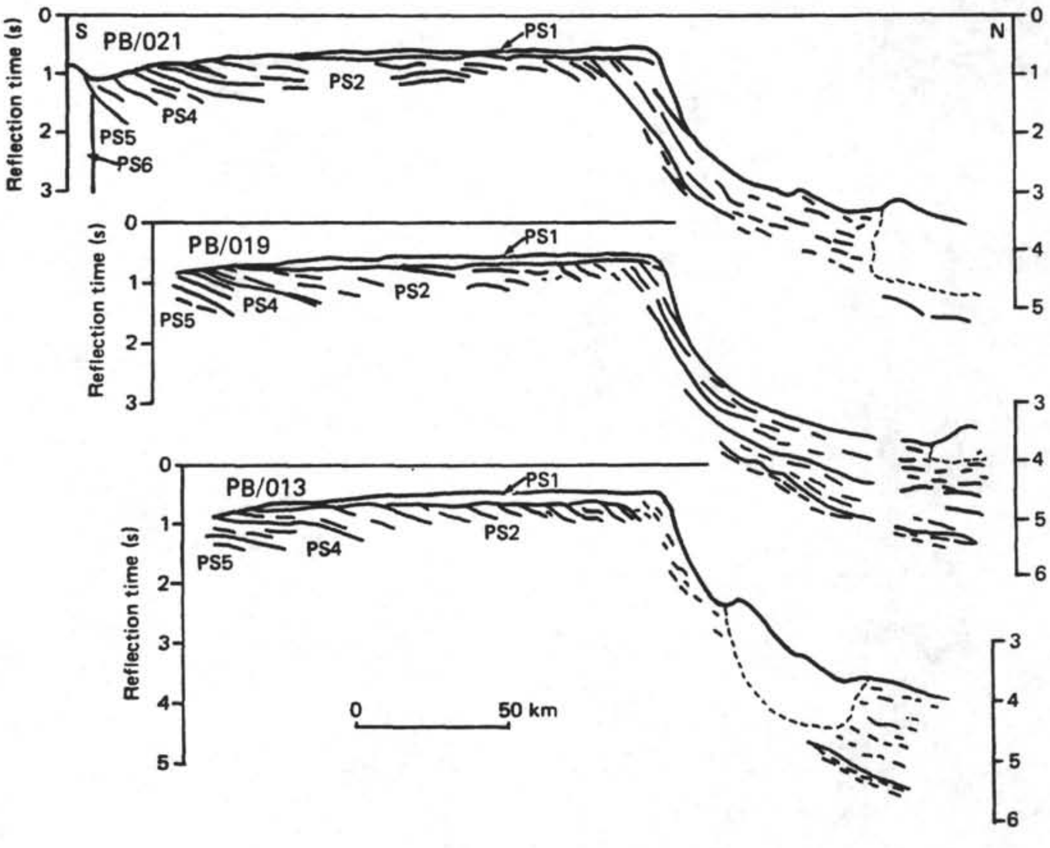
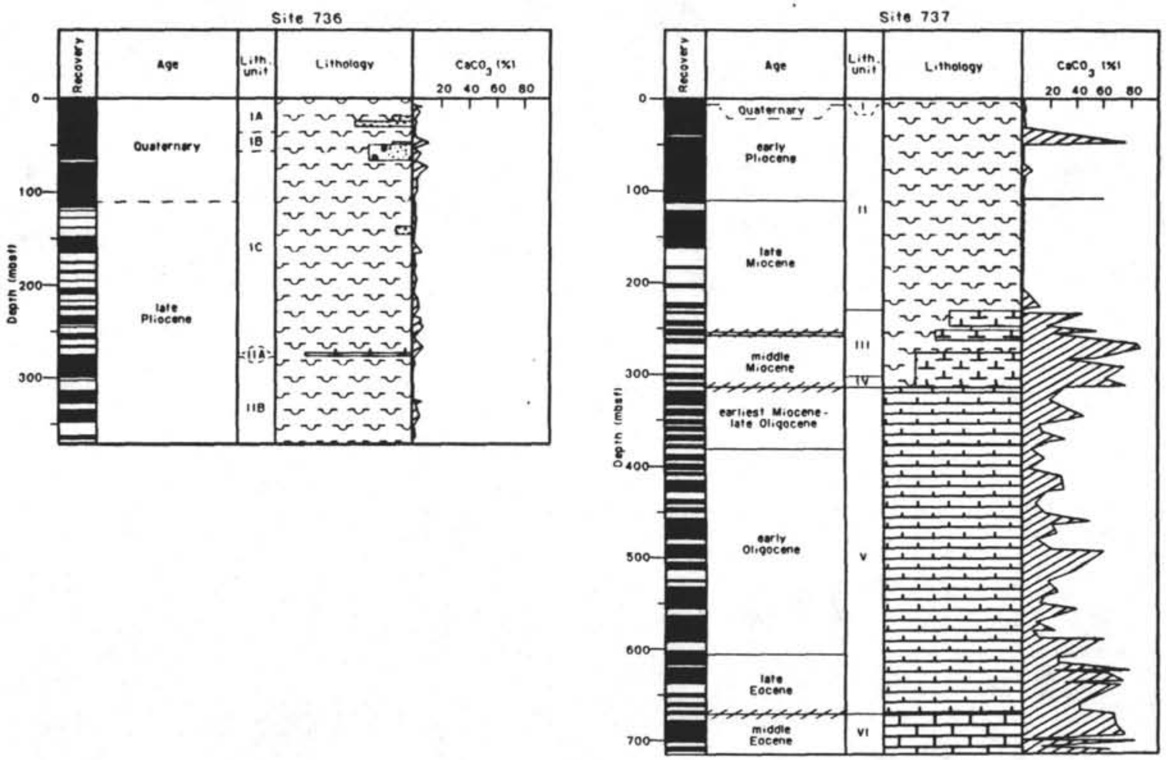

S
PB/021
PS1
N
PS2
PS4
PS5
PS6
Reflection time (s)
PB/019
PS1
PS2
PS4
PS5
Reflection time (s)
PB/013
PS1
PS2
PS4
PS5
Reflection time (s)
0
50 km

Figure 4.



Site 736
Recovery
Age
Lith. unit
Lithology
CaCO3 (%)
20 40 60 80
Depth (mbsf)
0
100
200
300
Quaternary
late Pliocene
IA
IB
IC
IIA
IIB
Site 737
Quaternary
early Pliocene
late Miocene
middle Miocene
earliest Miocene-late Oligocene
early Oligocene
late Eocene
middle Eocene
I
II
III
IV
V
VI
400
500
600
700

Figure 5.

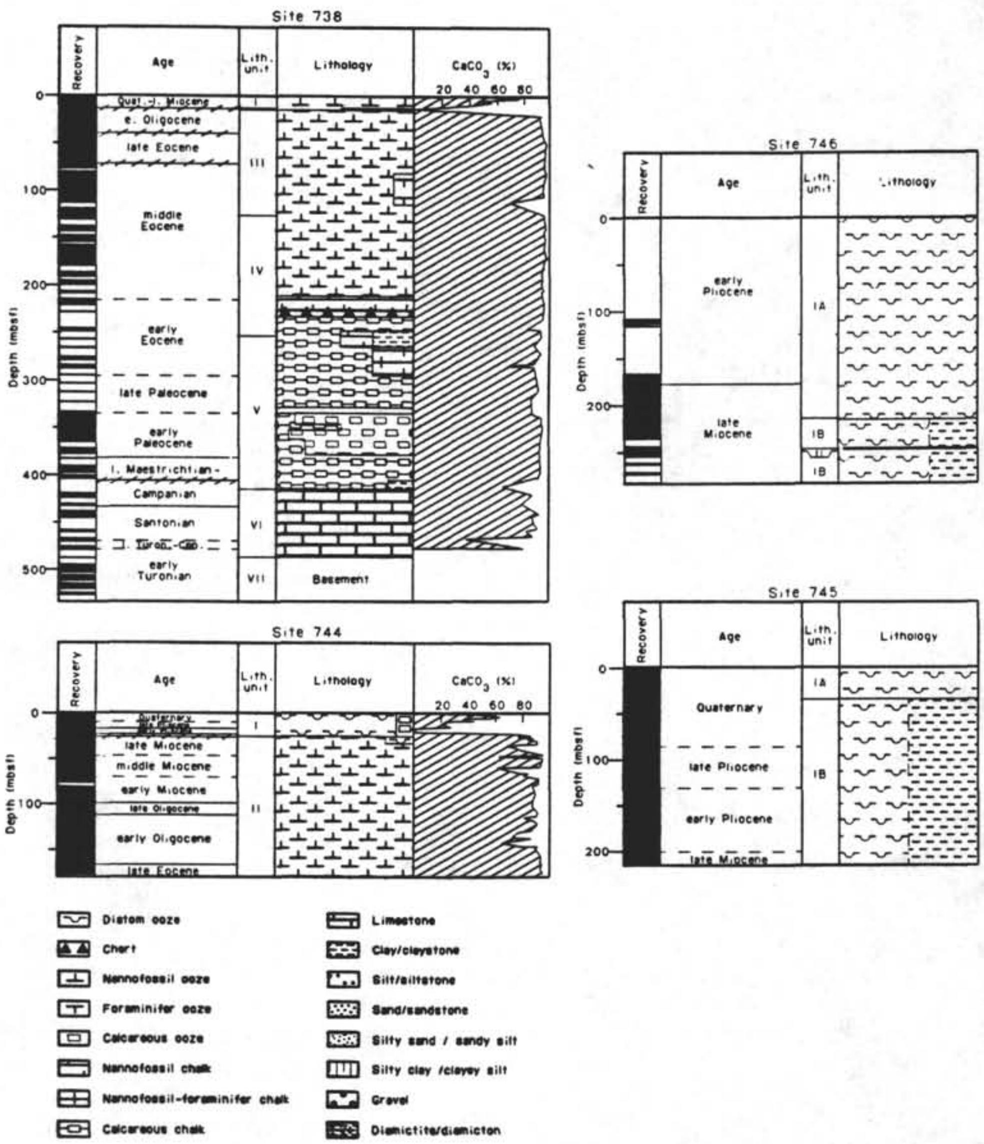

Site 738
Recovery
Age
Lith. unit
Lithology
CaCO3 (%)
20 40 60 80
Depth (mbsf)
e. Oligocene
late Eocene
middle Eocene
early Eocene
late Paleocene
early Paleocene
Campanian
Santonian
early Turonian
Basement
Site 744
late Miocene
middle Miocene
early Miocene
early Oligocene
late Eocene
Site 746
early Pliocene
late Miocene
Site 745
Quaternary
late Pliocene
early Pliocene
late Miocene
Diatom ooze
Chert
Nannofossil ooze
Foraminifer ooze
Calcareous ooze
Nannofossil chalk
Nannofossil-foraminifer chalk
Calcareous chalk
Limestone
Clay/claystone
Silt/siltstone
Sand/sandstone
Silty sand / sandy silt
Silty clay /clayey silt
Gravel
Diamictite/diamicton

Figure 6.

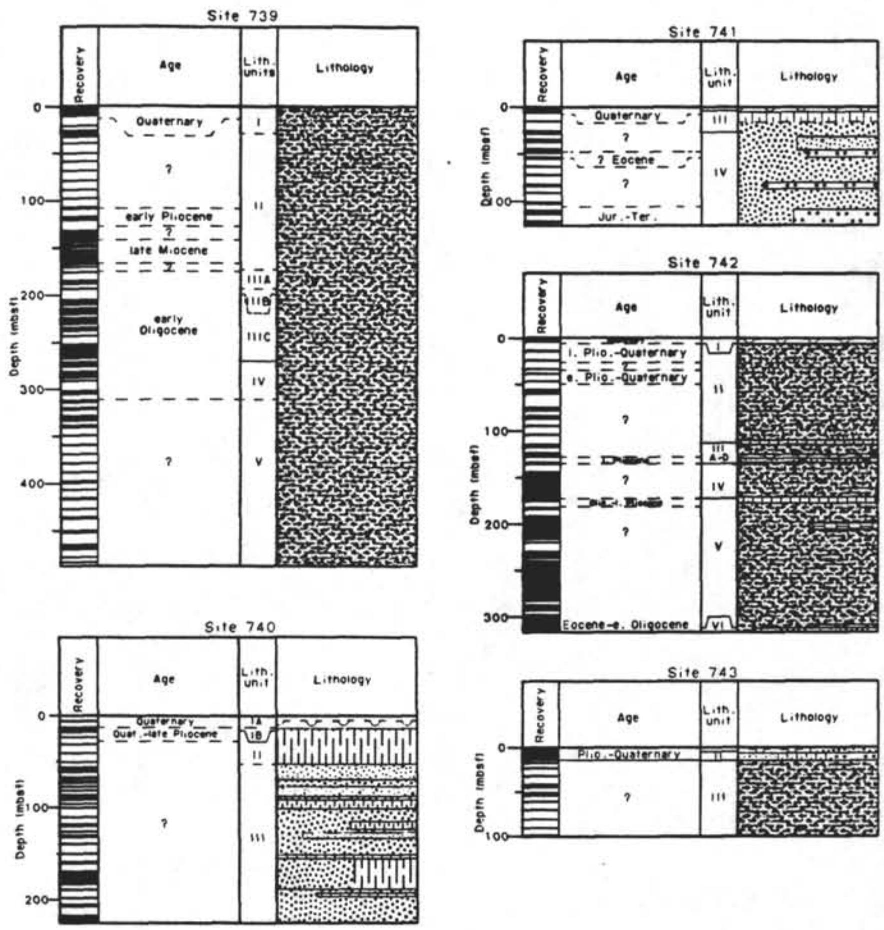

Site 739
Recovery
Age
Lith. units
Lithology
Depth (mbsf)
Quaternary
early Pliocene
late Miocene
early Oligocene
Site 740
Quaternary
Quat.-late Pliocene
Site 741
Quaternary
? Eocene
Jur.-Ter.
Site 742
l. Plio.-Quaternary
e. Plio.-Quaternary
Eocene-e. Oligocene
Site 743
Plio.-Quaternary

Figure 7.

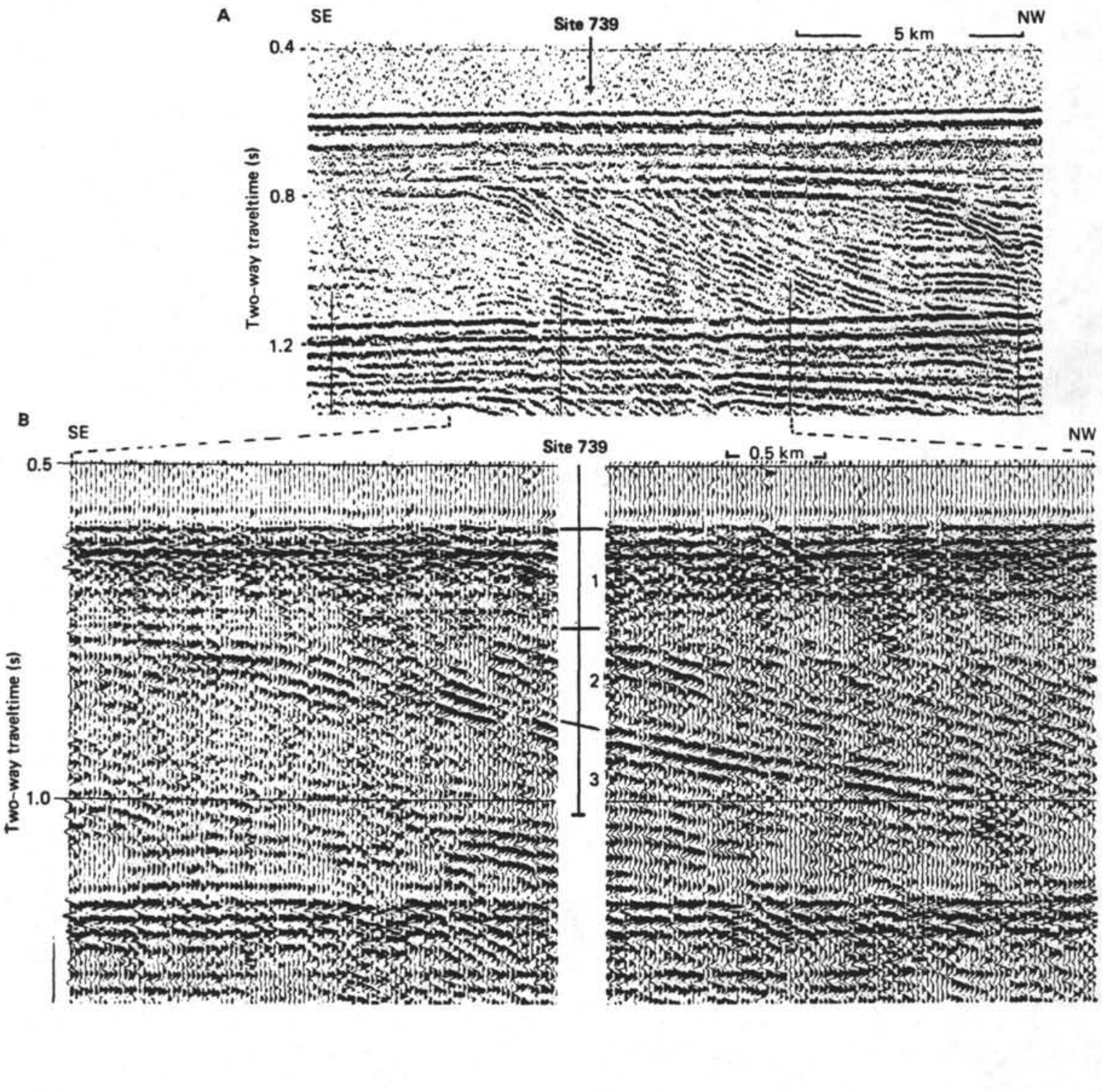

A
SE
Site 739
5 km
NW
0.4
0.8
1.2
Two-way traveltime (s)
B
SE
Site 739
0.5 km
NW
0.5
1.0
1
2
3
Two-way traveltime (s)

Figure 8.

OPERATIONS REPORT

The ODP Operations and Engineering personnel aboard JOIDES Resolution for Ocean Drilling Program Leg 119 were:

Operations Superintendent	Glen Foss

Third-party contractor personnel:

Weather Observer	Dennis Cain
Ice Observer	Vernon Rockwell
Schlumberger Logger	Andy Porat*

*Address:
Schlumberger Offshore Services
369 Tristar Drive
Webster, TX 77598

OPERATIONS SYNOPSIS

The fifth high-latitude voyage of the scientific research drillship JOIDES Resolution concentrated its activities in the southern Indian Ocean in the Kerguelen Plateau and Prydz Bay, areas of Antarctica. The latitudinal transect from the northern part of the plateau to the Antarctic continental margin was drilled to determine the origin and history of the plateau and the history of East Antarctica/India rifting, as well as the paleoclimatic history of the region from the Late Cretaceous to Holocene.

The expedition commenced on 14 December 1987 at Port Louis, Mauritius, and ended on 21 February 1988 at Fremantle, Western Australia. Total length of the voyage was 68.7 days, of which 37.0 days were spent on site, 27.4 days under way, and 4.5 days in port. Icebergs and pack ice were responsible for delays totaling about 4.4 days and for early termination of three holes.

Operational results of Leg 119 substantiated those of Leg 113 and confirmed that ODP drilling/coring operations in Antarctic waters are operationally feasible. The cost of such operations in time and resources, however, is considerably greater than in more hospitable environments.

A total of 22 holes were cored at 11 drill sites. Some operational highlights included the successful spudding and drilling of several holes in the hard glacial substrate of Prydz Bay, the employment of the support vessel Maersk Master for ice management duties, and the use of a free-fall reentry funnel to save a valuable hole after bit failure.

MAURITIUS PORT CALL

Leg 119 began with the first mooring line at Berth 5, Port Louis Harbor, at 0615 hr, 14 December. The major port call activities were logistical, with large shipments of ODP cores and special drilling/coring equipment from Leg 118 to be off-loaded. The oncoming shipments for the Antarctic voyage were larger than normal, and a considerable amount of freight was backloaded from local storage in Mauritius. Other work items were the annual American Bureau of Shipping inspection for the ship; repair of number 7 engine and number 2 crane; repair of cracks in the thruster wells; loading of drill water, lube oil, and 900 mt of fuel; and UDI and ODP crew changes.

The last line was cast off the dock at 1730 hr, 18 December.

MAURITIUS TO SITE 736

Generally good weather prevailed during the scheduled eight-day transit to the Kerguelen Plateau. Winds were light to moderate and usually from astern. With the help of a following current, a very good average speed of 11.7 kt was achieved for the first days. On 22 December the Southern Ocean greeted JOIDES Resolution with beam winds gusting to 45 kt. The swell built to 7 m, and the vessel experienced rolls to 20°. Speed dropped briefly below 10 kt, but conditions moderated after about a day. Following winds then returned and assisted the ship into colder waters before they shifted to the south and impeded progress somewhat.

The total transit/survey distance of 1943 nmi was covered at an average speed of 11.0 kt.

SITE 736--NORTH KERGUELEN PLATEAU

Hole 736A

Operations began slowly, with temperatures of 3-4°C and wind gusting to 45 kt. Hole 736A was spudded at 1800 hr, 26 December at a depth of 639.5 m by drill pipe measurement (DPM). In this report, depths to the mudline and below the seafloor are calculated from the dual-elevator stool on the rig floor (DES depths).

Hydraulic piston cores (APC) were taken from the seafloor to 118 mbsf before pullout force reached 60,000 lb. Extreme vessel motion resulted in short APC stroke, failed core liners, and sheared overshot pins. Oriented APC and heat flow probe runs were only partially successful because of vessel motion.

Three extended core barrel (XCB) cores were then attempted, but recovery was poor in the soft diatom ooze. The APC corer was then redeployed, and three more successful APC cores were recovered before the system survived a 130,000 lb pullout. XCB coring continued, with recovery only about 20%, to 253 mbsf. Coring was terminated at that point to change to the standard rotary core barrel (RCB) bottom-hole assembly (BHA) for the planned deep penetration.

Hole 736B

Because of adverse weather and a core liner failure, the uppermost sediments had been incompletely recovered in Hole 736A. A second effort was made to recover the valuable material when the bit had cleared the seafloor after abandonment of Hole 736A. Three quick APC cores were taken for 27.4 mbsf at 638.6 m depth. Under much-improved weather conditions, complete core recovery was achieved. A round trip was then made for an RCB BHA.

Hole 736C

Following the pipe trip, the soft upper sediments were quickly drilled to a depth of 207 mbsf. Continuous RCB coring then began, with results equivalent to those with the XCB through the repeated interval. The sediment became somewhat firmer with depth, and the recovery rate improved to about 65%.

When 371 m of fairly uniform ooze had been penetrated, the drilling objectives of the site were reevaluated by the shipboard scientists. The determination was that the desired scientific results could be achieved more efficiently by terminating operations at Site 736 and moving to nearby prospectus site KHP-3.

Hole 736C was therefore filled with weighted mud and abandoned. The drill string was recovered, and the drillship departed Site 736 at 1630 hr on 29 December.

SITE 737--NORTH KERGUELEN PLATEAU

Hole 737A

Coring operations began with an APC core to recover the "mud line" at 574.5 m. Swells to 8 m again complicated the operation, but the experienced crew was able to compensate the coring line for much of the motion. Core recovery was quite good. An overpull of 90,000 lb prompted the switch to XCB mode at 167 mbsf.

Recovery of the next 107 m of diatom ooze with the XCB was only 21%. Upon reaching softer sediment, an APC core was tried. A weak component in the APC barrel failed, and the hole was abandoned after an unsuccessful fishing attempt.

A round trip was then made for the RCB BHA in anticipation of the deeper limestone and chert.

Hole 737B

Following the trip, Hole 737B was spudded at 1930 hr, 31 December. The hole was drilled to 114 mbsf before the "wash barrel" was recovered. Two cores were then taken to recover the missed interval of Core 119-737A-14H. After another drilled interval to 253 mbsf, continuous RCB coring began. Core recovery improved with depth below 300 mbsf. At about 465 mbsf, the diatom ooze gave way to chalk, which became more indurated with depth and graded to limestone. Below about 690 mbsf, there were scattered chert nodules, but not enough to affect drilling operations. At 715.5 mbsf the scientific drilling objective had been reached, and coring was stopped.

A wireline trip was made to actuate the mechanical bit release (MBR), and the end of the drill string was pulled to logging depth at 125 mbsf. The hole was successfully logged with the seismic stratigraphy and lithodensity combination tools, but only after the pipe had been run back into the hole twice to clean out bridges.

JOIDES Resolution, in company with the recently arrived support vessel Maersk Master, departed for the Prydz Bay operating area at 1015 hr, 4 January.

SITE 737 TO SITE 738

On 6 January the first iceberg of the voyage was spotted at latitude 58°47'S. The density of bergs, growlers, and bergy bits increased until about 40 ice contacts were present on the radar screen (12-nmi range) at any given time between 60°30' and 61°15'S. With Maersk Master in the van, a detour of about 30 nmi to the east was made to avoid the greatest ice concentration. The density of bergs then decreased as the vessel proceeded southward.

The first pack ice was encountered at about 66°30'S. Thoroughly scattered pack ice floes persisted as prospectus site PB-6 was approached. Ice coverage was not greater than 1/10, and drilling appeared feasible. The ice coverage quickly increased to about 3/10 as the final approach to the site was made. Maersk Master scouted ahead, but saw no opening. JOIDES Resolution was forced to reverse course only 5 nmi from her destination and steam back toward more open waters.

The two vessels then backtracked to prospectus site SKP-6A with plans to return to Prydz Bay after 8-10 days.

SITE 738--SOUTH KERGUELEN PLATEAU

Hole 738A

The first hole was a single APC core that was feared to be of poor quality because the APC shearpins apparently had failed on the wireline trip down the pipe. The bit was pulled above the seafloor for a second attempt.

Hole 738B

Oriented APC cores were then taken to refusal depth at 105 mbsf. Core recovery with the APC was 97.7%.

Coring continued with the XCB to 216 mbsf. Recovery began to decrease with depth because of an increase in indurated zones and traces of chert. Because chert and basement rocks were anticipated deeper in the section, the pipe was tripped for the RCB BHA and coring system.

Hole 738C

The new hole was drilled to 197 mbsf before RCB coring began. Chert nodules were encountered in the chalky ooze from the beginning and had their usual disastrous effect on core recovery, with only about 25% recovery over the first 87 m of cored interval. At 410 mbsf, the soft chalk turned abruptly to hard limestone, and the rate of penetration (ROP) dropped sharply. Localized chert concentrations persisted, but the expected massive cherts did not materialize and, apart from reduced recovery, no drilling problems were caused by the chert.

Volcaniclastic "basement" rocks were encountered at 486 mbsf. At 534 mbsf, the scientific drilling objectives were considered complete, and coring was terminated.

Successful logging runs were again made with the seismic stratigraphy and lithodensity combinations. The third tool, VSP, became stuck at the end of the drill string and had to be "rescued" by crimping and cutting the logging line with the Kinley tool, effectively ending logging operations.

Maersk Master towed and prop-washed several icebergs and bergy bits to allow coring operations to continue at Site 738. Two iceberg delays cost 14-1/2 hr at Hole 738C, but the bergs were diverted and the hole was not lost.

JOIDES Resolution departed for the Prydz Bay operating area for the second time at 0545 hr, 17 January.

SITE 739--OUTER PRYDZ BAY

Hole 739A

The pack ice of a week earlier had disappeared completely. The APC was deployed to spud the hole in only 423 m of water. Two APC attempts penetrated only 5-1/2 m, and the suspected glacial dropstones were found to be too hard. The vessel was offset 20 m.

Hole 739B

One APC core recovered 1.9 m. Two XCB cores penetrated an additional 5.3 m in 3 hr, recovered 2 cm of sediment and destroyed the cutting shoes. The material was too hard for APC or XCB, and a round trip was made for the RCB BHA.

Hole 739C

About 13 m of relatively soft material was penetrated before hard drilling was encountered. The hard substrate drilled evenly but very slowly with the available bit weight. The hard sediment was found to be diamictite, with highly indurated clay and silt acting as "mortar" between cobbles, gravel, sand, and a few boulders.

ROP and core recovery increased as the BHA weight could be supported and as the sediment became less compacted. Glacial material persisted, and core recovery again decreased below 300 m, with signs of bit failure. Coring was terminated at 487 mbsf as the JOIDES Safety Panel depth restriction of 500 m was approached.

After the second interruption for the approach of an iceberg, the bit was released for logging. An excellent seismic stratigraphy log combination was recorded, and the hole was abandoned by plugging with cement.

SITE 740--INNER PRYDZ BAY

Hole 740A

Soft diatom ooze and clay were cored for 13 m before the hard, glacially deposited material was again encountered. Boulders and cobbles of very hard rock types persisted to 54 mbsf. A sequence of claystone, siltstone, and sandstone beds was then encountered.

An unnacceptably low ROP indicated bit failure at 125 mbsf. The free-fall funnel (FFF) was deployed, and a round trip was made for a new bit. A successful TV/sonar reentry was made, but sand and cuttings plugged the BHA before coring could be continued. A second round trip and reentry were required and were again accomplished without incident.

Coring then continued for another 95 m with a much-improved ROP. Core recovery was improved, but continued to be below normal. The sediments continued to be a clastic sequence of apparent terrestrial origin and of little value to the scientific objectives of the voyage. At 225.5 mbsf, coring was terminated at the request of the shipboard scientists.

The hole was plugged with cement, and the core bit was pulled above the seafloor.

Hole 740B

Because the seafloor sediments had been incompletely recovered in the process of spudding Hole 740A, an additional "mud line" core had been requested. The bit was lowered to 826.5 m with an inner barrel in place. The core barrel was recovered with 1.6 m of core and the sediment/water interface intact.

SITE 741--INNER PRYDZ BAY

Hole 741A

Hole 741A was started with a good-quality RCB "punch core" that recovered 4.1 m of soft ooze and clay and established seafloor depth at 561.9 m. The next 50 m required over 13 hr of tedious low RPM/low weight-on-bit drilling. An increase in ROP then signaled the breakthrough into non-glacial sediments. The new material was a sequence of sandstones and siltstones. Recovery remained low, with drilling parameters indicating beds of poorly consolidated sand. Core recovery began to improve below 100 mbsf, but coring was terminated at the request of the shipboard scientists at 128.1 mbsf.

The hole was plugged with cement, and the drill string was tripped. The ship was under way for a newly approved site to the northwest at 1200 hr, 29 January.

SITE 742--OUTER PRYDZ BAY

The new site was situated about 18 nmi southeast of Site 739. Problems were experienced in locating the beacon and achieving stable positioning in the extremely shallow (420 m) water with winds gusting to 40 kt.

About 24 m of soft sediment was cored above the hard diamictite. Nine hours were required to core to a depth of 38 mbsf. A large iceberg then threatened to drive the rig off location. For the second time, an FFF was assembled and dropped. The berg eventually moved away, and withdrawal and reentry were not required.

RCB coring then continued with good hole conditions but poor core recovery. Normal recovery was usually only a few cobbles, which apparently were rolling under the bit and also jamming the core catchers. At about 150 mbsf, the drill entered a more normally compacted glacial unit with fewer/smaller hard rocks. Core recovery and ROP both increased dramatically from that point.

Coring operations were terminated at 316 mbsf when traces of gas with a composition suggesting migration from a deeper source were detected.

The bit was released, the hole was prepared for logging, and successful logs were recorded on two of three attempts.

The hole was then plugged with cement and abandoned.

SITE 743--ANTARCTIC OUTER CONTINENTAL SHELF BREAK

The final drill site on the southeast-northwest transect of the Prydz Bay area lay just seaward of the edge of the continental shelf on a steep northward slope. Because softer marine sediment was anticipated, the APC/XCB BHA was used in an attempt to achieve better core quality and recovery.

Hole 743A was spudded with an APC core that found the seafloor at 999 m and recovered 1.3 m of coarse sand and clay. Five APC cores penetrated only to 15.8 mbsf before the hard material forced the switch to XCB mode.

Coring then continued through a sequence of relatively soft clays, gravels, cobbles, boulders, and (probably) sands. Unstable hole conditions soon caused drilling problems. Recovery was extremely low, XCB equipment was being destroyed and Prydz Bay operating time was running out. The hole reached its total depth of 98.1 mbsf, and the vessel departed for the southern Kerguelen Plateau operating area.

SITE 743 TO SITE 744

With Maersk Master again leading the way, the ships headed north to complete the planned drilling program with two brief sites on the southern Kerguelen Plateau. The first site to be occupied was prospectus site SKP-6A, about 330 nmi to the north, which had already been drilled as Site 738. A shallow penetration was planned about 2 nmi east of Site 738 to core an upper sediment section that was not present at Site 738.

Upon arrival at the planned drill site, the iceberg density was too great for drilling, and the ships diverted to the alternate site SKP-6B, about 100 nmi northwest. The ubiquitous icebergs were again too numerous for drilling on the prospectus coordinates, but a fairly clear area was located and approved a few miles to the west.

SITE 744—SOUTH KERGUELEN PLATEAU

Hole 744A

Spud-in with a "mud line" APC core occurred at 0045 hr, 6 February, and established the seafloor depth at 2317.8 m. APC coring proceeded rapidly, but core recovery was only about 60% for the first 80 m--relatively meager for the APC system. The normal high recovery rate was then achieved to total depth at 176.1 mbsf, where scientific objectives were fulfilled. APC refusal depth was not reached.

After a temperature probe was run at total depth, the drill string was pulled clear of the seafloor for a second hole.

Hole 744B

The second hole was drilled to repeat the upper, incompletely recovered interval of Hole 744A. The same coring techniques were used, except that cores were retrieved at a somewhat slower wireline speed. Complete core recovery was achieved to total depth of 79.5 mbsf. Another temperature probe measurement was taken at total depth, and the bit was again raised above the seafloor.

Hole 744C

The third penetration was cored for the purpose of providing dedicated cores for special scientific studies. Three APC cores were taken from the seafloor to 26 mbsf with full recovery. The drill string was then pulled, and the vessel departed for Site 745 (SKP-8A) at 1430 hr, 7 February.

SITE 745--KERGUELEN SEDIMENT RIDGE

Hole 745A

The site lay near the boundary of two zones of the water velocity correction tables. PDR depth was 4095 m, with the adjacent zone reading 6 m deeper. The bit was positioned at 4093.5 m for the first APC attempt. The core barrel was retrieved full, having been "shot" from below the seafloor. As the "mud line" was of scientific importance, the bit was repositioned 5 m higher and a second spud attempt was made.

Hole 745B

A new hole was designated because the same interval was cored twice. The second spud attempt recovered 5.5 m of sediment, indicating a seafloor depth of 4093 m.

APC cores were taken in soft diatom ooze to 215 mbsf with excellent recovery and core quality. Termination of the hole was forced by the approach of an iceberg, after an earlier berg had interrupted operations for 8-1/2 hr.

SITE 746--KERGUELEN SEDIMENT RIDGE

Hole 746A

An alternate drilling location was selected that was on the same local ridge of sediment as Site 745, near the reference seismic line and out of immediate danger from approaching icebergs. The vessel was slowly offset, with the drill string suspended, on GPS to a position 3 nmi to the north.

The objective of the site was to continue coring the stratigraphic section that had been started on Site 745. The hole was therefore drilled to 165 mbsf with only a single APC core at 107-116 m for a check of biostratigraphy. Continuous APC coring then continued to refusal at 227 mbsf. XCB cores were taken to 281 mbsf, where the hole had to be abandoned because of an approaching iceberg (again the second interruption for bergs on the site).

The remaining few hours of site time were used to conduct bending stress tests on the drill string with a special strain gauge-equipped drill pipe joint.

SITE 746 TO FREMANTLE

After a slow start in reduced visibility caused by snow and darkness in iceberg country, JOIDES Resolution made good speed on the transit to Fremantle. Anticipated adverse weather in the "50's" and "40's" did not materialize. Speed was reduced on 17 February to meet the scheduled arrival time in Fremantle. Leg 119 ended with the first mooring line in Fremantle Harbor at 0710 hr, 21 February 1988.

OCEAN DRILLING PROGRAM
OPERATIONS RESUME
LEG 119

Total Days (14 December 1987 - 21 February 1988)	68.9
Total Days in Port	4.5
Total Days Under Way (including survey)	27.4
Total Days on Site	37.0

Trip Time	7.17
Coring Time	20.96
Drilling Time	0.81
Logging/Downhole Science Time	3.21
Reentry Time	0.34
Mechanical Repair Time (contractor)	0.16
Hole Trouble	0.55
Wait on Ice	1.03
Other	2.81

Total Distance Traveled (nmi)	6861.0
Average Speed (kt)	10.2
Number of Sites	11.
Number of Holes	22.
Total Interval Cored (m)	3652.1
Total Core Recovery (m)	2101.8
Percent Core Recovered	57.6
Total Interval Drilled (m)	793.5
Total Penetration (m)	4445.6
Maximum Penetration (m)	715.5
Maximum Water Depth (m from drilling datum)	4093.0
Minimum Water Depth (m from drilling datum)	422.9

OCEAN DRILLING PROGRAM
BEACON SUMMARY
LEG 119

SITE NO.	MAKE	FREQ. KHz	SERIAL NUMBER	SITE TIME HOURS	WATER DEPTH	REMARKS
736	DATASONICS	15.0	452 (352 DCR)	89	640	DROPPED 2347, 25 DEC - OUT OF POSITION COULD NOT RECOVER - NO RESPONSE TO COMMANDS
736	BENTHOS	16.5	37791	85	640	DROPPED 0400 26 DEC. GOOD BEACON
737	DATASONICS	15.5	453 (352 DCR)	92	575	DROPPED OUT OF POSITION; RECOVERED BY MAERSK MASTER
737	BENTHOS	14.5	37834	87	575	GOOD BEACON
738	DATASONICS	16.0	454 (352 DCR)	173	2263	GOOD SIGNAL FOR DURATION; INDICATED RELEASE BUT NEVER SURFACED
739	DATASONICS	15.5	453 (352 DCR)	113	423	GOOD BEACON - SURFACED IN 16 MINUTES
740	DATASONICS	15.5	453 (352 DCR)	98	818	APPARENTLY RELEASED BUT DID NOT SURFACE
741	DATASONICS	16.5	455 (352 DCR)	38	562	GOOD BEACON - SURFACED IN 14 MINUTES
742	DATASONICS	16.5	455 (352 DCR)	80	426	GOOD BEACON - SURFACED BUT COULDN'T LOCATE
743	DATASONICS	14.5	451 (352 DCR)	30	999	GOOD BEACON - SURFACED IN 22 MINUTES RECOVERED BY MAERSK MASTER
744	DATASONICS	14.5	451 (352 DCR)	44	2318	GOOD BEACON - SURFACED IN 49 MINUTES RECOVERED BY 471
745	BENTHOS	15.5	37846	6	4093	GOOD UNTIL ABRUPT FAILURE -- FLOODED?
745	DATASONICS	14.5	451 (352 DCR)	90	4093	DROPPED 2208, 8 FEB; RECOVERED ON DEPARTURE (TURNED OFF WHEN RELEASED)
746	DATASONICS	16.0	401 (352)	30	4070	GOOD BEACON

OCEAN DRILLING PROGRAM
SITE SUMMARY
LEG 119

HOLE	LATITUDE	LONGITUDE	DEPTH METERS	NUMBER OF CORES	METERS CORED	METERS RECOVERED	PERCENT RECOVERED	METERS DRILLED	TOTAL PENET.	TIME ON HOLE	TIME ON SITE
736A	49°24.12'S	71°39.61'E	639.5	30	252.3	147.1	58.3	---	252.3	52.75	
736B	49°24.12'S	71°39.61'E	638.6	3	27.4	27.8	101.5	---	27.4	5.50	
736C	49°24.16'S	71°39.65'E	639.5	17	164.1	77.3	47.1	206.9	371.0	26.25	
				50	443.8	252.2	56.8	206.9	650.7		84.5
737A	50°13.67'S	73°01.97'E	574.5	29	273.2	181.6	66.5	---	273.2	36.75	
737B	50°13.67'S	73°01.95'E	574.5	50	481.3	298.1	61.9	234.2	715.5	91.75	
				79	754.5	479.7	63.6	234.2	988.7		128.5
738A	62°42.54'S	82°47.25'E	2263.2	1	2.8	2.8	100.0	---	2.8	13.75	
738B	62°42.54'S	82°47.25'E	2263.0	24	214.3	170.6	79.6	---	214.3	26.75	
738C	62°42.55'S	82°47.25'E	2263.0	35	337.2	146.0	43.3	196.6	533.8	131.00	
				60	554.3	319.4	57.6	196.6	750.9		171.5
739A	67°16.57'S	75°04.91'E	422.9	2	5.6	5.7	102.3	---	5.6	7.00	
739B	67°16.55'S	75°04.91'E	422.9	3	7.2	1.9	26.7	---	7.2	7.25	
739C	67°16.58'S	75°04.91'E	422.9	62	486.8	168.6	34.6	---	486.8	99.00	
				67	499.6	176.2	35.3		499.6		113.25
740A	68°41.22'S	76°43.25'E	818.0	31	225.5	72.2	32.0	---	225.5	92.75	
740B	68°41.21'S	76°43.25'E	824.9	1	1.6	1.6	100.0	---	1.6	4.75	
				32	227.1	73.8	32.5		227.1		97.5
741A	68°23.16'S	76°23.02'E	561.9	14	128.1	33.6	26.2	---	128.1		38.25
742A	67°32.98'S	75°24.27'E	426.2	34	316.0	168.7	53.4	---	316.0		80.0
743A	66°54.99'S	74°41.42'E	999.2	14	98.1	21.8	22.2	---	98.1		29.25
744A	61°34.66'S	80°35.46'E	2317.8	20	176.1	144.9	82.3	---	176.1	25.00	
744B	61°34.66'S	80°35.45'E	2317.0	9	78.5	79.7	101.6	---	78.5	11.25	
744C	61°34.66'S	80°35.45'E	2318.5	3	26.0	26.8	103.1	---	26.0	8.00	
				32	280.6	251.4	89.6		280.6		44.25
745A	59°35.71'S	85°51.60'E	4093	1	9.5	9.9	103.8	0.5	10.0	9.50	
745B	59°35.71'S	85°51.60'E	4093	24	215.0	220.7	102.6	0	215.0	42.75	
				25	224.5	230.6	102.7	0.5	225.0		52.25
746A	59°32.82'S	85°51.78'E	4070	14	125.5	94.4	75.2	155.3	280.8		49.75
		TOTALS		421	3652.1	2101.8	57.6	793.5	4445.6		889.0
		APC			1041.8	995.3	95.5				
		XCB (TOTAL)			469.7	141.1	30.0				
		RCB			2140.6	966.1	45.1				
		XCB (BIT SEAL)			300.4	96.4	32.1				
		XCB (W/O SEAL)			169.3	44.7	26.4				

OCEAN DRILLING PROGRAM
BIT SUMMARY
LEG 119

HOLE	MFG	SIZE	TYPE	SERIAL NUMBER	METERS CORED	METERS DRILLED	TOTAL PENET	CUMULATIVE METERS	HOURS THIS HOLE	TOTAL HOURS	CONDITION/REMARKS
736A	RBI	11-7/16"	C-3 XCB	AE 3376	252.3	--	252.3	3839.1	3.9	74.4	NOT PULLED
736B	RBI	11-7/16"	C-3 XCB	AE 3376	27.4	--	27.4	3866.5	0.1	74.5	11 NO A E O 1/16 NO BHA
736C	RBI	9-7/8"	C-3 RCB	AT 128	164.1	206.9	371.0	371.0	5.5	5.5	NEW ALL SOFT OOZE
737A	RBI	11-7/16"	C-3 XCB	AE 3376	273.2	--	273.2	4139.7	3.0	77.5	11 NO A E O 1/16 NO
737B	RBI	9-7/8"	C-3 RCB	AT 128	481.3	234.2	715.5	1086.5	16.8	22.3	RELEASED NO SIGNS OF FAILURE
738A	RBI	11-7/16"	C-3 XCB	AE 3376	--	--	--	4139.7	0	77.5	FALSE START
738B	RBI	11-7/16"	C-3 XCB	AE 3376	214.3	--	214.3	4354.0	2.5	80.0	11 NO A F O 1/16
738C	RBI	9-7/8"	C-57 RCB	AS 007	337.2	196.6	533.8	606.8	39.0	62.0	RELEASED NO SIGNS OF FAILURE
739A	RBI	11-7/16"	C-3 XCB	AE 3376	--	--	--	4354.0	0	80.0	NOT PULLED
739B	RBI	11-7/16"	C-3 XCB	AE 3376	7.2	--	7.2	4361.2	3.0	83.0	11 NO A F O 1/16
739C	RBI	9-7/8"	C-3 RCB	AP 635	486.8	--	486.8	486.8	42.0	42.0	RELEASED-EVIDENCE OF SEVERE CONE WEAR FROM ABRASIVE FORMATION ALSO BU, SD, PN
740A	RBI	9-7/8"	C-3 RCB	AP 629	126.0	--	126.0	126.0	28.5	28.5	34 CD A E 1/16 WT PR
740A	RBI	9-7/8"	C-3 RCB	AP 630	99.5	--	99.5	99.5	14.0	14.0	
740B	RBI	9-7/8"	C-3 RCB	AP 630	1.6	--	1.6	101.1	0	14.0	31 WT A F I SD TD
741A	RBI	9-7/8"	C-4 RCB	AT 753	128.1	--	128.1	128.1	24.0	24.0	21 NO A F 1/16 SD TD
742A	RBI	9-7/8"	C-4 RCB	AT 759	316.0	--	316.0	316.0	28.0	28.0	RELEASED NO SIGNS OF FAILURE
743A	RBI	11-7/16"	C-3 XCB	AE 3376	98.1	--	98.1	4459.3	7.8	90.8	21 NO A F O 1/16 LN HP
744A	SYNTEC	9-7/8"	PDC XCB	0287	176.1	--	176.1	176.1	2.0	2.0	NOT INSPECTED
744B	SYNTEC	9-7/8"	PDC XCB	0287	78.5	--	78.5	254.6	0.5	2.5	NOT INSPECTED
744C	SYNTEC	9-7/8"	PDC XCB	0287	26.0	--	26.0	280.6	0.2	2.7	0 1 CT S X I BT TD
745A	SYNTEC	9-7/8"	PDC XCB	0287	--	0.5	0.5	281.1	--	2.7	NOT INSPECTED
745B	SYNTEC	9-7/8"	PDC XCB	0287	205.5	--	205.5	486.6	2.3	5.0	NOT INSPECTED
746A	SYNTEC	9-7/8"	PDC XCB	0287	125.5	155.3	280.8	767.4	2.5	7.5	23 CT A X I BT TD

TECHNICAL REPORT

The ODP Technical and Logistics personnel aboard JOIDES Resolution for Ocean Drilling Program Leg 119 were:

Laboratory Officer	Bill Mills
Curatorial Representative	Bob Wilcox
Computer System Manager	Bill Meyer
Electronics Technician	Jim Briggs
Electronics Technician	Dwight Mossman
Yeoperson	Dawn Wright
Photographer	Roy Davis
Marine Technician	Daniel Bontempo
Marine Technician	Stacey Cervantes
Marine Technician	Bettina Domeyer
Marine Technician	Kazushi Kuroki
Marine Technician	Mark Neschleba
Marine Technician	Mark Simpson
Marine Technician	Uwe Storrlein
Marine Technician	John Tauxe
Marine Technician	Katie Tauxe
Marine Technician	John Weisbruch

PORT CALL

This was a busy port call for freight activities. Cores, unused hard-rock guidebase parts, and regular scientific shipments were off-loaded throughout the port call. We also received supplies that were shipped for our leg plus those that had been stored in Mauritius during previous port calls. From supplies on the ship and from our incoming shipments, we had to make up the freight for Maersk Master, which was to arrive in port a few weeks later. Liquid helium dewars did not make it to Mauritius on time because of the Air France strike. These dewars plus two empty liquid nitrogen dewars were picked up by the Maersk Master and transferred to us at sea.

UNDERWAY ACTIVITIES

Because of the remoteness of and great distances between our sites, almost half the leg was spent in transit, a total of 6861 nmi. Magnetometer and bathymetric data were collected during all transits, unless the threats of ice and low visibility forced us to retrieve the magnetometer.

Limited data were available from previous site surveys for some of our sites. Therefore, our geophysical gear was used extensively this leg. Over 478 nmi of single channel seismic data were collected and nine successful sonobuoy drops were made.

The JOIDES Safety Panel required that all of the Prydz Bay sites be surveyed before any drilling could be done. On our first attempt to penetrate inner Prydz Bay, we encountered the remains of last winter's pack ice. Because drilling was still possible, we deployed gear and surveyed as the ship picked its way through the ice at 3 kt. We avoided fouling our seismic gear on the ice by rigging snatch blocks on the fantail catwalk and pulling the gear inboard. A tag line was also attached to the water gun tow bundle, to shake off any ice that might snag. We collected about 20 min of data before our survey was cut short by pack ice closing in and the ship was forced to turn around. No equipment was damaged by ice, but a hard turn by the ship (to avoid ice), while retrieving the streamer, resulted in dragging the active streamer section over several large pieces of ice. No damage was noted.

ON SITE ACTIVITIES AND LABORATORY STATUS

Curation

Eleven sites and 22 holes were cored. Ice-rafted debris and diamictites limited recovery at the Prydz Bay sites, but nannofossil and siliceous oozes made for more normal recovery at the Kerguelen sites. Over 15,000 samples were taken this leg.

To keep from damaging the cores and from wasting diamond blades, we cut all diamictite cores by hand after we discovered that cutting sections of diamictite caused severe dishing of the blades.

Physical Properties

A new lead shield was made for the GRAPE source. Local radiation levels were reduced substantially, but the additional weight of the new housing plus heavy seas caused the stepping motor to stall frequently. To alleviate this problem the load compensator was adjusted and acceleration values in GRAPE software were reduced.

A new freeze dryer was installed in the physical properties lab, similar to the one in the chemistry lab.

Paleomagnetics

This lab saw heavy use, as over 1000 core sections were measured by the cryogenic magnetometer and susceptibility meter. Also, 2582 discrete samples were measured on the minispin. Several major problems with cryomag software were discovered, and fixes were applied.

On 4 January, Maersk Master met us and delivered two dewars (56 liters) of liquid helium, which was transferred to the cryomag.

Downhole Measurements

None of the APC shoe temperature recorders were used this leg. Instead, the WSTP tool was used in the Uyeda recorder configuration. No pore water samples were taken. Thirteen runs were made but three were too noisy to use, because of the ship's heave.

XRD-XRF Lab

This lab saw minimal use because the recovered basement rocks were highly altered and no one in the science party was interested in interpreting any shipboard XRD data.

Chemistry Lab

There were minor problems in the chemistry lab with one gas chromatograph (GC2), the Rock Eval, and the freeze dryer. GC2 was producing ghost peaks. The Rock Eval was repaired by adjusting the TCD overprotection pot. The freeze dryer pump needs a new shaft seal and gasket; parts are on order.

Thin Section Lab

One hundred fifty-two thin sections were made this trip. Half of them required impregnation. A new movable exhaust hood was added to the lab to vent fumes from epoxies and grinding oils. This hood was piped into the foc'sle deck bathroom exhaust duct instead of using the fan and carbon trap provided.

Paleontology Lab

A full-time paleontology lab technician was aboard for this leg to help with sample preparations and at the sampling table. He also assisted with core handling.

Fantail and U/W Geophysics

Equipment problems were minor and fixable. Magnetometer problems from the previous leg were repaired within the first few days of the leg. Both magnetometer bottles were found to have ruptured diaphragms. One was repaired with the spare.

The use of a tanner gas injection system for the water guns' air supply eliminated most of our icing problems, although the port gun still would ice up unless copious amounts of tanner gas were injected. The original injection pump would not pressure up, so the Sprague pump from the downhole lab was pressed into service. It lacked the metering capabilities of the other pump, so every 15 min of underway watch the watchstander manually injected 10 strokes into the system.

During the transit to Perth at the end of the leg, the port side streamer (active, stretch and tow leader) was replaced with new spares. The old streamer is being shipped home for repairs, and for modification to a standard configuration.

The VSP experiments planned for this leg were reduced to shot points. This type of experiment does not require the energy of our big guns, so approval was sought and received from SEDCO to shoot one 80 $in.^3$ water gun from its boom, at a water depth of 15 m. If we had used both guns, we would have had to lower them the full length of their towing cables.

During Prydz Bay drilling we were requested to have the 400 $in.^3$ water gun ready for towing. Before we could do any towing, SEDCO required that we lengthen the tow cables to 140 ft instead of 100 ft to keep from damaging seals on the main props. Although the 400 $in.^3$ water gun experiment was cancelled, the 400 $in.^3$ water gun was towed for 30 minutes on the transit to Perth to test the lengthened (150 ft) tow bundle and a new tail buoy/exhaust design. Everything worked fine and the 400 $in.^3$ water gun gave a beautiful record on the new port streamer.

A new version of HIGHRES was installed (unix3.1) and the 80 mbyte hard disk was made operational. The 1107 GPS receiver was dead the entire trip, but critical parts should arrive for the Leg 120 port call. Therefore, only transit and dead reckoning points were used for navigation. GPS fixes were recorded in the bridge log every 30 min by the mates.

Yeoperson, Library, and Science Lounge

The computer application SLIDES was introduced this leg. This application eliminates the need for the Smear Slide/Thin Section form.

The science lounge has a new look. The "video center" was replaced with new shelves and an electronics cabinet. All "leisure reading" paperback books were moved from the library and placed in the new shelves. Additional shelving and doors for the laser disk cabinets will be added during future legs.

One of the bookshelves in the library was removed to make room for the new Xerox machine. The displaced bookshelf was put in the conference room.

Computer Facilities

No problems were encountered with the VAX hardware but the PRO 350s had a number of component failures this trip.

On the VAX system a new RA81 disk drive was installed and the VAX/VMS operating system was upgraded to version 4.5. System disk structure and archiving/backup procedures were redesigned to provide more disk space.

Storekeeping

All major storage areas on the ship were reorganized, creating more shelf space. Similar items are stored now at the same location.

Weather and Ice Observations

Two weathermen were aboard this leg to maintain daily weather and ice observations.

Reentry Equipment

Two reentries were made this leg. Rigging the VIT frame posed no problems and operations were trouble-free.

Photo Lab

The core lab photo table was adjusted so that all the tick marks line up. Only minor repairs and fix-ups were needed in the photo lab.

Physical Plant

A 208-volt outlet was added to the XRF prep area to accommodate the ashing furnace, and a 440-volt outlet was added to the catwalk for the new heater. Cables and platforms were installed in the casing hold for the French Petroleum Institute's ship-motion monitoring system.

Safety

New fire fighting and hazardous chemical suits were added to the METS inventory. The METS practiced with SEDCO's emergency squad on all drills.

Special Activities

The second annual Antarctic barbecue was held in Prydz Bay this year. We were joined by 12 members of Australia's Davis Station, who flew over in three helicopters. Two helicopters landed on *JOIDES Resolution* and the other on *Maersk Master*. *Maersk Master* tied up alongside to join the fun.

On a dead calm day in Prydz Bay the Captain put over the lifeboats so that the ship's mates could train on lifeboat piloting.

Toward the end of the leg, would-be aerospace engineers held a kite-flying contest on the helideck.