10. SITE 741[1]

Shipboard Scientific Party[2]

HOLE 741A

Date occupied: 27 January 1988

Date departed: 29 January 1988

Time on hole: 1 day, 14 hr, 15 min

Position: 68°23.16′S, 76°23.02′E

Bottom felt (rig floor; m, drill-pipe measurement): 561.9

Distance between rig floor and sea level (m): 10.5

Water depth (drill-pipe measurement from sea level, m): 551.4

Total depth (rig floor; m): 690.0

Penetration (m): 128.1

Number of cores: 14

Total length of cored section (m): 128.1

Total core recovered (m): 33.60

Core recovery (%): 26

Oldest sediment cored:
Depth sub-bottom (m): 128.1
Nature: siltstone and sandstone
Earliest age: Early Cretaceous(?)
Latest age: Tertiary
Measured velocity (km/s): 2.289

Principal results: Ocean Drilling Program (ODP) Site 741 is situated in the inner part of Prydz Bay, on the shelf of East Antarctica (68°23.16′S, 76°23.02′E, 551.4 m water depth). Below a 24-m-thick cover of probable glacial deposits, approximately 100 m of sediments was sampled. The sediments form part of an approximately 2-km-thick, slightly tilted sequence resting on the basement at Prydz Bay. The sampled interval is stratigraphically placed at about 1500 m above the stratigraphic level of the top of the preglacial sediments in Hole 740A, which is about 600 m above the surface of basement. The main objective of coring was to examine the upper part of the sequence, especially any marine intervals, in order to (1) explain the development of the Lambert Graben, a structure that has been linked to the rifting between the Indian subcontinental block and the Antarctic continent and (2) determine the hitherto unknown preglacial conditions of the area.

Drilling began on 28 January 1988. Based on the experience at Site 740, rotary drilling was used. Drilling terminated at a final depth of 128.1 m below seafloor (mbsf) because no preglacial marine sediment was found. The core recovery was generally poor (average 26.3%), but 5 of 14 cores had less than 6% recovery.

The sediments encountered at Site 741 can be divided into four lithologic units. Unit I (0–0.66 mbsf) consists of olive-gray diatom ooze with minor quartz silt, presumably of Holocene age. Unit I shows a sharp color contrast to Unit II (0.66–4.1 mbsf), which is a silty clay containing up to 1% gravel and 20% diatoms; the proportion of diatoms decreases with depth. Unit III (4.1–24.05 mbsf) consists of fragments of gneiss up to 12 cm in length. Core recovery within this interval is poor; thus, the thickness and overall composition of Unit III is unknown. Unit IV (24.05–128.1 mbsf) consists mainly of gray sandstone and siltstone with less than 10% clay and minor quartz granules. The unit is characterized by the presence of several fining-upward sequences and one coarsening-upward sequence, all less than 20 cm thick. The sandstone and siltstone are structured mainly by horizontal lamination and subordinate cross stratification. Carbonized plant fragments, possibly including remnants of wood, occur throughout most of the unit. Most of the carbonized plant debris is allochthonous. Pyrite and bioturbation are locally developed in parts of this unit. Preliminary age determinations based on spore and pollen analysis suggest that the age of the unit is probably Early Cretaceous (Albian).

The sedimentological character of Unit IV is consistent with deposition on a low-lying, low-relief alluvial plain. No marine sedimentation appears in the recovered sequence. The dark, organic-rich sediment and abundant carbonized plant fragments indicate a wet environment characterized by high plant productivity and limited oxidation. On the basis of the limited data available, Unit III is tentatively interpreted as glacial debris, which is possibly part of the overlying, structureless Unit II. The latter unit is thought to represent a glaciomarine shelf deposit. Unit I probably was deposited in the Holocene when summer ice cover was minimal and surface-water plankton productivity was high relative to the rate of deposition of terrigenous components.

BACKGROUND AND OBJECTIVES

Site 741 (68°23.16′S, 76°23.02′E, in 551.4 m of water) was drilled near target Site PB-3 on the shelf of East Antarctica in eastern Prydz Bay. Located on the landward slope of the Four Ladies Bank, the site is part of a transect of sites across the shelf along seismic profile PB-21 of Stagg (1985). Site 741 is about 36 km northwest of Site 740.

The general background of Site 741 is described in the "Background and Objectives" section of the "Site 740" chapter (this volume). The main objective at Site 741 was to characterize and date the upper part of the approximately 2.5-km-thick sequence of sediments (seismic unit PS-4 of Stagg, 1985) that probably rests on the basement of the inner part of the bay. The preglacial sedimentary sequence cored at Site 740 consists of continental sediments of unknown age, stratigraphically placed 500–600 m above the presumed basement. The top of the presumed preglacial sequence at Site 741 is placed stratigraphically about 100 m above the top level at Site 740. If this sequence is linked with the subsidence, which could be expected on a passive margin, following the separation of the Antarctic and the Indian continental plates, it is likely that the upper part of the sequence consists of dateable marine sediments. The slightly inclined sediments of seismic unit PS-4 (Stagg, 1985) are unconformably overlain by presumably glacial sediments. The thickness of this layer is uncertain because it is not distinguishable on the seismic record of Stagg (1985) owing to the long bubble pulse, but it is expected to be between 25 and 100 m thick. On a meter scale, the seafloor seems to be hard and uneven, probably as a result of ice scouring.

The main objective of the coring at Site 741 was to investigate the upper part of seismic unit PS-4, especially the marine intervals, in order to (1) elucidate the development of the Lambert Graben, a structure that has been linked to the rifting between the Indian and Antarctic continental plates; (2) describe

[1] Barron, J., Larsen, B., et al., 1989. *Proc. ODP, Init. Repts.*, 119: College Station, TX (Ocean Drilling Program).

[2] Shipboard Scientific Party is as given in the list of Participants preceding the contents.

the unknown preglacial conditions of the area; (3) study the glacial stratigraphy, especially in relation to the early history of the glaciation in East Antarctica; and (4) study the overlying sediment as an example of the glacial-interglacial sedimentation on the shelf bank, as part of the overall model of a shelf dominated by glacial processes.

SITE GEOPHYSICS

Site Survey

A brief geophysical survey (ODP line 119-06) was conducted near Site 741 prior to drilling (Fig. 1). The survey was done with standard geophysical gear (see "Explanatory Notes" chapter, this volume) and global positioning system satellite navigation. Two seismic lines were recorded across the site under calm sea conditions, with no sea ice and only occasional large icebergs.

The first survey line crossed the area from southeast to northwest parallel and close to line PB-21, a six-channel seismic-reflection line recorded by the Australian Bureau of Mineral Resources (Stagg, 1985). The ODP survey line provided greater resolution of the uppermost part of the dipping strata beneath the site. The ship then moved to a point about 2 km northeast of the site, and the second survey line, a crossline, was recorded. Sonobuoy 6 was deployed along the crossline, about 1 km before the site, and was recorded to an offset of 6 km. The beacon was dropped at shotpoint 32449 along the crossline. After completing the line, the ship returned to the beacon and began drilling operations. The seismic results are discussed in "Seismic Stratigraphy" section (this chapter).

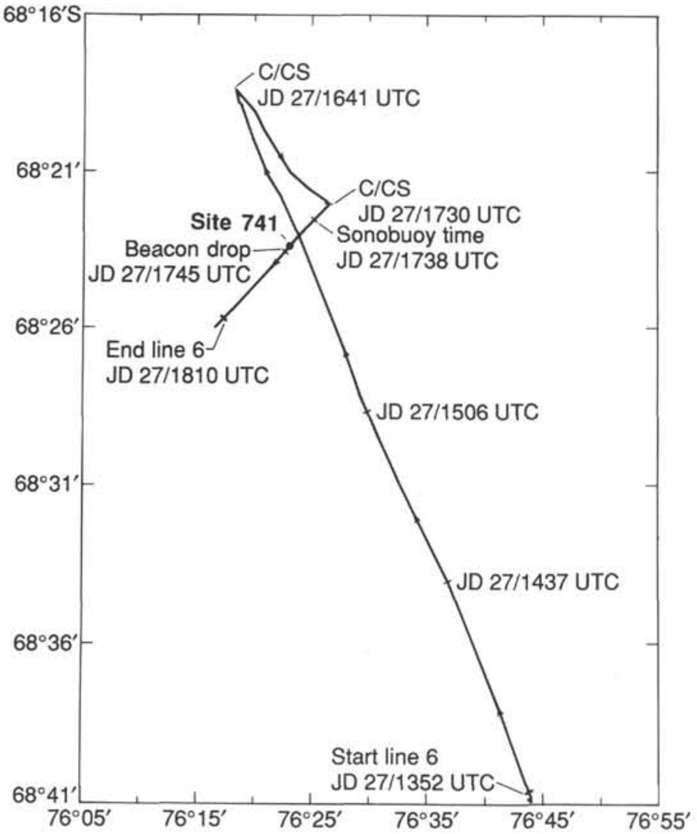

Figure 1. Index map of seismic lines recorded during site surveys for Site 741.

Sonobuoy Data

The sonobuoy was used to determine interval and refraction velocities for the sedimentary section beneath Site 741 and to examine the continuity of rock units using wide-angle reflection data (Table 1). The sonobuoy was deployed successfully and appeared to function normally; however, only weak seismic signals were recorded from the direct-wave and reflected arrivals, even with calm sea conditions (Fig. 2). The poor response resulted in part from high noise levels in the water column and from poor penetration of seismic energy into the sedimentary section.

High noise levels were caused by echoes from seafloor multiple reflections, which were generated by each 9-s water gun shot and not fully attenuated by the following shot. Also, the seismic energy was seemingly dispersed and attenuated by probable ice scourings on the seafloor and mostly uniform velocities at shallow subsurface depths. The weak direct wave probably resulted from a sharp velocity inversion in the water column at 15–20 m depth (see "Biology and Oceanography" section, this chapter). Minor corrections (−15 m/s) were added to rms and refraction velocities to correct for a questionable direct wave (see sonobuoy error discussion, "Underway Geophysics" chapter, this volume).

Three wide-angle reflections were traced to offsets of up to 5 km (Fig. 2) and gave good rms velocities. The computed interval velocities are 2.47 to 2.79 km/s for the upper 979 m of the sedimentary section (Fig. 3). The primary reflections (e.g., those above the seafloor multiple) are very weak for horizontal offsets of 0–1.5 km, but become stronger and more readily identifiable at greater offsets. Secondary reflections (e.g., those within the first seafloor multiple), are generally easier to trace than primary reflections, because of the natural attenuation of high frequencies over the longer travel path and because of the shallower inclination of multiple reflections on the sonobuoy record. The secondary reflections indicate better layer continuity than the primary reflections.

Interval velocities at Site 741 are similar to those for Site 740, which lies landward and penetrates older strata of the seaward-dipping Prydz Bay sequence. The relatively high velocities at Site 741 indicate greater sediment compaction than expected for present burial depths. Some compaction caused by grounded ice-sheet loading is likely but is probably limited to the upper glacial strata, based on downhole logging at Sites 739 and 741. Former burial by at least 500 m of sedimentary rocks is likely. This once-overlying sedimentary section was probably removed by ice erosion.

Refraction arrivals were recorded to offsets of 6 km yielding head-wave velocities of 2.25 km/s near the seafloor to 2.94 km/s

Table 1. Preliminary results for sonobuoy 6, Site 741.

Horizon[a]	Vrms (km/s)	Vint[b] (km/s)	Ti[b] (s)	Zi (km)	Vrfr (km/s)	To (s)
AA	1.455	2.47	0.76	0.551	2.25	0.606
BB	1.815	2.79	1.08	0.946	2.38	0.654
CC	2.132	—	1.50	1.530	2.94	0.989

Note: Vrms = rms velocity for horizon; Vint = interval velocity computed using Vrms, Ti, and Dix equation (e.g., Vint between horizon AA and BB is 2.47 km/s); Ti = vertical incidence reflection time (two-way) in horizon; Zi = total depth from sea level to horizon (water depth = 551 m); Vrfr = refraction velocities cannot be directly associated with a specific horizon, rather they comprise a gradient from near seafloor to horizon CC; To = intercept time for refractor.

[a] Letters of horizons do not correlate between drill sites and do not correspond to prior stratigraphic analyses.

[b] Velocities and times used for computing depths Zi.

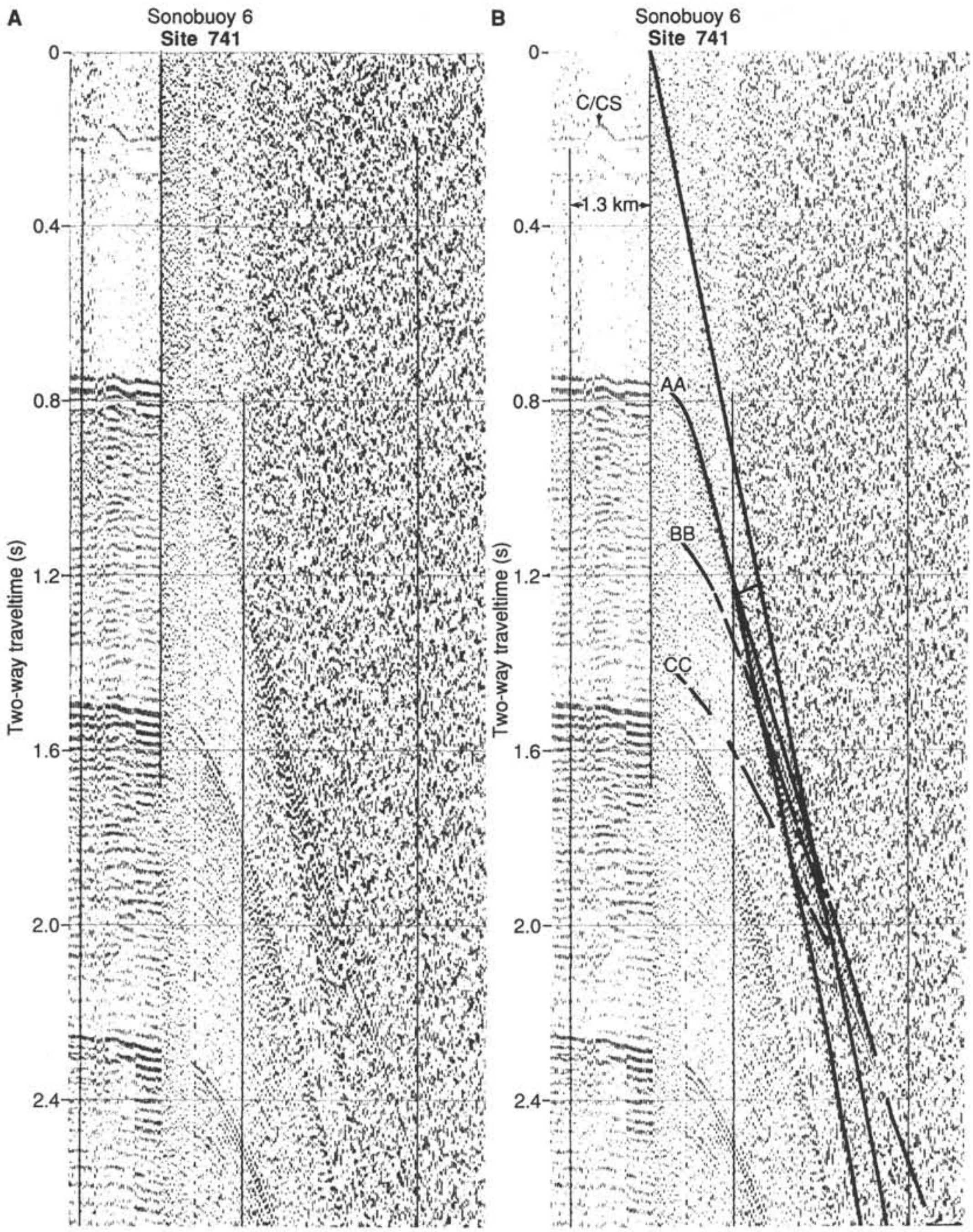

Figure 2. Vertical-incident seismic and sonobuoy seismic records for sonobuoy station 6. **A.** Raw data. **B.** Interpreted data. Site 741 lies about 1.5 km west of the point where the sonobuoy was deployed. Letters denote layers given in Table 1. See Figure 1 for location.

near the top of reflector CC at 979 mbsf. Refractions were not observed beyond the 6-km range because of the small size of the seismic source (two 80-in.[3] water guns). The refraction arrivals are continuous and gently curved, indicating that velocities increase continuously and slowly, rather than abruptly, with depth.

Major velocity inversions are not apparent in the sedimentary section, although thin, high-velocity layers exist. Low-velocity zones are not indicated in refraction data by "shingling," or time displacement, of the refraction arrivals. Evidence for thin layers is a single weak refractor of short duration (0.3 km) and high velocity (5.0 km/s) at shallow subseafloor depth (between AA and BB, not marked, Fig. 2). Initially, the refractor was ignored as noise, but was considered real following the core recovery of nearly 2 m of highly cemented sandstone with a laboratory-measured velocity of over 4.7 km/s. In general, the large velocity fluctuations observed in the glacial deposits at Sites 739 and 742 are not indicated by the sonobuoy or seismic data at Site 741. The total thickness of the layer is unknown because core recovery was not complete. Other layers such as this may exist and make good reflections (e.g., the sandstone layer is a good reflector in the secondary, but not primary, wide-angle reflection data); however, the layers are not thick because abrupt

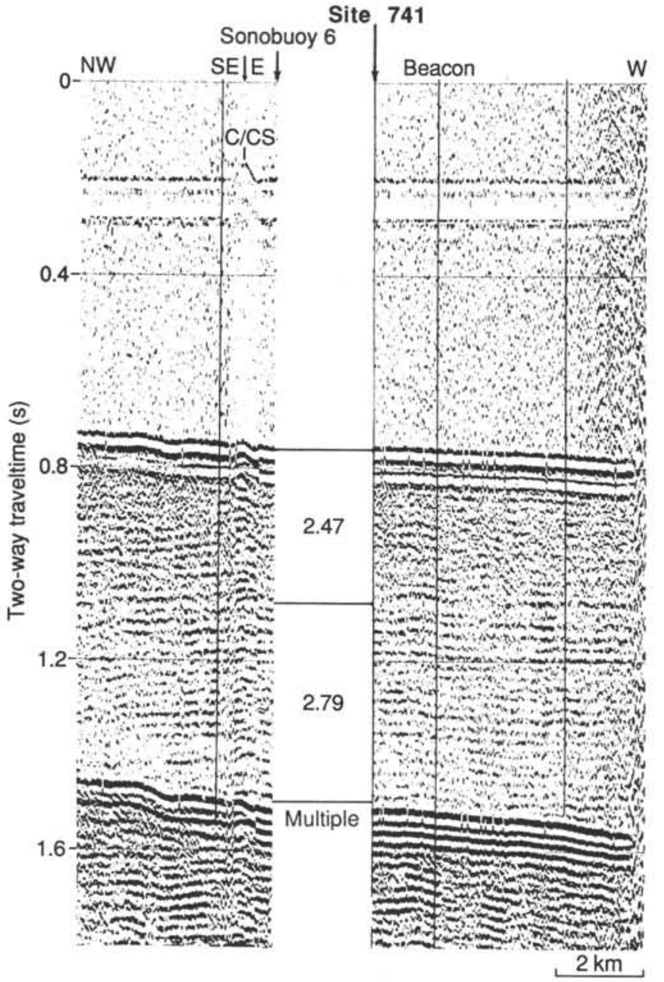

Figure 3. Vertical-incident seismic profile across Site 741 showing interval velocities from sonobuoy data.

high-amplitude, first-break refraction arrivals with very high velocity do not occur.

The total thickness of the sedimentary section cannot be determined from the present refraction data. Yet, projection of the acoustic basement reflector from Site 740 shows the sedimentary section to be at least 2.0 km thick at Site 741.

In summary, the upper 979 m of the sedimentary section at Site 741 is characterized by interval and refraction velocities in the range of 2.25 to 2.94 km/s. Thin interbedded high-velocity layers are likely but not common at Site 741, as they are elsewhere in glacial sequences beneath Prydz Bay. The velocities increase with depth and are higher than expected for normally compacted rocks at equivalent burial depths. The sedimentary section at Site 741 has probably been buried at greater depths, compacted, uplifted, and eroded.

OPERATIONS

Site 740 to Site 741

JOIDES Resolution steamed northwestward at full speed for 18 km before she slowed for deployment of the seismic gear about 11 km in advance of the first crossing of the anticipated drill site. The approach line was continued northwest past the site about 7 km before a wide looping turn to starboard was made for a second approach on a southwesterly course. A sonobuoy was launched about 0.8 km northeast of the site, and a beacon was dropped as the location was crossed. After an extension of the line about 3.2 km to the southwest for refraction data, the vessel turned, retrieved gear, and returned to the drill site.

Site 741–Inner Prydz Bay

The pattern for spudding holes successfully in the hard glacial sediments of Prydz Bay had now been established. Hole 741A was started with a good-quality rotary core barrel (RCB) "punch core" that recovered 4.1 m of soft ooze and clay and established seafloor depth at 551.4 m below sea level. The next 50 m required over 13 hr of tedious, low RPM/low weight-on-bit drilling. On average, each of those hours only produced about 1 m of core as cobbles and pebbles of metamorphic and igneous rock interfered with the coring process (Table 2).

An increase in rate of penetration then signaled the breakthrough into nonglacial sediments. The new material was a sequence of sandstones and siltstones. Core 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 128.1 mbsf.

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

LITHOSTRATIGRAPHY AND SEDIMENTOLOGY

Lithology

The sediments found at Site 741 were divided into four lithologic units (Table 3). The upper three units represent a young, unlithified marine sequence unconformably overlying the indurated older sediments of Unit IV. Comparable superficial cover deposits were found at other sites in Prydz Bay (see "Lithostratigraphy and Sedimentology" sections, "Site 739," "Site 740," and "Site 742" chapters, this volume). Unit IV seems to be a nonmarine siliciclastic succession of probable Early Cretaceous (?Albian) age.

Unit I

Sections 119-741A-1R-1 through 119-741A-1R-1, 66 cm; depth, 0–0.66 mbsf.
Age: Quaternary, probably Holocene.

Unit I consists of olive (5Y 5/4) diatom ooze (about 75% diatoms) with a content of about 20% of silt-size terrigenous

Table 2. Coring summary, Site 741.

Core no.	Date (Jan. 1988)	Time (local)	Depth (mbsf)	Length cored (m)	Length recovered (m)	Recovery (%)
119-741A-						
1R	28	0200	0.0–4.1	4.1	4.07	99.2
2R	28	0630	4.1–13.9	9.8	0.60	6.1
3R	28	0845	13.9–23.9	10.0	0.00	0.0
4R	28	1155	23.9–33.5	9.6	3.73	38.8
5R	28	1440	33.5–43.2	9.7	2.50	25.8
6R	28	1745	43.2–52.9	9.7	5.88	60.6
7R	28	1945	52.9–62.5	9.6	2.12	22.1
8R	28	2040	62.5–72.2	9.7	0.53	5.5
9R	28	2220	72.2–81.9	9.7	0.11	1.1
10R	29	0000	81.9–91.5	9.6	3.05	31.8
11R	29	0035	91.5–101.2	9.7	0.00	0.0
12R	29	0150	101.2–110.8	9.6	1.96	20.6
13R	29	0525	110.8–120.5	9.7	5.27	54.3
14R	29	0820	120.5–128.1	7.6	3.78	49.7
				128.1	33.60	26.3

Table 3. Lithostratigraphic summary, Hole 741A.

Unit	Lithology	Depth (mbsf)	Cores	Age
I	Diatom ooze with quartz silt	0–0.66	1R-1, 0 cm, to 1R-1, 66 cm	Holocene
II	Clayey silt with diatoms	0.66–4.10	1R-1, 66 cm, to 2R-1, 0 cm	Quaternary
III	Metamorphic rock fragments	4.10–24.05	2R-1, 0 cm, to 4R-1, 15 cm	?
IV	Fine-grained siliciclastic sediments	24.05–128.1	4R-1, 15 cm, to 14R-3, 75 cm	?Early Cretaceous (Core 119-741A-6R)

minerals, predominantly quartz silt. Radiolarians, silicoflagellates, and sponge spicules are present but rare. The sediments appear to be homogeneous, but this may be due to the soupy consistency arising from severe drilling disturbance. A living worm was found at 20 cm, resting on a lonestone, indicating that bioturbation may be in part responsible for the homogeneity.

Several pebbles up to 4 cm in length are mainly subangular and of metamorphic origin. Near the base of the unit is a patch of coarse sand and granules that appears to be composed mainly of angular to subangular quartz grains.

Unit I shows a sharp color contrast with Unit II.

Unit II

Sections 119-741A-1R-1, 66 cm, through 119-741A-2R-1, 0 cm; depth, 0.66–4.1 mbsf.
Age: Quaternary.

Unit II is a clayey silt with up to 20% diatoms, the proportion of which decreases downward. Beside clay minerals, quartz silt is the major detrital component. The sediment changes in color downward from greenish gray (7.5GY 5/0) to gray (5Y 5/1), although the sediment appears to be very homogeneous as well as soupy due to drilling disturbance. No sedimentary structures were detected. The one pebble in Section 119-741A-1R-1, 120 cm, is thought to be due to drilling contamination.

Unit III

Sections 119-741A-2R-1 through 119-741A-4R-1, 15 cm; depth: 4.1–24.05 mbsf.
Inferred age: Eocene–Quaternary.

Unit III consists of fragments of metamorphic rocks up to 12 cm in length. They partly show linear fabrics. Recovery within this interval was poor; only 60 cm was recovered in Core 119-741A-2R and none in Core 119-741A-3R, while the 15 cm of garnet-bearing granulite fragments at the top of Core 119-741A-4R are possibly due to hole cave-in contamination. Thus, the thickness and overall composition of Unit III are unknown.

The age of the unit is inferred to be Eocene through Quaternary(?) on the basis of the age of the underlying and overlying units.

Unit IV

Sections 119-741A-4R-1, 15 cm, through 119-741A-14R-3, 75 cm; depth, 24.05–128.1 mbsf.
Age: (?)Albian.

Unit IV consists of fine-grained, light gray (10Y 6/1) to black (5Y 2.5/0) siliciclastic sediments with varying proportions of carbonized plant fragments (Fig. 4). Alternating layers of siltstone and fine- to medium-grained sandstone dominate the unit. Coarse sandstones represent about 10% of the total thickness, whereas beds of claystones and of conglomerates amount merely to a few percent.

In Core 119-741A-7R, four alternating layers of conglomerates and coarse sandstones cemented by calcite were found, with a total thickness of 1.9 m (Fig. 5). Both the occurrence of conglomerates and the carbonate cementation are unique to this core. The hard conglomerates are clast supported, with grains up to 5 mm in length set in a matrix of coarse sand. The following grains are abundant in the conglomerate: quartz, feldspar, garnet, biotite, and pyrite. The grains are mostly subrounded to rounded. The conglomerates are slightly stratified, whereas the coarse sandstones show cross bedding delineated by enrichment of fine-grained black minerals. No carbonized plant fragments were detected in this part of the succession.

Apart from the cemented strata, ripple cross lamination occurs in only a few sections (e.g., Section 119-741A-12R-1, 145 cm). Layering is common throughout the unit, but it may be poorly defined. Only rarely is the stratification deformed (e.g., in Section 119-741A-14R-1, 35 cm; Fig. 6). In Section 119-741A-13R-3, black carbonaceous fragments show imbricate patterns. Fining-upward sequences are common (e.g., Section 119-741A-12R-1), but a few coarsening-upward sequences occur (e.g., Section 119-741A-6R-2). Burrowing and bioturbation occur at intervals throughout the unit, particularly in the finer-grained sandstones and siltstones (Fig. 7). Pyrite occurs as grains and concretions.

The occurrence of carbonized plant material (charcoal and mineral coal) is random, despite local enrichments. Also, several layers do not have any visible carbonaceous fragments. Pollen analysis (see "Biostratigraphy" section, this chapter) indicates an Early Cretaceous (?Albian) age for these sediments.

Interpretation

If the pebbles and the coarse sand in Unit I are not due to drilling contamination, the poorly sorted terrigenous component indicates an influence of ice rafting on the biogenic diatom ooze.

The clayey silt of Unit II may have been deposited in a distal glaciomarine setting, sufficiently far from the active ice margin to allow biogenic activity. The upward increase in diatom abundance indicates gradual glacial recession and climatic amelioration.

For Unit III, drilling operations indicated a mixture of boulders in finer sediments, the latter being washed away. Thus Unit III possibly represents the remnants of a diamicton.

The sedimentological character of Unit IV is consistent with deposition on a low-lying, low-relief alluvial plain. No evidence exists of any marine influence on sedimentation from the recovered sequence. The carbonized plant fragments and the presence of pyrite indicate limited oxidation in the subsurface. Most of the carbonized plant debris seems to be allochthonous in origin. However, shorebased analysis is required to determine if the succession has been reworked (see "Biostratigraphy" section).

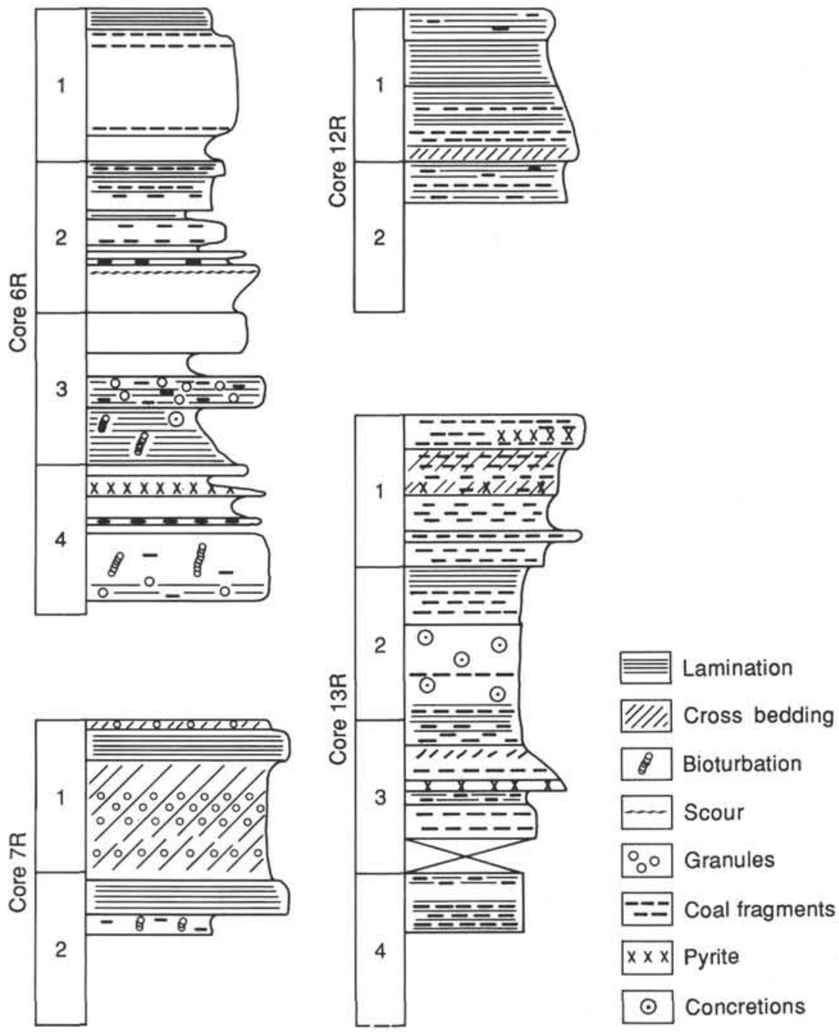

Figure 4. Lithologic sections illustrating fining-upward sequences and sedimentary structures in Unit IV from Hole 741A.

BIOSTRATIGRAPHY

Upper Pliocene to Quaternary and probable Albian sediments were recovered at Site 741.

Calcareous nannofossils were absent throughout the section. A diverse benthic foraminiferal assemblage was recovered from the mud line, but only one planktonic foraminifer, *Neogloboquadrina pachyderma*, was found.

Diatoms were only present in two core-catcher samples (Cores 119-741A-1R and 119-741A-4R) and consisted of rare to common, poorly to moderately well-preserved specimens. Sample 119-741A-1R-CC is placed in the upper Quaternary, while a late Pliocene–Quaternary age is indicated for Sample 119-741A-4R-CC. Radiolarians were not present at this site.

Moderately diverse spore and pollen assemblages were recorded from Samples 119-741-6R-CC, 119-741A-8R-CC, and 119-741A-12R-CC through 119-741A-14R-CC. Preservation was moderate to good. On the basis of comparisons with other high-latitude assemblages, these samples are regarded as probably Albian in age, although the presence of one or two Tertiary pollen grains may indicate that the whole sequence has been reworked into Tertiary sediments.

Calcareous Nannofossils

No calcareous nannofossils were found in the core-catcher samples from Site 741.

Foraminifers

Foraminifers at Site 741 were only present in the mud-line sample and the first core-catcher sample. The core-catcher sample contains one specimen of *Epistominella* whereas the mud-line sample shows a rich, highly diverse foraminiferal assemblage that is not preserved downcore. The latter sample was stained with Rose Bengal. The presence of a living surface population constituting 30%–40% of the total population clearly indicates the recovery of the water/sediment interface. A few specimens of *Neogloboquadrina pachyderma*, the only planktonic species observed, were found in the mud-line sample.

Agglutinated species dominate the assemblage, but calcareous species occur in lower abundance and are less diverse. Common calcareous genera include *Eponides, Epistominella, Globocassidulina, Nonionella,* and *Fursenkoina*. These taxa are also represented in the living population. The arenaceous component is dominated by tubular species and the genera *Reophax,*

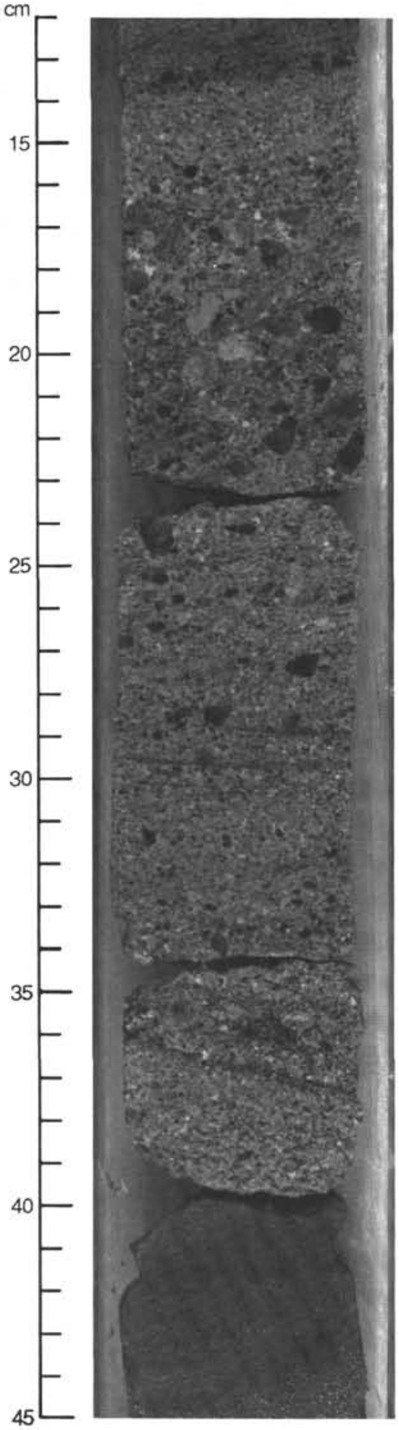

Figure 5. Carbonate-cemented conglomerate (Section 119-741A-7R-2, 12–45 cm). Note the stratification in the lower part and the coarsening-upward trend. The largest clasts are mostly small pebbles of quartz and feldspar.

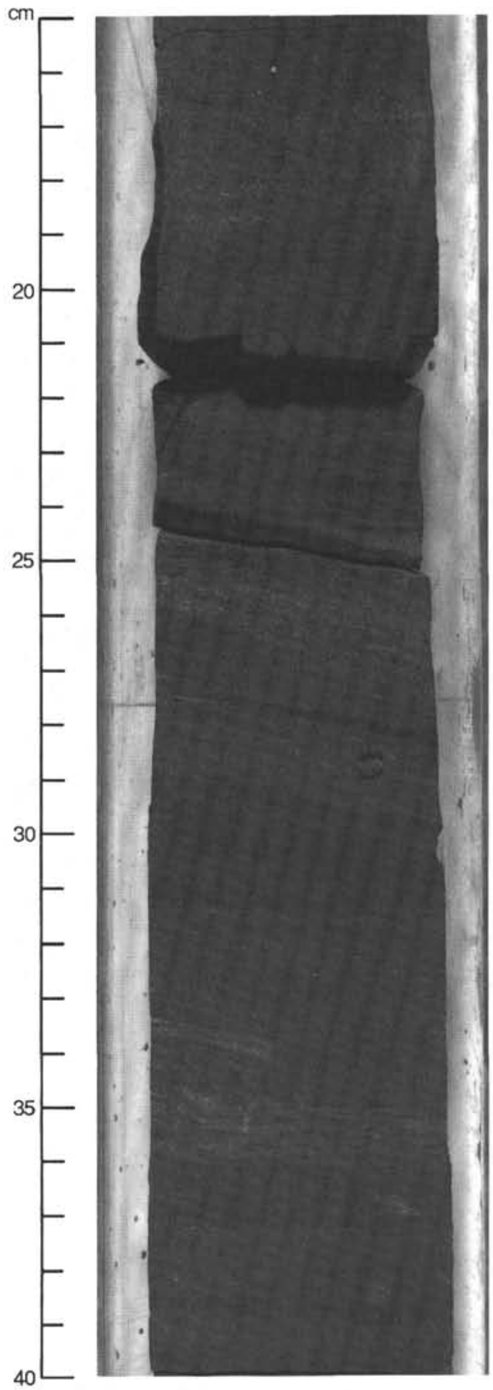

Figure 6. Deformed laminae in siltstone (Section 119-741A-14R-1, 15–40 cm).

Trochammina, Miliammina, Textularia, Adercotryma, and *Cribrostomoides*. Compared with Hole 740B, this more seaward site shows a higher species diversity, including a calcareous assemblage, and a higher abundance of living specimens. The composition of the agglutinated surface assemblage resembles that of Hole 739C. The substrate of Holes 741A and 739C differs from Hole 740B in having a larger mineral component and fewer diatoms in the sand fraction, perhaps forming a more favorable substrate for agglutinated foraminifers.

Diatoms

Of the core-catcher samples examined from Site 741, diatoms were observed only in Cores 119-741A-1R and 119-741A-4R. The diatom assemblage consists of rare to common and poorly to moderately well-preserved specimens. The occurrences of *Nitzschia cylindrus, Thalassiosira lentiginosa, Thalassiosira gravida, Nitzschia kerguelensis*, and *Nitzschia ritscheri* allow

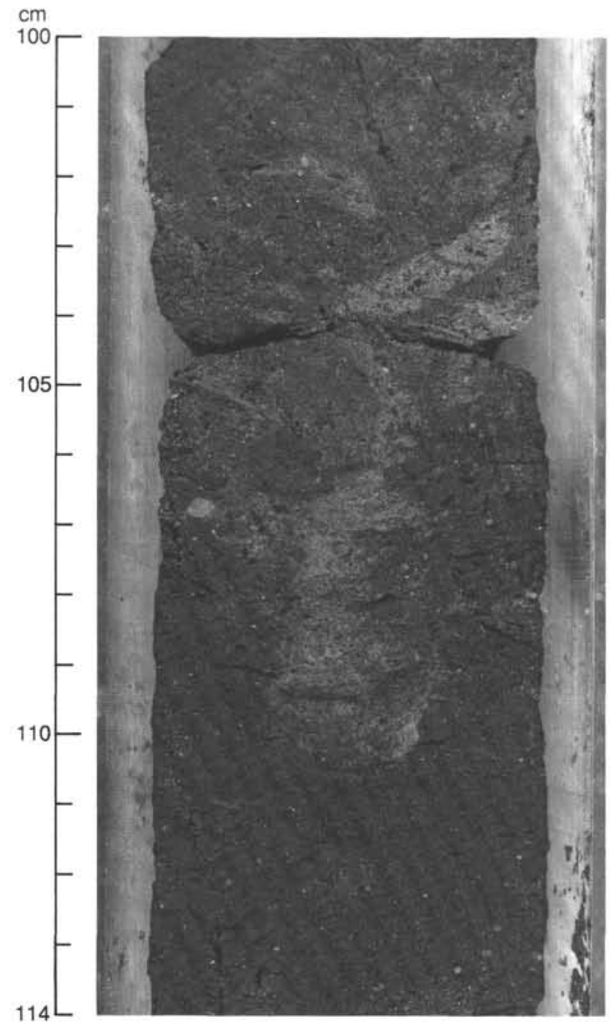

Figure 7. Spreiten-type burrow in coarse sandstone, with black clasts of mineral charcoal (Section 119-741A-6R-4, 100–114 cm).

placement of Sample 119-741A-1R-CC into the Quaternary *Thalassiosira lentiginosa* Zone. The few species present in Sample 119-741A-4R-CC suggest a late Pliocene–Quaternary age for this sample.

Radiolarians

No radiolarians were recorded from Site 741.

Palynomorphs

Samples 119-741-6R-CC through 119-741A-14R-CC were examined for their palynological content. All contained some organic-walled microfossils, but Samples 119-741A-6R-CC, 119-741A-8R-CC, and 119-741A-12R-CC through 119-741A-14R-CC proved to be particularly useful. The latter samples contain moderately preserved to well-preserved, moderately diverse spore and pollen assemblages, commonly with large amounts of woody material and leaf cuticle. The color of the organic material ranges from light yellow to black, indicating a range of thermal maturation values. No marine palynomorphs were recovered.

The assemblages are dominated by relatively long-ranging (Jurassic-Tertiary) taxa, in particular *Microachrydites antarcticus* and *Cyathidites minor*, with lesser amounts of *Cicatricosisparites* spp., *Classopollis* spp., *Densoisporites velatus, Gleicheniidites senonicus*, and *Aequitriradites spinulosus*. Stratigraphically significant taxa include *Balmeisporites holodictyus, Kraeuselisporites majus*, and several species of *Triporolites* which seem to indicate a probable Albian age for this material (D. J. Batten, pers. comm., 1988). Comparison with Australian floras indicates that these assemblages fall somewhere within the *Microachrydites-Hoegisporis* Superzones of Helby et al. (1987).

The presence of a small number of poorly preserved Tertiary forms, referable to the genus *Tricolpites*, and one specimen of *Triporopollenites scabratus* may indicate that the entire succession has been reworked into Tertiary sediments. However, clarification of this awaits a more detailed shorebased study.

PALEOMAGNETICS

Thirty-nine discrete samples were collected from Cores 119-741A-4R through 119-741A-14R. A stratigraphic plot of sample inclinations and intensity is shown in Figure 8. With the exception of one sample, the samples displayed negative inclinations, which indicates normal polarization in the Southern Hemisphere. Half-core cryogenic magnetometer measurements were made on the archive halves of Cores 119-741A-1R through 119-741A-14R after demagnetization to 5 mT. As with the discrete sample data, the vast majority of inclination measurements from these cores are characterized by very steep inclinations in a negative direction (Fig. 9). However, alternating field demagnetization experiments on nine samples in fields up to 60 mT indicated that the samples displayed wide swings in sample direction on demagnetization, resulting from unstable magnetization. No age assignments have been made because these rocks are not stably magnetized.

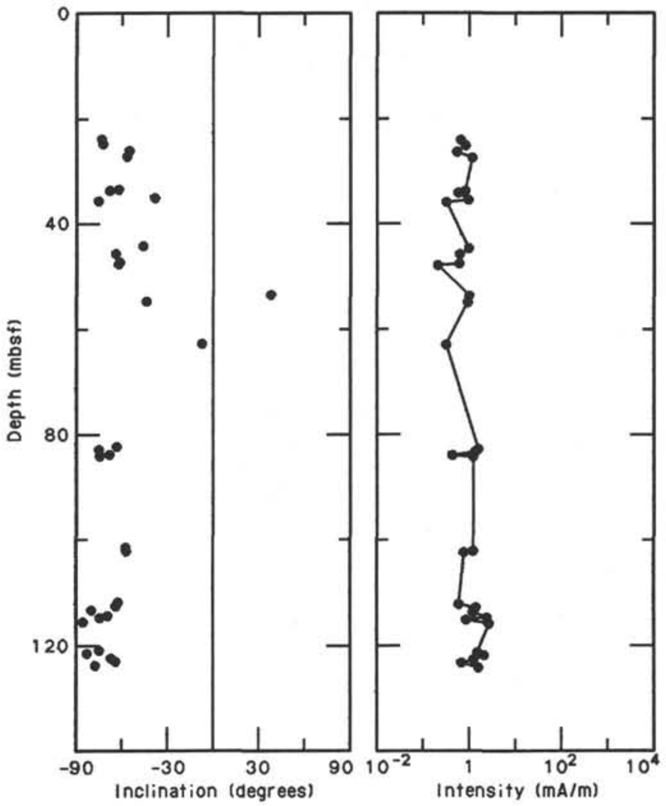

Figure 8. Stratigraphic plot of natural remanent magnetization inclinations and intensity from Hole 741A discrete samples.

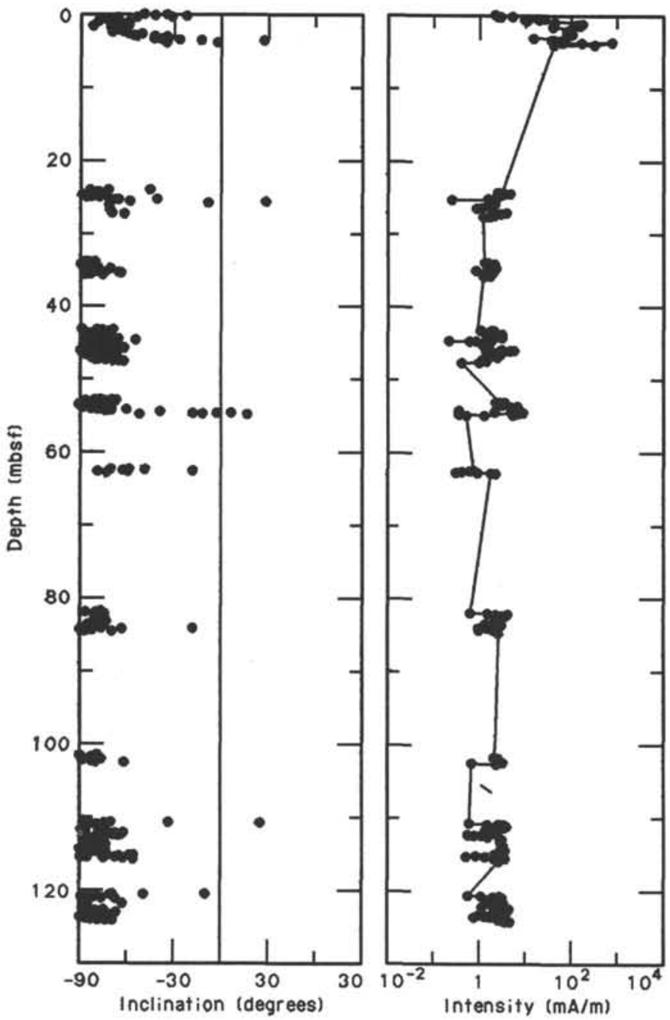

Figure 9. Stratigraphic plot of magnetic inclination and intensity of sediment cores measured on the cryogenic magnetometer. Most of the sediments appear to be characterized by normal magnetization (negative inclinations within the Southern Hemisphere); however, alternating field demagnetization studies indicate the samples are unstably magnetized. These sections were azimuthally unoriented.

SEDIMENTATION RATES

The sequence recovered at Site 741 is biostratigraphically dated by benthic and planktonic foraminifers as Quaternary, by diatoms as late Pliocene–Quaternary, and by pollen as (?)Early Cretaceous.

The uppermost 33.5 m of diatom ooze is dated as late Pliocene–Quaternary. A significant hiatus is present between 33.5 and 43.2 mbsf. The underlying 74.9 m of terrestrially derived sediments are provisionally dated as Albian.

INORGANIC GEOCHEMISTRY

Three whole-round minicores 5–10 cm in length were taken for interstitial-water geochemical studies at Site 741. Sample 119-741A-1R-2, 145–150 cm (3 mbsf), consists of Quaternary clayey siltstone with minor diatom frustules. Samples 119-741A-4R-2, 140–150 cm, at 27 mbsf and 119-741A-13R-3, 140–150 cm, at 115 mbsf were taken from a terrestrial, gray sandstone of probable Early Cretaceous age. Organic carbon is abundant only in the sandstone, which contains a large amount of reworked coal fragments. All the sediment minicores contain >0.1% calcium carbonate.

Results

Site 741 interstitial-water samples were analyzed for pH, alkalinity, salinity, chloride, sulfate, magnesium, calcium, phosphate, ammonium, and silica using the methods outlined in the "Explanatory Notes" chapter (this volume). Only one of the samples was large enough to permit the full complement of analyses. Charge-balance calculations were performed on each of the interstitial-water samples to check for gross irregularities in the data. Sodium and potassium were calculated by multiplying the ratio of each cation to chloride for average seawater, using the values given by Stumm and Morgan (1981), by the chloride concentration of each sample. All of the samples have charge imbalances >2%, indicating that drilling contamination was minimal and that the waters have a seawater origin. All of the data obtained at Site 741 are displayed in Table 4.

Dissolved magnesium and calcium concentrations are well correlated ($r = -1.0$) in the uppermost 115 mbsf at Site 741. The small number of samples makes any interpretation of the data tenuous at best, but the diffusion gradients of calcium and magnesium appear to be well defined. Magnesium concentrations decrease about 26% with increasing depth between 3 and 115 mbsf, while calcium increases 57% over the same interval. The good correlation implies that the concentrations of magnesium and calcium are primarily controlled by diffusion properties over the sampling range (see McDuff and Gieskes, 1976; McDuff, 1978; Gieskes, 1983).

Sulfate, phosphate, and ammonium concentrations in the interstitial-water samples indicate that the abundance of reactable organic matter is limiting microbial activity at Site 741. The concentration of dissolved sulfate drops about 29% from 3 to 115 mbsf in Hole 741A. This small decrease implies that the supply of reactable organic matter to the sediments was too low (i.e., surface-water productivity was low) and/or that sedimentation rates were not high enough to entrap sufficient organic matter to fuel the sulfate-reduction pump that removes sulfate from interstitial waters. The high sulfate concentration (26.5 mmol/L), low ammonium concentration (0.04 mmol/L), and slightly elevated phosphate concentration (12 μmol/L) at 3 mbsf show the lack of intense microbial catabolism near the sediment/water interface.

Dissolved silica concentrations decrease sharply below the contact between glaciomarine and terrestrial sediments at Site 741. The relatively high abundance of dissolved silica at 3 mbsf is due to the dissolution of biogenic silica. Low concentrations of silica in the deeper interstitial-water samples indicate that soluble silicates are lacking in the terrestrial sediments. Much of the dissolved silica in the diatomaceous sediments probably diffuses into the overlying water column.

ORGANIC GEOCHEMISTRY

Hydrocarbon Gases

The headspace procedure was used approximately every 30 m to determine hydrocarbon gases. The samples all had methane levels below 6 ppm. Ethane was not detected in any samples from Site 741. Two vacutainer samples were taken to supplement the headspace data because the core was too hard to get a sample plug of mud for headspace analysis. Vacutainer samples also showed only methane, at levels of 6 ppm or less. Vacutainer samples for cores that are considerably smaller than the inside diameter of the core liner are suspect, as gases can easily escape out the ends of the core liner before it is capped.

Carbon Analysis

Inorganic carbon and total carbon were determined on many physical-properties samples and all of the interstitial-water squeeze cake samples. Where total carbon was determined, total organic

Table 4. Interstitial-water geochemical data, Hole 741A.

Core, section, interval (cm)	Depth (mbsf)	Volume (mL)	pH	Alkalinity (mmol/L)	Salinity (g/kg)	Magnesium (mmol/L)	Calcium (mmol/L)	Chloride (mmol/L)	Sulfate (mmol/L)	Phosphate (μmol/L)	Ammonium (mmol/L)	Silica (μmol/L)	Mg^{2+}/Ca^{2+}
119-741A-													
1R-2, 145–150	2.95	28	7.4	3.00	35.0	50.2	10.5	556	26.5	12	0.04	556	4.8
4R-2, 140–150	26.80	2	—	—	35.5	44.8	13.8	561	22.8	—	0.16	85	3.2
3R-3, 140–150	115.20	3	—	—	34.2	37.0	16.5	546	18.7	—	0.14	103	2.2

carbon (TOC) was calculated. See Table 5 and Figure 10 for detailed data.

Carbonate content is very low at Site 741 due to the lack of marine influence (see "Lithostratigraphy and Sedimentology" section). All samples have >3% carbonate except Sample 119-741A-4R-1, 92–96 cm, which contains 17.7% carbonate.

Site 741 is characterized by high organic matter below 27 mbsf. Values greater than 40% TOC represent coal samples that are intermittent throughout the sequence. TOC values of 2%–7% are from dark shale samples.

Rock-Eval Pyrolysis

Rock-Eval pyrolysis was performed on the samples that were run for TOC. Table 6 lists the data and important calculations. Figure 11 is a plot of T_{max} and TOC. Figure 12 shows measured parameters S1, S2, and S3. Figure 13 shows pyrolysized carbon (PC), productivity index (PI), and S2/S3 calculated from the data. Figure 14 is a modified van Krevelen plot of oxygen index (OI) vs. hydrogen index (HI).

One maturity indicator of the organic carbon, T_{max}, is extremely variable. Carbon of T_{max} extremes is indicative of intense reworking of the material (Tissot and Welte, 1984). The youngest material from the Eocene has the lowest T_{max}, therefore, the autochthonous material was very immature. The older material was recycled Cretaceous(?), possibly from two or more sources of different ages. Palynological evidence (coloration and characterization of spore types) confirms reworking and the possibility of Eocene and Lower Cretaceous (Albian) material (see "Biostratigraphy" section). Shorebased vitrinite reflectance studies of the material will better classify the maturity of the coal materials.

Table 5. Total carbon, inorganic carbon, organic carbon, and carbonate carbon, Site 741.

Core, section, interval (cm)	Depth (mbsf)	Total carbon (%)	Inorganic carbon (%)	Organic carbon (%)	$CaCO_3$ (%)
119-741A-					
1R-1, 109–110	1.09	0.16	0.01	0.15	0.1
1R-2, 145–150	2.95	0.22	0.00	0.22	0.0
4R-1, 92–96	24.82	2.62	2.12	0.50	17.7
4R-2, 140–150	26.80	0.17	0.00	0.17	0.0
4R-3, 46–49	27.36	2.66	0.01	2.65	0.1
5R-1, 0–1	33.50	62.31	0.04	62.27	0.3
5R-1, 38–39	33.88	6.28	0.06	6.22	0.5
5R-1, 108–109	34.58	2.88	0.35	2.53	2.9
5R-2, 38–43	35.38	0.72	0.01	0.71	0.1
5R-2, 39–40	35.39	0.68	0.02	0.66	0.2
5R-2, 87–88	35.87	0.92	0.01	0.91	0.1
6R-3, 38–43	46.58	6.86	0.01	6.85	0.1
7R-2, 40–43	54.80	0.36	0.05	0.31	0.4
8R-1, 10–12	62.60	46.98	0.02	46.96	0.2
10R-1, 74–75	82.64	1.31	0.72	0.59	6.0
10R-1, 140–150	83.30	1.23	0.07	1.16	0.6
12R-1, 53–54	101.73	0.81	0.00	0.81	0.0
13R-1, 30–31	111.10	2.70	0.18	2.52	1.5
13R-3, 37–38	114.17	6.60	0.01	6.59	0.1
13R-3, 140–150	115.20	2.41	0.01	2.40	0.1
14R-1, 34–35	120.84	3.38	0.03	3.35	0.3
14R-3, 12–13	123.62	2.57	0.01	2.56	0.1

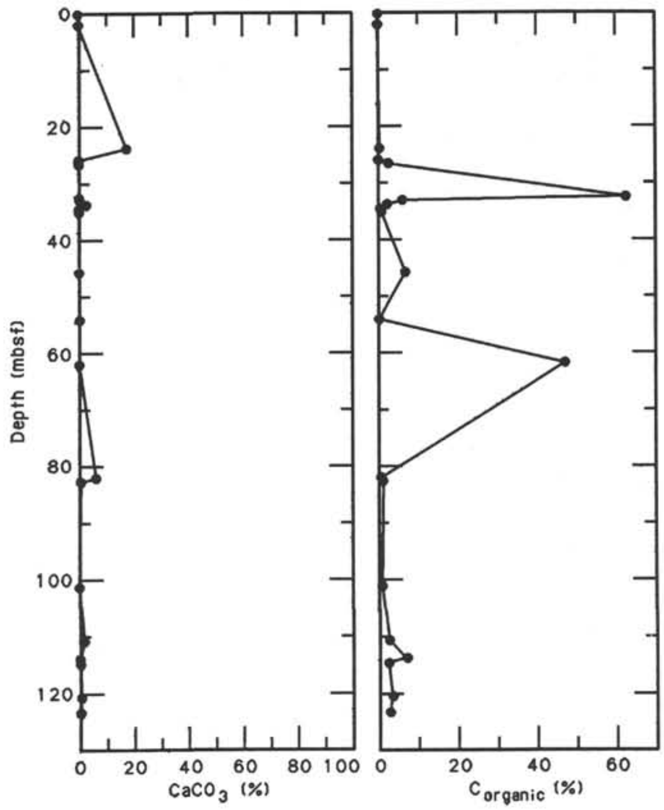

Figure 10. Carbonate carbon and organic carbon, Site 741.

Kerogen of increasing maturity trends toward the origin of the modified van Krevelen diagram (Waples, 1985). Site 741 is characterized by all of the samples having low hydrogen and oxygen indices. This is expected for the samples containing mature carbon, but low T_{max} (indicating immaturity) values should have higher indices. One means of generating carbon with low HI, OI, and T_{max} would be deposition in an oxygenated environment, along with the admixture of reworked carbon of high maturity. The reworked carbon would depress both HI and OI without significantly affecting the T_{max} of the fresh, immature carbon (Deroo et al., 1984).

The kerogen at Site 741 is type III terrestrial and is, therefore, unlikely to have hydrocarbon-producing potential. This is difficult to see on the modified van Krevelen diagram, as the samples cluster around the convergence of types I, II, and III kerogen. Since the PC of all of the samples is 16% or less of the TOC values, the kerogen can be characterized as type III (Kvenvolden and McDonald, 1986). Microscopic inspection of the kerogen shows the presence of some terrestrial particulates.

Table 6. Rock-Eval pyrolysis, Site 741.

Core, section, interval (cm)	Depth (mbsf)	Weight (mg)	T_{max} (°C)	S1 (mg HC/g)	S2 (mg HC/g)	S3 (mg CO_2/g)	Productivity index	S2/S3	Pyrolysized carbon (0.08 [S1 + S2])	Total organic carbon (wt%)	Hydrogen index (mg HC/g C_{org})	Oxygen index (mg CO_2/g C_{org})
119-741A-												
1R-1, 109–110	1.09	102.2	501	0.12	1.49	0.33	0.07	4.51	0.13	0.15	993	220
1R-2, 145–150	2.95	98.9	528	0.08	0.14	0.19	0.36	0.73	0.01	0.22	64	86
4R-1, 92–96	24.82	99.5	535	0.18	0.63	7.37	0.22	0.08	0.06	0.50	126	1474
4R-2, 140–150	26.80	100.7	478	0.22	1.09	0.04	0.17	27.25	0.10	0.17	641	24
4R-3, 46–49	27.36	99.4	431	0.19	3.55	0.71	0.05	5.00	0.31	2.65	134	27
5R-1, 0–1	33.50	96.4	397	2.83	26.42	9.04	0.10	2.92	2.43	62.26	42	15
5R-1, 38–39	33.89	104.2	436	0.16	4.93	1.91	0.03	2.58	0.42	6.22	79	31
5R-1, 108–109	34.58	105.0	431	0.24	3.60	1.80	0.06	2.00	0.32	2.53	142	71
5R-2, 38–40	35.38	102.6	477	0.07	0.96	0.32	0.07	3.00	0.08	0.71	135	45
5R-2, 39–40	35.39	106.2	472	0.06	0.85	0.32	0.07	2.65	0.07	0.66	129	48
5R-2, 87–88	35.87	99.3	484	0.16	0.84	0.37	0.16	2.27	0.08	0.91	92	41
6R-3, 38–43	46.58	109.1	432	0.12	3.44	1.87	0.03	1.83	0.29	6.85	50	27
7R-2, 40–43	54.80	104.1	514	0.08	0.61	0.24	0.12	2.54	0.05	0.31	197	77
8R-1, 10–12	62.60	99.4	402	0.55	14.89	9.13	0.04	1.63	1.28	46.96	32	19
10R-1, 74–75	82.64	117.0	534	0.03	0.53	12.23	0.05	0.04	0.04	0.59	90	2073
10R-1, 140–150	83.30	98.6	486	0.38	1.18	5.45	0.24	0.21	0.13	1.16	102	470
13R-1, 30–31	111.10	107.9	431	0.14	1.87	1.04	0.07	1.79	0.16	2.52	74	41
13R-3, 37–38	114.17	100.2	431	0.18	4.25	1.19	0.04	3.57	0.36	6.59	64	18
13R-3, 140–150	115.20	94.8	476	0.16	1.22	0.78	0.12	1.56	0.11	2.40	51	33
14R-1, 34–35	120.84	109.7	475	0.03	1.11	0.99	0.03	1.12	0.09	3.35	33	30
14R-3, 12–13	123.62	103.7	429	0.09	3.32	0.53	0.03	6.26	0.28	2.56	130	21

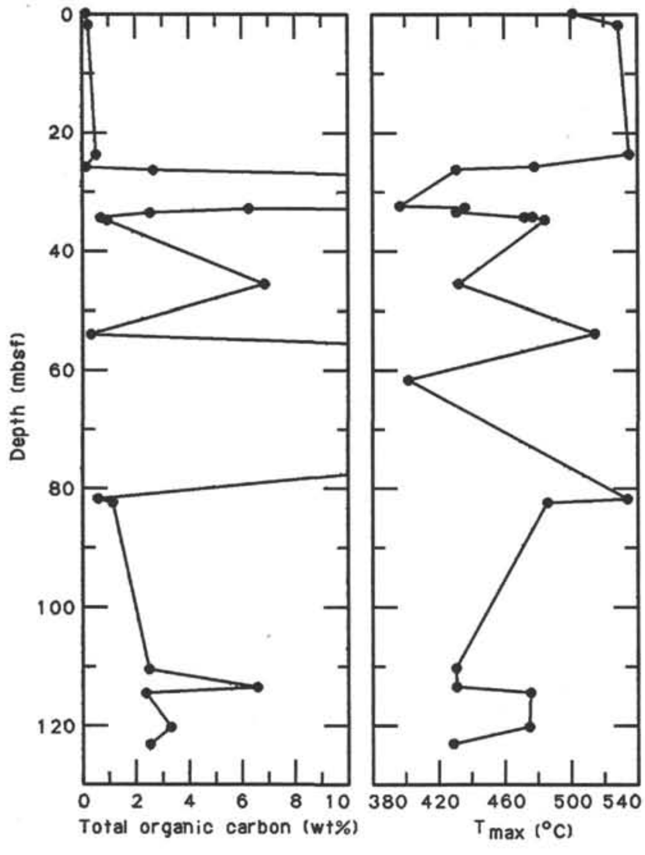

Figure 11. Total organic carbon and T_{max}, Site 741.

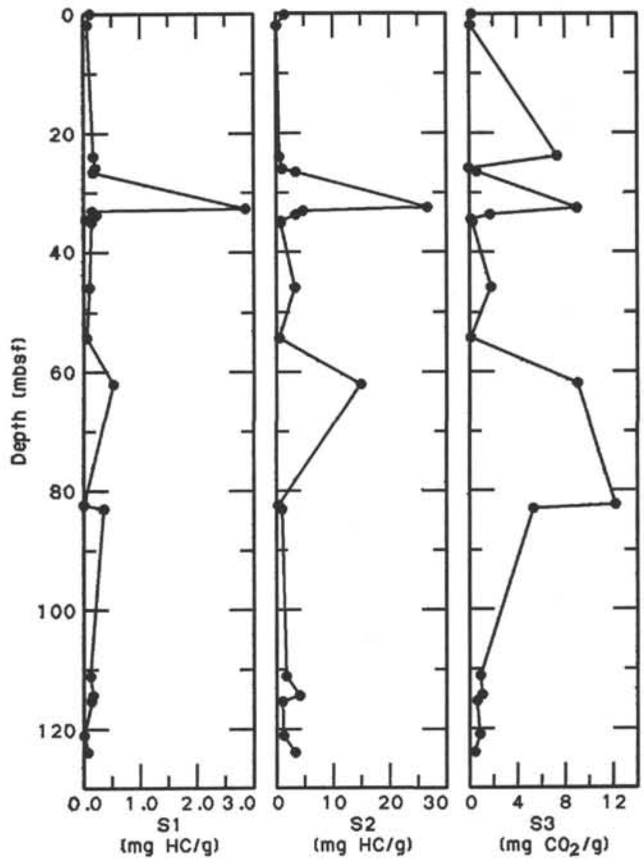

Figure 12. S1, S2, and S3, Site 741.

Values of Samples 119-741A-1R-1, 109–110 cm, and 119-741A-4R-2, 140–150 cm, which have only 0.15% and 0.17% TOC, respectively, are plotted within the type I/type II regime of the modified van Krevelen plot. Deroo et al. (1984) estimated that Rock-Eval instrument function becomes erratic near these levels, so these points are possibly spurious.

S1 values (mg free hydrocarbons/g rock) are very low except for Sample 119-741A-5R-1, 0–1 cm, where S1 = 2.83. This sample is well above the "oil show" level of 1.00. Gravimetric determination of hexane-extractable organic matter confirmed that this high S1 value was not due to contamination.

BIOLOGY AND OCEANOGRAPHY

Physical Characteristics of the Marine Ecosystem

At the third site in Prydz Bay, surface-seawater temperatures ranged from +0.8° to +1.7°C on 28–29 January during the oc-

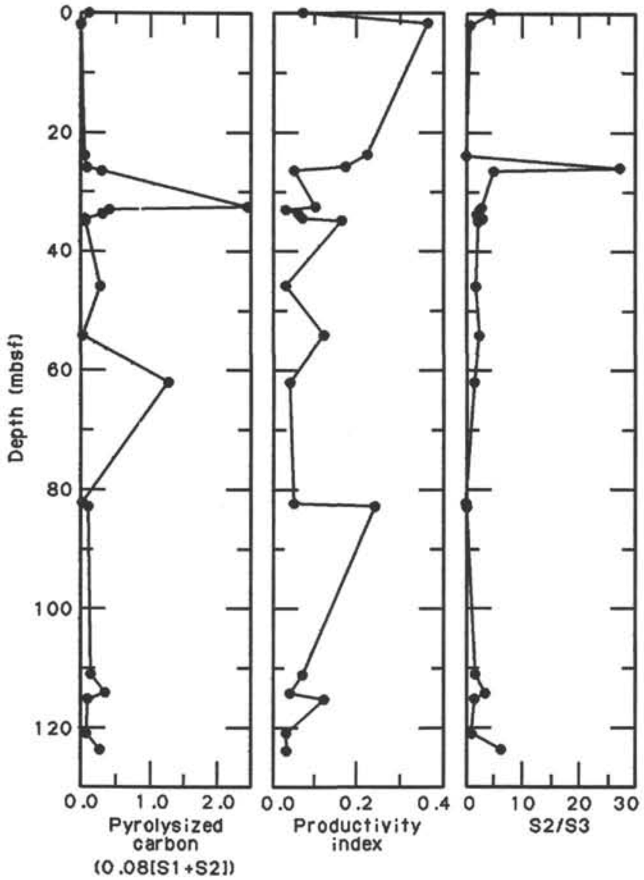

Figure 13. Pyrolysized carbon, productivity index, and S2/S3, Site 741.

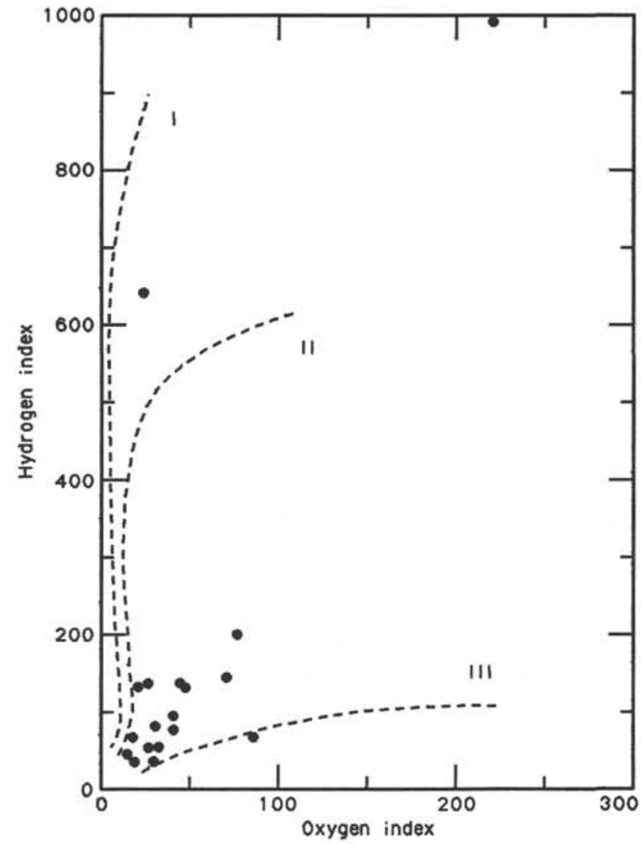

Figure 14. Modified van Krevelen plot of oxygen index vs. hydrogen index, Site 741.

cupation of Site 741 (see Table 7). Sunlight continued for many hours in spite of increasing cloudiness on the first day. The water column was stable, with the pycnocline at 15–18 m (Fig. 15). From the Secchi disc reading, the level in the water column illuminated by 1% of the surface incident light was well above the thermocline and increasingly shallow, from only 10.8 m the first day to 9.5 m the second. However, the down and up traces of the conductivity, temperature, and depth (CTD) SEACAT unit once again indicated internal waves at or below 20 m, with agreement from the offset of temperature and salinity profiles (Fig. 15). Because noise appeared in the signal in the top 20 m of the downtrace as the instrument entered the water, we could not see if waves occurred that would cycle the phytoplankton into and out of the euphotic zone. However, the phytoplankton was not limited to the upper 10 m.

Table 7. Wind and weather summary for Site 741 (68.4°S, 76.3°E), January 1988.

28 January/0000–2359 hr
- Wind: Northeast to east 10–18 kt increasing to 22–28 kt late in the period.
- Sea-surface temperature: 0.8°C–1.7°C.
- Waves: 0.5–1 m increasing to 2–3 m late in the period.
- Sky: Clear to partly cloudy until 1900 hr, then mostly cloudy. Pressure falling.
- Air temperature: Max. 0.2°C at 1200 hr. Min. −1.7°C at 0600 hr.

29 January/0000–0700 hr
- Wind: Northeast to east 22–28 kt.
- Sea-surface temperature: 0.9°C–1.4°C.
- Waves: 2–3 m.
- Sky: Mostly cloudy until 0400 hr, then partly cloudy. Pressure slowly falling.
- Air temperture: Max. −2.9°C at 0600 hr. Min. −3.2°C at 0000 hr.

Phytoplankton

The phytoplankton was sampled in the water column by horizontal net tows, vertical net hauls, and from filtered water samples. The chlorophyll *a* level remained high at this site, with the maximum between 25 and 30 m in the water column, as at Site 740. Dominant at all depths were *Corethron criophilum* and *Corethron inerme*, both with some auxospore formation. Diameters ranged from 12 μm pre-auxospore to 70 μm post-auxospore. Although auxospores were very noticeable in the samples, they accounted for only 4% of all *Corethron* cells in the top 50 m, 15.3% in the next 50 m, and 10.7% from 100 to 200 m. Many cells were empty or did not autofluoresce under epifluorescent illumination (Table 8). The healthiest population occurred in the 50–100-m range. At this depth, long chains of several species of *Chaetoceros, Eucampia antarctica* (southern form), and *Nitzschia* species formed ribbon colonies. Heavily pigmented clusters of a gymnodinioid dinoflagellate also were seen from the 50–100-m sample.

From the deepest level (100–200 m), some winter forms and resting spore formation were noted. *Eucampia antarctica* (southern form, flexed only dorsal/ventrally) showed some production of the first pair of winter form doublets in vegetative cells. Although auxospores were not seen, valves were seen at maximum double the usual polar axis (broad girdle view of 105–125 μm) with rounded elevations. They appear to have been formed within spherical or ovoid membrane instead of being pressed against a sibling elevation. *Chaetoceros neglectus* was also beginning production of resting spores within vegetative chains at

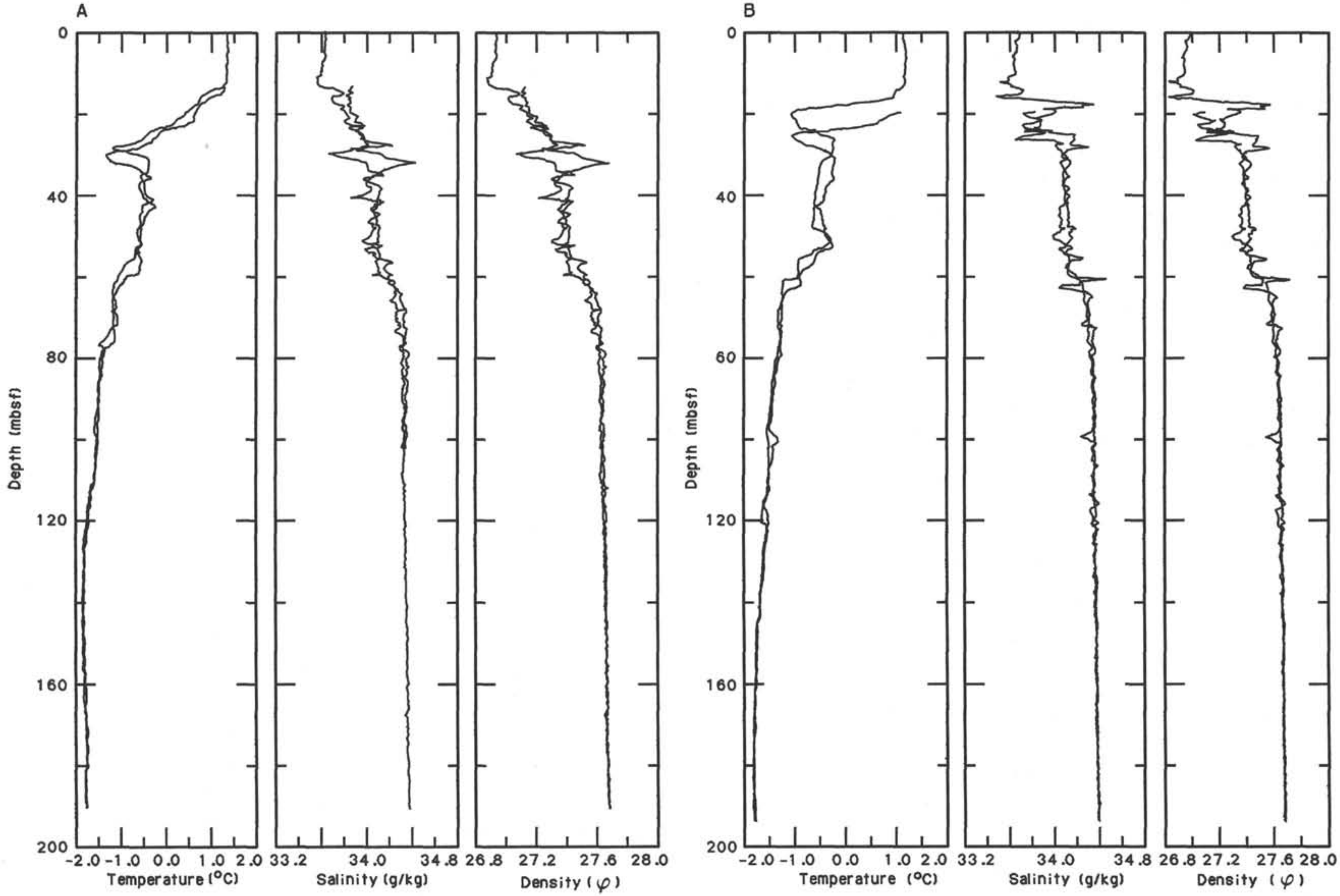

Figure 15. Conductivity, temperature, and depth profiles in the top 200 m of water, 28–29 January 1988. The top 15–20 m of the downtraces were removed because of signal noise as the instrument came to equilibrium in the water. **A.** CTD-12: operation 316, 0852–0906 hr (local time); 68°24.50′S, 76°21.00′E. **B.** CTD-13: operation 325, 0836–0847 hr (local time); 68°24.00′S, 76°20.00′E.

Table 8. Life stage and condition of *Corethron*, *Maersk Master* operation 326, 29 January 1988.

Condition	Depth below sea level		
	0–50 m	50–100 m	100–200 m
Vegetative cells (%)			
Empty	29	20	56.6
Autofluorescing	67	64.5	32.7
Auxospores (%)			
Empty	4	13.7	8.9
Autofluorescing	0	1.6	1.8

this depth interval. *Stellarima microtrias* was present with both the lightly silicified vegetative theca and the heavier theca, but not in resting spores. *Thalassiosira ritscheri* was common in the deepest sample, both as the lightly silicified vegetative theca (about 20 areolae in 10 μm) with fasciculated areola pattern and the much more coarse (about 20 areolae in 10 μm), heavily silicified theca with nearly linear areolation. A small *Thalassiosira* species was found making heavily silicified resting spores and is under investigation. At this depth a few fecal pellets had pigments, but most of the cells were thoroughly ground up, as seen in krill fecal pellets.

Diatoms in Surface Sediment

The sample from the water/sediment interface (Sample 119-741A-1R-1, 0 cm) contains a mixture of centric and pennate diatoms, although the genus *Nitzschia* dominates. The heavily silicified forms from the plankton were well represented, and the benthic species *Cocconeis imperatrix* was present as it was at Site 740, closer inshore in Prydz Bay. Other species that had not been seen in the mud line at Site 740 include *Navicula directa*, *Nitzschia pseudonana*, *Nitzschia ritscheri*, and *Thalassiosira gravida* (vegetative theca).

PHYSICAL PROPERTIES

The main objective of the physical-properties program at Site 741, as for all the Prydz Bay sites, was to study the variations in geotechnical parameters with different lithologies on a high-latitude, glaciated continental shelf. Of particular interest were the glacial diamictons, which were expected to carry information of various stages of the glacial history of the region and, hence, about eastern Antarctica in general. For further background information, see "Physical Properties" section, "Site 739" chapter.

Parameters measured were (1) index properties, (2) undrained shear strength (only two points measured in the upper 1.10 mbsf, not included in any figure or table), and (3) compressional-wave velocity (Fig. 16 and Table 9). Wet-bulk density was measured both gravimetrically and with the GRAPE. Velocity was measured both by means of the continuous *P*-wave logger (PWL) on whole-round cores and in discrete intervals in the Hamilton Frame Velocimeter in the uppermost, soft sediments. Only the latter method was used in the lithified part of the cored sequence. Techniques and laboratory methods used are further discussed in the "Explanatory Notes" chapter.

Only one hole (741A) was drilled at this site, to a total depth of 128.1 mbsf. Based on the experience with advanced piston coring and extended core barrel coring techniques from Site 739, only rotary coring was performed. Drilling disturbance is noticeable in both the soft top sediments and in the lower, indurated part of the sequence, typically as sheared drilling biscuits in the latter.

Results

The core recovery was poor at Site 741, averaging only 26.3%. Hence, even though relatively densely spaced measurements (at least one per section) were carried out in the recovered intervals, the ability to interpret the data was severely hampered by the large nonrecovery intervals.

The drilled sequence is divided in four lithologic units (see "Lithostratigraphy and Sedimentology" section): Unit I—an olive diatom ooze, Unit II—a clayey silt with up to 20% diatoms, Unit III—a sequence of abundant boulders of metamorphic rocks, and Unit IV—a sequence of fine-grained siliciclastic sedimentary rocks with a varying proportion of coal and plant fragments. The two upper units are of Quaternary age, Unit III has an inferred age between Quaternary and Eocene, while Unit IV most likely is of Early Cretaceous age (see "Biostratigraphy" section).

Anything but a broad division into geotechnical units would be speculative at this site. Because diatom ooze has been shown to have physical properties significantly different from clastic sediments (see "Physical Properties" sections in "Site 736," "Site 737," and "Site 738" chapters, this volume), the upper, thin layer of soft sediments is subdivided into two geotechnical units, corresponding to the two upper lithologic units, while the rest of the drilled sequence is defined as one geotechnical unit. All measured physical properties are presented in Figure 16 and Table 9.

Unit G1

Geotechnically, unit G1 (0–0.66 mbsf) of diatom ooze is recognized by its high water content and porosity, 54% and 74%, respectively, and low bulk density, 1.49 g/cm^3. This is best expressed in the plots of the GRAPE-measured bulk density and the PWL-measured velocities where the steep gradient in the top of the graphs marks the transition into the clastic sediments. Note, however, that the mud-line core usually is quite disturbed in its upper part.

Unit G2

As no physical properties were measured between 3.67 and 24.10 mbsf, the lower boundary of unit G2 (0.66–4.1 mbsf) is only tentatively placed at 4.1 mbsf, which is in accordance with the lithostratigraphy (see "Lithostratigraphy and Sedimentology" section), assuming that the difficulties in obtaining core recovery were caused by a change in the character of the sediments. Based on experience from Site 739, this could be caused by the presence of overconsolidated, boulder-rich diamictites. Unit G2 consists of apparently normally consolidated diamicton, probably of a glaciomarine origin. It has a water content of about 24%, porosity of 45%, and bulk density of approximately 2.0 g/cm^3. The velocity ranges between 1500 and 1600 m/s and the shear strength is below 10 kPa. The only two measured shear strengths at Site 741 are from this unit.

Unit G3

Geotechnical unit G3 (4.1–128.1 mbsf, total depth) corresponds to lithologic Units III and IV. As no measurements are available between 4.1 and 24.1 mbsf, little geotechnical data can be given for this interval. The decrease in core recovery, in addition to recovered boulders, indicates a change in lithology, possibly to a bouldery diamictite. However, with no physical properties measured, we have chosen to include this nonrecovery interval in geotechnical unit G3. In the recovered sediments, no significant trends appear concerning increasing or decreasing physical-properties values with depth. The water content generally varies between 10% and 15%, with a low of approximately

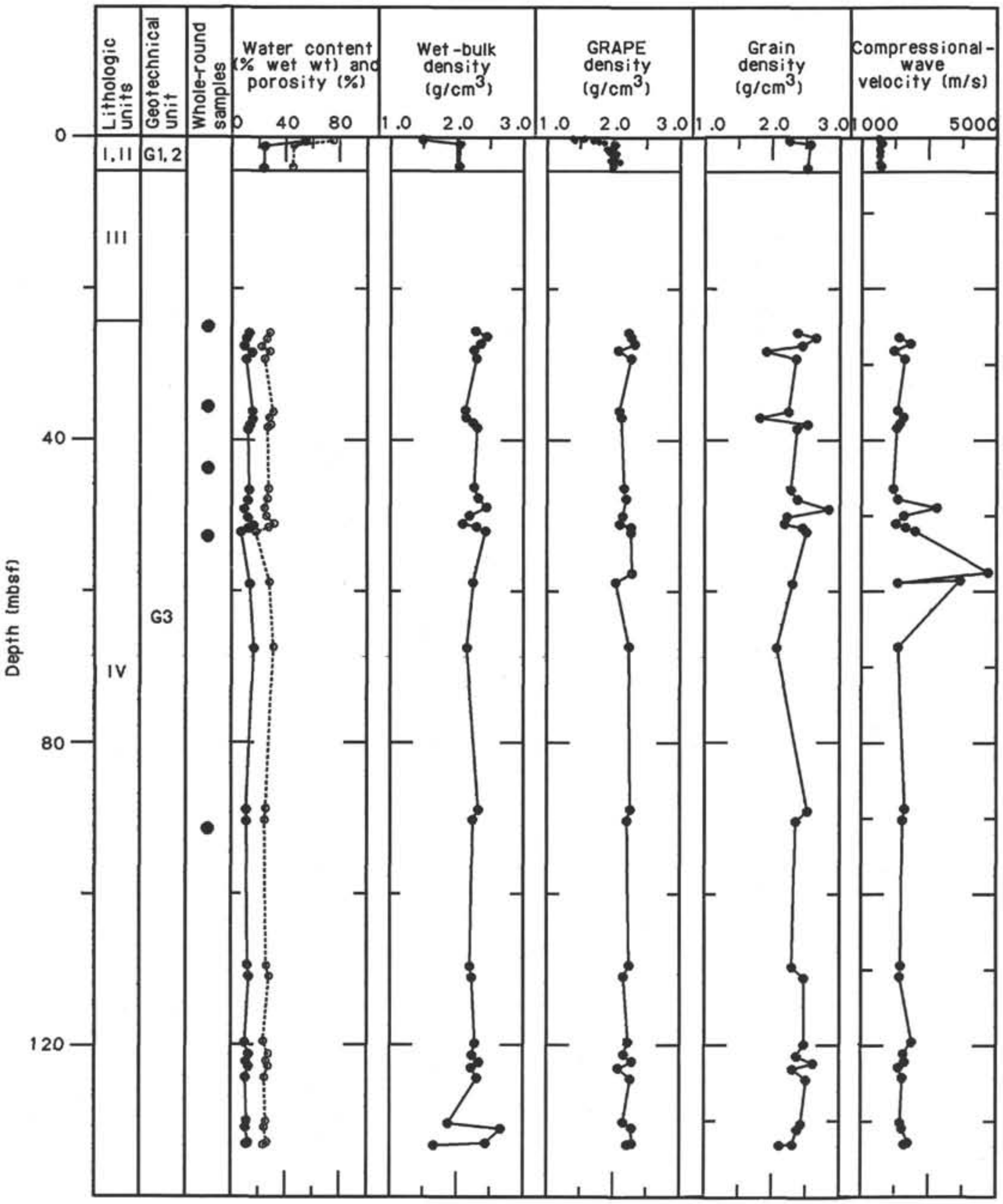

Figure 16. Physical-properties profiles, Site 741. Water content, solid symbols; porosity, open symbols. Small dots in the upper two units of the wet-bulk density measured by the GRAPE mark continuous GRAPE measurements, blocked into 0.1-m averages, whereas the rest of the values represent 2-min counts on discrete samples. Small dots in the upper two units are continuous PWL-measured compressional-wave velocities, blocked into 0.1-m averages.

8% at 48.5 mbsf (Fig. 16), whereas the porosity varies between 24% and 32%. The bulk density and grain density stay relatively constant on an average, but show more short-frequency scatter than the two former parameters. The most significant trend, however, is the generally low values of both the bulk and grain densities, the former between 2.1 and 2.4 g/cm^3 and the latter mostly between 2.4 and 2.6 g/cm^3. The cored, fine-grained silt and sandstones were too indurated for shear-strength measurements. The compressional-wave-velocity measurements generally lie between 2000 and 2500 m/s and show a scatter similar to that of bulk density. The two anomalously high velocities between 50 and 60 mbsf were measured on thin units of carbonate-cemented sandstones.

Summary

The depth profiles of physical properties measured at Site 741 define three geotechnical units, the upper two being diatom ooze and soft, glaciomarine diamicton, with properties typical for these lithologies. The lower 104 m of the third unit (G3), which is the main part of the cored sequence, defines a fine-grained silt and sandstone, relatively rich in carbonized plant fragments. The carbon content of the unit does not have any noticeable effect on the water content and porosity of the unit. Bulk and grain densities, on the other hand, are highly affected by the presence of carbonized plant fragments, causing generally low values. The scatter observed in these curves is most

Table 9. Physical properties measured at Site 741.

Core, section, interval (cm)	Depth (mbsf)	Water content (%)	Porosity (%)	Wet-bulk density (g/cm³)	Dry-bulk density (g/cm³)	Grain density (g/cm³)	GRAPE density[a] (g/cm³)	Compressional-wave velocity[b] A (m/s)	C (m/s)
119-741A-									
1R-1, 54	0.54	54.29	74.21	1.49	0.68	2.44	2.23		
1R-1, 109	1.09	24.67	46.30	2.04	1.54	2.67			1600.0
1R-3, 67	3.67	23.84	44.92	2.04	1.55	2.64			1580.7
4R-1, 20	24.10	13.72	28.33	2.28	1.96	2.53	2.23		
4R-1, 92	24.82	11.67	26.25	2.45	2.17	2.74	2.27	2117.9	
4R-2, 26	25.66	10.09	22.22	2.36	2.12	2.59	2.32	2457.0	
4R-2, 98	26.38	15.69	28.74	2.26	1.90	2.20	2.08	1982.7	
4R-3, 46	27.36	11.68	24.68	2.29	2.02	2.52	2.27	2292.4	
5R-1, 34	33.84	15.71	30.92	2.13	1.80	2.44	2.09	2077.4	
5R-1, 108	34.58	15.81	28.21	2.14	1.80	2.12	2.12	2249.2	2222.2
5R-2, 38	35.38	13.92	29.57	2.25	1.94	2.64		2142.9	
5R-2, 90	35.90	12.74	26.66	2.30	2.00	2.53		2058.8	
6R-1, 8	43.28	13.52	27.47	2.26	1.96	2.46	2.16	1954.5	
6R-1, 130	44.50	12.67	26.53	2.32	2.03	2.53	2.19	2083.9	
6R-2, 88	45.58	10.32	24.61	2.45	2.19	2.88		3239.7	
6R-3, 38	46.58	12.71	25.87	2.19	1.91	2.43	2.14	2268.7	
6R-3, 134	47.54	16.69	32.15	2.10	1.75	2.40	2.10	2038.3	
6R-4, 30	48.00	13.21	27.98	2.30	2.00	2.59	2.27	2319.4	
6R-4, 80	48.50	7.98	18.34	2.43	2.24	2.63	2.27	2603.9	
7R-2, 40	54.80	14.20	28.79	2.25	1.93	2.48		4743.1	
8R-1, 22	62.72	16.92	31.68	2.16	1.79	2.31	2.24	3918.4	
10R-1, 74	82.64	11.73	25.69	2.33	2.06	2.64	2.26	2091.7	
10R-2, 62	84.02	11.74	24.80	2.25	1.99	2.52	2.21	2291.5	
12R-1, 53	101.73	12.76	26.28	2.21	1.92	2.48	2.25	2180.5	
12R-2, 37	103.07	13.40	28.48	2.24	1.94	2.61	2.16	2142.0	
13R-1, 30	111.10	10.83	23.78	2.29	2.04	2.61	2.23	2506.6	2450.5
13R-2, 29	112.59	13.87	28.62	2.25	1.94	2.53	2.17	2267.5	2267.2
13R-2, 117	113.47	11.89	26.48	2.35	2.07	2.71	2.29	2310.1	2357.8
13R-3, 37	114.17	13.59	27.80	2.24	1.93	2.49	2.09	2129.2	2162.4
13R-4, 23	115.53	11.42	25.02	2.32	2.06	2.63	2.27	2238.3	2333.3
14R-1, 34	120.84	12.11	25.89	1.88	1.65	2.57	2.16	2171.3	2200.0
14R-1, 107	121.57	11.57	24.68	2.67	2.36	2.54	2.29	2220.4	2342.9
14R-2, 145	123.45	13.29	27.20	2.44	2.12	2.48	2.29	2397.8	2551.4
14R-3, 12	123.62	11.97	23.90	1.67	1.47	2.34	2.22	2289.2	2405.7

Note: Top of the measured interval (never exceeding 10 cm) is listed.
[a] Wet-bulk density measured by the GRAPE in 2-min counts on discrete samples.
[b] A = V_p measured normal to bedding; C = V_p measured parallel to bedding.

likely caused by local variations in the carbon content. Grain-size variations may, however, also be partly responsible for some of the small-scale variations seen. Where core recovery was good enough to permit dense measurements, as in Core 119-741A-6R, slightly higher water content and porosity tend to appear in the finer sandstones and siltstones than in the coarser sandstones. However, the variations are small and the sedimentological classification is mainly based on visual description and smear slides. Hence, the correspondence with grain size needs more detailed studies.

The scatter in velocity values is ascribed to the similar effects of textural changes and changes in carbon content. The two peak velocities, caused by cemented sandstones, are presented in Figure 16, although they are not representative for the recovered sediments. However, more cemented layers may exist in the low-recovery zones and could be one reason for the apparent stratification seen in the seismic records (see "Site Geophysics" section, this chapter). In the recovered sediment, the carbonate content is generally low, only rarely exceeding 0.5% (see "Inorganic Geochemistry" section, this chapter).

Velocity measurements were done on some samples in two directions—parallel and perpendicular to the bedding. The C direction (parallel to bedding) tends to be slightly higher by 30–150 m/s than the other direction, particulary toward the base of unit G3. The data points are, however, too few to have statistical significance, and the values show the opposite trend.

SEISMIC STRATIGRAPHY

Site 741 is in the southeastern part of Prydz Bay, about 30 km northwest of Site 740. The site lies above a sequence of reflectors that dip gently seaward beneath the continental shelf. The regional setting of these reflectors and other general information regarding the seismic stratigraphy of Prydz Bay are discussed in the "Seismic Stratigraphy" section, "Site 739" chapter.

The dipping reflectors beneath Site 741 are part of Stagg's (1985) unit PS-2, which he believes is the major sedimentary unit visible in seismic-reflection profiles across Prydz Bay. On ODP lines 119-06 and 119-07 (Fig. 17), which cross Site 741, two seismic units were drilled.

The uppermost seismic Unit I is the 70- to 80-ms-wide (75- to 85-m-thick) water gun reverberation caused by the large acoustic-impedance contrasts at and directly below the high-velocity (2.0–2.2 km/s) seafloor. All acoustic (e.g., sedimentary) structures within the upper 70–80 m were masked by this signal. The drill cores indicate that four distinct lithologies and a major unconformity occur within this signal at 0–25 mbsf. These include diatom ooze, clayey silt, and glacial cobbles (Quaternary?) and the top of a sequence of siliciclastic sediments (Lower Cretaceous?).

The second seismic unit, which extends to and below the bottom of Hole 741 at 128.1 mbsf, is characterized by low-amplitude and discontinuous reflections. At first appearance, the

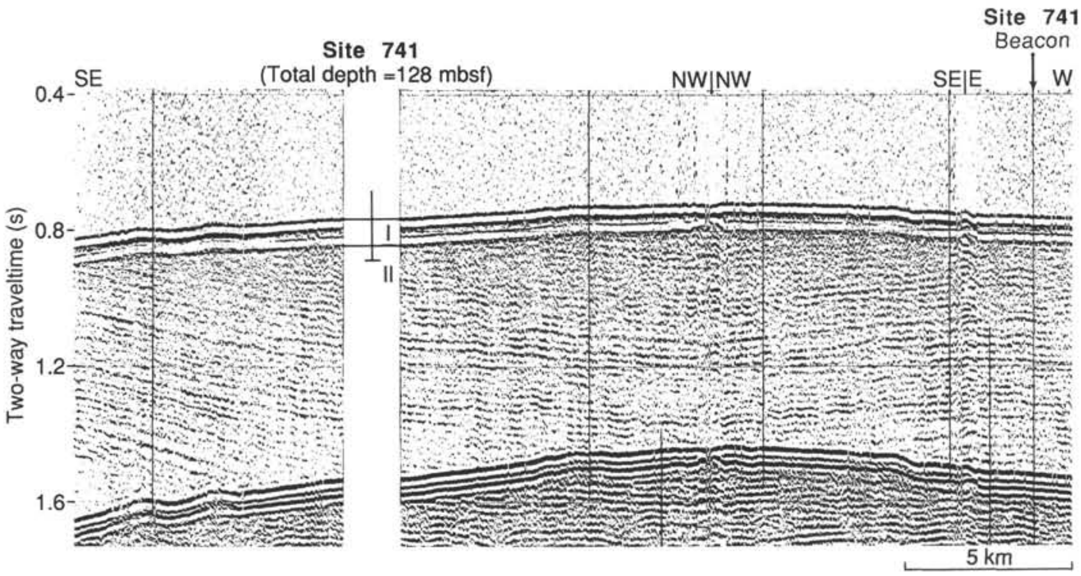

Figure 17. Analog seismic-reflection profile (ODP lines 119-06 and 119-07) across Site 741 with seismic Units I and II.

unit is highly disrupted, with numerous short and disjointed reflector segments. A large part of the disrupted appearance is probably due to many steeply dipping and crisscrossing diffractions, from seafloor irregularities, that are overprinted on a weakly reflective layered sequence (see "Seismic Stratigraphy" section, "Site 739" chapter, for further noise description). These diffractions are more readily observed on high-frequency, band-pass plots that enhance the interfering seismic signals. If the noise was removed, the reflections probably would appear more continuous, albeit still of low amplitude.

Seismic Unit II consists of layers that contain fine-grained, stratified sandstones and siltstones with carbonized plant and wood debris. These nonmarine rocks were probably deposited on a low-lying, low-relief alluvial plain (see "Lithostratigraphy and Sedimentology" section). The acoustic character and gentle dips of the reflectors are consistent with relatively uniform sand/shale compositions and low-relief topography.

The low amplitude of the reflections in seismic Unit II probably results from small velocity variations over large depths and possibly large velocity changes within very thin layers (1–2 m thick). Hamilton Frame velocity measurements are relatively uniform (2.1–2.2 km/s) from 24 to 124 mbsf, with the exception of a few, high-velocity (up to 4.7 km/s) cemented sand layers that are less than 1.5 m thick (see "Physical Properties" section). Sonobuoys indicate that refraction velocities increase uniformly with depth and that wide-angle reflections are also low amplitude.

If the results of synthetic seismic studies at Sites 737–739 and 742 are applied to Site 741 (see "Logging" sections in those chapters), then the small velocity variations, the gradual velocity increases due to burial compaction, and the very thin high-velocity layers near the limit of seismic resolution should not produce large-amplitude reflections at Site 741. Also, the attenuation of the seismic amplitudes may be due, in part, to the relatively rich abundance of carbonized plant material, which reduces the bulk and grain densities at Site 741 (see "Physical Properties" section).

The occurrence of high-velocity (4.7 km/s) calcareous sandstone at 55 mbsf in seismic Unit II indicates that high-amplitude reflectors below Hole 741A could also be thin units of hard sandstone. If present, the layers must be adequately thick to produce a strong reflection, but sufficiently thin so as not to produce a head-wave refraction. Refractions with velocities of 4.7 km/s do not occur in the sonobuoy data (see "Site Geophysics" section). Alternatively, the high-amplitude reflectors may be caused by low-velocity unlithified sands such as those observed at Sites 739 and 742.

The velocities of seismic Unit II are slightly higher than those expected for rocks at 25 m burial depth, indicating that the section has previously been compacted. Prior compaction may have occurred during burial beneath grounded ice or sediment. The distinct unconformity near the seafloor indicates that a thicker sedimentary section once existed and has been eroded.

The total thickness of the sedimentary section underlying Site 741 is unknown. The horizon drilled at 190 mbsf near the bottom of Hole 740B lies about 1.5 km below the bottom of Hole 741 (Fig. 18; see "Seismic Stratigraphy" section, "Site 740" chapter). The uniform acoustic character of seismic Unit II (e.g., weakly layered to discontinuous reflections) and the existence of nonmarine strata at Sites 740 and 741 indicate that the entire sedimentary section below Site 741 may be nonmarine rocks.

Northwest (seaward) of Site 741, reflections are nearly flat lying for about 25–30 km, where they are gently downbowed into a mid-shelf trough. The uniformity in acoustic character, thickness, and lack of faulting within seismic Unit II indicates that nonmarine depositional environments similar to those at Site 741 existed across the inner part of the central Prydz Bay shelf. The absence of major deformation indicates that the area has been relatively stable since seismic Unit II was deposited in Early Cretaceous? time, but general subsidence is not precluded.

Summary

Two seismic units are identified at Site 741. The upper unit (about 70–80 m thick) comprises the high-amplitude reflections due to water gun signal reverberations within the high-velocity rocks directly beneath the seafloor. The reverberations hide three Quaternary lithologic units and the unconformity at the top of the Early Cretaceous? age nonglacial sequence, all of which occur in the upper 25 mbsf. The second seismic unit, which has weak, discontinuous reflections, is composed, in the upper part, of fine-grained, nonmarine, fluvial? sandstones and siltstones of Early Cretaceous? age.

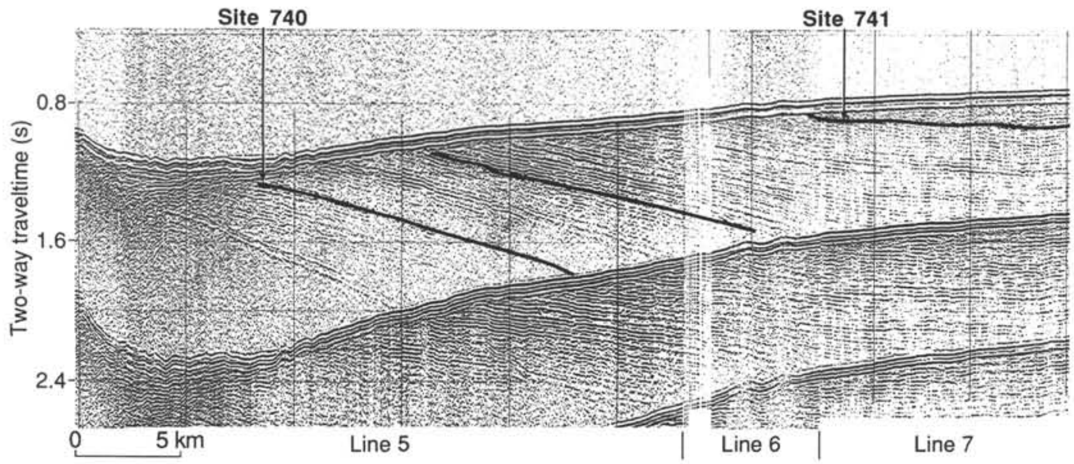

Figure 18. Interpreted analog seismic-reflection profile (ODP lines 119-05, 119-06, and 119-07), showing the relative positions of Sites 740 and 741.

Weak reflections beneath Site 741 indicate that velocities are probably relatively uniform with depth and that fluvial rocks with carbonized debris may exist throughout the sedimentary section (above the seafloor multiple at about 700 mbsf). Scattered strong reflections occur within seismic Unit II, and these may be either highly cemented sandstones (Hole 741A) or low-velocity unlithified sands (Sites 739, 740, and 742).

Seismic Unit II can be traced at least 50–60 km northwest of Site 741 to the edge of a gentle mid-shelf trough. The lateral continuity and absence of major internal deformation of seismic Unit II indicate that, during Early Cretaceous? time, the inner Prydz Bay shelf was a relatively stable, low-lying, alluvial plain with low relief.

SUMMARY AND CONCLUSIONS

Site 741 is situated in the inner part of Prydz Bay on the East Antarctic continental shelf at 68°23.16′S, 76°23.02′E, in 551.4 m of water. Drilling at this site penetrated a 24-m-thick sediment cover of probable glacial origin underlain by about 100 m of older continental clastics. Seismic data indicate that these sediments form part of a 2- to 3-km thick, subhorizontal sedimentary sequence that probably rests on the basement. Stratigraphically, the sampled interval lies about 1500 m above the top of the preglacial sediments found at Site 740, which is some 600 m above basement. The main objectives at Site 741 were to find the nonmarine to marine transition and the preglacial to glacial transition in order to (1) explain the geological evolution of the Lambert Graben, which may shed light on the rifting between the Indian subcontinental block and the Antarctic continent and (2) determine the hitherto unknown preglacial conditions of the area.

Drilling began on 28 January, but the rate of penetration was very slow until we broke through the glacial deposits at about 25 mbsf. However, core recovery remained low throughout the entire sequence drilled. The hole was terminated at a final depth of 128.1 mbsf because no marine sediments were found.

The sediments at Site 741 have been divided into four lithologic units. The three uppermost units form a young (?Pliocene to Quaternary), unlithified sequence of marine sediments, unconformably overlying an older, probably Early Cretaceous sequence of continental clastics of Unit IV.

Lithologic Unit I (0–0.66 mbsf) is a 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.

Lithologic Unit II (0.66–4.1 mbsf) is a 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 non-clay fraction of the sediment is predominantly quartz silt.

Lithologic Unit III (4.1–24.05 mbsf) lies within an interval of poor core recovery and consists of broken fragments of metamorphic rocks, some of which are from hole cave-in contamination. As a result, the thickness, age, and overall composition of this unit are unknown.

Lithologic 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 and 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 some sporadic claystone. The scour surface in some sequences is overlain by a clast-supported conglomerate composed of intraformational and extraformational clasts up to 5 mm long. The sandstones are structureless, vaguely laminated, or less commonly cross bedded on a small to medium scale. Locally the sandstones are cemented by carbonate (Core 119-741A-7R), but the majority are 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 sandstones 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 indicate that Unit IV was deposited by river channels. The precise location in 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. No evidence appeared of any marine influence on sedimentation. The general environmental setting was conducive to the growth of extensive vegetation along the channel banks and low-lying areas of the alluvial plain. As the channels shifted because 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 sandbodies indicates that the channels were probably perennial. This and the abundance of vegetation indicate a wet climatic regime.

Unit III is very 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 Unit I records present-day conditions of sedimentation.

Poor to moderately well-preserved diatoms were recovered from two core-catcher samples (Cores 119-741A-1R and 119-741A-4R). These indicate Quaternary and late Pliocene to Quaternary ages for these samples. Moderately diverse pollen and spore assemblages were recorded from Samples 119-741A-6R-CC, 119-741A-8R-CC, and 119-741A-12R-CC through 119-741A-14R-CC. Comparison with other high-latitude assemblages indicates that these samples are probably Albian in age, although reworking into Tertiary sediments cannot be ruled out at the present time. A diverse benthic-dominated foraminiferal assemblage was recovered from the mud line, but did not persist downcore. Only one specimen was recorded from the first core-catcher sample. Paleontological data indicate the presence of a significant hiatus between 33.5 and 43.2 mbsf, separating the upper Pliocene from the ?Lower Cretaceous.

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 is small and implies (1) that the supply of reactable organic matter to the sediment is low (low surface-water productivity) and/or (2) that sedimentation rates are too low to entrap organic matter and prevent diffusion of sulfate into the sediment column. The carbonate content at this site is generally low (<3%) because of the lack of a marine influence. However, a high terrestrial (type III kerogen) organic content exists 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.

Phytoplankton sampled in the water column at this site showed that, at depths of 0–50 and 50–100 m, vegetative cells were dominant over auxospores, and the majority of the cells autofluoresced. In contrast, at deeper levels (100–200 m), vegetative cells were still dominant but most of them were empty and did not autofluoresce.

Interpretation of the physical-properties tests 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 as one geotechnical unit. Unit G1 is a diatom ooze identified on the basis of its high water content and porosity and low bulk density. Unit G2 is a normally consolidated gravel-bearing diamicton, but, because of poor recovery, few physical properties were measured. Unit G3 is approximately equivalent to lithologic Units III and IV. It shows no significant changes in physical properties with depth. The slight changes that can be detected are largely due to the influence of texture and variations in carbon content.

Two acoustically-defined units were drilled at this site. The drill cores indicate that four lithologic units and a major unconformity occur within the first seismic unit at 0–25 mbsf. The second seismic unit, which extends down to and below the bottom of the hole at 128.1 mbsf, is characterized by low-amplitude, discontinuous reflections. The seismic 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 1.5 km below the bottom of Hole 741A. However, the uniform acoustic character of seismic Unit II and the occurrence of nonmarine sediments at Sites 740 and 741 indicate that the sedimentary section below Site 741 may also be nonmarine and that, acoustically, it can be traced 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 seismic Unit II.

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