5. PRINCIPAL RESULTS AND SUMMARY[1]

Shipboard Scientific Party[2] and Shore-Based Contributors[3]

INTRODUCTION

The 2,300-km-long Kerguelen Plateau in the remote antarctic sector of the Indian Ocean is the largest submerged plateau in the world (Fig. 1). As explained in the "Introduction" chapter (this volume), the origin and subsequent geologic and tectonic history of this imposing feature have long been topics of debate and speculation, problems that the Leg 120 scientists sought to investigate during their 69-day cruise out of Fremantle, Australia, from 21 February to 30 April 1988.

To this end, approximately 1081 m of core were recovered from 12 holes at 5 sites (747–751) occupied on the central part of the plateau during 28 operational days at sea (Fig. 1 and Table 1); 35 days were spent in transit. These holes complement the 11 sites previously drilled on the northern and southern portions of the plateau and on the adjacent Antarctic margin during Leg 119 (Sites 736–746; see Fig. 1).

As stated in the introductory chapter, Ocean Drilling Program (ODP) Leg 120 planned to test conflicting hypotheses about the plateau's origin as (1) a continental fragment, (2) the product of massive on- or off-axis mid-ocean-ridge volcanism (possibly hotspot related), or (3) a thermally or tectonically uplifted (and possibly thickened) block of oceanic crust. Furthermore, we wanted to learn when the plateau formed and how this little-explored portion of the Southern Ocean evolved during its subsequent history.

This chapter provides summaries of the drilling results from each site, followed by a brief synopsis of the history of the plateau based on these results. The drilling data are displayed and compared in various ways in Figures 2–5. Finally, we note special problems encountered while drilling in this sector of the Southern Ocean.

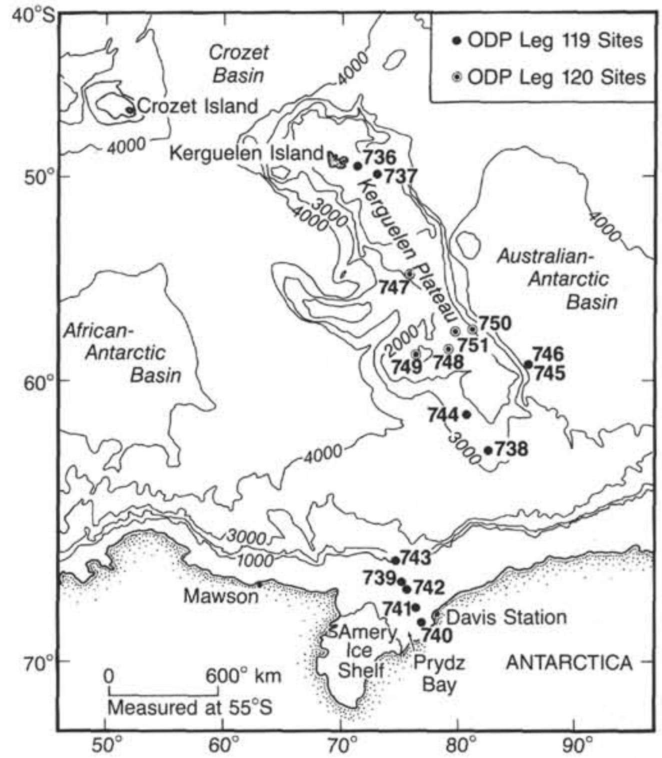

Figure 1. Bathymetric chart of the Kerguelen Plateau showing the location of Leg 120 sites and previously drilled Leg 119 sites.

SITE SUMMARIES

Site 747

Site 747 (54°48.68′S, 76°47.64′E; water depth, 1697.2 m; proposed site SKP-1) lies in the transition zone between the northern and southern parts of the Kerguelen Plateau approximately 500 km south of the Polar Front (Antarctic Convergence). A 296.5-m-thick lower Santonian through Pleistocene pelagic sedimentary section and 53.9 m of underlying basalt were cored in three holes with various combinations of advanced hydraulic piston corer (APC), extended core barrel (XCB), and rotary core barrel (RCB) coring. Although located beneath the present-day Antarctic Water Mass, the sediments contain carbonate throughout except for Maestrichtian–lower Paleocene volcaniclastic sands, breccias, and cobbles, which denote a major episode of uplift and erosion at this location on the plateau.

Lithologic units are recognized at Site 747 as follows:

Unit I (0–32.7 mbsf): Pleistocene to lower Pliocene foraminifer diatom oozes with minor ice-rafted debris and dropstones prevalent only in the upper 20 m, whereas occasional vitric ash layers occur throughout.

Unit II (32.7–181.9 mbsf): upper Miocene to Paleocene nannofossil ooze and chalk divisible into three subunits.

Subunit IIA (32.7–151.5 mbsf): upper Miocene and upper Oligocene nannofossil ooze with occasional vitric ash layers.

Subunit IIB (151.5–170.5 mbsf): upper Oligocene to lower Eocene nannofossil chalk with foraminifers, with hardgrounds near the base (169 mbsf).

Subunit IIC (170.5–181.9 mbsf): highly bioturbated lower Eocene to Paleocene nannofossil chalk, with large (centimeter-scale) burrows and occasional shallow-water fossils (e.g., bivalve fragments and larger benthic foraminifers) and a hardground at 173.1 mbsf.

Unit III (181.9–189.5 mbsf): lower Paleocene–upper Maestrichtian multicolored volcaniclastic, polygenetic sand, breccia, and cobbles with probable intercalated chalk layers.

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[1] Schlich, R., Wise, S. W., Jr., et al., 1989. *Proc. ODP, Init. Repts.*, 120: College Station, TX (Ocean Drilling Program).

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

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Table 1. Summary of Leg 120 sites.

Hole	Latitude (°S)	Longitude (°E)	Water depth (m)[a]	No. of cores	Cored (m)	Recovery (m)	Recovery (%)	Penetration (m)
747A	54°48.68′	76°47.64′	1695.0	27	256.0	227.3	88.7	256.0
747B	54°48.68′	76°47.64′	1697.2	6	50.3	48.9	97.2	50.3
747C	54°48.68′	76°47.64′	1695.2	16	144.5	49.5	34.3	350.5
748A	58°26.45′	78°58.89′	1287.5	2	19.0	19.3	101.3	19.0
748B	58°26.45′	78°58.89′	1290.9	25	225.1	190.2	84.5	225.1
748C	58°26.45′	78°58.89′	1290.5	87	760.0	185.9	24.5	935.0
749A	58°43.03′	76°24.45′	1071.5	1	9.5	10.0	105.7	9.5
749B	58°43.03′	76°24.45′	1069.5	14	123.8	64.7	52.2	123.8
749C	58°43.03′	76°24.45′	1069.5	16	147.5	29.9	20.3	249.5
750A	57°35.54′	81°14.42′	2030.5	[b]21	189.3	68.6	36.3	460.5
750B	57°35.52′	81°14.37′	2030.5	[c]5	57.4	24.6	42.9	709.7
751A	57°43.56′	79°48.89′	1633.8	18	166.2	162.9	98.0	166.2

[a] Water depths are drill-pipe-measurement (DPM) depths corrected for the distance between the rig floor and sea level (10.5 m).
[b] Five "wash" cores were also taken.
[c] Twelve "wash" cores were also taken.

Unit IV (189.5–295.1 mbsf): upper Maestrichtian–lower Santonian nannofossil chalk and thin nodular chert layers.

Unit V (296.6–350.5 mbsf): basalt flows composed of variably brecciated, veined, and altered aphyric to sparsely phyric basalts. Note 1.5-m gap between sediment and basalt.

The sequence documents a succession of tectonic and paleoceanographic events that highlight the geologic evolution of the Kerguelen Plateau. Vesicular basalt flows deposited in a shallow-water to subaerial environment capped the basement structure of the plateau prior to its subsidence and the accumulation of marine sediment, which began at this site by early Santonian times. The oldest sediments recovered are shallow-water glauconitic calcarenites with admixtures of fine volcanic debris eroded from the basement. These are overlain disconformably by deeper-water middle Campanian to Maestrichtian chalks with chert stringers and some *Inoceramus* and pelagic crinoid remains.

The succession is interrupted by a series of Maestrichtian–lower Paleocene debris flows consisting of clay-, sand-, and cobble-size clastics and breccias eroded subaerially from volcanic basement during what appears to have been a major tectonic event that affected much of the plateau. Debris flows include angular clasts of previously lithified Campanian chalk and chert that indicate substantial faulting of the seafloor. Uppermost Maestrichtian to lowermost Danian sediments are missing, but scattered volcanic debris were shed into the overlying heavily bioturbated Danian chalks.

The remaining Paleocene–lower Oligocene section is highly condensed and cut by three disconformities where most or all of the upper Paleocene, middle to lower upper Eocene, and a small portion of the upper lower Oligocene are missing. Hardgrounds are developed on two of these surfaces. Sedimentation rates for the remainder of the Neogene are remarkably constant at about 5 m/m.y., and sedimentation for this interval appears to have been continuous until the late Pleistocene. Although the predominance of biosiliceous ooze throughout the Pliocene-Pleistocene denotes the presence of the Antarctic Water Mass over this site, several species of both planktonic foraminifers and calcareous nannoplankton lived in the surface waters. The top of the section is dated at 0.35 Ma.

The essentially continuous calcareous upper Oligocene to upper Pleistocene record at a site this far south of the present-day Polar Front was unexpected, and this section will serve as an important reference section for an integrated high-latitude calcareous and siliceous microfossil biostratigraphy correlated with magnetostratigraphy and lower-latitude zonations. A good paleomagnetic polarity record was obtained down to the lower/upper Oligocene contact. Virtually all major events (anomaly correlatives) can be recognized, as well as the structure of most of the polarity chrons.

Excellent preservation of planktonic and benthic foraminifers should allow a complementary stable-isotope record to be established. Also noteworthy is the pristine preservation of the Danian calcareous microfossils. The Cretaceous planktonic foraminifers and calcareous nannofossil assemblages belong to the cool-water Austral Faunal Province and Falkland Plateau Floral Provinces, respectively, except for the lowest Campanian core, which shows a more temperate influence. Campanian-Maestrichtian sedimentation rates were a high 20 m/m.y., the result of increased productivity of calcareous and siliceous plankton coupled with a shallow depositional environment.

Based on macroscopic observations, the recovered basement rock consists of approximately 15 separate basalt flows. The separate flows appear compositionally similar and consist of dominantly aphyric, sparsely plagioclase-pyroxene phyric, and olivine-plagioclase phyric basalts. The flows are vesicular, indicating deposition in a shallow-water to subaerial environment. All volcanics exhibit variable degrees of brecciation, veining, and alteration. The alteration minerals consist of zeolites, clays (celadonite and smectites), and calcite filling in veins, vesicles, and amygdules. Fresh material was recovered from three flows. Trace element chemistry is similar to Transitional Mid-Ocean Ridge basalt (T-MORB).

The sequence below 90 mbsf was successfully logged despite gale force winds. The resistivity and natural gamma ray logs clearly delimit the major altered and less altered zones in the basement complex (which had been cored with only 38% recovery owing to high seas). The logs also detected basalt-breccia debris flows in the lower Maestrichtian that were not cored or were only partially cored during drilling.

The site was located close to the intersection of two multichannel seismic lines. A reflector at 0.24 s two-way traveltime (TWT) probably corresponds to Unit III, and basement matches a major reflector at 0.35 TWT.

Site 748

Site 748 (58°26.45′S, 78°58.89′E; water depth, 1290 m; proposed site SKP-3C) is a (minicone) reentry site located on the Southern Kerguelen Plateau in the western part of the Raggatt Basin, east of Banzare Bank. The site was intended to recover

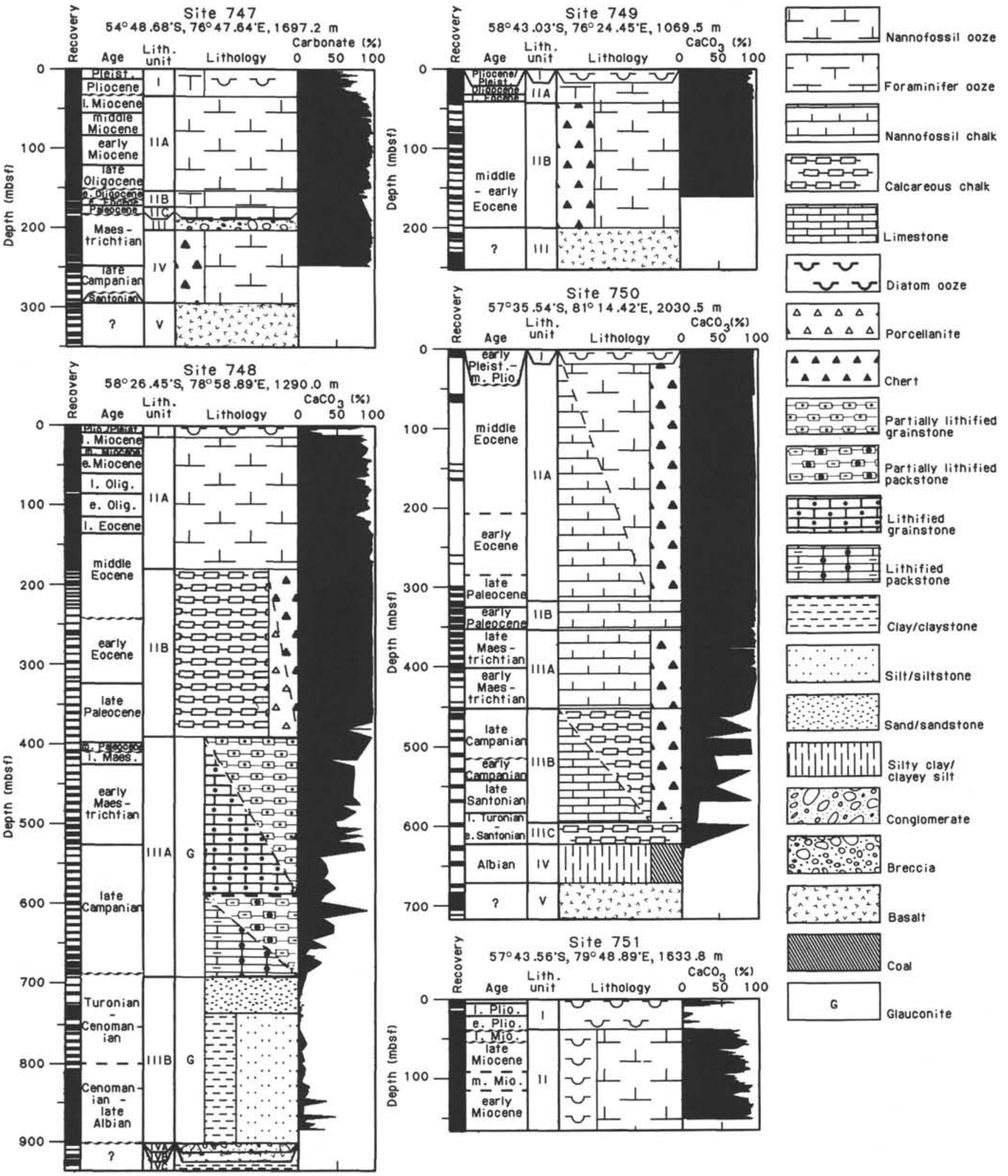

Figure 2. Stratigraphic columns for Leg 120 drill sites showing recovery, ages, lithologic units, lithologies, and percent carbonate.

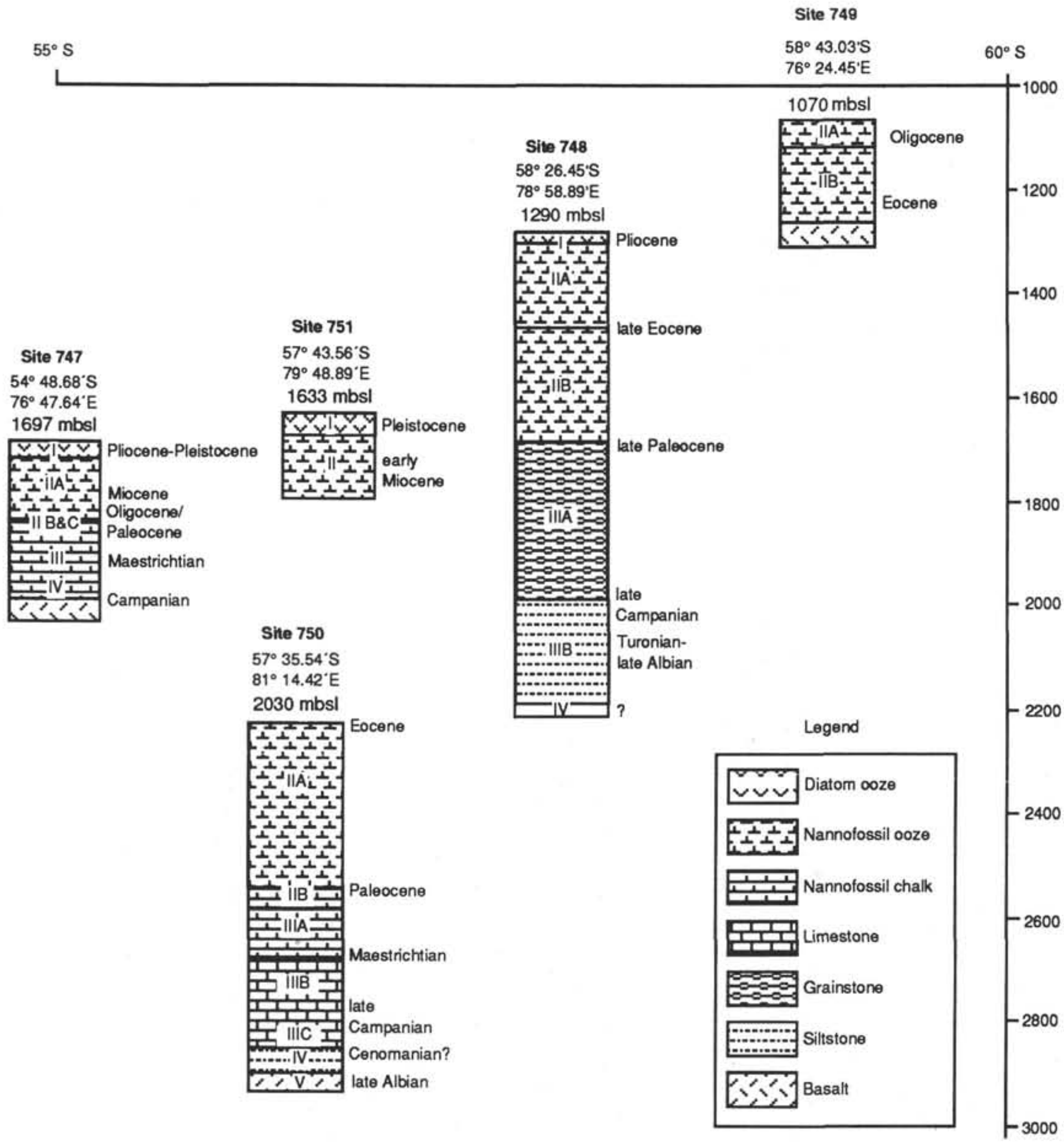

Figure 3. Leg 120 sites arranged according to water depth and latitude.

an expanded section of Paleogene and Cretaceous sediments in order to decipher the tectonic and geologic history of this portion of the plateau.

Two major reflectors lie at 0.83 and 0.41 s TWT below seafloor. Other reflectors deduced from seismic stratigraphic studies lie at 0.92, 0.61, 0.29, 0.16, and 0.09 s TWT below seafloor.

After coring the upper 215 m of the section with the APC and XCB until refusal, the reentry hole was initiated with the RCB and drilled to 550 mbsf; at this point a model Lamar Hayes (LH) reentry minicone was deployed in order to take advantage of a window of relatively calm weather for the operation. The hole was continued to 742 mbsf, whereupon a successful reentry procedure was conducted to change the bit. The hole was then drilled to a total depth of 935 m, where a failed flapper valve allowed massive backflow of sediments into the bottom hole assembly (BHA), thereby preventing further operations at this site, including logging.

Aside from the sediment recovered from the BHA, little material was trapped in cores (i.e., in core-catcher socks) taken over the basal 27 m of the hole, perhaps a result of malfunction of the flapper valve and/or excessive ship heave. Nevertheless, average core recovery over the last 95 m prior to these problems was 70%, and this is the deepest penetration yet achieved via minicone reentry.

We recognized the following lithostratigraphic units:

Unit I (0–13.3 mbsf): Pleistocene to lower Pliocene diatom ooze with radiolarian- and foraminifer-enriched intervals, dropstones, and ice-rafted debris.

Unit II (13.3–389.1 mbsf): upper Miocene to upper Paleocene nannofossil ooze, chalk, porcellanite, and chert divisible into two subunits.

Subunit IIA (13.3–180.6 mbsf): upper Miocene to middle Eocene nannofossil ooze with biosiliceous intervals.

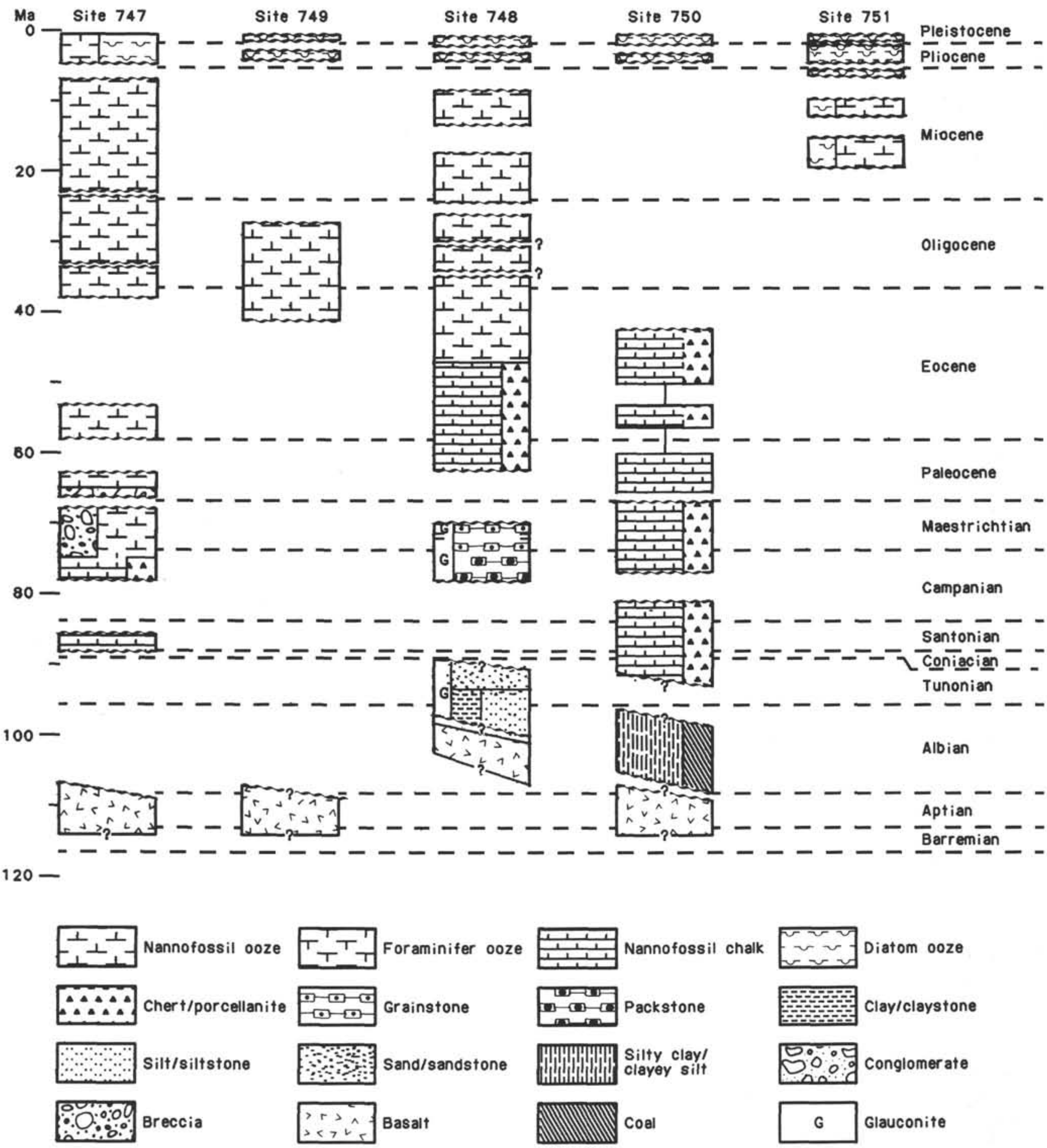

Figure 4. Simplified stratigraphy for Leg 120 sites.

Subunit IIB (180.6–389.1 mbsf): middle Eocene to upper Paleocene nannofossil ooze, chalk, porcellanite, and chert.

Unit III (389.1–898.8 mbsf): upper Paleocene to upper Turonian glauconitic packstones, wackestones, siltstones, and claystones, silicified in part and divided into three subunits.

Subunit IIIA (389.1–692.0 mbsf): upper Paleocene to upper Campanian glauconitic packstones and grainstones, intermittently silicified, with intervals of abundant bryozoans, inoceramid prisms, and crinoid columnals, plus rare red algal debris.

Subunit IIIB (692.0–897.6 mbsf): upper Albian–Turonian sandstones, siltstones, and claystones.

Subunit IIIC (897.6–898.8 mbsf): basalt-cobble conglomerate consisting of rounded, altered basalt cobbles and boulders, broken thick-walled mollusk fragments, and a matrix of glauconitic, calcareous siltstones; no baked contact is evident, but sparry calcite veins are common.

Unit IV (898.8–935.0 mbsf): highly altered basalt flow and underlying lithologies, undated but divided into two subunits.

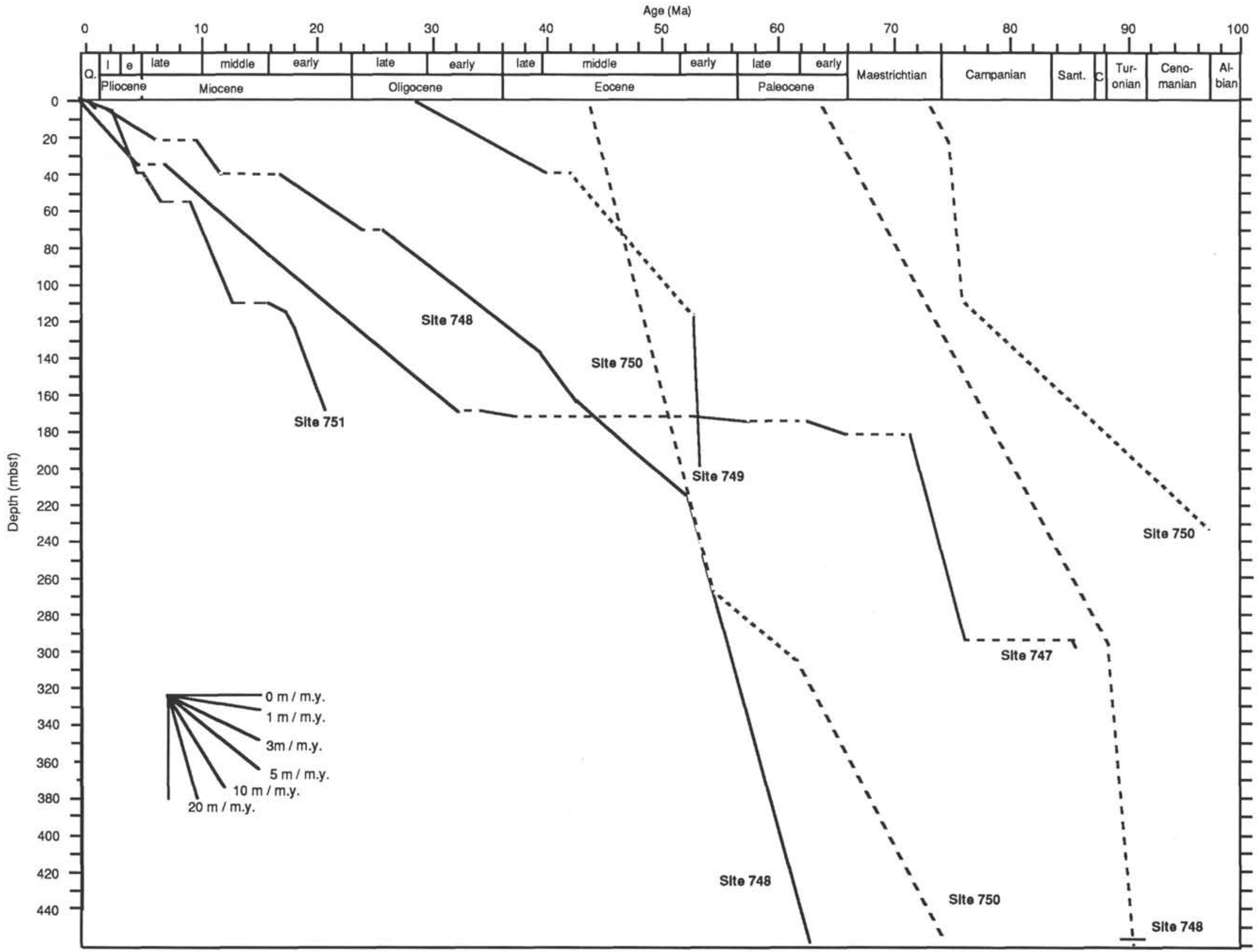

Figure 5. Composite sedimentation rate plot for Leg 120 sites.

Subunit IVA (898.8–902.2 mbsf): sparsely clinopyroxene-plagioclase phyric basalt, strongly weathered and altered.

Subunit IVB (902.2–935.0 mbsf): predominantly downhole cavings from Unit III plus some lithologies not encountered above.

All of this material was recovered only as fragments in core-catcher socks or the BHA; no intact cores were retrieved. Lithologies not observed previously are (1) red and green smectitic clay with goethite and hematite stains; (2) brown smectitic clay with fine calcite and siderite veins; and (3) highly altered pieces of basalt with alteration-mineral-filled vesicles.

The basalt cored at 898.8 mbsf has compositional characteristics similar to intraplate, oceanic-island alkaline basalts and is believed to represent the last of a series of basalt flows that, for lack of core recovery, can only be inferred to lie within Subunit IVB. The Unit IV basalts are necessarily younger than those that form the true basement of the Raggatt Basin. These younger flows are strongly weathered, and some appear to be interlayered with siltstones and claystones derived from that weathering. Wood fragments, if in place, denote the development of soils and vegetation on some flows. According to regional seismic data, true basement (located at 0.92 s TWT) was not penetrated at this site, but lay some 150–200 m below the total depth (TD) of Hole 748C.

Beginning with the basal conglomerate, the first sediments deposited in the basin are glauconitic with up to 0.5% organic matter, denoting a restricted marine environment. No calcareous or siliceous microfossils are preserved, but shore-based palynology studies date them as late Albian–Turonian.

High glauconite contents (up to 20%) characterized the remainder of Unit III as do total organic contents between 0.2 and 0.6% (maximum 1.0%). These are mostly Type III hydrocarbons composed of terrestrial and highly oxidized marine organic matter. Datable calcareous microfossils appear at 711 mbsf, and a variety of fossil invertebrates first occur immediately above this level. Some fossils, such as coralline red algae, serpulid worm tubes, and encrusting bryozoans, indicate periods of quite shallow-water paleodepths (up to inner shelf). The inoceramid remains, which compose up to 80% of some intervals, are exceptionally well preserved and should provide reliable isotopic paleotemperature data. We recovered some vertebrate teeth derived from sharks and possibly from the giant swimming lizard *Mosasaurus*.

Productivity (and consequently sedimentation rates) in this shallow, banklike environment, were quite high—some 60 m/m.y. Siliceous sponges as well as radiolarians, diatoms, and silicoflagellates contributed abundant biogenic silica that was ultimately responsible for the silicified layers in Subunit IIIA. The amount of glauconite produced over the entire 500-m-thick Unit III section is extraordinary, particularly in view of the high sedimentation rate.

Mesozoic calcareous nannofossil and planktonic foraminifer assemblages have a strong austral affinity, as inferred at Site 747 to the north. Sedimentation was apparently continuous from the late Campanian into the early Maestrichtian, but a portion of the middle Maestrichtian is missing. The uppermost Maestrichtian and Danian are also missing (hiatus = ~6–7 m.y.). This latter gap in the record corresponds to a widespread regional disconformity, noted as the prominent reflector at 0.41 s TWT below seafloor on our seismic records, and thought to mark a major tectonic and erosional event that affected much of the plateau (see Site 747 summary above). Subsidence of Site 748 following this erosional event was quite rapid, possibly as a result of extensional tectonics associated with rifting (e.g., 77°E Graben). Alternatively, there may have been strike-slip motion along the 77°E Graben with relatively little extension (Royer and Sandwell, in press).

The upper Paleocene through middle Eocene pelagic carbonate and chert sequence is apparently continuous and was deposited in deeper waters (similar to the present day) since subsidence had far outstripped the relatively high sedimentation rate of 20 m/m.y. Regional seismic analysis shows that the Paleogene depocenter for the basin had shifted considerably toward the east as a consequence of the profound Maestrichtian tectonic event.

Recovery of 100% in the upper 180 m of the section in Hole 748B provides an excellent Neogene calcareous-biosiliceous section with good paleomagnetic control that complements the record from Site 747. The main elements of the magnetic polarity record from Anomaly Correlatives 1 to 18 (Pleistocene to late Eocene) have been recognized. Both the upper and lower epoch boundaries of the thick (65–70 m) Oligocene section are clearly defined by bio- and magnetostratigraphy (Anomaly Correlatives 6C and 13). A striking occurrence of angular quartz sand and micas in the lower Oligocene represents ice-rafted debris, the presence of which is particularly strong evidence for the existence of a substantial ice sheet on the Antarctic continent at this time. Two minor hiatuses are present in the Oligocene, and parts of the lower and middle Miocene are missing (hiatus = 5–6 m.y.). A minor late Pliocene hiatus was detected (2.2–3.1 Ma), and the Pleistocene is condensed and discontinuous.

Site 749

Site 749 (58°43.03′S, 76°24.45′E; water depth, 1069.5 m; proposed site SKP-4A) is a reentry site located on the western flank of the Banzare Bank, on the Southern Kerguelen Plateau. The Banzare Bank corresponds to a smooth basement rise that crests east of the site at a water depth of about 700 m. The sediments gradually thin toward the top of the bank where several faults cut the basement structure. The site was intended to recover extensive basement rocks from the Southern Kerguelen Plateau with penetration of at least 200 m.

A very strong basement reflector is observed at about 0.24 s TWT below seafloor. Downslope the sediments thicken in all directions, especially by toplap. Thus, the oldest sediment cored at this site does not correspond to the age of basement.

The upper 43.8 m of section was cored with 100% recovery using the APC, until middle Eocene cherts were encountered that reduced APC and XCB recovery to only 26% for the subsequent 80 m. A change to the RCB yielded only 7% recovery through cherts, chalks, and oozes to the basement contact at 202 m. After obtaining 5 m of basalt, the succeeding two cores were essentially empty, and a model LH minicone was deployed that allowed us to reenter the hole after a bit change. This was the first use of a free-fall minicone for a dedicated basement site.

Inspection of the BHA on deck showed that severe pounding of the bit against the hard bottom had occurred in high seas at this shallow site, resulting in a badly worn bit and a broken flapper valve. The latter had precluded any recovery in the last two cores. A novel decision was made by the ODP Cruise Operations Superintendent, Mr. Lamar Hayes, to core without a flapper valve and to institute instead a weighted mud program to prevent backflow of cuttings into the BHA. After a successful (16-min) reentry, this procedure worked beyond expectations since the next two cores produced 17.83 m of basalt at a recovery rate of 94%. As the last core was being cut, a medical emergency involving Mr. Hayes ended operations at this site, and the *JOIDES Resolution* was put on course for Fremantle, Australia. Mr. Hayes died on 28 March 1988, and the ship arrived at Fremantle on 5 April 1988.

The following lithologic units were recognized at this site:

Unit I (0–0.24 mbsf): Pleistocene to mid-Pliocene diatom ooze with foraminifers and ice-rafted debris. A disconformity occurs at the base of the unit.

Unit II (0.24–202.0 mbsf): upper Oligocene to lower Eocene nannofossil ooze with chert, chalk, and porcellanite, divisible into two subunits.

Subunit IIA (0.24–43.6 mbsf): upper Oligocene to middle Eocene nannofossil ooze with foraminifers, plus some siliceous microfossils and minor volcanic ash in the upper 25 m.

Subunit IIB (43.6–202 mbsf): middle Eocene to lower Eocene nannofossil ooze, with chalk, chert, and porcellanite; 3% sponge spicules and radiolarians occur only between 53 and 82 mbsf.

Unit III (202–249.5 mbsf): clinopyroxene-plagioclase phyric basalts.

The 23.1 m of recovered basalt consists of five flows and one dike. Most flows have altered and vesicular tops but grade to fresh and more massive basalt toward the interior of the flow. The basalts are either quartz or olivine-normative tholeiite and range in magnesium content from 46.5 to 57.5. The high-magnesium basalt contains olivine and plagioclase (An_{60-80}) phenocrysts. All other basalts have plagioclase (An_{50-60}) as the main phenocryst phase, together with occasional clinopyroxene. The groundmass phases consist of plagioclase (An_{40-50}), clinopyroxene, and Fe-Ti oxides.

These basalts are more depleted in incompatible trace elements than those from the previous Leg 120 sites, although basalts from Holes 747C and 749C have similar Zr/Nb and P/Y ratios. Both Site 747 and 749 basalts are slightly more enriched in incompatible elements than normal Mid-Ocean Ridge basalt (MORB) and are compositionally similar to transitional basalt (T-MORB). On the basis of major and trace element chemistry, Site 749 basalts are similar to the Nauru Basin plateau basalts (Deep Sea Drilling Project [DSDP] Leg 89). In contrast to basalts from Site 747, the basalts from Site 749 do not form a coherent group or trend on key variation diagrams. This indicates that the basalts from Site 749 cannot be related to each other by simple fractional crystallization or partial melting alone.

Basalt alteration occurs in the groundmass, amygdules, and veins, and as a replacement for plagioclase phenocrysts. The alteration assemblage consists of laumontite (and stilbite), interlayered smectite, calcite, and occasionally quartz, which is diagnostic of the high-temperature zeolite facies (100°C–200°C). This alteration assemblage at Site 749 is not observed at normal mid-ocean ridge segments but does occur in places associated with a high heat flow, such as Iceland. The shallow depth of this alteration zone combined with its relative high temperature indicates a high paleoheat flow.

The oldest sediments above basement are dated as 54–55 Ma. Benthic foraminifers indicate that the water depth at this site has been virtually constant (between 1000 and 1500 m) since the early Eocene. Sedimentation rates, however, vary considerably; we infer rates to be as high as 70 m/m.y. for the lower and lower middle Eocene, to drop to 7 m/m.y. for the middle to upper middle Eocene, and to be 3.6 m/m.y. for the upper Eocene and Oligocene. The abnormally high sedimentation rate during the early and early middle Eocene may be attributed to constant synsedimentary scouring and redeposition of pelagic oozes, particularly from exposed basement surfaces, thereby contributing to a type of sediment "drift" deposit at this site.

Site 750

Site 750 (57°35.54′S, 81°14.42′E; water depth, 2030.5 m; proposed site SKP-3D) is located on the Southern Kerguelen Plateau in the eastern part of the Raggatt Basin, west of the deep Labuan Basin, approximately 900 km south of the present-day Polar Front. The primary objective was to recover an expanded Cretaceous section reflecting the early tectonic and depositional history of the Southern Kerguelen Plateau. A second objective was to obtain, if feasible, basement samples from a zone of dipping reflectors in the Raggatt Basin.

Beginning with this site on 14 April 1988, *JOIDES Resolution* resumed operations on the Southern Kerguelen Plateau following an unscheduled port call to Fremantle, Australia, requiring a transit of 17 days and 4400 nmi. The site approved during the transit as a substitute for Site SKP-3B is on the same seismic line, located 18 km to the east of SKP-3B. The basement reflector at Site 750 lies at about 0.69 s TWT below the seafloor, and three major seismic reflectors can be traced at 0.59, 0.46, and 0.31 s TWT.

Hole 750A was wash and interval cored with a rotary bit through middle and lower Eocene oozes, chalks, and cherts to 297.5 mbsf; below 143 mbsf the combination of cherts and heavy seas had their usual deleterious effect on core recovery, which was only 3% for the three rotary cores taken. After a 24-hr weather delay, continuous coring through Paleocene-Maestrichtian chalks to 423.3 mbsf yielded a nearly complete but drilling-disturbed Cretaceous/Tertiary boundary sequence at 348 mbsf; recovery was 47%.

The hole was ended at 460.5 mbsf by total bit failure (disintegration) after only 5½ hr of rotation, whereupon a successful logging run was made with a combination of seismic stratigraphy tools; a second run in rough seas with lithodensity tools was foiled by damage to the cable head. Operations were suspended on 18 April 1988 with hopes of reoccupying the site after drilling at Site 751 (prospective site SKP-2C), located 46 nmi to the west.

As it developed, the site was reoccupied on 20 April 1988, and Hole 750B was washed to 450 m with the RCB, taking only one wash core on the way. After pulling a second wash barrel, the hole was continued with rotary or wash cores taken every 10 to 30 m through a section of cherty Cretaceous chalks and limestones. Our intention to maintain a rate of progress of at least 10 m/hr was deemed necessary to reach basement before drilling time for the leg expired if the single bit were to survive to the projected total depth. Drilling with a hard-formation bit slowed considerably when the formation changed from marine limestone to terrestrial clay below 624 mbsf; however, a velocity inversion at that point considerably decreased the predicted depth to basement, which was encountered at 675.5 mbsf. Thereafter, a series of thick basalt flows were drilled with 67% recovery to a TD of 709.7 mbsf.

The following lithologic units were recognized:

Unit I (0–0.37 mbsf): lower Pleistocene to mid-Pliocene diatom ooze and lag deposit. Repeated within the first core by a double punch of the drillstring, this unit contains diatoms and foraminifers of early Pleistocene and mid-Pliocene age with a disconformity in between. The lag contains sand and ice-rafted pebbles with heavy manganese coatings, and a disconformity occurs at the base.

Unit II (0.37–357.0 mbsf): middle Eocene to lower Paleocene nannofossil ooze, chalk, and chert, divisible into two subunits.

Subunit IIA (0.37–317.2 mbsf): middle Eocene to upper Paleocene white nannofossil ooze, chalk, and chert.

Subunit IIB (317.2–357.0 mbsf): lower Paleocene white nannofossil chalk.

Crosscutting gray dissolution seams are evident below 317 mbsf. Just above the Cretaceous/Tertiary contact, the white chalk darkens downward to an olive gray color; dark specks are present and there is a concomitant increase in magnetic susceptibility. The lowermost Danian nannofossil Zone NP1 is present, but it contains reworked Cretaceous material. The Cretaceous/Tertiary contact, which was disturbed by drilling, marks an abrupt change in lithology from well-consolidated Danian chalk to soft Maestrichtian ooze of the nannofossil *Nephrolithus frequens* Zone. The more clay-rich lower Danian section appears to show up as a positive excursion on the resistivity logs, which may allow a more precise placement of the base of this subunit.

Unit III (357.0–623.5 mbsf): upper Maestrichtian to upper Turonian nannofossil chalk, chert, and intermittently silicified limestone, divided into three subunits.

Subunit IIIA (357.0–450.0 mbsf): upper Maestrichtian to lower Maestrichtian nannofossil chalk and minor chert. Dissolution seams characterize this subunit along with burrows, laminae, and rare stylolites. Some pale purple laminae may represent redox changes; three gray laminae contain 50% zeolite. Microfossils are exceptionally well preserved in the upper Maestrichtian; echinoid spines are a persistent component, and a brachiopod shell was found at 385 mbsf.

Subunit IIIB (450.0–594.6 mbsf): lower Maestrichtian to lower Santonian silicified limestone and calcareous chalk, poorly recovered. Bioclast fragments include small mollusks, crinoid columnals, and inoceramids.

Subunit IIIC (594.6–623.5 mbsf): lower Santonian to upper Turonian chalk with dark clayey interlayers. Cenomanian microfossils may be reworked; the darker clays may be redeposited. Pyritized wood fragments, a bivalve, and traces of glauconite are also present.

Unit IV (623.5–675.5 mbsf): Albian dark gray-brown silty claystone with charcoal and minor conglomerate.

This unit consists of a broad range of water-laid terrigenous claystones and siltstones, with some sandy or conglomeratic intervals. Carbonized wood fragments from land plants are abundant as are coarse, authigenic siderite and pyrite grains and concretions. Material in the first core recovered from this unit includes massive, plastic reddish brown, silty claystone composed primarily of kaolinite, but with up to 25% siderite (as coarse authigenic grains), 20% opaques, 6% pyrite, and 20% altered grains that may be derived from basalt. The next core yielded a much darker, grayish brown clayey siltstone that is more fissile and richer in organic matter (up to 7%).

A highly colorful, 25-cm-thick interval of soft-pebble conglomerate and sand displays grading, cross-stratification, and small-scale current bedding. Incorporated among the rounded to subrounded, 0.5–3-mm-diameter siltstone and claystone ferruginous grains are numerous large (centimeter-scale) pieces of carbonized wood. Wood fragments are also enclosed within siderite-cemented claystones, and a siderite concretion occurs at the base of the unit. Shore-based palynology studies (D. Hos, pers. comm., 1987, 1988; B. Mohr, pers. comm., 1988) date these terrestrial sediments as Albian (probably middle to late Albian) in age.

Unit V (675.5–709.7 mbsf): Basalt flows composed of moderately to highly altered plagioclase-clinopyroxene phyric basalt.

At least four flows were recovered; the third flow is an 11.5-m-thick massive basalt flow that represents the majority of the recovery. The lower two flows are separated by a chilled margin and are overlain by highly altered volcanics. The flows are restricted in composition to olivine-hypersthene normative tholeiite. The secondary mineral assemblage consists of interlayered smectite, heulandite-clinoptilolite, calcite, and minor quartz veining.

The three major seismic reflectors observed at Site 750 above basement at 0.31, 0.46, and 0.59 s TWT are related to major changes in the lithology, physical properties, and logging data. The reflector at 0.31 s can be correlated with the boundary between Subunits IIA and IIB (317.2 mbsf). The seismic reflectors at 0.46 and 0.59 s TWT must be correlated with the top of Subunit IIIB (450 mbsf) and the top of Subunit IIIC (594.6 mbsf), respectively. On the basis of these correlations, the calculated mean velocities for each lithologic unit or subunit are in good agreement with the measured compressional wave velocities. A clear but unusual velocity inversion is observed between 600 mbsf and the top of the basalt unit (675.5 mbsf). A similar inversion was already recorded at Site 748 in the western Raggatt Basin.

The basement and the sedimentary rocks drilled at this site provide interesting contrasts with those sampled elsewhere on the Kerguelen Plateau during this leg. In terms of incompatible trace-element abundances, basalts from Site 750 are the most depleted, thereby extending the array defined by samples from Sites 747 and 749. They also show slight differences in incompatible element ratios, possibly indicating differences in source characteristics. Nevertheless, Site 750 basement is transitional in composition between normal Indian Ocean MORB and Kerguelen Island and Heard Island OIB lavas. The secondary mineral assemblage at this site indicates intermediate- to high-temperature alteration comparable to the temperature regimes defined at Sites 747 and 749. The alteration occurred under oxidizing conditions, and the basalts were erupted in a subaerial or shallow subaqueous environment.

Site 751

Site 751 (57°43.56′S, 79°48.89′E; water depth, 1633.8 m; proposed site SKP-2C) is located in the central part of the Raggatt Basin on the Southern Kerguelen Plateau. It was intended to recover a high-resolution Neogene and Paleogene stratigraphic section deposited above the calcium carbonate compensation depth and well south of the present-day Polar Front, which lies 900 km to the north. This site is a key component of a latitudinal paleoceanography transect across the plateau. The *Marion Dufresne* MCS line MD47-05 shows a thick sedimentary cover of at least 2500 m at this locality. Owing to time constraints imposed by an unexpected mid-cruise round-trip between the Kerguelen Plateau and Fremantle, Australia, drilling at Site 751 was limited to the Neogene objective, which comprises a seismic sequence of 0.24 s TWT.

A 166.2-m-thick section of upper Pleistocene through middle lower Miocene mixed biosiliceous and calcareous ooze was cored by the APC, with 98% recovery. An unusual finding was an exceptionally young (early Pliocene age) porcellanite bed encountered in Core 120-751A-2H. Operations in high seas were ended when the APC piston rod failed during pullout, leaving the core barrel and the last core stuck in the hole.

The following lithologic units were recognized at Site 751:

Unit I (0–40.1 mbsf): upper Pleistocene (>0.2 Ma) to lower Pliocene diatom ooze with minor ice-rafted debris, foraminifers, volcanic ash, and porcellanite.

The carbonate content ranges from 0% to 70% whereas foraminifers range from ~3%–25% near the top to rare near the bottom of the unit. Ice-rafted debris is scattered in minor abundance throughout the unit, mostly as sand-size specks. The predominantly milky-white porcellanite, disturbed by drilling, fills the top 44 cm of Core 120-751-3H and contains some burrow-like casts. Two vitric ash layers are present in the lower Pliocene sediments.

Unit II (40.1–166.2 mbsf): upper Miocene to lower Miocene diatom nannofossil ooze.

Although nannofossils predominate, diatoms occur in equal or greater abundance in many intervals; foraminifers, radiolarians, and silicoflagellates are rare or occur in trace amounts. Faint green centimeter-scale laminae enriched in diatoms occur between 88 and 104 mbsf.

The lower Pliocene through lower Miocene represents an expanded section with sedimentation rates of 15–20 m/m.y., whereas much lower rates of about 3 m/m.y. characterize the abbreviated upper Pliocene–Pleistocene section. As many as four hiatuses have been detected. The most extensive of these can be correlated across the Raggatt Basin and spans an interval from about 12.5 to 16 Ma in the middle Miocene. A second represents about 3.5 m.y. between 9.5 and 6 Ma in the late Miocene. A third short hiatus represents about 0.4 m.y. between 4.8 and 5.2 Ma, whereas a fourth spans an interval of some 0.3 m.y. between 1.9 and 2.2 Ma in the late Pliocene. Magnetostratigraphic data are of mixed quality, but key polarity reversals are identified in the early Pliocene to late Miocene (Anomaly Correlatives 3, 3A, 4, and 5) and early Miocene (Anomaly Correlatives 5C through 6).

High biogenic silica contents in Unit I yielded low bulk densities and high porosity values relative to Unit II. Compressional wave velocity measurements indicate that the first reflector at 0.24 s TWT lies just below the bottom of the hole at about 185 m and may correspond to the Oligocene/Miocene contact. If so, sedimentation rates would suggest that a disconformity could be expected at this point.

The high carbonate contents and high sedimentation rates for the Miocene at this site, plus the co-occurrence of siliceous and calcareous microfossil groups, is unique for the high southern latitudes and will make this and other Leg 120 sites on the Kerguelen Plateau important reference sections for stable isotope and biomagnetostratigraphic studies. The most striking feature of this record is the rapid meter-scale alternations in microfossil assemblage characteristics and physical and sedimentologic properties, indicating that this site may have captured some of the high-frequency paleoclimatic variability observed in other parts of the world ocean.

DEVELOPMENTAL HISTORY

We briefly summarize the evolution of the Southern Kerguelen Plateau as follows. The basement of the plateau is composed of basalts erupted before the middle Albian, as early as 114 ± 1 Ma according to a K-Ar date obtained on dredged material by Leclaire et al. (1987a, 1987b). This basement age has been confirmed by a K-Ar date of 111.5 ± 3.2 Ma obtained on whole rock (Sample 120-749C-15R-3); it should be noted that the ^{40}Ar–^{39}Ar stepwise heating technique applied to this sample yields a well-defined plateau age of 109.6 ± 0.7 Ma (R. Montigny, pers. comm). At that time (Norman and Sclater, 1979), India had recently separated from East Antarctica and would have been moving northward, with the plateau forming in the intervening gap. The Kerguelen basement basalts were extruded at about the same time as the Rajmahal flood basalts of eastern India (Rampino and Stothers, 1988) and may have been contiguous with them.

Where sampled, the basement basalts appear to have been erupted close to or above sea level in a series of flows. They are thick and massive in the eastern part of the Raggatt Basin (Site 750) and fresh to altered on the Banzare Bank (Site 749); their secondary mineralogy is similar to rocks from regions of high heat flow, such as Iceland. The Leg 120 basalts show some intersite variation in incompatible element ratios, possibly indicating source heterogeneities. Basalts from Sites 747, 748, and 750 are transitional in composition between normal Indian Ocean MORB (Price et al., 1986) and Kerguelen and Heard island OIB lavas (Storey et al., 1988). Compositionally, they show affinities with Nauru Basin basalts (Saunders, 1985), transitional basalts from the Southwest Indian Ridge (le Roex et al., 1983), and the oldest basalts from Kerguelen Island (Storey et al., 1988).

Since no continental basement was drilled, our drilling results do not support a continental origin for the plateau. Seismic reflectors that dip in various directions have been noted within the basement at Site 750 and in the vicinity of Site 747 (Schaming and Rotstein, in press). These evidently do not represent continental strata or basement but, rather, result from basaltic lavas that flowed out in various directions from volcanic centers (Hinz, 1981; Rotstein et al., in press).

Following the emplacement of the uppermost plateau basalts, a considerable portion of the Southern Kerguelen volcanic edifice was clearly emergent and subject to intense weathering in a warm temperate or subtropical climate (in marked contrast to the one that exists in this region today). Rainfall was probably seasonal and sufficient enough to weather volcanics into the Albian kaolinitic clays recovered at Site 750. The actual source rock may not have been entirely the tholeiitic basalts drilled at that site but, rather, alkaline basalts located elsewhere in the watershed.

The watershed must have been quite extensive in this area to allow the derivation of strongly weathered kaolinite from these types of source rocks. The kaolinites accumulated in well-vegetated or forested subaqueous or subaerial environments, perhaps on marshy flood plains. The soft-pebble conglomerates at Site 750 probably denote fluvial conditions, and the authigenic siderite crystals are characteristic of coal swamps. The numerous large pieces of charcoal (up to 5 cm in diameter) and high organic carbon contents of up to 7% are compatible with such a terrestrial setting.

The nonmarine sediments cored at Site 750 are visually quite similar to those penetrated, but poorly sampled, in Unit IV at Site 748. A minimum Albian-Cenomanian age can be inferred for these units at Site 748 on the basis of the age of the overlying marine sediments, and it appears that nonmarine sediments were penetrated at both sites. Kaolinite-rich (up to 57%), dusky brown ferruginous marine clays have been reported beneath a middle Albian sequence drilled at DSDP Site 258 on the Naturaliste Plateau to the east (Davies, Luyendyk, et al., 1974), which at that time would have been positioned much closer to the Central Kerguelen Plateau and perhaps lay within the same basinal complex. Possible Albian sediments of fluviatile origin, described as "containing carbonaceous fragments and thin coals," have also been cored to the south in Prydz Bay at ODP Site 741 (see fig. 1 in Hambry et al., 1989, p. 105).

By late Albian or Cenomanian times, true ocean-island alkaline basalts were being erupted at Site 748 in the western Raggatt Basin; these denote the existence of an uncontaminated hotspot source beneath the plateau by this time. Petrographic evidence suggests that the basalts at Site 748, and those poorly recovered in Unit IV at that site, were extruded in a subaerial environment. They are seismically distinct from those that form the true basement of the Raggatt Basin and thus are younger. We did not encounter any younger basalts during this leg, but participants on Broken Ridge Leg 121 recovered large amounts of volcanic ash in pre-breakup strata, which suggested to them continued activity of the Kerguelen-Ninetyeast hotspot from early Turonian to middle Eocene times (Leg 121 Shipboard Scientific Party, 1988). Upon reconstruction, the hotspot would have likely been located somewhere between the Broken Ridge sites and the Leg 120 sites.

The oldest marine sediments recovered in the western Raggatt Basin are the basal basalt conglomerates of Subunit IIIC at

Site 748, which are late Albian or Cenomanian in age, according to shore-based palynomorph data. The glauconitic matrix within this unit contains up to 0.5% organic matter and virtually no pelagic carbonate, indicating a restricted marine environment. This matrix also contains fragments of thick-walled mollusk shells. The high-energy conditions that produced the conglomerate suggest that along the western portion of the plateau a volcanic coastline of some relief was being destroyed under strong wave action. With subsidence, however, the site of deposition remained shallow (shelf depths) and quite restricted, with Cenomanian to Turonian glauconitic silts, muds, and biosiliceous components accumulating along with weathering products of basalt; however, virtually no pelagic carbonate or other indications of an open-marine environment are present.

Because of the need to core at 30-m intervals, we recovered no cores that show the transition from nonmarine to marine conditions at Site 750 in the eastern Raggatt Basin. By late Turonian times, however, restricted (redeposited black shale?) conditions were changing to an open-marine environment characterized by pelagic carbonates and cherts. Sedimentation rates there increased markedly during the Santonian–lower Campanian, a function of high pelagic productivity coupled with open-marine conditions over shallow (i.e., slope depth)—but steadily deepening—environments of deposition. Glauconitic chalks overlying basaltic basement at Site 747 indicate subsidence of this portion of the plateau (north of the Raggatt Basin) by at least Santonian times. The onset of open-marine conditions there developed in concert with the further opening of the Indian Ocean through the dispersal of the Gondwana continents in this region.

Middle Campanian sediments are missing at all sites (Fig. 4), although the nature of the tectonic or erosional event responsible for their absence is not clear. Following this, the western Raggatt Basin subsided slowly and remained shallow, but appreciable carbonate sediments accumulated there for the first time (Fig. 2), along with continued high amounts of glauconitic sediment. The carbonates are bioclastic (rudstones, grainstones, and wackestones) rather than pelagic, and the rich invertebrate faunas (bryozoans, crinoids, inoceramids, echinoids, siliceous sponges, coralline "red" algae, and benthic foraminifers) denote high organic productivity, which also enhanced the formation of the glauconitic clays along with the shallow (i.e., shelf depth) depositional environment. This carbonate-shelf environment persisted well into the Maestrichtian (Fig. 4), where the record is truncated by a disconformity. The high sedimentation rate (46 m/m.y.; Fig. 5) easily kept pace with subsidence.

As indicated above, during the Campanian and late Maestrichtian the eastern margin of the Southern Kerguelen Plateau (in contrast to the western Raggatt Basin) was undergoing rapid subsidence, reaching its present-day depth of about 2000 mbsf (at Site 750) by Paleocene times. Open-marine, deeper-water sedimentation during this interval is characterized by nannofossil chalk, chert, intermittently silicified limestone, and no traces of glauconite. The corresponding sedimentation rate is estimated to be a high 10–20 m/m.y., indicating a productive pelagic regime (Fig. 5).

Throughout most of the Campanian-Maestrichtian, calcareous nannofossil and planktonic foraminifer assemblages at Sites 747, 748, and 750 exhibit a distinct austral affinity. An incursion from the north of transitional planktonic foraminifer and coccolith taxa was recorded in the upper Campanian at the northernmost site (Site 747), however, and the latest Maestrichtian assemblages sampled at Site 750 lose their strong austral affinities, indicating a progressive warming toward the close of the Cretaceous Period.

Beginning at about 75 Ma a major tectonic episode affected much of the central plateau as movement occurred along a system of large faults, including the 77°E Graben, that apparently developed at this time (Leclaire et al., 1987a, 1987b; Schlich et al., 1988; Colwell et al., 1988). At Site 747, this resulted in the uplift of basement above sea level and the emplacement of a series of debris flows consisting of clay-, sand-, and cobble-size clastics and breccias eroded from uplifted volcanic basement blocks. This event may have been related to initial stages of rifting that would eventually separate Broken Ridge from the Kerguelen Plateau.

By the end of this episode, the entire Southern Kerguelen Plateau had foundered, subsiding precipitously toward its present-day water depth. When sedimentation resumed in the Cenozoic, Site 748 in the west had descended from shelf depths in the mid-Maestrichtian to approximately 1000 m by the mid-Paleocene. Site 747 plummeted from about 500 m to as deep as 2000 m between the mid-Maestrichtian and the early Paleocene. Regional seismic analysis shows that by Eocene times the depocenter for the Raggatt Basin had shifted considerably toward the east as a consequence of the profound Maestrichtian–early Paleocene tectonic episode.

From the Paleocene through the middle Eocene, sedimentation (mainly nannofossil chalk and ooze with some occurrences of chert) was essentially continuous over the plateau at a rate of about 18 m/m.y. in the west (Site 748) and at a rate varying between 5 and 30 m/m.y. in the east. During this interval the plateau subsided slowly and remained at about the same paleodepth.

A hiatus of at least 2 m.y. occurred during the middle Eocene (Sites 748 and 750). At Site 747 (in the transition zone between the northern and southern plateaus), this hiatus extends over 15 m.y. This event can be related to the separation by seafloor spreading of the Northern Kerguelen Plateau and Broken Ridge, dated at 43–42 Ma by Munschy and Schlich (1987), a figure in close agreement with that deduced from Leg 121 drilling on Broken Ridge (48–42 Ma; Leg 121 Shipboard Scientific Party, 1988).

From the middle Eocene to the Pliocene, pelagic biosiliceous and carbonate sedimentation continued throughout the plateau. The sedimentation rate for the central plateau was very high and varied between 15 and 20 m/m.y. as pelagic productivity continued to be high (Fig. 5).

A major discovery within the lowermost Oligocene of Site 748 was the presence of a 37-cm-thick unit of ice-rafted debris consisting of abundant angular quartz sand, heavy minerals, and micas within the lowermost Oligocene nannofossil ooze. Shore-based scanning-electron microscope and energy-dispersive X-ray studies have documented fresh conchoidal fractures and surface textures on the quartz grains indicative of glacial origin, and the presence of a heavy-mineral suite is characteristic of metamorphic or plutonic source rocks (Breza et al., 1988). The ice-rafted debris interval is dated between 35 and 36 Ma (between paleomagnetic Chrons 12 and 13).

Direct physical evidence of appreciable lower Oligocene ice-rafted debris this far north of the Antarctic continent (the lowest latitudinal occurrence known) is highly significant and provides the ultimate proof for the existence of an early Oligocene ice sheet on the Antarctic continent, a topic which until now has been strongly debated (see review by Wise et al., 1985). To date, the strongest arguments for the existence of such an ice cap have been based on interpretations of the stable-isotope records of the world's oceans (Matthews and Poore, 1980; Miller and Fairbanks, 1983, 1985; Keigwin and Keller, 1984; Shackleton et al., 1984; Wise et al., 1985; Miller et al., 1987).

Wise et al. (1985) discuss the probable location, mode of formation, and possible extent of such an ice sheet. The proxy (i.e., stable isotope) evidence from the deep sea has been bolstered by drilling along the margins of Antarctica where lower

Oligocene tills and/or ice-rafted sediments have been dated in the Weddell Sea (Leg 113 Shipboard Scientific Party, 1987), Ross Sea (Barrett et al., in press), and Prydz Bay (Leg 119 Shipboard Scientific Party, 1988), directly south of the Kerguelen Plateau (Fig. 1). All of these occurrences indicated grounded ice at sea level.

It has been argued that the Weddell Sea and Prydz Bay occurrences necessitate the existence of an early Oligocene ice cap (Wise et al., 1987, and Leg 119 Shipboard Scientific Party, 1988, respectively). On the other hand, it can be argued that all of these occurrences may indicate only local glaciation, perhaps of nearby highlands or mountains; such an interpretation has been made for the Ross Sea occurrences (Leg 119 Shipboard Scientific Party, 1988). However, no such argument can reasonably be made for the occurrences of ice-rafted debris at Site 748, which lies nearly 1000 km north of Prydz Bay (Fig. 1). Ice rafting to localities this far removed from the Antarctic continent, into waters that during the early Oligocene were probably warmer than those in the region today, must have been supported by the presence of a continental ice sheet, however ephemeral and short lived its existence may have been.

During the late Miocene–early Pliocene, the sedimentary facies at all sites with Neogene sediment shifted from predominantly nannofossil ooze to diatom ooze as the Polar Front became established to the north (its present-day position is in the vicinity of Kerguelen Island) and the frigid Antarctic Water Mass expanded over the Leg 120 sites. Hiatuses occur at the Miocene/Pliocene boundary and within the Pliocene; the uppermost Pleistocene is missing at most sites. These hiatuses and low sedimentation rates (Fig. 5) are related to erosion that affected Sequences NQ1, PN1, and P2 over the entire Southern Kerguelen plateau.

Intermittent erosion from the late Miocene to the present at these latitudes is widespread on plateaus and similar promontories that lie in the path of the Antarctic Circumpolar Current. This current has been especially vigorous ever since Antarctica first became fully glaciated during the late Miocene. Its effect (especially of its Circumpolar Deep Water component) on features such as the Falkland Plateau has been discussed by Ciesielski and Wise (1977), Ciesielski et al. (1982), and Wise et al. (1985), among others.

OPERATIONS

The *JOIDES Resolution* operated nearly continuously in the high sustained winds and rough seas expected at these latitudes. Average winds blew at a steady 20–40 kt on good days and gusted between 50 and 70 kt on bad ones (Fig. 6). As during Leg 114, which met with similar weather conditions, the ship proved to be an exceptionally stable platform, and only 1.8 days were lost "waiting on weather."

Not expected, however, were the difficulties encountered while operating under these conditions at the relatively shallow Leg 120 sites (the water depths for our sites ranged between 1069 and 2030 m). The short drill strings were not sufficiently long and flexible to absorb the excessive heave of the ship. The results were unusual equipment failures that often coincided with high winds at shallow sites as the BHA was pounded against the bottom. Two successive failures of flapper valves occurred at the shallowest sites (Sites 748 and 749) where holes were lost during peak winds, whereas a bit failed after only 5½ hr of rotation at Site 750 during one of the stormiest episodes (Fig. 6).

Our salvation from the operational point of view was the availability of the Hayes minicone, which was the only reentry device that could be deployed under prevailing conditions with any degree of safety for the drill crew. On this leg, a record was set for penetration with this device (935 m at Hole 748C), and it was used successfully for the first time at a dedicated basement hole (Site 749).

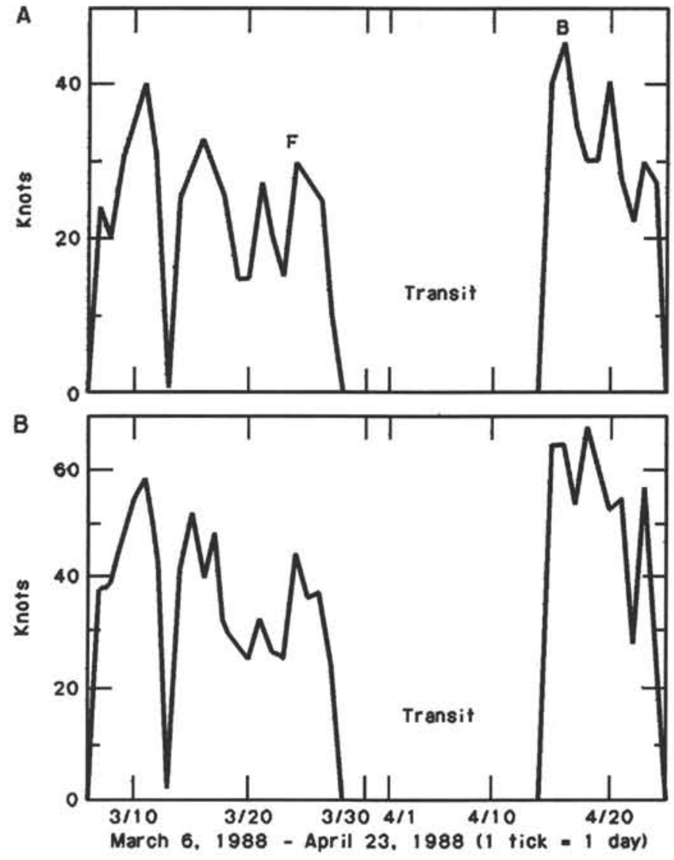

Figure 6. Average (A) and maximum (B) wind conditions during Leg 120. F = flapper valve and B = bit assembly (items that failed at the times indicated, causing loss of drill holes).

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