OCEAN DRILLING PROGRAM

LEG 119 SCIENTIFIC PROSPECTUS

KERGUELEN PLATEAU and PRYDZ BAY

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INTRODUCTION

Ocean Drilling Program Legs 119 and 120 will complete a latitudinal transect in the Southern Ocean between Kerguelen Island (49°S) and Prydz Bay, Antarctica (67°S). This transect will study the Late Cretaceous to Holocene paleoclimatic history of East Antarctica, the origin and tectonic history of the Kerguelen Plateau, and the Late Mesozoic rifting history of East Antarctica and India. ODP Leg 119 will drill sites on the northern and southern Kerguelen Plateau and on the Prydz Bay continental margin, while ODP Leg 120 will drill several sites on the central portion of the Kerguelen Plateau (Tables 1 and 2; Figures 1-7). This prospectus is concerned solely with the Leg 119 scientific objectives and was in part compiled using the drilling proposals submitted to the JOIDES panels by Barker (1987) and Schlich et al. (1987). For ease of discussion the prospectus deals separately with the Prydz Bay and the Kerguelen Plateau regions.

PRYDZ BAY

Prydz Bay lies at the oceanward end of the graben occupied by the Lambert Glacier and Amery Ice Shelf in East Antarctica (Figures 6 and 7). The Lambert Glacier drains a large part of the East Antarctic ice sheet, including the 3000-m-high subglacial Gamburtsev Mountains. The glacier follows the line of the Lambert Graben, which extends 700 km or more inland and is of Permian or Early Cretaceous age. The present ice drainage basin is believed to be long-lived because of this structural control, and Prydz Bay sediments should reflect all stages of Antarctic glaciation and the pre-glacial continental climate.

Drilling in Prydz Bay is aimed at understanding Antarctic climatic evolution - both before and during the development of the present continental ice sheet. Previous Antarctic drilling on ODP Legs 113 and 114 was concerned mainly with the evolution of the West Antarctic ice sheet, which first developed in the late Miocene (Barker, Kennett, et al., in press). Indirect evidence from pollen and sedimentology at ODP Site 693 suggested that East Antarctica was largely free of ice prior to the Oligocene and that the major isotopic enrichment in $\delta^{18}O$, which occurs in the tests of both benthic and planktonic foraminifers in the lowermost Oligocene throughout the world's oceans, signals the growth of the East Antarctic ice sheet (Barker, Kennett, et al., in press). In spite of this evidence, models for global fluctuation in eustatic sea level (Vail and Hardenbol, 1979) call for the presence of ice on Antarctica in the Early Cenozoic and Late Mesozoic. Due to a hiatus at ODP Site 693, Leg 113 failed to recover any record of Late Cretaceous through earliest Oligocene climatic conditions from the East Antarctic margin (Barker, Kennett, et al., in press).

In the Ross Sea in West Antarctica, DSDP Leg 28 demonstrated the existence of glacial deposits as old as 25 Ma which overlie an Oligocene glauconitic sandstone dated at 26.7 Ma (Hayes, Frakes et al, 1975). The glacial deposits indicate the existence of tidewater glaciers, not ice sheet conditions. Drilling in the western Ross Sea has extended the record of glacially related deposition back to the early Oligocene (Barrett, 1986), supporting the ODP 113 results. Unfortunately, the record is complicated by proximity to the Transantarctic Mountains, which were uplifted during the Cenozoic to their present elevation of over 4000 m (Gleadow et al; 1984).

The palynological record from surficial sediments around the continent provide further constraints, although age resolution is inadequate. Recycled palynomorphs from the Ross Sea (Truswell and Drewry, 1984), the west ice shelf to the Prydz Bay region (Kemp, 1972), and west of the Shackleton Ice Shelf (Truswell, 1982) all point to a vegetation cover, of either Permian (from the upper Permian sediments and a similar, congruent graben on the eastern Indian margin) or Neocomian (aulacogenic to Indian-Antarctic separation) age.

Today the icebergs calving from the Amery Ice Shelf cross western Prydz Bay and then turn westward along the margin, drifting with the coastal current. Eastern Prydz Bay, where the drilling sites lie (Figure 7), therefore is not in the main iceberg path at present. During glacial maxima, however, shelf ice appears to have grounded right across Prydz Bay, as demonstrated by the eroded, over-deepened shelf topography seen most prominently at the southern end of the profiles (the shelf on profile PB/021, for example, is 900 m deep inshore, shallowing to 400 m offshore). This inshore deepening is typical of Antarctic shelves, and suggests that the younger eastern Prydz Bay sediments will accurately reflect the glacial processes of the East Antarctic margin.

Bedrock in the Prydz Bay region is almost entirely formed of Precambrian igneous and metamorphic rocks (Grew, 1982; Collerson and Sheraton, 1986). The metamorphic rocks are a diverse assemblage of rocks with igneous and sedimentary precursors, and include quartzofeldspathic and basic gneisses and schists, pelitic schists and amphibolites, quartzites, marble and calc-silicate rocks, and an iron formation. Plutonic rocks range from gabbro to granite in composition and include large tracts of charnockite (hypersthene-bearing granite). Geochronologic and structural data allow subdivision of these rocks into an archean (250 Ma) terrane of granulite-facies metamorphic rocks, and younger Proterozoic (250-600 Ma) belts of generally lower metamorphic facies. Scattered intrusive bodies of Cambrian age cut the Precambrian rocks.

Geophysical surveys have established that the Lambert Glacier - Amery Ice Shelf region (Figure 8), the southward extension of Prydz Bay, is a rift structure in which depth to Moho is 22-23 km in contrast to 30-34 km on the rift flanks (Federov et al., 1982). A substantial thickness of sediment is present in the rift. The age of rifting is poorly constrained. The Permian strata may have been deposited in the early stages of rifting, and therefore in a similar tectonic setting to the Gondwana sequence in the Mahanadi and Godovari Valley in peninsular India. The rift has been interpreted by Stagg (1985) as the failed arm of a triple (or quadruple) junction developed during separation of Antarctica and India, in which case it dates from the Early Cretaceous. The alkaline mafic igneous rocks are likely to be associated with such rifting. The graben probably contains Upper Jurassic to Upper Cenozoic sedimentary rocks. The seaward end of the graben opens out into Prydz Bay. Palynological data suggest the presence of Lower Cretaceous non-marine beds and upper Cretaceous to Eocene marine strata, in addition to a restricted locality of Permian non-marine coal-bearing clastic strata exposed along the southwestern margin of the Amery Ice Shelf (Mond, 1972).

Seismic data from Prydz Bay have been interpreted by Stagg (1985) in terms of several sedimentary packages, separated by seismic reflectors, on both the shelf and slope (Figures 9 and 10). On the shelf an older sequence (PS3 to PS6), showing minor folding and faulting, is interpreted as a continental to possibly shallow marine sequence that pre-dates breakup. The younger sequence (PS1 to PS2) is interpreted as a post-breakup sequence of shallow marine sediments. A thin sequence at the seafloor is clearly disconformable on older strata and suggests that ice advance has removed parts of the underlying sequences. Stagg tentatively assigned ages to these sequences: Acoustic basement (PS6) in southeastern Prydz Bay, adjacent to the Vestfold Hills (Figure 8), is Cambrian and older; pre-breakup strata (PS3 to PS5) are Early Permian to Early Cretaceous; post-breakup strata (PS2) are early Cretaceous to Miocene(?), whereas the thin veneer at the sea-floor (PS1) is post-middle Miocene.

There is no direct age control on any of the sediments. Stagg (1985) interprets the section proposed for drilling to be of Permian to Holocene age, but this is based on (a) a Permian age for the Lambert Graben, (b) a Neocomian age for the faulting on the western profiles (Indian-Antarctic break-up) and (c) speculative correlation of sequences eastward, without cross-lines. For profile PB/021, on which the proposed sites lie, this interpretation has the rather curious consequence that the Neocomian separation of East Antarctica from India, which created the northern margin of Prydz Bay, produced no major unconformity. It seems equally likely that eastern Prydz Bay was not directly on the line of the Lambert Graben, whatever its age, and that the sequences shown on PB/021 and adjacent lines are all of Neocomian and younger age.

Prydz Bay drilling is aimed at stepping down a series of prograding seismic reflectors with four overlapping holes each of 500 m depth in an effort to document the Late Cretaceous to Holocene paleoclimatic history of East Antarctica as well as provide data on the timing of the East Antarctica-India separation in the Early Cretaceous. Clay mineralogy, pollen and spores, and neritic fauna and flora will provide evidence of environmental conditions along the East Antarctic margin. The history of ice sheet volume changes will be investigated through study of glacial erosion on the shelf, changes in the oxygen isotopes of foraminifers, and changes in sedimentology and in the flora and fauna, which give evidence of ice.

While the <u>JOIDES Resolution</u> carries out drilling in Prydz Bay, a water column sediment trapping program and a surface plankton collection program will be carried out on the ice support vessel, the

Maersk Master, by a party of 4 oceanographers. The water column sediment trapping program will involve the release of floating buoys with sediment traps suspended at 100-m and 200-m depths below sea level, and the plankton study will involve trapping of phytoplankton and zooplankton fecal pellets for analysis and comparison with planktonic microfossils preserved in downcore sediments. One scientist on the Resolution will participate in these studies, which offer an excellent opportunity to compare modern pelagic deposition in Prydz Bay with pelagic records found in Cretaceous and Cenozoic sediments there. The primary job of the Maersk Master in Prydz Bay (and possibly at the southern Kerguelen sites) will be to scout for approaching icebergs and to move drifting icebergs away from JOIDES Resolution. The two scientific programs on the Maersk Master will only be carried out when they do not interfere with the Maersk Master's primary mission of ice support.

KERGUELEN PLATEAU

Drilling on the Kerguelen Plateau is aimed at both tectonic and paleoceanographic objectives. On the one hand, the 2500-km-long plateau rises from 2 to 4 km above the surrounding seafloor and offers the opportunity to make a latitudinal transect between 49°S and 62°S in an area of the Southern Ocean where sediment thicknesses and carbonate preservation are enhanced. This area lies south of the present-day Antarctic Convergence and beneath the main flow of the Antarctic Circumpolar Current, and drilling on the Kerguelen Plateau should document the development and evolution of these two paleoceanographic features, which have a major effect on global climate and surface water circulation.

On the other hand, the origin and tectonic development of the Kerguelen Plateau (or Kerguelen-Gaussberg Ridge) has long been a matter of controversy (Munschy and Schlich, 1987). Reconstructions have debated the continental vs. oceanic origin of the plateau and have utilized bathymetry, seismic reflection, seismic sonobuoy refraction, dredges, piston cores, magnetics, and gravimetry without incorporating deep-sea drilling (Munschy and Schlich, 1987). Most recent interpretations favor an oceanic origin, with a Late Cretaceous to Eocene history as a shallow marine structure attached to Broken Ridge, which has since drifted to the eastern Indian Ocean off Australia. During the Eocene, the northern Kerguelen Plateau apparently was uplifted with spreading, causing separation of the Broken Ridge region at about 45-42 Ma. Subsidence of the main Kerguelen Plateau followed with possible clastic Oligocene deposits ovelain by Neogene calcareous and biosiliceous oozes (Munschy and Schlich, 1987).

The Kerguelen Plateau is bounded to the northeast by the Crozet Basin, to the east by the Australia-Antarctic Basin, and to the southwest by the Africa-Antarctic Basin. To the south, it is separated from Antarctica by the 3500-m-deep Princess Elizabeth Trough. The Kergulen Plateau has been divided into two distinct domains (Schlich, 1975; Houtz et al., 1977). The northern portion of the plateau, the Kerguelen-Heard Plateau, generally lies in water depths less than 1000 m, and includes the feature's only subaerial manifestations, Kerguelen, Heard, and McDonald islands. The southern portion of the feature, the Southern Kerguelen Plateau, is deeper, generally lying in water depths between 1500 and 2000 m. The transition zone, between 54°S and 58°S, exhibits a complex bathymetry with a large east-west-trending spur, the Elan Bank, extending westward from the main plateau over a distance of 600 km.

The age of the oceanic crust abutting the plateau varies and has been analyzed since 1966 by various authors. The Kerguelen Plateau and Broken Ridge form a symmetric pair of "aseismic ridges" separated by the Southeast Indian Ridge. Fracture zones and magnetic lineations related to this spreading center have been mapped and analyzed by Schlich and Patriat (1967 and 1971), Le Pichon and Heirtzler (1968), McKenzie and Sclater (1971), and Houtz et al. (1977). The seafloor close to the plateau has been dated by the observed magnetic lineations (Figure 1), using the magnetic time scale of Berggren et al. (1985). Le Pichon and Heirtzler (1968) identified anomalies 13, 16 and 17 (40 Ma) east of Heard Island. Schlich and Patriat (1971) recognized anomalies 1 to 11 (32 Ma) to the east and the north of Kerguelen Island. Farther to the south, eastward from Heard Island, Houtz et al. (1977) also identified anomalies 1 to 18 (42 Ma). Thus the isochrons close to the northeastern margin of the ridge are not parallel to this boundary but vary in age from 32 Ma (to the north) to 42 Ma (to the south). Northwest and west of the Kerguelen Plateau, magnetic anomalies 23, 24 and 28 (65 Ma) and magnetic anomalies 33 and 34 (84 Ma) have been identified (Schlich, 1975 and 1982). No seafloor spreading magnetic anomalies have been observed adjacent to the southwestern flank of the Kerguelen Plateau.

According to Le Pichon and Heirtzler (1968), the Kerguelen Plateau and Broken Ridge were separated in Eocene time. The reconstructions proposed by Houtz et al. (1977) and Goslin (1981) to total closure of Australia and Antarctica at anomaly 20 show an unacceptable overlap of Broken Ridge and the Kerguelen-Heard Plateau. Mutter and Cande (1983) and Mutter et al. (1985), employing a revised chronology for the breakup of Australia and Antarctica (Cande and Mutter, 1982), partially resolved the overlap problem. However, the resulting reconstruction does not exclude overlap of the northern portion of the Kerguelen Plateau with Broken Ridge.

The origin and crustal structure of the Kerguelen Plateau remain obscure despite geophysical and geological investigations. Three possibilities, each geochemically distinguishable, may explain the feature's origin and crustal nature: 1) it is a continental fragment; 2) it is a product of excessive on- or off-axis oceanic volcanism, possibly hotspot-related; 3) it is a thermally or tectonically uplifted and possibly thickened block of oceanic crust. None of these possibilities may be eliminated at present and it is possible, given the apparent structural complexities of the Kerguelen Plateau, that different parts of the feature have different origins (Coffin et al., 1986). Petrological (Giret, 1983) and geochemical studies (Dosso et al., 1979; Mahoney et al., 1983) on Kerguelen Island igneous rocks show clear affinities with the observations derived from other oceanic islands. The crustal structure of the Southern Kerguelen Plateau was modeled by Houtz et al. (1977) using gravimetric and seismic reflection/refraction data, and of the Kerguelen-Heard Plateau by Recq et al. (1983) and Recq and Charvis (1986) using two seismic refraction profiles shot on Kerguelen Island. The maximum thickness of the crust was determined to lie between 15 and 23 km. Furthermore, the seismic velocity depth distribution is similar to those of typical oceanic islands (Crozet) or plateaus (Madagascar).

The Southern Kerguelen Plateau has been the focus of three major research cruises in 1985 (Rig Seismic Survey 20) and 1986 (MD 47, MD 48) and interpretation of the geophysical and geological data is underway. Analysis of the SEASAT-derived free-air gravity field and seismic reflection data has led to an improved understanding of the Kerguelen Plateau (Coffin et al., 1986). South of 53°S the Kerguelen Plateau consists of two distinct sectors (Figure 2). The Southern sector, which corresponds to the Southern Kerguelen Plateau, consists of a broad anticlinal arch affected by multiple stages of normal faulting resulting in horst and graben development. The eastern sector abuts the main southern plateau and consists of a large abyssal basin (Labuan) and a prominent ridge (William's), both faulted.

Coffin et al. (1986) concluded that the Southern Kerguelen Plateau may be an amalgamation of disparate structural elements, including broad crustal uplifts, trapped oceanic crust, possible continental fragments, and possible fracture zone ridges and troughs. Recent dredging (MD 48) along a major graben (77° Graben of Houtz et al., 1977) recovered the first significant assemblage of basement rocks from the Southern Kerguelen Plateau. The horst samples are basaltic, suggesting an oceanic or oceanic island origin from the Southern Kerguelen Plateau. Shallow water limestones of probable Cretaceous and Paleogene ages were also recovered by dredging the basin, and Eocene and Cretaceous sediments were sampled on the faulted eastern flank of the Southern Kerguelen Plateau. The recent sampling supports the previous interpretation of Houtz et al. (1977) i.e., the Neogene section on the Southern Kerguelen Plateau, although perhaps thick locally in the Raggatt Basin, is generally thin, and furthermore is usually separated from older sediments by a major unconformity ("A") of Eocene age. Eocene sediments may include chert.

Figure 11 shows the two major seismic sequences (S and I) identified by Munschy and Schlich (1987) which are separated by a major discordance (A). Discordance A is a major event in the sedimentary section and marks a hiatus from the middle Eocene to the early Miocene (Munschy and Schlich, 1987). This event also separates pre-rifting from break-up and post break-up sequences. The main sedimentary basin on the Kerguelen-Heard Plateau was delineated from the seismic reflection data obtained in 1970 and 1972 by M/S Gallieni. Detailed geophysical and geological analysis of this basin was completed using data acquired in 1981 (MD 26) and 1983 (MD 35). The evolution of the Kerguelen Plateau, postulated from basin stratigraphy, can be summarized as follows (Munschy and Schlich, 1987) (Figure 12):

- In early Late Cretaceous time (about 100 Ma) the Kerguelen Plateau was faulted and elevated to shallow depths. Normal faulting occurred along the present limit of the sedimentary basin and along the present eastern margin of the plateau. This tectonic event corresponds to the first pre-rift faulting episode between the Kerguelen Plateau and Broken Ridge.

- From Late Cretaceous to Eocene time the Kerguelen Plateau remained a shallow marine structure, continuously subsiding at a rate of about 20 m/m.y., and was covered essentially by shelf pelagic sediments (Seismic Units I2 and I1) without obvious sedimentary hiatuses. Seismic Unit I3 represents the first deposition along the present Kerguelen platform.

- During the Eocene the eastern part of the Kerguelen Plateau was uplifted, probably close to sea level, and Unit I1 was partially eroded.

- By magnetic anomaly 18 time the plateau and Broken Ridge were clearly separated by spreading at the Southeast Indian Ridge. The breakup occured at 45-42 Ma, and newly-rifted margins subsequently subsided.

- During Miocene and possibly Oligocene time the plateau was covered by calcareous ooze containing siliceous biogenic components. The clastic component of the post-rift deposits is significant, and is derived essentially from Kerguelen Island. The first clastic deposits are probably Oligocene in age.

- Sedimentation continued throughout the late Miocene, Pliocene and Quaternary and consists of diatomaceous ooze, glauconized sand with ice rafted debris and ash layers corresponding to explosive volcanic activity.

Drilling at northern Kerguelen Plateau site KHP-1 (49^{o} 23.6'S, 71^{o} 39.5'E, water depth 660 m) is aimed at the recovery of an expanded section (910 m) of Neogene calcareous and biosiliceous oozes at the northern end of the paleoclimatic transect. A second objective will be to date the reflector at 910 m, which presumably represents a major middle Cenozoic unconformity signalling the uplift of the Kerguelen Plateau and subsequent rifting between the plateau and Broken Ridge (Munschy and Schlich, 1987).

Southern Kerguelen Site SKP-6A (62^{o} 44.0'S, 83^{o} 05.2'E, water depth 2700 m) will be drilled in order to obtain an Upper Cretaceous through Cenozoic reference section for the Southern Kerguelen Plateau, to determine the nature and age of the basement there, and to provide evidence of the rifting and subsidence of the Kerguelen Plateau. This site is planned for continuous APC and RCB coring to 550 mbsf, including 50 m of drilling in the basement.

An additional Southern Kerguelen site SKP-6B (61^{o} 31.4'S, 80^{o} 52.1'E, water depth 2260 m) is planned as a contingency site should drilling in Prydz Bay be impossible due to ice conditions. The sediment section at this site is expanded (1300 m) compared to that at nearby site SKP-6A which lies about 120 km to the southeast. It, therefore, will likely contain a more complete Upper Cretaceous to Cenozoic section than that recoverable at site SKP-6A.

DRILLING STRATEGY

APC, XCB, and RCB coring will be initiated at site KHP-1 in a conventional manner with the objective of reaching the 910 m deep reflector target. Should RCB coring require replacement of the bit before the objective is reached, a reentry cone will be put down and the top of new hole will be cement-cased, so that either ODP Leg 119 or Leg 120 might return to KHP-1 in order to reach reflector estimated to be at 1340 msbf, which is projected to represent to pre-rift sequence (Schlich, written comm., 1987). Placement of the reentry cone and casing the hole would add at least 3 days on to the operation time at KHP-1 and might jeopardize part of the program at Prydz Bay should ice conditions there be excellent. The Maersk Master will rendezvous with JOIDES Resolution at Kerguelan Island after the completion of KHP-1 and will proceed either to SKP-6A in company with JOIDES Resolution or to Prydz Bay in order to monitor ice conditions there. If ice conditions are becoming favorable at Prydz Bay, JOIDES Resolution will sail to Prydz Bay before SKP-6A.

The JOIDES Resolution will complete one day of geophysical surveying of the proposed Prydz Bay sites along 78°E between 67° 00'S and 67° 45'S. Drilling will begin at proposed site PB-6 at shot point 33.2118 along profile PB/021. This site lies landward of the shelf-slope break and seaward of the zone restricted from drilling by the JOIDES Pollution Prevention and Safety Panel. It appears to be near an ancient shelf-slope break and is a good place to compare the age of the sequence characterized by thin, well defined reflectors, which lies landward with the overlying sequence characterized by poorly defined, thicker reflectors, which lies seaward. Depending on the results at PB-6, subsequent drilling will be planned seaward at sites PB-7 and PB-8 or landward at sites PB-5 and PB-3 through PB-1. The primary paleoceanographic objective of Prydz Bay drilling is to obtain as complete a Cenozoic to Upper Cretaceous section as possible. The Maersk Master will be instructed to drop the beacons at sites chosen from the seismic survey and the results of drilling at PB-6. If everything goes well, and we are ahead of the drilling schedule and ice conditions permit, a fifth site in Prydz Bay may be drilled.

Drilling at SKP-6A will be APC, XCB, and RCB through 500 m of sediment and 50 m into basement if severe ice conditions exist. The Maersk Master will assist the drill ship at this site, otherwise she will be released for return to her home port. Should 3 days remain before we must sail back to Mauritius in order to make our February 20 scheduled arrival there, the top portion of SKP-6B will be double APC cored.

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Table 1 (Sept. 1, '87)

Leg 119 Kerguelen - Prydz Bay Drilling Program

Site	Latitude S	Longitude E	Water Depth (m)	Drilling Depth (m)	Drilling Time (Days)	Logging Time (Days)	Total Time (Days)
KHP-1	49°23.6'	71°39.5'	660	910	7.0*1	1.3*2	8.3
SKP-6A	62°44.0'	83°05.2'	2360	550	4.7	1.7	6.4
Prydz Bay sites (PB-1 to PB-8)							
	67°00.0-67°45.0'	78°00.0'	800	500	2.5(x4)	1.2(x4)	15.0*3

*1 Add 3.0 days if a reentry cone is required. In addition, 2-3 days may be required if sediments core more indurated than expected.
*2 Add 1.0 day if a VSP experiment is completed.
*3 1.0 day required for site survey.

Leg 119 Kerguelen Drilling Program (Prydz Bay Alternate)

Site	Latitude S	Longitude E	Water Depth (m)	Drilling Depth (m)	Drilling Time (Days)	Logging Time (Days)	Total Time (Days)
KHP-1	49°23.6'	71°39.5'	660	910	7.0*1	1.3*2	8.3
SKP-6A	62°44.0'	83°05.2'	2360	550	4.7	1.7	6.4
SKP-6B	61°31.4'	80°52.1'	2260	1000	12.0	2.2	14.2

*1 Add 3.0 days if a reentry cone is required. In addition, 2-3 days may be required for if sediments core more indurated than expected.
*2 Add 1.0 day if a VSP experiment is completed.

ALTERNATES							
SKP-8	61°17.8'	86°46.7'	3850	500	5.0	1.4	6.4
				(700)	(6.9)	(1.6)	(8.5)
KHP-3	50°14.2'	73°02.5'	570	1700	14.0	2.1	16.1

Table 2

Leg 119		
Operation Time (w/910 meters at KHP-1 and Prydz Bay)		30.6 days
Transit Time (10 knots)		26.0 days
Contingency Time		7.4 days
	Total	63.0 days

Leg 119		
Operation Time (w/910 meters at KHP-1 and SKP-6B [not Prydz Bay])		28.9 days
Transit Time (10 knots)		25.5 days
Contingency Time		5.6 days
	Total	63.0 days

FIGURE CAPTIONS

Figure 1. The Kerguelen Plateau in the south central Indian Ocean. Bathymetry in meters is from GEBCO (Hayes and Vogel, 1981; Fischer et al., 1982). Fracture zones and magnetic anomalies are from Schlich and Patriat (1967, 1971), Le Pichon and Heirtzler (1968), Schlich (1975, 1982), Houtz et al. (1977), and Tilbury (1981).

Figure 2. Present-day location of surface water masses of the Southern Hemisphere (from Kennett, 1978).

Figure 3. Bathymetric map of the Kerguelen Plateau and Prydz Bay regions (from Munschy and Schlich, 1987). Bathymetry in meters. Regions outlined are shown at a larger scale in Figures 4-6.

Figure 4. Location of proposed sites KHP-1 and KHP-3 positioned on seismic survey lines from R/V Marion Dufresne cruise MD26 (1981) and cruise MD47 (1986). Bathymetry in meters.

Figure 5. Location of proposed central and southern Kerguelen sites position on seismic survey lines from R/V Marion Dufresne cruise MD47 (1986) and R/V RiG Seismic cruise RS02 (1985). Bathymetry in meters.

Figure 6. Location of proposed sites in Prydz Bay (see Figure 7 for greater detail). Bathymetry in meters.

Figure 7. Seismic survey lines from cruise Nella Dan (1982) in Prydz Bay. Proposed sites are located on line PB/021.

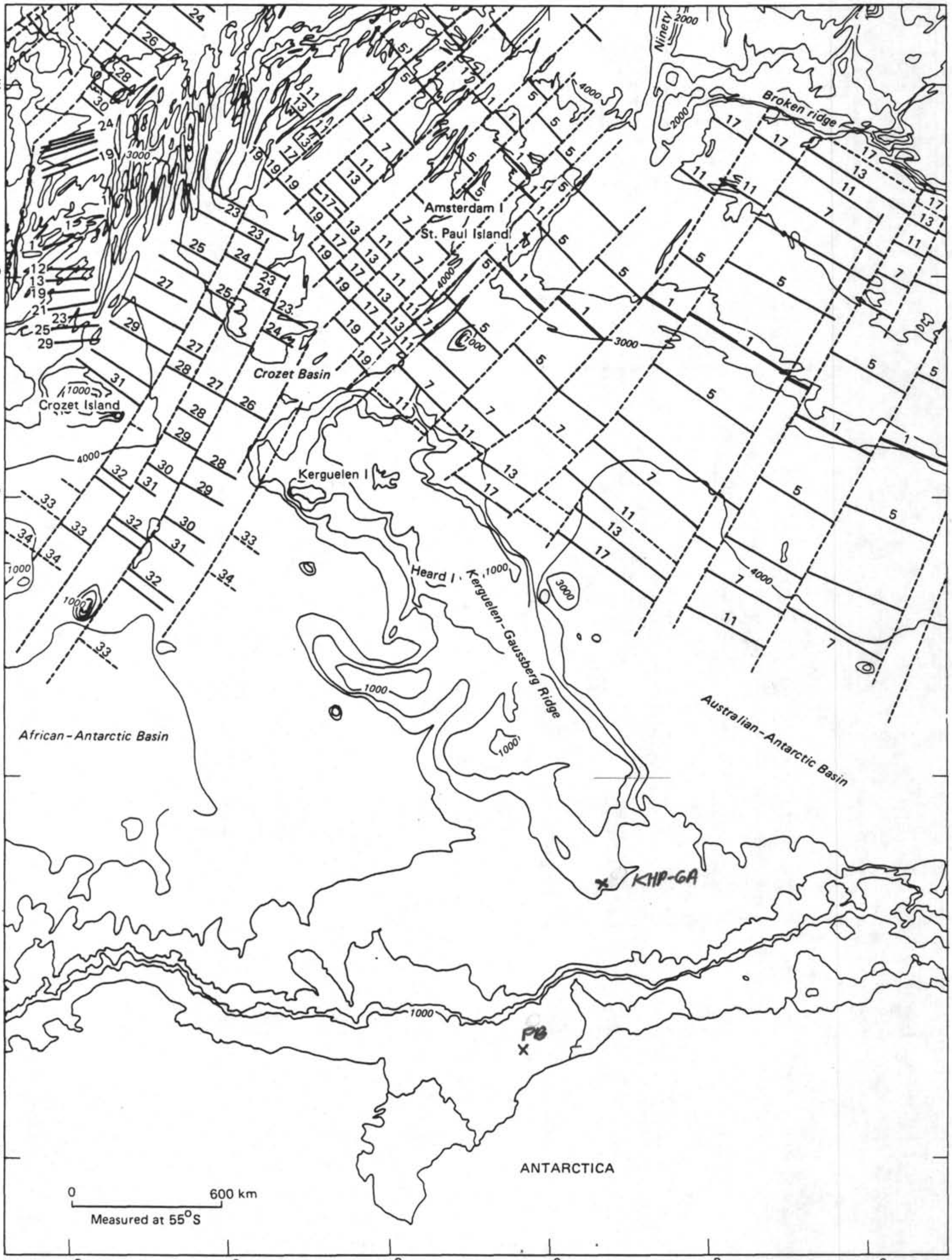
Figure 8. Schematic geologic map of the Prince Charles Mountains region with selected Rb-Sr geochronologic data. Solid black indicates outcrops; boundaries under glacial cover are diagrammatic only (from Tingey, 1982).

Figure 9. Line drawings of seismic sections along Lines PB/013, PB/019, and PB/021 (from Stagg, 1985). (See text for discussion).

Figure 10. Line drawings of seismic sections along Lines PB/023-033, PB/031, and PB/027 (from Stagg, 1985). (See text for discussion).

Figure 11. Chronology of seismic units identified by Munschy and Schlich (1987) for the Kerguelen Plateau region.

Figure 12. Schematic representation of the geological evolution of the Kerguelen-Heard Plateau from Cretaceous to Holocene time (Munschy and Schlich, 1987). (See text for discussion).



30°E
40°
50°
60°
70°
Ninety
Broken ridge
Amsterdam I
St. Paul Island
Crozet Basin
Crozet Island
Kerguelen I
Heard I
Kerguelen - Gaussberg Ridge
African - Antarctic Basin
Australian - Antarctic Basin
KHP-6A
PB
ANTARCTICA
0
600 km
Measured at 55°S
50°S
60°
70°
80°
90°
100°

Figure 1

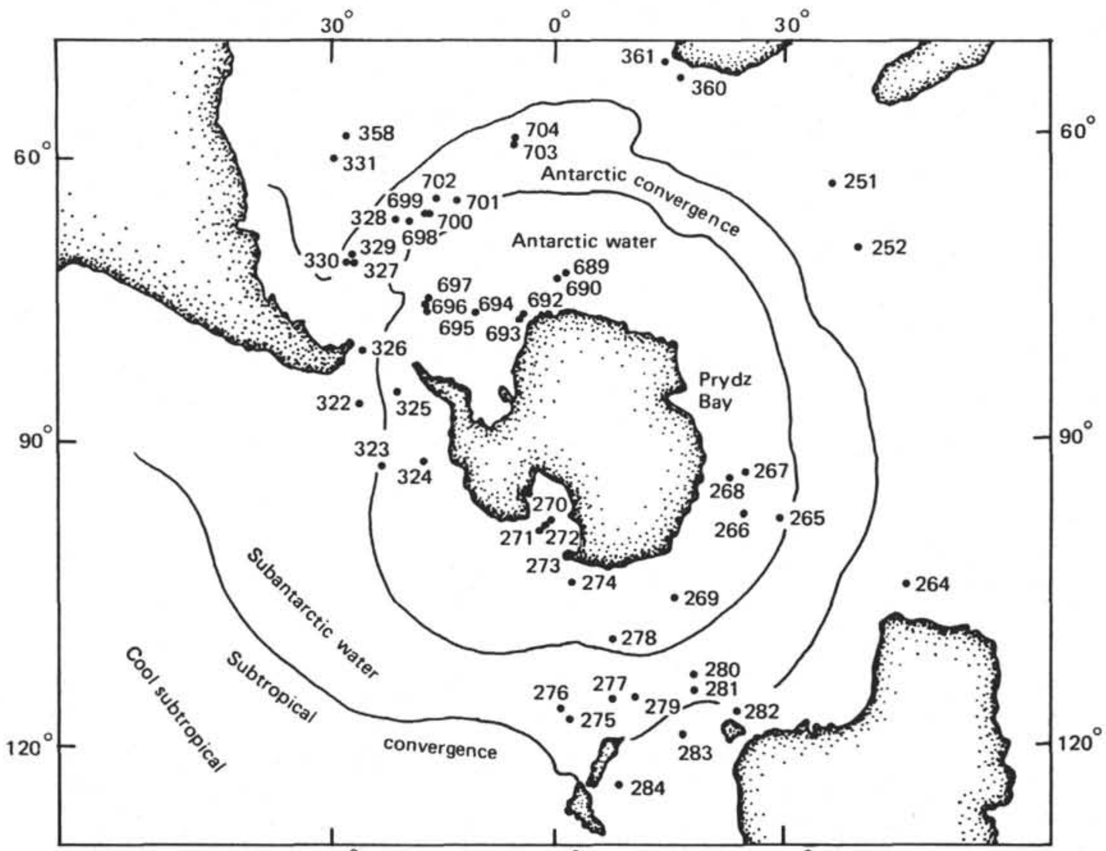

30°
0°
30°
60°
60°
90°
90°
120°
120°
150°
180°
150°
Antarctic convergence
Antarctic water
Prydz Bay
Subantarctic water
Subtropical
convergence
Cool subtropical
358
331
704
703
361
360
251
252
702
699
701
328
700
698
329
330
327
689
690
697
696
694
692
695
693
326
322
325
323
324
267
268
265
266
270
271
272
273
274
269
264
278
280
281
277
276
279
282
275
283
284

Figure 2

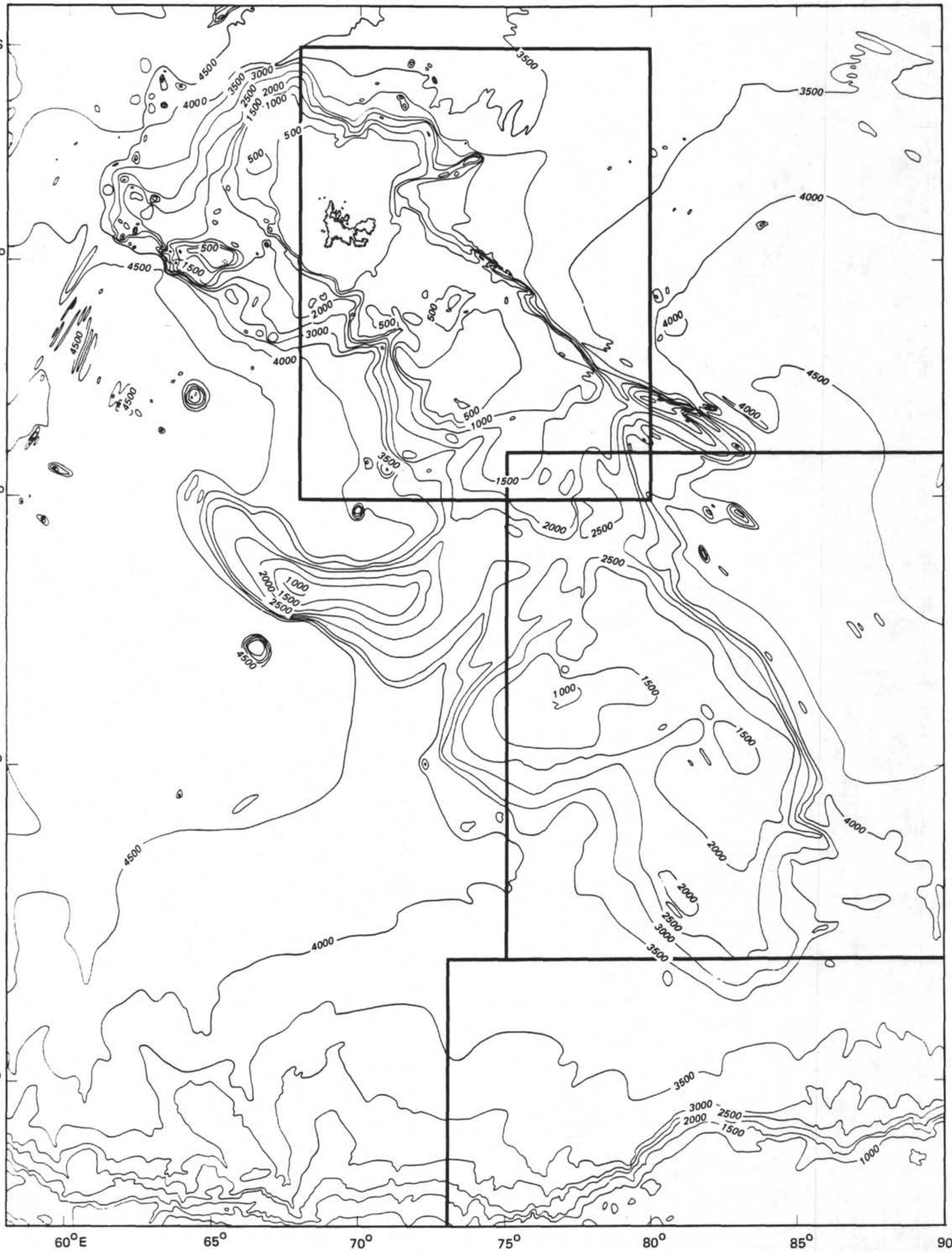

45°S
50°
55°
60°
65°
60°E
65°
70°
75°
80°
85°
90°
4500
4000
3500
3000
2500
2000
1500
1000
500

Figure 3

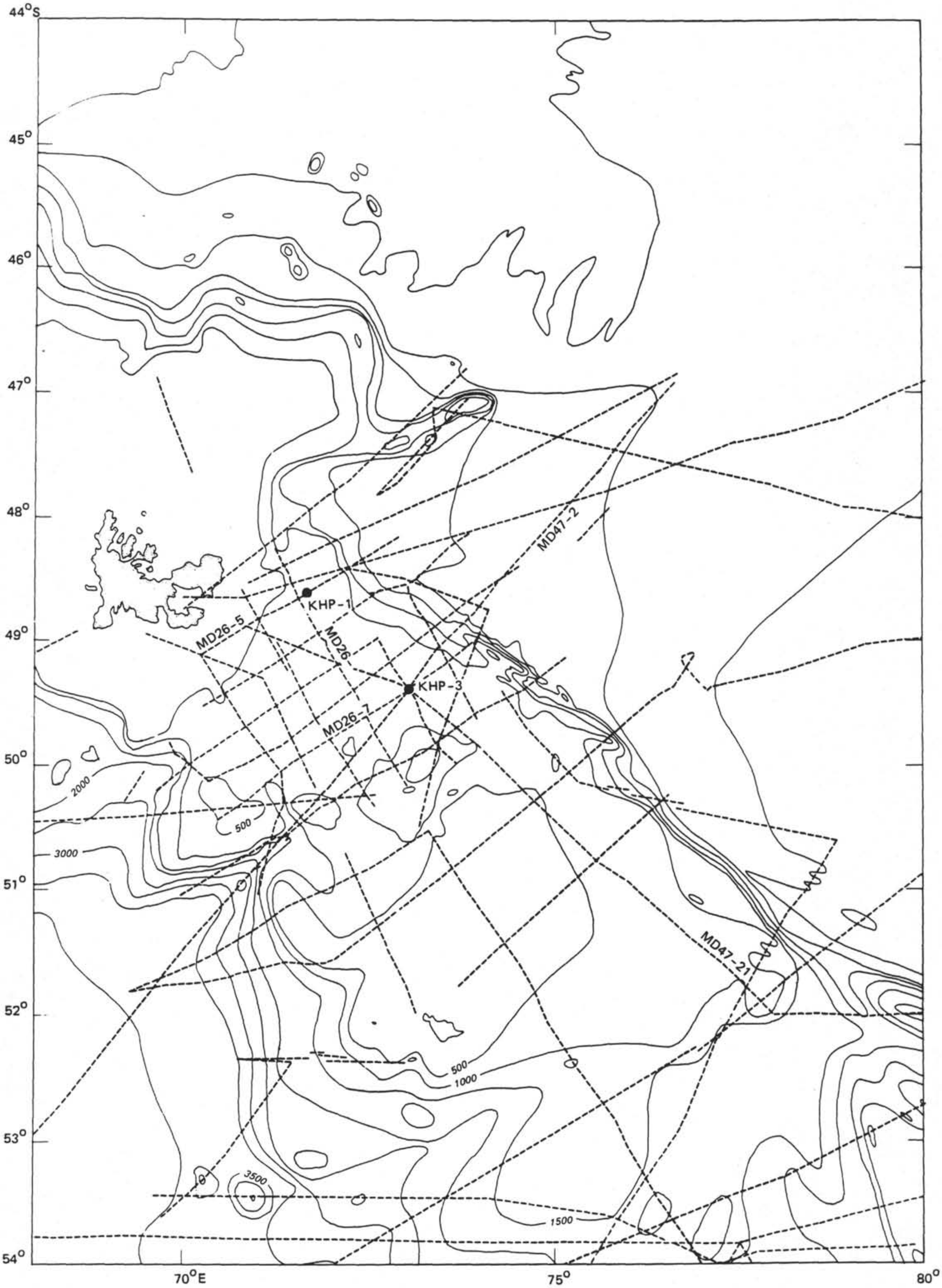

44°S
45°
46°
47°
48°
49°
50°
51°
52°
53°
54°
70°E
75°
80°
KHP-1
KHP-3
MD26-5
MD26
MD26-7
MD47-2
MD47-21
2000
500
3000
1000
3500
1500

Figure 4

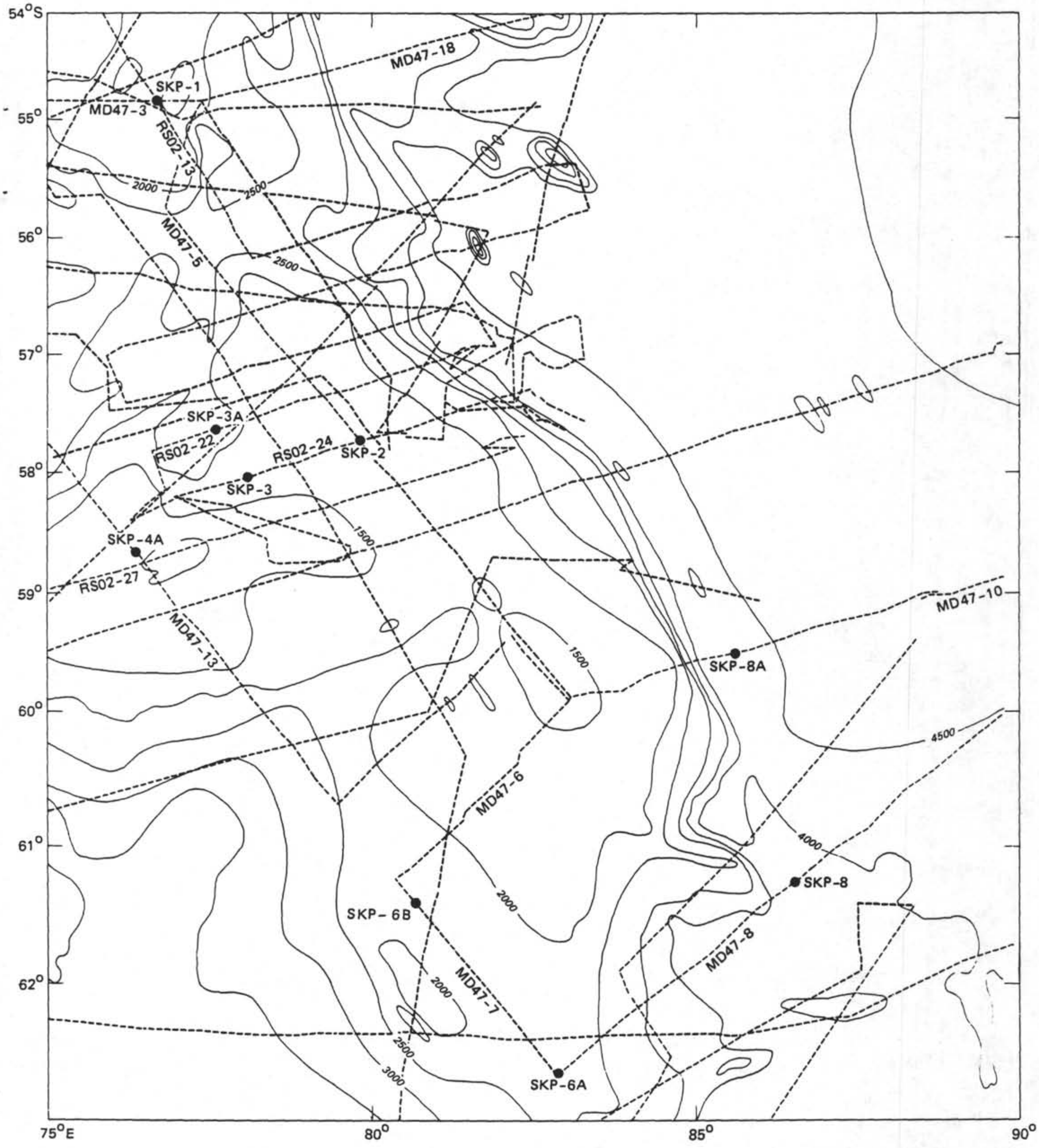

54°S
55°
56°
57°
58°
59°
60°
61°
62°
75°E
80°
85°
90°
MD47-18
SKP-1
MD47-3
RS02-13
MD47-5
SKP-3A
RS02-22
RS02-24
SKP-2
SKP-3
SKP-4A
RS02-27
MD47-13
MD47-10
SKP-8A
MD47-6
SKP-6B
MD47-7
SKP-6A
MD47-8
SKP-8
2000
2500
1500
3000
4000
4500

Figure 5

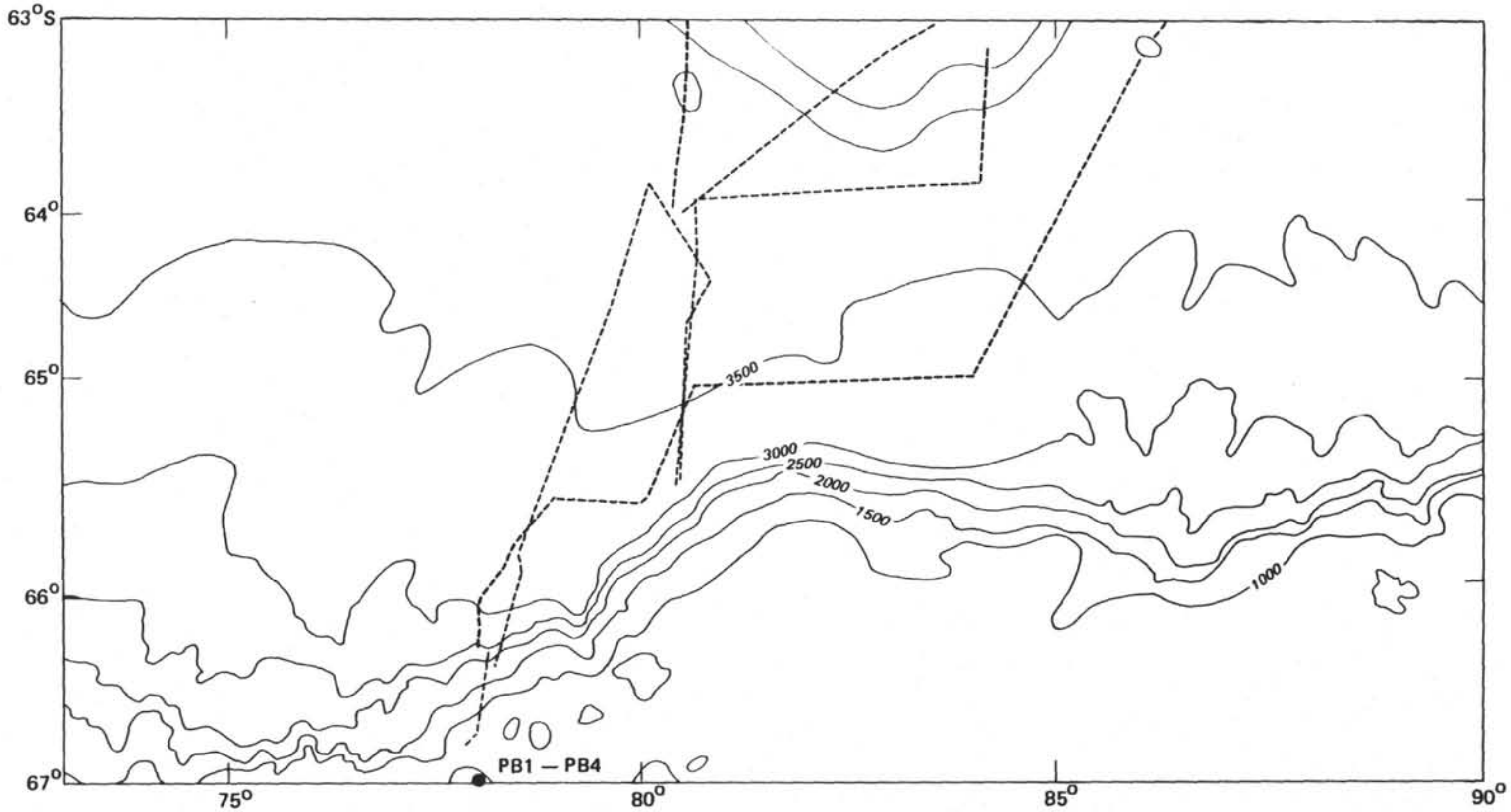


Figure 6

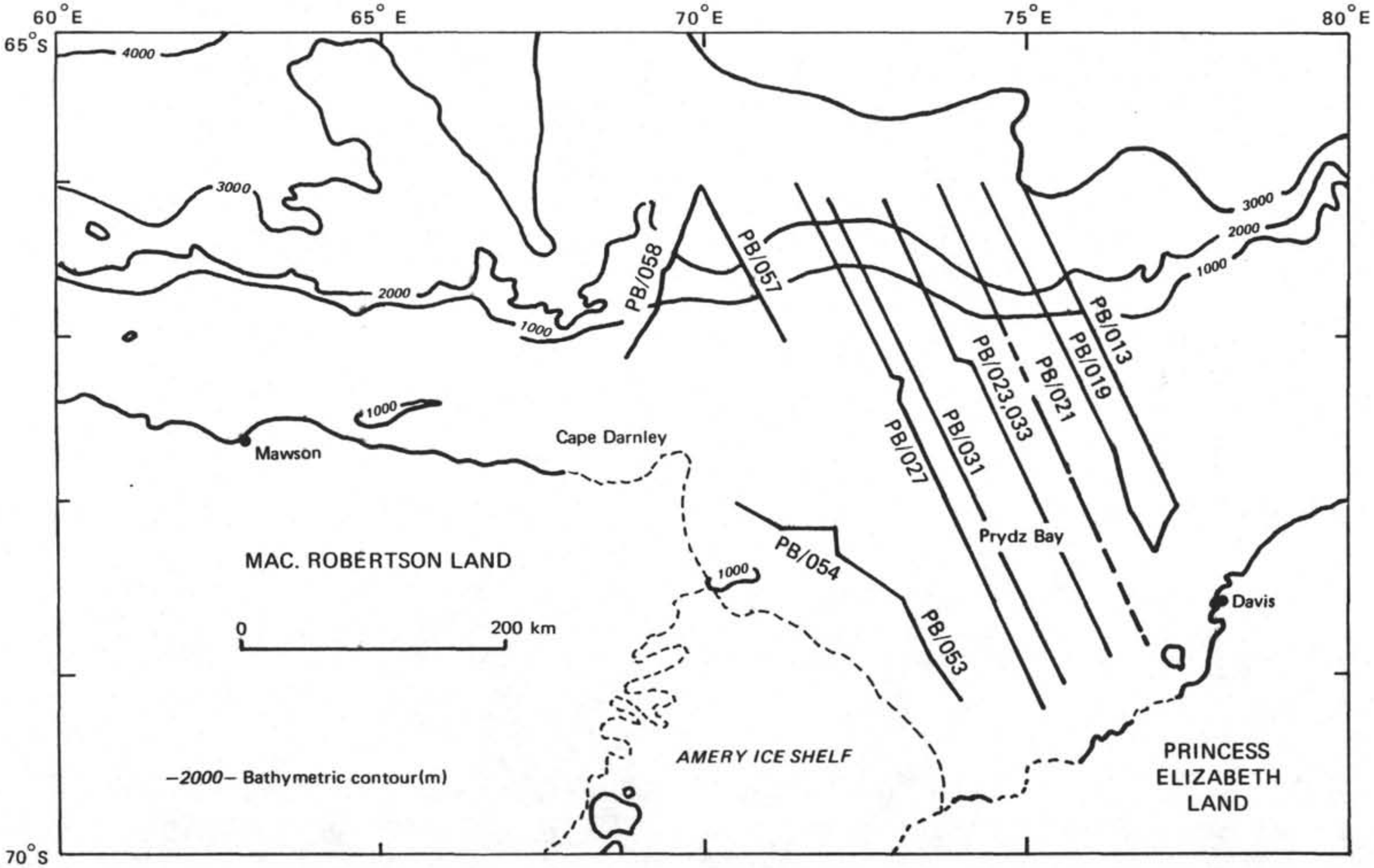

60°E
65° E
70°E
75°E
80°E
65°S
70°S
4000
3000
2000
1000
PB/058
PB/057
PB/013
PB/019
PB/021
PB/023,033
PB/031
PB/027
PB/054
PB/053
Mawson
Cape Darnley
Prydz Bay
Davis
MAC. ROBERTSON LAND
0
200 km
AMERY ICE SHELF
PRINCESS
ELIZABETH
LAND
-2000- Bathymetric contour(m)

Figure 7

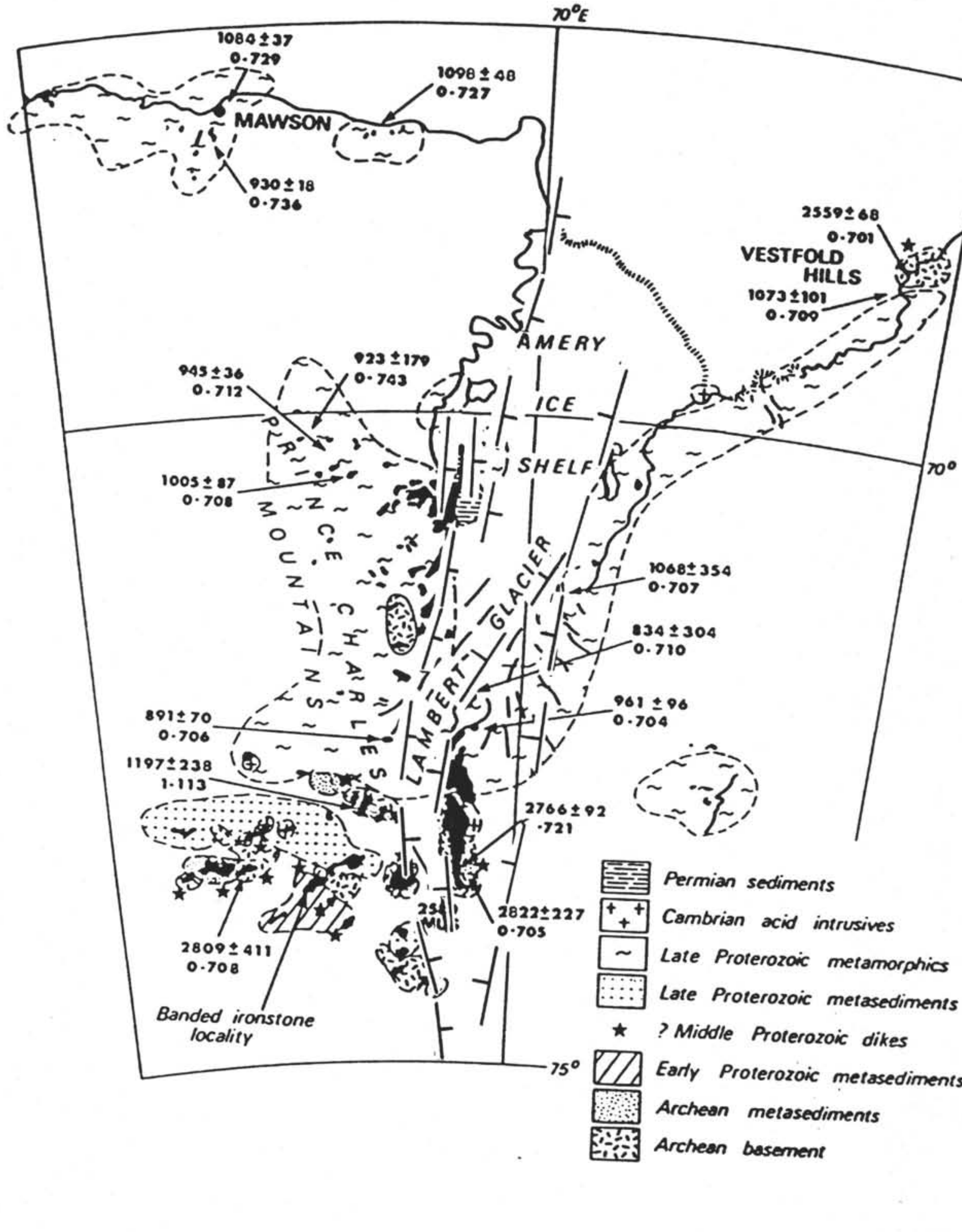
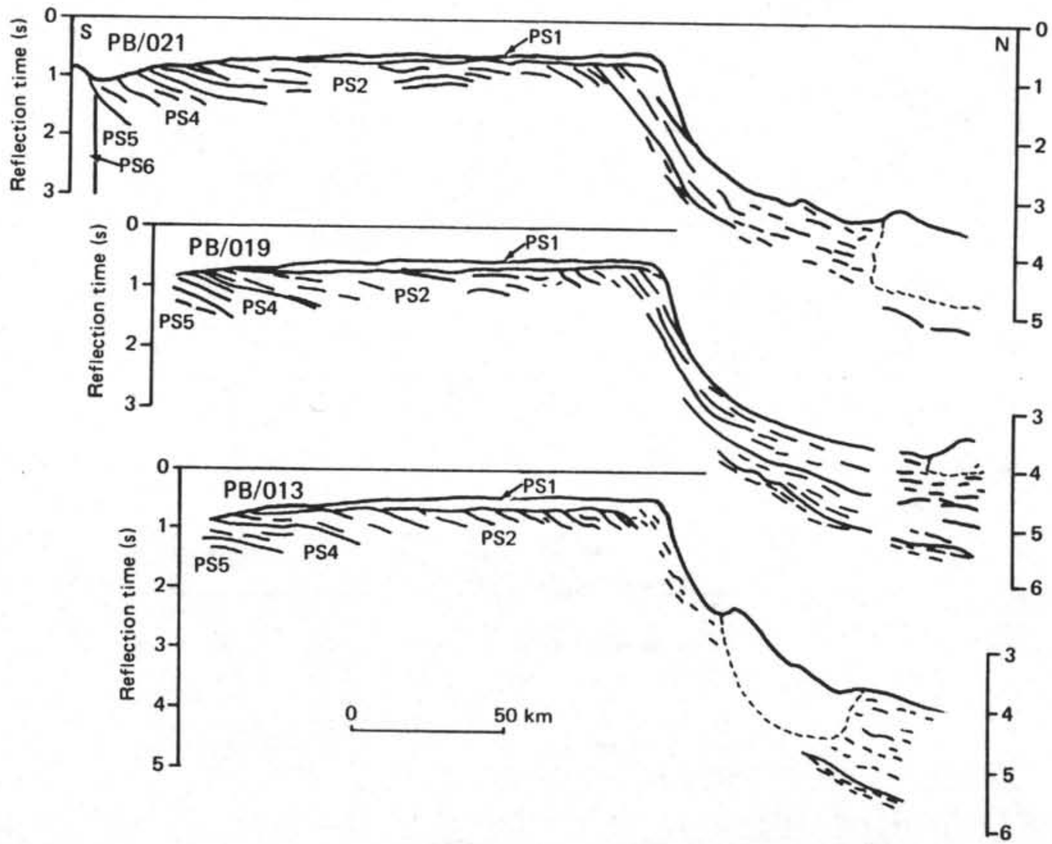
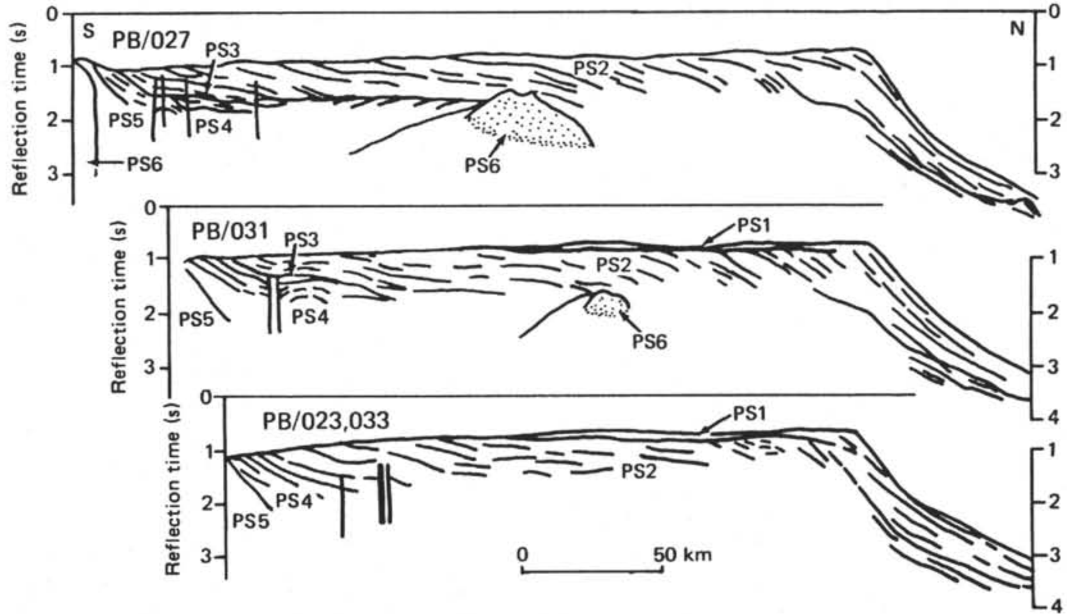

70°E
1084 ± 37
0·729
1098 ± 48
0·727
MAWSON
930 ± 18
0·736
2559 ± 68
0·701
VESTFOLD
HILLS
1073 ± 101
0·709
AMERY
ICE
SHELF
923 ± 179
0·743
945 ± 36
0·712
1005 ± 87
0·708
PRINCE CHARLES MOUNTAINS
LAMBERT GLACIER
1068 ± 354
0·707
834 ± 304
0·710
961 ± 96
0·704
891 ± 70
0·706
1197 ± 238
1·113
2766 ± 92
·721
2822 ± 227
0·705
2809 ± 411
0·708
Banded ironstone
locality
70°
75°
Permian sediments
Cambrian acid intrusives
Late Proterozoic metamorphics
Late Proterozoic metasediments
? Middle Proterozoic dikes
Early Proterozoic metasediments
Archean metasediments
Archean basement

Figure 8



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

Figure 9



S
PB/027
PS3
PS2
PS5
PS4
PS6
PS6
N
Reflection time (s)
PB/031
PS3
PS1
PS2
PS5
PS4
PS6
PB/023,033
PS1
PS2
PS4
PS5
0
50 km

Figure 10

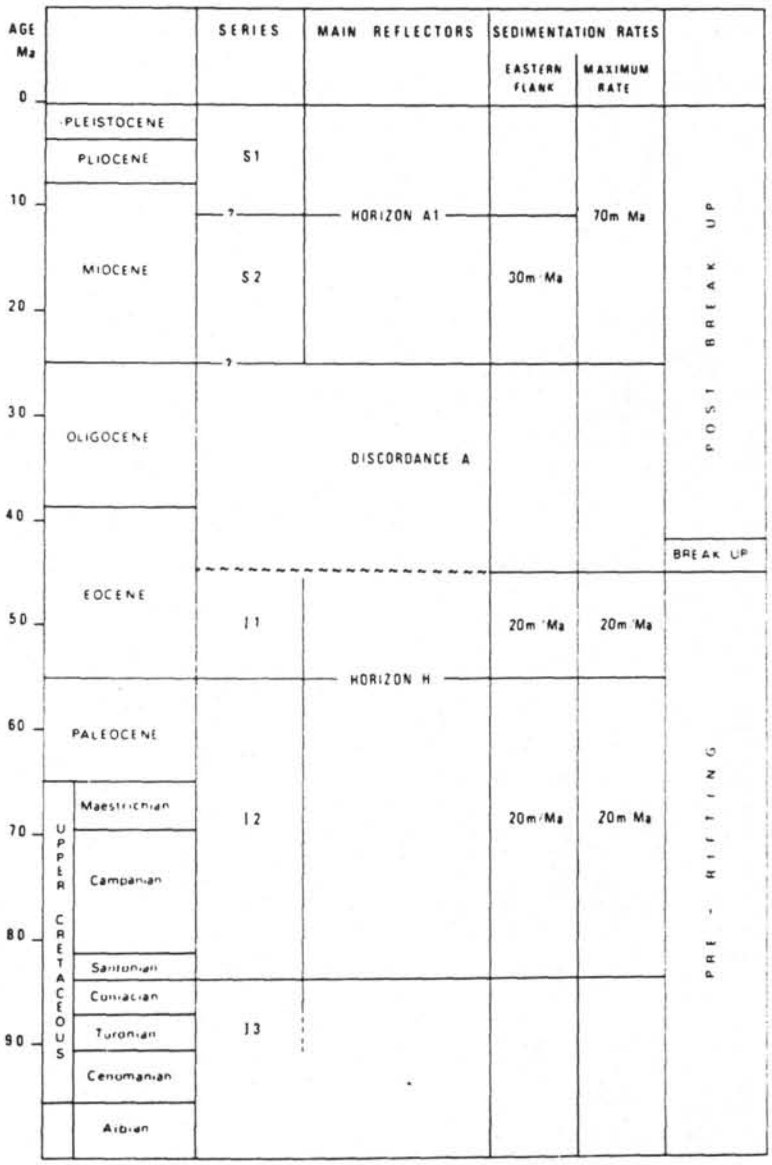

AGE Ma
SERIES
MAIN REFLECTORS
SEDIMENTATION RATES
EASTERN FLANK
MAXIMUM RATE
0
10
20
30
40
50
60
70
80
90
PLEISTOCENE
PLIOCENE
MIOCENE
OLIGOCENE
EOCENE
PALEOCENE
UPPER CRETACEOUS
Maestrichian
Campanian
Santonian
Coniacian
Turonian
Cenomanian
Albian
S1
S2
I1
I2
I3
?
HORIZON A1
DISCORDANCE A
HORIZON H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

Figure 11 .

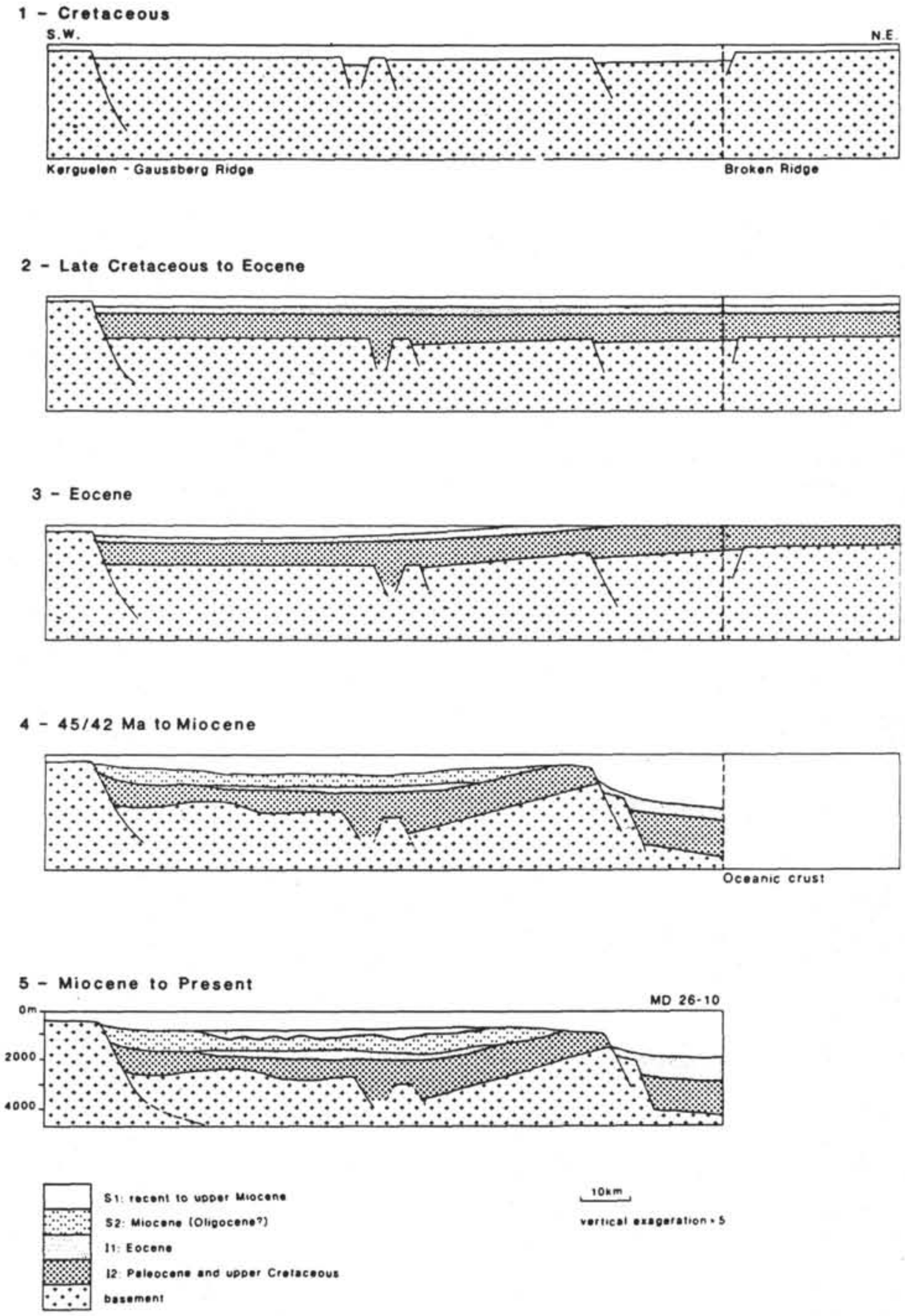

1 - Cretaceous
S.W.
N.E.
Kerguelen - Gaussberg Ridge
Broken Ridge
2 - Late Cretaceous to Eocene
3 - Eocene
4 - 45/42 Ma to Miocene
Oceanic crust
5 - Miocene to Present
MD 26-10
0m
2000
4000
S1: recent to upper Miocene
S2: Miocene (Oligocene?)
I1: Eocene
I2: Paleocene and upper Cretaceous
basement
10km
vertical exageration × 5

Figure 12

<u>SITE</u> <u>NUMBER</u>: KHP-1 (Northern Kerguelen Plateau)

<u>POSITION</u>: 49°23.6'S, 71°39.5'E <u>JURISDICTION</u>: French

<u>SEDIMENT</u> <u>THICKNESS</u>: 3170 m <u>PRIORITY</u>: 1

<u>WATER</u> <u>DEPTH:</u> 660 m

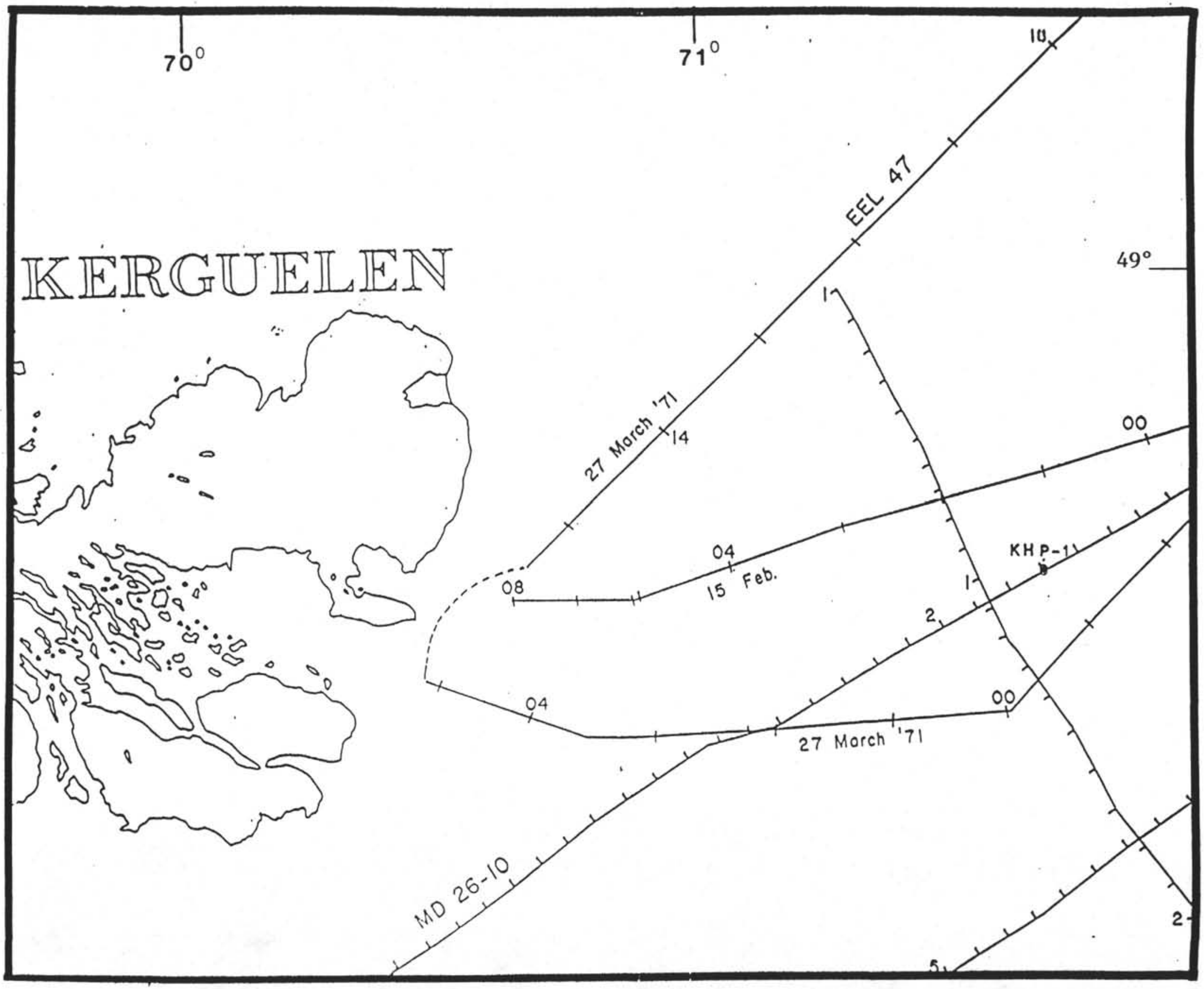
<u>PROPOSED</u> <u>DRILLING</u> <u>PROGRAM</u>:
APC, XCB and RCB continuous coring to 910 mbsf.

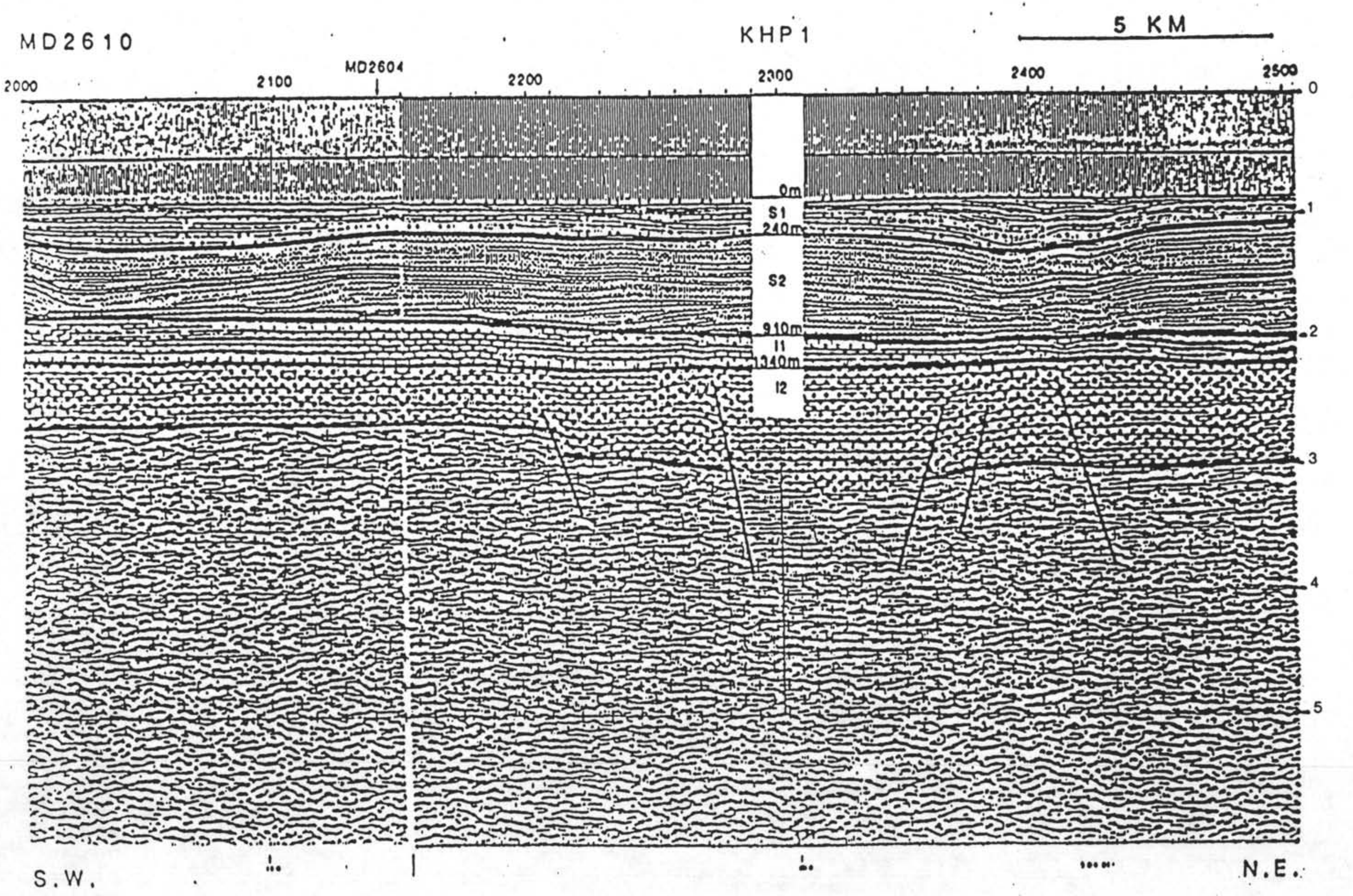
<u>SEISMIC</u> <u>RECORD</u>:
Seismic profiles MD 26-10 (2300)

<u>LOGGING</u>:
Standard Schlumberger (3 runs) and Vertical Seismic Profile (VSP).

<u>OBJECTIVES</u>:
To obtain a complete stratigraphic record from the Oligocene to Holocene; to sample and date the major unconformity; to document the tectonic (rifting from Broken Ridge) and subsidence history from the Eocene to Holocene; and to determine the age and evolution of Kerguelen Island.

<u>SEDIMENT</u> <u>TYPE</u>:
Calcareous oozes with siliceous biogenic components, diatomaceous oozes, chalk, glauconitic sands, clastic deposits.


70°
71°
KERGUELEN
49°
EEL 47
27 March '71
14
10
00
04
15 Feb.
08
KHP-1
1
2
00
04
27 March '71
MD 26-10
2
5


MD2610
KHP1
5 KM
2000
2100
MD2604
2200
2300
2400
2500
0m
S1
240m
S2
910m
I1
1340m
I2
0
1
2
3
4
5
Two Way Traveltime (Sec.)
S.W.
N.E.

SITE NUMBER: SKP-6A (Southern Kerguelen Plateau)

POSITION: $62^{o}44.0'S$, $83^{o}05.2'E$ JURISDICTION: Antarctic Treaty

SEDIMENT THICKNESS: 500 m PRIORITY: 1

WATER DEPTH: 2360 m

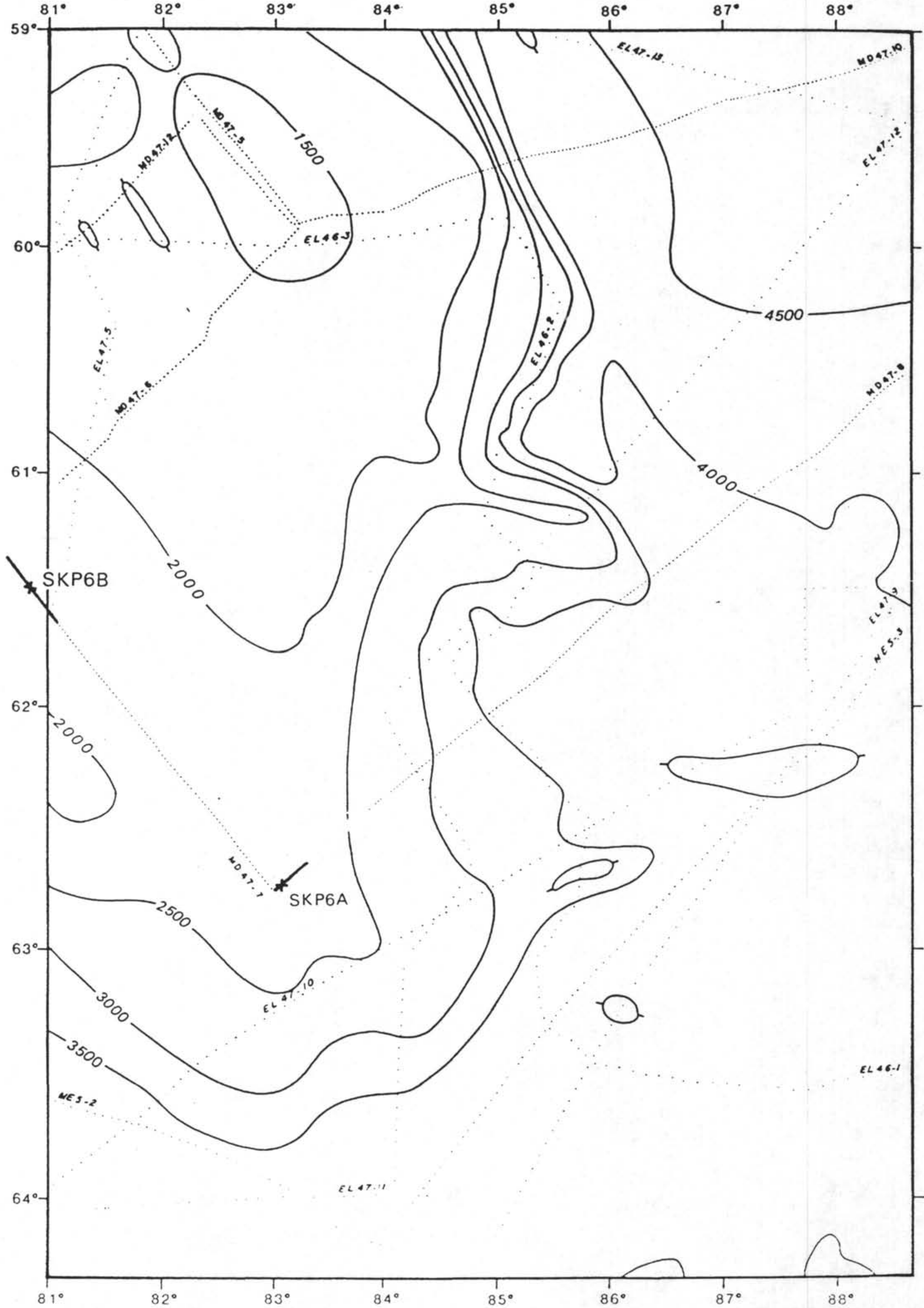
PROPOSED DRILLING PROGRAM:
APC and RCB continuous coring to 550 mbsf.

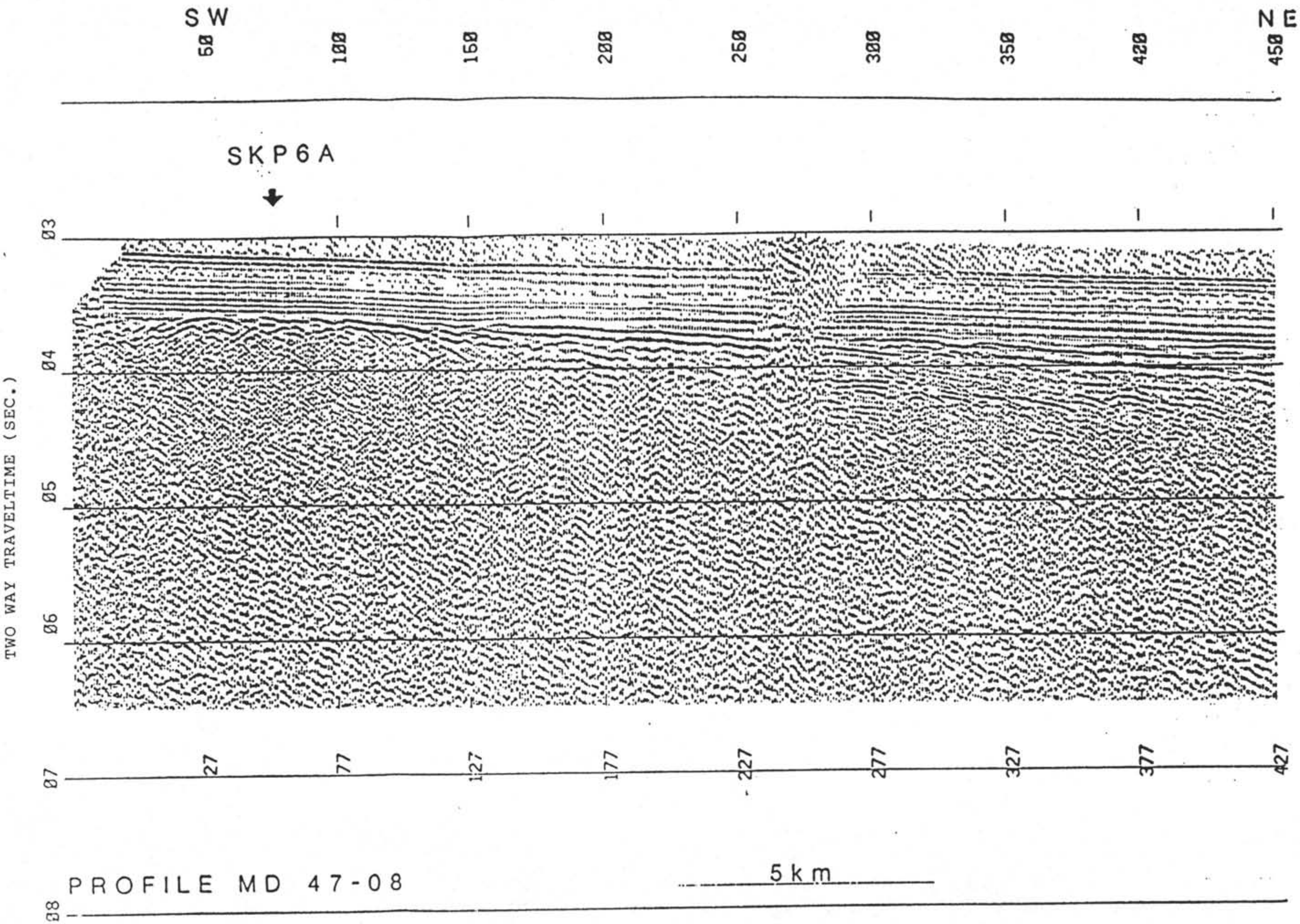
SEISMIC RECORD: Seismic profiles MD47-08 (0800/SP50).

LOGGING:
Standard Schlumberger (3 runs).

OBJECTIVES:
To obtain a continuous Neogene and Paleogene stratigraphic section from the Southern Kerguelen Plateau. Determine the nature and age of basement from the Southern Kerguelen Plateau. Determine Paleogene and Mesozoic history of changing ocean conditions, rifting and subsidence of the Kerguelen Plateau.

SEDIMENT TYPE:
Calcareous and siliceous oozes, chalk, volcanics, and basement.


81°
82°
83°
84°
85°
86°
87°
88°
59°
60°
61°
62°
63°
64°
1500
2000
2000
2500
3000
3500
4000
4500
SKP6B
SKP6A
EL47-13
MD47-10
MD47-12
MD47-5
EL46-3
EL47-12
EL47-5
MD47-6
EL46-2
MD47-8
EL47-3
ME5-3
MD47-7
EL47-10
ME5-2
EL47-11
EL46-1


SW
NE
5Ø
1ØØ
15Ø
2ØØ
25Ø
3ØØ
35Ø
42Ø
45Ø
SKP6A
Ø3
Ø4
Ø5
Ø6
Ø7
Ø8
TWO WAY TRAVELTIME (SEC.)
27
77
127
177
227
277
327
377
427
5 km
PROFILE MD 47-08

SITE NUMBER: Prydz Bay sites (PB)

POSITION: 67° - 67°45.0'S, 78°E JURISDICTION: Antarctic Treaty

SEDIMENT THICKNESS: about 1.5km PRIORITY: 1

WATER DEPTH: 800 m

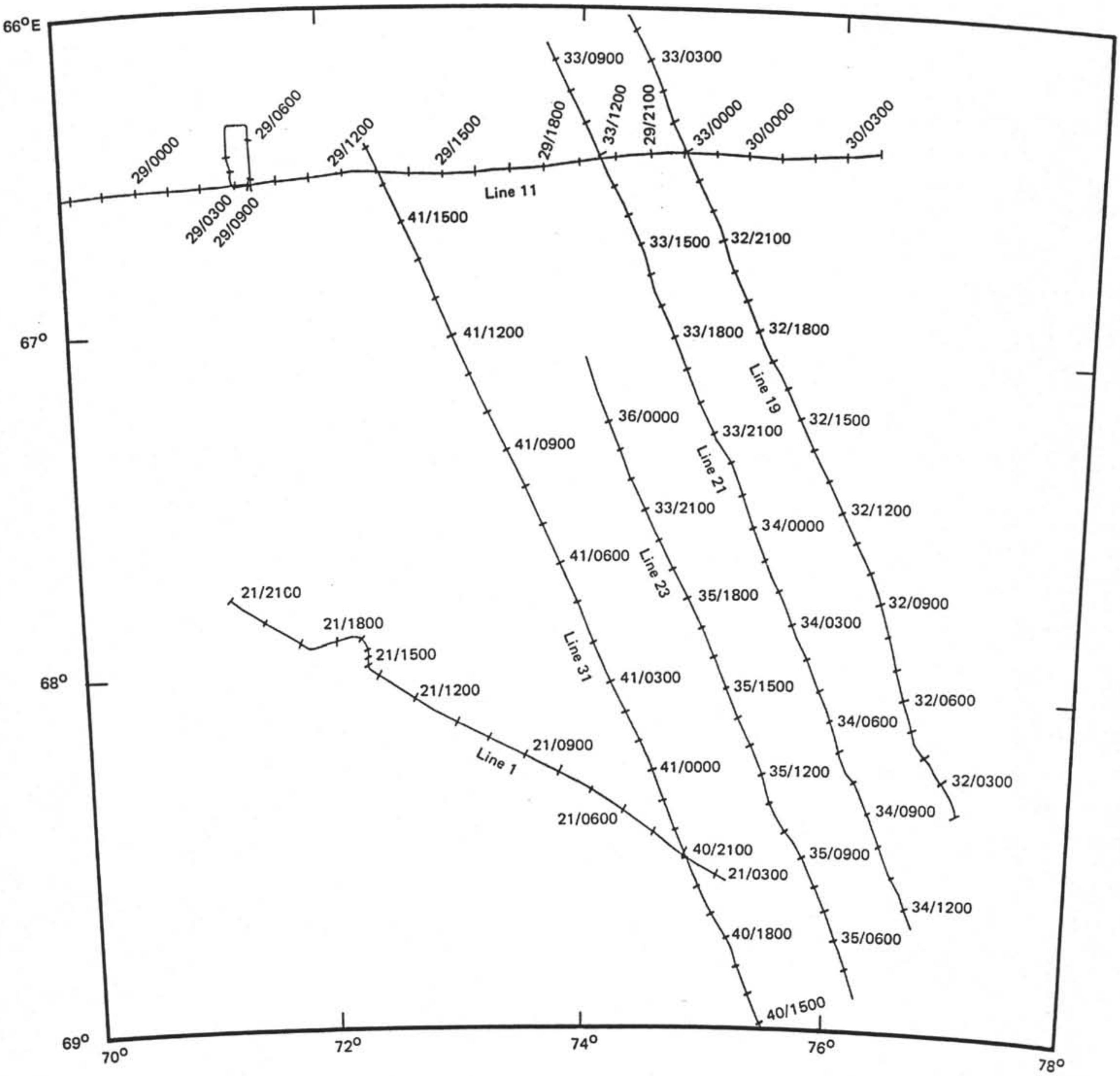
PROPOSED DRILLING PROGRAM:
APC and XCB continuous coring to 500 mbsf at each site.

SEISMIC RECORD:
Line PB-021.

LOGGING:
Standard Schlumberger (3 runs)

OBJECTIVES:
To document the preglacial and glacial history of East Antarctica; the timing of glacial erosion; breakup and paleoenvironmental history of the continental margin; and the ocean response to changing Antarctic climate.

SEDIMENT TYPE: Unconsolidated to consolidated sedimentary rocks and glacial marine sediments.


66°E
67°
68°
69°
70°
72°
74°
76°
78°
Line 11
Line 19
Line 21
Line 23
Line 31
Line 1
29/0000
29/0300
29/0600
29/0900
29/1200
29/1500
29/1800
29/2100
30/0000
30/0300
33/0000
33/0300
33/0900
33/1200
33/1500
33/1800
33/2100
32/2100
32/1800
32/1500
32/1200
32/0900
32/0600
32/0300
34/0000
34/0300
34/0600
34/0900
34/1200
36/0000
35/1800
35/1500
35/1200
35/0900
35/0600
41/1500
41/1200
41/0900
41/0600
41/0300
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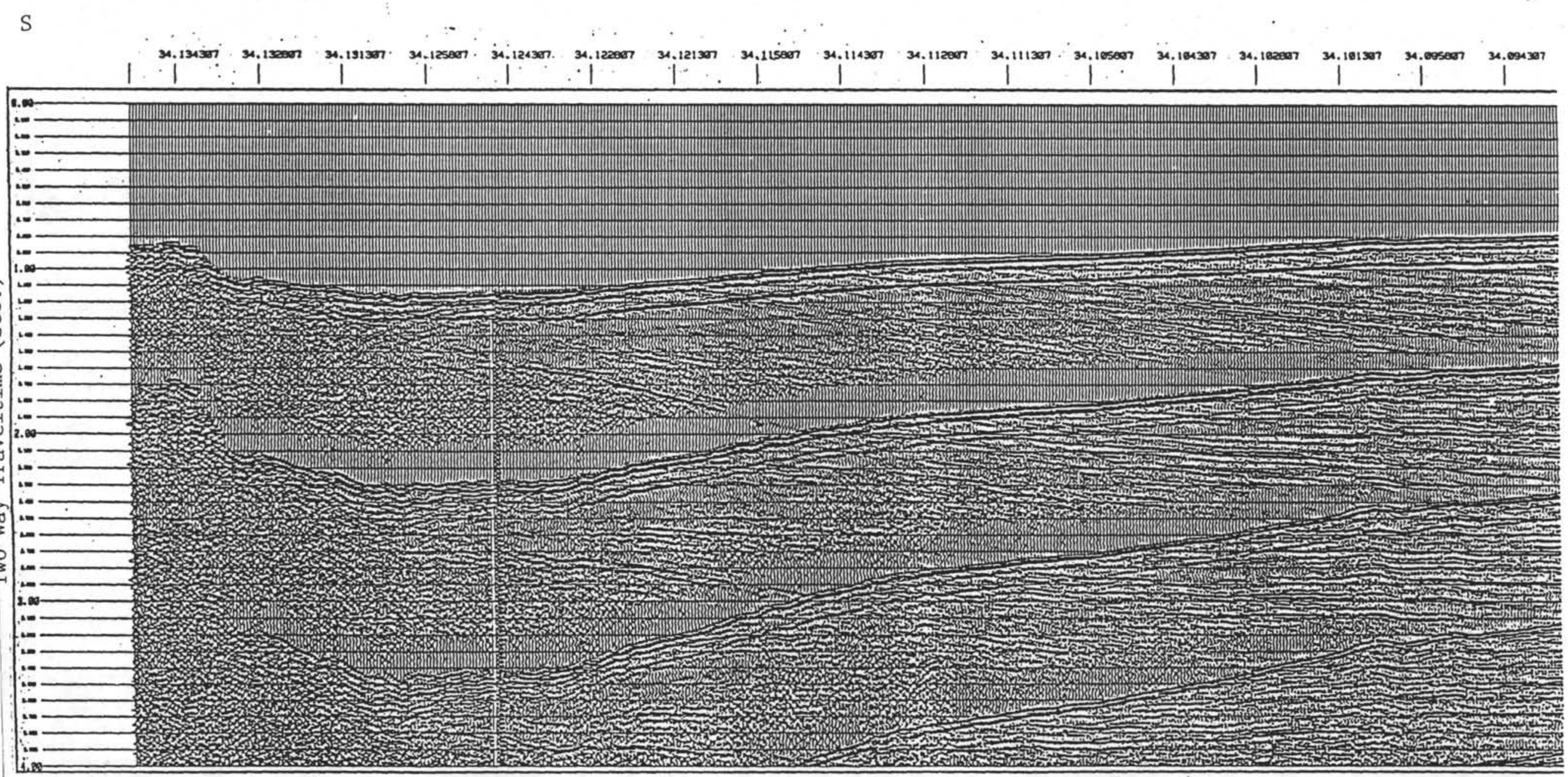
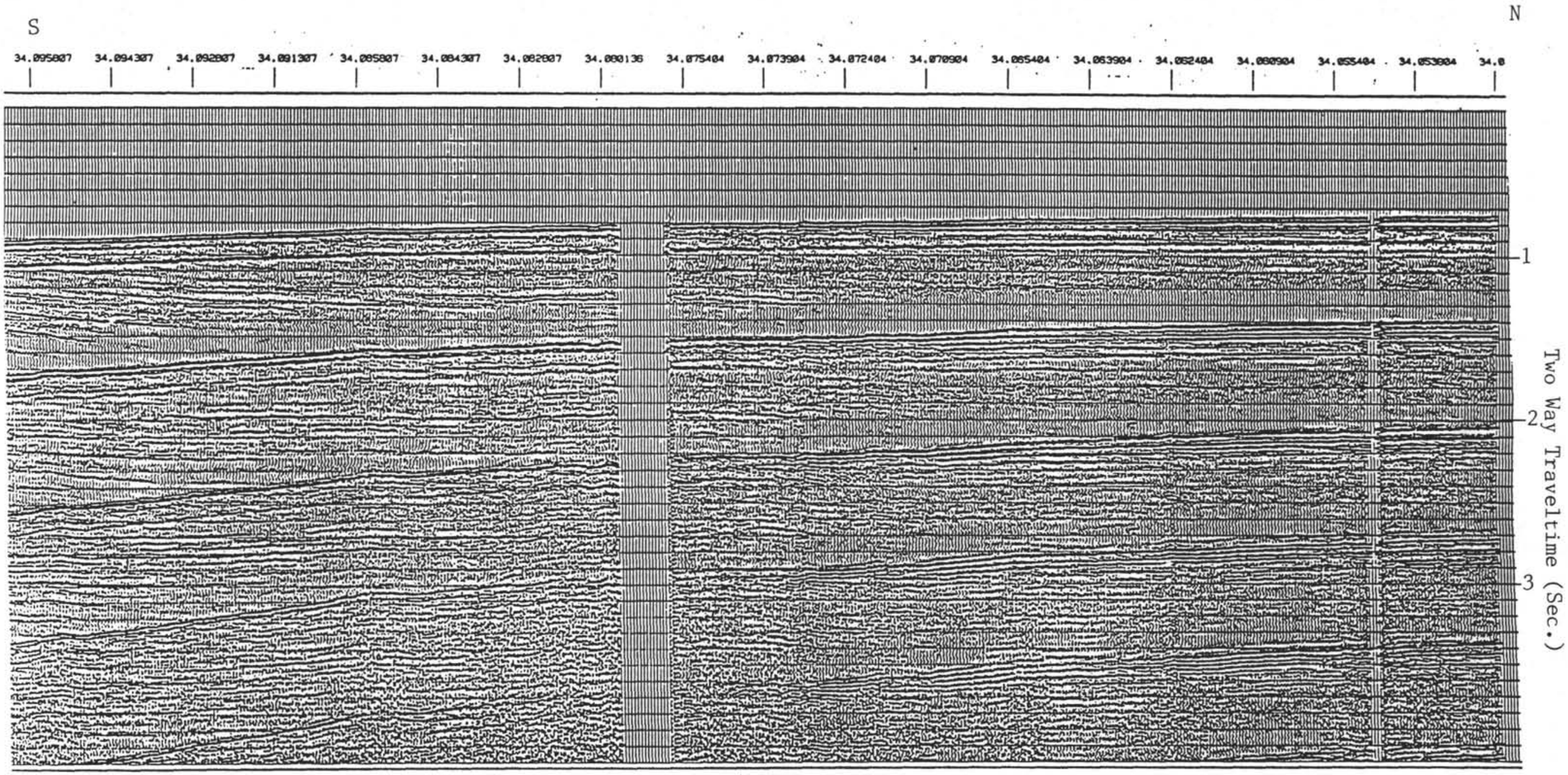
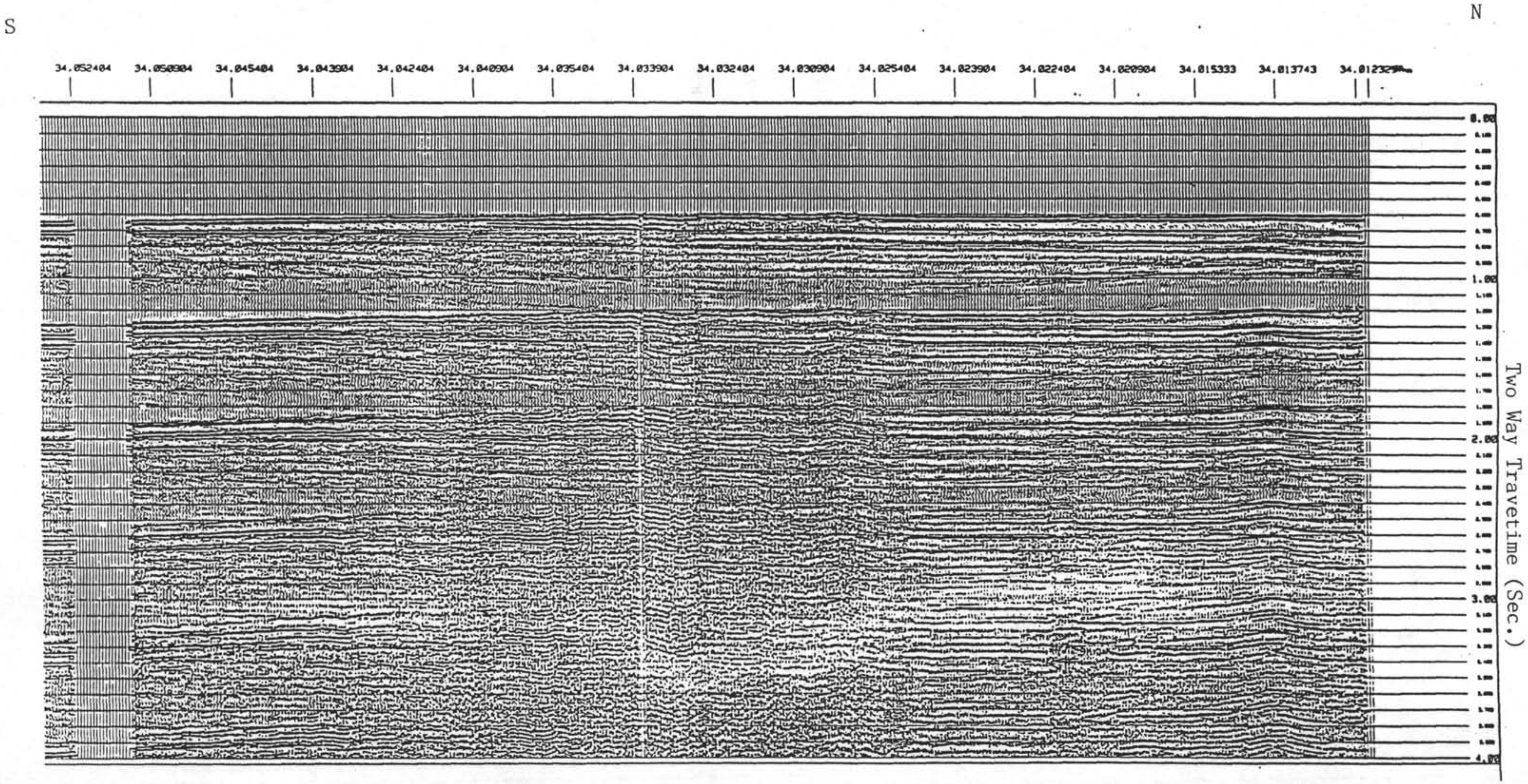
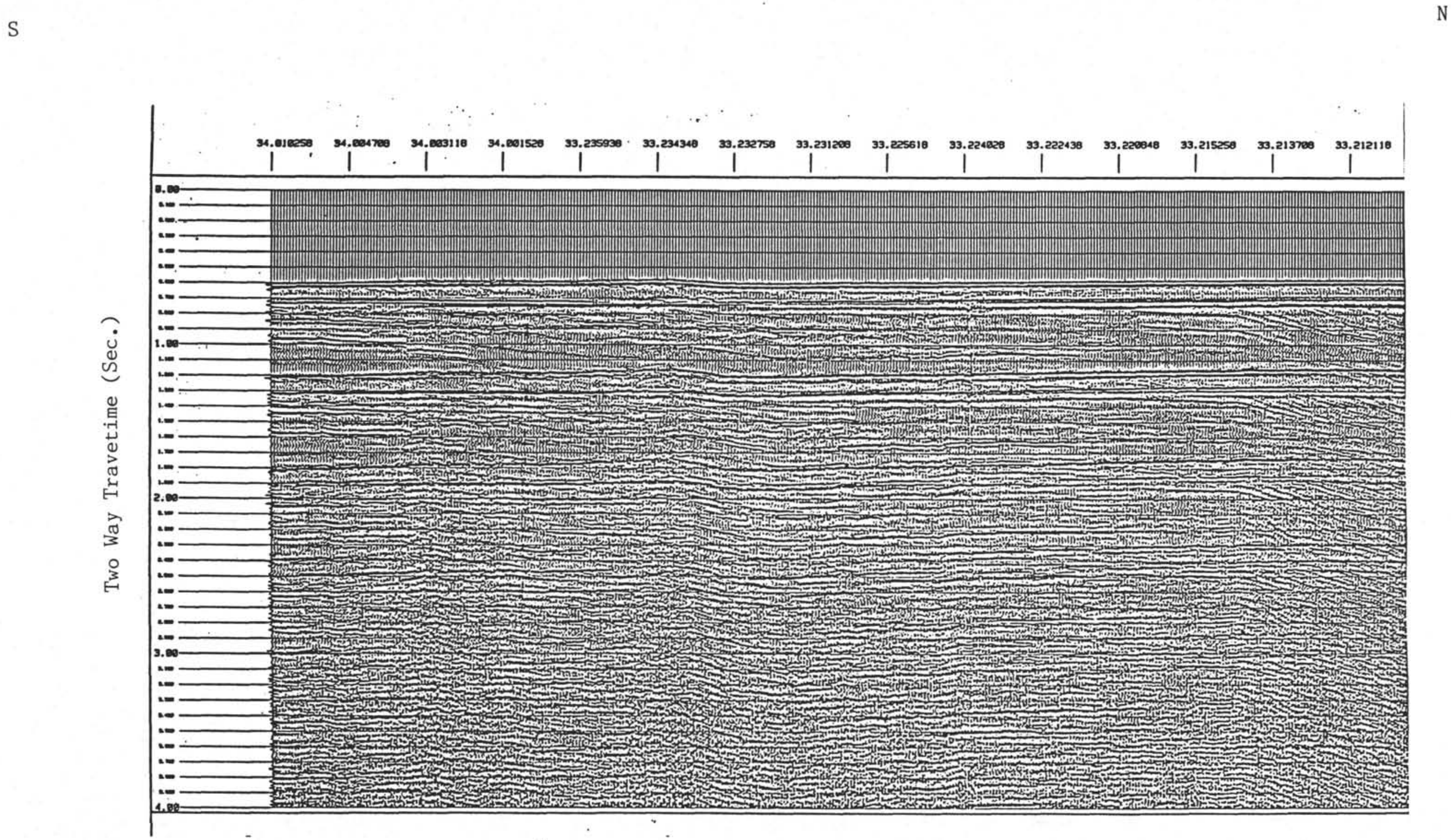
21/0600
21/0300


S
N
34.134307
34.132007
34.131307
34.125007
34.124307
34.122007
34.121307
34.115007
34.114307
34.112007
34.111307
34.105007
34.104307
34.102007
34.101307
34.095007
34.094307
0.00
1.00
2.00
3.00
4.00
Two way traveltime (sec.)



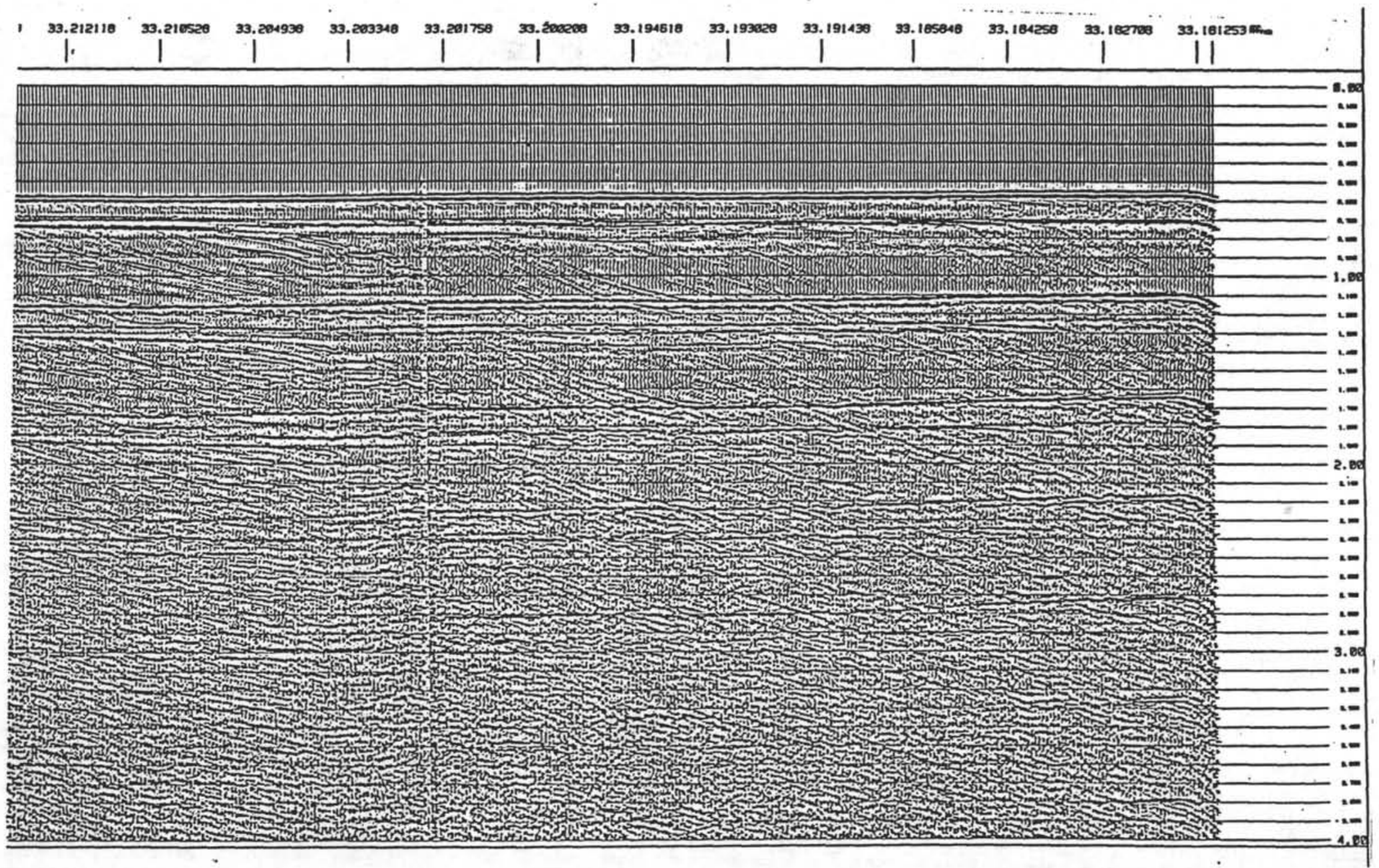
S
N
34.095807
34.094307
34.092807
34.091307
34.085807
34.084307
34.082807
34.080136
34.075404
34.073904
34.072404
34.070904
34.065404
34.063904
34.062404
34.060904
34.055404
34.053804
34.0
1
2
3
Two Way Traveltime (Sec.)


S
N
34.052404
34.050904
34.045404
34.043904
34.042404
34.040904
34.035404
34.033904
34.032404
34.030904
34.025404
34.023904
34.022404
34.020904
34.015333
34.013743
0.00
1.00
2.00
3.00
4.00
Two Way Traveltime (Sec.)

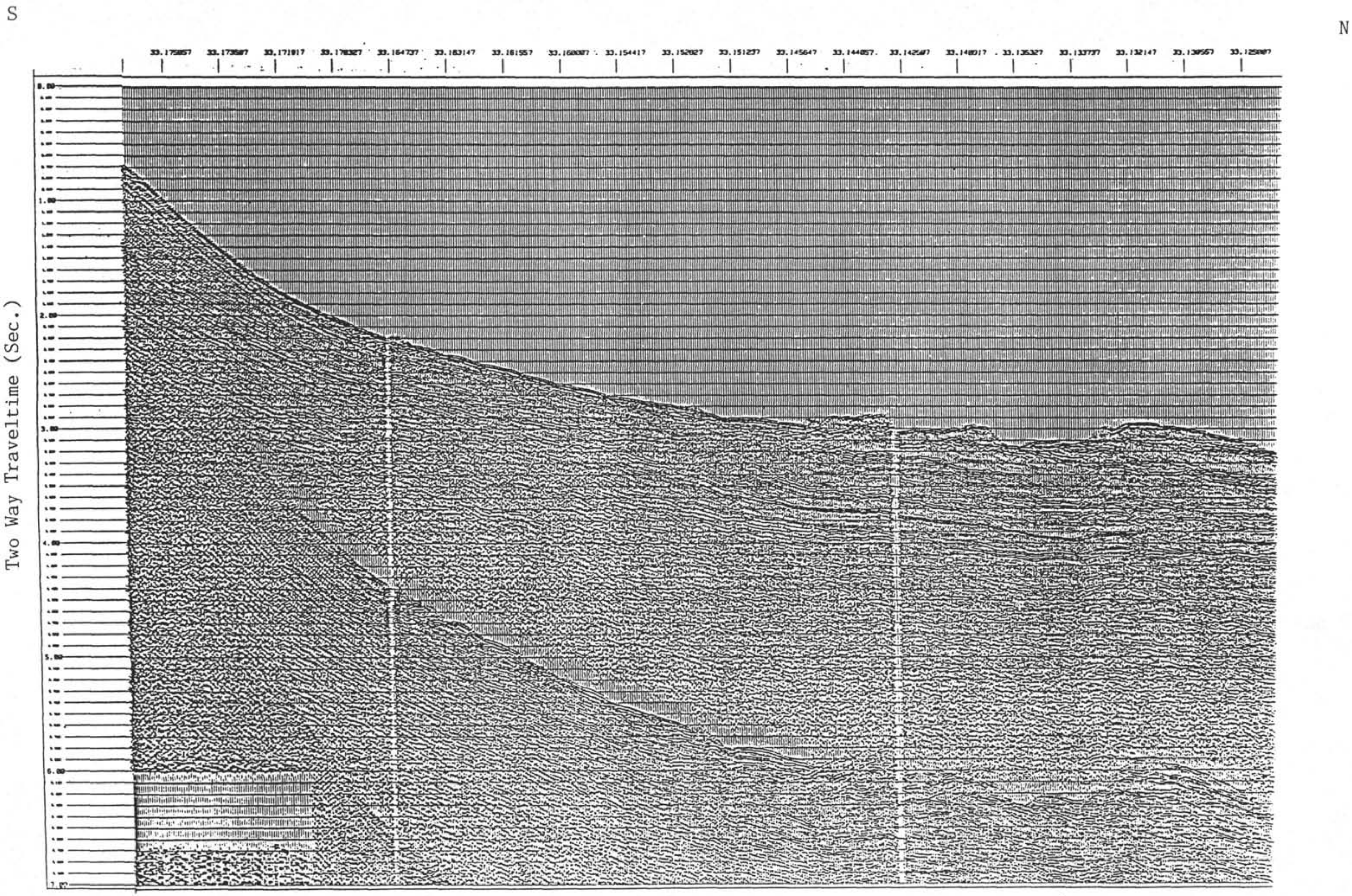

S
N
Two Way Travetime (Sec.)
34.010250
34.004700
34.003110
34.001520
33.235930
33.234340
33.232750
33.231200
33.225610
33.224020
33.222430
33.220840
33.215250
33.213700
33.212110
0.00
1.00
2.00
3.00
4.00

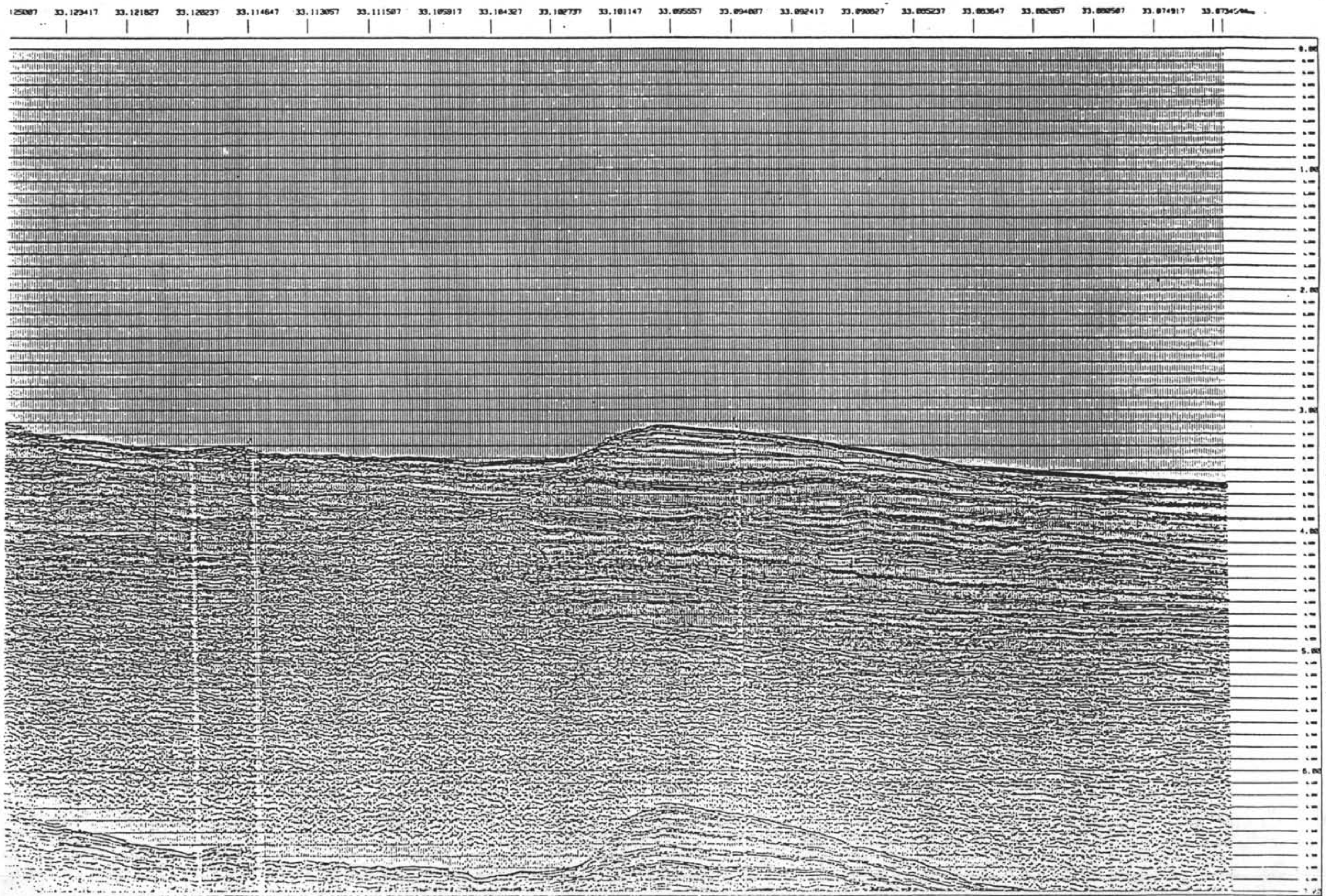
S

N



Two Way Traveltime (Sec.)


S
N
Two Way Traveltime (Sec.)


S
N
Two Way Traveltime (Sec.)

ALTERNATE SITE NUMBER: SKP-6B (Southern Kerguelen Plateau)

POSITION: 61°31.4'S 80°52.1'E

JURISDICTION: Antarctic Treaty

SEDIMENT THICKNESS: 1300?m

PRIORITY: alternate for Prydz Bay

WATER DEPTH: 2260m

PROPOSED DRILLING PROGRAM:
APC and XCB or RCB continuous coring to a depth of 1000 mbsf.

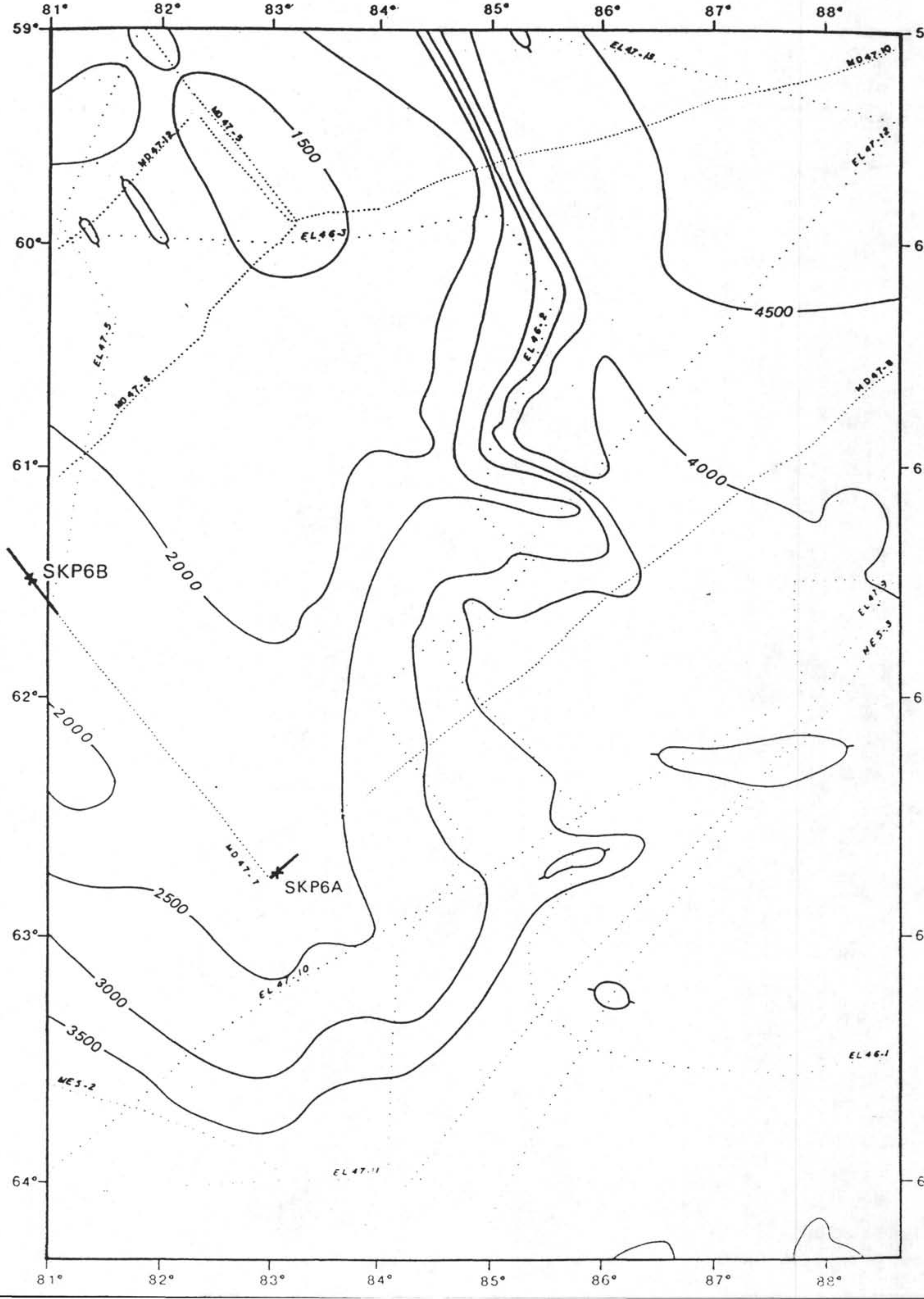
SEISMIC RECORD: MD47-07 (SP608)

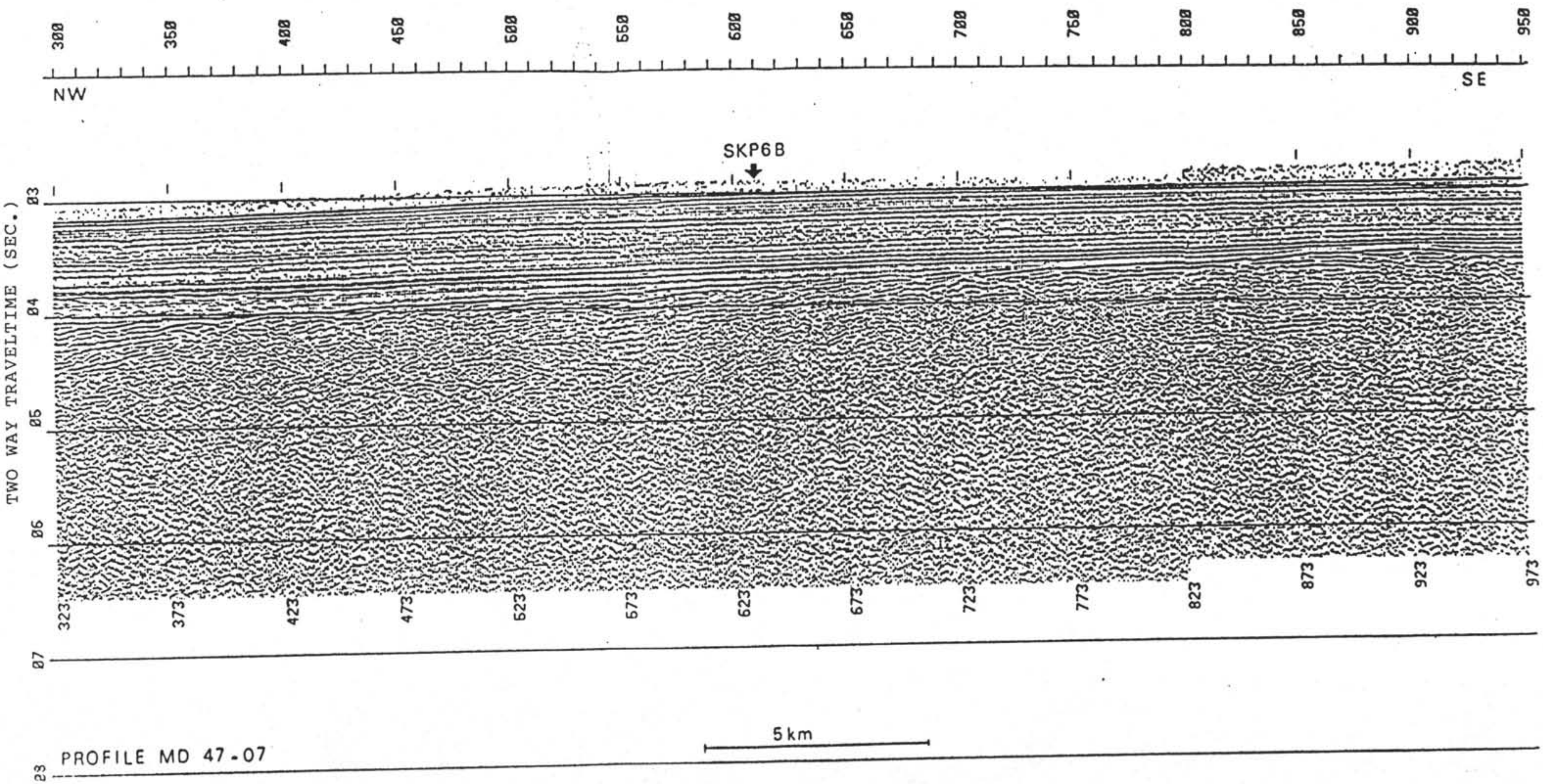
LOGGING:

Standard Schlumberger (3 runs).

OBJECTIVES:
To determine the nature of the sedimentary units, shift of the polar front, and determine the evolution and tectonic history of the Southern Kerguelen Plateau.

SEDIMENT TYPE: Calcareous and siliceous oozes, chalks, volcanics and basement.


81°
82°
83°
84°
85°
86°
87°
88°
59°
60°
61°
62°
63°
64°
1500
4500
4000
2000
2000
2500
3000
3500
SKP6B
SKP6A
EL47-13
MD47-10
MD47-12
MD47-8
EL47-12
EL46-3
EL47-5
MD47-6
EL46-2
MD47-9
MD47-7
NES-3
EL47-10
NES-2
EL46-1
EL47-11



NW
SE
SKP6B
TWO WAY TRAVELTIME (SEC.)
5 km
PROFILE MD 47-07

ALTERNATE SITE NUMBER: SKP-8 (Kerguelen Sediment Ridge)

POSITION: 61°17.8'S, 86°46.7'E JURISDICTION:

SEDIMENT THICKNESS: 500 m PRIORITY: 2

WATER DEPTH: 3850 m

PROPOSED DRILLING PROGRAM:
APC continuous coring.
RCB continuous coring.

SEISMIC RECORD: MD 47-08 multichannel profile (SP 5120)?.

LOGGING:
Standard Schlumberger (3 runs).

OBJECTIVES:
To sample the sediment ridge close to the southeastern limit of the plateau; to document the paleoceanographic history of the SOUTHERN Kerguelen Plateau, including the initiation and development of Circumpolar and Antarctic Bottom Water (AABW) circulation.

SEDIMENT TYPE:
Calcareous and siliceous ooze, chalk, chert and volcanics.

ALTERNATE SITE NUMBER: SKP-8A (Kerguelen Sediment Ridge)

POSITION: 59°32.0'S, 85°49.5'E JURISDICTION:

SEDIMENT THICKNESS: 1000 m PRIORITY: 2

WATER DEPTH: 4090 m

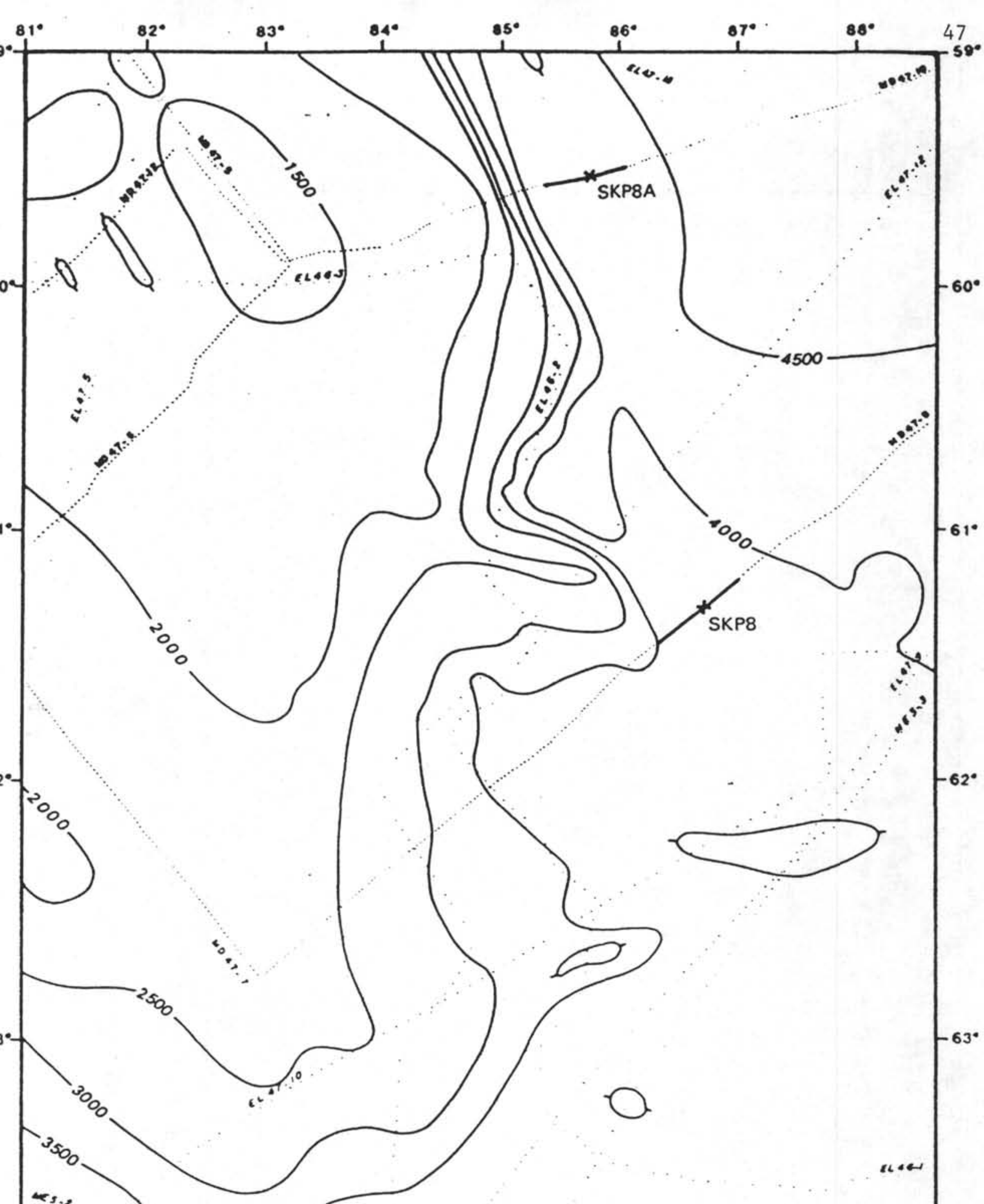
PROPOSED DRILLING PROGRAM:
APC continuous coring.
RCB continuous coring.

SEISMIC RECORD: MD 47-10 multichannel profile (SP 8110).

LOGGING:
Standard Schlumberger (3 runs).

OBJECTIVES:
To sample the sediment ridge close to the southeastern limit of the plateau; to document the paleoceanographic history of the southern Kerguelen Plateau, including the initiation and development of circumpolar and Antarctic Bottom Water (AABW) circulation.

SEDIMENT TYPE:
Calcareous and siliceous ooze, chalk, chert and volcanics.


81°
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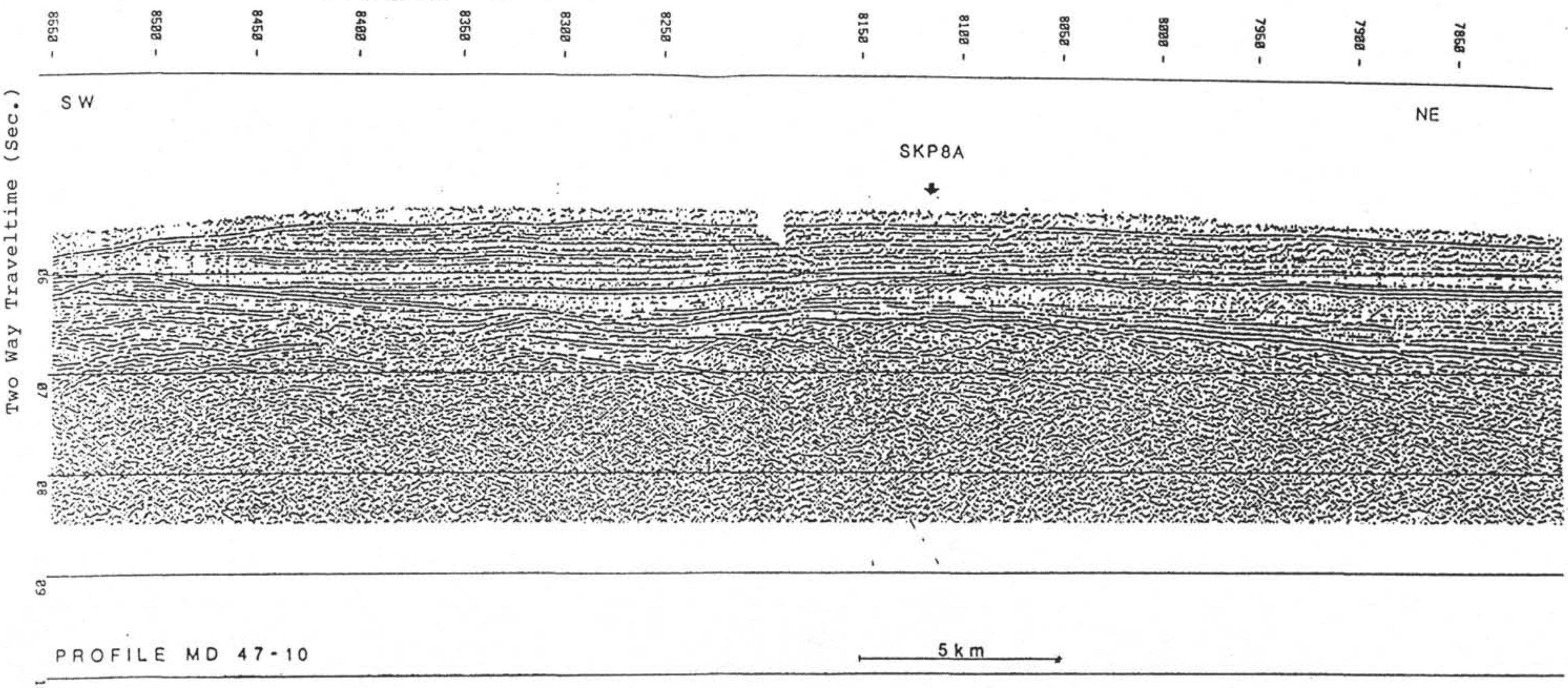
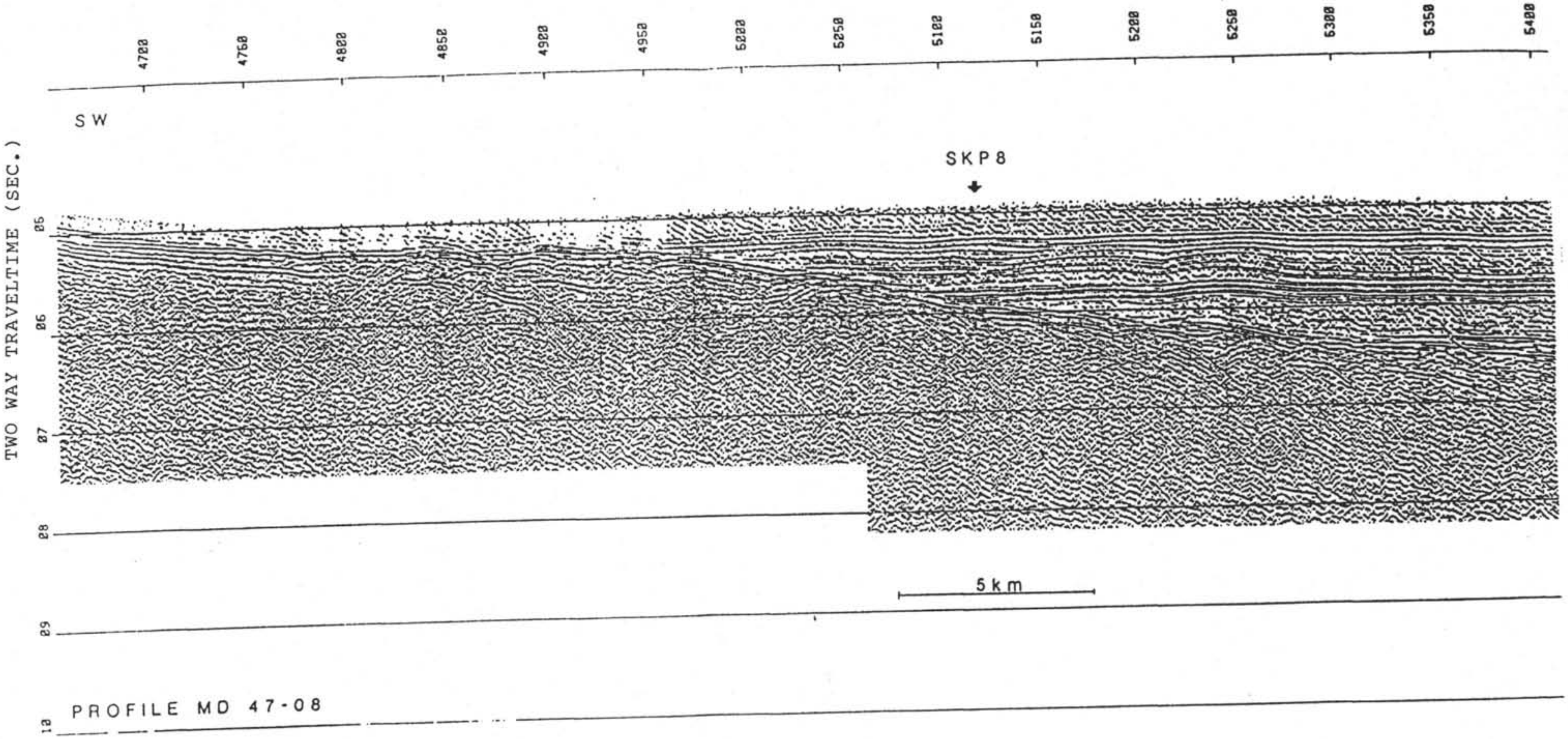
4500
SKP8A
SKP8
EL47-11



8550
8500
8450
8400
8350
8300
8250
8150
8100
8050
8000
7950
7900
7850
SW
NE
SKP8A
Two Way Traveltime (Sec.)
PROFILE MD 47-10
5 km


4700
4750
4800
4850
4900
4950
5000
5050
5100
5150
5200
5250
5300
5350
5400
SW
SKP8
TWO WAY TRAVELTIME (SEC.)
05
06
07
08
09
10
5 km
PROFILE MD 47-08

ALTERNATE SITE NUMBER: KHP-3 (Kerguelen-Heard Plateau)

POSITION: $50^{o}14.2'S$, $73^{o}02.5'E$ JURISDICTION: French

SEDIMENT THICKNESS: 1630 m PRIORITY: 3

WATER DEPTH: 570 m

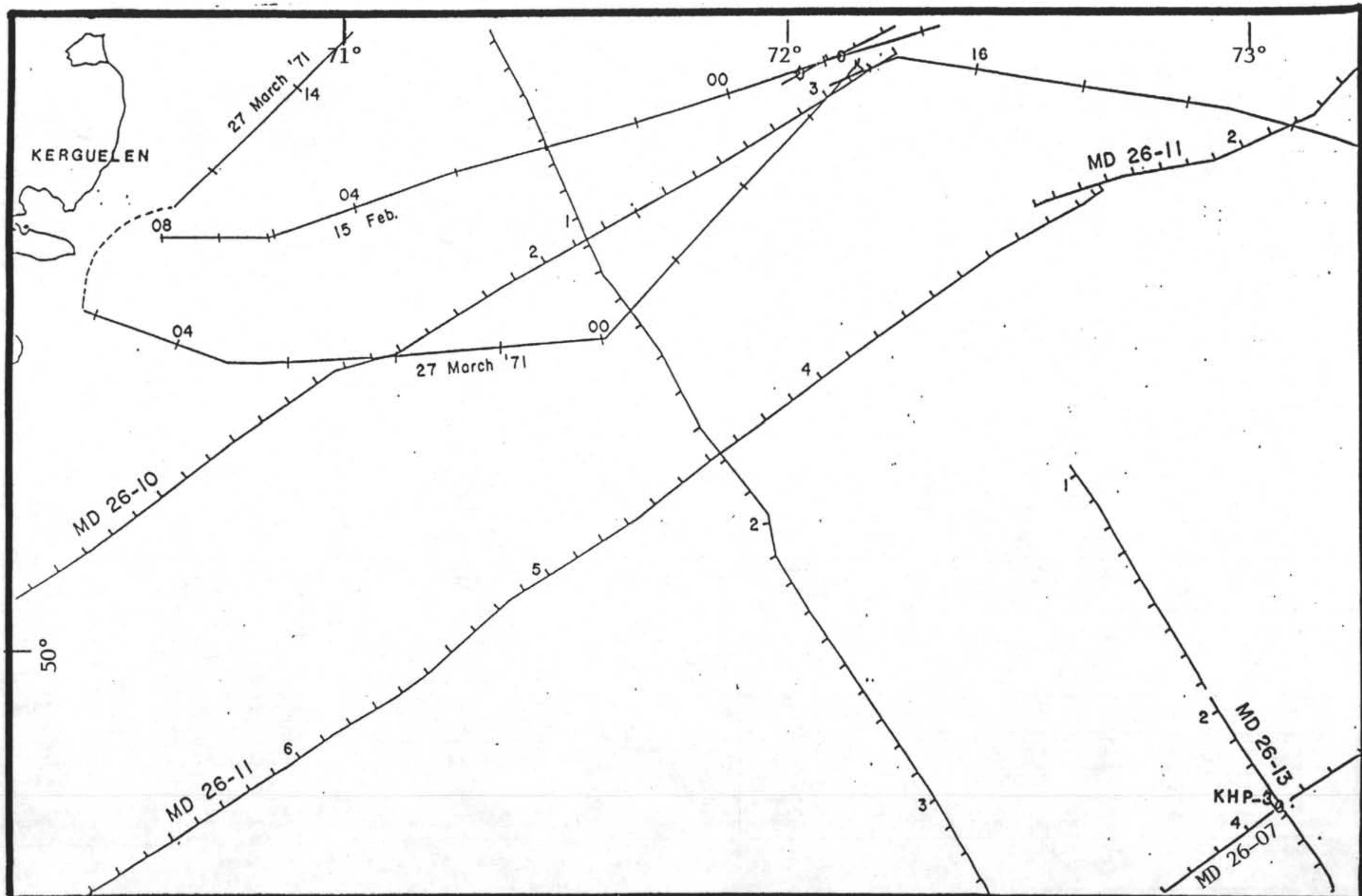
PROPOSED DRILLING PROGRAM:
APC continuous coring.
RCB continuous coring with re-entry.

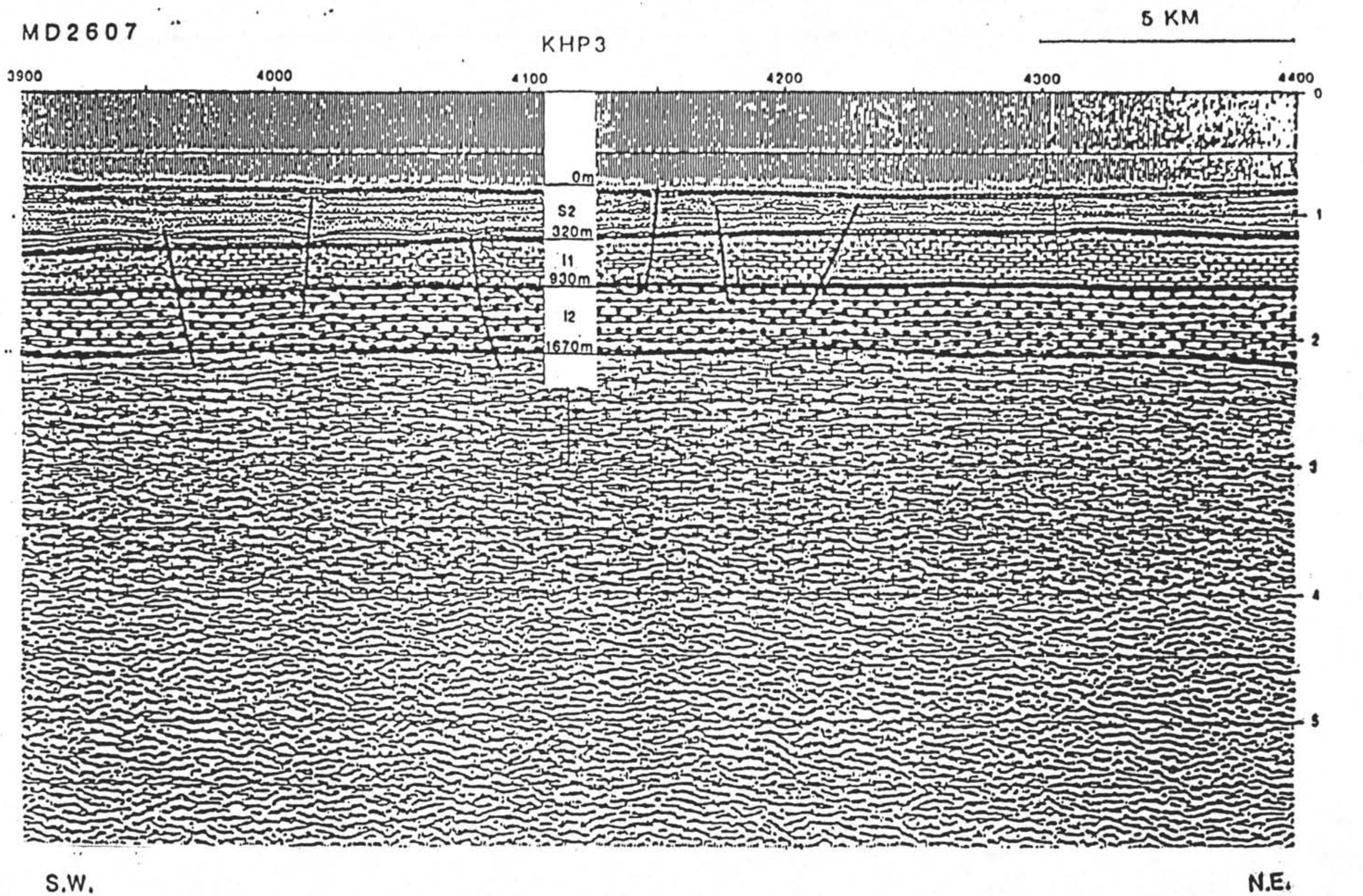
SEISMIC RECORD: MD 26-07 and MD 26-13 multichannel profiles.

LOGGING:
Standard Schlumberger (3 runs); vertical seismic profile (VSP).

OBJECTIVES:
To obtain a complete stratigraphic record from Eocene to Upper Cretaceous; to sample and date the major unconformity; to determine the age and nature of the basement underlying the plateau; to study the tectonic and subsidence history from the Late Cretaceous to Eocene.

SEDIMENT TYPE:
Diatomaceous glauconitic sand, calcareous ooze and chalk, chert, basement.


KERGUELEN
71°
72°
73°
50°
27 March '71
14
00
16
04
15 Feb.
08
04
00
27 March '71
MD 26-10
MD 26-11
MD 26-11
MD 26-13
KHP-30
MD 26-07


MD2607
KHP3
5 KM
3900
4000
4100
4200
4300
4400
0
1
2
3
4
5
0m
S2
320m
I1
930m
I2
1670m
S.W.
N.E.
Two Way Traveltime (Sec.)

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Sedimentologist:	TO BE NAMED
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Weather Observer: TO BE NAMED