LEG 183

KERGUELEN PLATEAU-BROKEN RIDGE:
A Large Igneous Province

Modified by F. Frey from Proposal 457-Rev. submitted by:

F.A. Frey, M. Coffin, D. Weis, M. Schaming et al.

Staff Scientist: Paul Wallace **Co-Chief Scientists: Fredrick Frey**
Millard Coffin

ABSTRACT

Leg 183 will penetrate igneous basement to depths of ~200 m at several morphologically and tectonically diverse locations on the Kerguelen Plateau-Broken Ridge Large Igneous Province (LIP) in the Southeast Indian Ocean. This leg will build on results obtained by basement drilling at four Ocean Drilling Program (ODP) sites on the Central and Southern Kerguelen Plateau during Legs 119 and 120. LIPs are important to understand because the very large amounts of magma entering the crust in a relatively short time interval reflect mantle processes that differ from those causing magmatism at diverging and converging plate margins (e.g., LIPs may result from decompression melting of a mantle plume). A major objective of this leg is to infer eruption rates (km^3/yr) by determining the eruption ages of the uppermost igneous crust at several locations. Additional goals are to determine the mechanism of plateau growth and the tectonic history of the plateau by integrating seismic data with studies of the sedimentary and igneous cores. Specifically, these cores will be used to address the following issues: (1) the timing and extent of initial uplift; (2) the relative roles of subaerial and submarine volcanism; (3) the cooling and subsidence into a submarine environment; and (4) the multiple episodes of post-emplacement deformation. A unique aspect of this LIP is its clear association with a long hot-spot track that formed from ~82 to 38 Ma (i.e., the Ninetyeast Ridge with seven Deep Sea Drilling Project and ODP drill holes that penetrated igneous basement), and the Kerguelen Archipelago and Heard Island, which have a volcanic record from ~40 Ma to the present. Studies of the subaerial lavas from these islands and submarine lavas recovered by drilling provide a 115-Ma record of volcanism that can be used to

understand the origin and evolution of the large and long-lived Kerguelen Plume. This plume is particularly important because it is a source of the "enriched isotopic component" that forms an end-member in the isotopic arrays defined by ocean island basalts, and it may have been important in creating the distinctive isotopic characteristics of Indian Ocean ridge basalts. Determination of the spatial and temporal variations in geochemical characteristics of the basalts forming the Kerguelen Plateau and Broken Ridge are essential for understanding the early history of the Kerguelen Plume.

INTRODUCTION

Large igneous provinces (LIPs) are a significant type of planetary volcanism found on the Earth, moon, Venus, and Mars (Coffin and Eldholm, 1994). They represent voluminous fluxes of magma emplaced over relatively short time periods, such as expected from decompression melting of an ascending relatively hot mantle plume. Terrestrial LIPs are dominantly mafic rocks formed during several distinct episodes in Earth history, perhaps in response to fundamental changes in the processes that control energy transfer from the Earth's interior to its surface. Formation of LIPs may be a principal mechanism for stabilizing crust on the Earth's surface. The ocean basins contain two very large LIPs, Kerguelen Plateau/Broken Ridge in the Indian Ocean (Fig. 1) and Ontong Java in the Pacific Ocean, that are elevated regions of the ocean floor encompassing areas of ~2 x 10^6 km^2 (Coffin and Eldholm, 1994). These Lips are important for several reasons. They provide information about mantle compositions and dynamics that are not reflected by volcanism at spreading ridges, and they may comprise future building blocks of continental crust. In addition, the magma fluxes represented by oceanic plateaus are not evenly distributed in space and time; their episodicity punctuates the relatively steady-state production of crust at seafloor spreading centers. These intense episodes of igneous activity temporarily alter the flux of solids, particulates, volatiles, and heat from the lithosphere to the hydrosphere and atmosphere, possibly resulting in global environmental change and excursions in the chemical and isotopic composition of seawater (e.g., Larson, 1991; Ingram et al., 1994; Jones et al., 1994). Although LIPs now account for only 5% to 10% of the heat and magma expelled from the earth's mantle, the giant LIPs may have contributed as much as 50% in Early Cretaceous time (Coffin and Eldholm, 1994), thereby indicating a substantial change in mantle dynamics from the Cretaceous to the present (e.g., Stein and Hofmann, 1994). Despite their huge size and distinctive morphology, oceanic plateaus remain among the least understood features in the ocean basins. This leg is focused on sampling the Kerguelen Plateau/Broken Ridge LIP with the objectives of determining the age and composition of the basement volcanic rocks in all major parts of the LIP, and on determining the tectonic history of the LIP beginning with the mechanisms of growth and emplacement and continuing with the multiple episodes of post-emplacement deformation that created the present complex bathymetry (Figs. 2- 4).

BACKGROUND

Physical Description

The Kerguelen Plateau is a broad topographic high in the Southern Indian Ocean surrounded by deep ocean basins: to the northeast by the Australian-Antarctic Basin; to the south by the 3500-m-deep Princess Elizabeth Trough; to the southwest by the Enderby Basin; and to the northwest by the Crozet Basin (Fig. 2). The plateau stretches approximately 2300 km between 46˚ and 64˚S in a southeast-trending direction toward the Antarctic continental margin. It is between 200 and 600 km wide and stands 2-4 km above the adjacent ocean basins. The age of the oceanic crust abutting the Kerguelen Plateau is variable (Fig. 2). As summarized by Schlich and Wise (1992), the oldest magnetic anomalies range from 11, ~32 Ma, in the northeast, to anomaly 18, ~43 Ma, off the central part of the eastern plateau. Farther to the south, the east flank of the Southern Kerguelen Plateau is bounded by the Labuan Basin. Basement of the Labuan Basin has not been sampled, but its age and structure appear to be similar to the main Kerguelen Plateau (Rotstein et al., 1991; Munschy et al., 1992). To the northwest, magnetic anomaly sequences from 23 to 34 have been identified in the Crozet Basin, but on the southwest flank no convincing anomalies have been identified in the Enderby Basin, although Mesozoic anomalies have been suggested (Li, 1988; Nogi et al., 1991; Coulon, 1995). An Early Cretaceous age for the Enderby Basin is assumed in most plate reconstructions (e.g., Royer and Coffin, 1992).

Beginning with the early studies of Schlich (1975) and Houtz et al. (1977), and as summarized by Munschy and Schlich (1987), the plateau has been divided into two distinct domains. The Northern Kerguelen Plateau (NKP), ~46˚ to 54˚S, has shallow water depths, <1000 m, and basement elevations 3-4 km above the adjacent seafloor with the maximum elevations forming the Kerguelen, Heard, and McDonald Islands (Fig. 2). Broken Ridge and the Northern Kerguelen Plateau are conjugate Early Cretaceous provinces (Fig. 1) that were separated by seafloor spreading along the Southeast Indian Ridge (SEIR) during the Eocene (Mutter and Cande, 1983). The Southern Kerguelen Plateau (SKP) is generally characterized by deeper water, 1500 to 2500 m, and it is tectonically more complex (Figs. 2, 4). It is characterized by several large basement uplifts and was affected by multiple stages of normal faulting, graben formation, and strike-slip faulting (e.g., Coffin et al., 1986; Fritsch et al., 1992; Rotstein et al., 1992; Royer and Coffin, 1992; Könnecke and Coffin, 1994; Angoulvant-Coulon and Schlich, 1994). On the basis of gravity data, seismic results, and the study of sedimentary sections (Fröhlich and Wicquart, 1989), Coffin and Eldholm (1994) infer a break between the Mesozoic and Cenozoic parts of the plateau immediately south of the Kerguelen Archipelago and north of a major sedimentary basin (Fig. 4).

Crustal Structure

Based on multichannel seismic reflection data, Schaming and Rotstein (1990) suggested that basaltic crust forms the northern and southern parts of the Kerguelen Plateau; however, volcanic morphology is largely absent in the SKP because of the subaerial erosion that preceded subsidence. Numerous dipping basement reflectors that are interpreted as flood basalt constructions have been identified in the crust of the Southern Kerguelen Plateau (Coffin et al., 1990; Schaming and Rotstein, 1990; Schlich et al., 1993). Ocean-bottom-seismometer wide-angle reflection and refraction experiments have been undertaken recently on both the northern and southern sectors of the plateau (Charvis et al., 1993, 1995; Operto and Charvis, 1995, 1996). On the northern plateau, igneous crust can be divided into two parts: (1) an upper Layer 2 with an average thickness of 5.5 km and a velocity gradient ranging from 4.3 to 6.1 km/s, and (2) a lower layer ~17 km thick with velocities from 6.6 to 7.4 km/s (Charvis et al., 1995; Recq et al., 1994). This crustal structure differs significantly from that below the Kerguelen Archipelago where the upper igneous crust is thicker, ~10 km, and the lower crust is thinner, 7-9 km (Recq et al., 1990). These observations, in conjunction with geological sampling and tectonic reconstructions, are used to infer that the NKP from the Kerguelen Archipelago northwestward is younger than 42 Ma (Royer and Coffin, 1992; Munschy et al., 1992; Charvis et al., 1993, 1995). On the southern plateau, the igneous crust can be divided into three layers: (1) an upper crustal layer ~5.3 km thick with velocities ranging from 3.8 to 6.5 km/s; (2) a lower crustal layer ~11 km thick with velocities of 6.6 to 6.9 km/s; and (3) a 4- to 6-km-thick transition zone at the base of the crust characterized by an average velocity of 6.7 km/s (Recq et al., 1994; Operto and Charvis, 1995, 1996). This low-velocity, seismically reflective transition zone at the crust-mantle interface has not been imaged on the NKP, and it is the basis for the hypothesis that parts of the SKP are fragments of a volcanic passive margin, similar to the Rockall Plateau in the North Atlantic Volcanic Province (Schlich et al., 1993; Operto and Charvis, 1995, 1996).

Previous Sampling of Igneous Basement

What was learned from previous sampling (ODP Legs 119 and 120 and dredging) of the Kerguelen Plateau/Broken Ridge LIP? Based in large part on ODP-related studies, we can now conclude that decompression melting of the Kerguelen Plume was a major magma source for the Kerguelen Plateau/Broken Ridge system. Although sampling and age dating are grossly insufficient, large volumes of subaerially erupted tholeiitic basalt magma formed much of the central and southern plateau during the interval from ~115 to 85 Ma. Specifically, constraints from the ages of overlying sediments combined with K-Ar and $^{40}Ar/^{39}Ar$ dating of a dredged basalt (Leclaire et al., 1987), and basalts from ODP Leg 120 (Whitechurch et al., 1992) led to an inferred emplacement age of 110-120 Ma for the central portion of the Kerguelen Plateau. The age data base has been recently augmented by the $^{40}Ar/^{39}Ar$ study of Pringle et al. (1994) and Storey et al. (1996) who report ages ranging from 108.6 Ma to 112.7 Ma for basement basalts from ODP Sites 738, 749, and 750; therefore, south of 57˚S the uppermost Kerguelen Plateau is ~110 Ma. In contrast, basalts from Site 747 on the central part of the plateau are much younger, ~85 Ma. This age is similar to the 83-88 Ma age for lavas from Broken Ridge Dredge Sites 8 and 10 (Fig. 3; Duncan, 1991), which is consistent with the pre-rifting position of Site 747 relative to these Broken Ridge dredge sites. Also, piston coring of sediments on the northeast flank of the plateau between the Kerguelen Archipelago and Heard Island recovered upper Cretaceous cherts and calcareous oozes of probable Santonian age (Leclaire et al., 1987). In summary, we have very few high quality age data for the 2.3 x 10^6 km^2 (equivalent to ~8 Icelandic plateaus) of the Kerguelen Plateau/Broken Ridge LIP. Nevertheless, it is evident that large magma volumes erupted over short time intervals, possibly as two or even three pulses: the SKP at ~110 Ma, the central KP and Broken Ridge at ~85 Ma and much of the Kerguelen Archipelago and perhaps the northernmost portion of the Kerguelen Plateau at ~40-23 Ma (Nicolaysen et al., 1996). Sampling by drilling at other sites throughout the plateau is required to determine if formation of this LIP was truly episodic or if there was a continuous south to north decrease in the age of volcanism.

Although the Kerguelen Plateau is a volcanic construction formed in a young oceanic basin (Royer and Coffin, 1992; Munschy et al., 1994), evidence is equivocal as to whether it was emplaced at a spreading center (e.g., Iceland) or off-ridge (e.g., Hawaii; Coffin and Gahagan, 1995). Oxidized flow tops and the vesicularity of lava flows at ODP Sites 738 and 747, however, are consistent with eruption in a subaerial environment. Moreover, at ODP Site 750 the basement lavas are overlain by nonmarine, organic-rich sediments containing up to 5-cm pieces of charcoal. Coffin (1992) concluded that the drill sites in the SKP had long, >10 Ma, histories of subaerial volcanism and erosion followed by subsidence caused by cooling. Higher temperature metamorphism, based on zeolite mineralogy, at Site 749 and then at Sites 747 and 750 may indicate erosion to deeper levels at Site 749 (Sevigny et al., 1992).

The islands on the NKP are dominantly formed of <40-Ma transitional and alkaline lavas. In contrast, dredging along the 77˚E graben of the Kerguelen Plateau and from Broken Ridge (Figs. 1 and 4) recovered basaltic rocks whose compositions are similar to ocean island tholeiites; they clearly are not typical mid-ocean-ridge basalt (MORB) (e.g., Davies et al., 1989; Weis et al., 1989; Mahoney et al., 1995). Tholeiitic basalts also form the igneous basement of the Kerguelen Plateau at drill Sites 738, 747, 749, and 750 (Fig. 5). Except for an alkaline basalt flow 200 m above basement at Site 748, the long-term volcanism, ~115 to 38 Ma, associated with the Kerguelen Plume, i.e. the Kerguelen Plateau and Ninetyeast Ridge, are exclusively tholeiitic (e.g., Frey et al., 1991; Saunders et al., 1991; Storey et al., 1992; Frey and Weis, 1995). The significance of this result is that tholeiitic compositions are derived by relatively high extents of melting, (e.g., Kent and McKenzie, 1994), and the inference is that the Kerguelen plume was a high-flux magma source for a long time. However, to date the MgO and olivine-rich melts expected from the melting of large amounts of high-temperature plumes (Storey et al., 1991) have not been recovered. In fact, in contrast to the tholeiitic lavas forming the Hawaiian shields, there is no evidence for melt segregation at relatively high pressures within the garnet stability field (Frey et al., 1991).

Most of the lavas from the Kerguelen Plateau and Broken Ridge have Sr and Nd isotopic ratios which range from ratios typical of enriched MORB from the SEIR to ratios proposed for the Kerguelen Plume (Fig. 5). In Pb-Pb isotopic ratios most of the lavas from the Kerguelen Plateau define an elongated field that is subparallel to that for SEIR MORB; however, like lavas forming the Kerguelen Archipelago, the Kerguelen Plateau lavas are offset from the MORB field to higher $^{208}Pb/^{204}Pb$ at a given $^{206}Pb/^{204}Pb$ composition (Fig. 5). These isotopic data have been interpreted as resulting from mixing of the Kerguelen Plume with entrained depleted asthenosphere (e.g., Weis et al., 1992). In contrast, basalts from ODP Site 738 on the southern extremity of the Kerguelen plateau and Dredge 8 from eastern Broken Ridge (Fig. 1) have atypical geochemical characteristics for oceanic lavas. These lavas have very high $^{87}Sr/^{86}Sr$, low $^{143}Nd/^{144}Nd$, and high $^{207}Pb/^{204}Pb$ ratios, which accompany relatively low $^{206}Pb/^{204}Pb$ compositions (Fig. 5). Although the sampling density is limited, Mahoney et al. (1995) show that lavas from plateau locations closest to continental margins, e.g., Site 738 in the far south, Dredge 8 from eastern Broken Ridge, and lavas from the Naturaliste Plateau (Fig. 1), have the most extreme isotopic characteristics (e.g., $^{87}Sr/^{86}Sr$ >0.7090), which are accompanied by relative depletions in Nb and Ta and relatively high $^{207}Pb/^{204}Pb$ ratios. They conclude that these geochemical features arose from a continental lithosphere component (e.g., Storey et al., 1989) that contributed to magmatism near the edges of the Kerguelen Plateau/Broken Ridge system. The geochemical evidence for this continental component is consistent with geophysical evidence for the southernmost part of the plateau consisting of a passive margin fragment (Schlich et al., 1993; Operto and Charvis, 1995).

SCIENTIFIC OBJECTIVES

The most significant question that can be directly answered by studying igneous basement is how much magma was erupted over what time interval? Specifically, we want to address these questions: (1) How long did it take to form the plateau? (2) Was the growth episodic or continuous? (3) Do eruption ages vary systematically with location on the plateau? and (3) Did the plateau grow by lateral accretion (i.e., similar to Iceland), or by vertical accretion and underplating? Answers to these questions are required to understand the processes that lead to voluminous magma production, and to assess the impact of Cretaceous volcanism on the surficial environment by estimating fluxes into the ocean-atmosphere system. An aspect of oceanic plateau volcanism that has been explored in only cursory detail (e.g., Sevigny et al., 1992) is the role of hydrothermal alteration in controlling elemental and isotopic fluxes. The extent, nature and duration of hydrothermal processes on the plateau can be determined by drilling several holes with 200 m basement penetration. In addition, integration of seismic data with logging data and studies of sedimentary and igneous cores will bear on objectives such as (1) determining whether there is a correlation between magmatic episodes and tectonic events and (2) determining the tectonic evolution of the LIP from the time of emplacement to the present.

Several lines of evidence support the interpretation that the Kerguelen Plume has been a long-term source of magma for major bathymetric features in the eastern Indian Ocean. For example, the systematic north-south age progression on the Ninetyeast Ridge is consistent with a hot-spot track formed as the Indian plate migrated northwards over the Kerguelen Plume (Duncan, 1991). Also the isotopic similarities between lavas from the Ninetyeast Ridge, with the younger lavas forming the Kerguelen Archipelago and Heard Island and the older lavas forming the Kerguelen Plateau and Broken Ridge (Fig. 5), indicate that the Kerguelan Plume played an important role (Weis et al., 1992; Frey and Weis, 1995, 1996). However, a continental lithosphere source component has been recognized in some lavas from the SKP and eastern Broken Ridge (Mahoney et al., 1995). Also wide-angle seismic data collected by ocean bottom seismometers in the Raggat Basin of the SKP have defined a reflective zone at the lower crust-mantle boundary that was interpreted to be stretched continental lithosphere (Recq et al., 1994; Operto and Charvis, 1995, 1996). The present geochemical data set shows that a continental lithosphere component is obvious in lavas at only two sites (Dredge 8 on BR and Site 738 in the SKP, Fig. 5). There is no evidence for a continental component in lavas from the Central Kerguelen Plateau, the Ninetyeast Ridge, and the Kerguelen Archipelago (Frey et al., 1991). Determination of the spatial and temporal role of this lithosphere component is required to evaluate if this continental component is a piece of Gondwana lithosphere that was incorporated into the plume.

Because the isotopic characteristics of plume, asthenosphere, and lithosphere sources are usually quite different, the temporal geochemical variations in stratigraphic sequences of lavas can be used to determine the relative roles of plume, asthenosphere, and lithosphere sources in plume-related volcanism; in particular, the proportion of these sources changes systematically with time and location (e.g., Chen and Frey, 1985; Gautier et al., 1990; White et al., 1993; Peng and Mahoney, 1995), thereby providing an understanding of how plumes "work." In addition to answering questions about plume-lithosphere interactions, geochemical data for plateau lavas will define the role of depleted asthenosphere in creating this plateau. A MORB-related asthenosphere is apparent in some of the Ninetyeast Ridge drill sites (e.g., as reflected by the Sr and Nd isotopic ratios of lavas from Site 756; Weis and Frey, 1991) and is an expected consequence of the plume being close to a spreading ridge axis during formation of the Ninetyeast Ridge. Transects of relatively shallow basement holes (200 m) in the Kerguelen Plateau can be used to define spatial and short-term variability during the waning phase of plateau volcanism. A surprising result of the shallow penetrations of the Kerguelen Plateau is that sampling of 35-50 m of igneous basement at several plateau sites shows that lavas at each site have a suite of distinctive geochemical characteristics: each site has a distinctive combination of Sr and Nd isotopic ratios (Fig. 5). Does this heterogeneity reflect the spatial heterogeneities in a plume or localized differences in mixing proportions of components derived from asthenosphere, plume, and slivers of continental lithosphere? Interpretation requires a knowledge of temporal variations in geochemical characteristics at several locations.

DRILLING STRATEGY

A major goal is to obtain a comprehensive database of eruption ages and lava compositions for the entire LIP; therefore, the strategy is to sample igneous basement to depths of ≥200 m at as many morphologically and tectonically distinct regions of the KP/BR LIP as possible on one drilling leg (Table 1 and Figs. 2, 3, 4).

PROPOSED SITES

At present, the following localities were selected for drilling, but this site selection is subject to revision after completion of early 1997 site survey cruises.

KIP-2B

This site is on the NKP, which has never been sampled. A site north of the Kerguelen Archipelago is required to establish the age, composition, and emplacement environment of the NKP (presumed to be Cenozoic in age), as well as to test plate reconstructions. Site KIP 2B is in shallow water (~150 m) and efforts are being made to identify a suitable deep-water site on the NKP.

KIP-3A

Several distinct, roughly circular bathymetric and gravity highs form a linear trend between the Kerguelen Archipelago and Heard Island (Figs. 3, 4), the two recently active volcanic islands in the NKP. This site was selected because it is on one of several aligned gravity highs that may reflect a hotspot track between Heard and Kerguelen Islands.

KIP-6B

This site is on Elan Bank, which is a prominent east-west oriented bathymetric and gravity high west of the Central Kerguelen Plateau (Figs. 2, 4). This major morphotectonic component of the Kerguelen Plateau province is unsampled; the site will constrain its age, composition, emplacement environment, and uplift-subsidence history.

KIP-7A

This site in the Central Kerguelen Plateau is about 100 km north of ODP Site 747. The determined age of basalts at Site 747 is ~85 Ma and represents the only sampled basement of Late Cretaceous age found on the Kerguelen Plateau. Drilling at Site KIP-7A will evaluate the areal extent of Late Cretaceous crust. In addition, the sedimentary section will help constrain the post-emplacement tectonic history.

KIP-12A

This site on the Southern Kerguelen Plateau is located on a bathymetric and gravity high (Figs. 2, 4). The location was selected to evaluate the areal extent of continental crustal contamination north of ODP Site 738 (Figs. 2, 5), as well as the age of this part of the plateau. Several hundred meters of sediment will help to constrain the uplift/subsidence history.

KIP-9A

This site on the Eastern Broken Ridge will provide the first in situ basement samples from the entire Broken Ridge (Fig. 3). Although the final location is waiting on the processing and subsequent examination of Conrad 2708 seismic data, it will be located near Dredge 8, whose lavas are similar in age (88 Ma) to lavas from ODP Site 747. Unlike lavas from the central part of the Kerguelen plateau, Dredge 8 lavas contain a continental lithosphere component (Fig. 5). This site will define the spatial extent of this component.

LOGGING PLAN

The main contributions of the downhole measurement program for Leg 183 are to enable accurate mapping of the volcano stratigraphy, volcanic facies variations, and structural features; to interpret tectonic stresses; and to facilitate correlation between the core data and regional seismic reflection profiles. The geophysical tool string (triple-combo) will be run in all holes. This string provides measurements of the porosity-dependent density, porosity, velocity and resistivity logs, in addition to variations in natural gamma radiation. These logs are useful for determining petrophysical and lithologic variations in both volcanic and sedimentary intervals (e.g., Broglia and Moos, 1988; Planke, 1994).

The Formation MicroScanner (FMS) provides a detailed resistivity image of the borehole wall. It has previously been used successfully in a volcanic setting on Leg 152 (Cambray, in press; Planke and Cambray, in press), and will be recorded in all basement holes on Leg 183. The log provides a detailed volcano stratigraphy and is particularly useful to image altered and fractured zones which may be poorly sampled during coring. It also has potential to provide important structural and stress field information, and it can be used for core-log integration.

Seismic reflection data are essential to extrapolate the drilling results away from and between the drill sites. Synthetic seismograms constructed from the velocity and density logs provide a link between the core and the reflection data. Reliable synthetic seismograms require calibration with downhole seismic data. These calibration data will be obtained by using a well sonic tool (WST) in holes with a sediment penetration of more than 500 m.

Other speciality tools will only be run at selected sites. The dipole shear imager (DSI) tool can provide shear-wave velocity information in both the relatively slow lava flow margins and relatively fast flow interiors. Such data are important as inputs for modeling seismic wave-propagation in volcanic sequences. The Azimuthal Resistivity Imager (ARI) is a high-resolution deep resistivity imaging tool. The data are useful for obtaining formation dip and thin-bed resistivity as the measurements are not influenced by drilling-induced fractures. The borehole televiewer (BHTV) provides an acoustic image of the borehole wall, which is useful for structural and stress field analysis (e.g., Paillet and Kim, 1987; Castillo and O'Neill, 1992). The interpretation of geochemical stratigraphy including alteration zones is facilitated by the geochemical tool (GLT) (e.g., Pratson et al., 1992). At this time we note the possibility of utilizing the GLT, but do not include it as definite part of the Logging Plan (Table 1).

REFERENCES

Angoulvant-Coulon, M.-P., and Schlich, R., 1994. Mise en evidence d'une nouvelle direction tectonique sur le plateau de Kerguelen. C.R. Acad. Sci. Paris, 319, series II, 929-935.

Broglia, C., and Moos, D., 1988. In-situ structure and properties of 100-Ma crust from geophysical logs in DSDP Hole 418A, *Proc. ODP, Sci. Results*, 102: College Station, TX (Ocean Drilling Program), 29-47.

Cambray, H., in press. Structures within Hole 971A, southeast Greenland rifted margin, *Proc. ODP, Sci.. Results*, 152: College Station, TX (Ocean Drilling Program).

Castillo, D.A., and O'Neill, B., 1992. Constraints on the state of stress in old oceanic crust of the Indo-Australian plate, northwest of Australia, *Proc. ODP, Sci. Results,* 123: College Station, TX (Ocean Drilling Program), 503-513.

Charvis, P., Operto, S., Könnecke, L.K., Recq, M., Hello, Y., Houdry, F., Lebellegard, P., Louat, R., and Sage, F., 1993. Structure profonde du domaine nord du plateau de Kerguelen (océan Indien austral): résultats préliminaires de la campagne MD66/KeOBS. *C.R. Acad. Sci. Paris*, 316:341-347.

Charvis, P., Recq, M., Operto, S., and Brefort, D., 1995. Deep structure of the northern Kerguelen Plateau and hot spot related activity. *Geophys. J. International*, 122:899-924.

Chen, C.Y., and Frey, F.A., 1985. Trace element and isotopic geochemistry of lavas from Haleakala volcano, East Maui, Hawaii: Implications for the origin of Hawaiian lavas. *J. Geophys. Res.,* 90:8743-8768.

Coffin, M.F., 1992. Emplacement and subsidence of Indian Ocean Plateaus and submarine ridges, synthesis of results from scientific drilling in the Indian Ocean. Geophys. Monograph 70, *Amer. Geophys. Union*, 115-125.

Coffin, M.F., Munschy, M., Colwell, J.B., Schlich, R., Davies, H.L., and Li, Z.G., 1990. Seismic stratigraphy of the Raggatt Basin, southern Kerguelen Plateau: tectonic and paleoceanographic implications. *Bull. Geol. Soc. Amer*., 102:563-579.

Coffin, M., and Eldholm, O., 1994. Large igneous provinces: crustal structure, dimensions, and external consequences. *Rev. Geophys.*, 32:1-36.

Coffin, M.F., Davies, H.L., and Haxby, W.F., 1986. Structure of the Kerguelen Plateau province from SEASAT altimetry and seismic reflection data. *Nature*, 324:134-136.

Coffin, M.F., and Gahagan, L.M., 1995. Ontong Java and Kerguelen Plateau: Cretaceous Islands? *Jour. Geol. Soc. Lond.* 152:1047-1052.

Coulon, M.P., 1995. Tectonique du plateau de Kerguelen: relations avec le mouvement des plaques lithosphèriques. Thèse de doctorat, Université Louis Pasteur, Strasbourg, France.

Davies, H.L., Sun, S.-S., Frey, F.A., Gautier, I., McCulloch, M.T., Price, R.C., Bassias, Y., Klootwijk, C.T., and Leclaire, L., 1989. Basalt basement from the Kerguelen Plateau and the trail of a Dupal plume. *Contr. Mineral. Petrol.*, 103:457-469.

Duncan, R.A., 1991. Age distribution of volcanism along aseismic ridges in the eastern Indian Ocean. *In* Weissel, J., Peirce, J., Taylor, E., Alt, J. et al., *Proc. ODP, Sci. Results* 121: College Station, TX, (Ocean Drilling Program), 507-517.

Frey, F.A., Jones, W.B., Davies, H., and Weis, D., 1991. Geochemical and petrologic data for basalts from Sites 756, 757, and 758: Implications for the origin and evolution of Ninetyeast Ridge. *In* Weissel, J., Peirce, J., Taylor, E., Alt, J. et al., *Proc. ODP, Sci. Results* 121: College Station, TX, (Ocean Drilling Program), 611-659.

Frey, F.A., and Weis, D., 1995. Temporal evolution of the Kerguelen plume: geochemical evidence from ~38 to 82 Ma lavas forming the Ninetyeast Ridge. *Contrib. Mineral. Petrol.*, 121:12-28.

Frey, F.A., and Weis, D., 1996. Reply to Class et al. discussion of "Temporal evolution of the Kerguelen Plume: geochemical evidence from ~38 to 82 Ma lavas forming the Ninetyeast Ridge." *Contrib. Mineral. Petrol.*, 124:104-110.

Fritsch, B., Schlich, R., Munschy, M., Fezga, F., and Coffin, M.F., 1992. Evolution of the southern Kerguelen Plateau deduced from seismic stratigraphic studies and drilling at Sites 748 and 750. *In* Wise, S.W., Jr., Schlich, R., et al., *Proc. ODP, Sci. Results*, 120: College Station, TX (Ocean Drilling Program), 895-906.

Fröhlich, F., and Wicquart, E., 1989. Upper Cretaceous and Paleogene sediments from the northern

Kerguelen Plateau. *Geo-Marine Letters*, 9:127-133.

Gautier, I., Weis, D., Mennessier, J.-P., Vidal, P., Giret, A., and Loubet, M., 1990. Petrology and geochemistry of Kerguelen basalts (South Indian Ocean): evolution of the mantle sources from ridge to an intraplate position. *Earth Planet. Sci. Lett.*, 100:59-76.

Houtz, R.E., Hayes, D.E., and Markl, R.G., 1977. Kerguelen Plateau bathymetry, sediment distribution, and crustal struture. *Marine Geology*, 25:95-130.

Ingram, B.L., Coccioni, R., Montanari, A., and Richter, F.M., 1994. Strontium isotopic composition of mid-Cretaceous seawater. *Science*, 264:546-550.

Jones, C.E., Jenkyns, H.C., Coe, A.L., and Hesselbo, 1994. S.P., Strontium isotopic variations in Jurassic and Cretaceous seawater. *Geochim. Cosmochim. Acta*, 58:3061-3074.

Kent, R.W., and McKenzie, D., 1994. Rare earth element inversion models for basalts associated with the Kerguelen mantle plume. V.M. Goldschmidt Conf. abstract, *Min. Mag.*, 58A:471-472.

Könnecke, L., and Coffin, M.F., 1994. Tectonics of the Kerguelen Plateau, Southern Indian Ocean. *EOS Trans. Amer. Geophys. Union*, 75:154.

Larson, R.L., 1991. Geological consequences of superplumes. *Geology*, 19:963-966.

Leclaire, L., Bassias, Y., Denis-Clocchiatti, M., Davies, H., Gautier, I., Genous, B., Giannesini, P.-J., Patriat, P., Segoufin, J., Tesson, M. ,and Wannesson, J., 1987. Lower Cretaceous basalt and sediments from the Kerguelen Plateau. *Geo. Mar. Lett.*, 7:169-176.

Li, Z.G., 1988. Structure, origine, et évolution du plateau de Kerguelen. Thèse de doctorat, Université Louis Pasteur, Strasbourg, France.

Mahoney, J., Jones, W., Frey, F.A., Salters, V., Pyle, D., and Davies, H., 1995. Geochemical characteristics of lavas from Broken Ridge, the Naturaliste Plateau and Southermost Kerguelen Plateau: Early volcanism of the Kerguelen hotspot. *Chem. Geol.* 120:315-345.

Munschy, M., and Schlich, R., 1987. Structure and evolution of the Kerguelen-Heard Plateau (Indian Ocean) deduced from seismic stratigraphy studies. *Mar. Geol.*, 76:131-152.

Munschy, M., Dyment, J., Boulanger, M.O., Boulanger, D., Tissot, J.D., Schlich, R., Rotstein, Y., and Coffin, M.F., 1992. Breakup and sea floor spreading between the Kerguelen Plateau-Labuan Basin and Broken Ridge-Diamantina Zone. *In* Wise, S.W., Jr., Schlich, R., et al., *Proc. ODP, Sci. Results*, 120: College Station, TX (Ocean Drilling Program), 931-944.

Munschy, M., Fritsch, B., Schlich, R., and Rotstein, Y., 1994. Tectonique extensive sur le Plateau de Kerguelen. *Mem. Soc. Géol. France*, 166:99-108.

Mutter, J.C., and Cande, S.C., 1983. The early opening between Broken Ridge and Kerguelen Plateau. *Earth Planet. Sci. Lett.*, 65:369-376.

Nicolaysen, K., Frey, F.A., Hodges, K., Weis, D., Giret, A., and Leyrit, H., 1996. ^{40}Ar/^{39}Ar Geochronology of flood basalts forming the Kerguelen Archipelago. *Eos, Trans. AGU*, 77:F824.

Nogi, Y., Seama, N., Isozaki, N., Hayashi, T., Funaki, M., and Kaminuma, K., 1991. Geomagnetic anomaly lineation and fracture zones in the basin west of the Kerguelen Plateau. *Eos, Trans. Amer. Geophys. Union*, 72:445.

Operto, S., and Charvis, P., 1995. Kerguelen Plateau: A volcanic passive margin fragment? *Geology*, 23:137-140.

Operto, S., and Charvis, P., 1996. Deep structure of the southern Kerguelen Plateau (southern Indian Ocean) from ocean bottom seismometer wide-angle seismic data, *J. Geophys. Rev.*, 101:25,077-25,103.

Paillet, and Kim, 1987. Character and distrubution of borehole breakouts and their relationship to in situ stresses in deep Columbia river basalts. *J. Geophys. Res.*, 92:6223-6234.

Peng, Z.X., and Mahoney, J.J., 1995. Drill hole lavas from the northwestern Deccan Traps, and the evolution of the Réunion hotspot mantle. *Earth Planet. Sci. Letts.*, 134:169-185.

Planke, S., 1994. Geophysical response of flood basalts from analysis of wireline logs: ODP Site 642, Vøring volcanic margin. *J. Geophys. Res.*, 99:9279-9296.

Planke, S., and Cambray, H., in press. Seismic properties of flood basalts from Hole 917A downhole data, southeast Greenland volcanic margin, *Proc. ODP, Sci.. Results*, 152: College Station, TX (Ocean Drilling Program).

Pratson, E.L., Broglia, C., and Castillo, D., 1992. Geochemical well logs from the Argo Abyssal Plain and Exmouth Plateau northeast Indian Ocean Sites 765 and 766 of Leg 123, *Proc. ODP, Sci. Results*, 123:

College Station, TX, (Ocean Drilling Program), 637-656.

Pringle, M.S., Storey, M., and Wijbrans, J., 1994. $^{40}Ar/^{39}Ar$ Geochronology of mid-Cretaceous Indian ocean basalts: Constraints on the origin of large flood basalt. *Eos, Trans. AGU*, 75:728.

Recq, M., Brefort, D., Maled, J., and Veinante, J.-L., 1990. The Kerguelen Isles (southern Indian Ocean) new results on deep structure from refraction profiles. *Tectonophys*., 182:227-248.

Recq, M., Operto, S., and Charvis, P., 1994. Kerguelen Plateau: a hot-spot related oceanic crust. *Eos Trans. Amer. Geophys. Union*, 75:583.

Rotstein, Y., Munschy, M., Schlich, R., and Hill, P.J., 1991. Structure and early history of the Labuan Basin, south Indian Ocean. *J. Geophys. Res.*, 96:3887-3904.

Rotstein, Y., Schlich, R., Munschy, M., and Coffin, M.F., 1992. Structure and tectonic history of the southern Kerguelen Plateau (Indian Ocean) deduced from seismic reflection data. *Tectonics*, 11:1332-1347.

Royer, J.-Y., and Coffin, M.F., 1992. Jurassic and Eocene plate tectonic reconstructions in the Kerguelen Plateau region. *In* Wise, W.S., Schlich, R. et al., *Proc. ODP, Sci. Results*, 120: College Station, TX (Ocean Drilling Program), 559-590.

Salters, V.J.M., Storey, M., Sevigny, J.H., and Whitechurch, H., 1992. Trace element and isotopic characteristics of Kerguelen-Heard Plateau Basalts. *In* Wise, S.W., Schlich, R. et al., *Proc. ODP, Sci. Results*, 120: College Station, TX (Ocean Drilling Program), 55-62.

Saunders, A.D., Storey, M., Gibson, I.L., Leat, P., Hergt, J., and Thompson, R.N., 1991. Chemical and isotopic constraints on the origin of basalts from the Ninetyeast Ridge, Indian Ocean: Results from Deep Sea Drilling Program Legs 22 and 26 and Ocean Drilling Program Leg 121. *In* Weissel, J., Peirce, J., Taylor, E., Alt, J. et al., *Proc. ODP, Sci. Results*, 121: College Station, TX (Ocean Drilling Program), 559-590.

Schaming, M., and Rotstein, Y., 1990. Basement reflectors in the Kerguelen Plateau, south Indian Ocean: Implications for the structure and early history of the plateau. *Geol. Soc. Amer. Bull*., 102:580-592.

Schlich, R., 1975. Structure et age de l'ocean Indien occidental. *Mem. Hors-Ser. Soc. Geol. Fr.*, 6:1-103.

Schlich, R., Coffin, M.F., Munschy, M., Stagg, H.M.J., Li, Z.G., and Revill, K., 1987. Bathymetric chart of the Kerguelen Plateau, Bureau of Mineral Resources, *Geology and Geophysics*, Canberra, Australia, Institut de Physique du Globe, Strasbourg, France.

Schlich, R., Rotstein, Y., and Schaming, M., 1993. Dipping basement reflectors along volcanic passive margins—new insight using data from the Kerguelen Plateau. *Terra Nova*, 5:157-163.

Schlich, R., and Wise, S.W., 1992. The geologic and tectonic evolution of the Kerguelen Plume: An introduction to the scientific results of Leg 120. *In* Wise, S.W., Schlich, R., et al., *Proc. ODP, Sci. Results*, 120: College Station, TX (Ocean Drilling Program), 5-30.

Sevigny, J., Whitechurch, H., Storey, M., and Salters, V.J.M., 1992. Zeolite-facies metamorphism of central Kerguelen Plateau basalts. *In* Wise, S.W., Schlich, R., et al., *Proc. ODP, Sci. Results*, 120: College Station, TX (Ocean Drilling Program), 63-69.

Smith, W.H.F., and Sandwell, D.T., 1995. Marine gravity field from declassified Geosat and ERS-1 altimetry. *Eos, Trans. Amer. Geophys. Union*, 76:F156.

Stein, M., and Hofmann, A.W., 1994. Mantle plumes and episodic crustal growth. *Nature*, 373:63-68.

Storey, M., Saunders, A.D., Tarney, J., Gibson, I.L., Norry, M.J., Thirlwall, M.F., Leat, P., Thompson, R.N., and Menzies, M.A., 1989. Contaminaton of Indian Ocean asthenosphere by the Kerguelen-Heard mantle plume. *Nature*, 338:574-576.

Storey, M., Mahoney, J.J., Kroenke, L.W., and Saunders, A.D., 1991. Are oceanic plateaus sites of komatiite formation? *Geology*, 19:376-379.

Storey, M., Kent, R.W., Saunders, A.D., Salters, V.J., Hergt, J., Whitechurch, H., Sevigny, J.H., Thirlwall, M.F., Leat, P., Ghose, N.C., and Gifford, M., 1992. Lower Cretaceous volcanic rocks on continental margins and their relationship to the Kerguelen Plateau. *In* Wise, S.W., Schlich, R., et al., *Proc. ODP, Sci. Results*, 120: College Station, TX (Ocean Drilling Program), 33-53.

Storey, M., Pringle, M.S., Coffin, M.F., and Wijbrims, J., 1996. Geochemistry and geochronology of Kerguelen Plateau basalts: Results from ODP Legs 119 and 120. *Eos, Trans. Amer. Geophys. Union*, 76:W123.

Weis, D., and Frey, F.A., 1991. Isotope geochemistry of Ninetyeast Ridge basalts: Sr, Nd, and Pb evidence for the involvement of the Kerguelen hotspot. *In* Weissel, J., Peirce, J., Taylor F., Alt, J. et al., *Proc. ODP, Sci. Results*, 121: College Station, TX (Ocean Drilling Program), 591-610.

Weis, D., Frey, F.A., Giret, A., and Cantagrel, J.M., 1997. Geochemical characteristics of the youngest volcano (Mount Ross) in the Kerguelen Archipelago: Inferences for magma flux and composition of the Kerguelen Plume, submitted. *Earth Planet. Sci. Letts*.

Weis, D., Frey, F.A., Leyrit, H., and Gautier, I., 1993. Kerguelen Archipelago revisited: geochemical and isotopic study of the Southeast Province lavas. *Earth Planet. Sci. Letts.,* 118:101-119.

Weis, D., Bassias, Y., Gautier, I., and Mennessier, J.-P., 1989. Dupal anomaly in existence 115 Ma age: Evidence from isotopic study of the Kerguelen Plateau (South Indian Ocean). *Geochim. Cosmochim. Acta*, 53:2125-2131.

Weis, D., White, W.M., Frey, F.A., Duncan, R.A., Dehn, J., Fisk, M., Ludden, J., Saunders, A., and Storey, M., 1992. The influence of mantle plumes in generation of Indian oceanic crust. *In* Duncan, R.A. et al. (Eds.) Synthesis of results from Scientific Drilling in the Indian Ocean. *Geophysical Monograph 70*, American Geophysical Union, 57-89.

White, W.M., McBirney, A.R., and Duncan, R.A., 1993. Petrology and geochemistry of the Galapagos Islands: portrait of a pathological mantle plume. *J. Geophys. Res*., 98:19,533-19,563.

Whitechurch, H., Montigny, R., Sevigny, J., Storey, M., and Salters, V., 1992. K-Ar and $^{40}Ar/^{39}Ar$ ages of central Kerguelen Plateau basalts. *In* Wise, S.W., Schlich, R., et al., *Proc. ODP, Sci. Results*, 120: College Station, TX (Ocean Drilling Program), 71-77.

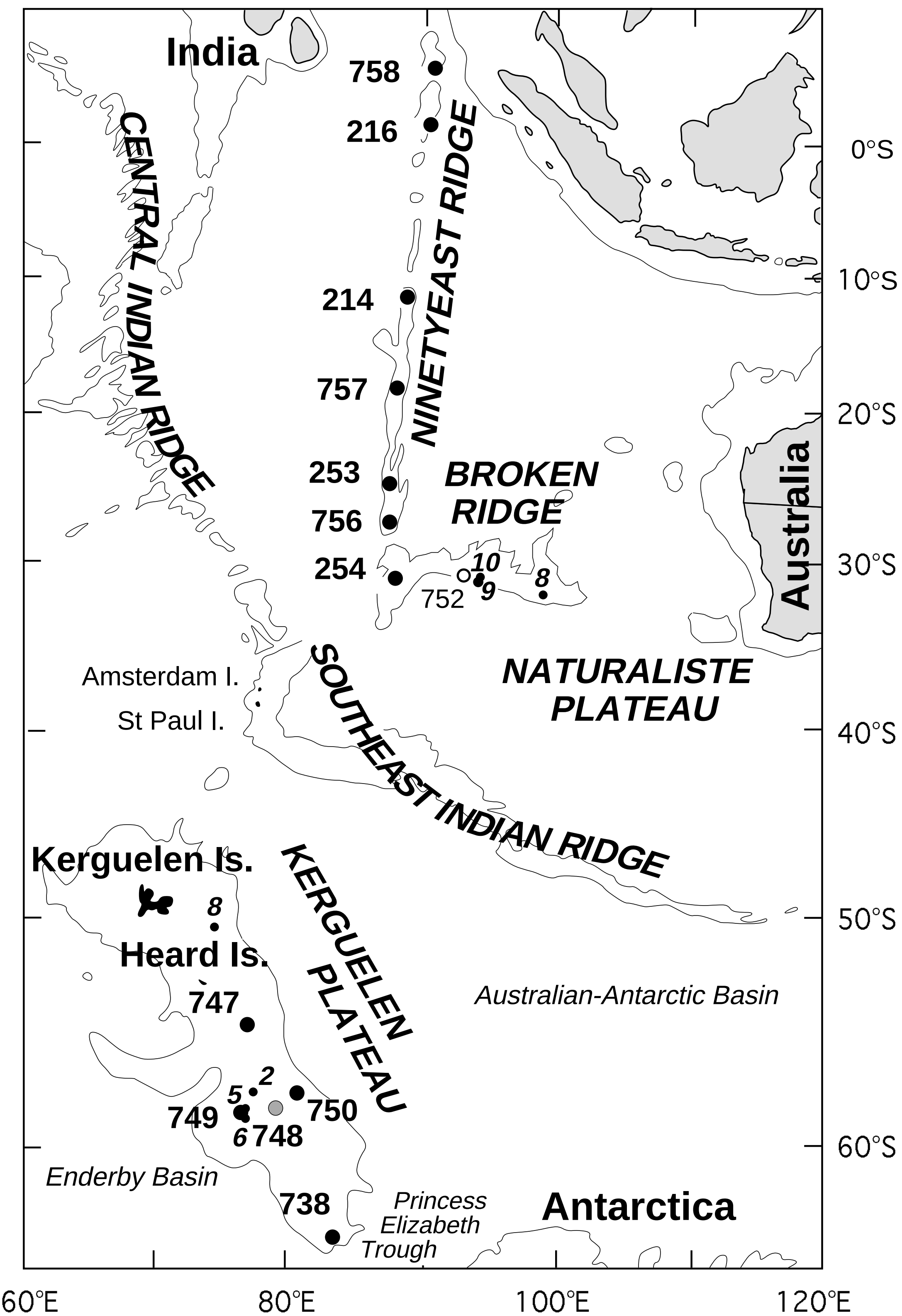

Figure 1. Map of the eastern Indian Ocean showing major physiographic features. DSDP and ODP drill sites on the Ninetyeast Ridge and Kerguelen Plateau are indicated, as are dredge sites and an ODP drill site on Broken Ridge. Igneous basement was not obtained at ODP Sites 748 and 752.

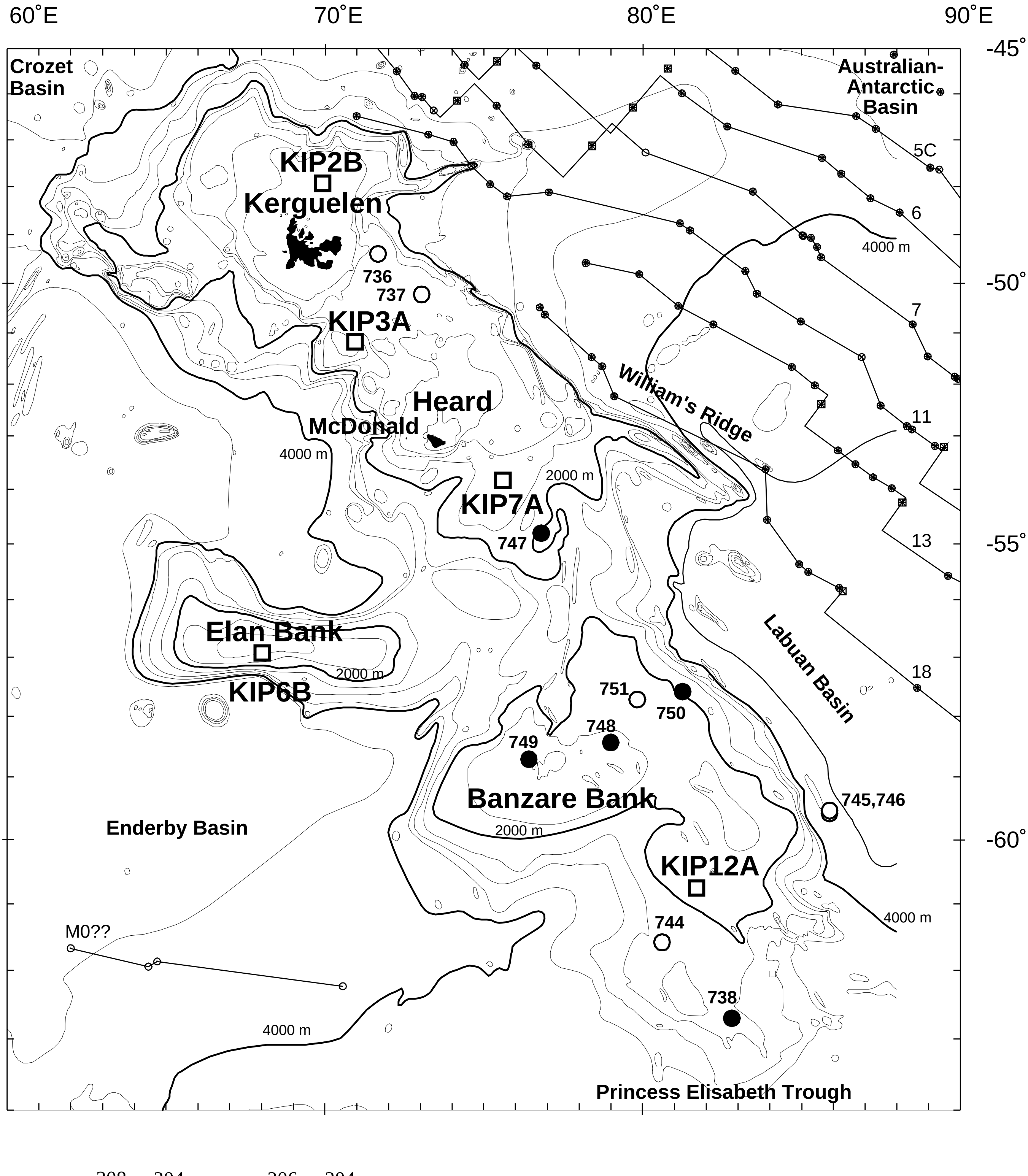

Figure 2. $^{208}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ showing measured data points for basalts recovered from the Kerguelen Plateau and Broken Ridge. Shown for comparison are measured fields for SEIR MORB and lavas from St. Paul and Amsterdam Islands and initial ratios for lavas from the Kerguelen Archipelago and the Ninetyeast Ridge. The proposed field (Weis et al., 1993) for the plume is labeled "Southeast UMS." Data sources are as in Figure 5B.

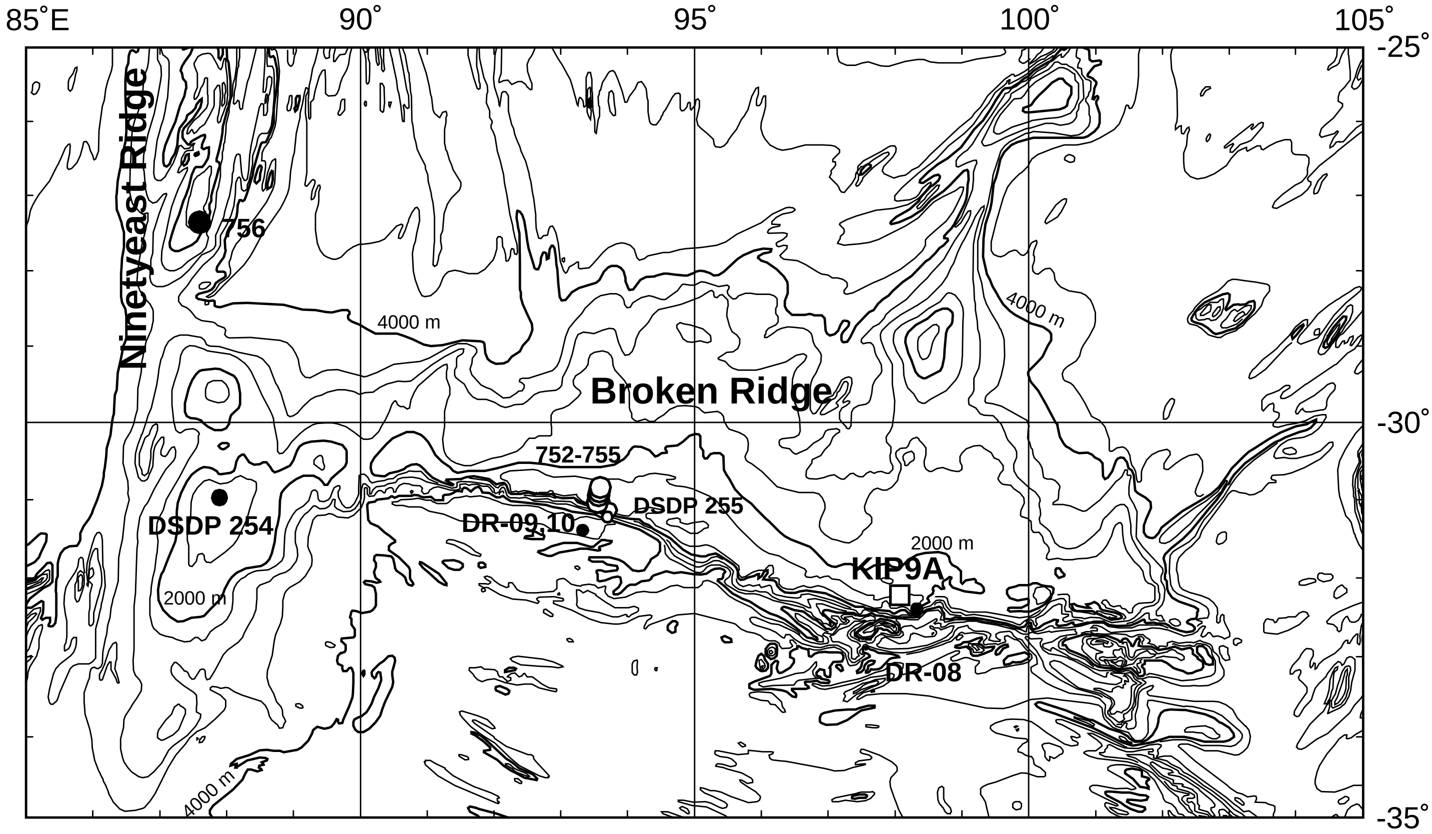

Figure 3. Bathymetric map for Broken Ridge. Previous DSDP and ODP drill sites and dredge locations (DR-X) that recovered igneous basement are indicated by filled circles. The proposed Leg 183 drill Site KIP-9A is indicated by an open square.

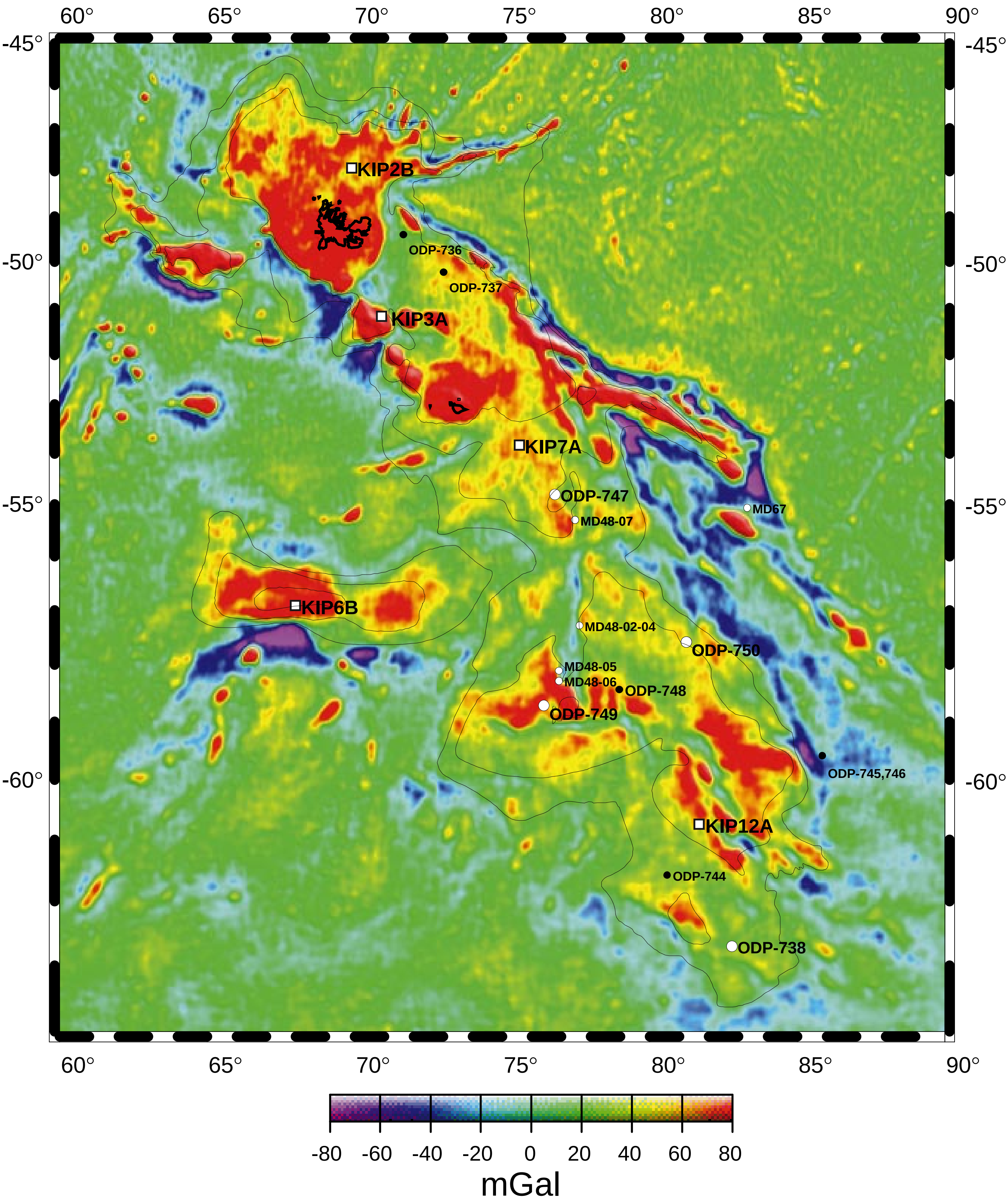

Figure 4. Satellite-derived gravity field for the Kerguelen Plateau (Smith and Sandwell, 1995) showing important morphotectonic components of the plateau, location of previous ODP drill sites (open circles indicate that igneous basement was recovered), locations of the MD dredge sites which recovered basaltic basement and the proposed drill sites (KIP) for Leg 183 (open squares). Bathymetric contours (1000 and 3500 m) are from Schlich et al. (1987).

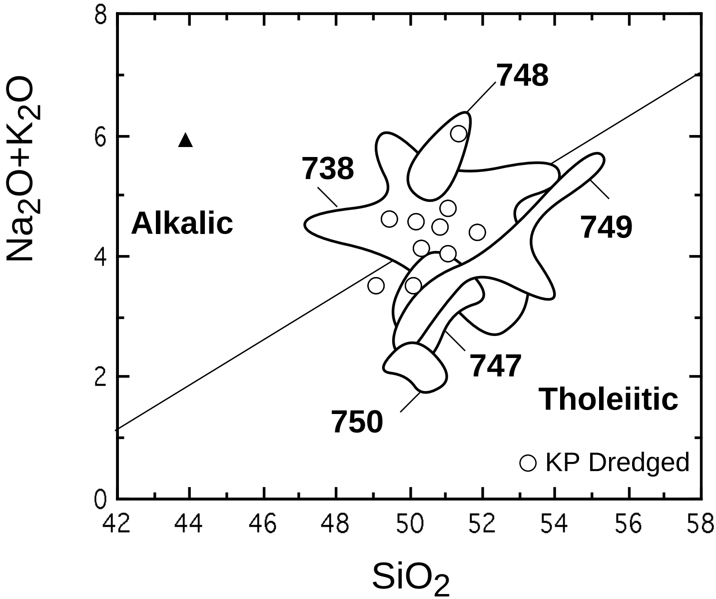

Figure 5A. Total alkalis vs. SiO_2 plot (wt.% with FeO adjusted to 85% of total iron) for classifying tholeiitic and alkalic basalts. Lavas from Kerguelen Plateau ODP Sites 747, 749, and 750 are tholeiitic basalts. The abovebasement lavas from ODP Site 748 are alkalic basalts. The lavas dredged from the central Kerguelen Plateau (open circles)and ODP Site 738 straddle the boundary line, largely because the alkali contents of these lavas were increased during post magmatic alteration. As an extreme example, the solid triangle indicates a highly altered sample (Hole 750B, 19R-1, 47-50 cm) from ODP Site 750. Lavas from Dredges 9 and 10 on Broken Ridge are also tholeiitic, whereas lavas from Dredge 8 overlap with the field for ODP Site 738. Data from Davies et al. (1989), Storey et al. (1992), and Mahoney et al. (1995).

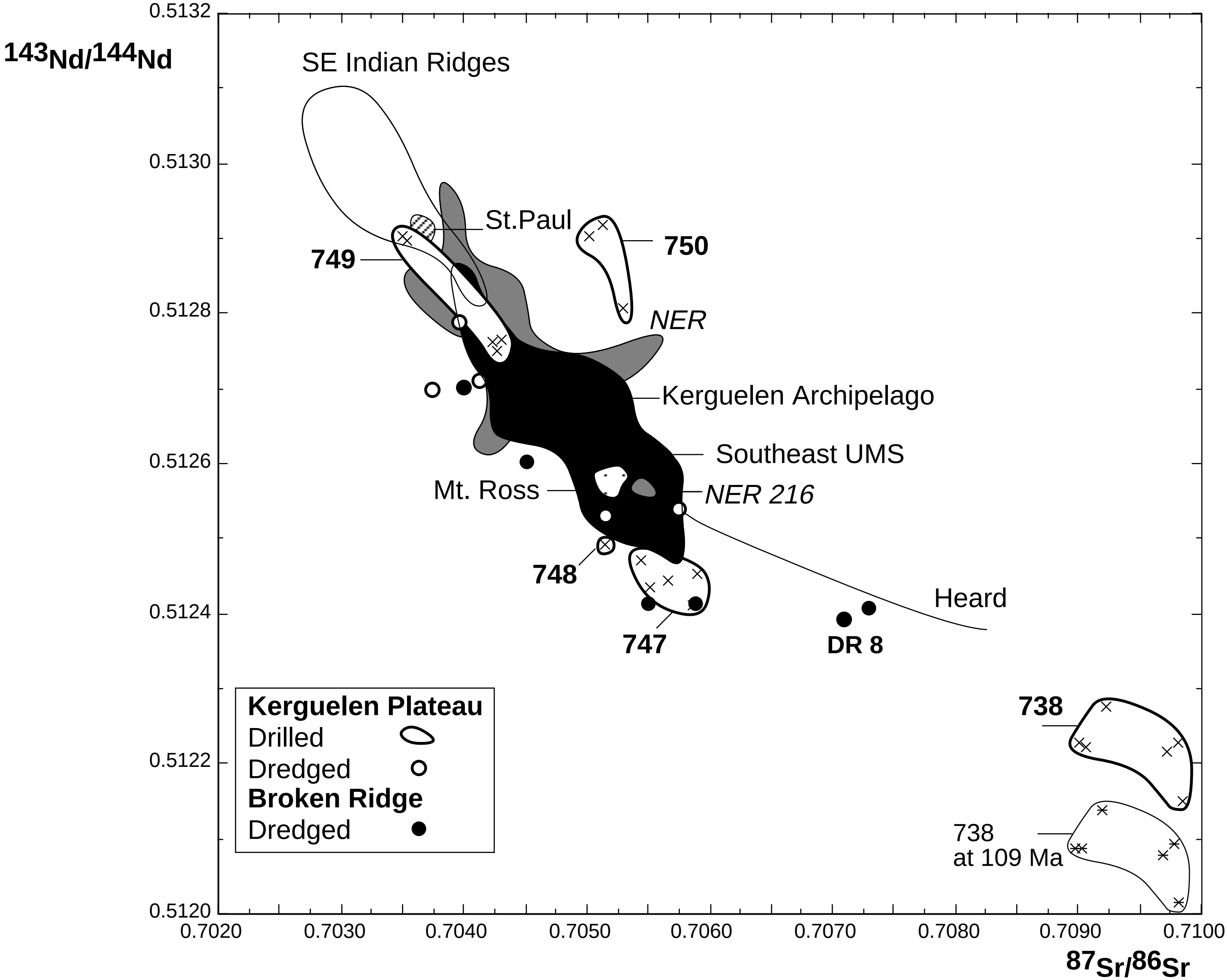

Figure 5B. $^{143}Nd/^{144}Nd$ versus $^{87}Sr/^{86}Sr$ showing data points for basalts recovered from the Kerguelen Plateau and Broken Ridge. The Broken Ridge samples are measured data corrected to an eruption age of 88 ma, the dredged Kerguelen Plateau samples are measured data corrected to an eruption age of 115 Ma. The effects of age correction are shown by the two fields (measured and age corrected) for ODP Site 738 on the southern Kerguelen Plateau. Data for other ODP sites are not age corrected because parent/daughter abundance ratios are not available. Data for Kerguelen Plateau and Broken Ridge samples are from Weis et al. (1989), Salters et al. (1992), and Mahoney et al. (1995). Shown for comparison are fields for SEIR MORB, St. Paul and Heard Islands, and Ninetyeast Ridge (NER and NER DSDP Site 216), the entire Kerguelen Archipelago with subfields indicated for the youngest archipelago lavas (Mt. Ross and Southeast UMS), which Weis et al. (1993, 1997) interpret as representative of the Kerguelen Plume.

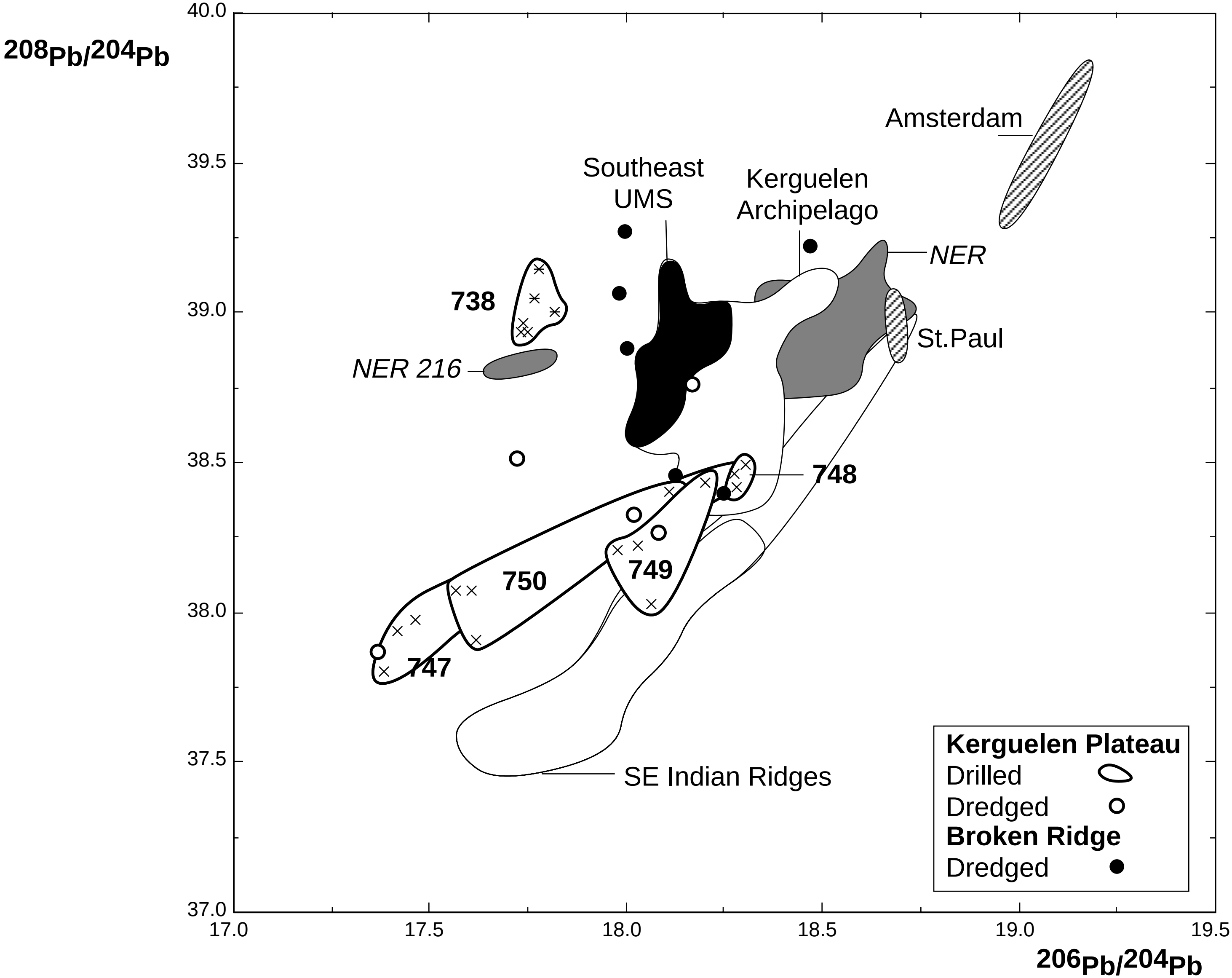

Figure 5c. $^{208}Pb/^{204}Pb$ vs. $^{206}Pb/^{204}Pb$ showing measured data points for basalts recovered from the Kerguelen Plateau and Broken Ridge. Shown for comparison are measured fields for SEIR MORB and lavas from St. Paul and Amsterdam Islands and initial ratios for lavas from the Kerguelen Archipelago and the Ninetyeast Ridge. The proposed field (Weis et al., 1993) for the plume is labeled "Southeast UMS." Data sources are as in Figure 5B.

TABLE 1

PROPOSED SITE INFORMATION AND DRILLING STRATEGY

SITE: KIP-2B	**PRIORITY**: 1	**POSITION**: 47˚56.4'S, 69˚54.6'E
WATER DEPTH: 150 m	**SEDIMENT THICKNESS**: ~750 m	**TOTAL PENETRATION**: ~950 m
SEISMIC COVERAGE: Single channel seismic line GA 3-A		

Objectives: 200 m of basement penetration

Drilling Program: RCB

Logging and Downhole Operations: Triple Combo, FMS, WST, DSI/ARI, BHTV, possibly GLT

Nature of Rock Anticipated: Basalt

SITE: KIP-3A	**PRIORITY**: 1	**POSITION**: 51˚10.9'S, 70˚54.5'E
WATER DEPTH: ~600 m	**SEDIMENT THICKNESS**: ~250 m	**TOTAL PENETRATION**: ~450 m
SEISMIC COVERAGE: Multi-channel seismic line MD 26-07		

Objectives: 200 m of basement penetration

Drilling Program: RCB

Logging and Downhole Operations: Triple Combo, FMS, DSI/ARI, BHTV, possibly GLT

Nature of Rock Anticipated: Basalt

SITE: KIP-6B	**PRIORITY**: 1	**POSITION**: 56˚54.9'S, 67˚59'E
WATER DEPTH: ~950 m	**SEDIMENT THICKNESS**: ~200 m	**TOTAL PENETRATION**: ~400 m
SEISMIC COVERAGE: Single channel seismic line ELT 54-03		

Objectives: 200 m of basement penetration

Drilling Program: RCB

Logging and Downhole Operations: Triple Combo, FMS, DSI/ARI, BHTV, possibly GLT

Nature of Rock Anticipated: Basalt

SITE: KIP-7A **PRIORITY**: 1 **POSITION**: 53˚40'S, 75˚35.3'E
WATER DEPTH: ~1200 m **SEDIMENT THICKNESS**: ~650 m **TOTAL PENETRATION**: ~850 m
SEISMIC COVERAGE: Multichannel seismic line RS 47-13

Objectives: 200 m of basement penetration

Drilling Program: RCB

Logging and Downhole Operations: Triple Combo, FMS, WST, DSI/ARI, BHTV, possibly GLT

Nature of Rock Anticipated: Basalt

SITE: KIP-9A **PRIORITY**: 1 **POSITION**: 32˚19.7'S, 98˚04.2'E
WATER DEPTH: 1325 m **SEDIMENT THICKNESS**: ~100 m **TOTAL PENETRATION**: ~300 m
SEISMIC COVERAGE: Single channel seismic line RC 2708

Objectives: 200 m of basement penetration

Drilling Program: RCB

Logging and Downhole Operations: Triple Combo, FMS, DSI/ARI, BHTV, possibly GLT

Nature of Rock Anticipated: Basalt

SITE: KIP-12A **PRIORITY**: 1 **POSITION**: 60˚40.3'S, 81˚49.1'E
WATER DEPTH: ~1800 m **SEDIMENT THICKNESS**: ~550 m **TOTAL PENETRATION**: ~750 m
SEISMIC COVERAGE: Multichannel seismic line MD 47-06

Objectives: 200 m of basement penetration

Drilling Program: RCB

Logging and Downhole Operations: Triple Combo, FMS, WST, DSI/ARI, BHTV, possibly GLT

Nature of Rock Anticipated: Basalt