OCEAN DRILLING PROGRAM

LEG 152 SCIENTIFIC PROSPECTUS

EAST GREENLAND MARGIN

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May 1993

Scientific Prospectus No. 52
First Printing 1993

Distribution

Copies of this publication may be obtained from the Director, Ocean Drilling Program, Texas A&M University Research Park, 1000 Discovery Drive, College Station, Texas 77845-9547. Orders for copies may require payment for postage and handling.

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Academy of Sciences (Russia) - Inactive
Canada/Australia Consortium for the Ocean Drilling Program
Deutsche Forschungsgemeinschaft (Federal Republic of Germany)
Institut Français de Recherche pour l'Exploitation de la Mer (France)
Ocean Research Institute of the University of Tokyo (Japan)
National Science Foundation (United States)
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European Science Foundation Consortium for the Ocean Drilling Program (Belgium, Denmark, Finland, Iceland, Italy, Greece, The Netherlands, Norway, Spain, Sweden, Switzerland, and Turkey)

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ABSTRACT

Divergent rifted margins are among the most prominent topographic features on our planet. One type of divergent rifted margin that was discovered barely 10 years ago, the so-called volcanic rifted margin, is now recognized as perhaps the most common style developed along the Atlantic margins. This style has also been identified along stretches of the Antarctic margins and around the Indian Ocean.

Leg 152 represents the second in an eight-leg program, proposed by the NARM-DPG, to investigate rifted margins. Four legs will be devoted to each margin type, volcanic and nonvolcanic. Leg 152, selected as first priority by the North Atlantic Rifted Margin Detailed Planning Group (NARM-DGP), will be the first leg to address processes at volcanic rifted margins by drilling a transect of proposed sites at 63°N, southeast Greenland.

The southeast Greenland transect is located approximately 550 km south of the original center of the Iceland hotspot in a region of apparent structural simplicity, with a well-understood, simple plate kinematic history. Breakup took place within cratonic lithosphere, forming two conjugate margins, one in southeast Greenland and the other represented by the Rockall-Hatton margin, previously drilled by the Deep Sea Drilling Project (DSDP). This transect of a total of four proposed sites is designed to constrain a number of different features of the margin including the timing of breakup, the nature of the lithospheric deformation, magmatic processes, flexural deformation rates, emplacement mechanisms, geochemical and volumetric trends in the magmatism, spreading rates prior to formation of the first oceanic magnetic isochrons, syn- and post-constructional subsidence of the volcanic carapace, and the post-breakup subsidence of the spreading ridge. Proposed site EG63-1 will sample, through deep basement penetration (400 m), the initial volcanism, while proposed site EG63-2 will sample the central part of the high-production volcanic phase in an area of interpreted steady-state wedge formation. It is further hoped that deep penetration (400 m) at this site can be used to recover the more rift-proximal deposits, cyclicities, and lava stratigraphy, which will bear on emplacement models. Geochemical data from the Reykjanes Ridge will be used as a reference for comparison with the rocks recovered at these sites. Site EG63-2 will further be used to study flexural deformation and associated strain rates in detail and with EG63-1 will provide a subsidence profile across a margin

showing simple topography. Proposed site EG63-4, scheduled for a later drilling leg, will extend these investigations into the oldest part of the seaward-dipping basalt sequence. Proposed site EG63-3, another alternate site, by shallow (150 m) penetration of the basement, is intended to sample the phase of waning volcanism and increased subsidence.

INTRODUCTION

The North Atlantic Rifted Margin Detailed Planning Group (NARM-DPG) met in 1991 to plan a program to study the problems of rifted margin formation and evolution. The group identified two important classes of margins to be studied: those continental rift margins in which anomalous intense magmatism had dominated the rifting process (volcanic rifted margins) and those continental rift margins in which magmatism seems to have been absent or incidental to the rifting process (nonvolcanic margins). The DPG recommended that ODP focus on type areas for each class (Larsen, Sawyer, et al., 1991). For the nonvolcanic margins this involved conjugate margin drilling of the Iberia-Newfoundland margins, a project started by Leg 149. For the volcanic rifted margins the northeast Atlantic margins and their relation to the Iceland hotspot were chosen as the main objective.

Leg 152 is the first leg out of a total of four legs proposed by the NARM-DPG for the study of the tectono-magmatic development of volcanic rifted margins. The four legs planned by the DPG involve three margin transects (Fig. 1). The first-priority transect is the EG63 transect offshore of southeast Greenland. The second priority is a transect across the Voering margin off central Norway. The third priority is a second transect across the southeast Greenland margin (EG66 transect). The three transects have been chosen to provide comparable drilling data from margins or segments of margins in different lithospheric settings, with partly different structural development and with different offset from the supposed center of the Icelandic mantle plume. Within each transect the temporal evolution of the margin will be imaged.

The southeast Greenland transect EG63 was considered the highest priority and main transect by the NARM-DPG because of its simple and well-constrained setting and because of the conjugate Rockall-Hatton margin already drilled by DSDP Leg 81 (Roberts, Schnitker, et al., 1984). Thus it was considered likely that detailed variations with time in crustal accretion rates and in the composition of the voluminous igneous rocks laid down along this margin during breakup could be retrieved by drilling. These could then be interpreted in terms of the various models proposed for volcanic rifted-margin formation. To fully complete the four sites planned for the EG63 transect will require more than two legs of drilling. Leg 152 is planned to drill two sites along the transect, one at the landward end of the transect (EG63-1) and one within the central part of the transect (EG63-2). Depending on results from Leg 152, up to two more sites later will be added (EG63-3, -4) and initial holes deepened as appropriate.

In addition to the tectono-magmatic objectives of Leg 152, North Atlantic paleoceanographic and paleoclimatic objectives will be addressed.

VOLCANIC RIFTED MARGINS

Volcanic rifted margins (VRMs) are characterized by significant igneous-magmatic crustal accretion and substantial surface volcanism during continental breakup. During breakup, eruption occurs largely above sea level for some time after initiation of continental drift. Figure 2 shows the idealized zonation of a volcanic rifted margin into a three fold division: a landward zone of plateau basalts, sills, and dikes; a central zone of baselap-free, seaward-dipping, and offlapping lava-flow units (seaward-dipping reflector sequence, SDRS); and a seaward zone of seafloor-spreading crust generated at increasing water depth. In contrast to nonvolcanic rifted margins, volcanic rifted margins tend not to show a wide zone of crustal attenuation toward the ocean-continent transition (OCT). A fairly thick crust (20-25 km) with high seismic velocities in the lower crust is observed around the transition zone.

The emplacement mode of the volcanics and the syndepositional subsidence pattern associated with volcanism are clearly different in Zones I and II (Fig. 2). A fairly simple concordant infill and subsidence pattern is present within Zone I, in strong contrast to the nonconcordant, offlapping infill pattern and associated flexural subsidence pattern within Zone II (SDRS). This peculiar structure has caused an intense debate on the emplacement mode and crustal heritage of the SDRS (Hinz, 1981; Mutter et al., 1982; Smythe, 1983; Roberts, Schnitker, et al., 1984; Larsen and Jacobsdottir, 1988; Eldholm et al., 1989). There is now a general consensus, however, that the kinematic model for crustal accretion in Iceland (Palmason, 1973, 1980) can qualitatively explain the structure as a continuous process of igneous crustal accretion emanating from a central linear rift zone. Larsen and Jacobsdottir (1988) demonstrated the potential quantitative applicability of the Palmason model using input parameters based on seismic stratigraphy. Objectives of Leg 152 include retrieval of more precise quantitative data for such modeling.

Evidence for significant tectonic stretching and thinning of the crust and lithosphere (e.g., basement-involved normal faulting) along volcanic rifted margins during breakup is presently scarce and inconclusive, but could be masked by the continental flood basalts (CFBs) and/or the feather edge of the SDRS (Hooper, 1990; Larsen and Marcussen, 1992; Skogseid and Eldholm, 1989). Also large CFBs are in general little deformed by faulting. However, some CFBs show marked faulting and downflexing along narrow, margin-parallel deformation zones relatively close to the line of breakup (e.g., western Ghat flexure, the Lembobo flexure, and the East Greenland coastal dike swarm and flexure; see Fig. 3). These flexures seem to mark the transition from relatively nondeformed, cratonic lithosphere seaward into deformed and downflexed lithosphere below the onlapping feather edge of the SDRS. Clearly, the effective elastic thickness and flexural rigidity of this downflexed continental lithosphere is very much reduced. Leg 152 will be drilling immediately seaward of the East Greenland flexure and dike swarm and will provide constraints on the timing and the flexural deformation rates associated with the formation of this tectonic feature.

One of the major objectives of the EG63 transect and Leg 152 is to provide stratigraphically well-constrained sampling of the magmatic evolution associated with the development of the most striking feature of VRMs, the SDRS. These huge volcanic edifices belong to some of the largest igneous provinces (LIPS) known from Earth history.

Several models attempt to explain the formation of large volumes of magma at rifted plate margins. These range from catastrophic plume "impact" models, where a plume ascending from the lower mantle impacts and initiates magmatism when it hits the base of the lithosphere (Richards et al., 1989), through the more passive plume "incubation" models, whereby a large plume head slowly incubates beneath a lithospheric cap (Kent et al., 1992) and releases melt only when the lithosphere is stretched (White and McKenzie, 1989). Other models imply no role for a plume, for example, the broad thermal anomalies of Anderson et al. (1992) and the convective overturn model of Mutter et al. (1982).

These different models are not mutually exclusive, and components of several or all of them may contribute to the formation and petrological characteristics of VRMs. Some of the key differences between the models are the degree of temperature anomaly within the asthenosphere, the shape and life length of the temperature anomaly and the role of "passive" plate drag and associated mechanical thinning of the lithosphere in the process of melting of the asthenosphere and the excessively strong generation of magmatic melts.

The EG63 transect and Leg 152 will investigate these variables by examining in detail the temporal evolution of the magmatism from its start, through its excessive phase and into its waning stage and "normal" seafloor spreading. Eventually the transect is also intended to provide an image of the spatial variations of these variables and the possible influence of different lithospheric settings and reactions. This is the main objective of the planned two other transects (Vøring margin and EG66 transects, Fig. 1).

SCIENTIFIC OBJECTIVES AND METHODOLOGY

Summary of Scientific Objectives

1. To constrain the timing of, and tectono-magmatic variation across, an archetypal seaward-dipping reflector sequence (SDRS).

2. To determine and constrain volcanic emplacement mechanisms and investigate the nature of underplating.

3. To evaluate the relationship between the Iceland plume and the southeast Greenland volcanic rifted margin.

4. To understand the subsidence and oceanographic history of the Irminger Basin, Arctic bottom water overspill across the Iceland-Greenland Ridge, and the glaciation history of southern Greenland.

Tectono-Magmatic Objectives

A first-order objective is to determine to what extent rifting at a volcanic rifted margin is active or passive. In the active model, extension is driven by local forces acting on the plate, such as those produced by a buoyant mantle plume. With the passive model, the plate responds to remote plate forces. The relationship between rifting and magmatism at volcanic margins will vary, according to whether rifting is active or passive. If rifting is passive, we may observe significant stretching of the lithosphere *before* major volcanism (White and McKenzie, 1989), whereas if the rifting is active, hot plume mantle may rise to shallow levels, decompress, and melt without significant prior stretching of the lithosphere (Duncan and Richards, 1991). Data from drilling cannot alone resolve this fundamental issue. However, the whole array of drilling-derived data regarding the temporal evolution in magmatism, geochemically as well as plate-kinematically, coupled with the deformation rate of the lithosphere, will help considerably in resolving the controversy between active and passive rifting.

Timing of the SDRS

Constraints on the timing of magmatism (and subsidence of the margin) will be provided by a combination of radiometric dating of volcanic rocks, paleomagnetism, and high-resolution biostratigraphy of late Paleocene and early Eocene sediments. Timing and duration of volcanism can be constrained by radiometric dating of volcanic rocks. ^{40}Ar-^{39}Ar laser dating of phenocrysts, for example, can yield uncertainties lower than 1 %, provided suitable material is available. Paleo-secular variation of the magnetic field measured from oriented cores of rapidly accumulated basalts can, it is hoped, provide high-resolution relative dating on the order of 5-10 k.y. It is generally believed that the whole SDRS was emplaced during Chron 24R, but systematic and partly linear magnetic anomalies exist landward of Anomaly 24N. It is unclear if these represent dateable, older magnetic reversals as old as Chron 26R/27N, or if they represent less specific paleo-intensity variations in the magnetic field. In both cases the paleomagnetic data will be used as far as possible to provide high-resolution stratigraphic control. Late Paleocene and early Eocene biostratigraphy south of the Faeroe-Greenland Ridge should have a high potential for precise dating, and it is hoped that the drilling data will provide new avenues for refined correlation with the existing magnetic time scale. Drill samples can also provide material for tephrochronological studies, thus enabling investigations of the long-term evolution of the North Atlantic Volcanic Province.

Tectono-Magmatic Evolution

At the ocean/continent boundary, flexure rather than localized fault failure seems to prevail. The crustal flexure is associated with and caused by extreme differential and syn-formational subsidence of the order of perhaps 5 km/m.y. The deep (400 m) sampling of basement scheduled for Leg 152 can constrain both the overall timing of this deformation, as well as provide detailed imaging and high-resolution relative timing of local flexural response. From these data, strain rates, effective elastic thickness of the lithosphere, and flexural rigidity can be calculated. Possible lateral flow of material at deeper levels can be inferred from these observations, and the overall thermal regime can be estimated independent of the estimates based on the composition of the erupted magmatic rocks. In addition, the spreading rate during the early phase of spreading, prior to the first datable seafloor-spreading anomalies, can be established through drilling.

A major, transient thermal anomaly is likely to have been present during breakup to have produced the excessive amounts of magmatic melts. Modeling of major element variations such as Na content and CaO/Al_2O_3 ratios will be used to estimate extent and pressure of melting. In addition, Mg-rich picritic liquids, formed by extensive melting, may be common. Alkaline magmas formed by lower degrees of melting at great depth may also occur. With time, i.e., within the younger and outer part of the SDRS, these thermal effects would be expected to dissipate, particularly in the case of a plume head model in which a great deal of the thermal energy would be used in melt formation at an early stage of rifting.

Mixing of lower mantle with entrained upper mantle in the plume head might be expected to produce rapid fluctuations in magma composition, which will be reflected, for example, in variations in trace-element and isotopic systematics with stratigraphic height in the volcanic sequence. Significant contamination of the earliest emplaced basic lavas could also be expected if the mantle melts have to actively rift and traverse a thick and only moderately fractured crust.

Because the parental magma of basalts in the different models originates at different mantle depths and follows a different time-temperature path, petrological and geochemical studies of drill-core samples and estimates of magma production rates will constrain the relative importance of the three models. Plume components from deep mantle sources in the volcanic rifted margin sequences can be identified and quantified by geochemical studies. Although plumes differ from one another in source composition, they commonly show enrichments in trace elements (e.g., light rare earth elements, barium, thorium) and distinct radiogenic isotopic ratios of strontium, neodymium, and lead (e.g., Sun et al., 1975; Zindler and Hart, 1986). In addition, modeling of major element variations in oceanic tholeiites has shown that variations in sodium content and CaO/Al_2O_3 ratios are particularly sensitive to the extent of melting, and FeO is sensitive to the pressure of melting (Klein and Langmuir, 1987; McKenzie and Bickle, 1988).

SDRS Emplacement and Magmatic Underplating

Emplacement history of the volcanic rocks and the possible role of underplating can be detailed and investigated by the scheduled deep (400 m during Leg 152, later to be deepened) basement drilling. The drilling data and calibrated seismic mapping in 3D will allow calculation of individual flow volumes, variations in magma production rates with time, and variations in residence time in shallow crustal magma chambers (primitive vs. fractionated magmas, aphyric vs. porphyritic). The data will be used to investigate possible cyclicities, to verify original flow directions, and to analyze for possible crust-magma anatectic reactions suggestive of underplating. This quantification of the volcanic system together with the deformation pattern of the lithosphere, will provide important, though indirect, information on the suggested processes of magmatic underplating.

Relationship of the Iceland Plume to the Volcanic Rifted Margin

One specific objective of Leg 152 is to obtain sufficient material from the SDRS, and in future legs from the "normal" oceanic crust distal to the volcanic margin, with which the composition of the basaltic magmas may be determined. Extrapolation of elemental and isotopic data will enable estimates of mantle compositions and temperatures to be made. These will be compared with existing data from Iceland and the Mid-Atlantic Ridge (MAR). Questions that may be raised include: Do the basalts of the SDRS show spatial and temporal variations in composition, consistent with changes in input from the continental lithosphere, plume mantle, and asthenosphere? Do the basalts of the SDRS have MORB-like or Icelandic compositions? This may enable us to determine whether the basalts represent melting of plume-heated MORB-like asthenosphere or melting of ancestral Icelandic plume mantle. It is hoped that this in turn may provide important information about the dynamics of the plume system.

Paleoceanographic and Paleoclimatic Objectives

Following formation of the SDRS the new igneous lithosphere started to subside, and an ocean basin gradually formed between the Greenland margin and the paleo-Reykjanes Ridge. This basin, called the Irminger Basin, was, and to a large extent still is, bound to the north by the prominent basement ridge between Iceland and Greenland, part of the Faeroe-Iceland-Greenland Ridge, which formed over the center of the Iceland plume (Figs. 5 and 6). One of the objectives of Leg 152 is to study the history of the Irminger Basin. Specific objectives are the tectonic subsidence history, the history of overflow of Arctic water across the Iceland-Greenland Ridge, initiation of North Atlantic drift deposits, and the record within the basin of the glaciation history of the South Greenland continent.

Subsidence Analysis

Subsidence of the rifted volcanic margin is a key issue to be addressed by the drilling during Leg 152. While the drill sites are now located in a variety of water depths, ranging from 520 to 2095 m, it is believed that most of the lavas which form the dipping reflector sequences were erupted under subaerial conditions close to sea level. The sediments which form the cover at each site should therefore record the transition from the terrestrial to the outer shelf/slope environment. Backstripping techniques, such as the Airy isostatic equations of Sclater and Christie (1980), can be employed to reconstruct the tectonically driven subsidence from the sedimentary column. As well as calculating accumulation rates, determination of paleo-water depths will be critical. At shallow water depths, early in the subsidence history, sedimentary facies and trace-fossil assemblages, together with the microfaunal assemblage and its state of preservation, can be used to closely constrain subsidence history. Later, as the margin subsided into greater water depths, the degree of uncertainty in the water-depth estimate will increase. The subsidence analysis will enable us to estimate the rate of thermal contraction of the lithosphere after the formation of the anomalous thick crust. A transect of two or more sites will furthermore allow changes in these factors to be traced across the margin and toward the Reykjanes Ridge, presently at 2000 m water depth.

Overflow of the Iceland-Greenland Ridge

There are few oceanic gateways that can compete with the Greenland-Scotland Ridge in having such a profound influence on the present world hydrography (Bott et al., 1983). Reconstructions of the subsidence history of the ridge system suggest that its eastern parts sank beneath sea level sometime during middle Eocene times, and during early to middle Miocene times in the Denmark Strait area between Iceland and Greenland. The distribution of shallow-water benthic foraminifers, however, indicates that the Nordic Seas were effectively isolated from any "deep" Atlantic influence until middle Miocene times (Berggren and Schnitker, 1983; Thiede, 1983; Thiede and Eldholm, 1983). The overflows have both influenced the Atlantic and the global deep-water masses through their contribution to North Atlantic Deep Water (NADW) production and to the formation of North Atlantic sedimentary records. It is hoped that Leg 151 drilling results from the main source regions of deep Arctic water can be used to characterize the physical and chemical state of surface and deep waters north of the Greenland-Scotland Ridge (151 Scientific Prospectus). Drilling, during Leg 152, in the Irminger Basin will complement this study by providing data on the overflow history of this water mass across the Iceland-Greenland Ridge, through the Denmark Strait.

Glaciation History, North Atlantic Drift Deposition

The Norwegian-Greenland Seas and the Arctic Ocean are surrounded by landmasses that acted as loci for the late Cenozoic Northern Hemisphere ice sheets. The history of large glaciations in the high northern latitudes has been firmly documented only back to approximately 2.5 Ma (Shackleton et al., 1984; Ruddiman and Raymo, 1988; Jansen et al., 1988), although glaciation in some areas must have started earlier in the Neogene. With the presently available material it is impossible to document clearly when glaciers started to evolve in the Arctic and high subarctic, and it is impossible to describe the glaciation history of the different individual areas, i.e., when was Greenland glaciated?

The Greenland continent spans more than 20° in latitude from the subarctic in the south to the high Arctic in the north. The glaciation history and dynamics of ice sheets in relation to climate changes might therefore be expected to be different in the north and south. The strongest climatic gradients supposedly have existed in the south. Transect EG63 is ideally positioned for monitoring the development of the southern ice cap of Greenland from the results obtained from drilling. The inner site EG63-1 is positioned in the center of a major fjord/shelf/trough/fan system (Fig. 7). More seaward sites are located within the distal parts of this system, which clearly was an important outlet system for the southern ice cap of Greenland during glacial times.

REGIONAL SETTING

Continental breakup and seafloor spreading started in the northeast-Atlantic during late Paleocene time (Fig. 5). Breakup was accompanied by large outpourings of basaltic magma and the formation of seaward-dipping reflector sequences along much of the Greenland and northern European conjugate margins (Fig. 6). The precise timing of the age of initiation of rifting, continental separation, and formation of the SDRS is not perfectly known. The first datable seafloor-spreading anomaly is Anomaly 24 and spreading was originally believed to have started just prior to Anomaly 24 (Talwani and Eldholm, 1977). However, the presence of a broad SDRS landward of Anomaly 24 suggests the existence of an intense period of igneous crustal accretion prior to Anomaly 24 (Mutter et al., 1982; Larsen and Jacobsdottir, 1988). As yet, it is not known exactly when this early and anomalous accretion of igneous crust started, and whether there are regional variations in the timing of initiation of volcanism along the line of breakup. However, Anomaly 25N has not been identified, and the pre-Anomaly 24 SDRS is generally associated with a broad magnetic low (Fig. 4).

Breakup and seafloor spreading were initiated within two different zones of lithosphere. South of Iceland, the line of breakup was a linear, nonsegmented rift zone within old cratonic lithosphere; the present spreading axis still follows this simple pattern (Reykjanes Ridge). North of Iceland, breakup took place in lithosphere which had been affected by the Caledonian orogeny, followed by Devonian through Cretaceous rifting and basin formation. Several transform faults developed in this region. North of Iceland, spreading later ceased along the Aegir Ridge, and correspondingly the Kolbeinsey Ridge propagated northward to accommodate the extension (Fig. 5). Spreading adjustments also occurred farther north, causing local duplication of Anomaly 24 on the Vøring margin and a corresponding absence of it and some younger anomalies on the conjugate Greenland margin.

The powerful thermal anomaly required to generate the large volumes of basaltic magma in the SDRS (White and McKenzie, 1989) testifies to the influence of the ancestral Icelandic mantle plume. The Iceland plume was supposedly located beneath east-central Greenland during breakup (Fig. 1), and its activity is recorded in intense plutonism and volcanism in this region (Brooks, 1973; Larsen, 1978; Brooks and Nielsen, 1982; Larsen and Watt, 1985). The east Greenland volcanic sequence is a major continental flood basalt province extending from south of Kangerdlugssuaq northward to Shannon Island (Fig. 6). Since the lavas were erupted during magnetic Anomaly 24R times (Larsen et al.,1989; Upton et al.,1980), they may overlap in time with the SDRS formed at the same latitude and with CFBs from the Faeroe Islands on the eastern side of the rifted continent (Waagstein, 1988; Gariepy et al., 1983). The zone of SDRSs broadens along the Greenland margin toward Iceland, and thus progressively overlaps younger magnetic anomalies toward the Greenland-Iceland Ridge (Fig. 6). The distribution and internal architecture of SDRSs north of Iceland is more complex due to the more complicated spreading history (Eldholm et al., 1989).

DRILLING STRATEGY

Transect EG63 (Figs. 3, 7, and 8) is located close to 63°N, and is approximately 550 km south of the center of the syn-breakup, ancestral Iceland hotspot. The transect of four proposed sites, two of which (EG63-1 and EG63-2) are scheduled to be drilled during Leg 152, is in an area of cratonic lithosphere that underwent only limited tectonic stretching prior to breakup (Larsen, 1988, 1990). The landward part of the ocean-continent transition is developed as a coast-parallel, intense dike swarm and crustal flexure of the cratonic basement rocks (Nielsen, 1978; Myers, 1980). This structure can be followed along the inner to mid shelf (Larsen, 1978) southward to the proposed southeast Greenland transect at about 63°N, where it is replaced seaward by the SDRS.

The drilling transect starts on the middle to outer part of the narrow shelf, only about 40 km offshore (Fig. 8). The inner to mid-shelf is floored by basement rocks with a thin Quaternary cover (Fig. 9). The outer shelf is floored by the landward feather edge of the southeast Greenland

SDRS covered by up to 1.5-km-thick Paleogene and Neogene sediments. The planned drilling transect extends seaward across the wide southeast Greenland margin for about 150 km and terminates in oceanic crust of Anomaly 24 age close to the seaward end of the SDRS. The seafloor-spreading anomaly pattern is simple and well developed in this region, thus allowing easy determination and precise estimates of spreading rates. Spreading rates from late Anomaly 24R time to 23R time seem to have been unusually high, about 3 cm/yr (half rate, Larsen, 1980), compared to present-day values close to 1 cm/yr (Fig. 4). The seaward termination of the southeast Greenland SDRS is diachronous, with termination prior to Anomaly 24B in the south and progression of the SDRS onto slightly younger crust farther north, and much younger crust close to the Iceland hotspot.

The SDRS attains a uniform geometry and steady-state development from around 25-40 km seaward of its feather edge and maintains the same architecture until its seaward termination. The SDRS is seismically imaged to great depth (5-7 km; Larsen and Jacobsdottir, 1988). The along-strike study of individual SDRS units bounded by particularly strong reflectors shows that the southeast Greenland SDRS indeed comprises wedge-shaped units, which continue uniformly along strike for more than 100 km parallel to the ocean-continent transition and the seafloor-spreading anomalies.

These observations and the application of the kinematic model for crustal accretion in Iceland (Palmason, 1973, 1980) led Larsen and Jacobsdottir (1988) to conclude that the southeast Greenland SDRS consists of mainly subaerial erupted basalts that originated from narrow (5 km) and very long (100-200 km or more) fissure zones or small rifts parallel to the seafloor-spreading isochrons. These fissures or rifts probably showed little faulting and relief across the rift zone and little topographic variation along strike. The average volcanic productivity and crustal accretion rate probably exceeded present-day levels from Iceland by a factor of at least 3. The total stratigraphic thickness of the whole SDRS, summing maximum thicknesses at depth, is about 50 km (Larsen and Jacobsdottir, 1988).

The EG63 transect is located along the 61°N flowline (61°N at the Reykjanes Ridge), which, according to isotopic and LREE data, is within the distal portion of the source signature from the Icelandic plume. Formation of the SDRS wedge terminated between Anomaly 24B and 24A along this transect and flowline. The transect will show whether the source compositional anomaly extended farther south during breakup than it does at present. If the composition of the older part of the SDRS on the main transect is similar to basalts recovered from the conjugate Hatton margin farther south (i.e., N-type MORB from around the 58°N flowline) and from the MAR around 58°N, substantial decoupling of the thermal and source compositional anomaly during breakup may have occurred. If, on the other hand, the older part of the SDRS displays a source compositional anomaly (i.e., Icelandic or transitional compositions), then somewhere along the flowline (i.e., along transect) there must be a change in composition toward N-type MORB. In either case, important information will be obtained about the spatial and temporal extent of the compositional vs. thermal-plume components during breakup.

The four proposed EG63 transect sites together will provide extremely good control on the subsidence history across this margin for integration with the seismically documented facies developments on the shelf, slope, and abyssal plain. These in turn have clear bearings on the overflow history of the Faeroe-Iceland-Greenland Ridge, the formation of regional North Atlantic unconformities, and the glaciation history of southern Greenland and Iceland (Miller and Tucholke, 1983; Miller et al., 1985).

PROPOSED SITES

Proposed Site EG63-1

This site is located on the southeast Greenland continental shelf, on the oldest, landward edge of the SDRS (Chron 25N or older) in a water depth of 520 m (Figs. 9 and 10). Approximately 440 m of sediment, probably ranging in age from Paleocene to Holocene, overlies the SDRS. Studies of the seismic reflection profiles suggest that three sedimentary units will be drilled: (1) 260 m of Holocene sediments, probably glacial tills, unconformably overlying (2) 80 m of Eocene to Miocene clastic shelf sediments, which in turn overlie (3) 100 m of Paleocene to lower Eocene terrigenous to shallow-water clastic sediments. The lowest part of the sedimentary succession may in part be volcaniclastic, with carbonates occurring above.

The basaltic basement comprises a series of seaward-dipping flows, probably massive in character, and interbedded with thin sedimentary zones. At Site EG63-1, the base of the basaltic succession cannot be seen on the seismic sections. To the west, however, the basalts appear to overlie continental crustal basement unconformably. The SDRS rapidly thickens eastward. This site is designed to optimize recovery of the older parts of the SDRS whilst also recovering the Paleocene to Miocene sedimentary successions. Basement penetration to 400 m is scheduled (Table 1).

Furthermore, at site EG63-1 a regional shelf unconformity, separating the strongly prograding sequence below the outer self from overlying concordant and horizontal strata, has been interpreted by Funder and Larsen (1989) and Larsen (1990) to reflect an approximately 1-2 m.y.-old complete glaciation of the shelf by grounded shelf ice. Recent high-resolution seismic data (Fig. 8) tend to support this interpretation but also indicate that the underlying strongly prograded sequence is the result of deposition below and in front of a surging shelf ice guided by the deep trough system present on the shelf. Drilling at sites EG63-1 and -2 will test this hypothesis.

Proposed Site EG63-2

Proposed site EG63-2 is located near the center of the SDRS outcrop on the upper continental rise in a water depth of 1875 m (Figs. 9 and 11). Approximately 1220 m of upper Paleocene to Holocene sediments overlies basaltic basement. From seismic data the sedimentary succession probably comprises (1) 350 m of hemipelagic post-Miocene clastics, including possible contourites; (2) 520 m of post-lower Eocene sand/silt/clay turbidites; (3) 350 m of Paleocene/lower Eocene shelf sediments (shallow marine sands and carbonates grading down into terrigenous sediments with volcaniclastic deposits).

As with site EG63-1, the basaltic basement comprises a series of seaward-dipping flows, probably massive in character, interbedded with thin sedimentary zones. Again, the base of the basaltic succession (probably a sheeted dike complex) cannot be seen on the seismic sections. This site is designed to optimize recovery of the thicker parts of the SDRS, younger than those recovered at site EG63-1, whilst also recovering the Paleocene to Miocene sedimentary successions. Basement penetration to 400 m is scheduled (Table 1). This site is the ideal place for a deep well into the SDRS, which is well developed and well seismically imaged here (including along-strike data). A steady-state magmatic development has clearly been established.

Below the continental slope and rise, the thick, prograded shelf sequence laterally passes into a rather thick, deep-water sequence showing stratigraphic features of drift deposits. Site EG63-2 will drill through this supposedly strongly expanded, upper Neogene sequence (Fig. 11) and thus will potentially provide important data on both the glaciation history as well as possible orbital forcing of climate, as evidenced by cyclicity within these North Atlantic drift deposits.

PROPOSED CONTINGENCY SITES

The following two sites are planned for drilling on legs subsequent to Leg 152. They are included here only as contingency sites, and they are not likely to be drilled during Leg 152.

Proposed Site EG63-3

Proposed site EG63-3 (Figs. 9 and 12) is placed at the seaward end of the SDRS in a position where some deep SDRS units still can be discerned at depth but where the shallow igneous crust has lost the seismic structure typical of SDRS. This site thus represents the transition to "normal" submarine volcanism. Subsidence rates, the thermal structure of the crust, and the chemical composition of the basalts may all be transitional in character between the "steady state" SDRS and "normal" oceanic crust. Approximately 1420 m of sedimentary rocks will be drilled at this site; they are likely to have similar characteristics to those expected at site EG63-2. Basement penetration to 150 m is proposed (Table 1).

Proposed Site EG63-4

Proposed site EG63-4 (Figs. 9 and 13) is placed landward of Site EG63-2 and is contingent upon the results at site EG63-2. Site EG63-4 is located 20 km landward of site EG63-2, making a stratigraphic overlap between the two sites possible if proposed site EG63-2 is ultimately deepened to about 1000 m into basement. Approximately 1180 m of sediments, with characteristics similar to those at site EG63-2, overlies basaltic basement. Basement penetration of 150 m is proposed if drilling at this site is necessary during Leg 152.

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TABLE 1. SUMMARY SITE INFORMATION, LEG 152.

Site	Lat./Long.	Water Depth (m)	Seismic Profile	Sediment Depth TWT (s)	Sediment Thickness (m)	Basement (m)
EG63-1	63°27.46'N 39°43.30'W	520	MCS Line GGU81- 08 SP 320	0.45	440	400
EG63-2	63°05.52'N 38°38.10'W	1875	MCS Line GGU81- 08 SP 1682	1.15	1220	400
EG63-3	63°40.45'N 37°27.26'W	2095	MCS Line GGU81- 08 SP3233	1.30	1420	150
EG63-4	63°12.43'N 38°56.42'W	1840	MCS Line 81- 08 SP 1291	1.20	1180	150

TABLE 2. DRILLING AND TRANSIT TIME ESTIMATES, LEG 152.

Site	Priority	Drilling Option	Transit Time(days)[1]	Time on site (days)
Transit: Reyjavik to EG631			1.9	
EG63-1	1	APC/XCB Hole[2]	0.6	
		RCB Hole[3]		13.6
		Logging[4]		3.2
Transit: EG63-1 to EG63-2			0.2	
EG63-2	1	APC/XCB Hole	0.9	
		RCB Hole		26.2
		Logging		5.0
Transit: EG63-2 to St Johns				4.2
Subtotal			6.2	49.5
Total				55.7 days

Contingency Sites

Site	Priority	Drilling Option	Transit Tim (days)[1]	Time on site (days)
EG63-3	2	APC/XCB Hole		1.4
		RCB Hole		20.2
		Logging		3.9
Total				25.5
EG63-4	2	APC/XCB Hole[5]		1.3
		RCB Hole[6]		16.4
		Logging[4]		4.0
Total				21.7

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[1] Time estimate based on average ship speed of 10.5 kt.

[2] XCB/APC hole. APC to refusal or 50 mbsf. Change to XCB until 150 mbsf.

[3] RCB hole. Drill to 150 mbsf, followed by RCB coring to 550 mbsf. Hole will then be logged and casing set and cemented in conjunction with a reentry cone. RCB coring will continue until 400 m basement penetration has been achieved, involving 5 bit changes.

[4] Logging. This will be accomplished in two stages. The upper 490 m at EG63-1 and the upper 550 m at EG632 will be logged prior to casing and reentry cone deployment. Deeper portions of the hole will be logged after RCB coring to 400 m basement penetration.

[5] XCB/APC hole. APC to refusal or 200 mbsf. Change to XCB until 250 mbsf.

[6] RCB hole. Drill to 250 mbsf, followed by RCB coring to 550 mbsf. Hole will then be logged and casing set and cemented in conjunction with a reentry cone. RCB coring will continue until 150 m basement penetration has been achieved, involving one bit change.

FIGURE CAPTIONS

Figure 1. Supposed location and distribution of the Iceland hotspot at the time of breakup (White and McKenzie, 1989). According to this model, rifting and breakup can start over a large area of the thermal plume head. In the northeast Atlantic, the line of breakup apparently crossed right over the plume center. Also shown are the three proposed ODP transects: EG63, EG66, and VM-VP.

Figure 2A. Idealized zonation of a volcanic rifted margin. Zone I may be a "sedimentary equivalent" to the Zone II volcanic edifice and may, or may not, be floored by older rift basins. If breakup takes place in a cratonic area such as in southeast Greenland, Zone I may develop only very few or no pre- to syn-rift sediments and merely is a gentle basement arch. A striking feature of volcanic margins is the rather thick crust and high-velocity lower crust found below the outer continental crust and the oldest oceanic crust. It has been suggested that crustal thickening is due to magmatic underplating (White and McKenzie, 1989). SDRS = seaward-dipping reflector sequence.

Figure 2B. Schematic cross section of a volcanic margin development in a cratonic area. However, some syn-breakup sediments are likely to occur between basement and the onlapping SDRS wedge. Also some fault failure within the continental basement may occur, although overshadowed by the significant flexural deformation. Continential flood basalts (CFB) may build up within Zone I. Note the differences from Figure 2A. Most real examples show variations between these two different developments.

Figure 3. Three-dimensional view of the southeast Greenland shelf seen from the south. Note how the crystalline basement extends over most of the shelf in the south. The width of the crystalline basement on the shelf narrows to the north and occupies relatively much less of the shelf because the sedimentary shelf has prograded seaward in the northern area. OCT = approximate ocean-to-continent transition. The trend of the OCT is oblique to the coastline and very close to the shore in the north. The classic East Greenland dike swarm can be seen along the coast from about lat. 66°N (Wager and Deer, 1938) and most likely is the start of the oceanic lithosphere as suggested by H.C. Larsen (1978). Modified from Larsen (1990).

Figure 4. Opening of the northeast Atlantic. Note the mid-Tertiary development of a spreading axis propagating northward from Iceland, causing a secondary SDRS wedge to form. This wedge is much less well developed than the early Tertiary breakup wedge. From Larsen (1988). GSFZ = Greenland-Senja Fracture Zone; JMFZ= Jan Mayen Fracture Zone; EJMFZ = Early Jan Mayen Fracture Zone; IRZ = Icelandic Rift Zone; IGR = Iceland-Greenland Ridge ; IFR = Iceland Faeroe Ridge; KR = Kolbeinsey Ridge; JMR = Jan Mayen Ridge; EGEA = East Greenland Extinct Axis.

Figure 5. Magnetic-intensity variations measured along the main southeast Greenland transect. A broad zone of low magnetic anomalies characterizes the region between the continental basement of Greenland and the first strong spreading magnetic anomaly, 24. Small positive anomalies in this pre-anomaly 24 crust may correlate with anomalies 25 and 26. If this is the case, then rifting would have initiated earlier (pre-anomaly 26) than predicted and would have proceeded at a moderate rate of 1.5 cm/yr. If these positive features merely represent noise on the record, then rifting may have been later (pre-anomaly 24) and more rapid, 4.1 cm/yr. Generation of the SDRS took place over 7-8 m.y. in the slow rift model compared to only 2-3 m.y. in the fast scenario.

Figure 6. Map of the North Atlantic region, showing the location of dipping reflector sequences, basalt and sill complexes, and relevant DSDP, ODP, and commercial boreholes. The thick, dashed line represents a crustal, isovolumeteric line and is the approximate (younger) limit of the initial magmatic pulse that accompanied the opening of the North Atlantic Ocean. Note that this pulse is diachronous. NAVP = North Atlantic Volcanic Province

Figure 7. Bathymetry (in meters) of the southeast Greenland shelf and continental slope, showing the location of sites EG63-1 to EG63-4.

Figure 8. Map of the southeast Greenland margin, showing the multichannel seismic (MCS) coverage for sites EG63-1 to EG63-4 up to 1992. Inset shows position of new lines acquired in the immediate vicinity of the drill sites in 1992.

Figure 9. Seismic line of the southeast Greenland transect to be drilled during Leg 152, showing location of sites EG63-1 through EG63-4. Both sites EG63-1 and EG63-2 will be drilled as reentry sites for possible later deepening following initial results. Q: Quaternary; N: Neogene; P: Paleogene; B: continental basement; SDRS: seaward-dipping reflector sequence; M: multiples.

Figure 10. Site EG63-1 is located at the landward feather edge of the SDRS wedge where it onlaps to down-flexed continental basement. A penetration into the SDRS wedge of 400 m is scheduled during Leg 152, although the hole may be deepened to the original 500 m proposed if drilling conditions permit. Further deepening to the basement could be achieved in subsequent legs if considered desirable. Q: Quaternary; N: Neogene; P: Paleogene; B: continental basement; SDRS: seaward-dipping reflector sequence; M: multiples.

Figure 11. Site EG63-2 is located within the central part of the approximately 100-km-wide SDRS wedge. Basement penetration to 400 m is scheduled, with further deepening being possible by deployment of a reentry cone. N: Neogene; P: Paleogene; SDRS: seaward-dipping reflector sequence. Migrated MCS data.

Figure 12. Site EG63-3 is located on the seaward edge of the SDRS wedge where a small "outer high" is present. The high probably marks the transition to submarine spreading, thus reflecting increased subsidence. Drilling to 150 m basement penetration or bit destruction is proposed. P/N?: Paleogene/Neogene?; P: Paleogene; SDRS: seaward-dipping reflector sequence. Migrated MCS data.

Figure 13. Site EG63-4 is located 20 km landward of Site EG63-2 within the central part of the SDRS. There is potential for stratigraphic overlap between the two sites, as shown by the overlap in the seismic lines of Figures 11 and 12. Drilling to 150 m basement penetration or bit destruction is proposed. N: Neogene; P: Paleogene; SDRS: seaward-dipping reflector sequence. Migrated MCS data.

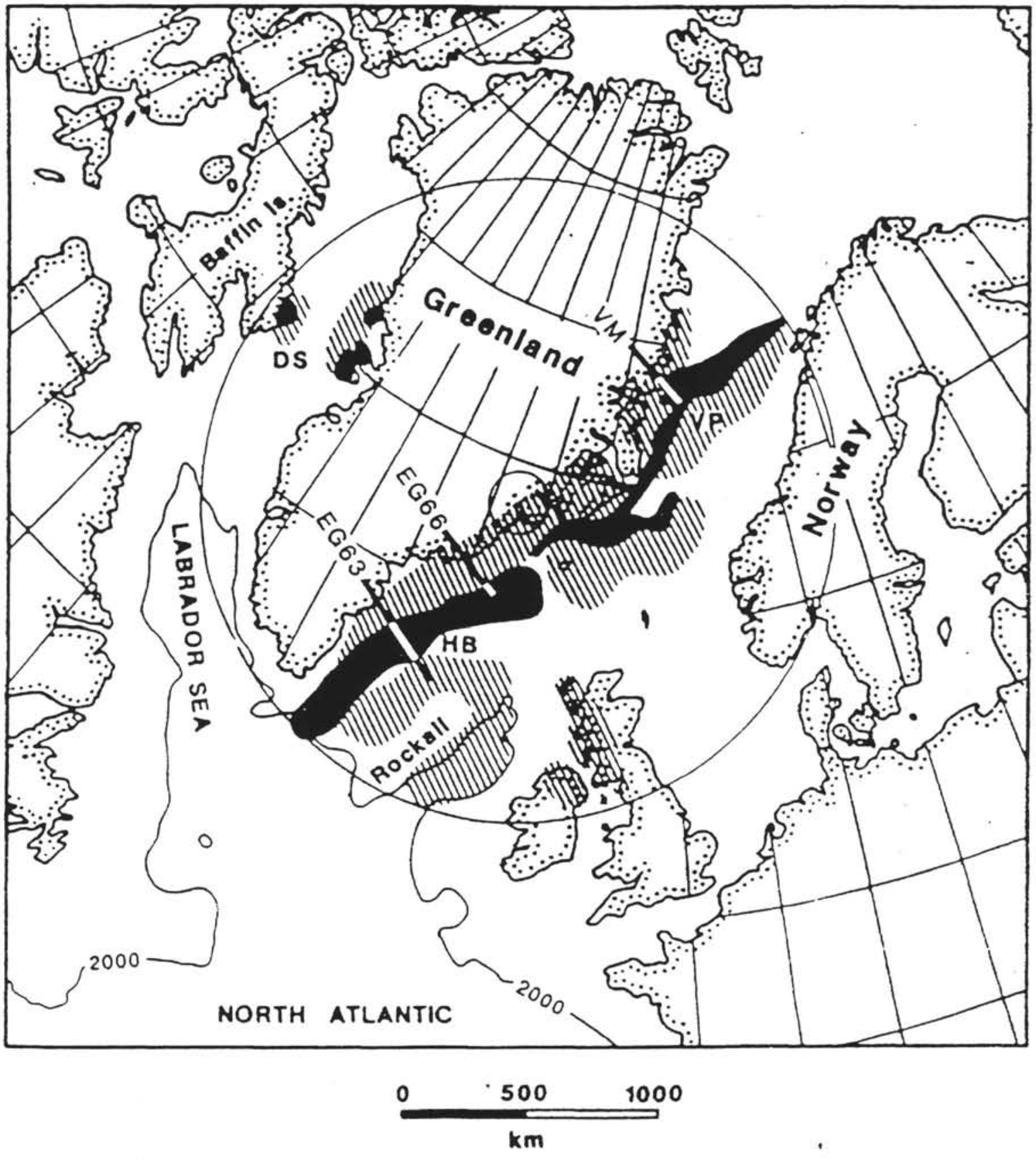
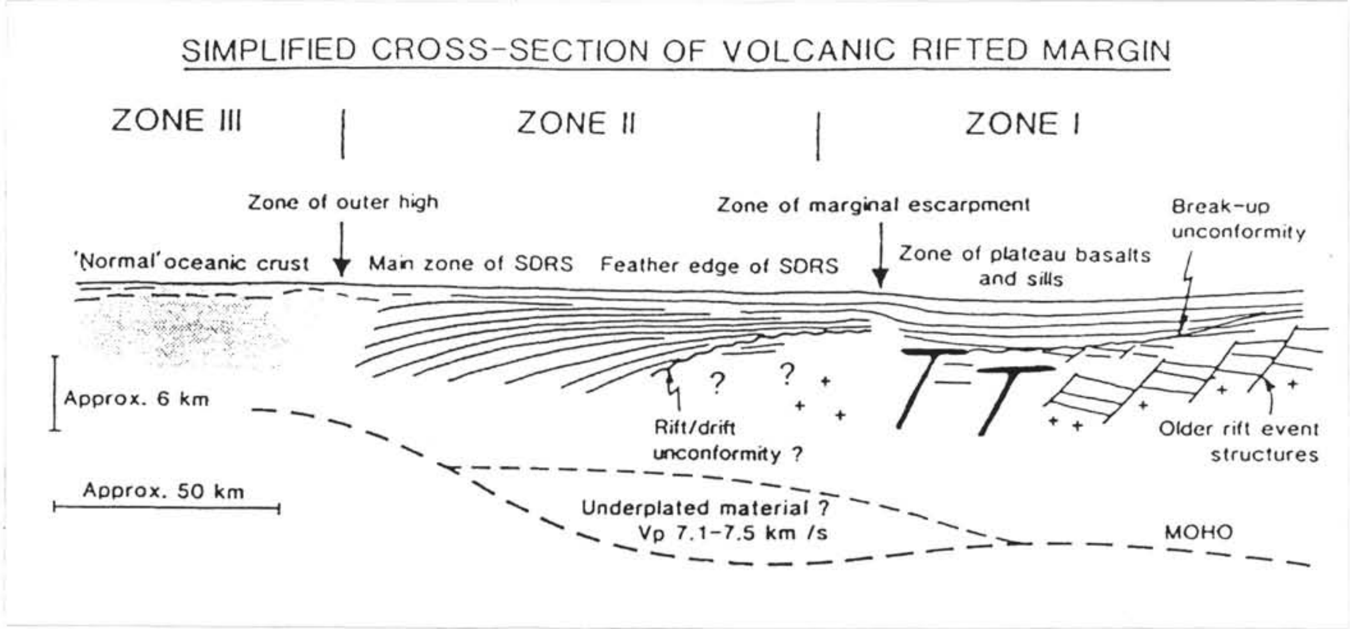
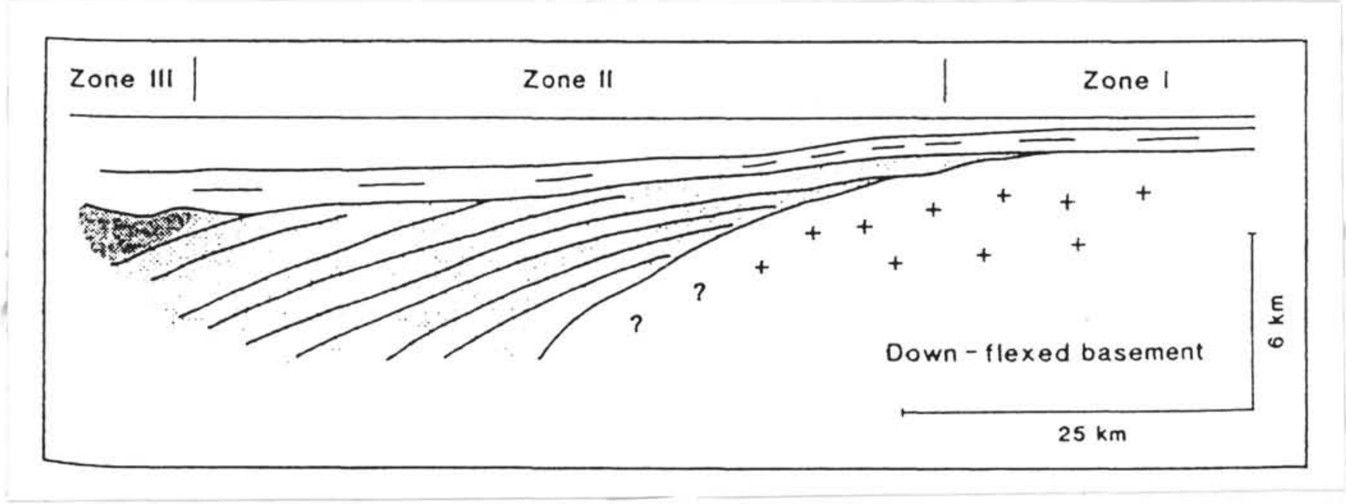

Baffin Is.
DS
Greenland
VM
VP
Norway
LABRADOR SEA
EG66
EG63
HB
Rockall
2000
2000
NORTH ATLANTIC
0
500
1000
km

Figure 1


SIMPLIFIED CROSS-SECTION OF VOLCANIC RIFTED MARGIN
ZONE III
ZONE II
ZONE I
Zone of outer high
Zone of marginal escarpment
Break-up unconformity
'Normal' oceanic crust
Main zone of SDRS
Feather edge of SDRS
Zone of plateau basalts and sills
Approx. 6 km
?
?
Rift/drift unconformity ?
Older rift event structures
Approx. 50 km
Underplated material ? Vp 7.1-7.5 km /s
MOHO

A


Zone III
Zone II
Zone I
?
?
Down - flexed basement
6 km
25 km

B

Figure 2

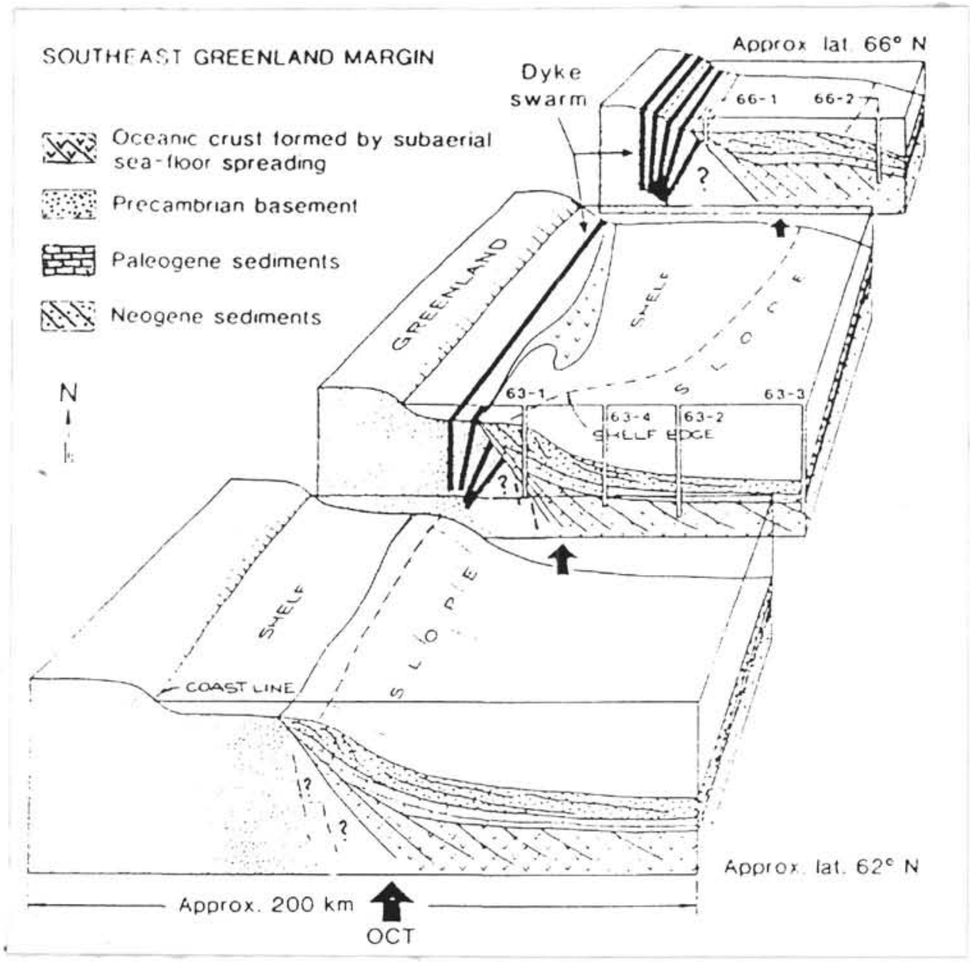

SOUTHEAST GREENLAND MARGIN
Oceanic crust formed by subaerial sea-floor spreading
Precambrian basement
Paleogene sediments
Neogene sediments
N
Dyke swarm
Approx. lat. 66° N
66-1
66-2
GREENLAND
SHELF
SLOPE
63-1
63-4
63-2
63-3
SHELF EDGE
?
SHELF
SLOPE
COAST LINE
?
Approx. lat. 62° N
Approx. 200 km
OCT

Figure 3

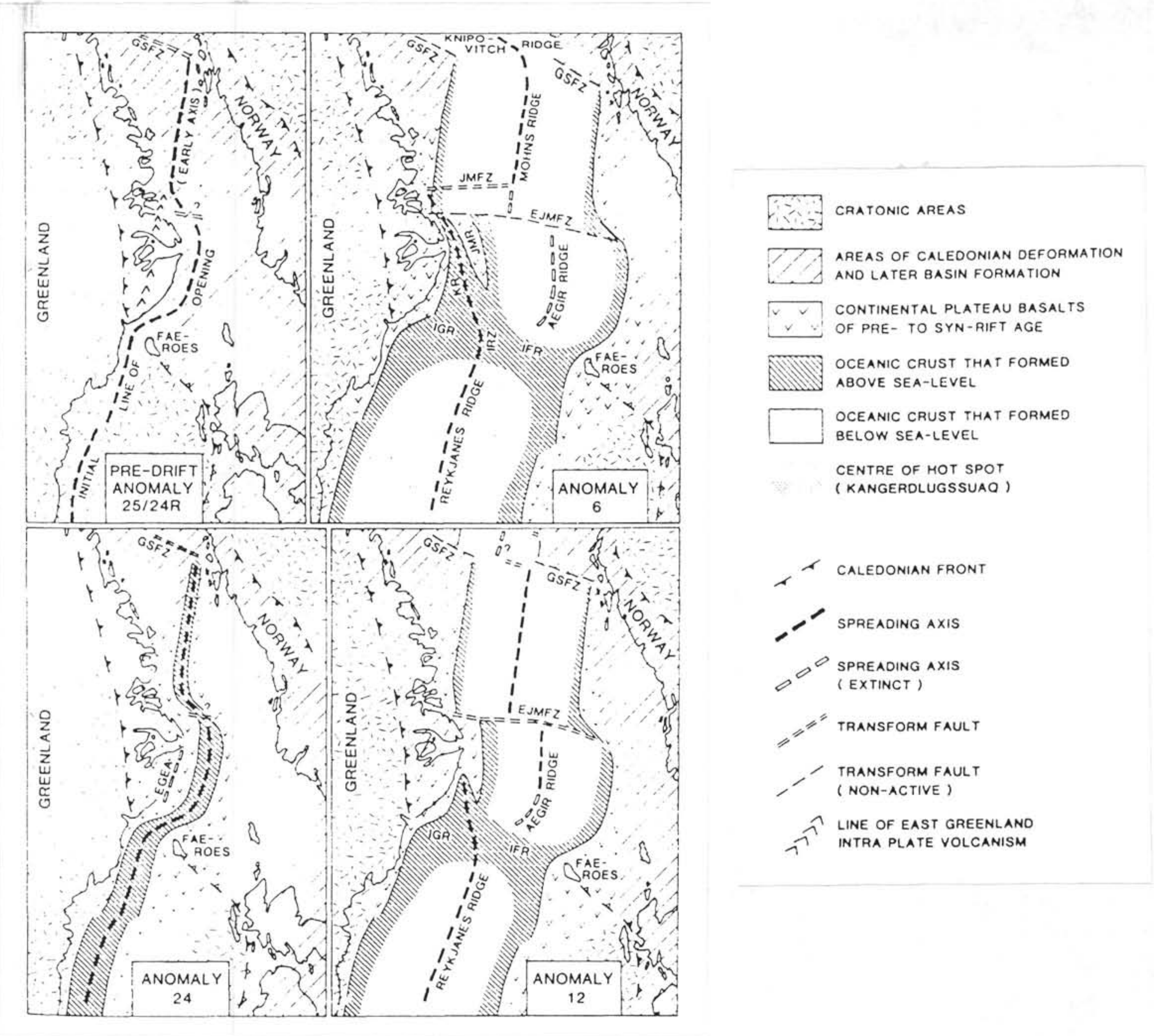

GREENLAND
NORWAY
GSFZ
(EARLY AXIS)
OPENING
LINE OF
INITIAL
FAE-ROES
PRE-DRIFT ANOMALY 25/24R
KNIPOVITCH RIDGE
MOHNS RIDGE
JMFZ
EJMFZ
JMR
KR
AEGIR RIDGE
IGR
IRZ
IFR
REYKJANES RIDGE
ANOMALY 6
EGEA
ANOMALY 24
ANOMALY 12
CRATONIC AREAS
AREAS OF CALEDONIAN DEFORMATION AND LATER BASIN FORMATION
CONTINENTAL PLATEAU BASALTS OF PRE- TO SYN-RIFT AGE
OCEANIC CRUST THAT FORMED ABOVE SEA-LEVEL
OCEANIC CRUST THAT FORMED BELOW SEA-LEVEL
CENTRE OF HOT SPOT (KANGERDLUGSSUAQ)
CALEDONIAN FRONT
SPREADING AXIS
SPREADING AXIS (EXTINCT)
TRANSFORM FAULT
TRANSFORM FAULT (NON-ACTIVE)
LINE OF EAST GREENLAND INTRA PLATE VOLCANISM

Figure 4

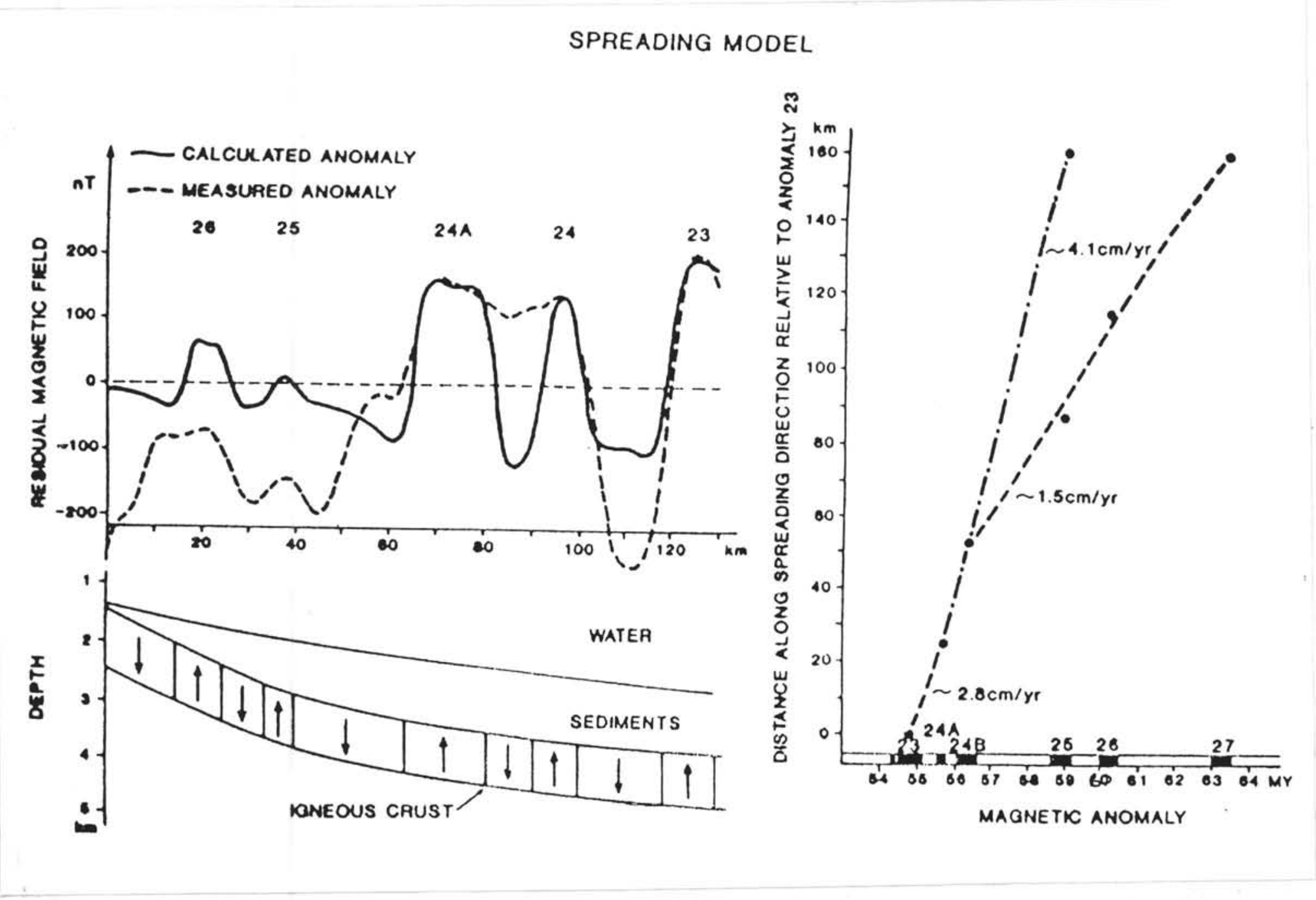

SPREADING MODEL
CALCULATED ANOMALY
MEASURED ANOMALY
nT
RESIDUAL MAGNETIC FIELD
200
100
0
-100
-200
26
25
24A
24
23
20
40
60
80
100
120
km
DEPTH
1
2
3
4
5
km
WATER
SEDIMENTS
IGNEOUS CRUST
DISTANCE ALONG SPREADING DIRECTION RELATIVE TO ANOMALY 23
km
160
140
120
100
80
60
40
20
0
~4.1cm/yr
~1.5cm/yr
~2.8cm/yr
23
24A
24B
25
26
27
54
55
56
57
58
59
60
61
62
63
64 MY
MAGNETIC ANOMALY

Figure 5

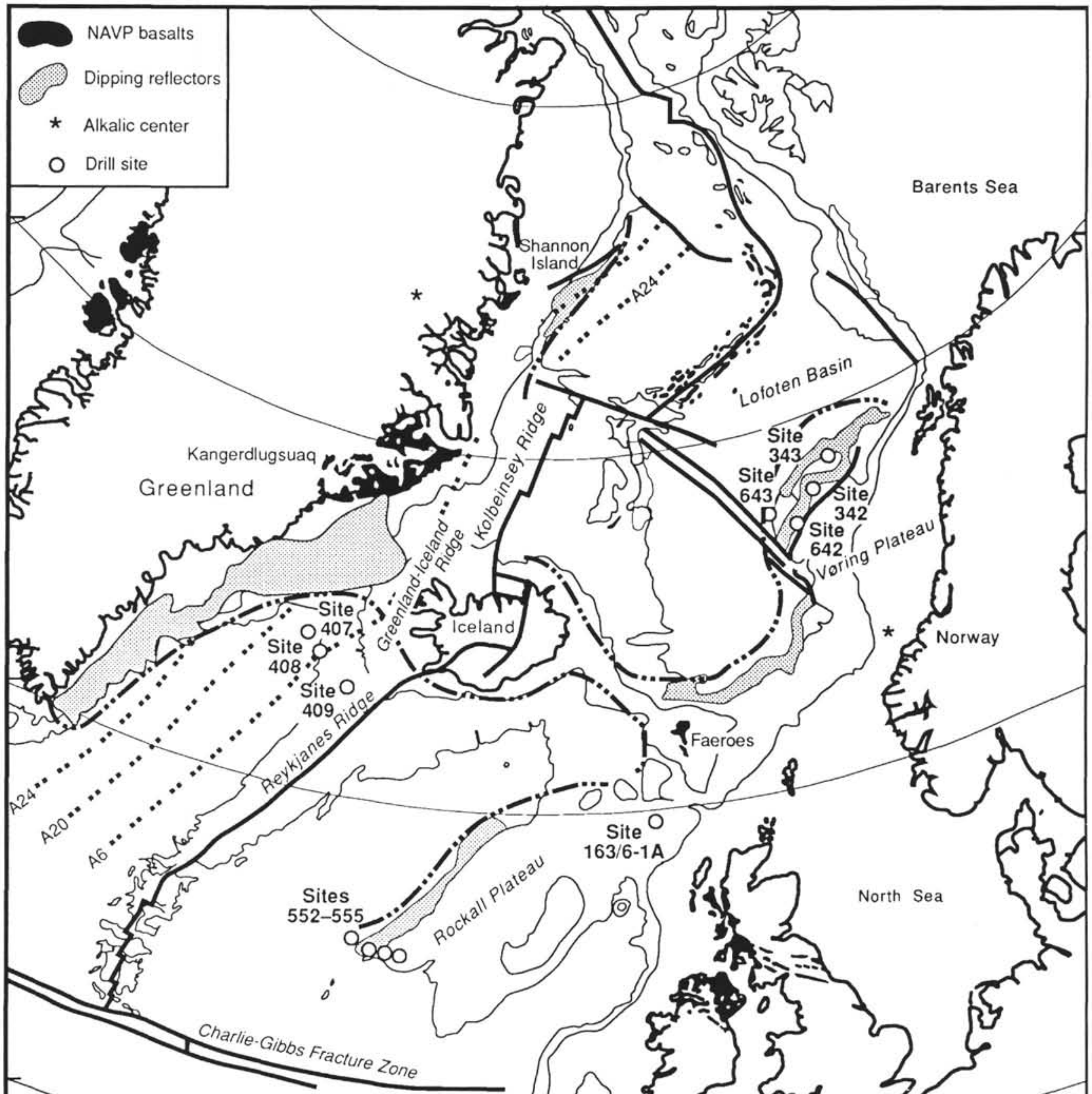

NAVP basalts
Dipping reflectors
Alkalic center
Drill site
70°
60°
50°
-30°W
-15°
0°
Barents Sea
Shannon Island
A24
Lofoten Basin
Kangerdlugsuaq
Greenland
Kolbeinsey Ridge
Greenland-Iceland Ridge
Site 343
Site 643
Site 342
Site 642
Vøring Plateau
Site 407
Site 408
Site 409
Iceland
Norway
Reykjanes Ridge
Faeroes
A24
A20
A6
Site 163/6-1A
Sites 552–555
Rockall Plateau
North Sea
Charlie-Gibbs Fracture Zone

Figure 6

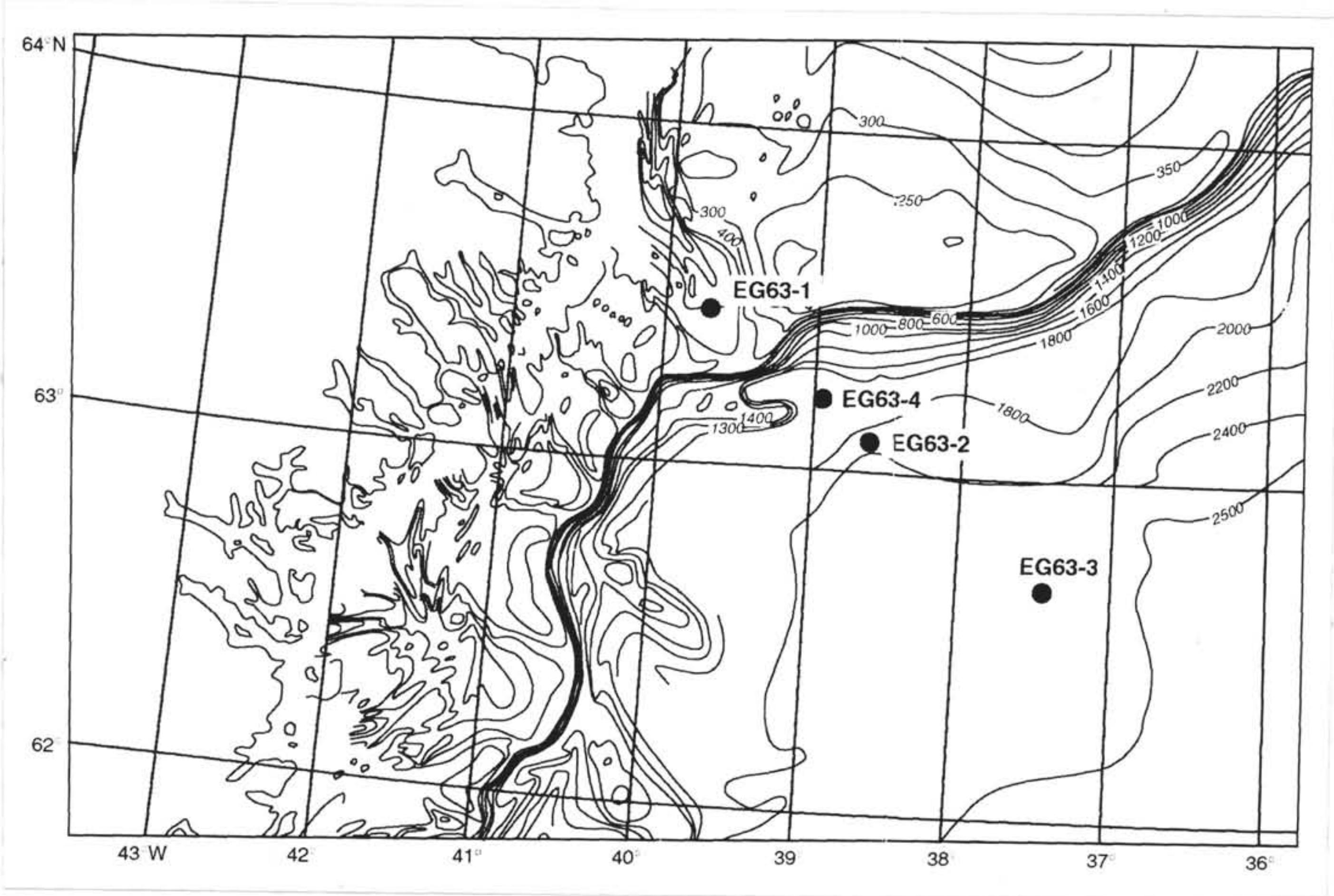

64°N
63°
62°
300
250
350
1000
1200
1400
1600
1800
2000
2200
2400
2500
300
400
EG63-1
1000
800
600
EG63-4
1400
1300
1800
EG63-2
EG63-3
43°W
42°
41°
40°
39
38°
37°
36°

Figure 7

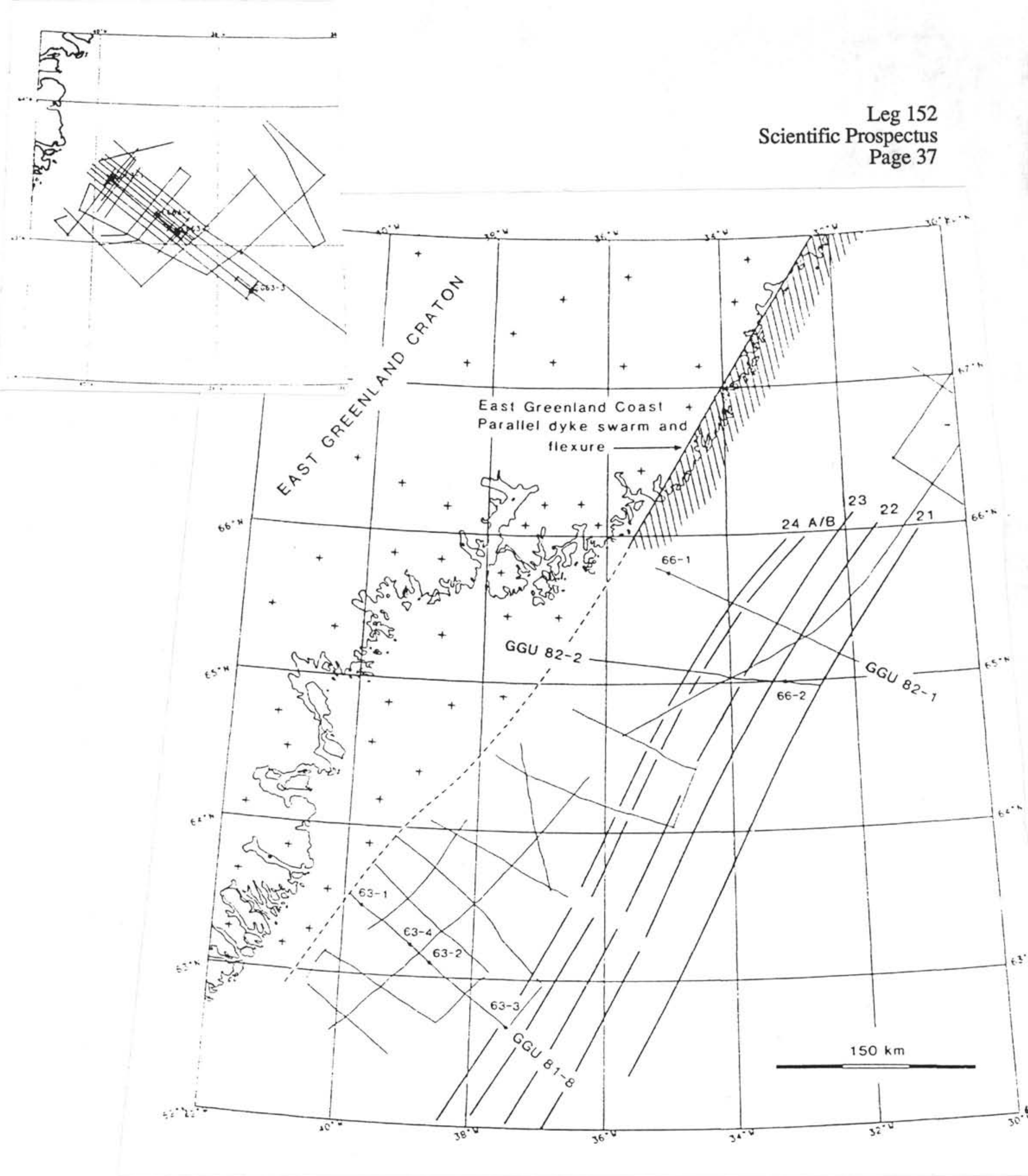

EAST GREENLAND CRATON
East Greenland Coast
Parallel dyke swarm and
flexure
24 A/B
23
22
21
66-1
GGU 82-2
GGU 82-1
66-2
63-1
63-4
63-2
63-3
GGU 81-8
150 km
66°N
65°N
64°N
63°N
62°N
67°N
40°W
38°W
36°W
34°W
32°W
30°W
63-3

Figure 8

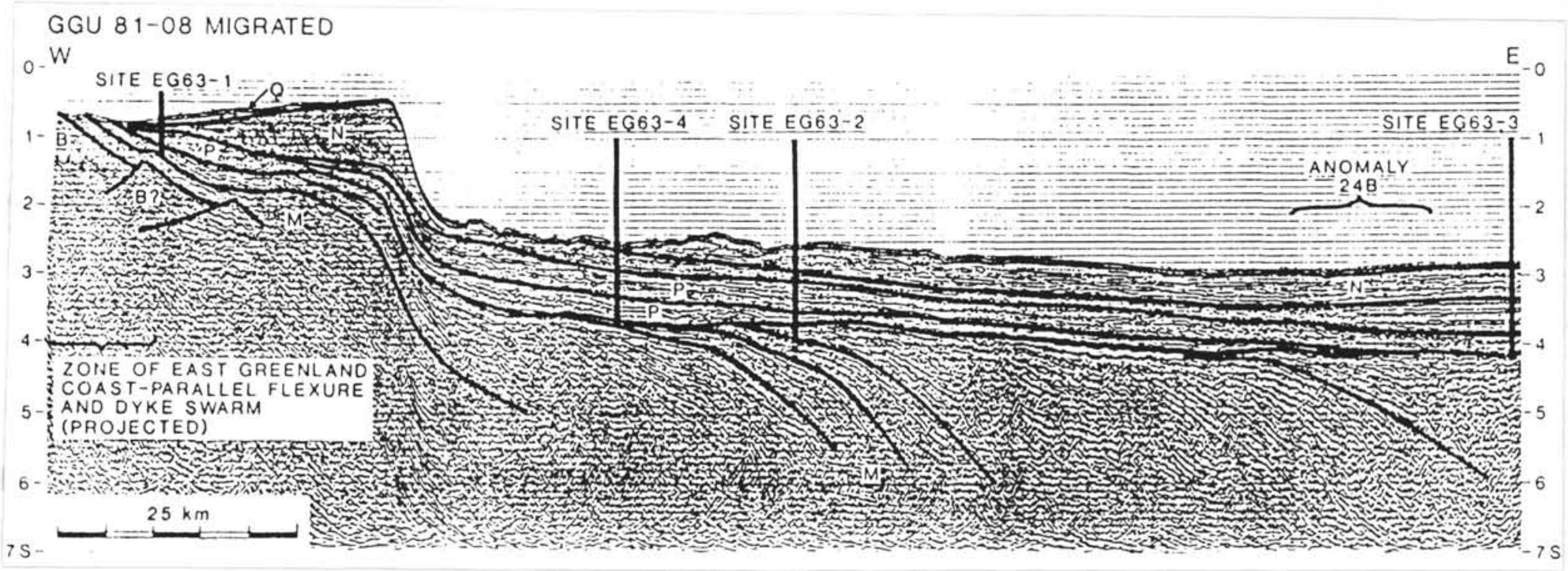

GGU 81-08 MIGRATED
W
E
SITE EG63-1
Q
N
B
P
B?
M
SITE EG63-4
SITE EG63-2
SITE EG63-3
ANOMALY 24B
P
P
N
ZONE OF EAST GREENLAND COAST-PARALLEL FLEXURE AND DYKE SWARM (PROJECTED)
M
25 km
0
1
2
3
4
5
6
7 S

Figure 9

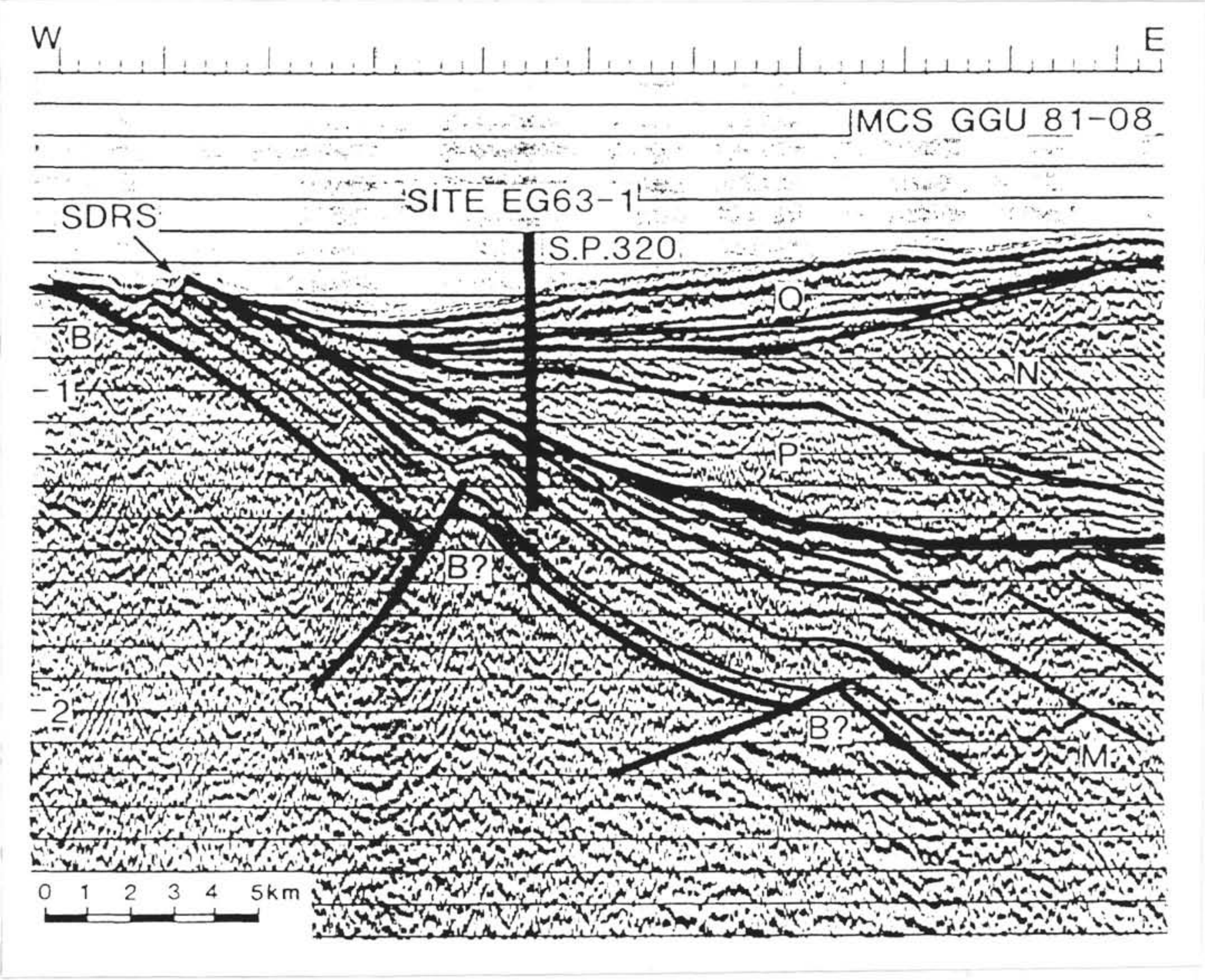


Figure 10

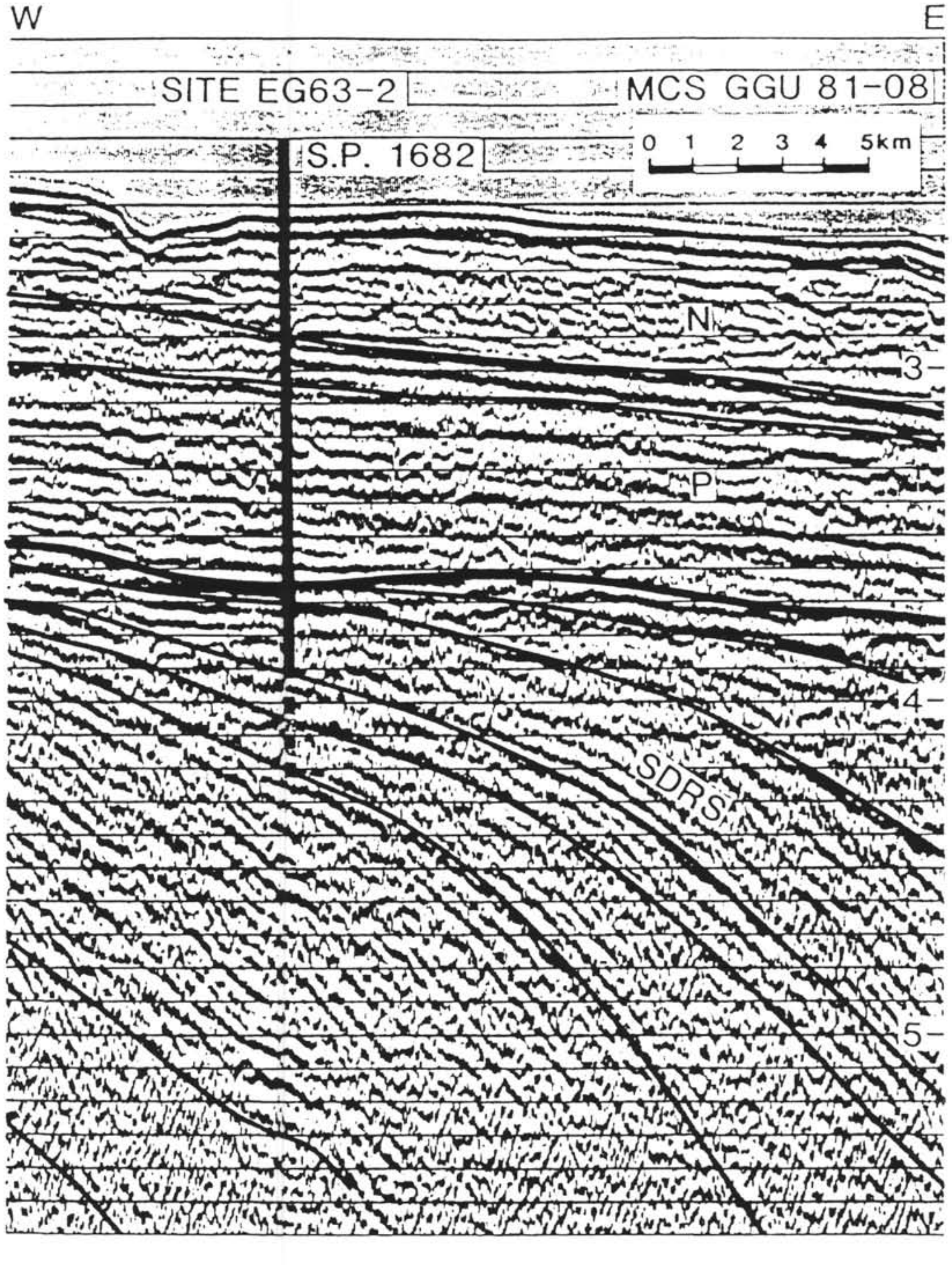


Figure 11

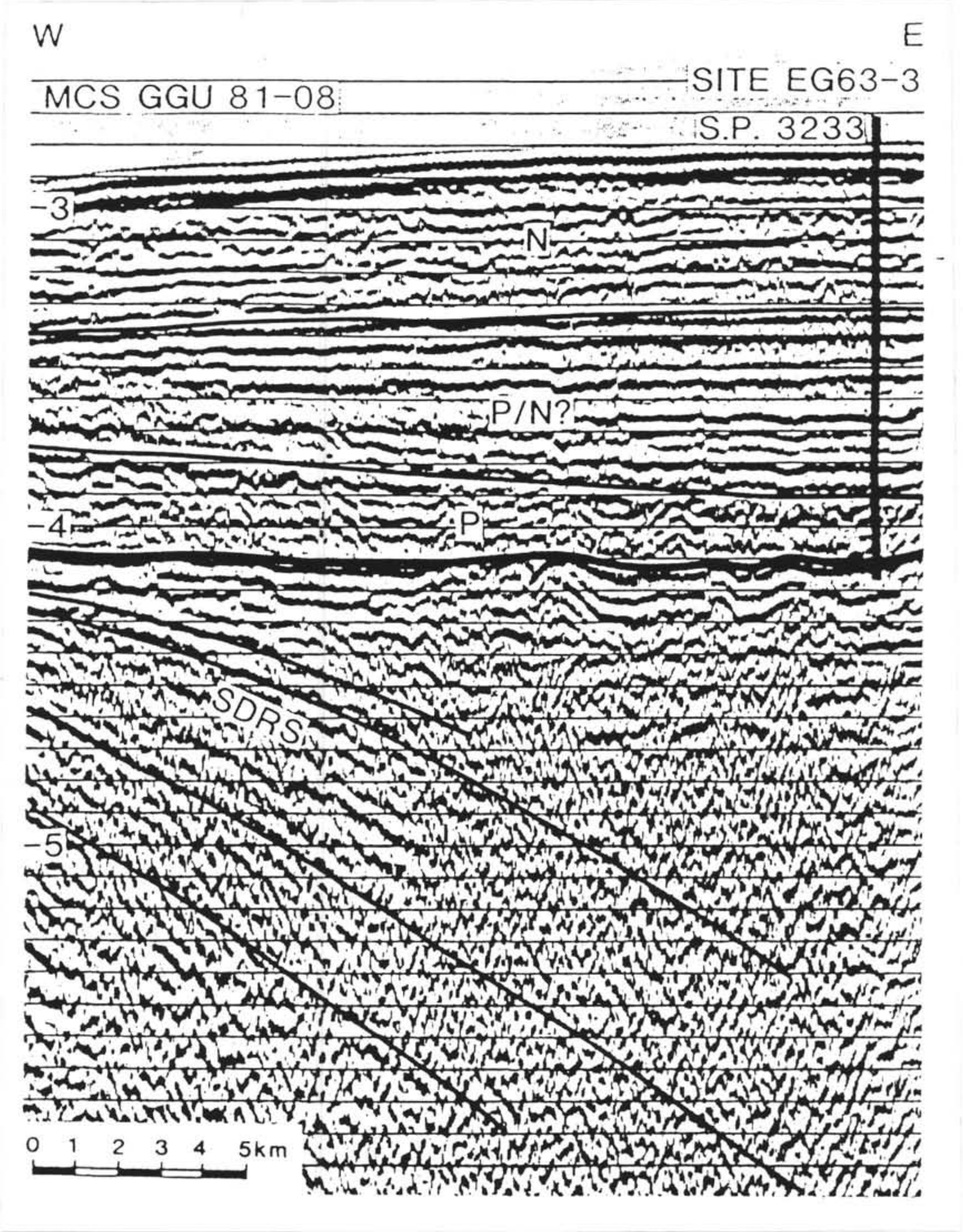


Figure 12

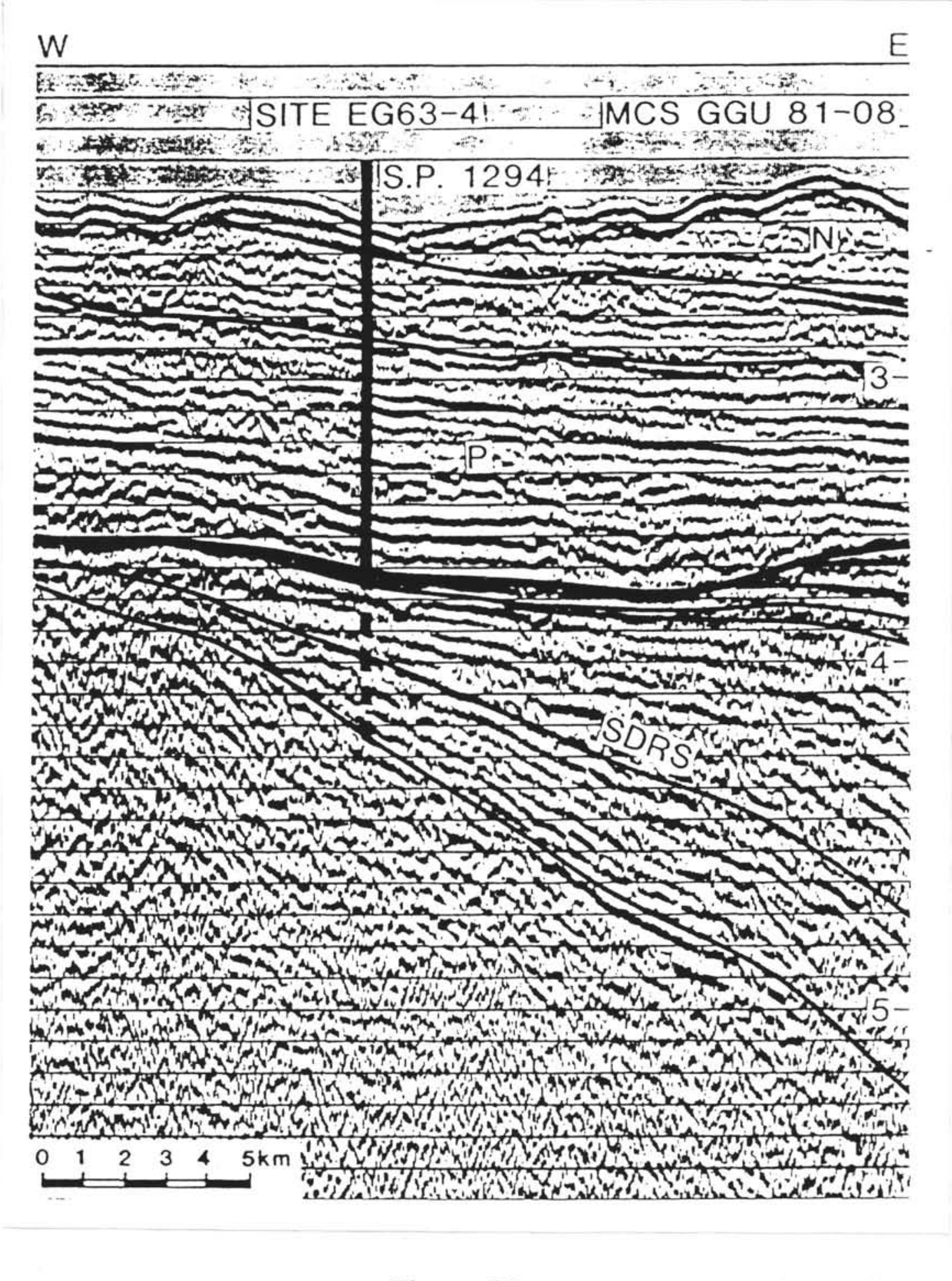


Figure 13

Site: EG63-1

Priority: 1

Position: 63°27.46'N, 39°43.30'W

Water Depth: 520 m

Sediment Thickness: 440 m

Seismic Coverage: MCS Line GGU81-08 SP 320

Objectives: To determine the age, magnetic properties (polarity and paleo-secular variations), composition, lava stratigraphy, volcanic productivity rates, cyclicities, possible continental lithospheric contamination, and geochemical signature of the continental feather edge of the marginal seaward-dipping volcanic sequence. To determine the vertical movements of the inner part of the wedge. To constrain timing of overflow of the Iceland-Greenland Ridge and of the extensive late Neogene to Quaternary unconformity by radiometric and biostratigraphic age determination.

Drilling Program:

1. APC coring of the sedimentary cover until refusal, estimated at 50 mbsf, followed by continued deepening of the A-hole to 100 mbsf by XCB.

2. B-hole is drilled by RCB to 100 mbsf and then cored to 550 mbsf, after which the hole will be logged. A reentry cone will be deployed and the hole cased to 550 mbsf. The B-hole will be deepened by RCB coring until a basement penetration of 400 m is achieved. Entire hole below the casing will then be logged.

Logging and Downhole Operations: Standard strings (Quad combo geophysical, geochemical, and FMS). Magnetic susceptibility and borehole televiewer (BHTV) may be run.

Nature of Rock Anticipated: Glacial tillite, Neogene. Sand/silt/clay turbidites above Paleogene shelf sediments (shallow marine sands/carbonates). Basalts with minor interbedded sediments.

Site: EG63-2
Priority: 1
Position: 63°05.52'N, 38°38.10'W
Water Depth: 1875 m
Sediment Thickness: 1220 m
Seismic Coverage: MCS Line GGU81-08 SP 1682

Objectives: To determine the age, magnetic properties (polarity paleo-secular variations and paleo-intensity variations), composition, and geochemical signature (and its variation) of basalts in the middle zone of the seaward-dipping reflector sequences. To investigate the subsidence of basalts during and after deposition. To recover and date the deep-sea signals of overflow of the Iceland-Greenland Ridge, regional North Atlantic unconformities, glaciation of southern Greenland, and possible cyclicities within an expanded late Cenozoic drift deposit.

Drilling Program:

1. APC coring of the sedimentary cover until refusal, estimated at 50 mbsf, followed by continued deepening of the A-hole to 150 mbsf by XCB.

2. B-hole will be drilled by RCB to 150 mbsf and then cored to 550 mbsf, after which the hole will be logged. A reentry cone will be deployed and the hole cased to 550 mbsf. The B-hole will be deepened by RCB coring until a basement penetration of 400 m is achieved. Entire hole below the casing will then be logged.

Logging and Downhole Operations: Standard strings (Quad combo geophysical, geochemical, and FMS). Magnetic susceptibility and borehole televiewer (BHTV) may be run.

Nature of Rock Anticipated: Pelagic Neogene, possibly contourites. Sand/silt/clay turbidites above Paleogene shelf sediments (shallow marine sands/carbonates). Basalts with minor interbedded sediments.

Site: EG63-3

Priority: 2

Position: 40.45'N, 37°27.26'W

Water Depth: 2095 m

Sediment Thickness: 1420 m

Seismic Coverage: MCS Line GGU81-08 SP 3233

Objectives: To determine the geochemical signature (plume components in particular) of the basement rock. To investigate the increased subsidence within the system reflected by the presumed transition to submarine spreading. To investigate the deepening of the basin south of the Iceland-Greenland Ridge, the overflow of this ridge, and the regional North Atlantic unconformity formation.

Drilling Program:

1. APC coring of the sedimentary cover until refusal, estimated at 200 mbsf, followed by continued deepening of the A-hole to 250 mbsf by XCB.

2. B-hole will be drilled by RCB to 250 mbsf and then cored to 550 mbsf, after which the hole will be logged. A reentry cone will be deployed and the hole cased to 550 mbsf. The B-hole will be deepened by RCB coring until a basement penetration of 150 m is achieved. Entire hole below the casing will then be logged.

Logging and Downhole Operations: Standard strings (Quad combo geophysical, geochemical, and FMS). Magnetic susceptibility and borehole televiewer (BHTV) may be run.

Nature of Rock Anticipated: Pelagic Neogene, possibly contourites. Sand/silt/clay turbidites above Paleogene shelf sediments (shallow marine sands/carbonates). Basalts with minor interbedded sediments and hyaloclastites.

Site: EG63-4
Priority: 2
Position: 63°12.43'N, 38°56.42'W
Water Depth: 1840 m
Sediment Thickness: 1180 m
Seismic Coverage: MCS Line 81-08 SP 1291

Objectives: To determine the age, composition, and geochemical signature (and its variation) of the oldest deep-water section of basalts in the seaward-dipping reflector sequences.

Drilling Program:

1. APC coring of the sedimentary cover until refusal, estimated at 200 mbsf, followed by continued deepening of the A-hole to 250 mbsf by XCB.

2. B-hole will be drilled by RCB to 250 mbsf and then cored to 550 mbsf, after which the hole will be logged. A reentry cone will be deployed and the hole cased to 550 mbsf. The B-hole will be deepened by RCB coring until a basement penetration of 150 m is achieved. Entire hole below the casing will then be logged.

Logging and Downhole Operations: Standard strings (Quad combo geophysical, geochemical, and FMS). Magnetic susceptibility and borehole televiewer (BHTV) may be run.

Nature of Rock Anticipated: Pelagic Neogene, possibly contourites. Sand/silt/clay turbidites above Paleogene shelf sediments (shallow marine sands/carbonates). Basalts with minor interbedded sediments.

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