DRILLING THE NEWFOUNDLAND HALF OF THE NEWFOUNDLAND - IBERIA TRANSECT: THE FIRST CONJUGATE MARGIN DRILLING IN A NON-VOLCANIC RIFT

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ABSTRACT. The underlying premise of many empirical, analytical, and numerical models of continental rifting is that mantle melt supply and/or temperatures prior to and during extension govern structural architecture and magmatic construction in the rift. However, drilling on the Iberia margin has documented extreme extension with little or no decompression melting of the asthenospheric mantle, defying model predictions. The puzzles raised by Iberia drilling are compounded by observations from geophysical studies on the conjugate Newfoundland margin, which document significant cross-rift asymmetries in basement depth, amount of tectonic extension, and other deep structure. These results raise fundamental, overarching questions about rifting of non-volcanic margins, including the cause and extent of mantle unroofing, the presence or absence of decompression melting, the origin of the deep and crustal asymmetry between conjugates, the age-subsidence and strain-partitioning history, and the relation of rift events to development of shallow-water unconformities and the stratigraphic record. We propose three competing hypotheses for development of the rift in which these questions are subsumed and which make specific predictions that can be tested by ocean drilling on the Newfoundland margin. The drilling we propose is in a position exactly conjugate to the Iberia Abyssal Plain drilling transect and is based on a detailed grid of MCS and OBS/H surveys which we recently completed. The single most productive and direct test of our hypotheses can be accomplished by a deep hole (up to ~2300 m) in the central Newfoundland Basin, which is proposed here. Analysis and review of drilling results from that hole will define the optimum program for any further drilling along the Newfoundland-Iberia transect.

1.0 INTRODUCTION

Continental extension, breakup, and eventual formation of new oceanic spreading centers are fundamental parts of the plate tectonic cycle. Consequently, rifted-margin studies have been at the core of scientific ocean drilling since its inception. In the mid-1980's ODP drilling on the Galicia and Voring margins (Legs 103 and 104 respectively) demonstrated clearly that rifted margins show surprising diversity in magmatic productivity, basin architecture, and strain history. The remarkable discovery from the Galicia is that it showed no magmatism whatsoever, despite extreme lithospheric thinning. Subsequent drilling (Legs 149, 173) on the Iberia Abyssal Plain (IAP) just south of Galicia made a similarly surprising and key finding. During the final stages of continental breakup the mantle was exhumed, interacting with sea water to form a layer of serpentinite with crustal-type seismic velocities. This mechanically weak layer of rock forms the "crust" beneath syn- to post-rift sediments in a "transition zone" (hereafter, TZ) seaward of known extended continental crust but landward of apparently normal ocean crust. These results challenge many former notions about rifting, and they force us to reconsider the meaning of such concepts as the continent-ocean transition, final breakup, early oceanic crust, and the significance of a breakup unconformity.

The puzzles raised by IAP-Galicia drilling are further enhanced by results of geophysical studies on the conjugate Newfoundland Basin (NB) margin (Fig. 1). These studies show that while there are at least some similarities in thickness and velocity structure of the TZ on the two margins, there are also apparent asymmetries in basement depth, amount of tectonic extension, and other deep structure (e.g., Fig. 2). Thus, very fundamental questions are raised by drilling and geophysical studies in the Newfoundland-Iberia (NI) rift:

•Is the perceived asymmetry between the Newfoundland and Iberia margins real, and if so, what mechanisms account for the deformation (e.g., simple shear?).

•What is the mechanical process responsible for pervasive unroofing of the upper mantle off Iberia, and did a similar process unroof mantle off Newfoundland?

•Did lithospheric thinning and removal of the continental crust occur with or without decompression melting of the asthenospheric mantle (e.g., was the entire rift amagmatic)?

•What were the nature and timing of rift events (e.g., end of rifting, subsidence, initial seafloor spreading) in the NB and how do they correlate with those in the IAP?

•How do spatial and temporal strain partitioning predicted from these events relate to symmetric or asymmetric extension, distribution of melt products in the rift, development of stratigraphic sequences, and well documented synrift and "break-up" unconformities on the shallow margins?

•Can it be demonstrated that strain rates were sufficiently slow that conductive cooling suppressed melting of the rising asthenospheric mantle?

We propose to address these overarching questions by drilling that will test three alternate hypotheses for the origin of the TZ on the NB conjugate margin (Fig. 3) (details of these hypotheses and their predictions are outlined in section 6.0 and Table 1, and specific drilling plans are given in section 8.0): Hypothesis 1 - The Newfoundland crust is thinned continental, and the NI rift evolved by asymmetric shear; thus the conjugate margins experienced very different subsidence and/or melt emplacement histories. Hypothesis 2 - The Newfoundland crust, like that off Iberia, is exhumed mantle; the asymmetry between margins may be explained by asymmetric shear and/or melt emplacement. Hypothesis 3 - The TZ on both margins was formed by slow or ultra-slow seafloor spreading and consists of some combination of exhumed mantle and melt products; either the interpreted asymmetry between margins is not real, or it must be explained by some other, as yet unknown mechanism. Drilling objectives to test these hypotheses and to address the overarching questions above are summarized in Table 1.

A detailed deep crustal seismic study (Fig. 4) has just been completed in three major transects on the Newfoundland margin to complement extensive geophysical studies of the Iberia margin. These new data make it possible to select Newfoundland drill sites that are both well characterized and exactly conjugate to the existing IAP drill sites. In the present proposal we focus on one ca. 2.3-km deep hole in the Newfoundland Basin that we feel will make the single strongest advance in addressing the questions and hypotheses noted above, and thus in understanding the entire rift system. The hole (NNB01A) is on our Transect 2 (Figs. 1, 2, 4) conjugate to the Leg 149/173 IAP drilling transect, and it will require one full ODP leg. This deep-hole approach will provide two important, first-order advances in rifted-margin studies. First, it will penetrate the entire sequence of basin fill and uppermost basement, thus allowing us to analyze the complete rift-to-drift history through time — a major omission of previous rifted-margin drilling legs. Second, it will provide the first-ever sampling of a rifted-margin conjugate, allowing us to reconstruct the history of the full rift rather than half the rift. Once the NB conjugate drilling data are available, models of continental breakup will have to satisfy rigorous observations on both margins, and it will no longer be possible to sweep inconvenient problems under the "conjugate carpet." Beyond completion of the single deep hole, we envisage a suite of subsequent, shallower holes along a transect that will complete this study. We present a preliminary assessment of how this subsequent drilling might be approached; however, its eventual layout will depend strongly on scientific results and review of the first drilling in the Newfoundland Basin.

In the following, we summarize known structure and recent interpretations of the NI rift (Sections 2.0 - 4.0), paying particular attention to our new survey results from the Newfoundland margin (5.0). We then outline our hypotheses on rift development (6.0) and a summary of sedimentary objectives (7.0), and we propose drill sites on the Newfoundland margin to test the hypotheses (8.0). Expected results and future studies, as well as the relation of this proposal to previous ODP planning, to MARGINS, and to IODP, are in Sections 9.0 and 10.0, respectively.

2.0 PLATE RECONSTRUCTION OF THE NEWFOUNDLAND-IBERIA RIFT

The most recent plate reconstructions of the Newfoundland-Iberia conjugate margins are given by Srivastava et al. (1). Figure 1 shows their plate positions for anomaly M0 (early Aptian, ~121 Ma [the time scale of Gradstein et al. (2) is used here]). In this reconstruction, thick continental crust of Flemish Cap (FC) is opposite extended continental crust of Galicia Bank (GB) at the northern end of the rift. To the south, our proposed drilling transect (Transect 2; Figs. 2a,d and 4b) in the northern Newfoundland Basin (NNB) is constrained by matches of existing M0 picks to fall within ±10 km of its IAP drilling conjugate. Further closure of the conjugates to at least anomaly M3 (early Barremian, ~126 Ma) is possible, and this probably occurred around a pole not far north of the rift, as suggested by the southward-widening zone of post-M3 ocean crust and the southward-splayed structural trends in older crust.

How far, and in what configuration, the NI rift can be closed beyond anomaly M3 is a matter of intense debate. Srivastava et al. (1,3) suggest that TZ crust older than anomaly M3 is oceanic and exhibits interpretable M-series magnetic anomalies back to anomalies M15 to M17 (Berriasian, ~137-142 Ma) in the southern part of the IAP-NNB basins, to M10-M11 (Valanginian-Hauterivian, 131-133 Ma) in the northern part. In contrast, Whitmarsh and Miles (4), Discovery 215 Working Group (5), and Dean et al. (6) interpret ocean crust to extend landward along the IAP drilling transect only to anomaly M3 (as depicted in Fig. 1) or, less likely, to M8 (4). The contested TZ landward of M3 is where peridotite ridges were drilled (Sites 897, 899; Figs. 5-7) and where seismic data show crustal structure that is characteristic of neither extended continental nor oceanic crust (7). On the conjugate NB margin, anomaly ~M3 coincides with a significant change in basement character and with the seaward pinchout of a high-amplitude, basinwide reflection (U) that closely overlies basement (e.g., Figs. 1, 2d). Some event appears to have caused a change in basement structure and possibly composition at anomaly ~M3 time. More detailed examination of features on each of the conjugate margins is presented below.

3.0 SUMMARY OF STRUCTURE ON THE IBERIA DRILLING TRANSECT

The GB and IAP margins are considered to be type examples of a non-volcanic margin because no seaward-dipping reflections have been recognized in crustal seismic profiles and no significant quantities of synrift magmatic material have been sampled. The basement surface, mapped from numerous seismic reflection profiles, exhibits a series of buried ridges that form a complex 3-D pattern in the IAP (Fig. 6). The easternmost ridges that connect northward into the continental crust of Galicia Bank terminate abruptly toward the south, leaving a very deep and lower-relief basement beneath the southeastern part of the abyssal plain. Toward the west, ridges become progressively more lineated and congruent to anomaly M0 (Figs. 5, 6). These ridges form several segments that connect to the north with the peridotite ridge (PR), originally identified west of Galicia Bank and drilled at Site 637 (8). The peridotite ridge has been associated with the final stages of rifting and the initiation of seafloor spreading off Galicia Bank, based on drilling results from ODP Leg 103 (9, 10).

Holes drilled by ODP Legs 149 and 173 traverse the entire ocean-continent transition along a profile crossing the IAP just south of Galicia Bank (Figs. 1, 2a, 5, 6; refs. 11-13). Near the continental slope and southern flank of Galicia Bank, drilling of the large fault-bounded basement blocks at Sites 901 and 1065 recovered pre-rift (Tithonian) sedimentary rocks and fossil evidence for a shallow-water, continental shelf environment. On MCS profile LG-12 (Fig. 7; ref. 14) bounding faults merge downward onto a low-angle reflection event, the H reflector. H is very similar in appearance to the S reflector on the Galicia Bank, which has been used as evidence for detachment or décollement tectonics (e.g., ref. 15, 16); the H reflector may indicate a similar form of deformation beneath the eastern IAP (14).

To the west, Sites 900, 1067 and 1068 drilled a fault block just seaward of a strong east-dipping, mid-crustal H-reflector (Fig. 7) (14, 17, 18). From wide-angle seismic modeling (19), these sites are close to a seaward transition from thinned continental crust to what is interpreted as basement consisting mainly of serpentinized peridotite. Sites 900, 1067 and 1068 sampled possible lower continental crust and serpentinized peridotite (Fig. 2a). A MORB-like gabbro sampled at Site 900 was tectonically exhumed above the 200-250 °C isotherm at 136 Ma (early Valanginian) during final extension of the continental crust and before the onset of seafloor spreading (20). Recent dating of zircons from this sample, however, gives ages of 270 Ma (21) suggesting that the gabbro was part of the lower continental crust well before the onset of Mesozoic rifting. At Site 1069 just to the west, Tithonian pre-rift sediments similar to those at Sites 901 and 1065 were sampled (Fig. 2a). This is thought to be the seaward-most outlier of extended continental crust.

Farther seaward, in the TZ, Site 899 did not sample basement but recovered a breccia of serpentinite and serpentinized peridotite, while Site 897 sampled a peridotite ridge. The TZ widens to ~130 km along the IAM-9 line 50 km to the south (Fig. 6), where a thin (1.0-2.5 km), acoustically unreflective basement layer is observed overlying a more reflective layer (22). This structure is interpreted to be a result of serpentinization of upper-mantle peridotite, with the unreflective upper basement layer representing a zone of more extensive (but downward decreasing) serpentinization.

Site 1070, 20 km seaward of the PR but 30 km landward of the J magnetic anomaly (M1-M0), is the westernmost on the IAP drilling transect. It sampled more serpentinized peridotite breccias that were intruded by veins of gabbro. These rocks are interpreted from geophysical evidence to be close to, or to overlie, crust created shortly after the onset of "normal" seafloor spreading.

Constraints on timing and duration of rifting are summarized in Figure 8. Initiation of rifting must postdate the shallow-water Tithonian sediments cored at Sites 901, 1065 and 1069 but predate the formation of oceanic crust. Thus minimum duration of rifting of ~7 m.y. (136.4 to 129 Ma, earliest Valanginian to early Hauterivian) can be derived from shearing of the Site 900 gabbro and modeling of surface magnetics (M8) according to Dean et al. (6) (Fig. 8). This duration could be shorter, <4 m.y., if pre-M8 anomalies picked by Srivastava et al. (1) are correct. Because dated, in situ pre-rift sediments younger than lower Tithonian have yet to be recovered, and because seafloor spreading may not have started until anomaly ~M3, maximum duration of rifting could be as long as 23 m.y. (149-126 Ma) (Fig. 8).

Using the 7 m.y. and 23 m.y. estimates for duration of rifting, pure-shear thermal models (e.g., ref. 23) yield a minimum thickness estimate of 1 to 3.5 km of igneous material produced from mantle melting with ß=15, and a 3 to 5 km thickness estimate with ß=50 (6). Given the preponderance of serpentinite and the virtual absence of any igneous melt products in IAP drill hole samples, as well as systematic evidence in seismic data for widespread serpentinized peridotite within basement, a major question remains in understanding the formation of this non-volcanic margin -- where is the predicted igneous crust? One possibility is that simple-shear deformation squelched melt production, as has been suggested for ß even beyond 50 (24). Another possibility is that the melt is in the Newfoundland plate (e.g., Fig. 3c). From density considerations it's also possible basaltic melt could pond at a depth of 1-2 km beneath a serpentinite lid, which would be consistent with seismic and magnetic models along profile IAM-9 (25). Finally, melt might have such laterally diffuse distribution that drilling has simply failed to hit patches where it was deposited (6). This emphasizes a fundamental limitation of existing ODP drill holes on the Iberia margin, i.e., that only basement highs have been sampled; neither basement nor synrift to early post-rift fill have been sampled in the intervening basins to constrain the occurrence of melt emplacement, rift timing and duration, or subsidence or strain history.

4.0 STRUCTURE OF THE CONJUGATE NEWFOUNDLAND MARGIN

The Newfoundland Basin is a deep-water basin (~4500m) separated from the shallow Grand Banks by the Carson, Salar-Bonnition, and Flemish Pass basins (Fig. 1). At its north end, Flemish Cap is Precambrian continental crust about 30 km thick (26), and at its south end the Southeast Newfoundland Ridge (SENR) is a thickly sedimented volcanic rise that may have continental underpinnings (27). From the SENR northward to the southern NNB, the eastern edge of the Newfoundland Basin is marked in the subsurface by an isochron-parallel basement ridge (locally a pair of ridges) coincident with the high-amplitude J magnetic anomaly (anomalies M1-M0). Landward, an apparent anomaly M3 can be identified, but older magnetic anomalies have low amplitudes and are very difficult to correlate or identify convincingly.

In the deep Newfoundland Basin landward of anomaly ~M3 is a very flat, high-amplitude, basin-wide reflection (U), which closely overlies or intersects the underlying basement (Figs. 2a,b,d). The zone containing this reflection and extending west to the seaward, presumably continental edge of Flemish Cap (Fig. 2a) is the approximate conjugate of the TZ on the IAP margin. In the southern NNB and southward, the U reflection appears locally to truncate the underlying basement, and where traced landward it ties into the extensive mid-Cretaceous Avalon unconformity on the Grand Banks (Fig. 2b) (27, 28). Based on these characteristics, Tucholke et al. (28) suggested that the reflection is an unconformity that was eroded at sea level, presumably over extended continental crust. No such reflection exists on the Iberia side of the rift (Figs. 2a,c).

Marked asymmetries between the Newfoundland and Iberia conjugates also appear in TZ basement (Figs. 2a,b). Basement below the U reflection in the NB has relatively low-amplitude topography, whereas peak-to-trough amplitudes on the IAP margin average well over a kilometer.

These differences imply significantly less brittle extension in the TZ on the NB margin. Newfoundland basement also averages a kilometer or more shallower than IAP basement.

Thickness and velocity structure of crystalline crust in the Newfoundland Basin have not been well constrained. Refraction data south of Flemish Cap (26) showed continental crust thinning to 10 km about 25 km south of the shelf break. Beyond that point a refraction velocity of 7.2 km/s predominates to an unknown depth; this may be either a thick high-velocity igneous layer or extensively serpentinized mantle beneath thin crust. In the central NNB, Srivastava et al. (1) made two OBH measurements with similar results. Reid (29) also reported a refraction transect farther south, extending from the east-central Grand Banks margin into the southern NB. The change in margin structure there is abrupt, with most crustal thinning occurring over a 30-km interval beneath the Salar basin (Fig. 1). The lack of a deep 7.2-7.5 km/s crustal layer in this zone suggests little if any underplating, consistent with characterization of this margin as non-volcanic. Immediately seaward, however, a zone of high-velocity (7.2 km/s) crust extends for 50-60 km and could represent lower continental crust (e.g., garnet granulite), volcanic underplating, or mantle serpentinization. Beyond this zone is anomalous, very thin crust (as little as 3 km) with low velocity (4.5-5 km/s) and high gradient. Whitmarsh et al. (7) and Pinheiro et al. (30) obtained similar results on the Iberia margin. Such crust in most respects is not typical of either normal oceanic crust or the currently known character of thinned continental crust.

A month ago (as of this writing) we completed extensive MCS and wide-angle ocean-bottom seismometer/hydrophone (OBS/H) surveys on the Newfoundland margin during Ewing Cruise 00-07 (Fig. 4). Very preliminary modeling of a few OBS/H records on Transect 2 in the eastern part of the TZ between anomaly M3 and Flemish Cap indicates that velocities at the top of basement are 5.1 km/s and are in the range of 6.0-6.4 km/s at the base of the crust. The crust is only 2-3 km thick over mantle with velocity of 8.0 km/s. This unusual crust does not exhibit the 7+ km/s layer noted above and conceivably is thinned continental crust. However, much more extensive analysis will need to be done before significant conclusions can be formulated.

5.0 NEWFOUNDLAND BASIN SITE SURVEY & PRELIMINARY RESULTS

5.1 Site Survey

Our recent MCS and OBS/H data were acquired in three major transects (Figs. 1, 4): Transect 1, conjugate to Leg 103 drilling on Galicia Bank; Transect 2, conjugate to Legs 149 and 173 drilling in the IAP; and Transect 3, conjugate to the southern IAP. We acquired one major MCS line and a coincident OBS line in separate passes on each of the transects; the OBS lines were shot with greater shot spacing to minimize previous-shot noise, and the instruments acquired 24, 24, and 21 OBS/H records along the three transects, respectively. In addition, we focused an MCS grid survey along Transect 2 (Fig. 4), which is the prime transect for NB drilling. We produced migrated brute stacks of all MCS data at sea, and on lines critical to the prime NB drilling transect (Transect 2) we made initial velocity repicks and restacks to improve the migrated sections. These profiles and crossing lines are included with the Site Description forms for reference.

In addition to the seismic data, we acquired magnetics, gravity, 3.5-kHz profiles, and Hydrosweep multibeam bathymetry. These and other, pre-existing data are summarized on the Site Description forms. All the MCS, OBH/S, and other geophysical results will be analyzed and refined in the coming months. Nonetheless, there are basic features of the data that we feel will not change significantly. We summarize them here as background to the proposed NB drilling.

5.2 Basement structure

Our data confirm that there is a major break in basement structure that follows roughly along anomaly M3 (Fig. 2d). West of M3, the basement surface has subdued topography and it lies below the U reflection on Transects 2 and 3 (the U reflection does not reach north to Transect 1). The basement surface is not a prominent reflection, but rather is characterized by disappearance of overlying strong reflections (see Site Description forms, NNB01). This suggests that basement impedance is similar to that of the overlying reflection sequences. We will be mapping this basement surface in detail as the MCS grid data are fully processed. On Transect 3, basement deepens westward below the Salar-Bonnition Basin, which is filled with evaporites and is considered to be floored by thinned continental crust (Fig. 1; see Fig. 2b for similar structure). On Transects 2 and 1, basement rises abruptly westward along the outer margin of Flemish Pass and Flemish Cap, delineating a major basement hinge (Flemish hinge, Figs. 1, 2d). This basement high is thought to be continental crust, and it is capped by a distinct sedimentary sequence that is restricted to the high (Site Description forms, NNB02A). Well defined deep reflections beneath the basement block suggest that there could be detachment structure analogous to the S and H reflectors off Iberia, but further processing is required to determine its character. Basement farther west on Transect 2 is continental crust rifted into major horsts and graben in the region of Flemish Pass. The horsts are capped by probably Paleozoic sediments that have been dissected by erosion, capped by ?Mesozoic fill, and then truncated by a major unconformity that most likely is a synrift or breakup unconformity.

East of anomaly ~M3, basement on Transect 2 rises sharply into major blocks (1-2 km relief) that continue somewhat beyond anomaly M0 and probably are fault-bounded (Fig. 2d; Site Description forms, NNB03A to NNB06A). These blocks form clear linear ridges that can be traced along-isochron among 4-5 parallel dip lines in the MCS grid (Fig. 4b). Morphologically, these blocks are similar to the peridotite ridges on the Iberia margin, although they are at significantly shallower depths (Fig. 2a,d). On Transects 1 and 3, basement also rises east of anomaly M3, but the morphology is more subdued and more typical of ocean crust. We tentatively suggest that melt supply along the outer end of Transect 2 may have been restricted compared to that in the other transects, resulting in enhanced tectonic extension during seafloor spreading.

5.3 The U Reflection

The U reflection is a very prominent, high-amplitude, and flat reflection that commonly is close to basement (Figs. 2a,b; NNB01 Site Description forms). Locally strong, overlying reflections form thin seismic sequences that pinch out on U. Above this is a clearly sedimentary and less reflective sequence that is conformable to U and to the strong post-U reflections. U pinches out eastward on crust near anomaly M3, with possible outliers close to M1. A reflection in a similar stratigraphic position appears well to the east on Transect 2, but it is not clear that it is equivalent to U (Fig. 2d). The interval between U and underlying basement (here, Sequence 1) is strongly laminated by high-amplitude reflections. These are relatively parallel to U at shallow levels, but at greater depths between basement blocks they sag or in some cases may be splayed and rotated (these features are visible in time sections [e.g., NNB01 Site Description forms] and will be even more pronounced in depth sections). Velocities in the U-basement interval have yet to be determined, but the high-amplitude reflections suggest that these deposits have high impedance contrasts. This is further indicated by the fact that the basement surface is typically identified by a downward disappearance of the sub-U laminated reflections. The origin of the U-basement interval is uncertain. It could be synrift sediment/volcanics or post-rift deposits.

In our new MCS data in the NNB, U typically laps onto basement highs. We have not recognized any location where U truncates underlying reflections or basement, although we cannot rule out such features until the data are fully processed. This contrasts with apparent truncations at U farther south in the NB. On Transect 3, U extends landward and appears to merge with the Avalon unconformity on the Grand Banks as observed in earlier seismic data in the southern NNB and southward (Fig. 2b). On Transect 2, U laps westward onto the basement high at the Flemish hinge (Fig. 2a); further data processing is needed before we can correlate this reflection farther landward.

5.4 Post-U Sequences

The post-U sedimentary sequence consists of four well defined seismic-stratigraphic intervals (see NNB01 Site Description forms). In the lower-middle part of the seismic section is a prominent set of high-amplitude reflections that is readily traceable throughout the Newfoundland Basin. We tentatively identify these as corresponding to the Horizons A^c to A^u intervals farther south in the western North Atlantic basin (31). The strong reflections are similar to those from high-impedance cherts of Horizon A^c (upper lower to lower middle Eocene); at the top of the interval is the first indication of erosion and lensing typical of current-controlled deposition, typically marked by Horizon A^u (?late Eocene to early Oligocene). Sequence 2, between U and A^u, is likely to contain Lower to middle Cretaceous black shales (Hatteras Formation), Upper

Cretaceous red shales and Maestrichtian limestones (Plantagenet Formation and Crescent Peaks Member), and Paleocene-Eocene cherty to calcareous mudstones (Bermuda Rise Formation) (32). Depending on the age and depth at which the base of the section was deposited, it may contain limestones (e.g., the Neocomian Blake-Bahama Formation).

Above A^u is an interval (Sequence 3) characterized by lensing of strata and possible sediment waves. We interpret this as deposition controlled by the southward-flowing deep western boundary current, probably in Oligocene time. This style of deposition was overwhelmed by apparent fan deposition (Sequence 4), characterized by fine-scale hummocky reflections. The age of this change is uncertain. It could have been triggered by erosion of the huge Grand Banks platform, e.g., during the major mid-Oligocene eustatic sea-level lowstand, or it could relate to later, Miocene fan development that is common elsewhere on North Atlantic margins (33). The shallowest sequence (5) is a relatively level, laminated interval of probable turbidites deposited across the lowermost rise and adjacent abyssal plain. These deposits began to accumulate shortly after fan deposition commenced; they interfinger with and gradually extend across the fan deposits.

6.0 HYPOTHESES FOR CRUSTAL ORIGIN AND RIFT EVOLUTION

From drilling and geophysical results on the Iberia side of the rift, it is generally agreed that extended continental crust reaches seaward to the area of Site 1069 along the IAP drilling transect, and a lesser distance seaward farther to the south (Fig. 5). Crustal origin in the TZ to the west remains contested. Srivastava et al. (1) maintain that the crust is oceanic, while Whitmarsh and Miles (4) and Dean et al. (6) consider crust leading up to ~M3 to be serpentinized mantle exhumed under generally amagmatic conditions (either by ultra-slow seafloor spreading or in an amagmatic continental rift (34)). "Normal" ocean crust has yet to be drilled along the IAP transect (the seawardmost site, 1070, recovered peridotite), so it is uncertain where such crust first appears. In addition to these uncertainties, no existing model takes account of the marked asymmetry in basement structure between the Newfoundland and Iberia sides of the rift (Fig. 2). We present here three hypotheses for origin of crust in the TZ and seaward of anomaly M3 that can be tested by drilling on the Newfoundland margin (see Table 1).

6.1 Hypothesis 1 - Extension of Continental Crust

Under this hypothesis, TZ crust on the west, old side of anomaly ~M3 in the Newfoundland Basin is highly thinned continental crust. This crust is shallower and smoother than crust of similar age under the IAP, which suggests that it may be the upper plate in an asymmetric detachment system (Fig. 3b). The lower, Iberia plate east of ~M3 would be exhumed lower continental crust and mantle. Interestingly, the pre-M3 Newfoundland basement does not seem to exhibit significant brittle extension, and there is little evidence in the IAP for lower continental crust in the TZ; how, then, was extreme thinning of the continental crust accomplished? One possible explanation is that lower crust was removed by ductile flow, with relatively little accompanying tectonic extension in the brittle upper crust (Fig. 3a) (35). This should be reflected in rapid synrift subsidence of the crust, despite limited brittle deformation.

The cross-rift asymmetry includes the prominent U reflection and U-basement sequence, so these features must be explained as well. We suggest that there are two likely origins. First, U may be a subaerially eroded unconformity and the sub-U interval is synrift sediments, as suggested by Tucholke et al. (28). We have done thermal mechanical modeling like that of Weissel and Karner (36) along an earlier MCS line (Conrad NB1, Fig. 2b), and we find that for U to be a subaerial unconformity, any reasonable upper mantle temperature up to ca. 1300°C requires minimum crustal thickness of ~20 km. Thus U would have to be a synrift unconformity and could not be a breakup unconformity eroded when continental extension ceased and seafloor spreading started.

Another possible explanation for the U-basement interval is that it consists of basalt flows. If these were subaerial, they would have to be synrift flows for the same reasons noted above. However, they could also be submarine flows. Remarkably smooth, submarine basalt flows extending over distances of hundreds of kilometers have been attributed to high effusion rates in areas such as the Pigafetta Basin (37), off Hawaii (38) and in the Caribbean (39). How could the U-basement interval possibly contain such extensive basalt flows when correlative crust in the IAP is virtually amagmatic? It is conceivable that melt extracted from the rising lower-plate mantle could permeate the Newfoundland upper plate, leaving the exhumed Iberia mantle virtually melt-free (see, e.g., Fig. 3c). Under the extended-continent hypothesis, post-M3, post-U basement is likely to represent a change to extended mantle or to more normal ocean crust, depending on melt supply.

6.2 Hypothesis 2 - Extreme Extension in an Amagmatic Rift

According to this hypothesis, continental extension proceeded under nearly amagmatic conditions to the point where only mantle was exposed, and then at some point an asymmetric shear developed within the exposed mantle (Fig. 3c). This hypothesis differs from the one above in that NB basement will be (serpentinized) mantle, and the U reflection cannot be a subaerial unconformity since it would be impossible to uplift extending mantle to sea level. If U was not formed subaerially, then the U-basement interval may well consist of basalt flows, generated in the asymmetric extensional system as noted above. Post-M3, post-U basement might represent a reduction in melt supply to the NB plate, with a consequent increase in tectonic extension.

6.3 Hypothesis 3 - Ocean Crust

This hypothesis calls for slow-spreading ocean crust both in the TZ and seaward of M3 (Figs. 2d, 3d). Slow-spreading ocean crust is known to expose lower crust and mantle in places, but it also has a significant supply of melt, generally considered necessary to lock in polarity reversals and generate identifiable magnetic anomalies. Clearly, this hypothesis precludes U from being a subaerial unconformity since thin ocean crust could not be exposed at sea level. It probably also precludes the U-basement interval from being basalt flows; such strong cross-rift asymmetry in melt distribution should be reflected by well developed magnetic anomalies over Newfoundland Basin and by contrasting, poorly developed anomalies over the IAP, which is not observed. Thus U could prove to have another, unknown origin, perhaps as a basin-wide sedimentary event that was restricted to the Grand Banks side of the rift. Conventional concepts of seafloor spreading do not explain the strong margin-to-margin asymmetry in basement depth or roughness; thus other, currently unknown effects would have to be invoked to account for these differences.

6.4 Origin of the Breakup Unconformity

The mechanism responsible for generating the "break-up unconformity" on rifted margins is usually thought to be either thermal uplift or in-plane force variation resulting from the cessation of rifting and the onset of seafloor spreading (e.g., refs. 40-43). Thus, in the absence of direct data about the time at which this change occurred, the age of the unconformity ascertained from seismic stratigraphy and well control is used as a proxy to date the end of rifting (e.g., refs. 40, 44-46). If, however, oceanic crust can be produced contemporaneously with rifting in continental basins (e.g., ref. 47), then the significance of the so-called "break-up unconformity" and, more importantly, the processes responsible for its formation, would be called into question.

Driscoll et al. (48) have established the age of the interpreted breakup unconformity inboard of Transect 2 as late Aptian (i.e., post-M0) through careful analysis of seismic stratigraphy and well control in the Jeanne d'Arc Basin north of the Egret Transfer Zone (Fig. 1). In addition, they documented episodes of active block rotation and correlative synrift unconformities in the late Barremian and early Aptian (M1-M0). If the M-series anomaly identifications in the NB and IAP are correct, all these episodes are recording continental rifting simultaneously with seafloor spreading (i.e., post-M3). If this proves to be true, it will require modifying estimates of how syn- and post-rift subsidence and strain partitioning are accommodated during margin development. We can test these ideas by documenting the timing of seafloor spreading in an ODP drilling transect across the Newfoundland Basin.

7.0 SEDIMENTARY OBJECTIVES

Although our primary drilling targets are the deep sedimentary section (to examine possible synrift sedimentation, and subsidence history) and basement, at the request of the SSEP's we summarize here some important objectives in the shallower sedimentary section. The proposed drill sites are in the western gateway between the high- and low-latitude oceans. "Conveyor belt" circulation between these latitudes probably has been important throughout the Cenozoic, so the sites are in a sensitive position to help understand timing and possible circulation forcing functions for several prominent early Cenozoic episodes of extreme climatic change. These include a) the Latest Paleocene Thermal Maximum (LPTM), which represents a time unique in Earth's history with respect to rate and degree of warming and was accompanied by major changes in ocean chemistry (49-51), b) the Early Eocene Climate Optimum (EECO) and c) the Early Oligocene Glacial Maximum (EOGM) (52-54). In addition, it has been proposed that strong abyssal circulation initiated in the North Atlantic in the late Eocene to early Oligocene (Horizon A^u) when a connection between the Norwegian-Greenland Sea and the Arctic basin opened at Fram Strait (e.g., ref. 55). The exact timing of this event, and the postulated northern source for the bottom water, however, are still not well understood. Biostratigraphic and isotopic analyses of foraminifera across the interpreted Horizon A^u interval in the Newfoundland Basin will help constrain the age of the deep-circulation event and confirm or negate a northern source for the bottom water.

8.0 PROPOSED DRILLING PROGRAM

Our drilling plan takes a two-pronged approach, with an initial focus (this proposal) on one deep hole that will penetrate the entire basin fill and the uppermost basement, to be followed (in a later leg that must await the IODP) by a transect of shallower holes to characterize basement composition across the margin. The network of high-quality MCS data that we acquired in July-August 2000 shows remarkable continuity of reflections line-to-line, ensuring that stratigraphic data acquired in a single, carefully selected site can be extrapolated across the entire Newfoundland basin. When combined with crustal thickness and composition estimates that will be derived from the dense wide-angle data on our three major transects, we will have a powerful data set for interpreting the thermal and deformation history of the NI conjugate margin pair.

8.1 Drilling Plan

Our major objectives and hypothesis tests (Table 1) are tied intimately to sampling basement, the basement-U interval, and a complete record of the overlying deep sedimentary section. This can be accomplished only by drilling a deep hole in a location landward of anomaly M3, and this is our primary drilling objective. Our primary site is NNB01A, which is located slightly off the crest of a basement block ca. 200 meters below the U reflection (Fig. 2d, see NNB01 Site Description forms). Basement depth is estimated in two ways: 1) from a preliminary average velocity (2.6 km/s) calculated by the Dix equation from the MCS common mid-point data (basement depth ~2200m), and 2) from preliminary modeling of OBS/H data near the site (1.6 - 2.71 km/s) (depth ~1900m). For initial planning purposes, we make the conservative assumption that the greater basement depth applies (the same assumption is made at other proposed sites). We propose at least 100 meters of penetration into basement, but greater penetration if time permits.

Based on discussions with ODP-TAMU, we propose the following drilling plan to optimize our chances of reaching and significantly penetrating basement: a) APC/XCB core and log the upper, soft sediments to ~500 m to obtain as complete a sedimentary record as possible (Hole A). b) Drill/wash to 500 m and RCB and log a pilot hole to 1300-1500 m, using a Free Fall Funnel for bit changes and re-entries (Hole B). If the pilot hole proves to be stable, continue coring and logging to total depth. c) If the pilot hole indicates unstable hole conditions or leaves significant uncertainty about reaching TD without casing, then Hole C would be drilled with a re-entry cone and casing set to 1300-1500 m. This would allow continued coring and logging for another 1000 m with substantially reduced risk. Logging would be done in three passes, correlating with each phase of hole deepening. It would consist of the two standard tool strings (Triple combo and FMS/sonic) and one specialty tool (GHMT) plus WST/VSP. With assumed ports in St. John's, Newfoundland, this plan takes one full ODP leg. We have filed detailed drilling/logging estimates made by ODP-TAMU with the JOIDES Office.

Alternate drill sites at NNB01B and NNB01C have the same objectives but present basement targets at slightly greater subbottom depths. If drilling at any of the NNB01 sites should prove to be impossible, backup sites would be NNB02A on the presumed continental basement block at the Flemish hinge (ca. 1800 meters to basement), and NNB03A on the basement block at anomaly M3, immediately east of the U pinchout (ca. 1600 meters to basement). Objectives at each of those sites is outlined in the next section. All sites lie along the main transect (Line 2MCS) and are intersected by a crossing profile (see Site Description forms).

8.2 Alternate Sites and Subsequent Drilling

We anticipate that results of drilling at NNB01 will dictate the course to be taken in subsequent drilling. Given that NNB01 will require a complete ODP leg, the plan for later drilling is expected to be carefully developed based on scientific results from the first, deep hole, and with input from drilling-program panels. In general, if NNB01 samples continental basement, then it is likely that later drilling should progress seaward (NNB03A to NNB06A) in order to define the maximum seaward limit of continental crust, the landward limit of ocean crust, and the character of any intervening transition (Fig. 2d).

If NNB01 samples oceanic basement, then drilling should move landward to NNB02A (Fig. 2d), which is interpreted to be a continental block at the Flemish hinge zone. As already noted, this block overlies deep intra-basement reflections that may include a detachment surface similar to the S and H reflectors off Iberia. If so, NNB02A will document whether the detachment rotated a continental block; in addition, the ages and stratigraphic relations among the rotated, presumed pre-rift to synrift sedimentary sequence capping the block and the unconformity separating it from post-rift sediments will strongly constrain how and when the shear zone evolved. Specific objectives at this site will be refined as we have the opportunity to process and analyze the MCS and OBS data across the site.

NNB02A and NNB03A are moderately deep holes, ~1900 m and ~1700 m respectively, conservatively assuming average sedimentary velocity of 2.6 km/s as noted above (~1800 and ~1300 m using alternate velocities from the area of NNB01). These depths include a minimum 100 m basement penetration. The drilling and logging plan for these holes is the same as for the NNB01 holes, with the exception that basement penetration may be possible without drilling a Hole C. Drilling and logging in NNB04A to NNB06A can be done with single-bit holes because none of the holes are deeper than about 750 m. If basement at any of these sites is serpentinite, the hole might productively be deepened to the point of bit destruction in order to investigate the variation in composition, alteration, and possibly melt interaction with depth in the serpentinites.

9.0 EXPECTED SCIENTIFIC OUTCOME AND REMAINING STUDIES

In the broadest sense, the scientific outcome of the proposed deep site is that it will be possible to make much more effective use of more than a decade of geophysical data (NB, IAP) and drilling data (IAP) that have been acquired on the NI conjugate margins. Observations made thus far have revolutionized our view of rifting in terms of both deformation mechanisms and associated magmatism. Nonetheless, these exciting observations, including our new deep crustal seismic study of the NB margin, cannot resolve some very fundamental questions until deep samples from the Newfoundland conjugate margin are obtained. Table 1 summarizes the objectives, primary analyses, and expected outcome of the proposed Newfoundland Basin deep-hole drilling.

We expect other important issues to be addressed by subsequent drilling. These first include refined sampling of pre-, syn- and post-rift sequences to improve control on timing and distribution of extension (e.g., NNB02A), as well as expanded spatial sampling in a transect across the margin (e.g., NNB03A to NNB06A) to understand distribution of basement types and constrain the timing and nature of rift events. In drilling the large ridges seaward of anomaly M3, serpentinized mantle may well be encountered; this leads into an important new set of objectives concerning the deeper nature of serpentinite ridges (e.g., the depth profile of serpentinization, unroofing history contained in low-temperature chronometers, initial origin from old continental lithosphere or convecting asthenosphere, and the proportion of igneous material within the serpentinite crust). A second set of important questions, also addressed by transect drilling, relates to how, when and where "normal" igneous crust was accreted to the margin. Finally, there are significant questions about how all these parameters varied in time and space from segment to segment along the margin. These may ultimately be investigated by, e.g., drilling off Flemish Cap (conjugate to Leg 103 GB drilling) to allow comparison with the NNB-IAP segment.

10.0 RELATION TO ODP, US MARGINS INITIATIVE AND THE IODP

Drilling proposals, DPG reports, workshops, and actual drilling over the past 15 years have made it clear that scientifically effective locations for studying mature, conjugate non-volcanic rifted margins are very limited when we consider geological constraints (e.g., sediment thickness and preservation of both margins) and logistical constraints (climate, political). Focus was provided a decade ago when the JOIDES advisory structure responded to a large number of rifted-margin proposals by forming the North Atlantic Rifted Margin Detailed Planning Group. Their report in 1991 distilled widespread proposals for about 25 legs of drilling into two primary study areas of highly contrasting rift style: 1) the volcanic rifted margins of East Greenland-Northwestern Europe, and 2) the non-volcanic rifted margins of Iberia-Newfoundland. A phased approach was proposed, with initially 4 legs of drilling to address first-order problems at one set of margins, to be followed later with another ca. 4 legs of drilling to complete studies on the conjugate margins. For the non-volcanic margin studies in particular, the concept of drilling conjugate margins to span the entire original rift zone was key to the proposed strategy. The ODP Long Range Plan (1996) re-emphasized this strategy and the importance of rifted-margin studies. The four-leg initial phase was drilled during 1993-1998 (Legs 149, 152, 163, 173). The conjugates have not been drilled.

The U.S. MARGINS initiative subsequently has defined a supplementary strategy to study young, active rifts, including downhole observatories to illuminate how low-angle extensional faults can move. ODP Leg 180 (Woodlark Basin) followed this concept within a setting of previous convergence and overthrusting, which recently started to rift apart. Rifting and breakup processes at rifted margins are also one of three main organizing themes currently being considered by the European Science Foundation in a European-scale margins initiative.

In preparation for the new Integrated Ocean Drilling Program (IODP), recent drilling community workshops (CONCORD, 1997; COMPLEX, 1999) have acknowledged the important findings made and questions posed by ODP drilling at rifted margins. The Initial Science Plan (ISP) of the IODP (as of ISP draft, September, 2000) therefore includes rifted margin drilling as one of eight new initiatives. The strategy supported by the ISP for non-volcanic margin drilling includes studies of mature conjugate margins such as proposed here, as well as studies of actively rifting environments.

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Table 1 - Objectives of Deep-Hole Drilling in the Newfoundland Basin

<table>
<tr><td colspan="3">OVERARCHING QUESTIONS</td></tr>
<tr><td colspan="3">•Are basement structure and composition symmetrical or asymmetrical across the NB-IAP conjugates?
•What mechanisms of rift extension account for the symmetry or asymmetry?
•What was the process responsible for mantle unroofing and did it operate on the Newfoundland margin?
•Was mantle unroofing accompanied by decompression melting in the asthenosphere, and if so, how was this melt distributed between the conjugates?
•What was the timing of rift events* in the NB (e.g., end of rifting, rapid subsidence, initiation of seafloor spreading) and how does it correlate to rift events in the IAP?
•What is the spatial and temporal history of strain partitioning predicted from these events?
  •Does it correlate with development of unconformities on the adjacent shallow-water margins?
  •Does it explain suppression or stimulation of melt as may observed in the rift?</td></tr>
<tr><td>HYPOTHESIS</td><td>PREDICTION</td><td>ISSUE (PRIMARY ANALYSES†)</td></tr>
<tr><td>Hypothesis 1 - Asymmetric extension of continental crust</td><td>1) NB basement is PC to Pz igneous and metamorphic.
2) U reflection is a synrift unconformity eroded near sea level.
3) U-basement interval is synrift sedimentary.
or
4) U-basement interval is synrift igneous.
5) U reflection is submarine and U-to-basement is basalt flows.</td><td>1) Origin and/or terrane (A,B,D); deformation and tectonic rotation history (A,C,F).
2) Age, duration, water depth of hiatus development (D,E); history of large post-U subsidence related to record of brittle upper-crust deformation and interpreted lower-crust ductile deformation (A,E).
3) Rift paleoenvironment & history (A,D,E,F); rift cessation - last rotation of sub-U blocks and fill (C,D,E,F,H).
4) As above, with analysis of weathering profile and melt origin, transport, continental contamination (A,B,D,F); cessation of volcanism (D, E).
5) Age (D,E for included or overlying sed's.); depth & subsidence (A,F-vesicle development, E-limited value in sed's?); melt source, transport, continental contamination (A,B,F).</td></tr>
<tr><td>Hypothesis 2 - Asymmetric extension of mantle</td><td>1) Basement is exposed mantle.
2) U reflection was formed at large water depths.
3) U-basement interval is basalt flows.</td><td>1) Exhumation history (A,B,D,G); tectonic deformation and alteration history (C,B,F); source, generation, interaction of melts (A,B).
2) Age-depth history of overlying sediments (E).
3) Source, transport, contamination of melts (A,B,F); emplacement age (D,E) and depth (A,F-vesicles, E-sediments); cessation of rifting - last rotation of sub-U blocks and fill (C,D,E,F,H); cessation of volcanism (D, E).</td></tr>
<tr><td>Hypothesis 3 - Oceanic crust</td><td>1) Basement is slow-spreading or ultra-slow-spreading ocean crust with minimal melt component.
2) Will have age-depth history representative of ocean crust.
3) May have enough remanent magnetization to record polarity reversals.
4) U-basement interval unlikely to be basalts, but composition unknown.</td><td>1) Origin and composition of melts, interaction with presumed peridotite host rock (A,B,F). Minimum age of seafloor spreading (D,E-superposed sediments).
2) Age-depth history of overlying sediments (E).
3) Magnetization of igneous rocks and serpentinites (F,H).
4) Determine composition and origin from cores and logging.</td></tr>
</table>

*These events are unlikely to be fully resolved by only a single deep hole; subsequent drilling along the transect will be required. †A - Petrology (igneous and/or sedimentary), B - Geochemistry, C - Structural geology - microstructure, D - Radiometric dating, E - Biostratigraphy (age, paleoenvironment, & paleodepth [best resolved in shallower depths]), F - Logging (see Site Description forms), G - Geobarothermometry, H - Paleomagnetics.

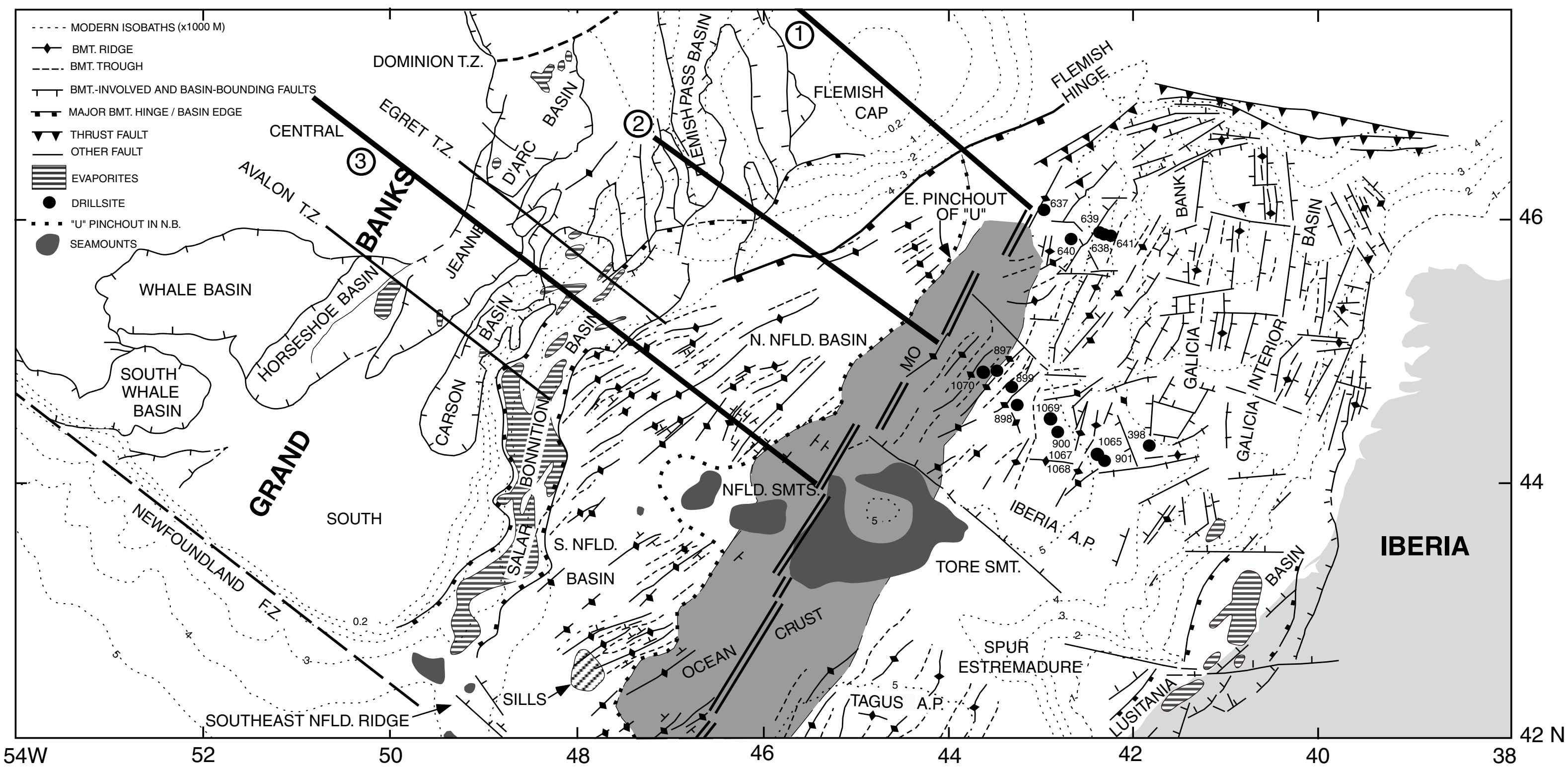


Fig. 1 - Reconstruction of the Newfoundland-Iberia rift at anomaly M0 (Newfoundland plate is fixed), based on the reconstruction pole of Srivastava et al. (1). Tectonic and other data are compiled from numerous sources (structural data to be derived from our recent Ewing 00-07 cruise (Fig. 4) are not included). Ocean crust (center, shaded) is presumed to have formed beginning near anomaly M3. South-to-north zipper-like opening would account for the observed splayed tectonic trends between the two margins and the northward-narrowing zone of ocean crust. On the Newfoundland side, the U reflection extends throughout the Newfoundland Basin and pinches out seaward near M3. Our three recent MCS/OBS transects across the Newfoundland margin are indicated by bold lines labeled with circled numbers.

mainBasin.ai

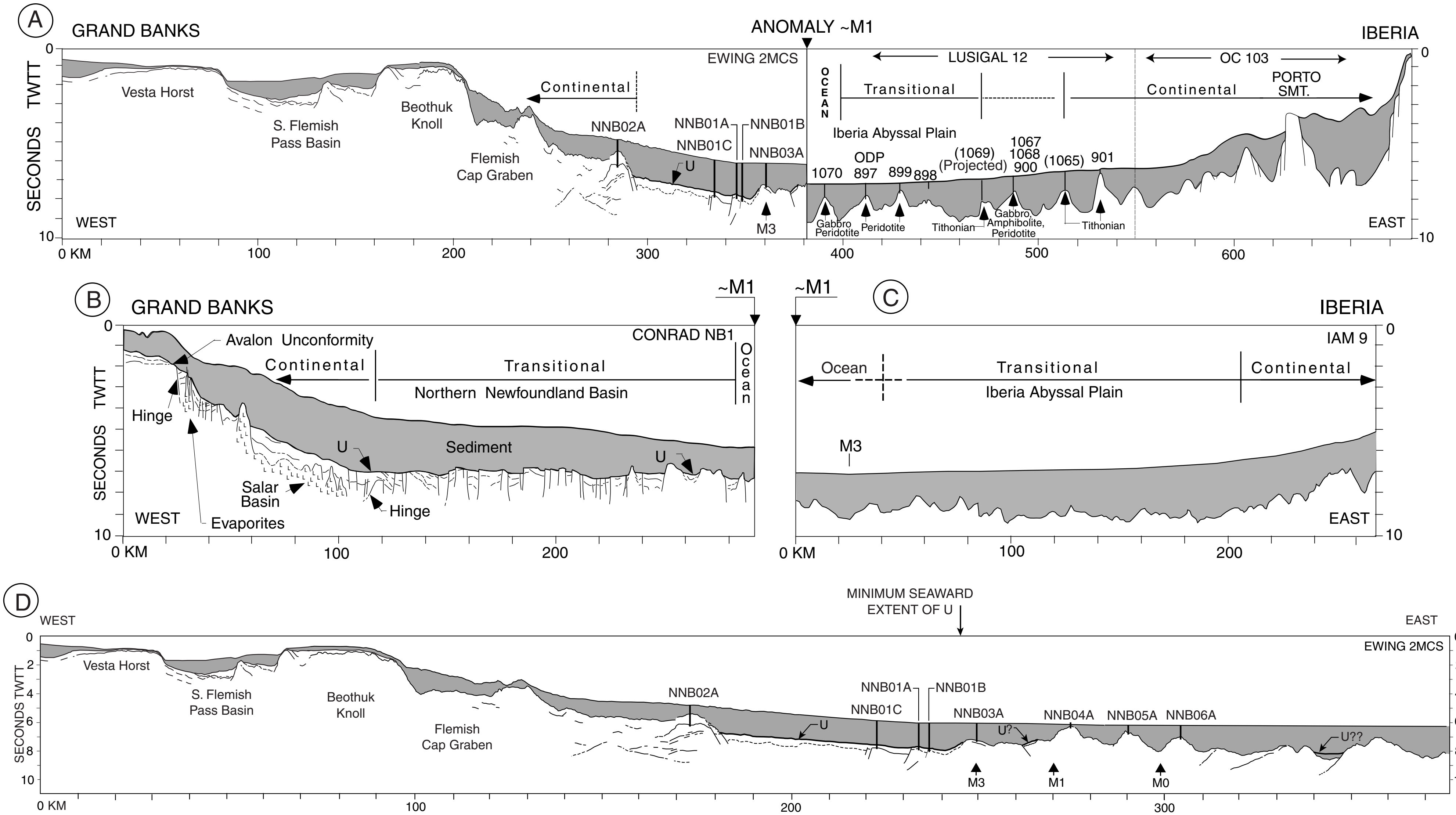


Fig. 2 - a) Reconstruction of conjugate seismic sections from the NNB and IAP to the time of anomaly ~M1. Left: Preliminary interpretation of Ewing Line 2MCS from our recent survey. Interpreted post-rift sediments are shaded gray. The deep, high-amplitude U reflection is highlighted and labeled. Proposed drill sites are also labeled. Right: Composite seismic section along the conjugate IAP drilling transect, adapted from (12). Drill sites are numbered and recovery at the bottom of each hole is indicated. b) Conrad MCS Line NB1 about 150 km south of Ewing Line 2MCS in the NNB, illustrating another view of NB basement structure and the closely overlying U reflection. c) IAM-9 MCS line about 50 km south of LG-12 in the IAP. In a) - c), note the marked asymmetries in basement depth and roughness between the NB and IAP sides of the rift. d) Preliminary interpretation of the full length of Ewing Line 2MCS with magnetic anomaly locations of Srivastava et al. (1) and proposed drill site locations. Profile locations are given in Figs. 4-6.

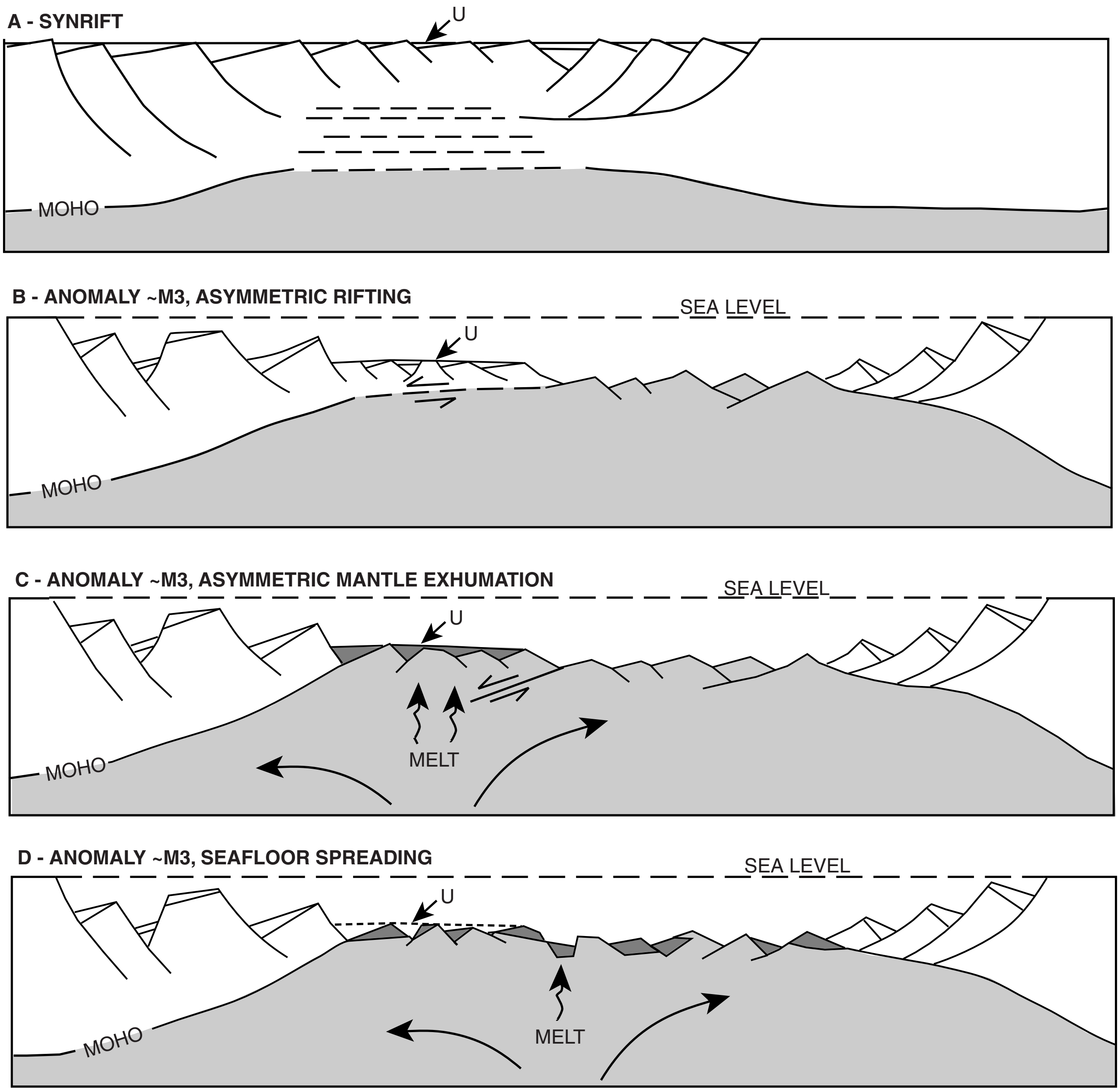


Fig. 3 - Schematic models to explain observed deep structural asymmetries between the NB (left) and IAP (right) margins of the NI rift. a) Synrift extension of continental crust. In the central part of the rift, lower crust is thinned ductilely (dashes) but brittle upper crust has limited tectonic extension (e.g., ref. 35). b) Anomaly ~M3: The rift evolves asymmetrically, with a thin remnant of continental crust forming an upper plate in the NB, and serpentinized peridotite and remnants of ductilely thinned lower crust forming a lower plate in the IAP. Bending stresses may account for faulting in the cold, brittle mantle footwall as it is exhumed. Depth differences of NB vs. IAP basement reflect buoyancy of thin continental crust vs. serpentinized mantle. The U reflection is a synrift unconformity developed near sea level. c) Anomaly ~M3: Mantle is exposed on both sides of the rift at an early stage, but an asymmetric shear then develops. Melt extracted from the lower plate permeates the NB upper plate and floods its surface to form the U-to-basement sequence in a submarine settings (dark gray). Depth differences of NB vs. IAP basement reflect buoyancy differences caused by melt intrusion/extrusion on the NB side. d) Anomaly ~M3: Ultra-slow or slow seafloor spreading. The U-basement sequence might be explained, e.g., as a sedimentary phenomenon peculiar to the Grand Banks margin, but it cannot be attributed to asymmetric emplacement of basalts. NB-IAP depth differences are unexplained.

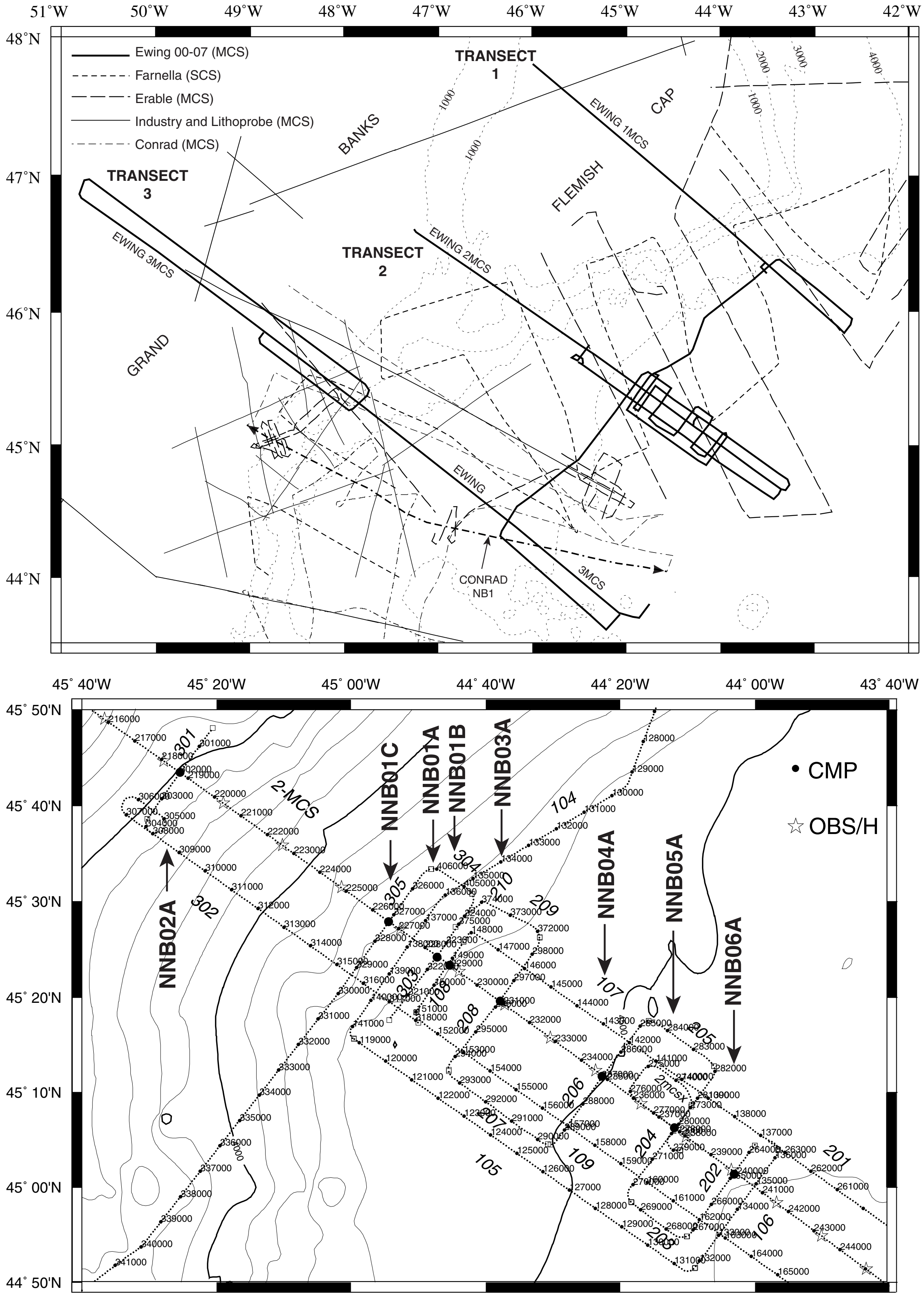


Fig. 4 - Top - Track map showing partial coverage of multichannel (MCS) and single-channel (SCS) seismic reflection profiles in northern Newfoundland Basin. Our new survey (Ewing 00-07) is shown by bold lines. Bottom - Tracks of our recent Ewing 00-07 MCS and OBS survey along Transect 2. Proposed drill sites are at track crossings and are indicated by filled circles and labeled arrows.

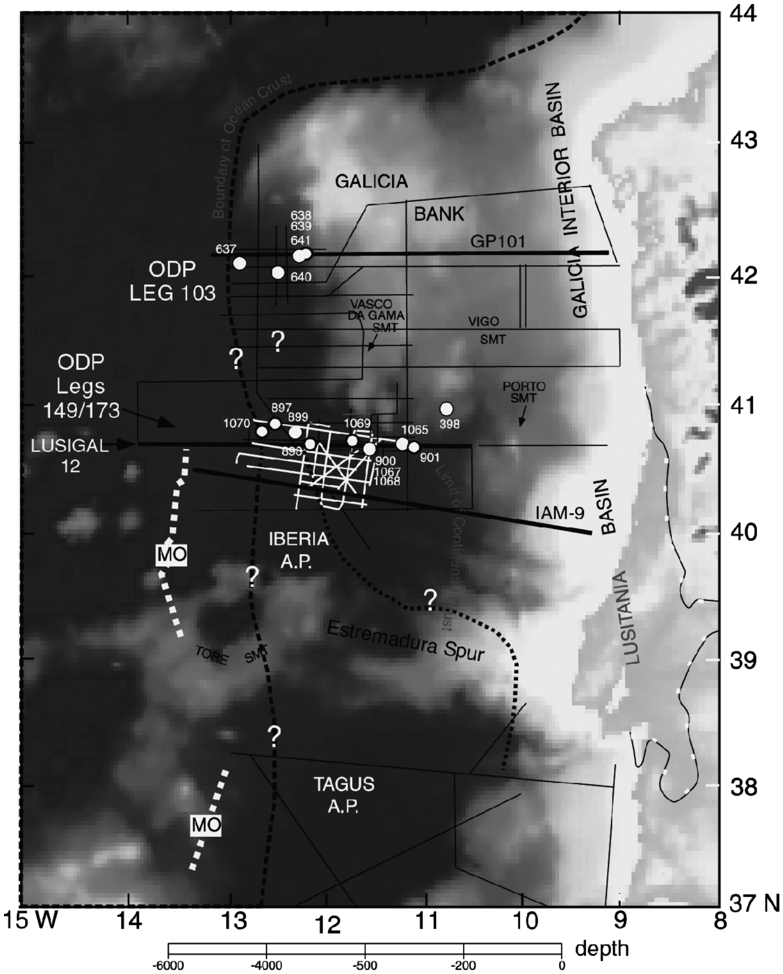
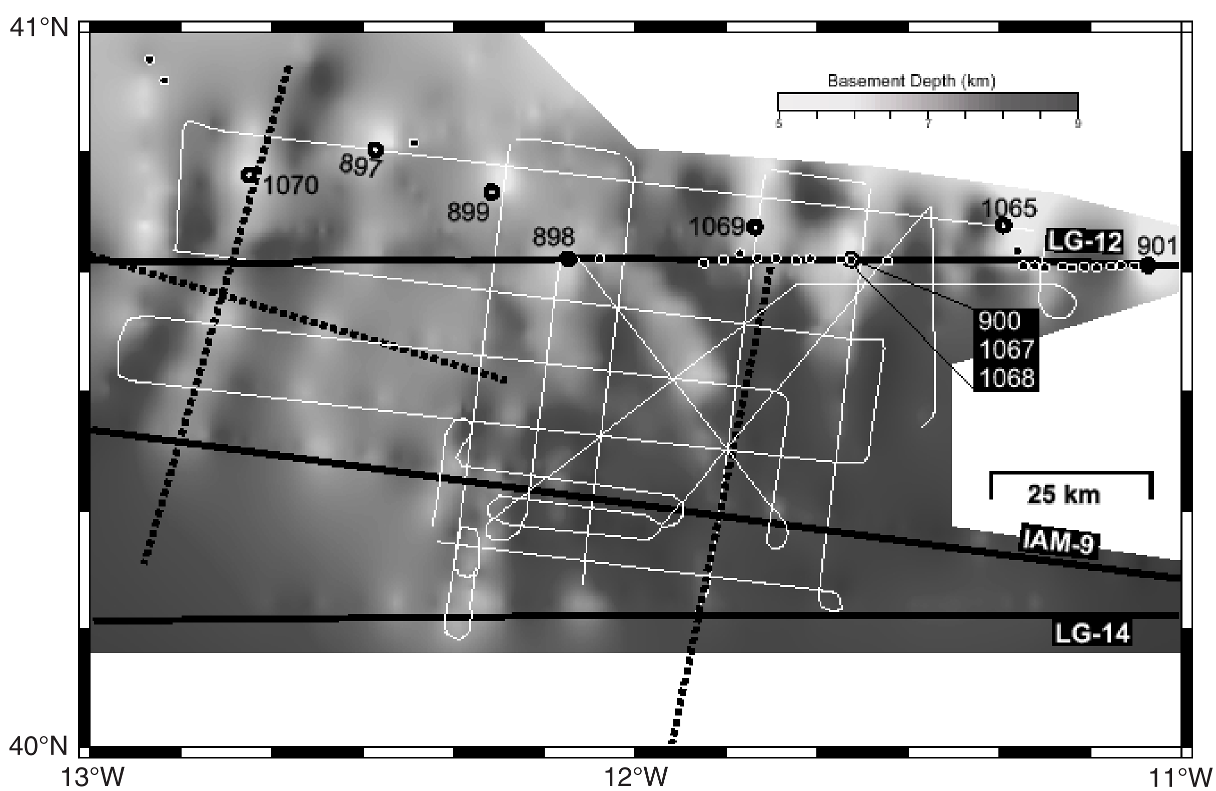


Fig. 5 - Bathymetric map of the Galicia Bank and Iberia Abyssal Plain region showing locations of existing DSDP/ODP boreholes and selected deep MCS profiles. Approximate eastern and western boundaries of the "transition zone" (TZ) between ocean crust and rifted continental crust are shown by short dashed lines.

Fig. 6 - Map of depth to basement (km below sea level) in the Iberia Abyssal Plain along and south of the ODP Leg 149/173 drilling transect. Locations of selected MCS profiles and heat flow stations (small filled circles) are indicated. From Louden and Chian (56).



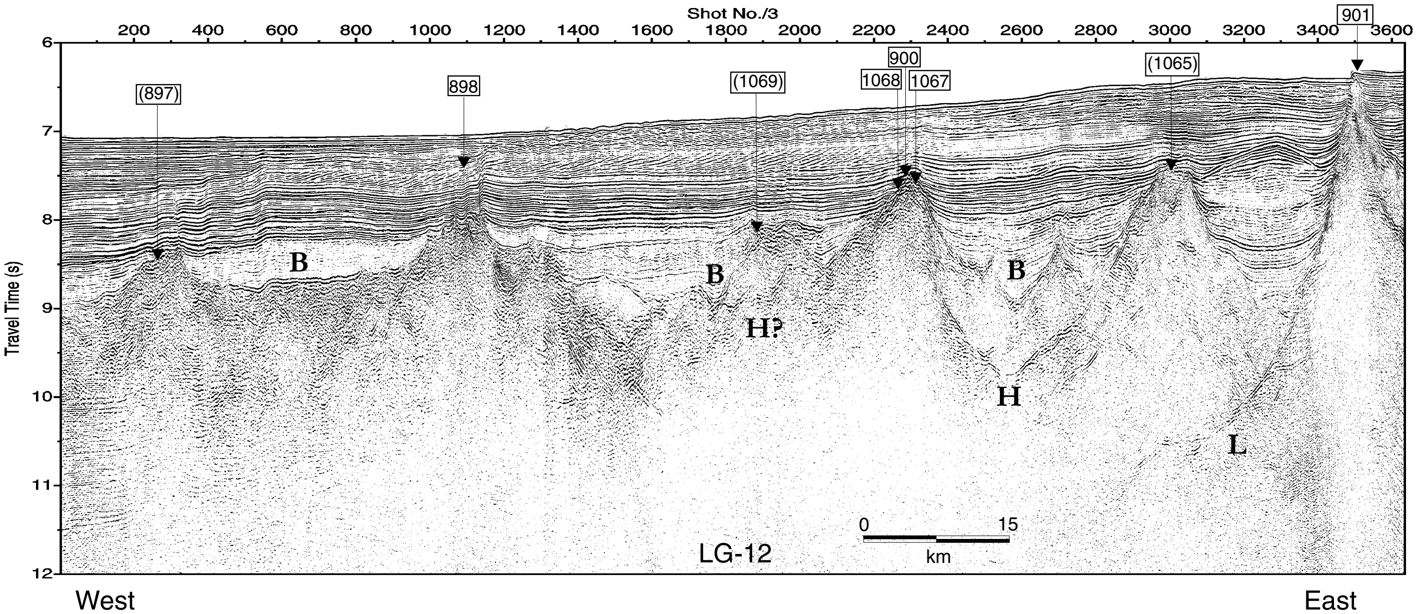


Fig. 7 - MCS profile LG-12 on the IAP margin showing morphological features of basement (B) and intra-basement reflectors (H and L). Locations of ODP sites (projected positions indicated by parentheses) of Legs 149 and 173 are indicated. From Chian et al. (19).

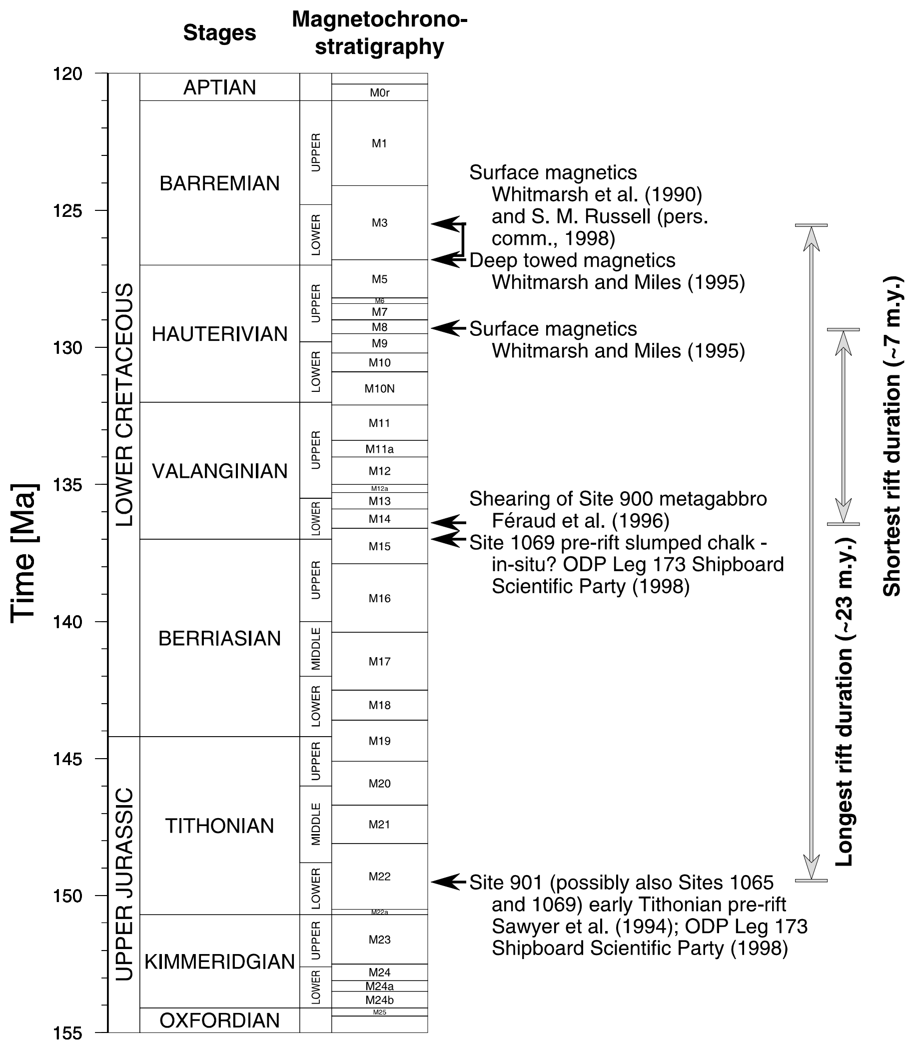


Fig. 8 - Summary of evidence for timing and duration of rifting in the Iberia Abyssal Plain (6). Time scale is that of Gradstein et al. (2).

ODP Site Description Forms:

Page 1 - General Site Information New Revised

Section A: Proposal Information

Title of Proposal	Drilling the Newfoundland Half of the Newfoundland - Iberia Transect: The First Conjugate Margin Drilling in a Non-Volcanic Rift
Proposal Number:	(Replaces 504)
Date Form Submitted:	1 October 2000
Site Specific Objectives (Must include general objectives in proposal)	Composition and igneous/tectonic history of basement. The nature of the "U" reflection and the composition and origin of the high-velocity interval between U and basement. Subsidence history of the stratigraphic sequence immediately above U. Age of a prominent reflection (Horizon Au?) which marks the initiation of abyssal current-controlled deposition in the basin, implications for a northern Atlantic gateway, and sedimentary characteristics of subsequent current-controlled sedimentation. Stratigraphic sequence development compared to development of synchronously deposited, formally defined formations that are widely developed in the western North Atlantic.
List Previous Drilling in Area:	None

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	**NNB01A**	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Northern Newfoundland Basin
Latitude:	Deg: 45	Min: 24.3 N	Jurisdiction:	International waters
Longitude:	Deg: 44	Min: 47.1 W	Distance to Land:	~360 n. miles
Priority of Site:	Primary: Yes	Alt:	Water Depth:	4559 meters

Section C: Operational Information

	Sediments. What is the total sed. thickness? ca. 2200 meters (@2.6 km/s) (may be as little as 1900 m, from preliminary OBS/H data)	Basement
Proposed Penetration (m)	Full sediment thickness, ~2200 meters (1900 meters)	At least 100 meters
General Lithologies:	From top to base: clays and silty clays, claystones, cherty claystones, claystones with limestone lenses, possible limestone beds.	Uncertain. May be, e.g., basalt, granite, Paleozoic metamorphics, serpentinite.
Coring Plan (circle):	1-2-3-APC ~~VPC*~~ XCB ~~MDCB*~~ ~~PCS~~ RCB Re-entry ~~HRGB~~ ** Systems Currently Under Development*	

Logging	Standard Tools	Special Tools	LWD

Plan:	Triple-Combo Neutron-Porosity Litho-Density ~~Natural Gamma Ray~~ Resistivity-Induction	FMS-Sonic Acoustic FMS	~~Borehole Televiewer~~ ~~Geochemical~~ ~~Resistivity-Laterolog~~ ~~High Temperature~~ GHMT, WST/VSP	~~Density-Neutron~~ ~~Resitivity-Gamma Ray~~
Estimated days:	Drilling/Coring: 48.6	Logging: 4.1		Total On-Site: 52.7*
Hazards/ Weather	*List possible hazards due to ice, hydrocarbons, dumpsites, cables, etc.* Icebergs can drift through this area, although this is not common and they tend to follow paths farther to the west; they are monitored by the International Ice Patrol. Variable currents up to 1.5 to 2 knots can occur; the area can be influenced by Gulf Stream eddies. --- * Times are a conservative estimate based on greater hole-depth estimate.			*What is your Weather Window?* June through September is optimum. Storms are more unpredictable and intense outside this window, and the chance of hurricane passage through this area increases until the end of November.

Instructions:

Please fill out these forms for each site that you are proposing to drill, including as much detail as possible. The following table describes the purpose of each page, what information is needed, and when each page should be submitted.

Page	Information needed	Used By	When to submit	Contact for more information
1	General Info. about proposals, site location and basic operational needs	JOIDES Office, Data Bank, Logging Group, ODP/TAMU, SSP, PPSP	When submitting preliminary proposal and when updating site information.	JOIDES Office email: joides@whoi.edu www: http://www.whoi.edu/joides/
2	Information regarding site survey data available and to-be-collected	JOIDES Office, Data Bank, SSP, PPSP	When submitting full proposal and when updating site survey information	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
3	Detailed Logging Plan	JOIDES Office, Logging Group, ODP/TAMU	When submitting full proposal and when updating logging plan	ODP-LDEO Wireline Logging Services email: borehole@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/BRG/brg_home.html
4	Lithologic Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
5	Pollution and Safety Hazard Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/

ODP Site Description Forms:
Page 2 - Site Survey Detail New Revised

Proposal #: (Replaces 504)	Site #: NNB01A	Date Form Submitted: 1 October 2000

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): None Crossing Lines(s): Location of Site on line (SP or Time only)
2	Deep Penetration seismic reflection			Primary Line(s): Ewing 00-07, 2MCS Location of Site on line (SP or Time only): SP 28433 (CMP 228470) Crossing Lines(s): Ewing 00-07, Line 303, SP 40137 (CMP 322504)
3	Seismic Velocity†			Ewing 00-07 wide-angle MCS and OBS/H data are currently being analyzed in detail.
4	Seismic Grid			Ewing 00-07. Deep penetration, 60-fold MCS reflection data acquired using R/V Ewing's 6000-m, 480-channel streamer and 20-gun, 8540 cubic inch (131 liter) airgun array.
5a	Refraction (surface)			None
5b	Refraction (near bottom)			Ocean-bottom seismometer and ocean-bottom hydrophone wide-angle reflection and refraction data are currently being analyzed. OBS/H records were acquired at approximately 11-14 km spacing along this part of the proposed drilling transect.
6	3.5 kHz			Ewing 00-07. Location of Site on line (Time): JD 211 @ 13:47:52 GMT
7	Swath bathymetry			Ewing 00-07 Hydrosweep data.
8a	Side-looking sonar (surface)			GLORIA long-range sidescan sonar in the vicinity.
8b	Side-looking sonar (bottom)			None.
9	Photography or Video			None.
10	Heat Flow			Oceanus Cruise 359, Leg 2 data in the vicinity, currently being analyzed.
11a	Magnetics			Ewing 00-07.
11b	Gravity			Ewing 00-07.
12	Sediment cores			In the vicinity (see LDEO data bank).
13	Rock sampling			None.

14a	Water current data			Ewing 00-07 and Oceanus 359-2.
14b	Ice Conditions			International Ice Patrol.
15	OBS microseismicity			None.
16	Navigation			Ewing 00-07 and Oceanus 359-2.
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

ODP Site Description Forms:
Page 3 - Detailed Logging Plan New Revised

Proposal #: (Replaces 504)	Site #: NNB01A	Date Form Submitted: 1 October 2000
Water Depth (m): 4559 meters	Sed. Penet (m): ca.2200 m (1900m)	Basement Penetration (m): At least 100 m

Do you need to use the conical side-entry sub (CSES) at this site? √ Yes potentially No

Are high temperatures expected at this site? √ No

Are there any other special requirements for logging at this site? Yes √ No

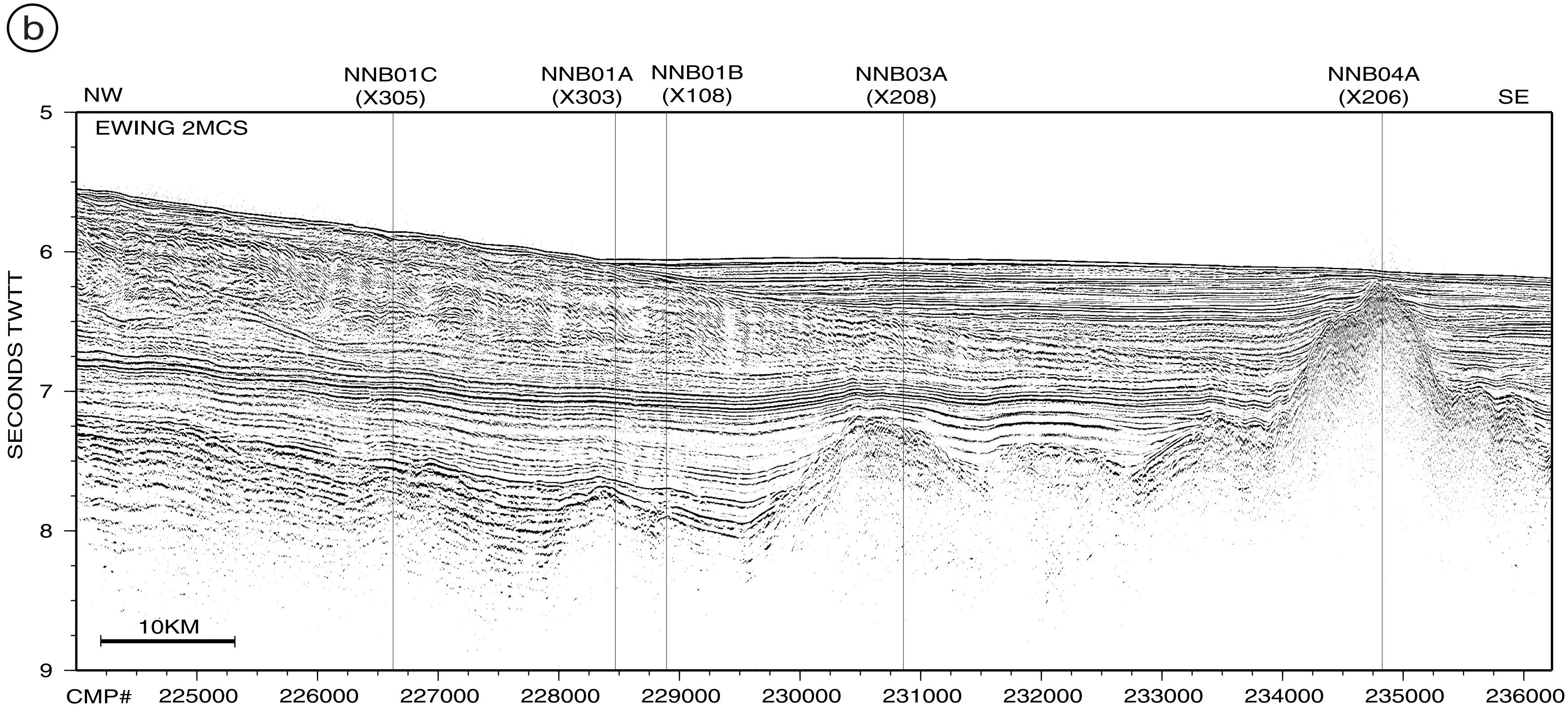
If "Yes" Please describe requirements:____

What do you estimate the total logging time for this site to be:_______________

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Accelerator Porosity Sonde (APS), part of the Triple Combo string, generates accurate porosity data required for estimates of density and seismic velocity, which will be used to correlate the lithostratigraphy to the seismic reflection data. Will also identify lithologic contacts downhole.	1
Litho-Density	Hostile Environment Litho-Density Sonde (HLDS), part of the Triple Combo toolstring, yields bulk density and together with downhole porosity and sonic data and will allow correlation of the lithostratigraphy to the seismic reflection data. The HLDS will also highlight lithologic boundaries in areas of poor core recovery.	1
Natural Gamma Ray		
Resistivity-Induction	Dual Induction Tool (DITE), part of the Triple Combo toolstring, will yield downhole resistivity data, which place constraints on apparent porosity, "pseudodensity", and/or "pseudovelocity" as well as lithologic boundaries in areas of poor core recovery. This will provide valuable data for identifying weathering and alteration horizons and contacts between possible continental crust or mantle and synrift basalt flows.	1
Acoustic	Dipole Sonic Imager (DSI), part of the FMS/Sonic toolstring, provides borehole compressional, shear, and Stoneley slownesses critical to correlating the lithology to seismic data, constructing depth sections, and it places additional constraints on rock formations in zones of poor core recovery.	1

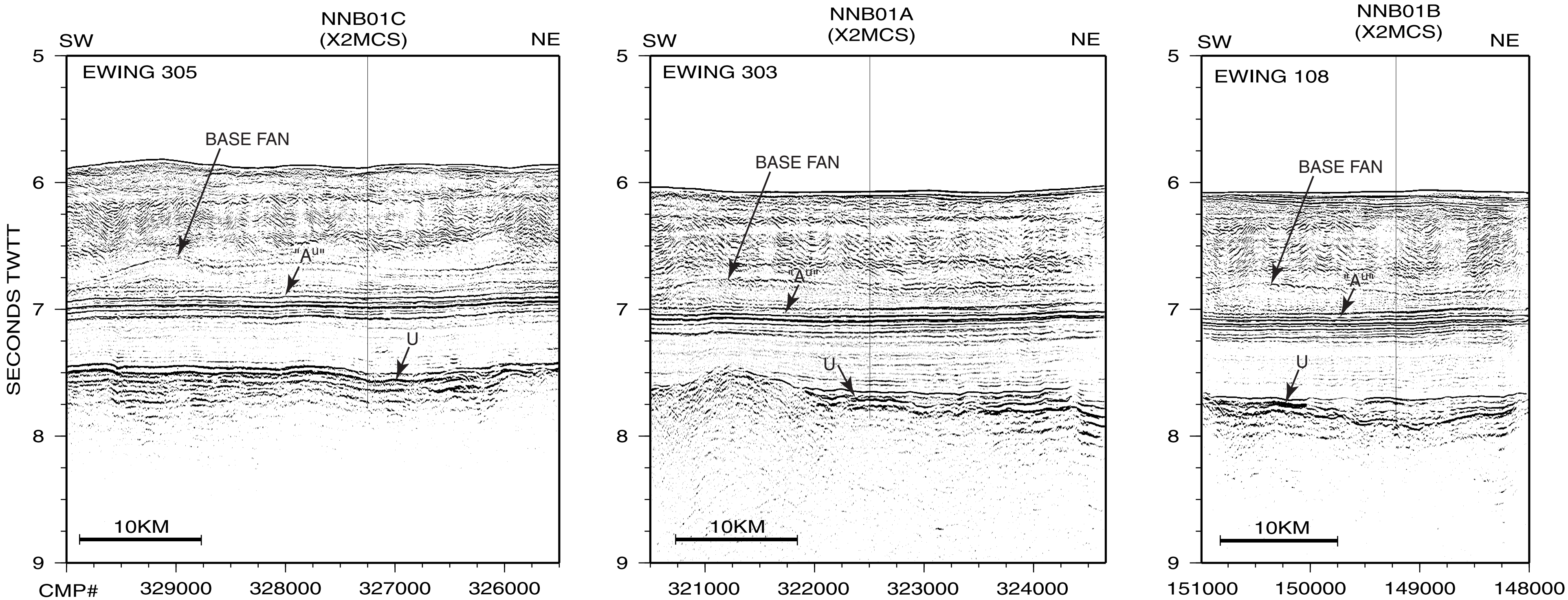
FMS	Formation MicroScanner (FMS), part of the FMS/Sonic toolstring, generates high resolution images of microresistivity that will provide great insight into mapping fractures, faults, foliations in both basement and overlying sediment. Will provide important constraints on tectonic evolution and emplacement history of basalt flows.	1
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: GHMT	Geologic High-Resolution Magnetic Tool (GHMT) provides magnetic susceptibility and total magnetic induction measurement, which will reveal the polarity of the remanent magnetization downhole. This information together will radiometric dating will provide a geochronology for the tectonic evolution of the NB-IAP rift. In addition, the magnetic susceptibility is a good proxy for paleoclimate cyclicity and it also provides valuable tie points for core-log correlation.	1
WST/VSP	The Well Seismic Tool consists of a geophone clamped to the side of the borehole. It is used to derive depth-travel time pairs and to calibrate the sonic logs and determine accurate drilling depths and their relative position with respect to targets on the seismic reflection profiles. If a second ship is available then we will use the VSP. There are two types of three-component Vertical Seismic Profile (VSP) tools available from Schlumberger. These tools clamp geophones downhole (either hydraulically in open holes or magnetically in cased holes) and record energy from seismic sources at the sea surface. The results provide confirmation of reflections on seismic sections below total depth, seismic ties to depth, and information on seismic anisotropy (from offset experiments).	1

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.



B - Section of Ewing Line 2MCS extending east of section A, showing proposed drill sites NNB01A,B,C, NNB03A, and NNB04A (see Fig. 2d). Data processing (stack, migration) is preliminary. Crossing lines are shown on a separate sheet.

2MCSp2.ai



Ewing MCS crossing lines for proposed drill sites NNB01A, NNB01B, and NNB01C. Data processing (stack, migration) is preliminary.

Urefl.ai

ODP Site Description Forms:

Page 1 - General Site Information New Revised

Section A: Proposal Information

Title of Proposal	Drilling the Newfoundland Half of the Newfoundland - Iberia Transect: The First Conjugate Margin Drilling in a Non-Volcanic Rift

Proposal Number:	(Replaces 504)	Date Form Submitted:	1 October 2000

Site Specific Objectives (Must include general objectives in proposal)	Composition and igneous/tectonic history of basement. The nature of the "U" reflection and the composition and origin of the high-velocity interval between U and basement. Subsidence history of the stratigraphic sequence immediately above U. Age of a prominent reflection (Horizon Au?) which marks the initiation of abyssal current-controlled deposition in the basin, implications for a northern Atlantic gateway, and sedimentary characteristics of subsequent current-controlled sedimentation. Stratigraphic sequence development compared to development of synchronously deposited, formally defined formations that are widely developed in the western North Atlantic.
List Previous Drilling in Area:	None

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	**NNB01B**	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Northern Newfoundland Basin
Latitude:	Deg: 45	Min: 23.5 N	Jurisdiction:	International waters
Longitude:	Deg: 44	Min: 45.5 W	Distance to Land:	~362 n. miles
Priority of Site:	Primary:	Alt: 1	Water Depth:	4563 meters

Section C: Operational Information

	Sediments. What is the total sed. thickness? ca. 2280 meters (@2.6 km/s) (may be as little as 1980 m, from preliminary OBS/H data)	Basement
Proposed Penetration (m)	Full sediment thickness, ~2280 meters (1980 m)	At least 100 meters
General Lithologies:	From top to base: clays and silty clays, claystones, cherty claystones, claystones with limestone lenses, possible limestone beds.	Uncertain. May be, e.g., basalt, granite, Paleozoic metamorphics, serpentinite.

Coring Plan (circle): 1-2-3-APC ~~VPC*~~ XCB ~~MDCB*~~ ~~PCS~~ RCB Re-entry ~~HRGB~~

** Systems Currently Under Development*

Logging Plan:	Standard Tools		Special Tools	LWD
	Triple-Combo Neutron-Porosity Litho-Density ~~Natural Gamma Ray~~ Resistivity-Induction	FMS-Sonic Acoustic FMS	~~Borehole Televiewer~~ ~~Geochemical~~ ~~Resistivity-Laterolog~~ ~~High Temperature~~ GHMT, WST/VSP	~~Density-Neutron~~ ~~Resitivity-Gamma Ray~~
Estimated days:	Drilling/Coring: 50.1	Logging: 4.2	Total On-Site: 54.3*	
Hazards/ Weather	*List possible hazards due to ice, hydrocarbons, dumpsites, cables, etc.* Icebergs can drift through this area, although this is not common and they tend to follow paths farther to the west; they are monitored by the International Ice Patrol. Variable currents up to 1.5 to 2 knots can occur; the area can be influenced by Gulf Stream eddies. -- * Times are a conservative estimate based on greater hole-depth estimate.		*What is your Weather Window?* June through September is optimum. Storms are more unpredictable and intense outside this window, and the chance of hurricane passage through this area increases until the end of November.	

Instructions:

Please fill out these forms for each site that you are proposing to drill, including as much detail as possible. The following table describes the purpose of each page, what information is needed, and when each page should be submitted.

Page	Information needed	Used By	When to submit	Contact for more information
1	General Info. about proposals, site location and basic operational needs	JOIDES Office, Data Bank, Logging Group, ODP/TAMU, SSP, PPSP	When submitting preliminary proposal and when updating site information.	JOIDES Office email: joides@whoi.edu www: http://www.whoi.edu/joides/
2	Information regarding site survey data available and to-be-collected	JOIDES Office, Data Bank, SSP, PPSP	When submitting full proposal and when updating site survey information	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
3	Detailed Logging Plan	JOIDES Office, Logging Group, ODP/TAMU	When submitting full proposal and when updating logging plan	ODP-LDEO Wireline Logging Services email: borehole@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/BRG/brg_home.html
4	Lithologic Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
5	Pollution and Safety Hazard Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/

ODP Site Description Forms:
Page 2 - Site Survey Detail New Revised

Proposal #: (replaces 504)	Site #: NNB01B	Date Form Submitted: 1 October 2000

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): None Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Ewing 00-07, Line 2MCS Location of Site on line (SP or Time only): SP 28486 (CMP 228893) Crossing Lines(s): Ewing 00-07, Line 108, SP 18526 (CMP 149216)
3	Seismic Velocity†			Ewing 00-07 wide-angle MCS and OBS/H data are currently being analyzed in detail.
4	Seismic Grid			Ewing 00-07. Deep penetration, 60-fold MCS reflection data acquired using R/V Ewing's 6000-m, 480-channel streamer and 20-gun, 8540 cubic inch (131 liter) airgun array.
5a	Refraction (surface)			None
5b	Refraction (near bottom)			Ocean-bottom seismometer and ocean-bottom hydrophone wide-angle reflection and refraction data are currently being analyzed. OBS/H records were acquired at approximately 11-14 km spacing along this part of the proposed drilling transect.
6	3.5 kHz			Ewing 00-07. Location of Site on line (Time): JD 211 @14:07:54 GMT
7	Swath bathymetry			Ewing 00-07 Hydrosweep data.
8a	Side-looking sonar (surface)			GLORIA long-range sidescan sonar in the vicinity.
8b	Side-looking sonar (bottom)			None.
9	Photography or Video			None.
10	Heat Flow			Oceanus Cruise 359, Leg 2 data in the vicinity, currently being analyzed.
11a	Magnetics			Ewing 00-07.
11b	Gravity			Ewing 00-07.
12	Sediment cores			In the vicinity (see LDEO data bank).
13	Rock sampling			None.

14a	Water current data			Ewing 00-07 and Oceanus 359-2.
14b	Ice Conditions			International Ice Patrol.
15	OBS microseismicity			None.
16	Navigation			Ewing 00-07 and Oceanus 359-2.
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

ODP Site Description Forms:
Page 3 - Detailed Logging Plan   New   Revised

Proposal #: (Replaces 504)	Site #: NNB01B	Date Form Submitted: 1 October 2000
Water Depth (m): 4563 meters	Sed. Pen (m): ca. 2280 meters (1980 m)	Basement Penetration (m): At least 100 m

Do you need to use the conical side-entry sub (CSES) at this site? √ Yes potentially No

Are high temperatures expected at this site? √ No

Are there any other special requirements for logging at this site? Yes √ No

If "Yes" Please describe requirements:____

What do you estimate the total logging time for this site to be:______________

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Accelerator Porosity Sonde (APS), part of the Triple Combo string, generates accurate porosity data required for estimates of density and seismic velocity, which will be used to correlate the lithostratigraphy to the seismic reflection data. Will also identify lithologic contacts downhole.	1
Litho-Density	Hostile Environment Litho-Density Sonde (HLDS), part of the Triple Combo toolstring, yields bulk density and together with downhole porosity and sonic data and will allow correlation of the lithostratigraphy to the seismic reflection data. The HLDS will also highlight lithologic boundaries in areas of poor core recovery.	1
Natural Gamma Ray		
Resistivity-Induction	Dual Induction Tool (DITE), part of the Triple Combo toolstring, will yield downhole resistivity data, which place constraints on apparent porosity, "pseudodensity", and/or "pseudovelocity" as well as lithologic boundaries in areas of poor core recovery. This will provide valuable data for identifying weathering and alteration horizons and contacts between possible continental crust or mantle and synrift basalt flows.	1
Acoustic	Dipole Sonic Imager (DSI), part of the FMS/Sonic toolstring, provides borehole compressional, shear, and Stoneley slownesses critical to correlating the lithology to seismic data, constructing depth sections, and it places additional constraints on rock formations in zones of poor core recovery.	1

FMS	Formation MicroScanner (FMS), part of the FMS/Sonic toolstring, generates high resolution images of microresistivity that will provide great insight into mapping fractures, faults, foliations in both basement and overlying sediment. Will provide important constraints on tectonic evolution and emplacement history of basalt flows.	1
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: GHMT WST/VSP	Geologic High-Resolution Magnetic Tool (GHMT) provides magnetic susceptibility and total magnetic induction measurement, which will reveal the polarity of the remanent magnetization downhole. This information together will radiometric dating will provide a geochronology for the tectonic evolution of the NB-IAP rift. In addition, the magnetic susceptibility is a good proxy for paleoclimate cyclicity and it also provides valuable tie points for core-log correlation. The Well Seismic Tool consists of a geophone clamped to the side of the borehole. It is used to derive depth-travel time pairs and to calibrate the sonic logs and determine accurate drilling depths and their relative position with respect to targets on the seismic reflection profiles. If a second ship is available then we will use the VSP. There are two types of three-component Vertical Seismic Profile (VSP) tools available from Schlumberger. These tools clamp geophones downhole (either hydraulically in open holes or magnetically in cased holes) and record energy from seismic sources at the sea surface. The results provide confirmation of reflections on seismic sections below total depth, seismic ties to depth, and information on seismic anisotropy (from offset experiments).	1 1

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

ODP Site Description Forms:

Page 1 - General Site Information New Revised

Section A: Proposal Information

Title of Proposal	Drilling the Newfoundland Half of the Newfoundland - Iberia Transect: The First Conjugate Margin Drilling in a Non-Volcanic Rift

Proposal Number:	(Replaces 504)	Date Form Submitted:	1 October 2000

Site Specific Objectives (Must include general objectives in proposal)	Composition and igneous/tectonic history of basement. The nature of the "U" reflection and the composition and origin of the high-velocity interval between U and basement. Subsidence history of the stratigraphic sequence immediately above U. Age of a prominent reflection (Horizon Au?) which marks the initiation of abyssal current-controlled deposition in the basin, implications for a northern Atlantic gateway, and sedimentary characteristics of subsequent current-controlled sedimentation. Stratigraphic sequence development compared to development of synchronously deposited, formally defined formations that are widely developed in the western North Atlantic.
List Previous Drilling in Area:	None

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	**NNB01C**	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Northern Newfoundland Basin
Latitude:	Deg: 45	Min: 28.0 N	Jurisdiction:	International waters
Longitude:	Deg: 44	Min: 54.3 W	Distance to Land:	~352 n. miles
Priority of Site:	Primary:	Alt: 2	Water Depth:	4412 meters

Section C: Operational Information

	Sediments. What is the total sed. thickness? ca. 2300 meters (@2.6 km/s) (may be as little as 1960 m, from preliminary OBS/H data)	Basement
Proposed Penetration (m)	Full sediment thickness, ~2300 meters (1960 m)	At least 100 meters
General Lithologies:	From top to base: clays and silty clays, claystones, cherty claystones, claystones with limestone lenses, possible limestone beds.	Uncertain. May be, e.g., basalt, granite, Paleozoic metamorphics, serpentinite.
Coring Plan (circle):	1-2-3-APC ~~VPC*~~ XCB ~~MDCB*~~ ~~PCS~~ RCB Re-entry ~~HRGB~~	

** Systems Currently Under Development*

Logging Plan:	Standard Tools		Special Tools	LWD
	Triple-Combo Neutron-Porosity Litho-Density ~~Natural Gamma Ray~~ Resistivity-Induction	FMS-Sonic Acoustic FMS	~~Borehole Televiewer~~ ~~Geochemical~~ ~~Resistivity-Laterolog~~ ~~High Temperature~~ GHMT, WST/VSP	~~Density-Neutron~~ ~~Resitivity-Gamma Ray~~
Estimated days:	Drilling/Coring: 46.3	Logging: 4.1	Total On-Site: 50.4 *	
Hazards/ Weather	*List possible hazards due to ice, hydrocarbons, dumpsites, cables, etc.* Icebergs can drift through this area, although this is not common and they tend to follow paths farther to the west; they are monitored by the International Ice Patrol. Variable currents up to 1.5 to 2 knots can occur; the area can be influenced by Gulf Stream eddies. --- * Times are a conservative estimate based on greater hole-depth estimate.		*What is your Weather Window?* June through September is optimum. Storms are more unpredictable and intense outside this window, and the chance of hurricane passage through this area increases until the end of November.	

Instructions:

Please fill out these forms for each site that you are proposing to drill, including as much detail as possible. The following table describes the purpose of each page, what information is needed, and when each page should be submitted.

Page	Information needed	Used By	When to submit	Contact for more information
1	General Info. about proposals, site location and basic operational needs	JOIDES Office, Data Bank, Logging Group, ODP/TAMU, SSP, PPSP	When submitting preliminary proposal and when updating site information.	JOIDES Office email: joides@whoi.edu www: http://www.whoi.edu/joides/
2	Information regarding site survey data available and to-be-collected	JOIDES Office, Data Bank, SSP, PPSP	When submitting full proposal and when updating site survey information	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
3	Detailed Logging Plan	JOIDES Office, Logging Group, ODP/TAMU	When submitting full proposal and when updating logging plan	ODP-LDEO Wireline Logging Services email: borehole@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/BRG/brg_home.html
4	Lithologic Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
5	Pollution and Safety Hazard Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/

ODP Site Description Forms:
Page 2 - Site Survey Detail New Revised

Proposal #: (Replaces 504)	Site #: NNB01C	Date Form Submitted: 1 October 2000

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): None Crossing Lines(s): Location of Site on line (SP or Time only)
2	Deep Penetration seismic reflection			Primary Line(s): Ewing 00-07, Line 2MCS Location of Site on line (SP or Time only): SP 28202 (CMP 226628) Crossing Lines(s): Ewing 00-07, Line 305, SP 40780 (CMP 327251)
3	Seismic Velocity†			Ewing 00-07 wide-angle MCS and OBS/H data are currently being analyzed in detail.
4	Seismic Grid			Ewing 00-07. Deep penetration, 60-fold MCS reflection data acquired using R/V Ewing's 6000-m, 480-channel streamer and 20-gun, 8540 cubic inch (131 liter) airgun array.
5a	Refraction (surface)			None
5b	Refraction (near bottom)			Ocean-bottom seismometer and ocean-bottom hydrophone wide-angle reflection and refraction data are currently being analyzed. OBS/H records were acquired at approximately 11-14 km spacing along this part of the proposed drilling transect.
6	3.5 kHz			Ewing 00-07. Location of Site on line (Time): JD 211 @12:25:20. GMT
7	Swath bathymetry			Ewing 00-07 Hydrosweep data.
8a	Side-looking sonar (surface)			GLORIA long-range sidescan sonar in the vicinity.
8b	Side-looking sonar (bottom)			None.
9	Photography or Video			None.
10	Heat Flow			Oceanus Cruise 359, Leg 2 data in the vicinity, currently being analyzed.
11a	Magnetics			Ewing 00-07.
11b	Gravity			Ewing 00-07.
12	Sediment cores			In the vicinity (see LDEO data bank).
13	Rock sampling			None.

14a	Water current data			Ewing 00-07 and Oceanus 359-2.
14b	Ice Conditions			International Ice Patrol.
15	OBS microseismicity			None.
16	Navigation			Ewing 00-07 and Oceanus 359-2.
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

ODP Site Description Forms:
Page 3 - Detailed Logging Plan New Revised

Proposal #: (Replaces 504)	Site #: NNB01C	Date Form Submitted: 1 October 2000
Water Depth (m): 4009 meters	Sed. Pen (m): ca. 2300 meters (1960 m)	Basement Penetration (m): At least 100 m

Do you need to use the conical side-entry sub (CSES) at this site? √ Yes Potentially No

Are high temperatures expected at this site? √ No

Are there any other special requirements for logging at this site? Yes √ No

If "Yes" Please describe requirements:______________________________

What do you estimate the total logging time for this site to be:______________

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Accelerator Porosity Sonde (APS), part of the Triple Combo string, generates accurate porosity data required for estimates of density and seismic velocity, which will be used to correlate the lithostratigraphy to the seismic reflection data. Will also identify lithologic contacts downhole.	1
Litho-Density	Hostile Environment Litho-Density Sonde (HLDS), part of the Triple Combo toolstring, yields bulk density and together with downhole porosity and sonic data and will allow correlation of the lithostratigraphy to the seismic reflection data. The HLDS will also highlight lithologic boundaries in areas of poor core recovery.	1
Natural Gamma Ray		
Resistivity-Induction	Dual Induction Tool (DITE), part of the Triple Combo toolstring, will yield downhole resistivity data, which place constraints on apparent porosity, "pseudodensity", and/or "pseudovelocity" as well as lithologic boundaries in areas of poor core recovery. This will provide valuable data for identifying weathering and alteration horizons and contacts between possible continental crust or mantle and synrift basalt flows.	1
Acoustic	Dipole Sonic Imager (DSI), part of the FMS/Sonic toolstring, provides borehole compressional, shear, and Stoneley slownesses critical to correlating the lithology to seismic data, constructing depth sections, and it places additional constraints on rock formations in zones of poor core recovery.	1

FMS	Formation MicroScanner (FMS), part of the FMS/Sonic toolstring, generates high resolution images of microresistivity that will provide great insight into mapping fractures, faults, foliations in both basement and overlying sediment. Will provide important constraints on tectonic evolution and emplacement history of basalt flows.	1
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: GHMT	Geologic High-Resolution Magnetic Tool (GHMT) provides magnetic susceptibility and total magnetic induction measurement, which will reveal the polarity of the remanent magnetization downhole. This information together will radiometric dating will provide a geochronology for the tectonic evolution of the NB-IAP rift. In addition, the magnetic susceptibility is a good proxy for paleoclimate cyclicity and it also provides valuable tie points for core-log correlation.	1
WST/VSP	The Well Seismic Tool consists of a geophone clamped to the side of the borehole. It is used to derive depth-travel time pairs and to calibrate the sonic logs and determine accurate drilling depths and their relative position with respect to targets on the seismic reflection profiles. If a second ship is available then we will use the VSP. There are two types of three-component Vertical Seismic Profile (VSP) tools available from Schlumberger. These tools clamp geophones downhole (either hydraulically in open holes or magnetically in cased holes) and record energy from seismic sources at the sea surface. The results provide confirmation of reflections on seismic sections below total depth, seismic ties to depth, and information on seismic anisotropy (from offset experiments).	1

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

ODP Site Description Forms:

Page 1 - General Site Information New Revised

Section A: Proposal Information

Title of Proposal	Drilling the Newfoundland Half of the Newfoundland - Iberia Transect: The First Conjugate Margin Drilling in a Non-Volcanic Rift
Proposal Number:	(Replaces 504)
Date Form Submitted:	1 October 2000
Site Specific Objectives (Must include general objectives in proposal)	Composition and metamorphic/igneous/tectonic history of basement in what appears to be the seawardmost, clearly continental crustal block. Lithology of the apparent synrift sedimentary package capping the block (Paleozoic sediments? reef carbonates?) and tectonic/rotation history of the block. Subsidence history and record of current-controlled deposition in the overlying stratigraphic sequence.
List Previous Drilling in Area:	None

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	**NNB02A**	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Northern Newfoundland Basin
Latitude:	Deg: 45	Min: 44.0N	Jurisdiction:	International waters
Longitude:	Deg: 45	Min: 25.4 W	Distance to Land:	~310 n. miles
Priority of Site:	Primary: Yes	Alt:	Water Depth:	3580 meters

Section C: Operational Information

	Sediments. What is the total sed. thickness? ca. 1800 meters (@2.6 km/s) (may be as little as 1700 m, from preliminary OBS/H data)	Basement
Proposed Penetration (m)	Full sediment thickness, ~1800 meters (1700 m)	At least 100 meters into basement
General Lithologies:	Top half of sequence: clays and silty clays, claystones, possible cherty claystones. Bottom half is uncertain, possibly reef/lagoonal carbonates or Paleozoic sediments.	Most likely PreCambrian to Paleozoic granite, metamorphics, or ophiolite sequence.

Coring Plan (circle):	1-2-3-APC ~~VPC*~~ XCB ~~MDCB*~~ ~~PCS~~ RCB Re-entry (possible) ~~HRGB~~ ** Systems Currently Under Development*			
Logging Plan:	Standard Tools		Special Tools	LWD
	Triple-Combo Neutron-Porosity Litho-Density ~~Natural Gamma Ray~~ Resistivity-Induction	FMS-Sonic Acoustic FMS	~~Borehole Televiewer~~ ~~Geochemical~~ ~~Resistivity-Laterolog~~ ~~High Temperature~~ GHMT, WST/VSP	~~Density-Neutron~~ ~~Resitivity-Gamma Ray~~
Estimated days:	Drilling/Coring: 50.7	Logging: 3.3	Total On-Site: 54.0 *	
Hazards/ Weather	*List possible hazards due to ice, hydrocarbons, dumpsites, cables, etc.* Icebergs can drift through this area, although this is not common and they tend to follow paths farther to the west; they are monitored by the International Ice Patrol. Variable currents up to 1.5 to 2 knots can occur; the area can be influenced by Gulf Stream eddies. --- * Times are a conservative estimate based on greater hole-depth estimate.		*What is your Weather Window?* June through September is optimum. Storms are more unpredictable and intense outside this window, and the chance of hurricane passage through this area increases until the end of November.	

Instructions:

Please fill out these forms for each site that you are proposing to drill, including as much detail as possible. The following table describes the purpose of each page, what information is needed, and when each page should be submitted.

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1	General Info. about proposals, site location and basic operational needs	JOIDES Office, Data Bank, Logging Group, ODP/TAMU, SSP, PPSP	When submitting preliminary proposal and when updating site information.	JOIDES Office email: joides@whoi.edu www: http://www.whoi.edu/joides/
2	Information regarding site survey data available and to-be-collected	JOIDES Office, Data Bank, SSP, PPSP	When submitting full proposal and when updating site survey information	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
3	Detailed Logging Plan	JOIDES Office, Logging Group, ODP/TAMU	When submitting full proposal and when updating logging plan	ODP-LDEO Wireline Logging Services email: borehole@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/BRG/brg_home.html
4	Lithologic Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
5	Pollution and Safety Hazard Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/

ODP Site Description Forms:
Page 2 - Site Survey Detail New Revised

Proposal #: (Replaces 504)	Site #: NNB02A	Date Form Submitted: 1 October 2000

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): None Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Ewing 00-07, 2MCS Location of Site on line (SP or Time only): SP 27211 (CMP 218697) Crossing Lines(s): Ewing 00-07, Line 301, SP 37625 (CMP 302004)
3	Seismic Velocity†			Ewing 00-07 wide-angle MCS and OBS/H data are currently being analyzed in detail.
4	Seismic Grid			Ewing 00-07. Deep penetration, 60-fold MCS reflection data acquired using R/V Ewing's 6000-m, 480-channel streamer and 20-gun, 8540 cubic inch (131 liter) airgun array.
5a	Refraction (surface)			None
5b	Refraction (near bottom)			Ocean-bottom seismometer and ocean-bottom hydrophone wide-angle reflection and refraction data are currently being analyzed. OBS/H records were acquired at approximately 14-15 km spacing along this part of the proposed drilling transect.
6	3.5 kHz			Ewing 00-07. Location of Site on line (Time): JD211 @06:37:40 GMT
7	Swath bathymetry			Ewing 00-07 Hydrosweep data.
8a	Side-looking sonar (surface)			GLORIA long-range sidescan sonar in the vicinity.
8b	Side-looking sonar (bottom)			None.
9	Photography or Video			None.
10	Heat Flow			Oceanus Cruise 359, Leg 2 data seaward of the site, currently being analyzed.
11a	Magnetics			Ewing 00-07.

11b	Gravity			Ewing 00-07.
12	Sediment cores			In the vicinity (see LDEO data bank).
13	Rock sampling			None.
14a	Water current data			Ewing 00-07 and Oceanus 359-2.
14b	Ice Conditions			International Ice Patrol.
15	OBS microseismicity			None.
16	Navigation			Ewing 00-07 and Oceanus 359-2.
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

ODP Site Description Forms:
Page 3 - Detailed Logging Plan New Revised

Proposal #: (Replaces 504)	Site #: NNB02A	Date Form Submitted: 1 October 2000
Water Depth (m): 3580 meters	Sed. Pen (m): ca. 1800 meters (1700 m)	Basement Penetration (m): At least 100 m

Do you need to use the conical side-entry sub (CSES) at this site? √Yes potentially No

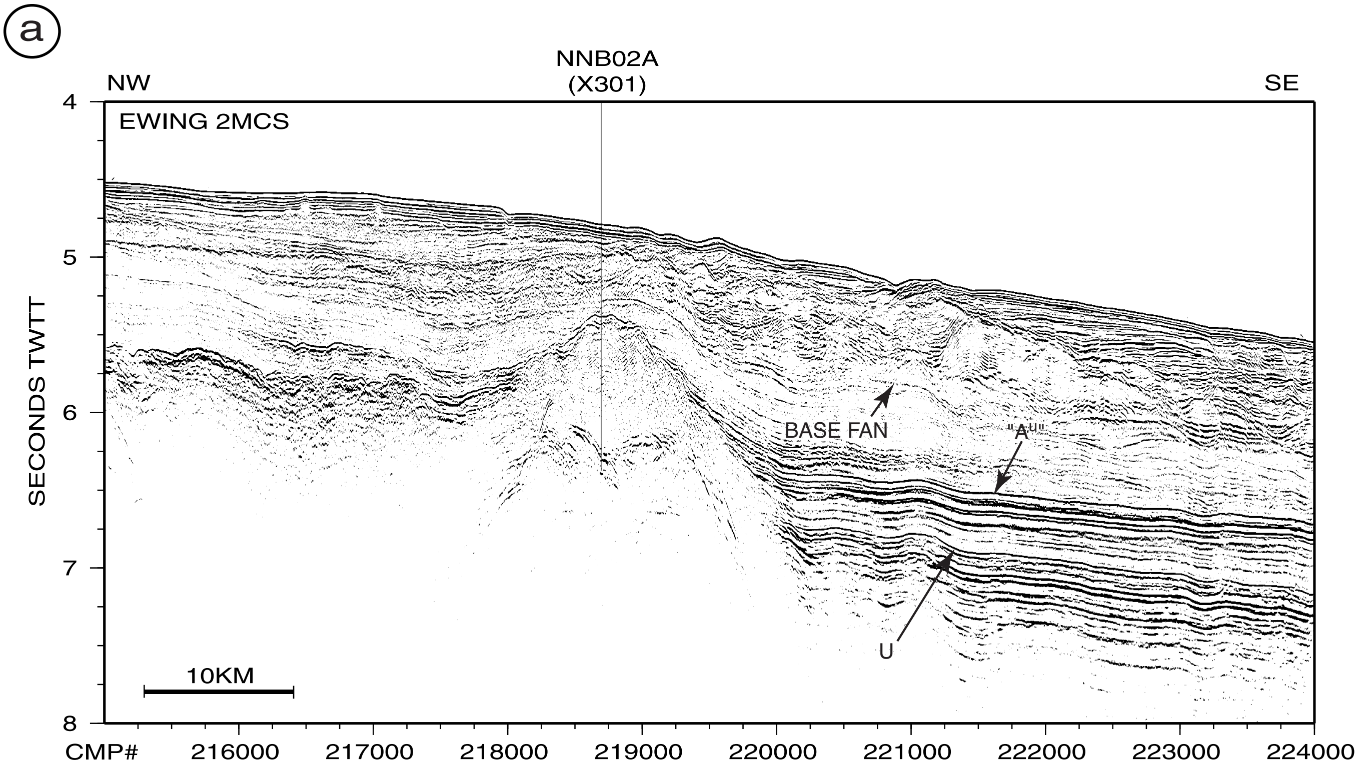
Are high temperatures expected at this site? √ No

Are there any other special requirements for logging at this site? Yes √ No

If "Yes" Please describe requirements:____
What do you estimate the total logging time for this site to be:______________

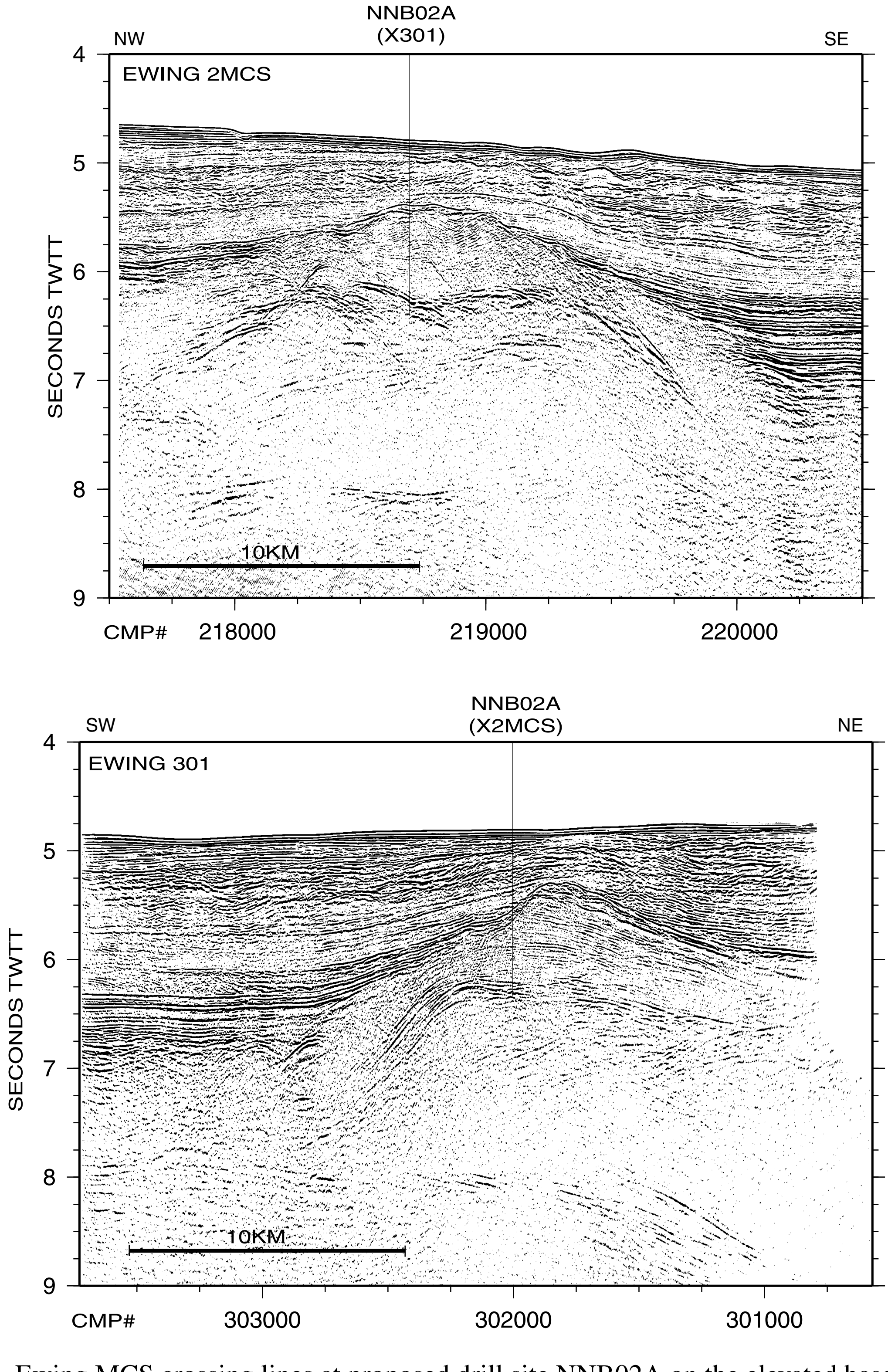
Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Accelerator Porosity Sonde (APS), part of the Triple Combo string, generates accurate porosity data required for estimates of density and seismic velocity, which will be used to correlate the lithostratigraphy to the seismic reflection data. Will also identify lithologic contacts downhole.	1
Litho-Density	Hostile Environment Litho-Density Sonde (HLDS), part of the Triple Combo toolstring, yields bulk density and together with downhole porosity and sonic data and will allow correlation of the lithostratigraphy to the seismic reflection data. The HLDS will also highlight lithologic boundaries in areas of poor core recovery.	1
Natural Gamma Ray		
Resistivity-Induction	Dual Induction Tool (DITE), part of the Triple Combo toolstring, will yield downhole resistivity data, which place constraints on apparent porosity, "pseudodensity", and/or "pseudovelocity" as well as lithologic boundaries in areas of poor core recovery. This will provide valuable data for identifying weathering and alteration horizons and contacts between possible continental crust or mantle and synrift basalt flows.	1
Acoustic	Dipole Sonic Imager (DSI), part of the FMS/Sonic toolstring, provides borehole compressional, shear, and Stoneley slownesses critical to correlating the lithology to seismic data, constructing depth sections, and it places additional constraints on rock formations in zones of poor core recovery.	1

FMS	Formation MicroScanner (FMS), part of the FMS/Sonic toolstring, generates high resolution images of microresistivity that will provide great insight into mapping fractures, faults, foliations in both basement and overlying sediment. Will provide important constraints on tectonic evolution and emplacement history of basalt flows.	1
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: GHMT WST/VSP	Geologic High-Resolution Magnetic Tool (GHMT) provides magnetic susceptibility and total magnetic induction measurement, which will reveal the polarity of the remanent magnetization downhole. This information together will radiometric dating will provide a geochronology for the tectonic evolution of the NB-IAP rift. In addition, the magnetic susceptibility is a good proxy for paleoclimate cyclicity and it also provides valuable tie points for core-log correlation. The Well Seismic Tool consists of a geophone clamped to the side of the borehole. It is used to derive depth-travel time pairs and to calibrate the sonic logs and determine accurate drilling depths and their relative position with respect to targets on the seismic reflection profiles. If a second ship is available then we will use the VSP. There are two types of three-component Vertical Seismic Profile (VSP) tools available from Schlumberger. These tools clamp geophones downhole (either hydraulically in open holes or magnetically in cased holes) and record energy from seismic sources at the sea surface. The results provide confirmation of reflections on seismic sections below total depth, seismic ties to depth, and information on seismic anisotropy (from offset experiments).	1 1



A - Section of Ewing Line 2MCS extending across the Flemish hinge, showing proposed drill site NNB02A (see Fig. 2d). Data processing (stack, migration) is preliminary. Crossing Line 301 is shown on a separate sheet.

2MCSp1.ai



Ewing MCS crossing lines at proposed drill site NNB02A on the elevated basement at Flemish hinge. Note 1) the presumably pre- to synrift sedimentary sequence that forms a restricted cap on the block, and 2) the deep, strong, coherent intra-basement reflections that may relate to deep faulting (e.g., an S, H, or L type reflection as observed on the IAP). Data processing (stack, migration) is preliminary.

ODP Site Description Forms:

Page 1 - General Site Information New Revised

Section A: Proposal Information

Title of Proposal	Drilling the Newfoundland Half of the Newfoundland - Iberia Transect: The First Conjugate Margin Drilling in a Non-Volcanic Rift

Proposal Number:	(Replaces 504)	Date Form Submitted:	1 October 2000

Site Specific Objectives (Must include general objectives in proposal)	Composition and igneous/tectonic history of basement. Subsidence history of the stratigraphic sequence immediately above basement. Age of a prominent reflection (Horizon Au?) which marks the initiation of abyssal current-controlled deposition in the basin, implications for a northern Atlantic gateway, and sedimentary characteristics of subsequent current-controlled sedimentation. Stratigraphic sequence development compared to development of synchronously deposited, formally defined formations that are widely developed in the western North Atlantic.
List Previous Drilling in Area:	None

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	**NNB03A**	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Northern Newfoundland Basin
Latitude:	Deg: 45	Min: 19.6N	Jurisdiction:	International waters
Longitude:	Deg: 44	Min: 37.9 W	Distance to Land:	~370 n. miles
Priority of Site:	Primary: Yes	Alt:	Water Depth:	4553 meters

Section C: Operational Information

	Sediments. What is the total sed. thickness? ca. 1600 meters (@2.6 km/s) (may be as little as 1180 m, from preliminary OBS/H data)	Basement
Proposed Penetration (m)	Full sediment thickness, ~1600 meters (1180)	Plus at least 100 meters into basement
General Lithologies:	From top to base: clays and silty clays, claystones, cherty claystones, claystones with limestone lenses, possible limestone beds.	Uncertain. Likely to be basalt or serpentinite.

Coring Plan (circle):	1-2-3-APC	~~VPC*~~	XCB	~~MDCB*~~	~~PCS~~	RCB	Re-entry possible	~~HRGB~~
	** Systems Currently Under Development*							

Logging Plan:	Standard Tools		Special Tools	LWD
	Triple-Combo Neutron-Porosity Litho-Density ~~Natural Gamma Ray~~ Resistivity-Induction	FMS-Sonic Acoustic FMS	~~Borehole Televiewer~~ ~~Geochemical~~ ~~Resistivity-Laterolog~~ ~~High Temperature~~ GHMT, WST, VSP	~~Density-Neutron~~ ~~Resitivity-Gamma Ray~~

Estimated days:	Drilling/Coring: 48.9	Logging: 3.4	Total On-Site: 52.3 *
Hazards/ Weather	*List possible hazards due to ice, hydrocarbons, dumpsites, cables, etc.* Icebergs can drift through this area, although this is not common and they tend to follow paths farther to the west; they are monitored by the International Ice Patrol. Variable currents up to 1.5 to 2 knots can occur; the area can be influenced by Gulf Stream eddies. -- * Times are a conservative estimate based on greater hole-depth estimate.		*What is your Weather Window?* June through September is optimum. Storms are more unpredictable and intense outside this window, and the chance of hurricane passage through this area increases until the end of November.

Instructions:

Please fill out these forms for each site that you are proposing to drill, including as much detail as possible. The following table describes the purpose of each page, what information is needed, and when each page should be submitted.

Page	Information needed	Used By	When to submit	Contact for more information
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2	Information regarding site survey data available and to-be-collected	JOIDES Office, Data Bank, SSP, PPSP	When submitting full proposal and when updating site survey information	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
3	Detailed Logging Plan	JOIDES Office, Logging Group, ODP/TAMU	When submitting full proposal and when updating logging plan	ODP-LDEO Wireline Logging Services email: borehole@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/BRG/brg_home.html
4	Lithologic Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
5	Pollution and Safety Hazard Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/

ODP Site Description Forms:
Page 2 - Site Survey Detail New Revised

Proposal #: (Replaces 504)	Site #: NNB03A	Date Form Submitted: 1 October 2000

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): None Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Ewing 00-07, 2MCS Location of Site on line (SP or Time only): SP 28731 (CMP 230858) Crossing Lines(s): Ewing 00-07, Line 208, SP 36843 (CMP 296218)
3	Seismic Velocity†			Ewing 00-07 wide-angle MCS and OBS/H data are currently being analyzed in detail.
4	Seismic Grid			Ewing 00-07. Deep penetration, 60-fold MCS reflection data acquired using R/V Ewing's 6000-m, 480-channel streamer and 20-gun, 8540 cubic inch (131 liter) airgun array.
5a	Refraction (surface)			None
5b	Refraction (near bottom)			Ocean-bottom seismometer and ocean-bottom hydrophone wide-angle reflection and refraction data are currently being analyzed. OBS/H records were acquired at approximately 11-14 km spacing along this part of the proposed drilling transect.
6	3.5 kHz			Ewing 00-07. Location of Site on line (Time) JD 211 @15:48:02 GMT
7	Swath bathymetry			Ewing 00-07 Hydrosweep data.
8a	Side-looking sonar (surface)			GLORIA long-range sidescan sonar in the vicinity.
8b	Side-looking sonar (bottom)			None.
9	Photography or Video			None.
10	Heat Flow			Oceanus Cruise 359, Leg 2 data in vicinity, currently being analyzed.
11a	Magnetics			Ewing 00-07.

11b	Gravity			Ewing 00-07.
12	Sediment cores			In the vicinity (see LDEO data bank).
13	Rock sampling			None.
14a	Water current data			Ewing 00-07 and Oceanus 359-2.
14b	Ice Conditions			International Ice Patrol.
15	OBS microseismicity			None.
16	Navigation			Ewing 00-07 and Oceanus 359-2.
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

ODP Site Description Forms:
Page 3 - Detailed Logging Plan New Revised

Proposal #: (Replaces 504)	Site #: NNB03A	Date Form Submitted: 1 October 2000
Water Depth (m): 4553 meters	Sed. Pen (m): ca. 1600 meters (1180 m)	Basement Penetration (m): At least 100 m

Do you need to use the conical side-entry sub (CSES) at this site? Yes √ No

Are high temperatures expected at this site? √ No

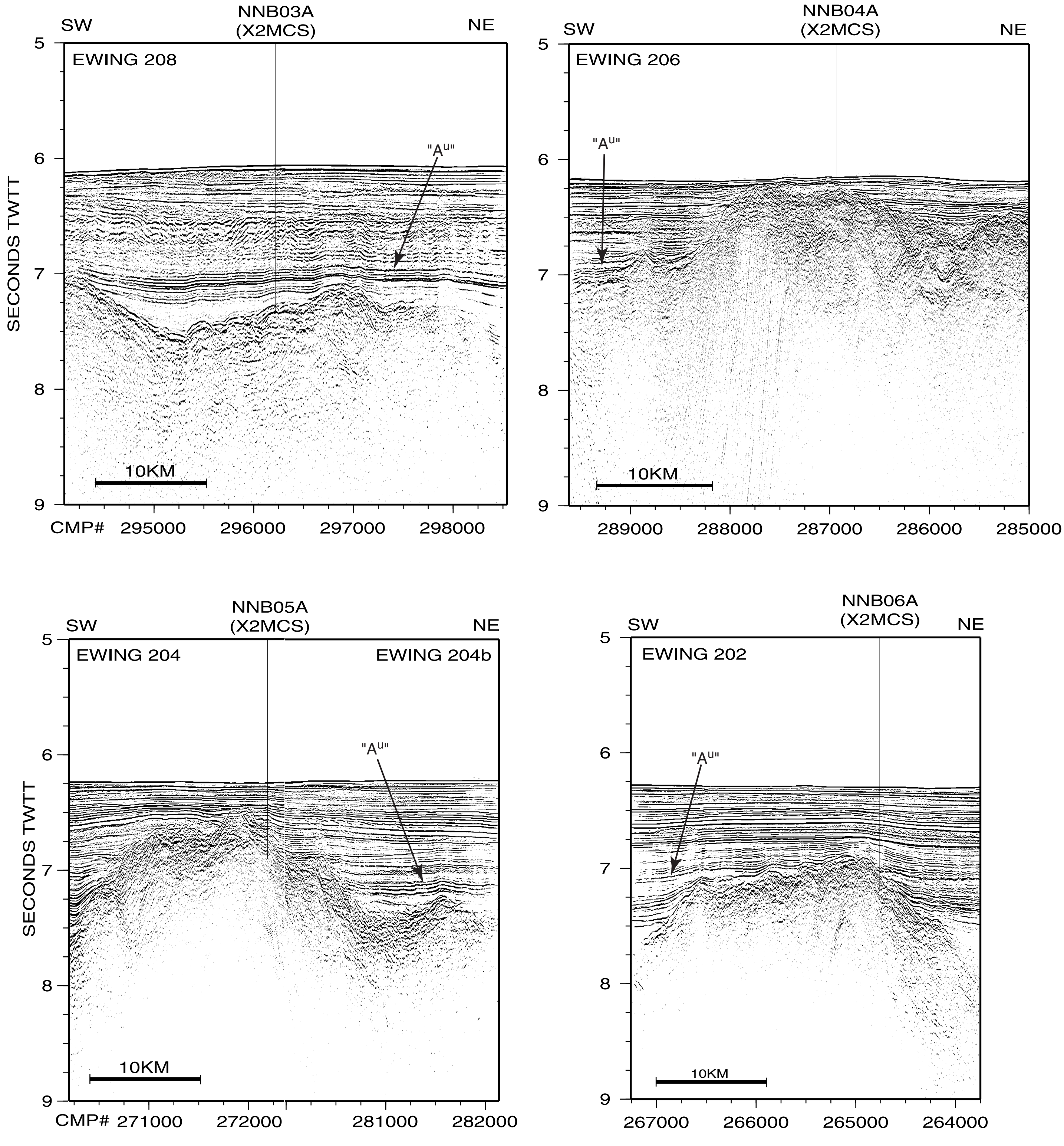
Are there any other special requirements for logging at this site? Yes √ No

If "Yes" Please describe requirements:____

What do you estimate the total logging time for this site to be:_______________

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Accelerator Porosity Sonde (APS), part of the Triple Combo string, generates accurate porosity data required for estimates of density and seismic velocity, which will be used to correlate the lithostratigraphy to the seismic reflection data. Will also identify lithologic contacts downhole.	1
Litho-Density	Hostile Environment Litho-Density Sonde (HLDS), part of the Triple Combo toolstring, yields bulk density and together with downhole porosity and sonic data and will allow correlation of the lithostratigraphy to the seismic reflection data. The HLDS will also highlight lithologic boundaries in areas of poor core recovery.	1
Natural Gamma Ray		
Resistivity-Induction	Dual Induction Tool (DITE), part of the Triple Combo toolstring, will yield downhole resistivity data, which place constraints on apparent porosity, "pseudodensity", and/or "pseudovelocity" as well as lithologic boundaries in areas of poor core recovery. This will provide valuable data for identifying weathering and alteration horizons and contacts between possible continental crust or mantle and synrift basalt flows.	1
Acoustic	Dipole Sonic Imager (DSI), part of the FMS/Sonic toolstring, provides borehole compressional, shear, and Stoneley slownesses critical to correlating the lithology to seismic data, constructing depth sections, and it places additional constraints on rock formations in zones of poor core recovery.	1

FMS	Formation MicroScanner (FMS), part of the FMS/Sonic toolstring, generates high resolution images of microresistivity that will provide great insight into mapping fractures, faults, foliations in both basement and overlying sediment. Will provide important constraints on tectonic evolution and emplacement history of basalt flows.	1
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		1
Other: GHMT WST/VSP	Geologic High-Resolution Magnetic Tool (GHMT) provides magnetic susceptibility and total magnetic induction measurement, which will reveal the polarity of the remanent magnetization downhole. This information together will radiometric dating will provide a geochronology for the tectonic evolution of the NB-IAP rift. In addition, the magnetic susceptibility is a good proxy for paleoclimate cyclicity and it also provides valuable tie points for core-log correlation. The Well Seismic Tool consists of a geophone clamped to the side of the borehole. It is used to derive depth-travel time pairs and to calibrate the sonic logs and determine accurate drilling depths and their relative position with respect to targets on the seismic reflection profiles. If a second ship is available then we will use the VSP. There are two types of three-component Vertical Seismic Profile (VSP) tools available from Schlumberger. These tools clamp geophones downhole (either hydraulically in open holes or magnetically in cased holes) and record energy from seismic sources at the sea surface. The results provide confirmation of reflections on seismic sections below total depth, seismic ties to depth, and information on seismic anisotropy (from offset experiments).	1 1



Ewing MCS crossing lines for proposed drill sites NNB03A, NNB04A, NNB05A, and NNB06A. Data processing (stack, migration) is preliminary.

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ODP Site Description Forms:

Page 1 - General Site Information New Revised

Section A: Proposal Information

Title of Proposal	Drilling the Newfoundland Half of the Newfoundland - Iberia Transect: The First Conjugate Margin Drilling in a Non-Volcanic Rift
Proposal Number:	(Replaces 504)
Date Form Submitted:	1 October 2000
Site Specific Objectives (Must include general objectives in proposal)	Composition and igneous/tectonic history of basement. If NNB01 samples continental basement, then Sites NNB03A to NNB06A will systematically sample basement eastward to define the maximum seaward limit of continental crust, landward limit of ocean crust, and the character of any intervening transition. If this basement high is serpentinite, this hole might be deepened to bit destruction in order to investigate the variation in composition, alteration, and possible melt interaction with depth.
List Previous Drilling in Area:	None

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	**NNB04A**	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Northern Newfoundland Basin
Latitude:	Deg: 45	Min: 11.8N	Jurisdiction:	International waters
Longitude:	Deg: 44	Min: 22.6 W	Distance to Land:	~390 n. miles
Priority of Site:	Primary: Yes	Alt:	Water Depth:	4624 meters

Section C: Operational Information

	Sediments. What is the total sed. thickness? ca. 85meters	Basement
Proposed Penetration (m)	Full sediment thickness, ~85 meters	At least 100 meters into basement
General Lithologies:	From top to base: Clays and silty clays.	Uncertain. Likely to be basalt or serpentinite.

Coring Plan (circle): ~~1-2-3-APC~~ ~~VPC*~~ ~~XCB~~ ~~MDCB*~~ ~~PCS~~ RCB ~~Re-entry~~ ~~HRGB~~

** Systems Currently Under Development*

Logging Plan:	Standard Tools		Special Tools	LWD
	Triple-Combo Neutron-Porosity Litho-Density ~~Natural Gamma Ray~~ Resistivity-Induction	FMS-Sonic Acoustic FMS	~~Borehole Televiewer~~ ~~Geochemical~~ ~~Resistivity-Laterolog~~ ~~High Temperature~~ GHMT	~~Density-Neutron~~ ~~Resitivity-Gamma Ray~~

Estimated days:	Drilling/Coring: 4.2	Logging: *3.2	Total On-Site: 7.4
Hazards/ Weather	*List possible hazards due to ice, hydrocarbons, dumpsites, cables, etc.* Icebergs can drift through this area, although this is not common and they tend to follow paths farther to the west; they are monitored by the International Ice Patrol. Variable currents up to 1.5 to 2 knots can occur; the area can be influenced by Gulf Stream eddies.		*What is your Weather Window?* June through September is optimum. Storms are more unpredictable and intense outside this window, and the chance of hurricane passage through this area increases until the end of November.

Instructions:

Please fill out these forms for each site that you are proposing to drill, including as much detail as possible. The following table describes the purpose of each page, what information is needed, and when each page should be submitted.

Page	Information needed	Used By	When to submit	Contact for more information
1	General Info. about proposals, site location and basic operational needs	JOIDES Office, Data Bank, Logging Group, ODP/TAMU, SSP, PPSP	When submitting preliminary proposal and when updating site information.	JOIDES Office email: joides@whoi.edu www: http://www.whoi.edu/joides/
2	Information regarding site survey data available and to-be-collected	JOIDES Office, Data Bank, SSP, PPSP	When submitting full proposal and when updating site survey information	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
3	Detailed Logging Plan	JOIDES Office, Logging Group, ODP/TAMU	When submitting full proposal and when updating logging plan	ODP-LDEO Wireline Logging Services email: borehole@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/BRG/brg_home.html
4	Lithologic Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
5	Pollution and Safety Hazard Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/

ODP Site Description Forms:
Page 2 - Site Survey Detail New Revised

Proposal #: (Replaces 504)	Site #: NNB04A	Date Form Submitted: 1 October 2000

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): None Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Ewing 00-07, 2MCS Location of Site on line (SP or Time only): SP 29227 (CMP 234827) Crossing Lines(s): Ewing 00-07, Line 206, SP 35740 (CMP 286928)
3	Seismic Velocity†			Ewing 00-07 wide-angle MCS and OBS/H data are currently being analyzed in detail.
4	Seismic Grid			Ewing 00-07. Deep penetration, 60-fold MCS reflection data acquired using R/V Ewing's 6000-m, 480-channel streamer and 20-gun, 8540 cubic inch (131 liter) airgun array.
5a	Refraction (surface)			None
5b	Refraction (near bottom)			Ocean-bottom seismometer and ocean-bottom hydrophone wide-angle reflection and refraction data are currently being analyzed. OBS/H records were acquired at approximately 11-14 km spacing along this part of the proposed drilling transect.
6	3.5 kHz			Ewing 00-07. Location of Site on line (Time): JD 211 @19:15:23 GMT
7	Swath bathymetry			Ewing 00-07 Hydrosweep data.
8a	Side-looking sonar (surface)			GLORIA long-range sidescan sonar in the vicinity.
8b	Side-looking sonar (bottom)			None.
9	Photography or Video			None.
10	Heat Flow			Oceanus Cruise 359, Leg 2 data in vicinity, currently being analyzed.
11a	Magnetics			Ewing 00-07.

11b	Gravity			Ewing 00-07.
12	Sediment cores			In the vicinity (see LDEO data bank).
13	Rock sampling			None.
14a	Water current data			Ewing 00-07 and Oceanus 359-2.
14b	Ice Conditions			International Ice Patrol.
15	OBS microseismicity			None.
16	Navigation			Ewing 00-07 and Oceanus 359-2.
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

ODP Site Description Forms:
Page 3 - Detailed Logging Plan New Revised

Proposal #: (Replaces 504)	Site #: NNB04A	Date Form Submitted: 1 October 2000
Water Depth (m): 4624 meters	Sed. Penetration (m): ca. 85 meters	Basement Penetration (m): At least 100 m

Do you need to use the conical side-entry sub (CSES) at this site? Yes √ No

Are high temperatures expected at this site? √ No

Are there any other special requirements for logging at this site? Yes √ No

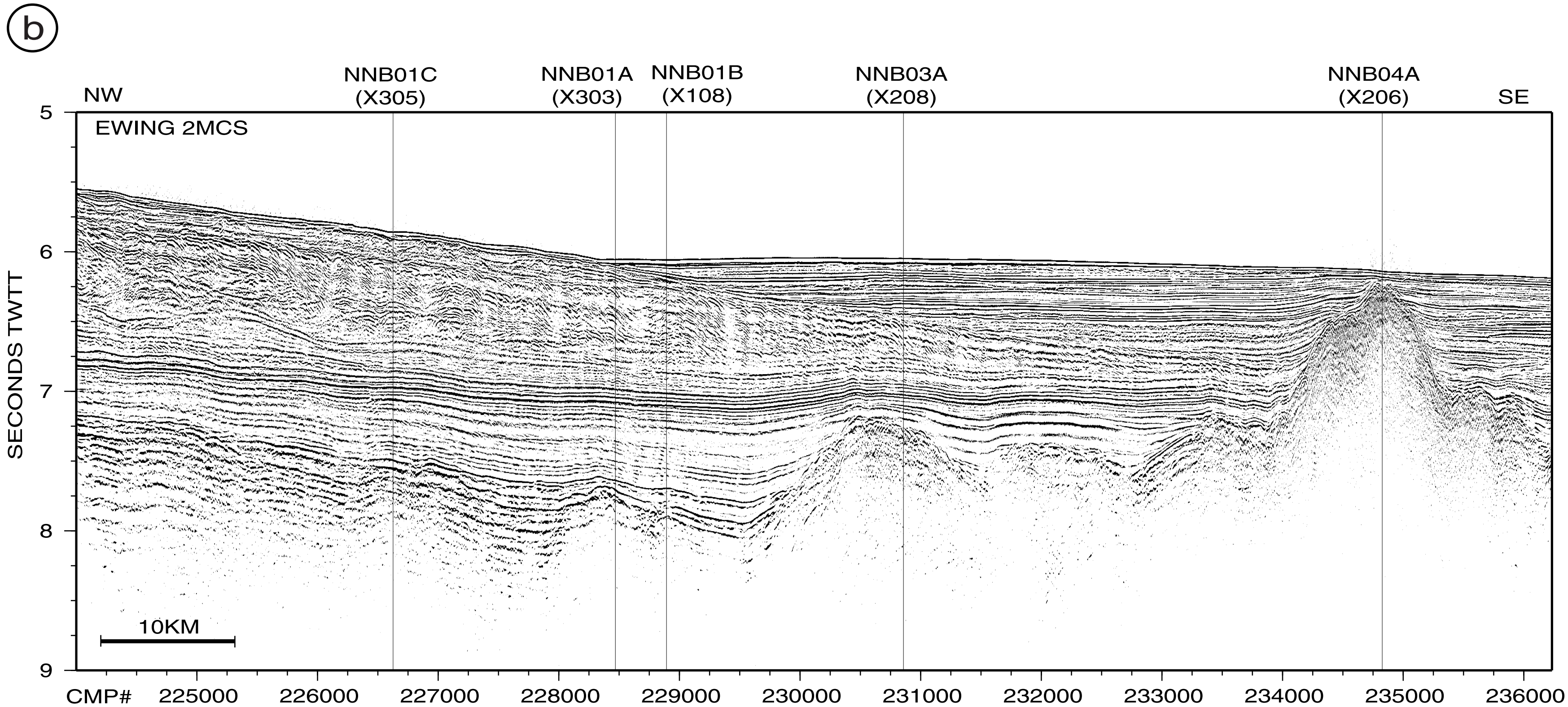
If "Yes" Please describe requirements:____

What do you estimate the total logging time for this site to be:______________

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Accelerator Porosity Sonde (APS), part of the Triple Combo string, generates accurate porosity data required for estimates of density and seismic velocity. Will also identify lithologic contacts downhole.	1
Litho-Density	Hostile Environment Litho-Density Sonde (HLDS), part of the Triple Combo toolstring, yields bulk density and together with downhole porosity and sonic data. The HLDS will also highlight lithologic boundaries in areas of poor core recovery.	1
Natural Gamma Ray		
Resistivity-Induction	Dual Induction Tool (DITE), part of the Triple Combo toolstring, will yield downhole resistivity data, which place constraints on apparent porosity, "pseudodensity", and/or "pseudovelocity" as well as lithologic boundaries in areas of poor core recovery. This will provide valuable data for identifying weathering and alteration horizons and contacts between crustal types.	1
Acoustic	Dipole Sonic Imager (DSI), part of the FMS/Sonic toolstring, provides borehole compressional, shear, and Stoneley slownesses critical to correlating the lithology to seismic data, constructing depth sections, and it places additional constraints on rock formations in zones of poor core recovery.	1

FMS	Formation MicroScanner (FMS), part of the FMS/Sonic toolstring, generates high resolution images of microresistivity that will provide great insight into mapping fractures, faults, foliations in basement. It will provide important constraints on tectonic evolution and emplacement history of any basalt flows.	1
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools GHMT	Geologic High-Resolution Magnetic Tool (GHMT) provides magnetic susceptibility and total magnetic induction measurements, which will reveal the polarity of the remanent magnetization downhole. This information together will radiometric dating will provide a geochronology for the tectonic evolution of the NB-IAP rift. In addition, the magnetic susceptibility provides valuable tie points for core-log correlation.	1

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.



B - Section of Ewing Line 2MCS extending east of section A, showing proposed drill sites NNB01A,B,C, NNB03A, and NNB04A (see Fig. 2d). Data processing (stack, migration) is preliminary. Crossing lines are shown on a separate sheet.

ODP Site Description Forms:
Page 1 - General Site Information New Revised
Section A: Proposal Information

Title of Proposal	Drilling the Newfoundland Half of the Newfoundland - Iberia Transect: The First Conjugate Margin Drilling in a Non-Volcanic Rift
Proposal Number:	(Replaces 504)
Date Form Submitted:	1 October 2000
Site Specific Objectives (Must include general objectives in proposal)	Composition and igneous/tectonic history of basement. If NNB01 samples continental basement, then Sites NNB03A to NNB06A will systematically sample basement eastward to define the maximum seaward limit of continental crust, landward limit of ocean crust, and the character of any intervening transition. If this basement high is serpentinite, this hole might be deepened to bit destruction in order to investigate the variation in composition, alteration, and possible melt interaction with depth.
List Previous Drilling in Area:	None

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	**NNB05A**	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Northern Newfoundland Basin
Latitude:	Deg: 45	Min: 06.2 N	Jurisdiction:	International waters
Longitude:	Deg: 44	Min: 11.8 W	Distance to Land:	~400 n. miles
Priority of Site:	Primary: Yes	Alt:	Water Depth:	4695 meters

Section C: Operational Information

	Sediments. What is the total sed. thickness? ca. 410 meters	Basement
Proposed Penetration (m)	Full sediment thickness, ~410 meters	At least 100 meters into basement
General Lithologies:	From top to base: clays and silty clays, claystones, cherty claystones, claystones with limestone lenses.	Uncertain. Likely to be basalt or serpentinite.

Coring Plan (circle): 1-2-3-APC ~~VPC*~~ XCB ~~MDCB*~~ ~~PCS~~ RCB ~~Re-entry~~ ~~HRGB~~

** Systems Currently Under Development*

Logging Plan:	Standard Tools		Special Tools	LWD
	<u>Triple-Combo</u> Neutron-Porosity Litho-Density ~~Natural Gamma Ray~~ Resistivity-Induction	<u>FMS-Sonic</u> Acoustic FMS	~~Borehole Televiewer~~ ~~Geochemical~~ ~~Resistivity-Laterolog~~ ~~High Temperature~~ GHMT	~~Density-Neutron~~ ~~Resitivity-Gamma Ray~~
Estimated days:	Drilling/Coring: 6.1	Logging: 3.2		Total On-Site: 10.3
Hazards/ Weather	*List possible hazards due to ice, hydrocarbons, dumpsites, cables, etc.* Icebergs can drift through this area, although this is not common and they tend to follow paths farther to the west; they are monitored by the International Ice Patrol. Variable currents up to 1.5 to 2 knots can occur; the area can be influenced by Gulf Stream eddies.			*What is your Weather Window?* June through September is optimum. Storms are more unpredictable and intense outside this window, and the chance of hurricane passage through this area increases until the end of November.

Instructions:

Please fill out these forms for each site that you are proposing to drill, including as much detail as possible. The following table describes the purpose of each page, what information is needed, and when each page should be submitted.

Page	Information needed	Used By	When to submit	Contact for more information
1	General Info. about proposals, site location and basic operational needs	JOIDES Office, Data Bank, Logging Group, ODP/TAMU, SSP, PPSP	When submitting preliminary proposal and when updating site information.	<u>JOIDES Office</u> email: joides@whoi.edu www: http://www.whoi.edu/joides/
2	Information regarding site survey data available and to-be-collected	JOIDES Office, Data Bank, SSP, PPSP	When submitting full proposal and when updating site survey information	<u>Site Survey Data Bank</u> email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
3	Detailed Logging Plan	JOIDES Office, Logging Group, ODP/TAMU	When submitting full proposal and when updating logging plan	<u>ODP-LDEO Wireline Logging Services</u> email: borehole@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/BRG/brg_home.html
4	Lithologic Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	<u>Site Survey Data Bank</u> email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
5	Pollution and Safety Hazard Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	<u>Site Survey Data Bank</u> email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/

ODP Site Description Forms:
Page 2 - Site Survey Detail New Revised

Proposal #: (Replaces 504)	Site #: NNB05A	Date Form Submitted: 1 October 2000

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): None Crossing Lines(s): Location of Site on line (SP or Time only)
2	Deep Penetration seismic reflection			Primary Line(s): Ewing 00-07, 2MCS Location of Site on line (SP or Time only): SP 29576 (CMP 237616) Crossing Lines(s): Ewing 00-07, Line 204, SP 33898 (CMP 272191)
3	Seismic Velocity†			Ewing 00-07 wide-angle MCS and OBS/H data are currently being analyzed in detail.
4	Seismic Grid			Ewing 00-07. Deep penetration, 60-fold MCS reflection data acquired using R/V Ewing's 6000-m, 480-channel streamer and 20-gun, 8540 cubic inch (131 liter) airgun array.
5a	Refraction (surface)			None
5b	Refraction (near bottom)			Ocean-bottom seismometer and ocean-bottom hydrophone wide-angle reflection and refraction data are currently being analyzed. OBS/H records were acquired at approximately 11-14 km spacing along this part of the proposed drilling transect.
6	3.5 kHz			Ewing 00-07. Location of Site on line (Time): JD 211 @21:39:25 GMT
7	Swath bathymetry			Ewing 00-07 Hydrosweep data.
8a	Side-looking sonar (surface)			GLORIA long-range sidescan sonar in the vicinity.
8b	Side-looking sonar (bottom)			None.
9	Photography or Video			None.
10	Heat Flow			Oceanus Cruise 359, Leg 2 data in vicinity, currently being analyzed.
11a	Magnetics			Ewing 00-07.

11b	Gravity			Ewing 00-07.
12	Sediment cores			In the vicinity (see LDEO data bank).
13	Rock sampling			None.
14a	Water current data			Ewing 00-07 and Oceanus 359-2.
14b	Ice Conditions			International Ice Patrol.
15	OBS microseismicity			None.
16	Navigation			Ewing 00-07 and Oceanus 359-2.
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

ODP Site Description Forms:
Page 3 - Detailed Logging Plan New Revised

Proposal #: (Replaces 504)	Site #: NNB05A	Date Form Submitted: 1 October 2000
Water Depth (m): 4695 meters	Sed. Penetration (m): ca. 410 meters	Basement Penetration (m): At least 100 m

Do you need to use the conical side-entry sub (CSES) at this site? Yes √ No

Are high temperatures expected at this site? √ No

Are there any other special requirements for logging at this site? Yes √ No

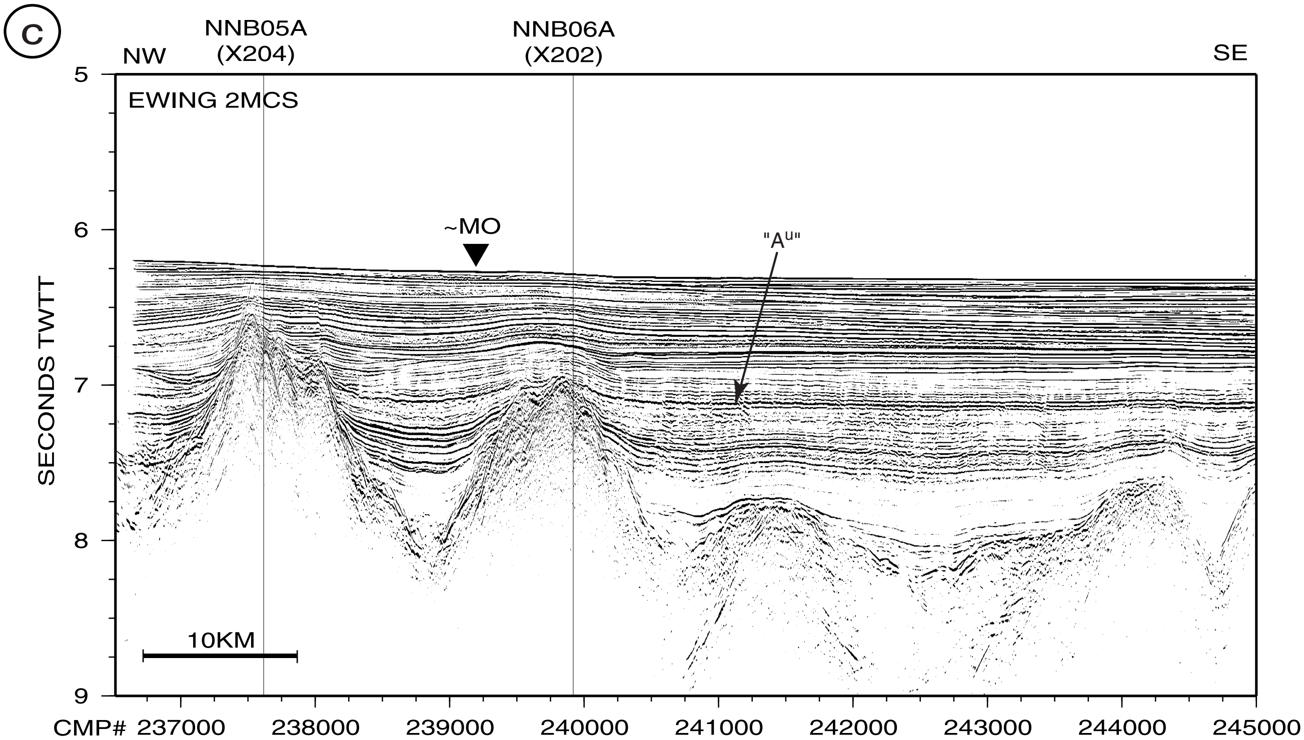
If "Yes" Please describe requirements:____

What do you estimate the total logging time for this site to be:______________

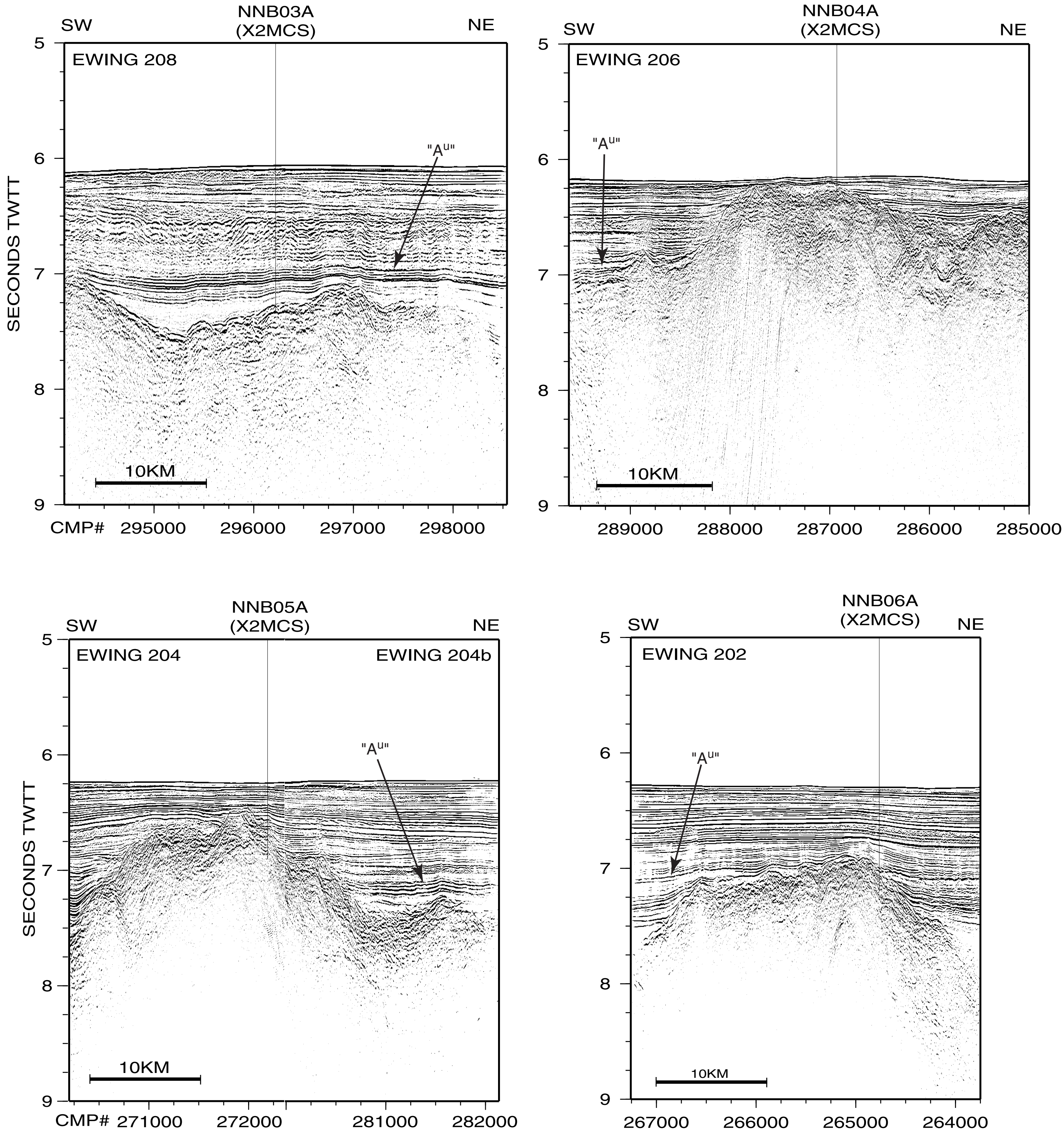
Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Accelerator Porosity Sonde (APS), part of the Triple Combo string, generates accurate porosity data required for estimates of density and seismic velocity, which will be used to correlate the lithostratigraphy to the seismic reflection data. Will also identify lithologic contacts downhole.	1
Litho-Density	Hostile Environment Litho-Density Sonde (HLDS), part of the Triple Combo toolstring, yields bulk density and together with downhole porosity and sonic data and it will allow correlation of the lithostratigraphy to the seismic reflection data. The HLDS will also highlight lithologic boundaries in areas of poor core recovery.	1
Natural Gamma Ray		
Resistivity-Induction	Dual Induction Tool (DITE), part of the Triple Combo toolstring, will yield downhole resistivity data, which place constraints on apparent porosity, "pseudodensity", and/or "pseudovelocity" as well as lithologic boundaries in areas of poor core recovery. This will provide valuable data for identifying weathering and alteration horizons and contacts between crustal types.	1
Acoustic	Dipole Sonic Imager (DSI), part of the FMS/Sonic toolstring, provides borehole compressional, shear, and Stoneley slownesses critical to correlating the lithology to seismic data, constructing depth sections, and it places additional constraints on rock formations in zones of poor core recovery.	1

FMS	Formation MicroScanner (FMS), part of the FMS/Sonic toolstring, generates high resolution images of microresistivity that will provide great insight into mapping fractures, faults, foliations in both basement and overlying sediment. Will provide important constraints on tectonic evolution and emplacement history of any basalt flows.	1
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools GHMT	Geologic High-Resolution Magnetic Tool (GHMT) provides magnetic susceptibility and total magnetic induction measurements, which will reveal the polarity of the remanent magnetization downhole. This information together will radiometric dating will provide a geochronology for the tectonic evolution of the NB-IAP rift. In addition, the magnetic susceptibility provides valuable tie points for core-log correlation.	1

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.



C - Section of Ewing Line 2MCS extending east of section B, showing proposed drill sites NNB05A and NNB06A (see Fig. 2d). Data processing (stack, migration) is preliminary. Crossing lines are shown on a separate sheet.



Ewing MCS crossing lines for proposed drill sites NNB03A, NNB04A, NNB05A, and NNB06A. Data processing (stack, migration) is preliminary.

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ODP Site Description Forms:
Page 1 - General Site Information New Revised

Section A: Proposal Information

Title of Proposal	Drilling the Newfoundland Half of the Newfoundland - Iberia Transect: The First Conjugate Margin Drilling in a Non-Volcanic Rift
Proposal Number:	(Replaces 504)
Date Form Submitted:	1 October 2000
Site Specific Objectives (Must include general objectives in proposal)	Composition and igneous/tectonic history of basement. If NNB01 samples continental basement, then Sites NNB03A to NNB06A will systematically sample basement eastward to define the maximum seaward limit of continental crust, landward limit of ocean crust, and the character of any intervening transition. If this basement high is serpentinite, this hole might be deepened to bit destruction in order to investigate the variation in composition, alteration, and possible melt interaction with depth.
List Previous Drilling in Area:	None

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	**NNB06A**	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Northern Newfoundland Basin
Latitude:	Deg: 45	Min: 01.6 N	Jurisdiction:	International waters
Longitude:	Deg: 44	Min: 03.0 W	Distance to Land:	~410 n. miles
Priority of Site:	Primary: Yes	Alt:	Water Depth:	4735 meters

Section C: Operational Information

	Sediments. What is the total sed. thickness? ca. 655 meters	Basement
Proposed Penetration (m)	Full sediment thickness, ~655 meters	At least 100 meters into basement
General Lithologies:	From top to base: clays and silty clays, claystones, cherty claystones, claystones with limestone lenses, possible limestone beds.	Uncertain. Likely to be basalt or serpentinite.
Coring Plan (circle):	1-2-3-APC ~~VPC*~~ XCB ~~MDCB*~~ ~~PCS~~ RCB ~~Re-entry~~ ~~HRGB~~	

** Systems Currently Under Development*

Logging Plan:	Standard Tools		Special Tools	LWD
	Triple-Combo Neutron-Porosity Litho-Density ~~Natural Gamma Ray~~ Resistivity-Induction	FMS-Sonic Acoustic FMS	~~Borehole Televiewer~~ ~~Geochemical~~ ~~Resistivity-Laterolog~~ ~~High Temperature~~ GHMT	~~Density-Neutron~~ ~~Resitivity-Gamma Ray~~
Estimated days:	Drilling/Coring: 10.6	Logging: 3.2		Total On-Site:13.8
Hazards/ Weather	*List possible hazards due to ice, hydrocarbons, dumpsites, cables, etc.* Icebergs can drift through this area, although this is not common and they tend to follow paths farther to the west; they are monitored by the International Ice Patrol. Variable currents up to 1.5 to 2 knots can occur; the area can be influenced by Gulf Stream eddies.			*What is your Weather Window?* June through September is optimum. Storms are more unpredictable and intense outside this window, and the chance of hurricane passage through this area increases until the end of November.

Instructions:

Please fill out these forms for each site that you are proposing to drill, including as much detail as possible. The following table describes the purpose of each page, what information is needed, and when each page should be submitted.

Page	Information needed	Used By	When to submit	Contact for more information
1	General Info. about proposals, site location and basic operational needs	JOIDES Office, Data Bank, Logging Group, ODP/TAMU, SSP, PPSP	When submitting preliminary proposal and when updating site information.	JOIDES Office email: joides@whoi.edu www: http://www.whoi.edu/joides/
2	Information regarding site survey data available and to-be-collected	JOIDES Office, Data Bank, SSP, PPSP	When submitting full proposal and when updating site survey information	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
3	Detailed Logging Plan	JOIDES Office, Logging Group, ODP/TAMU	When submitting full proposal and when updating logging plan	ODP-LDEO Wireline Logging Services email: borehole@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/BRG/brg_home.html
4	Lithologic Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
5	Pollution and Safety Hazard Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/

ODP Site Description Forms:
Page 2 - Site Survey Detail New Revised

Proposal #: (Replaces 504)	Site #: NNB06A	Date Form Submitted: 1 October 2000

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): None Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Ewing 00-07, 2MCS Location of Site on line (SP or Time only): SP 29864 (CMP 239918) Crossing Lines(s): Ewing 00-07, Line 202, SP 32969 (CMP 264764) (see attached)
3	Seismic Velocity†			Ewing 00-07 wide-angle MCS and OBS/H data are currently being analyzed in detail.
4	Seismic Grid			Ewing 00-07. Deep penetration, 60-fold MCS reflection data acquired using R/V Ewing's 6000-m, 480-channel streamer and 20-gun, 8540 cubic inch (131 liter) airgun array.
5a	Refraction (surface)			None
5b	Refraction (near bottom)			Ocean-bottom seismometer and ocean-bottom hydrophone wide-angle reflection and refraction data are currently being analyzed. OBS/H records were acquired at approximately 11-14 km spacing along this part of the proposed drilling transect.
6	3.5 kHz			Ewing 00-07. Location of Site on line (Time): JD 211 @23:35:10 GMT
7	Swath bathymetry			Ewing 00-07 Hydrosweep data.
8a	Side-looking sonar (surface)			GLORIA long-range sidescan sonar in the vicinity.
8b	Side-looking sonar (bottom)			None.
9	Photography or Video			None.
10	Heat Flow			Oceanus Cruise 359, Leg 2 data in vicinity, currently being analyzed.
11a	Magnetics			Ewing 00-07.

11b	Gravity			Ewing 00-07.
12	Sediment cores			In the vicinity (see LDEO data bank).
13	Rock sampling			None.
14a	Water current data			Ewing 00-07 and Oceanus 359-2.
14b	Ice Conditions			International Ice Patrol.
15	OBS microseismicity			None.
16	Navigation			Ewing 00-07 and Oceanus 359-2.
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

ODP Site Description Forms:
Page 3 - Detailed Logging Plan New Revised

Proposal #: (Replaces 504)	Site #: NNB06A	Date Form Submitted: 1 October 2000
Water Depth (m): 4735 meters	Sed. Penetration (m): ca. 655 meters	Basement Penetration (m): At least 100 m

Do you need to use the conical side-entry sub (CSES) at this site? Yes √ No

Are high temperatures expected at this site? √ No

Are there any other special requirements for logging at this site? Yes √ No

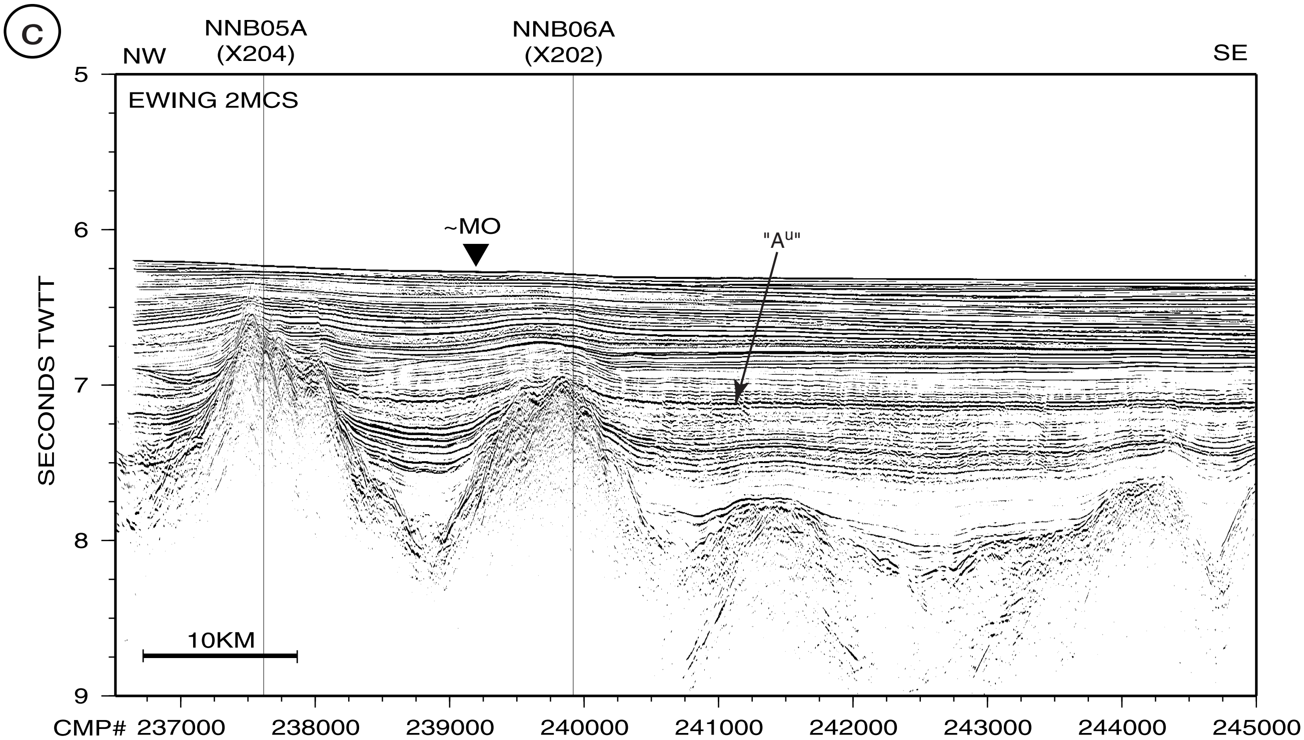
If "Yes" Please describe requirements:____

What do you estimate the total logging time for this site to be:_______________

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Accelerator Porosity Sonde (APS), part of the Triple Combo string, generates accurate porosity data required for estimates of density and seismic velocity, which will be used to correlate the lithostratigraphy to the seismic reflection data. Will also identify lithologic contacts downhole.	1
Litho-Density	Hostile Environment Litho-Density Sonde (HLDS), part of the Triple Combo toolstring, yields bulk density and together with downhole porosity and sonic data and it will allow correlation of the lithostratigraphy to the seismic reflection data. The HLDS will also highlight lithologic boundaries in areas of poor core recovery.	1
Natural Gamma Ray		
Resistivity-Induction	Dual Induction Tool (DITE), part of the Triple Combo toolstring, will yield downhole resistivity data, which place constraints on apparent porosity, "pseudodensity", and/or "pseudovelocity" as well as lithologic boundaries in areas of poor core recovery. This will provide valuable data for identifying weathering and alteration horizons and contacts between crustal types.	1
Acoustic	Dipole Sonic Imager (DSI), part of the FMS/Sonic toolstring, provides borehole compressional, shear, and Stoneley slownesses critical to correlating the lithology to seismic data, constructing depth sections, and it places additional constraints on rock formations in zones of poor core recovery.	1

FMS	Formation MicroScanner (FMS), part of the FMS/Sonic toolstring, generates high resolution images of microresistivity that will provide great insight into mapping fractures, faults, foliations in both basement and overlying sediment. Will provide important constraints on tectonic evolution and emplacement history of any basalt flows.	1
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools GHMT	Geologic High-Resolution Magnetic Tool (GHMT) provides magnetic susceptibility and total magnetic induction measurements, which will reveal the polarity of the remanent magnetization downhole. This information together will radiometric dating will provide a geochronology for the tectonic evolution of the NB-IAP rift. In addition, the magnetic susceptibility provides valuable tie points for core-log correlation.	1

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.



C - Section of Ewing Line 2MCS extending east of section B, showing proposed drill sites NNB05A and NNB06A (see Fig. 2d). Data processing (stack, migration) is preliminary. Crossing lines are shown on a separate sheet.

BIOGRAPHICAL SKETCH September 2000
(NSF Format)

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Professional Preparation:

S. D. School of Mines and Technology, B.S., Magna Cum Laude, Geology - 1968.

Massachusetts Institute of Technology - Woods Hole Oceanographic Institution Joint Program in Oceanography, Ph.D., Oceanography (Marine Geology) - 1973.

Lamont-Doherty Geological Observatory, Columbia University, Postdoctoral Fellow, Marine Geology - 1973-74.

Appointments/Employment:

Henry Bryant Bigelow Chair for Excellence in Oceanography, Woods Hole Oceanographic Institution, 1999-2003.

Woods Hole Oceanographic Institution - Assoc. Scientist, 1979-87; Senior Scientist, 1987-

Lamont-Doherty Geological Observatory, Columbia University - Postdoctoral Fellow, 1973-74; Research Associate, 1974-78; Senior Res. Assoc., 1978-79; Visiting Senior Res. Assoc. 1979-82; Adjunct Senior Res. Scientist, 1982-1991.

Woods Hole Ocean. Inst. - Teaching Assist. 1970-72; Graduate Research Assist., 1972-73.

Massachusetts Institute of Technology - Teaching Assistant, 1968-70.

Western Geophysical Corporation - Geophysicist, 1968 (Summer).

Pan American Petroleum Corporation - Prof. Assistant in Geophysics, 1966-67 (Summers).

S.D. School of Mines & Technology - Museum Assistant, Field Geologist, 1964-68.

Five Relevant Publications:

Tucholke, B.E., and V.A. Fry, Basement structure and sediment distribution in the northwest Atlantic Ocean, Am. Assoc. Petrol. Geol. Bull., 69, 2077-2097, 1985.

Ebinger, C.J., and B.E. Tucholke, Marine geology of Sohm Basin, Canadian Atlantic margin, Am. Assoc. Petrol. Geol. Bulletin, 72, 1450-1468, 1988.

Austin, J.A., Jr., B.E. Tucholke and E. Uchupi, Upper Triassic-Lower Jurassic salt basin southeast of the Grand Banks, Earth and Planet. Sci. Letters, 92, 357-370, 1989.

Tucholke, B.E., J.A. Austin, Jr., and E. Uchupi, Crustal structure and rift-drift evolution of the Newfoundland Basin, in A.J. Tankard and H. Balkwill, eds., Extensional Tectonics and Stratigraphy of the North Atlantic Margins, Am. Assoc. Petrol. Geol. Memoir 46, p. 247-263, 1989.

Srivastava, S.P., D. Voppel, and B.E. Tucholke (1989) Geophysical Atlas of the North Atlantic between 50° to 72°N and 0° to 65°W, Deutsches Hydrographisches Institüt, Hamburg, DHI Publ. NR 2302, 12 pp. + 21 maps, 1989.

Five Other Significant Publications:

Tucholke, B.E., R.E. Houtz, and D.M. Barrett, Continental crust beneath the Agulhas Plateau, southwest Indian Ocean, J. Geophys. Res., 86, 3791-3806, 1981.

Tucholke, B.E., and W.J. Ludwig, Structure and origin of the J-Anomaly Ridge, western North Atlantic Ocean, J. Geophys. Res., 87, 9389-9407, 1982.

Vogt, P.R., and B.E. Tucholke (ed's.), The Geology of North America, Volume M, The Western North Atlantic Region, Geol. Soc. America, Boulder, 696p. +11 plates, 1986.

Tucholke, B.E., and J. Lin, A geological model for the structure of ridge segments in slow-spreading ocean crust, J. Geophys. Res., 99, 11,937-11,958, 1994.

Tucholke, B.E., J. Lin and M.C. Kleinrock, Megamullions and mullion structure defining oceanic metamorphic core complexes on the Mid-Atlantic Ridge, J. Geophys. Res., 103, 9857-9866, 1998.

Five Synergistic Activities:

Project Co-Leader and Co-Editor: Western North Atlantic Synthesis - Decade of North American Geology, Geological Society of America, 1981-1986.

Ocean Drilling Programs: Shipboard Scientist, DSDP Leg 35, 1974. Co-Chief Scientist, DSDP Leg 43, 1975. COSOD Working Group on Origin and Evolution of Marine Sedimentary Sequences, Member, 1981. JOIDES Passive Margin Panel, 1981-1983. Interim U.S. Science Advisory Committee, Advanced Ocean Drilling Program, 1983. JOIDES Atlantic Regional Panel, 1984-1987. JOIDES Planning Committee, Alternate Member, 1986-1987; Member 1987-1992. JOIDES Tectonics Panel, Planning Committee Liaison, 1988-1992. JOI/USSAC Workshop on the Role of ODP Drilling in the Investigation of Global Changes in Sea Level, Steering Committee, Member; Chairman, Clastic Margins Working Group, 1988. JOIDES North Atlantic Rifted Margins Detailed Planning Group, PCOM Liaison, 1990- 1991.

Editorial: Associate Editor, Geological Society of America Bulletin, 1985-1988; Editorial Board, Geology, 1991-1993.

Office of Naval Research Special Research Project on Bottom/Subbottom Acoustic Reverberation, Executive Committee, 1989-1995.

Co-Convenor of symposia: South Atlantic/Indian Ocean: Geology and Physical Oceanography: AGU-ASLO, 1986; Symposium on Eustatics and Continental Margins: Second International Conference on Paleoceanography, 1986; Fine-Scale Seafloor Investigations of Mid-Oceanic Ridges Using ROV and Deep-Towed Instruments, AGU, 1993; Geological, Geophysical, and Acoustics Studies in the ONR Atlantic Natural Laboratory, Mid-Atlantic Ridge 23°-27.5° North, AGU, 1995.

Collaborators During the Past 48 Months:

D. Caress (MBARI); D. Christie (Oregon State Univ.); J. Collins (WHOI); H. Dick (WHOI); N. Driscoll (WHOI); J. Escartin (CNRS, Paris); K. Fujioka (JAMSTEC, Japan); J. Goff (University of Texas at Austin); H.G. Greene (MBARI); G. Hirth (WHOI); W.S. Holbrook (Univ. Wyoming); J. Hopper (Danish Lithosphere Center); T. Ishihara (Geol. Survey of Japan); G. Jaroslow (Sea Education Association); M. Kinoshita (Tokai Univ.); M.C. Kleinrock (Vanderbilt Univ.); H.C. Larsen (Danish Lithosphere Center); J. Lin (WHOI); K. Louden (Dalhousie Univ.); I.N. McCave (Univ. Cambridge); G.M. Purdy (NSF); T.B. Reed (Oceanic Imaging Consultants, Honolulu); J.-C. Sibuet (IFREMER); D. Smith (WHOI); S. Srivastava (Bedford Inst. Oceanogr.); W.K. Stewart (WHOI); S. Swift (WHOI); T. Tanaka (Chiba U.); M. Tivey (WHOI); G. Uenzelmann-Neben (Alfred Wegener Inst. Polar Marine Res.); B. West (Exxon); J. Wheeler (Geol. Survey Canada).

Graduate and Postdoctoral Advisors:

Graduate Advisor: Charles D. Hollister (deceased).
Post-Doctoral Advisor: John I. Ewing (retired).

Ph.D. Advisor and Postgraduate-Scholar Sponsor:

Past Five Years:

Gary E. Jaroslow (Ph.D. 1997, MIT/WHOI Joint Program) - Sea Education Association.
Amy McKnight (MIT/WHOI Joint Program) 1998 - present.

Total:

Principal thesis advisor: 5 Ph.D. students
Research paper advisor: 12 Ph.D. students
Ph.D. thesis committee: 11 Ph.D. students
Postdoctoral scholar advisor: 3 Ph.D.