OCEAN DRILLING PROGRAM

LEG 149 SCIENTIFIC PROSPECTUS

OCEAN-CONTINENT TRANSITION IN THE IBERIA ABYSSAL PLAIN

Dr. Dale S. Sawyer
Co-Chief Scientist, Leg 149
Department of Geology and Geophysics
Weiss School of Natural Sciences
Rice University
P.O. Box 1892
Houston, Texas 77251

Dr. Robert B. Whitmarsh
Co-Chief Scientist, Leg 149
Institute of Oceanographic Sciences
Deacon Laboratory
Brook Road, Wormley
Surrey GU8 5UB
United Kingdom

Dr. Andy Fisher
Staff Scientist, Leg 149
Ocean Drilling Program
Texas A&M University
College Station, Texas 77845-9547

Philip D. Rabinowitz
Director
ODP/TAMU

Jack Baldauf
Manager
Science Operations
ODP/TAMU

Timothy J.G. Francis
Deputy Director
ODP/TAMU

November 1992

Scientific Prospectus No. 49
First Printing 1992

Distribution

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

DISCLAIMER

This publication was prepared by the Ocean Drilling Program, Texas A&M University, as an account of work performed under the international Ocean Drilling Program, which is managed by Joint Oceanographic Institutions, Inc., under contract with the National Science Foundation. Funding for the program is provided by the following agencies:

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

This Scientific Prospectus is based on pre-cruise JOIDES panel discussions. The operational plans within reflect JOIDES Planning Committee and thematic panel priorities. During the course of the cruise, actual site operations may indicate to the Co-Chief Scientists and the Operations Superintendent that it would be scientifically or operationally advantageous to amend the plan detailed in this prospectus. It should be understood that any proposed changes to the plan presented here are contingent upon approval of the Director of the Ocean Drilling Program in consultation with the Planning Committee and the Pollution Prevention and Safety Panel.

ABSTRACT

Leg 149 is scheduled to core a transect of holes across the ocean-continent transition (OCT) off western Iberia to determine the changes in the physical and petrological nature of the acoustic basement. Four sites that span the OCT (IAP-2, IAP-3C, IAP-4, and IAP-5) have been chosen on basement highs to enable penetration of basement at each site to several hundred meters. We anticipate drilling three of these sites at most during Leg 149. Proposed site GAL-1 is included here as a third priority alternate site for the Iberia Abyssal Plain sites and will only be drilled if the leg objectives can not be achieved at the other four proposed sites.

The west Iberia margin is an excellent example of a nonvolcanic rifted or passive continental margin. The OCT in the central Iberia Abyssal Plain segment of the margin has been located by seismic reflection and refraction profiles and by magnetic and gravity modeling. These independent measurements all support a single conceptual model of the crust and upper mantle within the OCT. Leg 149 will test part of this model.

Secondary objectives of Leg 149 include examining the depth of the ooze/chalk transition, the history of sediment deformation in the Cenozoic, the post-rift subsidence history of the margin, and the late Cenozoic turbidite succession with a view to testing whether the turbidites are triggered by changes in sea level and hence climatic changes.

The objective at proposed site GAL-1, located west of Galicia Bank, is to determine whether acoustic basement over a reflector called S', a possible lateral equivalent of the nearby S reflector, consists of continental crustal rocks.

INTRODUCTION

The North Atlantic Rifted Margins Detailed Planning Group (NARM DPG) met in 1991 to plan a program to study the problems of rifted-margin formation and evolution. The group identified two important classes of rifted margins to be studied: margins in which magmatism has dominated the rifting process (volcanic margins) and margins in which magmatism seems to have been absent or incidental to the rifting process (nonvolcanic margins). The DPG recommended that ODP focus on a transect of each class and that each transect include a conjugate pair of margins. The criteria for selecting the locations of the two transects included (1) the existence of high quality geophysical data on the conjugate margins, (2) the presence of relatively thin sediment cover on the conjugate margins so that drilling to basement is possible using *JOIDES Resolution*, (3) the absence of salt, which could interfere with drilling, and (4) the absence of post-rift volcanism, which could have modified the divergent margin.

Leg 149 represents the first part of the program planned by the DPG for the study of nonvolcanic margins. The total program, probably requiring four 2-month legs, includes drilling of multiple sites in both the Iberia Abyssal Plain and the conjugate Newfoundland Basin, and one site on the Galicia Bank margin. Drilling on each of the margins should include sites that allow sampling of significant sections of basement with minimum sediment penetration, and sites that would sample thicker and stratigraphically more complete sequences of syn- and post-rift sediment. The program is also designed to allow assessment of the degree of symmetry in the structure and evolution of the conjugate margins. Characterization of crustal type within a wide zone of thin continental or oceanic crust in the Newfoundland Basin and Iberia Abyssal Plain and the position and nature of the OCT on the two margins are also important scientific objectives. Geophysical data suggest that seafloor exposures of mantle peridotite on the west side of Galicia Bank, to the north of this transect, extend into the Iberia Abyssal Plain. If such exposures are found during the proposed drilling, then they are clearly a feature of more than local significance. Sites designed to sample syn-rift sequences will constrain the timing of rifting and breakup, the rift environment, and possibly significant anomalous elevation and/or subsidence asymmetries which are strongly indicated by recently acquired seismic data. The subsidence histories of the conjugate margins will help to determine the relative importance of lithosphere-scale pure and simple mechanisms of shear extension.

BACKGROUND

Ocean-Continent Transition

The western continental margin of Iberia runs from Cape Finisterre in the north to Cape Saint Vincent in the south (Fig. 1). The continental margin has a straight narrow shelf and a steep continental slope. South of 40°N the slope is cut by numerous canyons. This simple picture is complicated by several offshore bathymetric features. The largest feature is Galicia Bank, a 200- x 150-km area within which the seafloor shoals to about 600 m water depth. Galicia Bank is characterized by a series of isolated seamounts on its southern edge (Vigo, Vasco da Gama and Porto), and is separated from northwestern Iberia by a broad submarine valley. At 39°N, the Estremadura Spur extends east-west over 100 km offshore and forms a barrier between the Iberia and Tagus abyssal plains. Lastly, the east-northeast trending Gorringe Bank forms the southern boundary of the Tagus Abyssal Plain and marks the surface expression of the seismically active Eurasia/Africa plate boundary.

Like many rifted or passive margins, the Iberia margin had a long history of rifting before the separation of Iberia from the Grand Banks of North America. Three main Mesozoic rifting episodes affected the west Iberia margin. These episodes are recorded in the deposits of the Lusitanian Basin, which is probably continuous with the Interior Basin separating Galicia Bank from northeastern Iberia (Wilson et al., 1989; Murillas et al., 1990). A Triassic to Early Jurassic (Liassic) continental rifting phase gave rise to graben and half-graben structures in which evaporites were deposited. The second rifting phase consisted of extension in the Late Jurassic. The last phase of extension occurred in the Early Cretaceous (from Valanginian to early Aptian time), coincided with the south-to-north breakup of Iberia from the Grand Banks and has been well documented based on geological and geophysical data at sea (Boillot, Winterer, et al., 1988; Whitmarsh et al., 1990; Pinheiro et al., 1992).

The rifting phases were accompanied by only minor volcanism (dikes and flows) within Iberia. Two phases of pre-breakup volcanism have been recognized by Ribeiro et al. (1979) and Martins (1991). A tholeiitic phase lasted from 190 to 160 Ma, and a second phase occurred from 135 to 130 Ma in the Lusitanian Basin, coeval with Late Jurassic rifting. This volcanism was relatively minor, and the west Iberia margin has essentially nonvolcanic characteristics. For example, there are clear tilted fault blocks and half grabens off Galicia Bank (Mauffret and Montadert, 1987), and there is no evidence of seaward-dipping reflectors or of substantial subcrustal underplating.

Parts of the west Iberia margin underwent two additional phases of deformation in the Eocene and the Miocene. The Eocene deformation was caused by the Pyrenean orogeny and the abortive subduction of the Bay of Biscay beneath the north Spanish margin; this deformation affected the margin adjacent to the Iberia Abyssal Plain and included the uplift of Galicia Bank and adjacent seamounts (Boillot et al., 1979). The Miocene deformation accompanied the formation of the Rif-Betic mountains and led to the gentle folding of sediments in the Iberia and northern Tagus abyssal plains, as apparent on reflection profiles (Masson et al., in press; Mauffret et al., 1989).

Several plate-tectonic reconstructions attempted to show the original positions of North America, Iberia, and Europe (Le Pichon et al., 1977; Masson and Miles, 1984; Klitgord and Schouten, 1986; Srivastava et al., 1988, 1990a). The along-strike positions of the North American and European plates are poorly constrained because the Mesozoic magnetic quiet zone lies offshore of the Grand Banks and Iberia, and no large fracture zones occur at this latitude. The various fits differ by tens of kilometers in the north-south direction. The situation is further complicated by intraplate deformation and "jumping" plate boundaries, which imply that Iberia was alternately attached to Africa or Europe (Srivastava et al., 1990b). The reconstruction by Srivastava et al. (1990a) is now regarded as the most closely constrained (Fig. 2).

The western margin of Iberia comprises three segments (the Tagus Abyssal Plain, from Estremadura Spur to Vasco da Gama Seamount, and west of Galicia Bank), which appear to have experienced progressive breakup from south to north in Early Cretaceous times. Geological and geophysical studies of each of these segments have provided a conceptual model for the nature of the ocean-continent transition on this nonvolcanic rifted margin. These studies and the subsequent model are outlined below.

Magnetic models indicate that seafloor spreading in the Tagus Abyssal Plain began about 136 Ma (Valanginian; Harland et al., 1990). A recent geophysical study of the Tagus Abyssal Plain (Pinheiro et al., 1992), using seismic refraction, seismic reflection and magnetic profiles, showed that the oceanic crust adjacent to the OCT is unusually thin (2 km) and that there is a transitional region between thinned continental crust and the thin oceanic crust, which, although not truly oceanic (for example, it has no seafloor-spreading magnetic anomalies), has a magnetization far stronger than is usually associated with continental crust. The thin oceanic crust is underlain by a 7.6 km/s layer, which is probably serpentinized peridotite.

Whitmarsh et al. (1990; in press, 1992) studied the middle segment off Iberia (between 39° and 41°30'N) using seismic refraction and reflection profiles, gravity and magnetics. Magnetic models suggest that seafloor spreading began about 130 Ma (Barremian). They also found that the oceanic crust adjacent to the OCT is thin (4 km), and that the OCT appears to be an intermediate type of nonoceanic crust with a strong magnetization.There is also evidence of a widespread layer with 7.6 km/s velocity (possibly serpentinized peridotite at the base of the crust under the OCT). The intermediate OCT crust is associated with an unusually smooth acoustic basement between the apparently most seaward-tilted continental rift block to the east and a highly linear ridge to the west. If tentative extrapolations of basement morphology are correct, this ridge represents the southward continuation of a peridotite ridge drilled off Galicia Bank.

The western margin of Galicia Bank, the third of the three segments, has been studied with seismic refraction and reflection profiles, and has also been sampled extensively with dredges, submersibles and by drilling (Horsefield, 1992; Mauffret and Montadert, 1987; Boillot, Winterer, et al., 1988; Boillot et al., 1988). A seismic refraction model across the margin shows a thinned continental crust at the OCT adjacent to a moderately thinned (5-km) oceanic crust, which thickens rapidly to the west. A layer with 7.2-7.3 km/s velocity underlies the thinned continental crust and may represent crustal underplating (Horsefield, 1992). In August 1992, a continuous gravity profile was obtained along an east-west seismic refraction line across the whole OCT. A complete crustal-density model across the OCT, constrained by seismic velocities, remains to be computed (J.C. Sibuet, personal communication). Because the Cretaceous quiet zone abuts the OCT at this margin, conventional seafloor magnetics can not date the beginning of seafloor spreading. However, the recognition of the paleomagnetic reversal period M0 below the breakup unconformity downhole at Site 641 (Ogg, 1988) indicates that breakup occurred about 120 Ma (Aptian). Sampling has shown unequivocally that a north-south basement ridge, which appears to coincide with an abrupt ocean/continent boundary, is composed of serpentinized peridotite.

The cumulative results from studies of these three segments of the west Iberia margin suggest that the following features are characteristic of the OCT in this region, and may exist elsewhere in similar settings:

1. Abnormally thin oceanic crust (2-4 km) with a seafloor spreading signature underlies part of the OCT;

2. "Intermediate", strongly magnetized, non-oceanic crust, capped by a smooth acoustic basement, exists immediately landward of the thin oceanic crust;

3. A subcrustal layer which has a velocity of 7.6 km/s and is probably serpentinized peridotite underlies much of the OCT; and

4. There may be a basement peridotite ridge within the OCT, as found west of Galicia Bank.

Presently, and pending the results of Leg 149 in particular, the explanation for the above characteristics of the OCT remains somewhat enigmatic. It seems likely that the thin oceanic crust represents the product of a transitional state between the slow, discontinuous extension of pure continental rifting and the faster, more continuous seafloor spreading which eventually replaces it. The presence of serpentinized peridotite at the base of the thin continental and oceanic crust may be explained by the improved access of seawater to the upper mantle, which is afforded by the thin crust, at least until the OCT is blanketed by thick sediments.

The S Reflector

A midcrustal (S) reflector is apparent on some multichannel seismic reflection profiles of the west Galicia margin. This reflector is either a single, strong reflector or a sequence of horizontal to gently dipping elementary reflectors (Hoffman and Reston, in press). In general, the reflector occurs at 0.6 to 1.6 s two-way travel time (twt) from the top of the acoustic basement (Mauffret and Montadert, 1987). Similar reflectors have been recognized on other rifted margins.

The origin of the S reflector is unknown. It has been tentatively interpreted as the seismic signature of a syn-rift detachment fault (Wernicke and Burchfiel, 1982; Boillot et al., 1987; Hoffman and Reston, in press) and as décollement at the brittle-ductile transition within the thinned continental crust (de Charpal et al., 1978; Montadert et al., 1979; Sibuet, 1992). The S reflector may also represent the tectonic contact between continental crustal material and underlying serpentinized peridotite, marking a detachment fault that was rooted in the mantle (Boillot et al., 1989, 1992). In any case, the reflector is clearly a structure related to the stretching of the lithosphere. The terranes located over, at the level of, and beneath the S reflector should be drilled and efforts made to clarify the relationship between these terranes and the ultramafic belt bounding the continental margin.

Unfortunately, the S reflector is deeply buried beneath sediments and continental basement (at least 3 km beneath the seafloor) in the region where it was first recognized. In order to sample these terranes, the reflector must be traced on seismic profiles to depths where drilling becomes feasible.

The northwestern edge of the deep Galicia margin (together with Galicia Bank) was uplifted during Cenozoic tectonic events, and the sedimentary cover was partly washed out by subsequent submarine erosion (Boillot et al., 1979; Grimaud et al., 1982; Mougenot et al., 1984). New seismic reflection data were obtained during a 1990 Lusigal cruise to map the S reflector and surrounding terranes northward, from the region where the S reflector is deeply buried, to the uplifted area where the sediment thins. This approach was hindered by the occurrence of a Cenozoic transverse fault crossing the deep margin. This fault prevented continuous imaging of the reflector from the area where it was actually defined to the area where it is suspected to approach the seafloor. However, other arguments based on seismic velocities and attenuation coefficients suggest that such a correlation exists. This reflector at the northwestern edge of the Galicia margin is referred to as S', a possible lateral equivalent of the nearby S reflector.

SCIENTIFIC OBJECTIVES AND METHODOLOGY

Ocean-Continent Transition

The principal objective of Leg 149 is to sample the crust within the OCT of the Iberia Abyssal Plain to establish the nature of the upper crust and test some of the predictions based on geophysical observations. Naturally this bold objective must be tempered by the accessibility of the crust using current technology. In order to achieve significant progress within a single leg, four sites (IAP-2, 3C, 4, and 5) have been chosen. These proposed sites lie on basement highs situated at critical points within the OCT (Figs. 3, 4, 5, and 8). We expect to drill three of these sites during Leg 149. The detailed objectives of each site are outlined below. In general, our aim is to penetrate several hundred meters into the acoustic basement, and to use cores and downhole logs from basement to determine its origin and history. This task will be accomplished through petrologic, mineralogic, chemical, physical, nuclear, electrical, and magnetic analyses of cores and boreholes drilled at each Leg 149 site.

Sedimentary History

Secondary objectives of Leg 149 relate to the sediments themselves. One aim is to discover the history of turbidite sedimentation in the Iberia Abyssal Plain. Work done in the Madeira Abyssal Plain indicates that, in general, a single turbidite was deposited each time sealevel changed between glacial and interglacial periods (Weaver and Kuijpers, 1986). We also expect to determine the extent to which the age and frequency of turbidites relates to past climatic changes. Another objective will be to date the deformation of the sediments and to relate these events to periods of deformation in Europe mentioned previously. An additional objective is to test estimates of the depth of the ooze/chalk transition made on the basis of seismic refraction measurements in the Iberia Abyssal Plain (Whitmarsh et al., 1989) and to relate the velocity logs to these predictions.

Heat Flow

We expect to measure heat flow at each of the Leg 149 sites, through measurements of thermal conductivities and thermal gradients. Thermal conductivity of the core samples will be measured routinely in the Physical Properties Lab. The thermal gradient will be determined by making *in-situ* temperature measurements in relatively shallow sediments (the upper 300-500 mbsf) at various depths with the APC tool and WSTP. Temperatures in open holes will be measured as part of most logging runs. Corrections for disturbances due to drilling and circulation may be applied to temperature logs based on results of successive runs in the same hole.

Late Post-Rift Subsidence

We expect to acquire data that can be used to estimate the late post-rift subsidence history of the Iberia Abyssal Plain. We will observe and document the depth, age, environment of deposition, and physical properties of each sedimentary unit. We do not expect the subsidence history of the Iberia Abyssal Plain to be precise at these sites because the basin was relatively sediment starved, and therefore continental slope conditions probably persisted throughout much of the postrift period. Estimates of depths of deposition of continental-slope sediments from paleoenvironmental observations are accurate to 500 m at best.

S Reflector

On Leg 149 we may address the S reflector problem by sampling the "enigmatic terrane" rocks that overly the S' reflector. We will use petrologic, chemical, and structural descriptions of the rocks to determine if they could be the intact hanging-wall block of a crustal detachment. If so, it may be possible and useful to core the S' reflector, a possible detachment fault, on a future leg.

DRILLING PLAN/STRATEGY

Iberia Abyssal Plain (proposed sites IAP-2, IAP-3C, IAP-4, IAP-5; Tables 1, 2)

Up to three holes will be drilled at each site. The first hole (hole A) will be cored using the RCB from the seafloor to bit destruction. We expect that the first bit will penetrate the top of basement but not reach several hundred meters into basement. At this point we will assess the stability of the hole:

1. If the sediments and upper basement are very stable, we will drop a free-fall funnel, change the RCB bit, and continue coring to the basement objective. The hole will be logged completely prior to abandonment.

2. If there are stability problems, we will log hole A and abandon it. We will then offset and begin hole B. We will set a reentry cone and case hole B through the unstable material. We will then core using one or more RCB bits to the basement objective. The unlogged part of the site will be logged in the reentry hole prior to abandonment.

In either case, depending on RCB core recovery and time remaining, we may elect to core an additional hole at the site, using the APC to refusal.

We will use the WSTP to measure *in situ* temperatures at depths of 50, 100, 150, and 200 m in the first RCB hole at each site. During APC coring we will use the APC temperature tool every 3-5 cores.

The holes will be logged using the standard Schlumberger suite of logging tools, including the formation microscanner (FMS), and the Lamont temperature tool. The temperature tool will be run on at least the first and last logging runs affording the best chance to extrapolate equilibrium temperatures. A velocity survey may be done using a surface source in one or more holes to correlate depth in the borehole to seismic reflection time. The magnetic susceptibility tool may also be run in the sediments at one or more sites.

Proposed site GAL-1; Tables 1, 2

One hole will be drilled at proposed site GAL-1. The RCB will be used to core and drill from the seafloor into the basement. If a bit change is required and time is available, a free-fall funnel will be deployed.

The RCB hole will be logged using the standard Schlumberger suite of logging tools. The temperature tool will be run on at least the first and last logging runs affording the best chance to extrapolate equilibrium temperatures.

Site Priority

We expect that the sites drilled during Leg 149 will be, in order of priority and drilling, IAP-4, IAP-2, and IAP-3C. The full program can be achieved if free-fall funnels are used instead of reentry cones, or no change of RCB bits are required.We will consider drilling proposed site IAP-5 third, instead of IAP-3C, if we find oceanic basement with no traces of continental lithosphere at proposed sites IAP-4 and IAP-2.

At each site, the uncased and cased RCB holes will have highest priority. APC coring will be given high priority at one of the sites (to be selected by the shipboard party). The APC coring will probably take place during intervals of two to three days prior to going into port (which happens twice during Leg 149), when deeper objectives cannot usefully be targeted.

Proposed site GAL-1 will be drilled only if time is available after completion of the drilling program at the IAP sites.

PROPOSED DRILL SITES

Proposed Site IAP-2

This site is situated over a basement high thought to be part of the most oceanward continental-rift block on this margin. The high has an irregular, possibly fault-controlled, surface (Fig. 5) and a trend just east of north, roughly parallel to the tectonic fabric of the oceanic crust to the west. The bounding faults of the block are not visible, nor does the block display any clear structure which might be used to indicate a direction of dip. About 850 m of sediment (Table 1), estimated to be as old as Santonian, overlies basement. Studies of the reflection profiles, and analogy with Site 398, suggest that the lithologies are ooze/chalk with turbidites overlying chalk, mudstone, and claystone. The post-Eocene unconformity lies at about 510 mbsf. Just east of the site a fault, or other tectonic disturbance, appears to pass up toward, but not reach, the seafloor. To the west of the site, about 1.5 s (1.6 km) of sediment overlies the acoustic basement, which is smooth and may be capped by, or composed of, lava or other igneous material. This is the "intermediate" crust in the conceptual model, which possesses relatively strong magnetization. To the east, the post-rift sedimentary section thickens to 2.2 s (2.8 km) and basement is expected to consist of pre-rift sediment or continental basement rocks.

Proposed Site IAP-3C

This site is situated over a shallow basement high, which magnetic modeling and seismic refraction results indicate is part of the thin oceanic crust associated with the OCT (Fig. 6). The basement high is strongly elongated in a direction just east of north and parallel with the general tectonic fabric of the oceanic crust in this area. The basement high has a rounded east-west cross section, and the overlying sediments are horizontal and undeformed. About 830 m of sediment, estimated to be as old as late Paleocene, overlies basement (Table 1). Studies of reflection profiles and analogy with Site 398, suggest that the lithologies are ooze/chalk with turbidites over chalk and mudstone. The post-Eocene unconformity lies at about 510 mbsf. The sediments thicken to about 2.0 s (2.4 km) in a basin to the west and to 1.8 s (2.1 km) to the east. The basement material is expected to be upper oceanic crust.

Proposed Site IAP-4

This site centers on a basement high which may be longitudinally continuous with the peridotite ridge drilled at Site 637 off Galicia Bank during Leg 103 (Fig. 7). This association is primarily based on basement morphology. The IAP-4 basement high occupies a critical location in our conceptual model of the OCT, lying precisely at the boundary between the intermediate crust and the thin oceanic crust apparently generated by seafloor spreading. The basement high is strongly elongated and trends just east of north. About 680 m of sediment, estimated to be as old as Maastrichtian, overlies basement. Studies of reflection profiles, and analogy with Site 398, suggest that the lithologies are ooze/chalk with turbidites overlying chalk, mudstone, and claystone. The post-Eocene unconformity lies at about 360 mbsf. The sediments are horizontal, but a low-angle, west-dipping structure can be seen on the east-west seismic profile across the site. The sediments thicken to 2.0 s (2.4 km) in a basin to the west and to 1.4 s (1.5 km) to the east. The acoustic basement to the east of the site is smooth and underlain by the intermediate crust described above. Although the acoustic basement may contain ultramafic rocks within a few hundred meters of the seafloor, it is uncertain that these ever actually cropped out. Thus the uppermost basement could be any mixture of lithology from continental basement rocks to igneous intrusive/extrusive material to tholeiitic lavas of the upper oceanic crust.

Proposed Site IAP-5

This site is centered over the next most oceanward basement high on profile Lusigal 12 and is situated east of proposed site IAP-2, and is an alternate for proposed site IAP-3C (Fig. 8). The basement high appears to be more or less circular in shape with the suggestion of a northwest-dipping internal interface. About 980 m of sediment, estimated to be as old as early Paleocene, overlies basement. Studies of reflection profiles, and analogy with Site 398, suggest that the lithologies are ooze/chalk with turbidites overlying chalk, mudstone, and claystone. The post-Eocene unconformity lies at about 560 mbsf. The sediment basins to east and west do not have a clear base, and the reflectors are indistinct in this region. The basement at this site is expected to be continental in character with little or no igneous intrusive material.

Proposed Site GAL-1

The location of proposed site GAL-1 is shown in Figures 9 and 10. The objective of drilling at this site is to sample the acoustic basement (enigmatic terrane) which overlies the S' reflector and underlies about 550 m of Cenozoic sediments. The basement rocks may contain crucial information about timing, pressure, temperature and kinematic conditions of their metamorphism and deformation during the rifting stage of the margin. Sampling the terrane overlying S' may constrain models of rifted-margin formation. The goals of drilling are:

- Petrologic identification of the rocks overlying S'. Currently, it is suspected that the enigmatic terrane covering S' is continental basement, whereas the underlying rocks probably are serpentinized peridotite, with S' being the crust/mantle boundary (Moho). The S reflector may be a target for a future ODP leg.

- Absolute timing of events. It may be possible to use geochronological dating of minerals which crystallized after metamorphism, after ductile deformation and possibly after brittle deformation of the sampled rocks, to establish the order and age of individual tectonic episodes.

REFERENCES

Boillot, G., Auxietre, J.L., Dunand, J.P., Dupeuple, P.A., and Mauffret, A., 1979. The northwestern Iberian margin: a Cretaceous passive margin deformed during Eocene. *Maurice Ewing Series 3*, Am. Geophys. Union, Washington D.C., 138-153.

Boillot, G., Beslier, M.O., and Comas, M., 1992. Seismic image of undercrusted serpentinite beneath a rifted margin. *Terra Nova*, 4:25-33.

Boillot, G., Comas, M.C., Girardeau, J., Kornprobst, J., Loreau, J-P., Malod, J., Mougenot, D., and Moullade, M., 1988. Preliminary results of the Galinaute cruise: dives of the submersible *Nautile* on the western Galicia margin, Spain. *In* Boillot, G., Winterer, E.L., et al., *Proc. ODP, Sci. Results*, 103: College Station, TX (Ocean Drilling Program), 37-51.

Boillot, G., Feraud, G., Recq, M., and Girardeau, J., 1989. Undercrusting by serpentinite beneath rifted margins: the example of the west Galicia margin (Spain). *Nature*, 341:523 -525 .

Boillot, G., Recq, M., Winterer, E., Meyer, A.W., Applegate, J., Baltuck, M., Bergen, J.A., Comas, M.C., Davies, T.A., Dunham, K., Evans, C.A., Girardeau, J., Goldberg, D.G., Haggerty, J., Jansa, L.F., Johnson, J.A., Kasahara, J., Loreau, J.P., Luna-Siera, E., Moullade, M., Ogg, J., Sarti, M., Thurow, J., and Williamson, M.A., 1987. Tectonic denudation of the upper mantle along passive margins: a model based on drilling results (ODP Leg 103; Western Galicia margin, Spain). *Tectonophysics*, 132:335-342.

Boillot, G., Winterer, E.L., et al., 1988. *Proc. ODP, Sci. Results,* 103: College Station, TX (Ocean Drilling Program).

de Charpal, O., Guennoc, P., Montadert, L., and Roberts, D.G., 1978. Rifting, crustal attenuation and subsidence in the Bay of Biscay. *Nature*, 275:706-711.

Grimaud, S., Boillot, G., Collette, B., Mauffret, A., Miles, P.R., and Roberts, D.G., 1982. Western extension of the Iberian-European plate boundary during the early Cenozoic (Pyrenean) convergence: a new model. *Mar. Geol.*, 45:63-77.

Harland, W.B., Armstrong, R.L., Cox, A.V., Craig, L.E., Smith, A.G., and Smith, D.G., 1990. *A geologic time scale 1989*. Cambridge Univ. Press.

Hoffman, H.J. and Reston, T.J., in press. The nature of the 5 reflector beneath the Galicia Bank rifted margin. Preliminary results from pre-stack depth migration.*Geology*.

Horsefield, S.J., 1992 *Crustal Structure across the Continent-Ocean Boundary*. Ph.D. thesis, Cambridge University.

Klitgord, K., and Schouten, H., 1986. Plate kinematics of the central Atlantic. *The Geology of North America,Vol. M*. Geol. Soc. Amer., 351-378.

Le Pichon, X., Sibuet, J.C., and Francheteau, J., 1977. The fit of the continents around the North Atlantic Ocean. *Tectonophysics*, 38:169-209.

Martins, L.F., 1991. *Activitade igneo Mesozoica em Portugal*. Ph.D. thesis, Univ. Lisbon.

Masson, D.G., Cartwright, J.A., Pinheiro, L.M., Whitmarsh, R.B., Beslier, M-O., and Roeser, H., in press. Localized deformation at the ocean-continent transition in the NE Atlantic.*Geology*.

Masson, D.G., and Miles, P.R., 1984. Mesozoic sea floor spreading between Iberia, Europe and North America. *Mar. Geology*, 56:279-287.

Mauffret, A., and Montadert, L., 1987. Rift tectonics on the passive continental margin off Galicia (Spain). *Mar. Petrol. Geol.*, 4:49-70.

Mauffret, A., Mougneot, D., Miles, P.R., and Malod, J.A., 1989. Cenozoic deformation and Mesozoic abandoned spreading centre in the Tagus Abyssal Plain (west of Portugal): results of a multichannel seismic survey. *Canad. J. Earth Sci.*, 26:1101-1123.

Montadert, L., de Charpal, O., Robert, D., Guennoc, P., and Sibuet, J.C., 1979. Northeast Atlantic passive continental margin: rifting and subsidence processes. *In* Talwani, M. and Ryan, W.B.F. (Eds.), *Deep Drilling results in the Atlantic ocean: Continental margin and Paleoenvironment*. M. Ewing Series 3, Am. Geophys. Union, Washington, 154-186.

Mougenot, D., Kidd, R.B., Mauffret, A., Regnauld, H., Rothwell, R.G., and Vanney, J.R., 1984. Geological interpretation of combined Sea-Beam, Gloria and seismic data from Porto and Vigo seamounts, Iberian continental margin. *Mar. Geophys. Res.*, 6:329-363.

Murillas, J., Mougenot, D., Boillot, G., Comas, M.C., Banda, E., and Mauffret, A., 1990. Structure and evolution of the Galicia Interior basin (Atlantic western Iberian continental margin). *Tectonophysics*, 184:297-319.

Ogg, J.G., 1988. Early Cretaceous and Tithonian magnetostratigraphy of the Galicia margin. *In* Boillot, G., Winterer, E.L., et al., *Proc. ODP, Sci. Results*, 103: College Station, TX (Ocean Drilling Program), 659-682.

Pinheiro, L.M., Whitmarsh, R.B., and Miles, P.R., 1992. The ocean-continent boundary off the western continental margin of Iberia. 11. Crustal structure in the Tagus Abyssal Plain. *Geophys. J.*, 109:106-124.

Ribeiro, A. and nine others, 1979. *Introduction a la géologie générale du Portugal.* Geol. Surv. Portugal, Lisbon.

Sibuet, J.C., 1992. Formation of non-volcanic passive margins: a composite model applied to the conjugate Galicia and southeastern Flemish Cap margins. *Geophysical Research Letters*, 19:769-772.

Srivastava, S.P., Roest, W.R., Kovacs, L.C., Oakey, G., Levesqu, S., Verhoef, J., and Macnab, R., 1990a. Motion of Iberia since the Late Jurassic: results from detailed aeromagnetic measurements in the Newfoundland Basin. *Tectonophysics*, 184:229-260.

Srivastava, S.P., Schouten, H., Roest, W.R., Klitgord, K.D., Kovacs, L.C., Verhoef, J., and Macna, R., 1990b. Iberian plate kinematics: a jumping plate boundary between Eurasia and Africa. *Nature*, 344:756-759.

Srivastava, S.P., Verhoef, J., and Macnab, R., 1988. Results from a detailed aeromagnetic survey across the northeast Newfoundland margin. Part 11. Early opening of the North Atlantic between the British Isles and Newfoundland, *Mar. Petrol. Geol.*, 5:324-327.

Weaver, P.P.E., and Kuijpers, A., 1986. Turbidite deposition and the origin of the Madeira Abyssal Plain. *In* Summerhayes, C.P., and Shackleton, N.J. (Eds.), *North Atlantic Paleoceanography*: Geol. Soc. London Special Publ., 21:131-143.

Wernicke, B., and Burchfiel, B.C., 1982. Modes of extensional tectonics. *Struct. Geol.*, 4, 2:105-115.

Whitmarsh, R.B., Miles, P.R., and Mauffret, A., 1990. The ocean-continent boundary off the western continental margin of Iberia 1. Crustal structure at 40°30'N. *Geophys. J.*, 103:509-531.

Whitmarsh, R.B., Miles, P.R., and Pinheiro, L.M., 1989. The seismic velocity structure of some NE Atlantic continental rise sediments; a lithification index? *Geophys. J.*, 101:367-378 .

Whitmarsh, R.B., Pinheiro, L.M., Miles, P.R., Recq, M., and Sibuet, J.C., in press. Thin crust at the western Iberia ocean-continent transition and ophiolites. *Tectonics*.

Wilson, R.C.L., Hiscott, R.N., Willis, M.G., and Gradstein, F.M., 1989. The Lusitanian Basin of west-central Portugal: Mesozoic and Tertiary tectonic, stratigraphic and subsidence history. *In* Tankard, A.J., and Balkwill, H.R. (Eds.) *Extensional tectonics and Stratigraphy of the North Atlantic margins:* Am. Assoc. Petrol. Geol. Mem., 46:341-361.

TABLE 1. SUMMARY SITE INFORMATION, LEG 149

Site	Lat./Long.	Water Depth (m)	Seismic Profile	Sediment Depth TWT (s)	Sediment Thickness (m)	Basement (m)
IAP-2	40°41.0'N 12°07.1'W	5250	Lusigal 12, SP 3130	0.88	850	*
IAP-3C	40°47.7'N 12°44.1'W	5500	Sonne 75-16, SP 310	0.85	830	*
IAP-4	40°50.3'N 12°28.5'W	5450	Sonne 75-16, SP 752	0.70	680	*
IAP-5	40°40.9'N 11°37.0'W	5100	Lusigal 12, SP 3980	0.98	980	*
GAL-1	42°40.0'N 12°48.0'W	4500	Lusigal 06, SP 1536	0.50	550	100

* = several hundred meters.

TABLE 2. DRILLING-TIME ESTIMATES, LEG 149

Site	Priority	Drilling Option[1]	Time (days) Drilling[2]	Time (days) Logging[3]	Total Days
IAP-4	1	Two RCB holes	21.0	2.8	23.8
		One RCB hole	12.0	1.7	13.7
		APC hole	3.5	---	3.5
IAP-2	1	Two RCB holes	21.0	2.9	23.9
		One RCB hole	13.6	1.8	15.4
		APC hole	3.5	---	3.5
IAP-3C	2	One RCB hole	13.5	1.6	15.1
		APC hole	3.5	---	3.5
IAP-5	2	One RCB hole	13.5	1.7	15.2
		APC hole	3.5	---	3.5
GAL-1	3	One RCB hole	9	1.3	10.3

[1] Drilling options

Two RCB holes:	First RCB hole cored to refusal (bit destruction) in basement, with logging in sediment section. Offset reentry hole cased through sediment, with drilling, coring, and logging in basement. Drilling time estimates assume 200 m of basement penetration in reentry holes.
One RCB hole:	Single RCB hole cored to refusal (bit destruction) in basement, followed by emplacement of free-fall funnel. One or more bit trips then allow additional penetration in basement (200 m assumed in time estimates) followed by logging through entire section.
APC hole:	APC core to refusal, assumed in time estimates to penetrate 300 mbsf.

[2] Drilling times include 4 WSTP runs in all RCB sediment holes.

[3] Logging includes standard three strings (geophysical, geochemical, and FMS) in open RCB holes, with the side-entry sub (SES); standard three strings in reentry basement holes, without SES.

TABLE 3. LEG 149 SCHEDULE

Leg 149A begins with port call Panama 10-13 March, departing Panama 14 March 1993.

			Time on Site (days)	Transit Time (days)
Transit from Panama to Ponta Delgada (end Leg 149A)				13.0
Arrive	Ponta Delgada	27 March		
(end Leg 149A, begin Leg 149B)				
Depart	Ponta Delgada	28 March	1.0	
Transit from Ponta Delgada to IAP-4 (first visit)				2.6
Arrive	IAP-4	30 March	17.0[1,2]	
Leave	IAP-4	16 April		
Transit from IAP-4 to Lisbon				0.8
Arrive	Lisbon	17 April	1.0	
(end Leg 149B, begin Leg 149C)				
Leave	Lisbon	18 April		
Transit from Lisbon to IAP-4 (return)				0.9
Arrive	IAP-4	19 April	6.8[1,2]	
Leave	IAP-4	26 April		
Transit from IAP-4 to IAP-2				0.3
Arrive	IAP-2	26 April	23.9[2]	
Leave	IAP-2	20 May		
Transit from IAP-2 to IAP-3C				0.3
Arrive	IAP-3C	20 May	4.0[3]	
Leave	IAP-3C	24 May		
Transit from IAP-3C to Lisbon				1.0
Arrive	Lisbon	25 May 1993		
(end Leg 149C)				
		Total Time (Legs 149A, 149B, 149C)		72.6
		Total Time (Legs 149B and 149C)		59.6

[1] Operations at proposed site IAP-4 split between port call for crew change. Exploratory RCB hole is to be cored and logged before port call; reentry hole will be started before port call, then completed and logged after port call.

[2] Drilling times for IAP-4 and IAP-2 assume two holes per site: RCB single-bit and full reentry. Drilling (and logging) times may be reduced significantly if conditions allow use of free-fall funnels in single RCB holes at each site. Time for 4 WSTP runs are included in each RCB single-bit hole.

[3] As much time as is available at the end of the leg will be devoted to coring a single-bit hole at Site IAP-3C, with the hope of recovering and characterizing basement at this site. Additionally, an APC hole may be drilled at one or more sites, depending on recovery, core quality, and time required during RCB and reentry work.

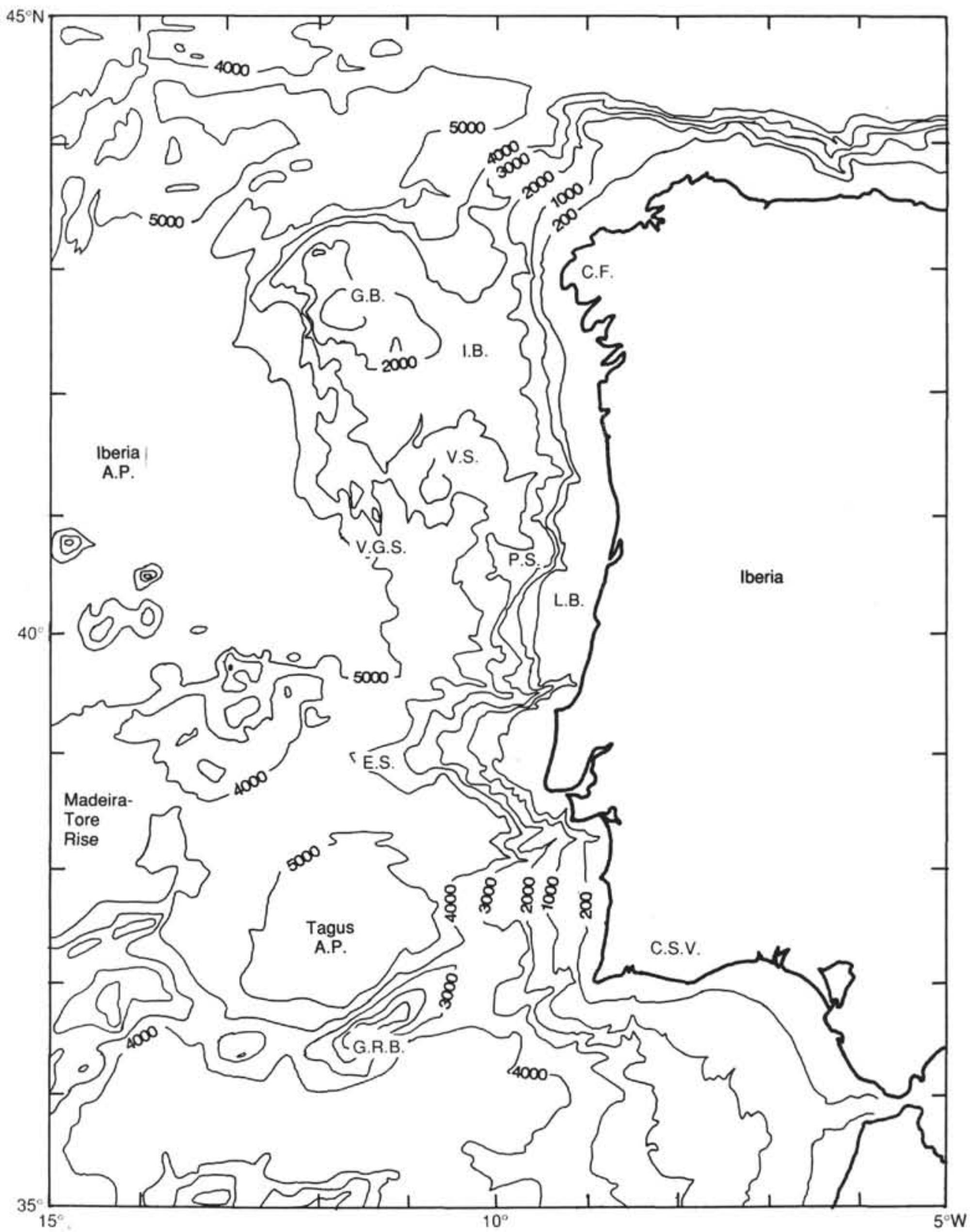

Figure 1. Bathymetry of the west Iberia margin (contours in meters). C.F.=Cape Finisterre; V.S.=Vigo Seamount; P.S.=Porto Seamount; V.G.S.=Vasco da Gama Seamount; C.S.V.=Cape Saint Vincent; G.R.B.=Gorringe Bank; G.B.= Galicia Bank; L.B.=Lusitanian Basin; I.B.=Interior Basin; E.S.=Estremadura Spur.

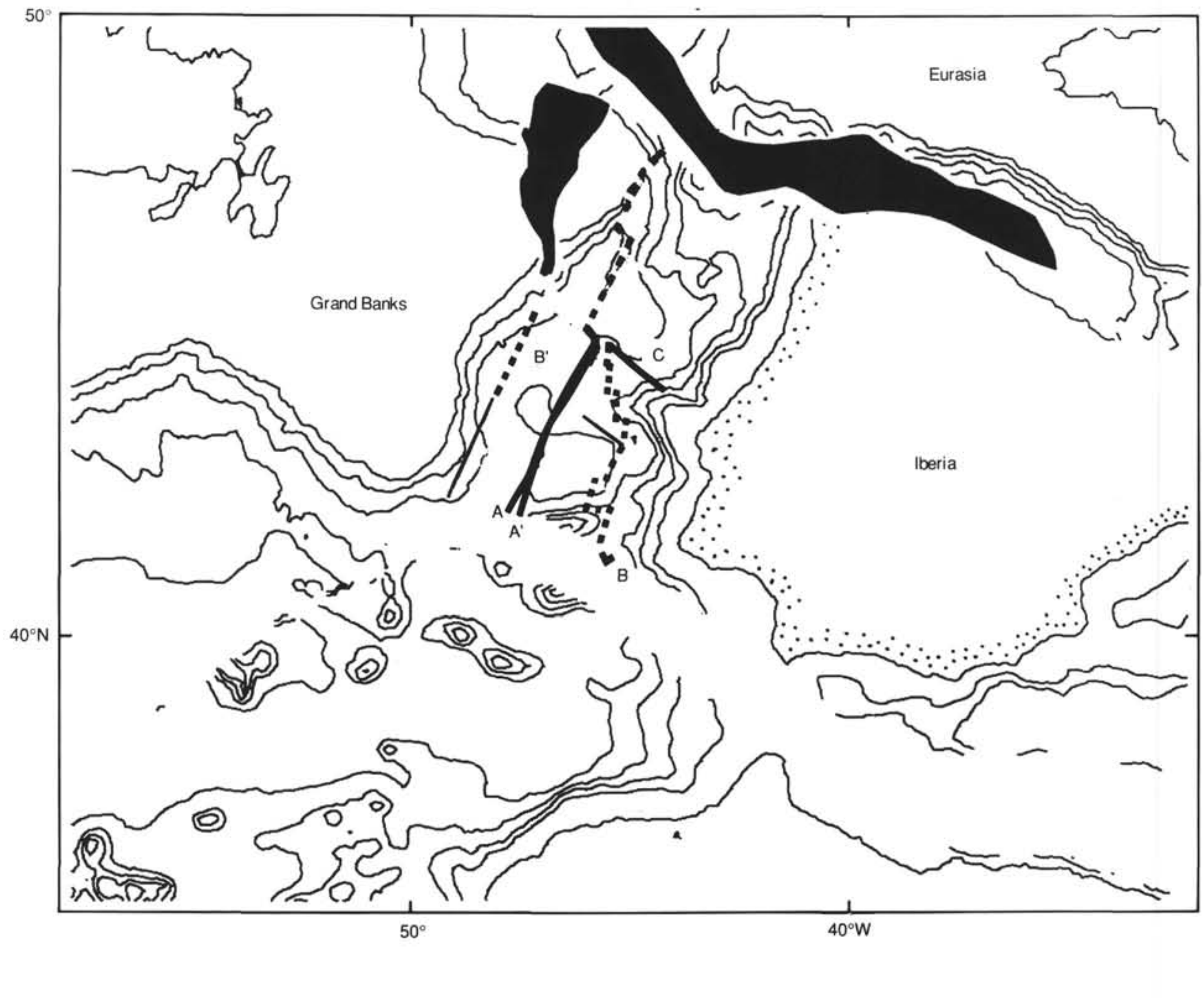

Figure 2. Bathymetric reconstruction of Iberia and the Grand Banks at chron M10 (from Srivastava et al., 1990a). C is a presumed fracture zone. B and B' are possible ocean/continent boundaries, and A and A' mark changes in the nature of the acoustic basement. Dotted areas are overlap.

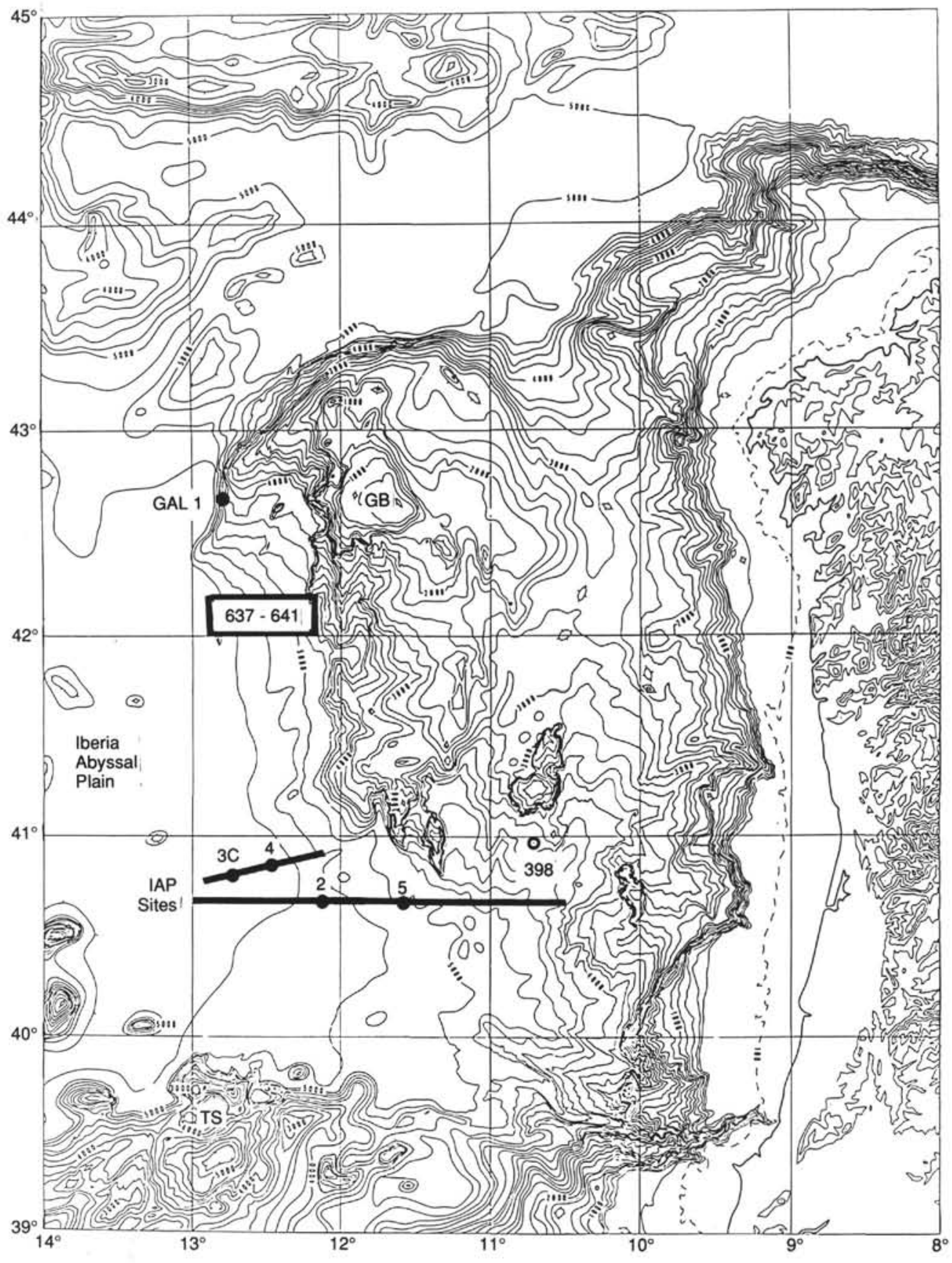

Figure 3. Location of Leg 149 proposed drill sites. Sites 398 (DSDP Leg 47) and 637 to 641 (ODP Leg 103) are also shown. G.B.=Galicia Bank; T.S.=Tore Seamount

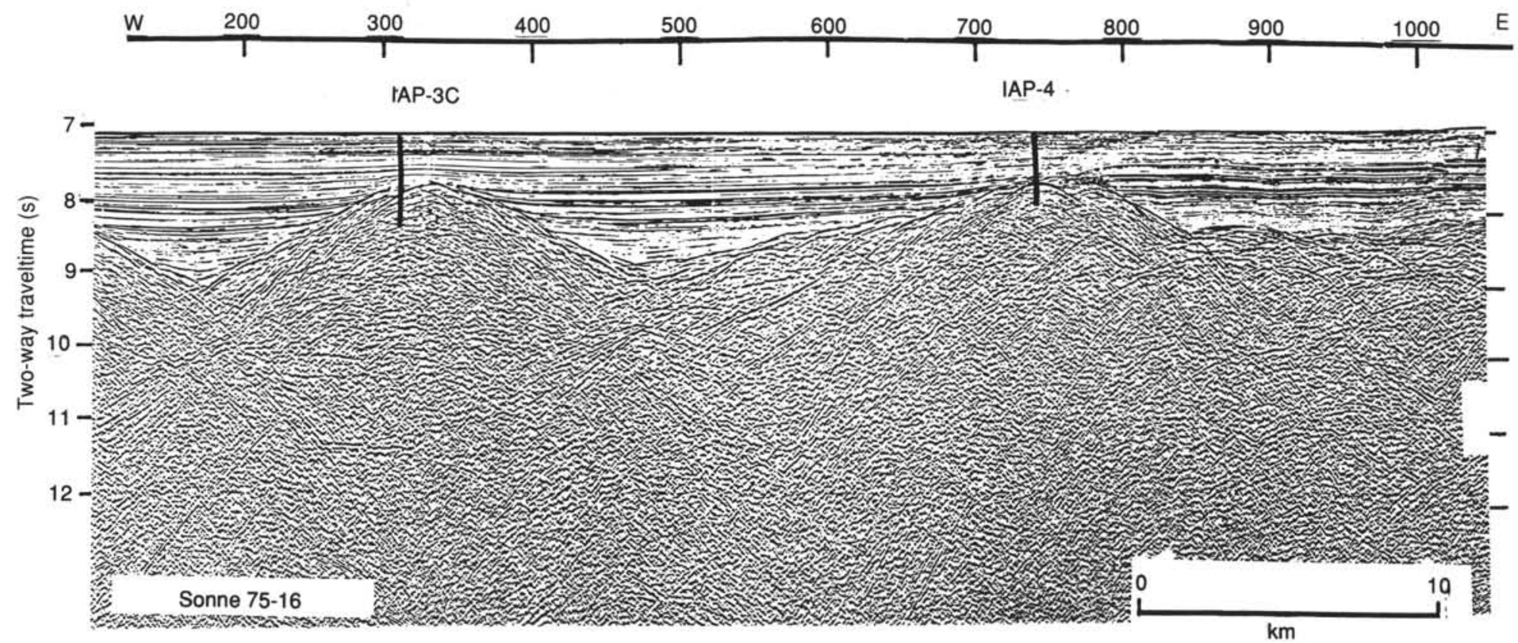

Figure 4. Location of proposed sites IAP-3C and IAP-4 on multichannel seismic reflection profile Sonne 75-16. Shot-point numbers are given at the top.

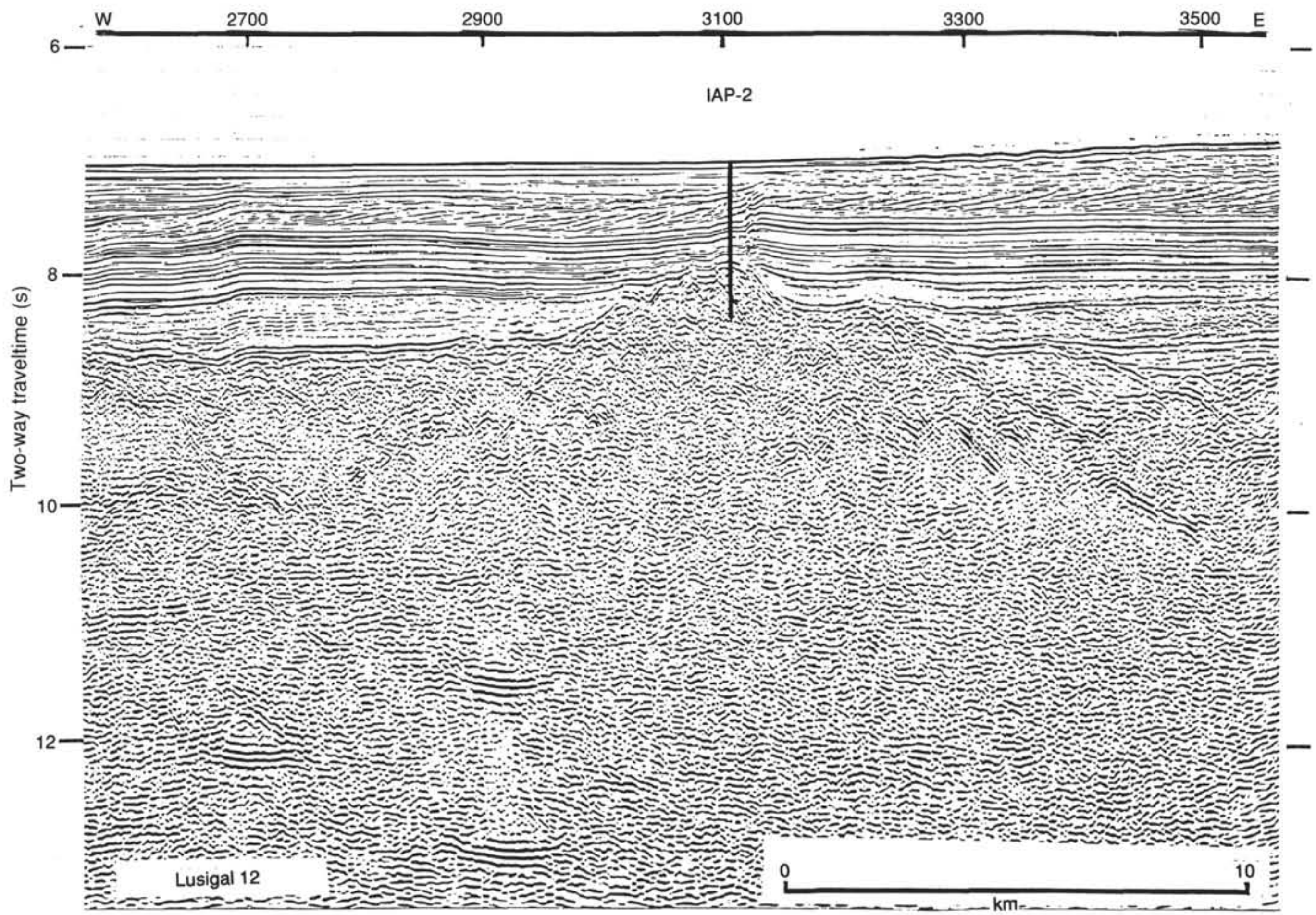

Figure 5. Location of proposed site IAP-2 on multichannel seismic reflection profile Lusigal 12.
Shot-point numbers are given at the top.

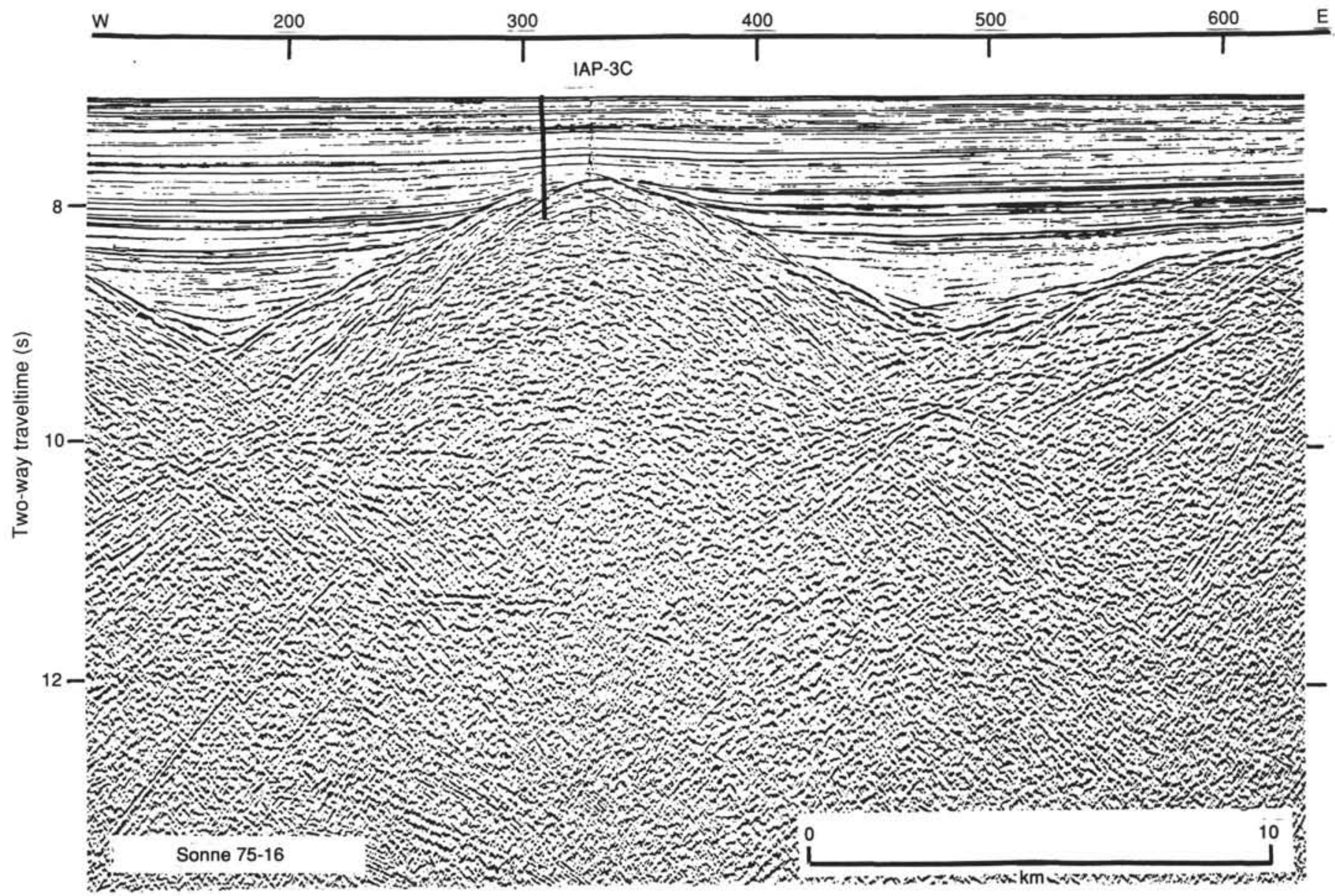

Figure 6. Location of proposed site IAP-3C on multichannel seismic reflection profile Sonne 75-16. Shot-point numbers are given at the top.

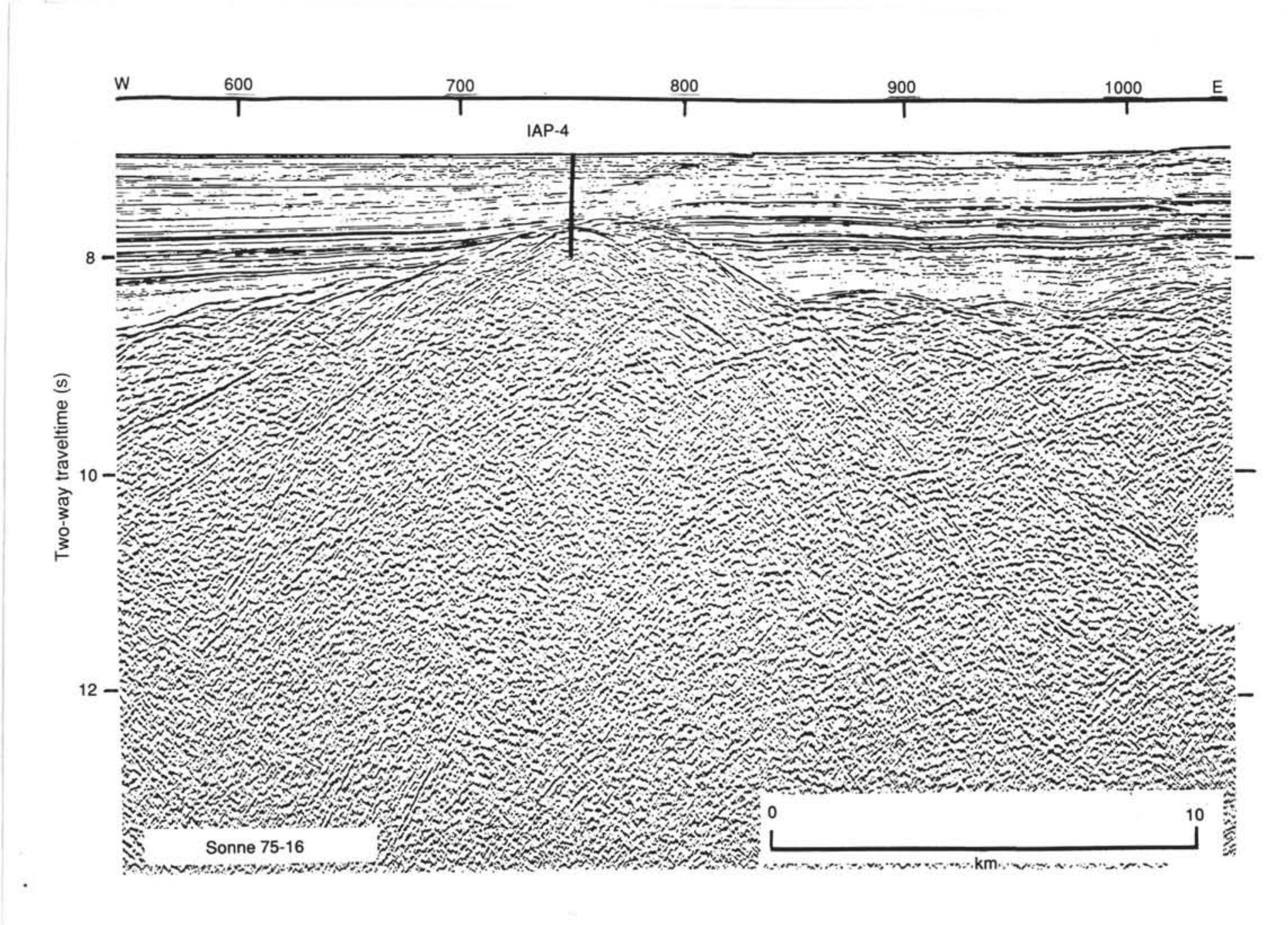

Figure 7. Location of proposed site IAP-4 on multichannel seismic reflection profile Sonne 75-16. Shot-point numbers are given at the top.

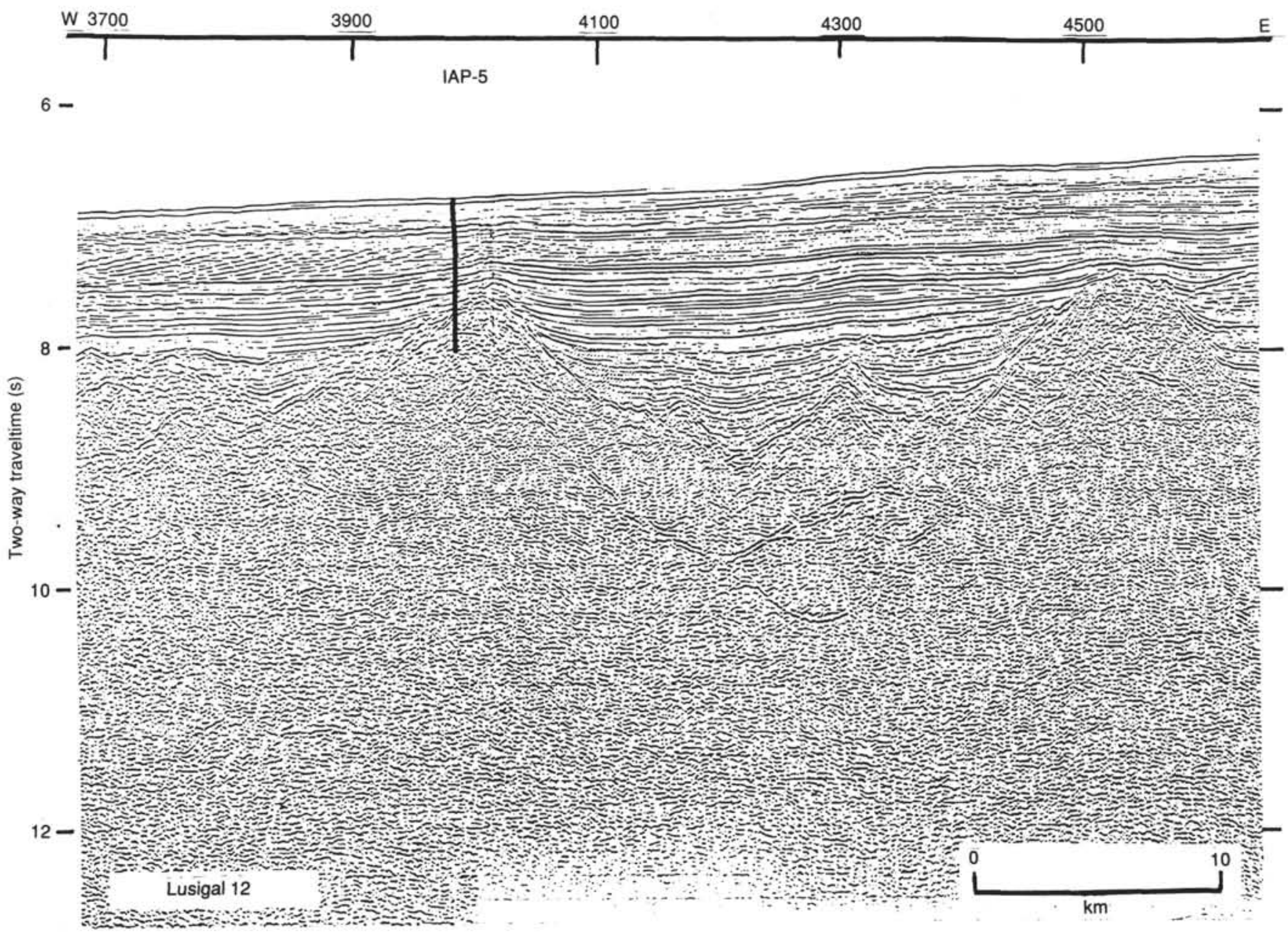

Figure 8. Location of proposed site IAP-5 on multichannel seismic reflection profile Lusigal 12. Shot-point numbers are given at the top.

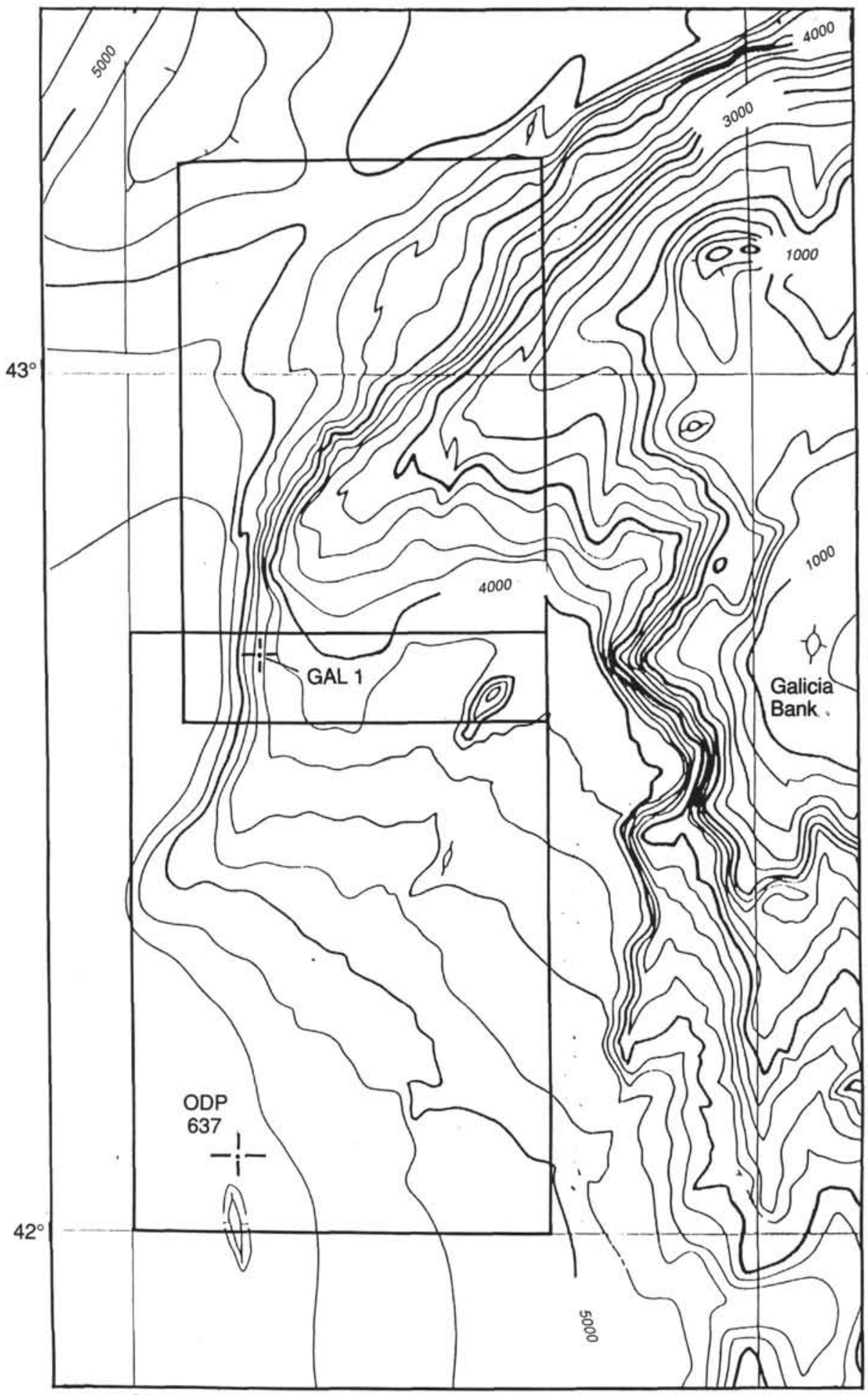

Figure 9. Location of proposed site GAL-1 west of Galicia Bank (contours in meters).

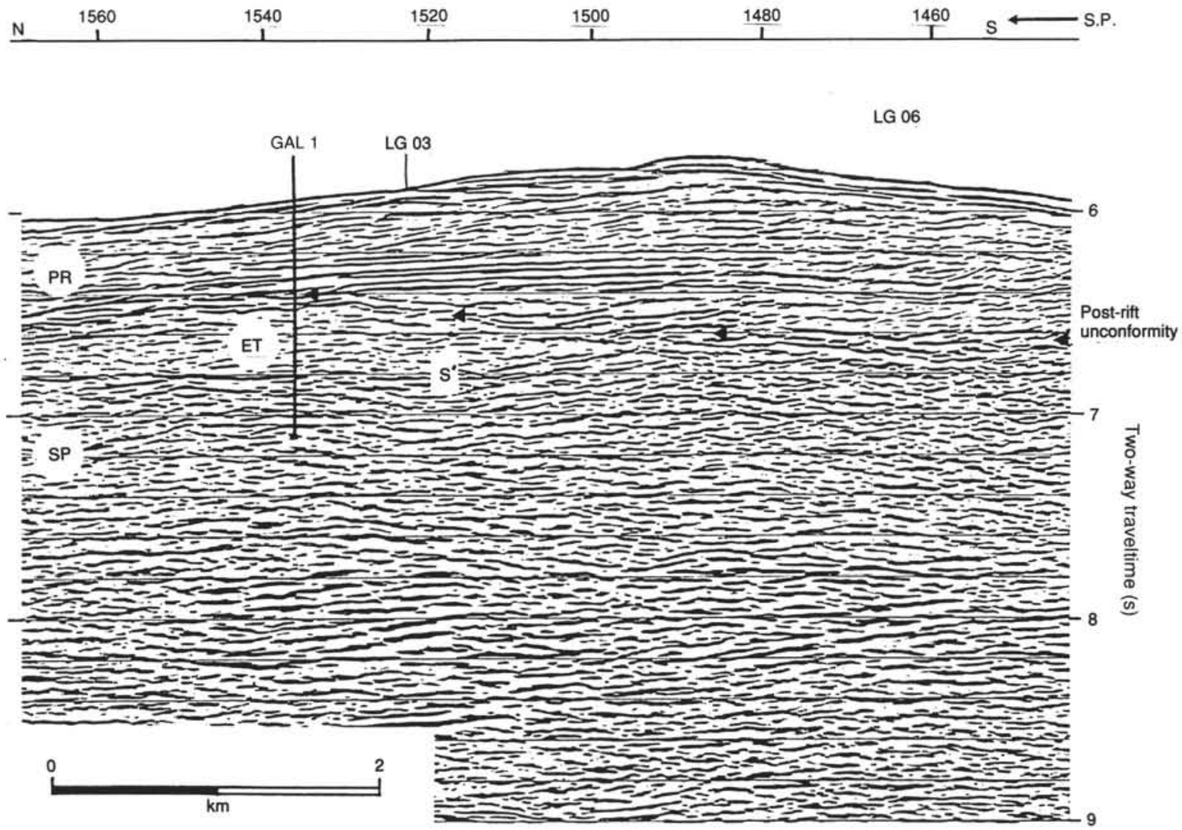

Figure 10. Location of proposed site GAL-1 on multichannel seismic reflection profile Lusigal 06. Crossing for Lusigal line 03 is indicated. PR=postrift sediments; ET=enigmatic terrane; SP=serpentinized peridotite sampled at diving Site GAL 86-06; S'=S' reflector.

Site: IAP-2

Priority: 1

Position: 40°41.0'N, 12° 07.1'W

Water Depth: 5250 m

Sediment Thickness: 850 m

Seismic Coverage: Sonne 75 Line 17 (see related Lines 18 and 22); Lusigal Line 12

Objectives: Sample the crust within the OCT to establish the nature of the upper crust and test geophysical predictions. Determine history of turbidite sedimentation. Date Cenozoic deformation. Measure heat flow. Estimate late post-rift subsidence.

Drilling Program:

1: RCB core to bit destruction in basement.

If hole is stable:

Drop FFF, RCB core in basement to TD, log entire hole, and abandon.

If hole unstable:

Log sediments in initial hole, offset and start new hole, set casing through unstable part of the hole, RCB core in basement to TD, log basement, and abandon.

2: APC core to refusal, and abandon (if time is available and RCB core is inadequate for sedimentary objectives).

Logging and Downhole Operations: Standard strings (Geophysical, Geochemical, and FMS). Four WSTP measurements in first RCB hole. Magnetic susceptibility log may be run.

Nature of Rock Anticipated: Pelagic clay, sand/silt/clay turbidites, ooze and chalk, mudstone, claystone, continental crust modified by rifting.

Site: IAP-3C

Priority: 2

Position: 40°47.7'N, 12°44.1'W

Water Depth: 5500 m

Sediment Thickness: 830 m

Seismic Coverage: Sonne 75 Line 16; Discovery 161 day 234

Objectives: Sample the crust within the OCT to establish the nature of the upper crust and test geophysical predictions. Determine history of turbidite sedimentation. Date Cenozoic deformation. Measure heat flow. Estimate late post-rift subsidence.

Drilling Program:

1: RCB core to bit destruction in basement.

If hole is stable:

Drop FFF, RCB core in basement to TD, log entire hole, and abandon.

If hole unstable:

Log sediments in initial hole, offset and start new hole, set casing through unstable part of the hole, RCB core in basement to TD, log basement, and abandon.

2: APC core to refusal, and abandon (if time is available and RCB core is inadequate for sedimentary objectives).

Logging and Downhole Operations: Standard strings (Geophysical, Geochemical, and FMS). Four WSTP measurements. Magnetic susceptibility log may be run.

Nature of Rock Anticipated: Pelagic clay, sand/silt/clay turbidites, ooze and chalk, claystone, altered oceanic crust.

Site: IAP-4
Priority: 1
Position: 40°50.3'N, 12°28.5'W
Water Depth: 5450 m
Sediment Thickness: 680 m
Seismic Coverage: Sonne 75 Line 16; Lusigal Lines 04 and 15.

Objectives: Sample the crust within the OCT to establish the nature of the upper crust and test geophysical predictions. Determine history of turbidite sedimentation. Date Cenozoic deformation. Measure heat flow. Estimate late post-rift subsidence.

Drilling Program:

1: RCB core to bit destruction in basement.
If hole is stable:
Drop FFF, RCB core in basement to TD, log entire hole, and abandon.
If hole unstable:
Log sediments in initial hole, offset and start new hole, set casing through unstable part of the hole, RCB core in basement to TD, log basement, and abandon.

2: APC core to refusal, and abandon (if time is available and RCB core is inadequate for sedimentary objectives).

Logging and Downhole Operations: Standard strings (Geophysical, Geochemical, and FMS). Four WSTP measurements in first RCB hole. Magnetic susceptibility log may be run.

Nature of Rock Anticipated: Pelagic clay, sand/silt/clay turbidites, ooze and chalk, claystone, serpentinized peridotite and/or continental crust and/or volcanic flows and sills.

Site: IAP-5

Priority: 2

Position: 40°40.9'N, 11°37.0'W

Water Depth: 5100 m

Sediment Thickness: 980 m

Seismic Coverage: Sonne 75 Line 21 (see also related Lines 20 and 22); Lusigal Line 12

Objectives: Sample the crust within the OCT to establish the nature of the upper crust and test geophysical predictions. Determine history of turbidite sedimentation. Date Cenozoic deformation. Measure heat flow. Estimate late post-rift subsidence.

Drilling Program:

1: RCB core to bit destruction in basement.
   If hole is stable:
      Drop FFF, RCB core in basement to TD, log entire hole, and abandon.
   If hole unstable:
      Log sediments in initial hole, offset and start new hole, set casing through unstable part of the hole, RCB core in basement to TD, log basement, and abandon.

2: APC core to refusal, and abandon (if time is available and RCB core is inadequate for sedimentary objectives).

Logging and Downhole Operations: Standard strings (Geophysical, Geochemical, and FMS). Four WSTP measurements. Magnetic susceptibility log may be run.

Nature of Rock Anticipated: Pelagic clay, sand/silt/clay turbidites, ooze and chalk, claystone, continental crust.

Site: GAL-1
Priority: 3
Position: 42°40.0'N, 12°48.0'W
Water Depth: 4500 m
Sediment Thickness: 550 m
Seismic Coverage: Lusigal Line 06 (see also related Line GP03).

Objectives: Determine lithologic composition of the "enigmatic terrane" above the S' reflector which appears to crop out to the west of the site.

Drilling Program:

1: RCB core to bit destruction in basement or 100-m basement penetration, log entire hole, and abandon.

Logging and Downhole Operations: Standard strings (Geophysical, Geochemical, and FMS).

Nature of Rock Anticipated: Pelagic clay, sand/silt/clay turbidites, ooze and chalk, claystone, continental crust.

SCIENTIFIC PARTICIPANTS

OCEAN DRILLING PROGRAM LEG 149

Co-Chief Scientist:

Dale S. Sawyer
Dept. of Geology and Geophysics
Weiss School of Natural Sciences
Rice University
P.O. Box 1892
Houston, Texas 77251

Co-Chief Scientist:

R.B. Whitmarsh
Institute of Oceanographic Sciences
Deacon Laboratory
Brook Road, Wormley
Surrey GU8 5UB
United Kingdom

Staff Scientist/Logging Scientist:

Andy Fisher
Ocean Drilling Program
Texas A&M University Research Park
1000 Discovery Drive
College Station, Texas 77845-9547

Sedimentologist:

TO BE NAMED

Sedimentologist:

Kathleen M. Marsaglia
Dept. of Geological Sciences
University of Texas @ El Paso
El Paso, Texas 79968

Sedimentologist:

Maria C. Comas
Instituto Andaluz de Geologia Mediterránea
CSIS and University of Grenada
Campus Fuentenueva-18002
Spain

Sedimentologist:

Doris Milkert
Geologisch-Paläontologisches Institut
und Museum
Olshausenstr. 40
D 2300 Kiel
Federal Republic of Germany

Sedimentologist:	Pedro Ramirez Dept. of Geological Sciences California State University 5151 State University Dr. Los Angeles, California 90032-8203
Igneous Petrologist:	Guy Cornen Université Nantes Laboratoire de Pétrologie 2 rue de la Houssiniere 44072 NANTES Cedex 03 France
Igneous Petrologist:	Karl E. Seifert Dept. of Geological Sciences Iowa State University 252 Science I Ames, Iowa 50011
Igneous Petrologist:	Ian Gibson Dept. of Earth Sciences University of Waterloo Waterloo, Ontario N2L 3G1 Canada
Nannofossil Paleontologist:	TO BE NAMED
Nannofossil Paleontologist:	Philippe De Kaenel Dept. of Geology Florida State University B-160 Tallahassee, Florida 32306
Paleontologist (Forams):	TO BE NAMED
Paleontologist (Benthic Forams):	TO BE NAMED
Organic Chemist:	Philip A. Meyers Dept. of Geological Sciences The University of Michigan 1006 C.C. Little Bldg. Ann Arbor, Michigan 48109-1063
Inorganic Chemist:	TO BE NAMED

Structural Geologist:	Marie-Odile Anne Beslier Laboratoire Géodynamique Sous-Marine-CNRS B.P. 48 06230 Villefranche-sur-Mer France
Structural Geologist:	Gregory Jones Dept. of Earth Sciences University of Leeds Leeds LS2 9JT United Kingdom
Physical Properties Specialist:	Dennis L. Harry Dept. of Geology and Geophysics Weiss School of Natural Sciences Rice University P.O. Box 1892 Houston, Texas 77251
Physical Properties Specialist:	Charlotte M. Krawcyk GEOMAR Forschungszentrum für Marine Geowissenschaften Wischhofstr. 1-3, 2300 Kiel 14 Federal Republic of Germany
Physical Properties Specialist:	Julia K. Morgan Cornell University Dept. of Geological Sciences Snee Hall Ithaca, New York 14852-1504
Physical Properties Specialist:	Luis de Menezes Pinheiro Departamento de Geosciencias Universidade de Aveiro Campo Universitario Santiago 3800 Aveiro Portugal
Paleomagnetist:	Toshiya Kanamatsu Ocean Research Institute University of Tokyo 1-15-1 Minamidai Nakano-ku Tokyo 164 Japan

Paleomagnetist:	Xixi Zhao Institute of Tectonics Dept. of Earth Sciences University of California, Santa Cruz Santa Cruz, California 95064
JOIDES Logging Scientist:	Jeremy C. Lofts Borehole Research Dept. of Geology University of Leicester University Road Leicester, LE1 7RH United Kingdom
LDGO Logging Scientist:	Mike Hobart Lamont-Doherty Geological Observatory Columbia University Palisades, New York 10964
LDGO Logging Technician:	Chuan Yin Lamont-Doherty Geological Observatory Columbia University Palisades, New York 10964
Schlumberger Engineer:	Dave Ritz Schlumberger Offshore Services 369 Tristar Drive Webster, Texas 77598
Operations Superintendent:	Eugene Pollard Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547
Development Engineer:	Scott McGrath Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547
Laboratory Officer:	Brad Julson Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547

Curatorial Representative:	Lorraine Southey Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547
Marine Computer Specialist/System Manager:	John Eastlund Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547
Marine Computer Specialist/System Manager:	Barry Weber Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547
Marine Laboratory Specialist/Yeoperson:	Michiko Hitchcox Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547
Marine Laboratory Specialist/Photography:	Brad Cook Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547
Marine Laboratory Specialist/Chemistry:	Phil Rumford Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547
Marine Laboratory Specialist/Chemistry :	Chieh Peng Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547
Marine Electronics Specialist:	Roger Ball Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547

Marine Electronics Specialist:	Eric Meissner Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547
Marine Laboratory Specialist/XRF-XRD:	Mary Ann Cusimano Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547
Marine Laboratory Specialist/SMT-FMS:	Donald Sims Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547
Marine Laboratory Specialist/Phys. Props.:	Jean Mahoney Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547
Marine Laboratory Specialist/Storekeeper:	TO BE NAMED Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547
Marine Laboratory Specialist:	Claudia Muller Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547
Marine Laboratory Specialist/Magnetics:	Monica Sweitzer Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547
Marine Laboratory Specialist:	Gus Gustafson Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, Texas 77845-9547

Marine Laboratory Specialist: Robert Kemp
Ocean Drilling Program
Texas A & M University Research Park
1000 Discovery Drive
College Station, Texas 77845-9547

Marine Laboratory Specialist: Steve Maury
Ocean Drilling Program
Texas A&M University Research Park
1000 Discovery Drive
College Station, TX 77845-9547

This staffing schedule is subject to change.