OCEAN DRILLING PROGRAM

LEG 195 SCIENTIFIC PROSPECTUS

WEST PHILLIPINE SEA SEISMIC OBSERVATORY

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July 2000

Scientific Prospectus No. 95

First Printing 2000

Distribution

Electronic copies of this publication may be obtained from the ODP Publications Home Page on the World Wide Web at: http://www-odp.tamu.edu/publications

D I S C L A I M E R

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:

Australia/Canada/Chinese Taipei/Korea Consortium for Ocean Drilling
Deutsche Forschungsgemeinschaft (Federal Republic of Germany)
Institut National des Sciences de l'Univers-Centre National de la Recherche Scientifique (INSU-CNRS; 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 Ocean Drilling (Belgium, Denmark, Finland, Iceland, Ireland, Italy, The Netherlands, Norway, Portugal, Spain, Sweden, and Switzerland.)
Marine High-Technology Bureau of the State Science and Technology Commission of the People's Republic of China

Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the National Science Foundation, the participating agencies, Joint Oceanographic Institutions, Inc., Texas A&M University, or Texas A&M Research Foundation.

This Scientific Prospectus is based on precruise JOIDES panel discussions and scientific input from the designated Co-Chief Scientists on behalf of the drilling proponents. 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 Manager 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 Science and Operations Committees (successors to the Planning Committee) and the Pollution Prevention and Safety Panel.

Technical Editors: Karen K. Graber and Lori J. Cagle

ABSTRACT

Ocean Drilling Program Leg 195 consists of a science segment devoted to drilling and casing a hole on the Philippine Sea abyssal seafloor (Site WP-1B) coupled with the installation of a broadband seismometer for a long-term sub-seafloor borehole observatory. The seismic observatory is an important component of the International Ocean Network seismometer net. By filling a large gap in the global station grid, the observatory will help increase the resolution of global tomographic studies, which have revolutionized understanding of mantle dynamics and structure. Moreover, the observatory will allow more precise study of the seismic structure of the crust and upper mantle of the Philippine plate, as well as better resolution of earthquake locations and mechanisms in the northwest Pacific subduction zone.

Drilling at Site WP-1B will also provide more precise basement age constraints for models of backarc spreading in the Philippine Sea as well as high-quality sediment sections that may be used to reconstruct the history of microplate motion, climate change, aeolian transport, and arc volcanism in the region.

INTRODUCTION

Tomographic studies using earthquake waves propagating through the Earth's interior have revolutionized our understanding of mantle structure and dynamics. Perhaps the greatest problem facing seismologists who wish to improve such tomographic models is the uneven distribution of seismic stations, especially the lack of stations in large expanses of ocean such as the Pacific. The International Ocean Network (ION) project, an international consortium of seismologists, has identified "gaps" in the global seismic net and is attempting to install digital seismometers in those locations. One of the highest ION priorities is to install a station beneath the deep seafloor of the Philippine Sea (Fig. 1).

Site WP-1B, situated in the west Philippine Basin west of the Kyushu-Palau Ridge (Fig. 2), is slated to become a long-term borehole seismic observatory, which will be neighbored by stations at Ishigaki, (ISG) and Tagaytay (TAG) to the west, by many Japanese stations to the north, by Minami-Torishima (MCSJ) Island station to the east, and by the stations at Ponpei (PATS) and

Port Moresby (PMG) to the south (Fig. 1). A seismic station at the center of the Philippine Sea plate is an essential addition to the surrounding stations and, together with existing land stations, will aid in understanding the global dynamics operating in the western Pacific (Fig. 2). Like other existing oceanic borehole observatories (Sites 1150 and 1151; Suyehiro, Sacks, Acton et al., in press), there is a nearby co-axial transoceanic telephone cable (TCP-2) to utilize for data recovery and power. However, the Site WP-1B installation is designed as a stand-alone system with its own batteries and recorder. Thus, once instruments are installed in the hole, they will be serviced for data analyses, distribution, and archiving. We plan to connect data, control, and power lines to the TPC-2 cable owned by the University of Tokyo after confirmation of data retrieval. This will be done under the auspices of an ongoing national program within Japan (Ocean Hemisphere Network Project). Initially, power will be supplied to the observatory by a battery pack, and data will be retrieved by a remotely operated vehicle (ROV; Fig. 3). The data will eventually become accessible worldwide through the Internet. Although data recovery will be costly and the data will not be available in real time until the system is connected to the TCP-2 cable, the scientific importance of the site to the ION concept is such that this is worthwhile.

Proposed Site WP-1B is also important because it will provide samples representative of the Eocene/Paleocene crust of the northern west Philippine Basin. Results from this site will augment those obtained on Deep Sea Drilling Project (DSDP) Legs 31 and 59, which were the first legs to sample and estimate the age of basement in the region and to confirm that the seafloor formed by backarc spreading. Results from this site will also add to our knowledge of backarc crustal structure and geochemistry, microplate tectonics, magnetic lineations, and sedimentation. Because core quality and dating techniques have vastly improved since these early legs, it is also anticipated that drilling at Site WP-1B will provide better age control on backarc spreading, as well as detailed records of Northern Hemisphere climate change, aeolian transport, and arc volcanism in the region during the Tertiary.

BACKGROUND

Borehole Seismic Observatories

The scientific importance of establishing long-term geophysical stations at deep ocean sites has been acknowledged by the Earth science and Ocean Drilling Program (ODP) communities and is expressed in various reports (COSOD II, JOI-ESF, 1987; Purdy and Dziewonski, 1988;

BOREHOLE, JOI/USSAC, 1995; Montagner and Lancelot, 1995; Ocean Drilling Program Long Range Plan, 1996). The objective is to understand the processes driving Earth's dynamical systems from a global to a regional scale by imaging the Earth's interior with seismic waves. Unfortunately, few seismometers are located on the 71% of the Earth's surface covered by oceans and this makes accurate imaging of some parts of the mantle impossible. New ocean-bottom sensors, the location of which have to be carefully selected to maximize results (Fig. 1), are needed to accomplish the goals of the international geoscience programs that rely on earthquake data. Aside from Site WP-1B, which will be drilled and instrumented on Leg 195, several other western Pacific sites have been selected for instrumentation. Observatories at Sites 1150 and 1151, on the inner wall of the Japan Trench (JT on Fig. 1), were installed during Leg 186 (Suyehiro, Sacks, and Acton, in press). In addition, Site WP-2, located in the northwest Pacific Basin, is scheduled to be drilled and instrumented during Leg 191 from July through September 2000.

Aside from plugging an important gap in the global seismic array, the Site WP-1B observatory will produce high-quality digital seismic data. Tests with other borehole seismometers show the noise level for oceanic borehole instruments is much lower than most land counterparts (e.g., Stephen et al., 1999; Fig. 4). Recent studies that exploit high-quality digital seismic data obtained on land have shown exciting new phenomena on mantle flows. In the western Pacific, for example, Tanimoto (1988) demonstrated the existence of a strong $l = 2$ (angular order) pattern of deep (>550 km) high-velocity anomalies from waveform inversions of R2, G1, G2, X1, and X2 surface waves. This suggests a complex interaction of subducting slabs with the surrounding mantle, including the 670-km discontinuity in the region (Tanimoto, 1988). However, because of sparse global coverage by existing seismic stations, current seismic wave resolution is insufficient to image the actual interaction of the plates with the mantle. More recent studies show the potential of new mantle imaging techniques, with finer scale images having been obtained in certain locations where high-quality data are dense, such as the deep extension of velocity anomaly beneath ridges (Zhang and Tanimoto, 1992; Su et al., 1992) or the fate of subducted plates at the 670-km discontinuity (van der Hilst et al., 1991; Fukao et al., 1992). These detailed conclusions come from extraction of more information from existing seismograms. Such studies are limited by sparse data coverage, a barrier that new ocean bottom stations can help break.

Seismic Observatory Design

The WP-1B observatory will be equipped with two broadband seismometers (Guralp CMG-1) attached to a pipe hung from the reentry cone (Figs. 5, 6), which will position the seismometers near the bottom of the cored hole. Installation of two identical seismometers will add redundancy to the observatory. A back-up sensor (PMD2023) also will be included. However, a combination of one Guralp CMG-1 seismometer and an additional back-up sensor (PMD2023) is an option. Signals from the seismometers will pass uphole by wires and be recorded in a data control box with a multiple-access expandable gateway (MEG). The observatory will be powered for about 3 yr by four units of 6-Watt batteries (SWB 1200, Kornsburg Simrad) attached to a battery frame that sits on the reentry cone (Figs. 5, 6).

In September 1989, a feedback-type accelerometer capsule was installed in Hole 794D in the Japan Sea during Leg 128 (Ingle et al., 1990; Suyehiro et al., 1992, 1995). The instrument recorded a teleseismic event (body-wave magnitude [Mb] 5.4 at ~4000-km epicentral distance) that clearly showed a surface wave dispersion train (Kanazawa et al., 1992). In May, a comparison of seafloor and borehole (Hole 396B) sensors was made using a deep-sea submersible for installation and recovery (Montagner et al., 1994). Although, at this stage, there is no consensus as to how we should establish seafloor seismic observatories, it is becoming clearer that oceans can provide low-noise environments. In August 1999, a seismometer and a strainmeter were cemented at Sites 1150 and 1151 in the deep-sea terrace of the Japan Trench during Leg 186 (Suyehiro, Sacks, Acton et al., in press). The tool was cemented in place to stop fluid motion around the sensors to lower the noise level and to record broadband seismic observations with high sensitivity. Because it is imperative that no fluid motion occur around the broadband seismometers at proposed Site WP-1B, the sensors will be cemented during Leg 195 as well. Once instruments are installed at the site, an ROV will activate the observatory by handling underwater mateable connectors (UMCs). In 2001, *Kaiko*, an ROV (Fig. 3) designed to operate in water depths up to 10,000 m by the Japanese Agency of Marine Science and Technology Center (JAMSTEC), will visit Site WP-1B to begin seismic observations.

Geologic Setting

Site WP-1B is located in the west Philippine Sea about 100 km west of the inactive Kyushu-Palau Ridge and 450 km north of the extinct Central Basin Fault (Fig. 2). Early interpretations of magnetic lineations (Hilde and Lee, 1984) indicate that the site lies on 49-Ma crust near Chron 21 and formed by northeast-southwest spreading on the Central Basin Fault. The spreading direction then changed to north-south at ~45 Ma and finally ceased at ~35 Ma. Because the earliest magnetic anomalies in the region predate the initiation of subduction at ~45 Ma along the Kyushu-Palau Ridge, Hilde and Lee considered that the Philippine Sea formed by entrapment of an older Pacific spreading ridge. More recent bathymetric and magnetic surveys (Okino et al., 1999) show that the site lies at the transition from well-defined anomalies south of the Oki-Daito Ridge to more complicated anomalies to the north, which implies that the crust to the north may have formed at a different spreading center.

SCIENTIFIC OBJECTIVES

Structure of the Philippine Sea Plate

The observations of seismic surface waves as well as various phases of body waves from earthquakes at the Philippine Sea plate margins will provide sufficient data to map differences in plate structures among different basins comprising the plate, e.g., the west Philippine; Shikoku, Japan; and Parece Vela Basins. Only a few previous studies with limited resolution exist on the lithospheric structure (Kanamori and Abe, 1968; Seekins and Teng, 1977; Goodman and Bibee, 1991). Surface wave data suggest that the plate is only ~30 km thick (Kanamori and Abe, 1968; Seekins and Teng, 1977). Such a value is inconsistent with predicted values from age vs. heat flow or depth curves (Louden, 1980). A long-line (500 km) seismic refraction experiment in the west Philippine Basin could not image the lithosphere/asthenosphere boundary (Goodman and Bibee, 1991).

Uppermantle Structure Beneath the Philippine Sea

Previous studies of spreading scenarios for the Philippine Sea have focused on kinematic processes. There is no consensus as to how marginal seas open, whether or not a single mechanism explains all backarc basins, or how the basins disappear. The mapping of the mantle flow and the subducting plate geometry is essential for understanding the dynamics of the mantle.

There are indications that the subducting Pacific plate does not penetrate below the 670-km discontinuity, and that it extends horizontally (Fukao et al., 1992; Fukao, 1992), but the resolution of these studies is poor (>1000 km) beneath the Philippine Sea and the northwestern Pacific, especially in the upper mantle, where significant discontinuities and lateral heterogeneities exist (Fukao, 1992). Site WP-1B will be a crucial network component in determining whether the Pacific plate is penetrating into the lower mantle in the Marianas Trench but not in the Izu-Ogasawara (Bonin) Trench and, if so, to understanding why (van der Hilst et al., 1991; Fukao et al., 1992; van der Hilst and Seno, 1993). In addition, Site WP-1B will allow imaging of the subducting slab to determine how the stagnant slab eventually sinks into the lower mantle (Ringwood and Irifune, 1988). Also, the mantle heterogeneity that causes the basalts sampled from the western Pacific marginal basins to have Indian Ocean ridge type isotopic characteristics (Hickey-Vargas et al., 1995) may be inferred from the detailed image of the mantle flow.

Important Component of ION

A global seismographic network was envisioned by the Federation of Digital Seismographic Networks to achieve a homogeneous coverage of the Earth's surface with at least one station per 2000 km in the northwestern Pacific area (Fig.1). Thus, the Site WP-1B seismic observatory will provide invaluable data, obtainable in no other fashion, for global seismology. Data from this observatory will help revolutionize studies of global Earth structure and upper mantle dynamics by providing higher resolution of mantle and lithosphere structures in areas now poorly imaged. In addition, this observatory will provide data from the backarc side of the Izu-Oagasawara, Mariana Trenches, giving greater accuracy and resolution of earthquake locations and source mechanisms.

Basalt Chemistry and Crustal Thickness

Recent studies on the relationship between midocean ridge basalt (MORB) chemistry and crustal thickness indicate that the degree of partial melting is strongly controlled by the temperature of the upwelling mantle at the ridge. The volume of the melt (represented by the crustal thickness) and its chemical composition are sensitive to the temperature. This means that a knowledge of crustal thickness in an oceanic basin makes it possible to estimate the temperature at which the crust was formed and the concentration of major and minor chemical elements in the resulting basalts (e.g., Klein and Langmuir, 1987; White and Hochella, 1992). To date, this type of work has concentrated on young MORBs. The chemical model on which these predictions are based still has large uncertainties, partly because there are few cases where the rock samples and high-quality seismic data were collected at the same location. Chemical analysis of the basalt samples from WP-1B should provide clues as to why the crust is thinner (3 to 4 km) than normal and whether it is because of the differences in the initial temperature conditions of the lithosphere.

Age of Basement

Although the age of the basement in the northern west Philippine Sea has been estimated from magnetic anomalies, paleontologic confirmation has been imprecise because of spot coring, core disturbance, and poor preservation of microfossils. By continuous coring to basement using modern coring techniques, we hope to obtain an accurate basement age from undisturbed microfossils, magnetostratigraphy, or radiometric dating of ash horizons. This information will be of considerable importance in constraining models of backarc spreading.

Tertiary Climate Record

Previous drilling in the west Philippine Sea was conducted on DSDP Legs 31 and 59 before the advent of piston coring and many of the holes were only spot cored. As a consequence, the available core from the region is almost useless for stratigraphic and paleontologic reconstructions. By obtaining a continuous, high-quality record of pelagic sedimentation supplemented by high-quality logs, we hope to obtain a proxy record of Tertiary climate change for the region. It is anticipated that the upper levels of the section may also contain a record of aeolian transport from Eurasia.

Ashfall Record

Although ash and tuff were present in the sediments recovered in the region on previous legs, it was impossible to reconstruct the ashfall stratigraphy because of core disturbance and the discontinuous nature of the coring. By continuous coring using advanced hydraulic piston coring (APC) and extended core barrel (XCB) techniques and correlation with high-resolution Formation MicroScanner (FMS), natural-gamma spectrometry tool (NGT), and ultrasonic borehole imager (UBI) logs, we hope to obtain a detailed record of arc volcanism around the Philippine Sea.

Philippine Plate Paleolatitude and Tectonic Drift

Paleomagnetic measurements of sediments and basalt cores are important because oriented samples are difficult to obtain from the oceans. The basalts record the direction of the magnetic field at the time the basalts were emplaced and can be used to infer the paleolatitude of the site (e.g., Cox and Gordon, 1984). Although it is unlikely that enough flow units will be cored at Site WP-1B to average secular variation adequately, the results will be useful in determining a Paleogene paleomagnetic pole for the Philippine plate. Sediments are typically a good recorder of the Earth's magnetic field and should contain a continuous record of movement of the Philippine plate through the Cenozoic.

PROPOSED SITE

Site WP-1B

Proposed Site WP-1B is situated on flat seafloor at a water depth of 5640 meters below sea level (mbsl) ~100 km west of the Kyushu-Palau Ridge axis along the eastern edge of the west Philippine Basin. The site lies on Chron 21, suggesting a basement age of 49 Ma. The sediment section is predicted to be ~400 to 450 m thick based on recent seismic reflection surveys showing a two-way traveltime to basement of 0.5 s. Drilling at other sites in the region on Legs 31 and 59 (Karig et al., 1975; Kroenke et al., 1980) recovered a relatively barren, deep-water section dominated by Holocene to Eocene/Paleocene(?) brown pelagic silty clays overlying basement near the Oki-Daito Ridge (DSDP Sites 294/295). At DSDP Sites 290 and 447 to the south, the section consists of a barren interval of Pliocene clays underlaid with Oligocene nannofossil-bearing silty clays mixed with ash. This was underlain by a thick section of polymict and volcanic breccias presumably derived from the Kyushu-Palau Ridge. Overlying basement consists of 80% basalt pillows and 20% dolerite. Because Site WP-1B lies in a similar setting at the foot of the Kyushu-Palau Ridge, it is likely that the section at the proposed site will be similar to that at Sites 290 and 497.

DRILLING STRATEGY

The proposed Site WP-1B drilling program consists of coring two pilot holes (A and B) to characterize the site prior to a third hole (c), in which a reentry cone and casing string will be set and the ION instrument string installed. Time on site estimates to accomplish these objectives are ~26 days. Coring/drilling Holes A and B will consume 10.8 days including wireline logging. Installation and setting up the reentry cone and casing for Hole C is estimated at 7.5 days, with the remaining time on site devoted to the installation of the instrument and battery package (Figs. 5, 6). Should time permit we are planning to core a fourth hole (D) with the APC/XCB as deep as possible.

Oriented piston coring with the APC to refusal (~200 mbsf) will be used in the first hole to ensure the most complete recovery and characterization of the upper sedimentary section. Below that, single XCB coring will be used to core the remaining sedimentary rock above basaltic basement (~370 mbsf), and an additional 10 m into basement, if possible. Hole B will be washed/drilled down with the rotary core barrel (RCB) to ~360 mbsf. Coring will commence and continue ~100 mbsf into the basaltic basement. A full suite of wireline logging will then be initiated (see the "Logging Plan" section).

A reentry cone will then be assembled and lowered to the seafloor with ~60 m of 16-in casing (actual length to be determined by a jet-in test after completion of Hole A). It will be washed to depth and the reentry cone released on the seafloor. The drill string will then be recovered and a drilling bottom-hole assembly (BHA) made up with a 14-3/4 in tricone bit. Hole C will then be reentered and the hole deepened to ~425 mbsf. The drill string will again be recovered before making up ~410 m of 10-3/4 in casing. The 10-3/4 in casing string will be cemented in place ~40 m into basement. The drill string will then be recovered and the final BHA to drill a 9-7/8-in hole will be assembled. Because the instrument string should be located in a relatively homogeneous and unfractured zone, the hole is planned to be ~100 m into basalt basement. Actual penetration will be decided upon in the field. This decision will be based on information provided by the cores and the wireline logs from Hole B, drilling data provided by the drillers, and the amount of allowable time remaining in the program to complete the leg objectives.

After the hole is drilled to depth and the drill string recovered, the instrument package will be made up and attached to the 4-1/2 in deployment casing. The instrument package for Leg 195 consists of two seismometers (Fig. 5, 6). Centralizers will be equally spaced on the casing string to keep it centralized within the borehole. Once lowered into place, the instruments will be cemented in place through the drill string and support tubing. Afterward, the drill string will be disconnected from the hanger/riser, leaving it at a predetermined height above the reentry cone (Fig. 6). A battery package will then be lowered into the throat of the reentry cone (Fig. 6) on the logging line and accoustically released. Finally, the drill string will be released and recovered back aboard the drillship.

SAMPLING PLAN

Sampling guidelines and policy are available at the following site: http://www-odp.tamu.edu/curation/sdp.htm. The Sample Allocation Committee (SAC), which consists of the two co-chiefs, staff scientist, and ODP curator onshore or curatorial representative aboard ship, will work with the entire science party to formulate a formal Leg 195-specific sampling plan for shipboard and postcruise sampling.

For Leg 195, we expect to recover ~400 m of sediment and <100 m basalt. All sample frequencies and sample volumes taken from the working half of the core must be justified on a scientific basis and will be dependent on core recovery, the full spectrum of other requests, and the cruise objectives. All sample requests must be made on the standard World Wide Web sample request form and approved by the SAC. Leg 195 shipboard scientists may expect to obtain a sufficient number of sediment samples to perform postcruise research and as many as 100 basalt samples of no more than 15 cm^3 in size. Additional samples may be obtained upon written request to ODP/TAMU (Texas A&M University) after initial data are analyzed. Depending on the penetration and recovery during Leg 195, the number of samples taken may be increased by the shipboard SAC. For example, studies requiring only small sample volumes (1 cm^3 or less, e.g., for veins, fluid inclusions, etc.) may require more than 100 samples to characterize a long section of core. The SAC will review the appropriate sampling interval for such studies as the cores are recovered. Samples larger than 15 cm^3 may also be obtained with approval of the SAC. Request for large samples must be specified on the sample request form. Sample requests may be submitted by shore-based investigators as well as the shipboard scientists. Based on sample requests received two months precruise, the SAC will prepare a temporary sampling plan, which will be revised on the ship as needed. Some redundancy of measurement is unavoidable, but minimizing redundancy of measurements among the shipboard party and identified shore-based collaborators will be a factor in evaluating sample requests.

If some critical intervals are recovered (e.g., fault gauge, ash layers, basement veins, etc.), there may be considerable demand for samples from a limited amount of cored material. These intervals may require special handling, a higher sampling density, reduced sampling size, or continuous core sampling by a single investigator. A sampling plan coordinated by the SAC may be required before critical intervals are sampled.

LOGGING PLAN

The logging program is designed to measure physical properties, hole shape, and to determine in situ stress, porosity, and fracture characteristics of the rock and sediment around the hole, which is important for a site intended for a long-term seismic observatory. The Formation MicroScanner will provide a detailed, oriented resistivity image of the borehole, including fractures and conductive zones. Temperature logs will be emphasized for identification of permeable zones and inflow/outflow from both drilling-induced and natural fractures in the hole. The spontaneous potential (SP) log will provide in situ measurement of the streaming potential, which is related to electrochemical and electrokinetic changes and pore-water flow in permeable formations. The ultrasonic borehole imager (UBI) will be used to characterize the shape and volume of the borehole in the vicinity of the seismometers. This will significantly improve success in grouting of the instruments. The UBI will also be used for the determination of breakouts for directional measurements of the in situ stress field. The dual laterolog (DLL) will permit a good characterization of highly resistive rocks from the oceanic basement because of its wide resistivity range.

At proposed Site WP-1B, we will run the standard triple-combo tool string, the FMS/sonic tool string (with a repeat pass in the basement interval), the DLL tool string, and the UBI in the basement interval. The triple combo tool string includes the natural gamma-ray sonde (NGS) to measure the natural radioactivity, the accelerator porosity sonde (APS) to measure porosity, the hostile environment lithodensity sonde (HLDS) to measure density, and the Dual Induction tool (DIT-E) to measure resistivity. The triple combo tool string also measures the spontaneous potential and makes a caliper measurement. The FMS/sonic tool string includes the Formation MicroScanner, the dipole shear sonic imager (DSI), and a natural gamma-ray tool (NGT). The DLL will be run with the NGT. We anticipate that it will take 38 hr for logging operations at Site WP-1B.

REFERENCES

Cox, A., and Gordon, R.G., 1984. Paleolatitudes determined from paleomagnetic data from vertical cores. *Rev. Geophys. Space Phys*., 22:47-72.

Fukao, Y., 1992. Seismic tomogram of the Earth's mantle: geodynamic implications. *Science*, 258:625-630.

Fukao, Y., Obayashi, M., Inoue, H., and Nenbai, M., 1992. Subducting slabs stagnant in the mantle transition zone. *J. Geophys. Res.*, 97:4809-4822.

Goodman, D., and Bibee, L.D., 1991. Measurements and modelling of possible mantle constituents from a long-line seismic refraction experiment in the West Philippine Basin. *Geophys. J. Int.*, 106:667-675.

Hickey-Vargas, R., Hergt, J.M., and Spadea, P., 1995. The Indian Ocean-type isotopic signature in western Pacific marginal basins: origin and significance. *In* Taylor, B., and Natland, J. (Eds.), *Active margins and marginal basins of the western Pacific*. Geophys. Monogr., Am. Geophysic. Union on Asilomar Conference, 88:175-197.

Hilde, T.W.C., and Lee, C-S., 1984. Origin and evolution of the West Philippine Basin: A new interpretation. *Tectonophysics*, 102:85-104.

Ingle, J.C., Jr., Suyehiro, K., von Breymann, M.T., et al., 1990. *Proc. ODP, Init. Repts.*, 128: College Station, TX (Ocean Drilling Program).

JOI-ESF, 1987. Report of the Second Conference on Scientific Ocean Drilling. Washington (JOI, Inc.).

JOI/USSAC, 1994. BOREHOLE: a plan to advance post-drilling sub-seafloor science. JOI/USSAC Workshop Rep., Univ. Miami, Miami, FL, 1-83.

Kanamori, H., and Abe, K., 1968. Deep structure of island arcs as revealed by surface waves. *Bull. Earthquake Res. Inst*., 46:1001-1025.

Kanazawa, T., Suyehiro, K., Hirata, N., and Shinohara, M., 1992. Performance of the ocean broadband downhole seismometer at Site 794. *In* Tamaki, K., Suyehiro, K., Allan, J., McWilliams, M., et al., *Proc. ODP, Sci. Results*, 127/128, (Pt. 2): College Station, TX (Ocean Drilling Program), 1157-1171.

Karig, D.E., Ingle, J.C., Jr., et al., 1975. *Init. Repts. DSDP*, 31: Washington (U.S. Govt. Printing Office).

Klein, E.M., and Langmuir, C.H., 1987. Global correlations of ocean ridge basalt chemistry with axial depth and crustal thickness. *J. Geophys. Res.*, B, 92:8089-8115.

Kroenke, L., Scott, R., et al., 1980. *Init. Repts. DSDP*, 59: Washington (U.S. Govt. Printing Office).

Louden, K.E., 1980. The crustal and lithospheric thicknesses of the Philippine Sea as compared to the Pacific. *Earth Planet.Sci. Lett.*, 50:275-288.

Montagner, J.-P., Karczewski, J-F., Romanowicz, B., Bouaricha, S., Lognonne, P., Roult, G., Stutzmann, E., Thirot, J.L., Brion, J., Dole, B., Fouassier, D., Koenig, J.-C., Savary, J., Floury, L., Dupond, J., Echardour, A., and Floc, H., 1994. The French pilot experiment OFM-SISMOBS: first scientific results on noise level and event detection. *Phys. Earth Planet. Inter.*, 84:321-336.

Montagner, J.-P., and Lancelot, Y. (Eds.), 1995. Multidisciplinary observatories on the deep seafloor, (INSU/CNRS, IFREMER, ODP-France, OSN/USSAC, ODP-Japan).

Ocean Drilling Program, 1996. Understanding Our Dynamic Earth through Ocean Drilling: Ocean Drilling Program Long Range Plan Into the 21st Century. Washington (Joint Oceanographic Institutions).

Okino, K., Ohara, Y., Kasuga, S., and Kato, Y., 1999. The Philippine Sea: new survey results reveal the structure and the history of marginal basins. *GRL.*, 26:2287-2290.

Purdy, G.M., and Dziewonski, A.M., 1988. *Proc. of a Workshop on Broadband Downhole Seismometers in the Deep Ocean*. Woods Hole Oceanographic Institution.

Ringwood, A.E., and Irifune, T., 1988. Nature of the 650 km seismic discontinuity: Implications for mantle dynamics and differentiation. *Nature*, 331:131-136.

Seekins, L.C., and Teng, T.L., 1977. Lateral variations in the structure of the Philippine Sea plate. *J. Geophys., Res.*, 82:317-324.

Stephen, R.A., Collins, J.A., and Peal, K.R., 1999. Seafloor seismic stations perform well. *Eos*, 80:592.

Su, W.J., Woodward, R.L., and Dziewonski, A.M., 1992. Deep origin of mid-ocean ridge velocity anomalies. *Nature*, 360:149-152.

Suyehiro, K., Kanazawa, T., Hirata, N., Shinohara, M., and Kinoshita, H., 1992. Broadband downhole digital seismometer experiment at Site 794: a technical paper. *In* Tamaki, K., Suyehiro, K., Allan, J., McWilliams, M., et al., *Proc. ODP, Sci. Results*, 127/128 (Pt. 2): College Station, TX (Ocean Drilling Program), 1061-1073.

Suyehiro, K., Kanazawa, T., Hirata, N., and Shinohara, M., 1995. Ocean downhole seismic project. *J. Phys. Earth*, 43:599-618.

Suyehiro, K., Sacks, S., Acton, G.D., et al., in press. *Proc. ODP, Init. Repts*, 186 [CD-ROM]. Available from: Ocean Drilling Program, Texas A&M University, College Station TX 77845-9547, USA.

Suyehiro, K., Sacks, S., Araki, E., Linde, A., Shinohara, M., and Leg 186 Science Party, 1999. Monitoring plate subduction in the Japan Trench. Am. Geophys. Union, 1999 Fall Meeting ()S21A-92). [Abstract].

Tanimoto, T., 1988. The 3-D shear wave structure in the mantle by overtone waveform inversion - II. Inversion of X-waves, R-waves, and G-waves. *J. Geophys*., 93:321-334.

Van der Hilst, R.D., Engdahl, R., Spakman, W., and Nolet, G., 1991. Tomographic imaging of subducted lithosphere below northwest Pacific island arcs. *Nature*, 353:37-43.

Van der Hilst, R.D., and Seno, T., 1993. Effects of relative plate motion on the deep structure and penetration depth of slabs below the Izu-Bonin and Mariana island arcs. *Earth Planet. Sci. Lett.*, 120:395-407.

White, A.F., and Hochella, M.F., 1992. Surface chemistry associated with the cooling and subaerial weathering of Recent basalt flows. *Geochim. Cosmochim. Acta,* 56:3711-3721.

Zhang, Y.S., and Tanimoto, T., 1992. Ridges, hotspots and their interpretation as observed in seismic velocity maps. *Nature,* 355:45-49.

FIGURE CAPTIONS

Figure 1. A. Location map of seismic station coverage in the northwest Pacific. Stations needed in the oceans worldwide. At least five major plates with consuming boundaries interact in the northwest Pacific, causing subduction, back-arc opening, slab collisions, terrane accretion, and island arc development. Solid circles indicate land seismic stations, whereas open circles are current and proposed seafloor borehole observatories. Note that a few borehole stations effectively complement and expand the existing network. YSS = Yuzhno Sakhalinsk, Russia, 46.9583°N, 142.7610°E; NMR = Nemuro, Japan, 36.1525°N, 145.7430°E; PHN = Pohang, Korea, 36.03°N, 129.36°E; HCH = Hachijo-shima, Japan, Reserved; OGS = Chichi-jima, Japan, 27.0570°N, 142.2030°; MCSJ = Minami-tori-shima, Japan, 24.290°N, 153.978°E; ISG = Ishigaki, Japan, 24.3793°N, 124.2347°E; PATS = Ponsei, Micronesia, 6.8367°N, 158.3125°E; PMG = Port Moresby, Papua New Guinea, -9.41°N, 147.16°E; TGY = Tagaytay, Philippines, 14.10°N, 120.94°E. **B.** Location of proposed Site WP-1B in relation to global seismicity. M = magnitude.

Figure 2. Location map showing Deep Sea Drilling Project Sites 290, 294, 295, and 447 and proposed Site WP-1B in the Philippine Sea.

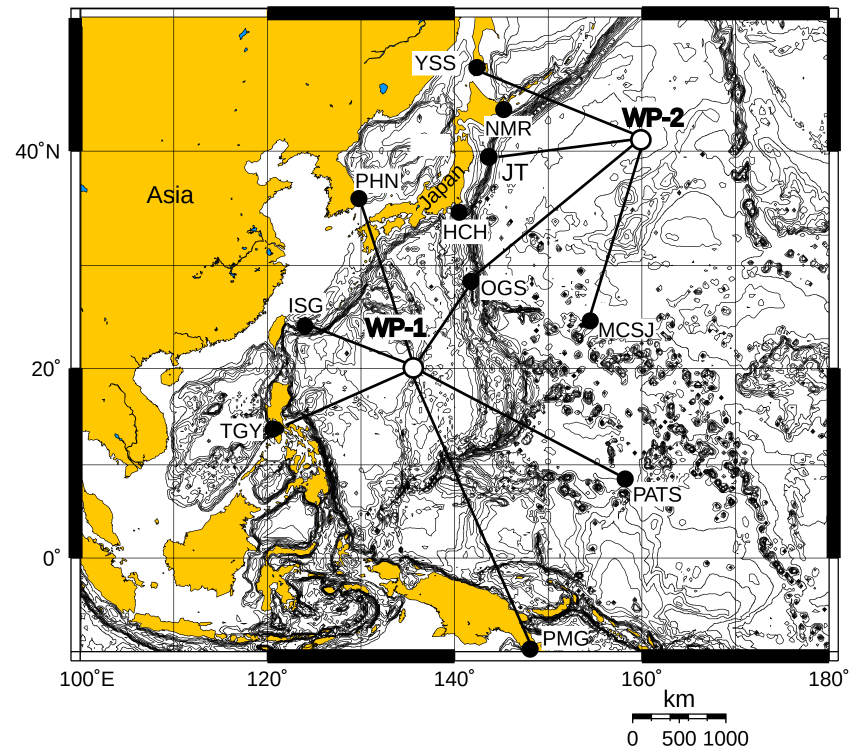
Figure 3. Photograph of the Japan Marine Science and Technology Center's (JAMSTEC) ROV, the *Kaiko*. All seafloor assembly electrical connections, the data storage unit, and the data handling and control unit (see Fig. 5A and 5B) can be removed and replaced by such an ROV. The *Kaiko* will visit Site WP-1B to activate the borehole observatory after Leg 195.

Figure 4. Noise spectra from the borehole seismometer at Site JT-1 (Leg 186) off Sanriku, Japan (from Suyehiro et al., 1999). The noise level is positioned at a satisfactory level between the high-noise model and the low-noise model. The rise of noise around 0.01 Hz is known to be infragravity wave noise induced from a long-period surface wave in the ocean. At Site WP-2, the borehole seismometer will be installed in the basement so that such serious noise should be sufficiently suppressed. The seismometer in Hole 1150D (proposed Site JT-1C; Leg 186) has a vertical (V) and two horizontal components that are perpendicular to each other. The direction of the horizontal components could not be determined during installation of the instrument; therefore, H1 and H2 denote the noise spectra from records of two horizontal components of the seismometer. dB = decibels.

Figure 5. A. Schematic block diagram of the seismic observatory components. **B.** Schematic configurations of the instrument package for broadband seismometry. All the equipment in this assembly is accessible to an ROV. Cables from the sensors grouted at ~500 mbsf terminate in a four-way underwater-mateable connector block. The data control unit (MEG) plugs into this connector block. A single output from the top of this package is coupled (by ROV) to the battery/recorder unit (PAT) installed after the sensors are grouted. A data recording unit (SAM) can be retrieved by an ROV when required. MEG = multiple-access expandable gateway. PAT = Power supply access terminal. SAM = storage acquistion module.

Figure 6. Schematic of the seafloor assembly with expected lithologies extrapolated from Leg 185. PAT = Power supply access terminal.

A


YSS
NMR
WP-2
40˚N
JT
PHN
Japan
Asia
HCH
OGS
ISG
WP-1
MCSJ
20˚
TGY
PATS
0˚
PMG
100˚E
120˚
140˚
160˚
180˚
km
0
500
1000

B

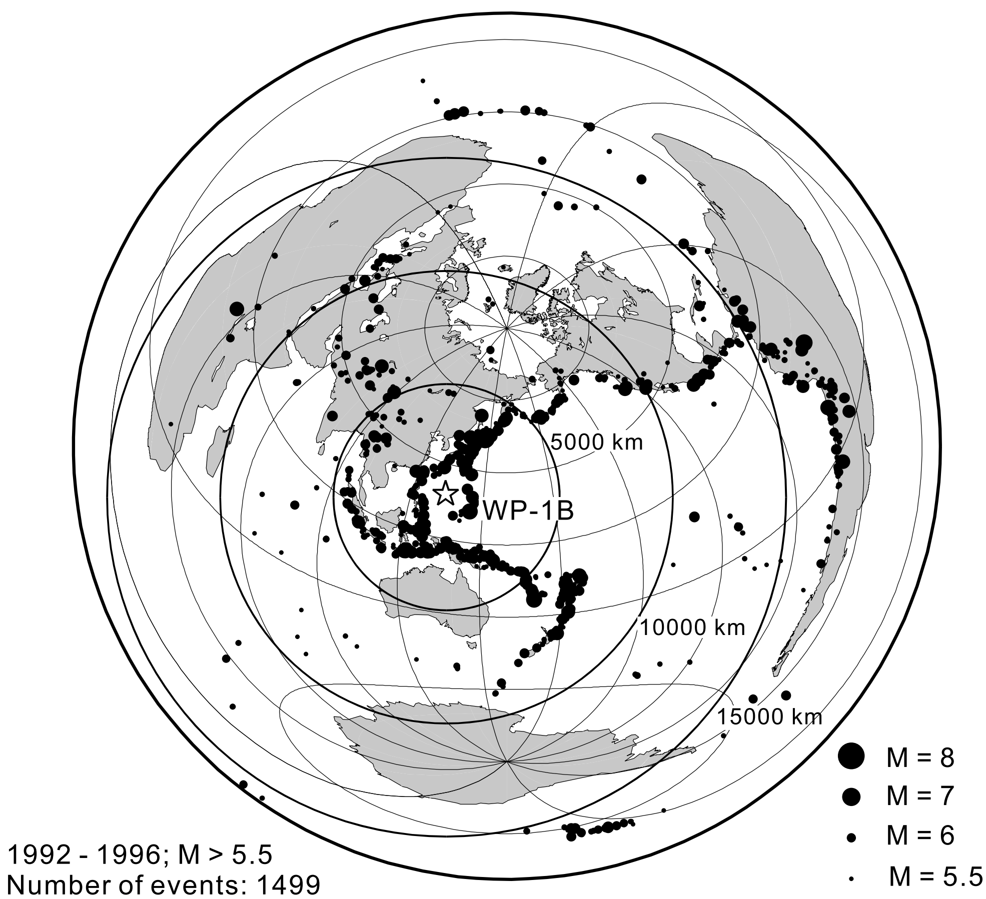

5000 km
WP-1B
10000 km
15000 km
M = 8
M = 7
M = 6
M = 5.5
1992 - 1996; M > 5.5
Number of events: 1499

Figure 1

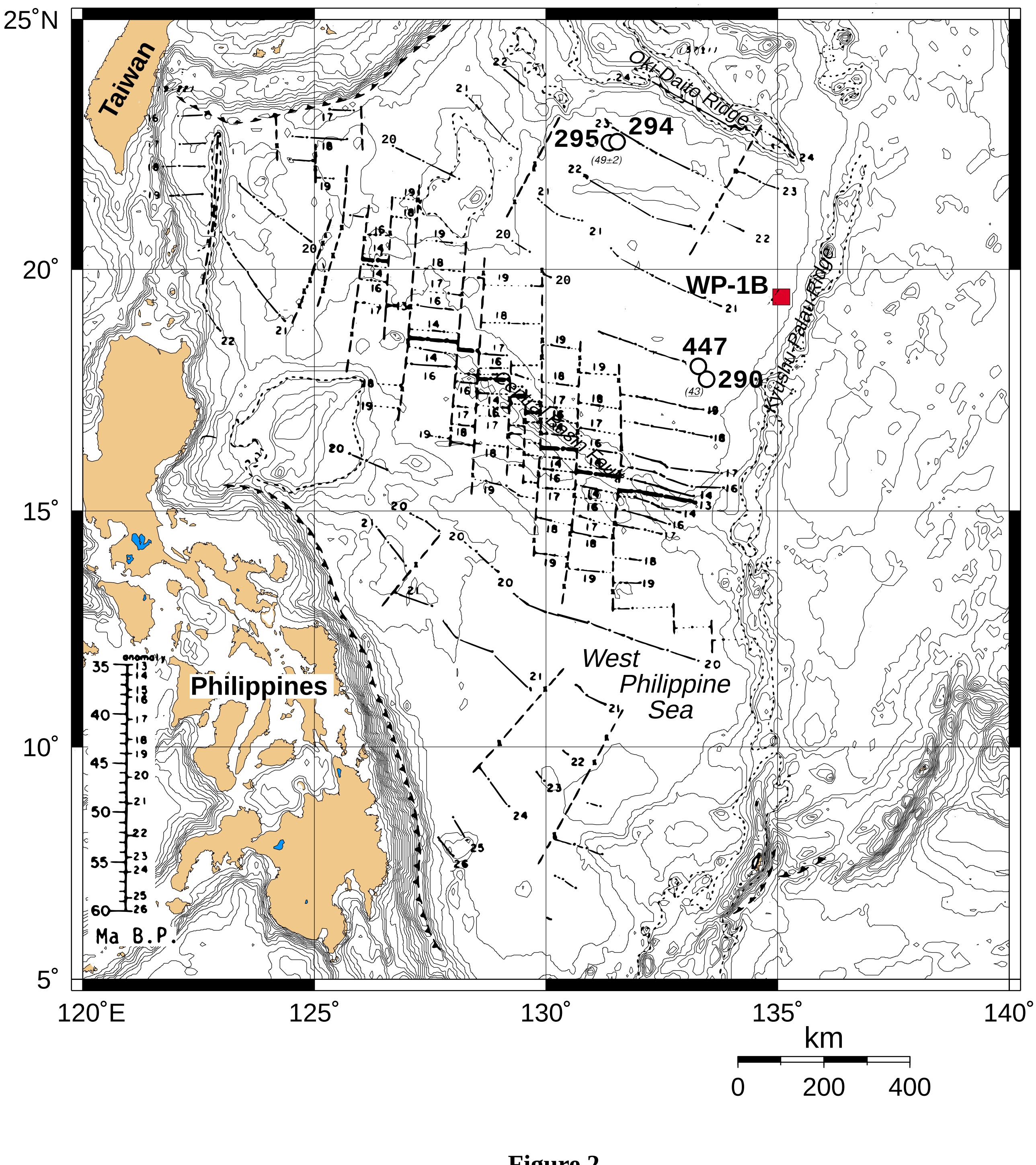

25°N
20°
15°
10°
5°
120°E
125°
130°
135°
140°
Taiwan
Philippines
Oki-Daito Ridge
Kyushu-Palau Ridge
Central Basin Fault
West Philippine Sea
295
294
(49±2)
WP-1B
447
290
(43)
km
0
200
400
anomaly
Ma B.P.

Figure 2

Figure 3

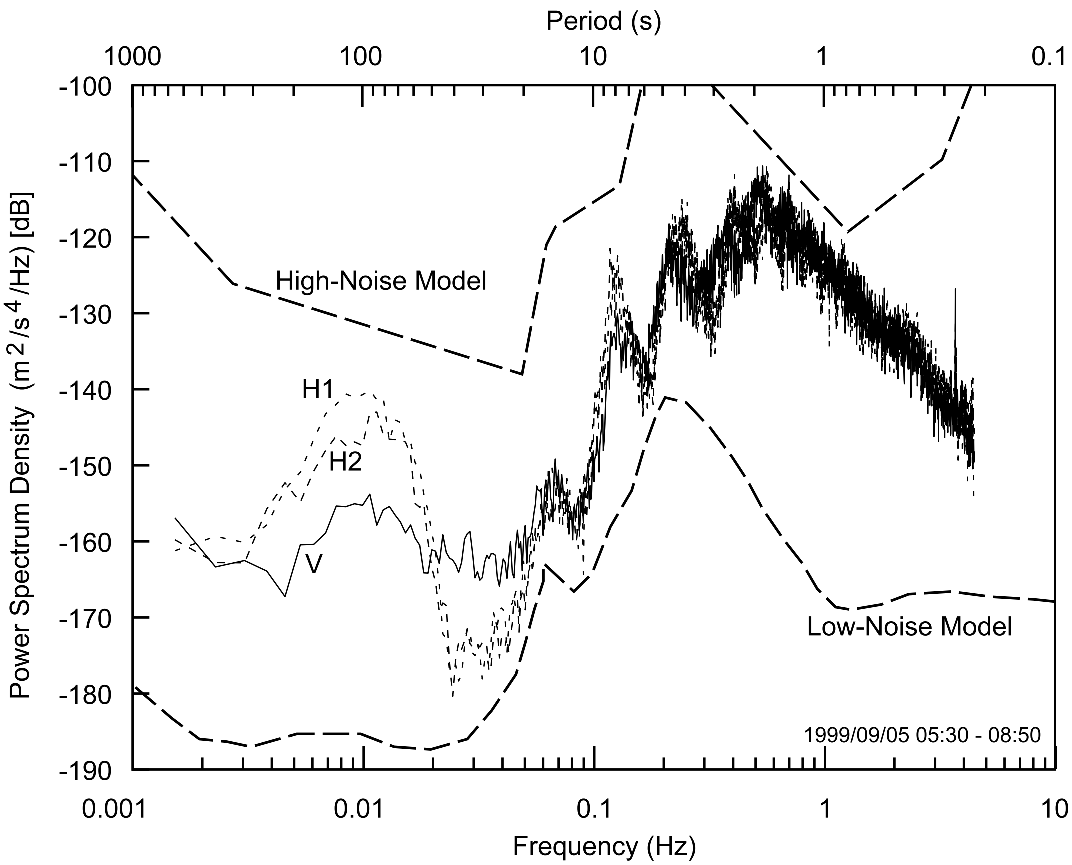

Period (s)
1000
100
10
1
0.1
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
Power Spectrum Density (m2/s4/Hz) [dB]
High-Noise Model
H1
H2
V
Low-Noise Model
1999/09/05 05:30 - 08:50
0.001
0.01
0.1
1
10
Frequency (Hz)

Figure 4

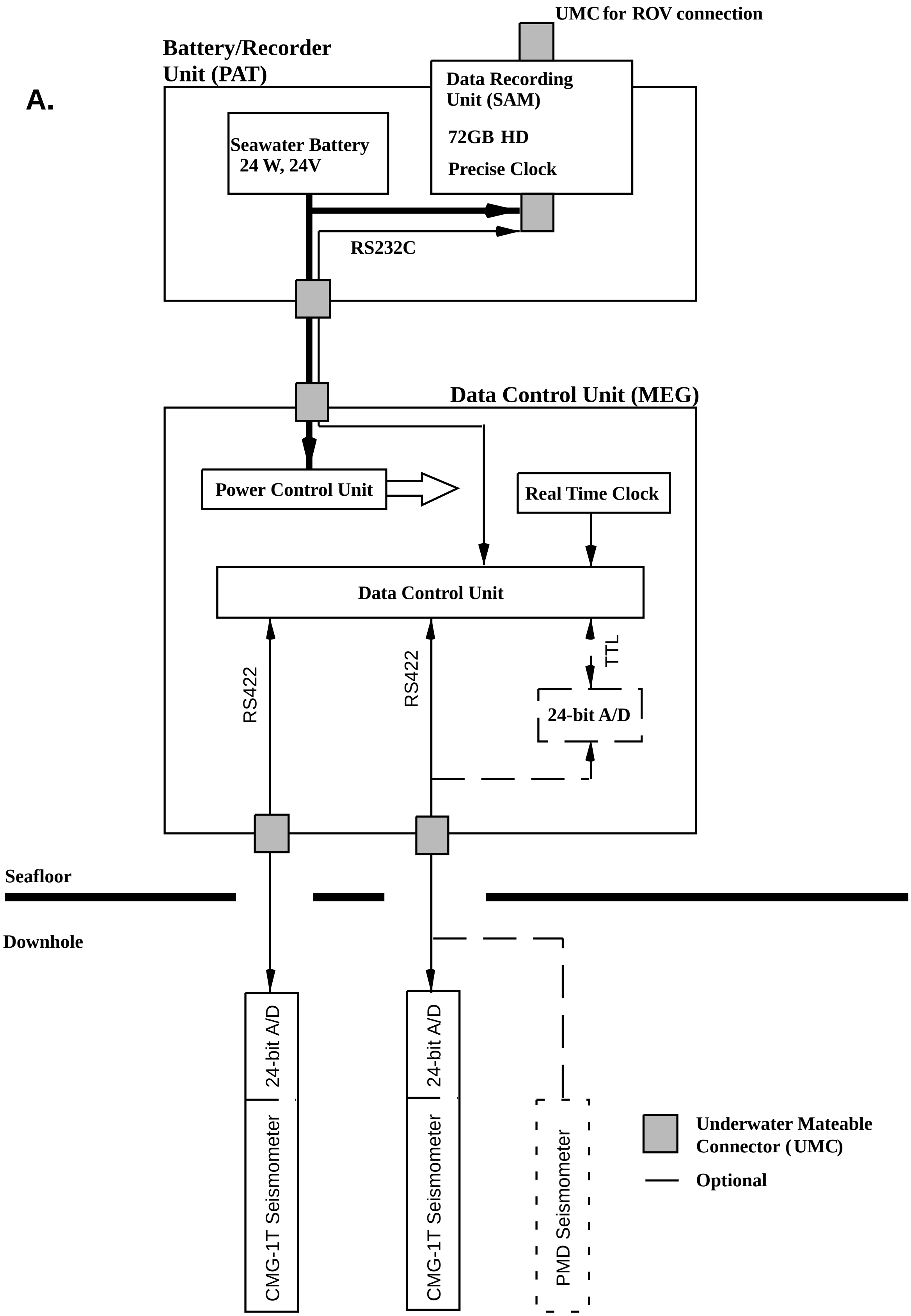

A.
UMC for ROV connection
Battery/Recorder
Unit (PAT)
Data Recording
Unit (SAM)
72GB HD
Precise Clock
Seawater Battery
24 W, 24V
RS232C
Data Control Unit (MEG)
Power Control Unit
Real Time Clock
Data Control Unit
RS422
RS422
TTL
24-bit A/D
Seafloor
Downhole
24-bit A/D
CMG-1T Seismometer
24-bit A/D
CMG-1T Seismometer
PMD Seismometer
Underwater Mateable
Connector (UMC)
Optional

Figure 5

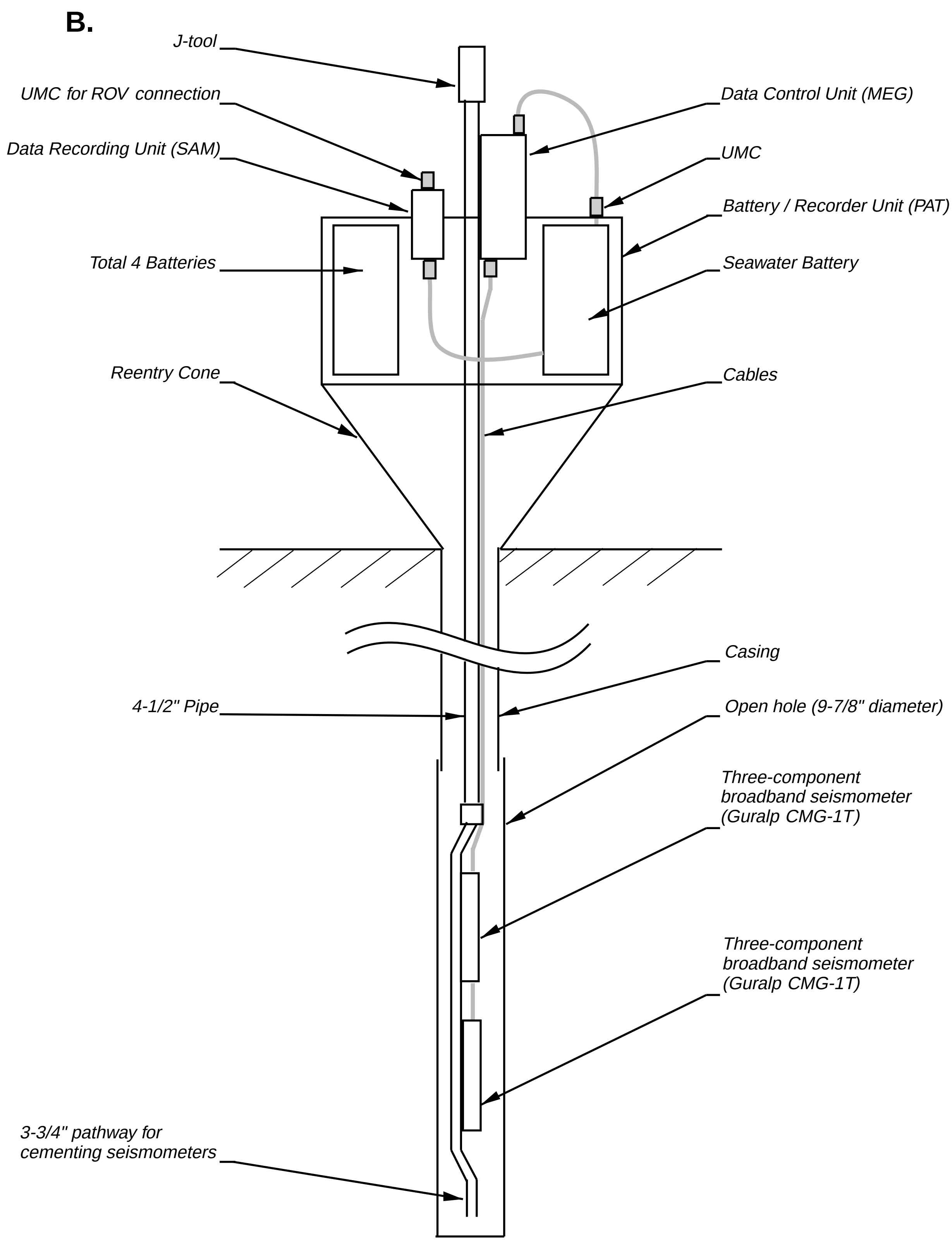


Figure 5 (continued)

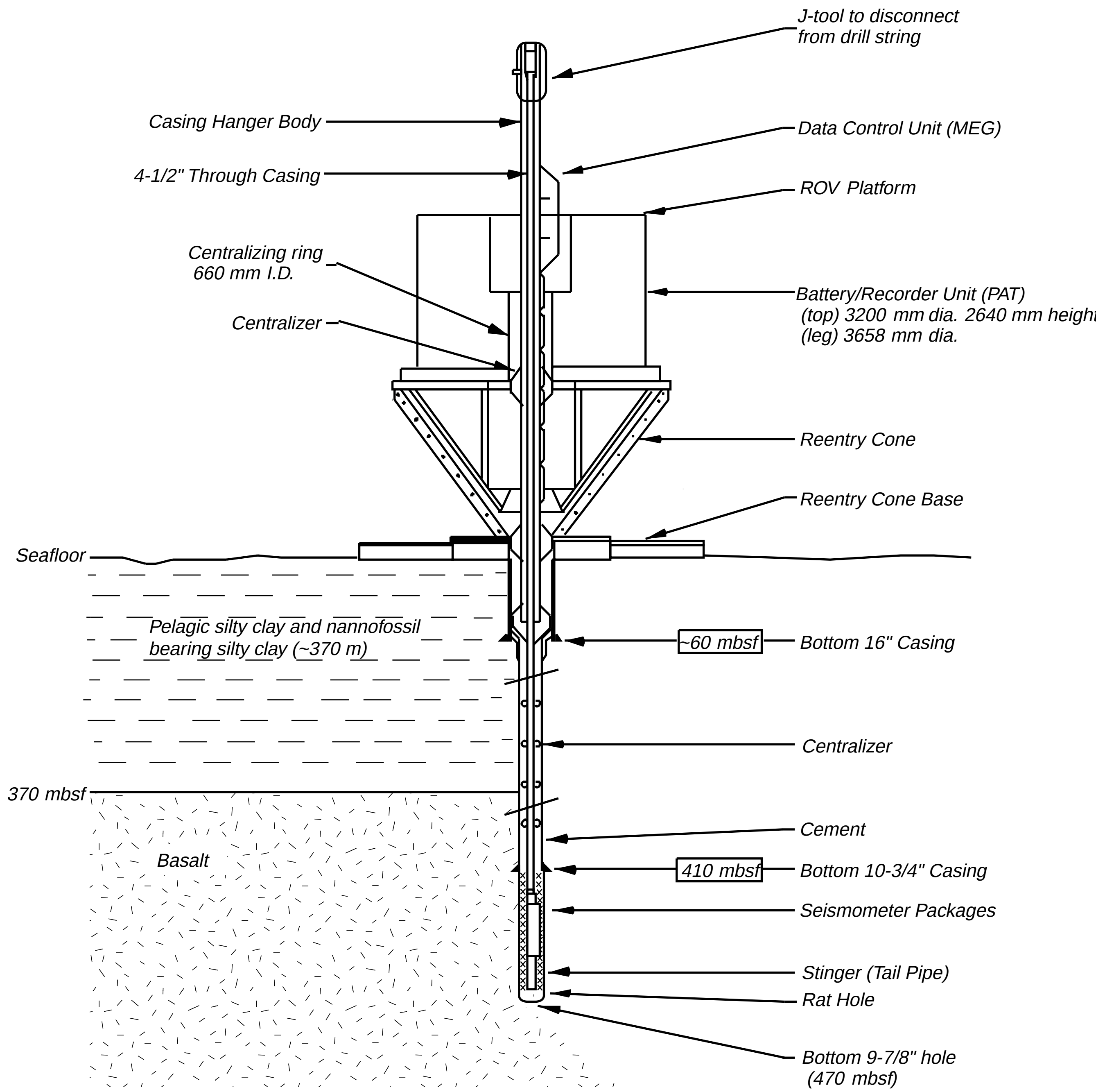
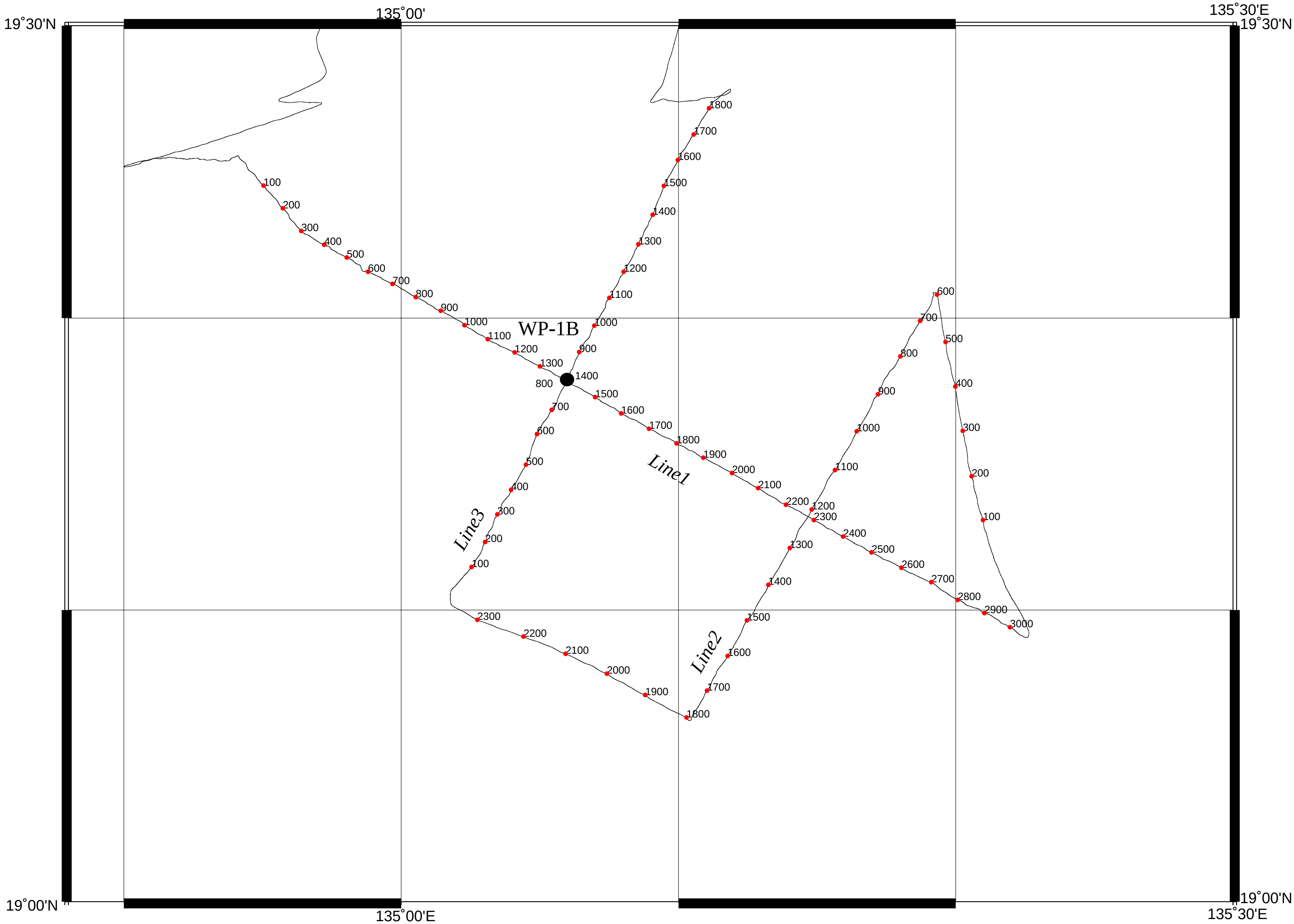

J-tool to disconnect from drill string
Casing Hanger Body
Data Control Unit (MEG)
4-1/2" Through Casing
ROV Platform
Centralizing ring 660 mm I.D.
Battery/Recorder Unit (PAT) (top) 3200 mm dia. 2640 mm height (leg) 3658 mm dia.
Centralizer
Reentry Cone
Reentry Cone Base
Seafloor
Pelagic silty clay and nannofossil bearing silty clay (~370 m)
~60 mbsf
Bottom 16" Casing
Centralizer
370 mbsf
Cement
Basalt
410 mbsf
Bottom 10-3/4" Casing
Seismometer Packages
Stinger (Tail Pipe)
Rat Hole
Bottom 9-7/8" hole (470 mbsf)

Figure 6

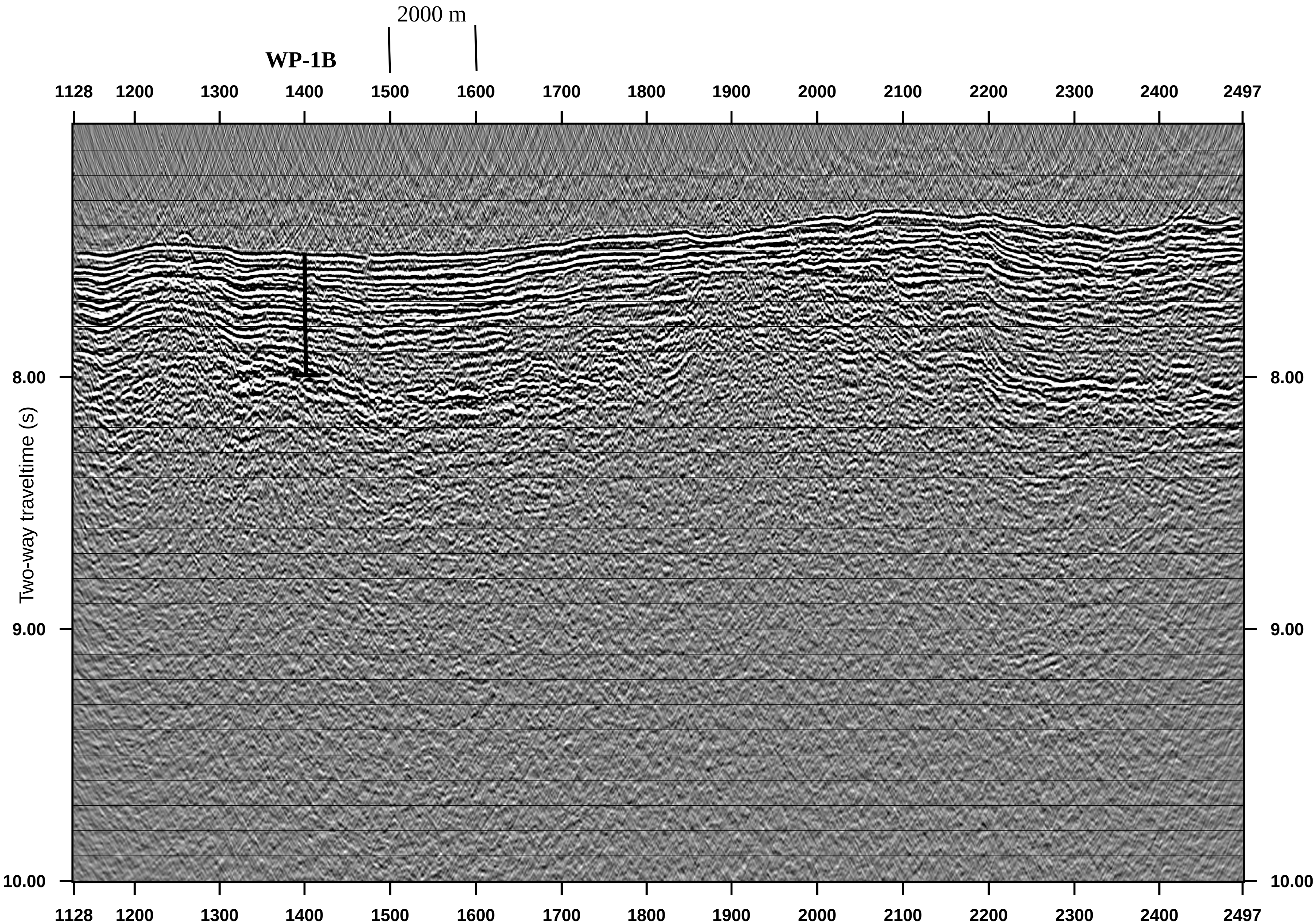
Leg 195 - WPAC Seismic Network/ION (Prop.431C Add4-Site WP-1B)

Operations Plan and Time Estimate:

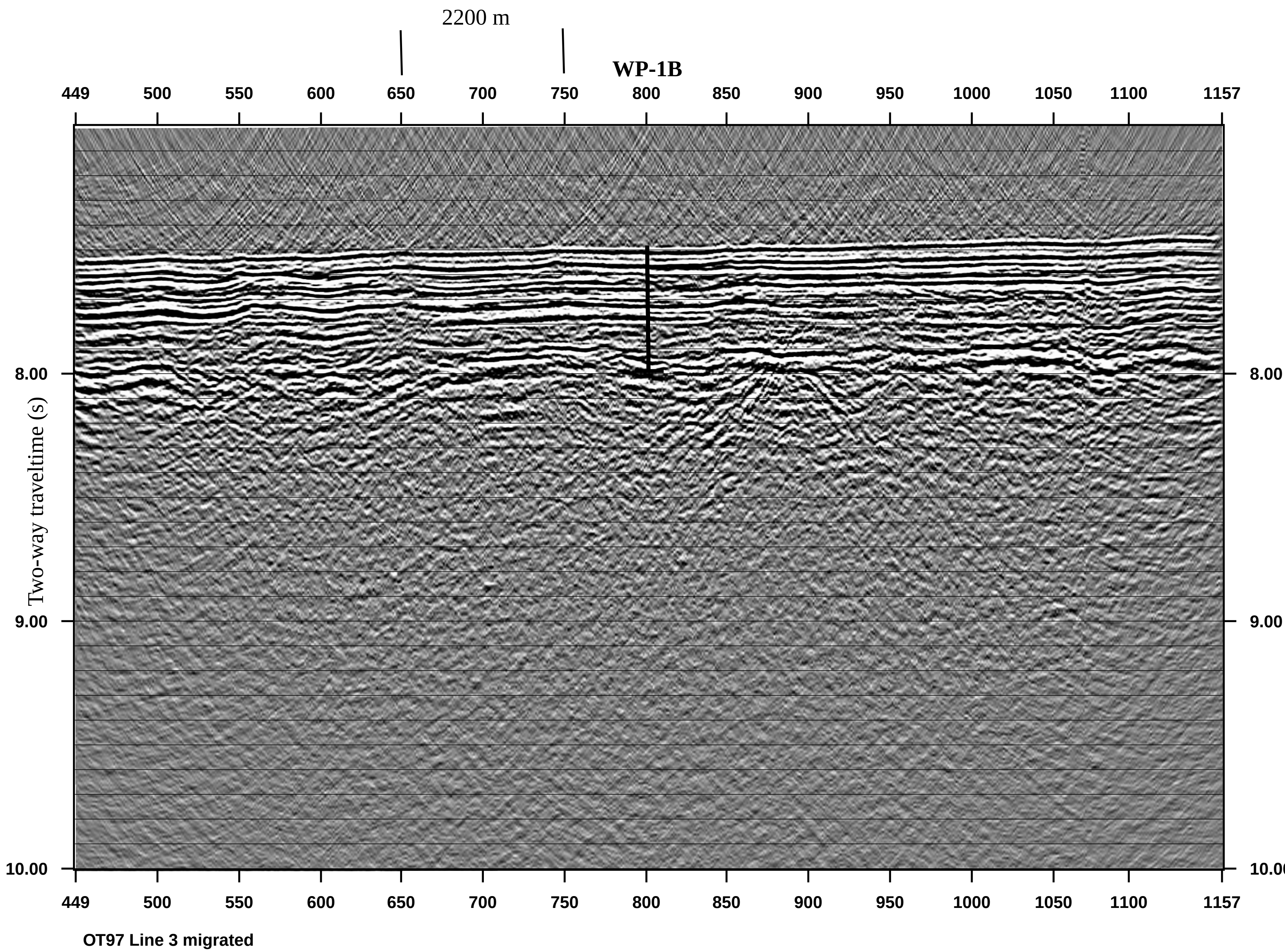
Site No.	Location (Lat/Long)	Water Depth (mbrf)	Operations Description (mbsf)	Transit (days)	Drilling (days)	Logging (days)	Total On-site (days)
Guam	13.27° N, 144.38° E		Transit f/Apra Harbor, Guam to WP-1B, ~664 nmi @ 10.5 kt [62.2 hr]	2.60			
			(Note: Clocks retarded 1 hour during transit)				
WP-1B	19°17.85'N	5658	Hole A: APC/XCB to ~380 mbsf (basement contact) [101.0 hrs]		4.2		26.0
	135°5.95'E		plug hole with cement then, after clearing sea floor,				
			conduct jet-in test for Hole C reentry cone installation				
			APC Core orientation, ~5 ea Adara temperature measurements				
			Hole B: Drill w/RCB c'bit to ~360 mbsf [120.2]		5.0	1.6	
			Core w/RCB to ~470 mbsf, release bit w/MBR				
			Wireline logging to include: rig-up, triple combo, FMS-sonic				
			(2-passes in basement), DLL, UBI, and rig-down [38.0 hrs]				
			Hole C: Set reentry cone, jet-in 60m 16" casing [365.5 hrs]		15.2		
			Drill to ~425 mbsf w/14-3/4" tricone bit				
			Set and cement ~410 m of 10-3/4" 54 lb/ft casing				
			Drill ahead to ~470 mbsf w/9-7/8" tricone bit				
			Deploy/cement seismometer instrument pkg @ ~460 mbsf				
			Deploy and release from battery platform				
			Hole D: Should operations in holes A thru C be completed ahead of		TBD		
			schedule, there is interest in drilling a second APC/XCB(?)				
			hole with any remaining time.				
			Note: At the time of this writing, the end port in Chinese Taipai was				
			still under evaluation. Keelung has been requested as the end port				
			for PR purposes. This is currently under review. This time estimate				
			and operating plan assumes Keelung as the end port, however				
			the initial port, Kao-hsuing is also shown for information only.				
Kao-hsiung	22.36°N, 120.17°E		Transit f/ WP-1B to Kao-hsiung, Taiwan, ~876 nmi @ 10.2 kt [84.9 hrs]	(3.54)			
or Keelung	25.09°N, 121.44°E		Transit f/ WP-1B to Keelung, Taiwan, ~826 nmi @ 10.2 kt [80.0 hrs]	3.33			
(Port for Taipei)			(Note: Clocks retarded 1 hour during transit)				
			SUBTOTAL:	**5.9**	**24.5**	**1.6**	**26.0**
			TOTAL OPERATING DAYS (Including 5 day port call):	**37.0**			



19°30'N
135°00'
135°30'E
19°30'N
WP-1B
Line1
Line2
Line3
19°00'N
135°00'E
135°30'E
19°00'N



OT97 Line 1 migrated


2200 m
WP-1B
449 500 550 600 650 700 750 800 850 900 950 1000 1050 1100 1157
Two-way traveltime (s)
8.00
9.00
10.00
OT97 Line 3 migrated

SITE SUMMARY

Site: WP-1B

Priority: 1
Position: 19°17.85´N, 135°05.95´E
Water Depth: 5658 meters below rig floor (mbrf)
Sediment Thickness: ~370 m
Target Drilling Depth: 470 mbsf
Approved Maximum Penetration: Pending PPSP approval
Seismic Coverage: Intersection of OT97 Line 1 and OT97 Line 3

Objectives: The objectives of Site WP-1B are to

1. Install long-term geophysical borehole observatory to monitor global seismicity.
2. Core 100 m of the upper basaltic oceanic crust to add knowledge of MORB chemistry and emplacement
3. Determine Philippine plate paleolatitude and tectonic drift
4. Determine Tertiary climate record
5. Determine the history of Tertiary aeolian transport
6. Determine the regional ashfall record

Drilling Program: APC/XCB to 380 mbsf, drill with RCB to 360 and core 100 m into basement (~470 mbsf). Drill instrumented borehole to ~470 mbsf, install reentry cone, and case through unstable section

Logging and Downhole Operations: Triple combo, FMS/sonic, DLL, UBI

Nature of Rock Anticipated: Brown pelagic silty clay underlain with Eocene-Oligocene nannofossil bearing silty clays with basal polymictic breccias and tuffs; basalt

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