OCEAN DRILLING PROGRAM

LEG 195 SCIENTIFIC PROSPECTUS

MARIANA CONVERGENT MARGIN/ WEST PHILIPPINE SEA SEISMIC OBSERVATORY

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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 Lorri L. Peters

ABSTRACT

Ocean Drilling Program Leg 195 consists of two science segments. The first segment is devoted to coring and setting a long-term observatory at the summit of South Chamorro Seamount (Site MAF-4B), which is a serpentine mud volcano on the forearc of the Mariana subduction system. The second segment is devoted to coring 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 subseafloor borehole observatory.

Drilling at the South Chamorro Seamount will (1) examine the processes of mass transport and geochemical cycling in the subduction zones and forearcs of nonaccretionary convergent margins; (2) ascertain the spatial variability of slab-related fluids within the forearc environment as a means of tracing dehydration, decarbonation, and water/rock reactions in subduction and supra-subduction zone environments; (3) study the metamorphic and tectonic history of nonaccretionary forearc regions; (4) investigate the physical properties of the subduction zone as controls over dehydration reactions and seismicity; and (5) investigate biological activity associated with subduction zone material from great depth.

The seismic observatory in the Philippine Sea 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

Operations during Leg 195 will concentrate on installing downhole instrumentation for two long-term observatories, one in the forearc of the Mariana subduction system, and the second in the middle of the Philippine plate (Fig. 1). Both sites will be cored to characterize the encountered materials (sediments, mud flows, and volcanics) and to achieve additional scientific objectives.

Mariana Subduction System

Geologic processes at convergent plate margins control geochemical cycling, seismicity, and deep biosphere activity within subduction zones. The study of input into a convergent plate margin by sampling the down-going plate provides the geochemical reference necessary to learn what geochemical factors influence the production of supra-subduction zone crust and mantle in these environments. The study of the output in terms of magma and volatiles in volcanic arcs and backarc basin settings constrains processes at work deep in the subduction zone, but these studies are incomplete without an understanding of the throughput, the nature of geochemical cycling that takes place between the time the subducting plate enters the trench and the time it reaches the zone of magma genesis beneath the arc. Tectonically induced circulation of fluids at convergent margins is a critical element in the understanding of chemical transport and cycling within convergent plate margins and ultimately in understanding global mass balance (e.g., COSOD II 1987; Langseth et al., 1988; Kulm and Suess, 1990; Langseth and Moore, 1990; Kastner et al., 1992; Martin et al., 1991). In the shallow to intermediate supra-subduction zone region, dehydration reactions release fluids from pore water and from bound volatiles in oceanic sediments and basalts of the down-going plate (Fryer and Fryer, 1987; Peacock, 1987, 1990; Mottl, 1992; Liu et al., 1996). Fluid production and transport affect the thermal regime of the convergent margin, metamorphism in the supra-subduction zone region, diagenesis in forearc sediments, biological activity in the region, and ultimately the composition of arc and backarc magmas. Furthermore, these fluids, their metamorphic effects, and the temperature and pressure conditions in the contact region between the plates (the décollement) affect the physical properties of the subduction zone where most major earthquakes occur.

The discovery of the earth's deep biosphere is recognized as one of the most outstanding breakthroughs in biological sciences. The extent of this biosphere is currently unknown, but we are becoming increasingly aware that life has persisted in environments ranging from active hydrothermal systems on midocean ridges to deep ocean sediments, but so far no detailed investigations have been made of the potential for interaction of the deep biosphere with processes active in convergent plate margins.

Determining unequivocally the composition of slab-derived fluids and their influences over the physical properties of the subduction zone, biological activity, or geochemical cycling in convergent margins requires direct sampling of the décollement region. To date, studies of décollement materials, mass fluxes, and geochemical interchanges have been based almost exclusively on data from drill cores taken in accretionary convergent margins (e.g., Kastner et al., 1992; Carson and Westbrook 1995; Maltman et al., 1997). Large wedges of accreted sediment bury the underlying crystalline basement, making it inaccessible by drilling, and the wedges interact with slab-derived fluids altering the original slab signal. The dehydration reactions and metamorphic interchanges in intermediate and deeper parts of the décollements have not been studied in these margins. By contrast, nonaccretionary convergent margins permit direct access to the crystalline basement and produce a more pristine slab-fluid signature for two reasons: (1) the fluids do not suffer interaction with a thick accretionary sediment wedge and (2) they pass through fault zones that have already experienced water-rock interactions, thus minimizing interaction with subsequently escaping fluids. Regardless of the type of margin studied, the deeper décollement region is directly inaccessible with current or even foreseeable ocean drilling technologies. We need a locality where some natural process brings materials from great depths directly to the surface. The Mariana convergent margin provides precisely the sort of environment needed, as the South Chamorro Seamount (Fig. 4), located on the southern Mariana forearc, is the only known site of active blueschist mud volcanism in the world.

The Mariana subduction system is nonaccretionary and the forearc is pervasively faulted (Fig. 2). It contains numerous large (30 km diameter and 2 km high) mud volcanoes (Fryer and Fryer, 1987; Fryer, 1992; 1996) (Figs. 2, 3). The mud volcanoes are composed principally of unconsolidated flows of serpentine muds with clasts of serpentinized mantle peridotite. Some have also brought up blueschist materials (Maekawa et al., 1995; Fryer, in press). Faulting of the forearc to great depth produces fault gouge that generates a thick gravitationally unstable slurry of mud and rock when mixed with slab-derived fluids. The slurry rises in conduits along the fault plane to the seafloor (Fig. 2) (Lockwood, 1972; Bloomer and Hawkins, 1980; Fryer et al., 1990; Phipps and Ballotti, 1992; Fryer, 1996). One of these faults supports the first discovered megafaunal community associated with a serpentine/blueschist mud volcano (Fryer, in press; Fryer et al., in press). These mud volcanoes are our most direct route to the décollement and episodically open a window through protrusion events, which provides a view of processes and conditions at depths of up to 35 km beneath the forearc (Fig. 2).

ION Seismometer in the Philippine Sea

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. 5A, 5B).

Site WP-1B, situated in the west Philippine Basin west of the Kyushu-Palau Ridge (Fig. 6), 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. 5A). 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. 6). Like other existing oceanic borehole observatories (Sites 1150 and 1151) (Suyehiro, Sacks, Acton et al., 2000), there is a nearby coaxial transoceanic telephone cable (TCP-2) to use 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. 7). 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

CORKs

The primary objective at the South Chamorro Seamount is to establish a reentry hole for the installation of a circulation obviation retrofit kit (CORK) or long-term downhole hydrologic observatory. The techniques that will be used for the CORK will be similar to those used during Legs 139, 164, 168, and 174B, when these tools were successfully installed. The methods are descibed in detail by Davis et al. (1992). A CORK will be installed at Site MAF-4B with a thermistor cable and an osmotic water sample to document the long-term temperature variations in the sealed hole as the natural hydrologic system reestablishes itself after drilling. This installation will provide a long-term record of (1) the rebound of temperatures toward formation conditions after the emplacement of the seal, (2) possible temporal variations in temperatures due to lateral flow in discrete zones, and (3) composition of the circulating fluids obtained with the osmotic water sampler. Data from the CORK experiment will be collected during a National Science Foundation-funded *Jason*/*DSL* 120 cruise that is tentatively scheduled during 2001 after Leg 195.

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; JOI/USSAC, 1994; Montagner and Lancelot, 1995; JOIDES 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. 5A), 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. 5A), were installed during Leg 186 (Suyehiro, Sacks, and Acton, 2000). In addition, Site WP-2, located in the northwest Pacific Basin, was recently successfully drilled and instrumented during Leg 191.

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 that the noise level for oceanic borehole instruments is much lower than for most land counterparts (e.g., Stephen et al., 1999) (Fig. 8). 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 anomalies 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 Site WP-1B observatory will be equipped with two broadband seismometers (Guralp CMG-1) attached to a pipe hung from the reentry cone (Figs. 9B, 10), 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-W batteries (SWB 1200, Kornsburg Simrad) attached to a battery frame that sits on the reentry cone (Figs. 9A, 9B, 10).

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., 2000). 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. 7) designed to operate in water depths of 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

South Chamorro Seamount

Site MAF-4B is located in the Mariana system, a nonaccretionary convergent margin with a pervasively faulted forearc. The Mariana system contains numerous large (30 km diameter, 2 km high) mud volcanoes (Fryer and Fryer, 1987; Fryer, 1992; 1996) (Fig. 3), which are composed principally of unconsolidated flows of serpentine muds with clasts of serpentinized mantle peridotite.

Only one active serpentine mud volcano (Conical Seamount) has ever been sampled by drilling and this was done during Leg 125 (Fryer, Pearce, Stokking et al., 1990). Little was then known of either the processes that formed such seamounts, their distribution, their relation to the tectonics of the forearc region, or of the potential for understanding the deeper forearc processes they reflect. Advances in the understanding of nonaccretionary forearcs over the last decade, such as the nature of geochemical cycling within them, their structure, tectonic evolution, and the various (thermal, hydrologic, metamorphic, biological) active processes involved in the formation of mud volcano seamounts, allow the planning of comprehensive studies of the intermediate-depth processes within the "subduction factory." We now know that serpentine mud volcanism in convergent margin settings is not merely a local curiosity of the Mariana system but occurs world-wide.

The South Chamorro Seamount (Fig. 4) is located on the southern Mariana forearc and exhibits the second strongest slab-fluid signal yet detected in the Mariana system. It is the only known site of active blueschist mud volcanism in the world and produced the only documented megafaunal assemblages associated with serpentine/blueschist mud volcanism.

West Philippine Sea

Site WP-1B, the site of the proposed seismometer installation, 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. 6). 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

Mass Transport Processes in Subduction Zones and Forearcs of Nonaccretionary Convergent Margins (MAF-4B)

Fluid Transport

The drill site on South Chamorro Seamount will help address the variability of fluid transport and composition within the forearc. Field studies indicate that most of the fluid flow in the Mariana forearc is channeled along forearc faults and fault-controlled conduits in mud volcanoes. The pore-fluid compositions are expected to vary depending on the nature of the channeling structures (diffuse network of small faults, major faults, and mud volcano conduits). In particular, fluids ascending along mud-volcano conduits, traveling along well-established paths in contact with previously metamorphosed wallrock, should carry the most pristine slab signature. This was certainly the case at Conical Seamount, drilled on Leg 125. The summit Site 780 produced by far the purest deep slab-derived fluids, based on their much lower chlorinity and higher K, Rb, B, H_2S, and sulfate, whereas the flank Sites 778 and 779 produced combinations of slab-derived fluid with seawater that had reacted with peridotite and basalt at shallower crustal levels (Mottl, 1992).

Mechanics and Rheology

The mechanics and rheology of serpentine muds in the Mariana forearc seamounts control the processes that formed the seamounts and their morphology. The rheological study of Mariana serpentine muds will place strong constraints on the mechanics that generate and emplace the serpentine muds, maintain the conduits, and construct the seamounts.

Shipboard torsion-vane testing on Leg 125 at Conical Seamount in the Marianas and at Torishima Forearc Seamount in the Bonin forearc showed that the serpentine muds are plastic solids with a rheology that bears many similarities to the idealized Cam clay soil model and is well described by critical-state soil mechanics (Phipps and Ballotti, 1992). These muds are thus orders of magnitude weaker than salt and are, in fact, comparable in strength to common deep-sea pelagic clays. To determine the physical properties of these muds, we must recover a number of whole-round samples from the serpentine seamount and analyze them mechanically at both shipboard and shore-based laboratories. The rate at which the muds rise relative to the fluids will likely influence the water-rock reactions and the character of the slab signal in fluids from these mud volcanoes. Better constraints on the nature of the fluids will permit a more accurate determination of the physical conditions of the décollement where the fluids originate.

Fluid Budgets

Although total fluid budgets are difficult to ascertain in any convergent margin, we suggest that they are more readily determined at nonaccretionary active margins because the hydrologic flow systems operate on longer time scales than do those at accretionary margins. Attempts to determine the total fluid budgets at accretionary active margins have been hindered by the presence of lateral heterogeneity and transient flow processes. Lateral heterogeneity results in different flow rates and compositions along strike of the margin. Transient flow apparently results largely from the valve-like influence of the accretionary complexes themselves.

Sediment properties vary with fluid pressure, and fluid pressure varies as a function of fluid production rate and transient hydrologic properties. Thus, the accretionary system acts as both a seal and a relief valve on the fluid flow system. The absence of such a short time scale, fluid pressure, and formation properties modulator at nonaccretionary systems should allow fluids to escape more steadily. To test this hypothesis, the physical nature of fluid flow at nonaccretionary settings must be determined. Then fluid budgets can be constructed to determine whether the expected long-term flow is consistent with observations or if the flow must occur transiently. The CORK experiment planned for the South Chamorro Seamount site will address this problem.

Spatial Variability of Slab-Related Fluids within the Forearc Environment as a Means of Tracing Dehydration, Decarbonation, and Water/Rock Reactions in the Subduction and Supra-Subduction Zone Environments (MAF-4B)

Along-Strike Variability

The composition of slab-derived fluids and deep-derived rock materials may differ along the strike of the forearc, reflecting regional variations in composition within the slab and supra-subduction zone lithosphere. The pore fluids from several of the forearc mud volcanoes already sampled are chemically distinct (Fryer et al., in press). This difference is probably associated not only with the depth to the slab, but also with the physical conditions under which water-rock reactions occur and the variations in the regional composition of the plate and over-riding forearc wedge.

The geochemistry of the fluids from Conical Seamount is described in detail in several publications (Fryer et al, 1990; Haggerty, 1991; Haggerty and Chaudhuri, 1992; Haggerty and Fisher, 1992; Mottl, 1992; Mottl and Alt, 1992). These investigators have shown the origin of the Conical Seamount fluids to be from dehydration of oceanic crustal basalt and sediment at the top of the subducting lithospheric slab. The compositions of the fluids from Pacman and seamounts further south are reported in Fryer et al. (in press). Pore fluids from these indicate a slab source, as evidenced by their lower chlorinity and higher K and Rb, similar to that observed at Conical Seamount by Mottl (1992).

Metamorphic and Tectonic History of Nonaccretionary Forearc Regions and Physical Properties of the Subduction Zone (MAF-4B)

Pressure and Temperature Indicators from Fluids

The composition of slab-derived and deep-derived metamorphosed rock is useful in defining geochemical processes and estimates of the thermal and pressure regime at depth, and thus, for determining physical properties of the décollement region. It is possible to constrain some of the pressure and temperature conditions under which certain dehydration reactions take place in the subducted slab. Pore fluids from ODP Site 780 at the summit of Conical Seamount are unusual because of geochemical and physical processes at depth. The observed enrichments in alkali elements and B in fluids from Site 780 are unambiguous indicators of a source temperature in excess of 150°C. The fact that these elements are depleted at Sites 778 and 779 on the flanks of Conical Seamount, relative to their concentrations in seawater, indicates that the deep slab signal can readily be overprinted by local peridotite-seawater reactions at lower temperatures. Not all chemical species are affected by this overprinting, however (i.e., sulfur isotopic composition of dissolved sulfate) (Mottl and Alt, 1992). Thus, to avoid potential reactions between sediment and slab-derived fluids, we need to collect fluids from the mud volcano conduits where continued focused flow provides a pathway for slab-derived "basement" fluids to reach the seafloor.

Metamorphic Parageneses

Studies of deep derived minerals and metamorphic rock fragments brought to the surface in mud flows in these seamounts will permit us to constrain the pressure and temperature regimes under which the metamorphism that formed them took place. We know, for instance, that the minimum pressures of formation for incipient blueschist materials from Conical Seamount are 6-7 kbar (Maekawa et al., 1995). We can estimate from the paragenesis of crossite schist recovered in cores from South Chamorro Seamount that pressures in excess of 7 kbar are consistent with their metamorphism (Fryer et al., in press). With stratigraphic control and deeper penetration (than that afforded by gravity and piston coring) of the muds from these sites, we will be able to quantify the assemblages of muds present in the flows and constrain the ranges of pressure and temperature of the source regions of these materials.

Biological Activity Associated with Deep-Derived Subduction Zone Material

The interest in research pertaining to a deep subsurface biosphere has developed as a result of the study of extreme environments and their possible link to the first living organisms that inhabited the Earth. The search for the last common ancestor in the geologic record is moving toward environments at high temperatures like those at spreading centers and hot spots on the ocean floor and on land. Microbes and microbial products are abundant in oceanic hydrothermal environments and are presumed to be representative of a community of thermophilic and hyperthermophilic organisms that originated beneath the seafloor (Fisk et al., 1998). Microbes are also involved in the transformation of minerals in the oceanic volcanic crust and in the cycling of elements in the crust; however, the origin of these microbes is much more controversial.

Drilling at Chamorro Seamount provides a unique opportunity to reexamine the hypothesis that microbes are capable of using alternative energy sources that would support a heterotrophic subsurface ecosystem. In addition, because the pore fluids are more pristine in nonaccretionary convergent margins, it will be easier to assess from the chemistry of both the muds and the fluids whether organic syntheses capable of supporting life are active.

Understanding the origin of the deep biosphere is fundamental to the ODP drilling program and will further address the compelling question of whether life arose in these types of environments rather than on the surface of the early Earth. Although several experimental studies indicate that a thermophilic origin of life is possible, definitive proof will depend on how successful future efforts, such as studying the material on South Chamorro Seamount, are at demonstrating that these conditions or organic components actually exist in the subsurface environment.

Structure of the Philippine Sea Plate (WP-1B)

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 of these areas (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 and age vs. 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 (WP-1B)

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 (WP-1B)

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. 5A). 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 key areas that are now poorly imaged. In addition, this observatory will provide data from the backarc side of the Izu-Oagasawara and Mariana Trenches, giving greater accuracy and resolution of earthquake locations and source mechanisms.

Basalt Chemistry and Crustal Thickness (WP-1B)

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 off ridge where the rock samples and high-quality seismic data were collected at the same location. Chemical analysis of the basalt samples from Site WP-1B should provide clues as to why the crust is thinner (3 to 4 km) than normal and whether it is due to the differences in the initial temperature conditions of the lithosphere.

Age of Basement (Site WP-1B)

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 (Site WP-1B)

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 (Site WP-1B)

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, Rotation, and Tectonic Drift (Site WP-1B)

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. By collecting oriented sediment cores it may be possible to study the rotation of the Philippine plate and the initiation of subduction of the Pacific plate.

PROPOSED SITES

Site MAF-4B

Proposed Site MAF-4B is located on the summit of South Chamorro Seamount in a water depth of 2930 meters below sea level (mbsl) ~70 nmi east of Guam in the western Pacific Ocean. It lies 85 km from the trench where the depth to slab is -26 km, based on Isacks and Barazangi (1977). Side-scan surveys of this seamount show that the southeastern sector of the edifice has collapsed and debris flows of serpentine material (dredged in 1981 and observed on *Shinkai* 6500 dives in 1995) blanket the inner slope of the trench from the summit of the seamount to the trench axis. The summit knoll sits at the apex of the sector collapse and its formation was most likely initiated in response to the collapse related activity. Submersible observations show the knoll's surface is broken into uplifted slabs of partially cemented serpentine mud (Fryer, 1996) separated by meter-deep fissures with cross-cutting orientations. Medium blue-green to dark blue serpentine mud and clasts of metamorphosed rocks are exposed. Seeps in the fissures support a vigorous biological community of mussels, gastropods, worm tubes, and galatheid crabs (Fryer and Mottl, 1992). The mussels are likely of the genus *Bathymodiolus*, a genus that contains methylotrophic symbionts in their gills and requires high concentrations of methane in the fluids on which they feed (K. Fujikura, pers. comm., 1996). The pore fluid compositions and the presence of reduced materials of a vigorous biological community at the surface suggest the summit knoll is a currently active seep region. The interior of the seamount shows little structure.

It is likely that this seamount is an active serpentine mud volcano similar to Conical Seamount (Fryer et al., in press) and would provide an excellent drill target for studies of the active processes of these mud volcanoes. It has the strongest slab-signature in pore fluids from among the seamounts sampled in 1997 (Wheat and Mottl, submitted) and is second only to Conical Seamount in strength of slab signal.

Site WP-1B

Proposed Site WP-1B is situated on flat seafloor at a water depth of 5640 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 DSDP Legs 31 and 59 (Karig, Ingle, et al., 1975;

Kroenke, Scott, 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 underlain by 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. The underlying 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 447.

CONTINGENCY PROGRAM
(Kuroshio Current)

The Kuroshio Current (Black Current) is the biggest western boundary surface current in the western Pacific. It plays an important role in the meridional transports of heat, mass, momentum, and moisture from the western Pacific warm pool (WPWP) to high latitudes of the north Pacific. Its role in the Pacific is as important as the Gulf Stream in the north Atlantic, yet little is known about its long-term evolution. The lack of knowledge of this important current system has hindered the construction of a complete scenario of climatic evolution for the Pleistocene, if not the entire Cenozoic of the west Pacific. Thus, if time permits, we are planning to drill shallow holes (410 m) on the southern slope of the southernmost Okinawa Trough. The main objective is to study the Pleistocene history of the Kuroshio Current on glacial-interglacial and millennial time scales.

A long record of the Kuroshio Current of the past 2 m.y. will offer a unique opportunity to study the roles of the Kuroshio in relation to sea-level fluctuation, global climatic variation, local tectonic development, and terrestrial environmental changes in East Asia at different time scales. The Kuroshiro Current site is designed to: (1) identify patterns of long-term climate change associated with the western Pacific boundary current during the past 2.0 m.y.; (2) examine the western Pacific component of long-term changes due to orbital forcing in the mid-Pleistocene (0.7 Ma) when Earth's climate system switched from a regime of dominant 41-k.y. cycles to 100-k.y. cycles; (3) explore any long-term El Niño/La Niña type of climate oscillation in the low-latitude Pacific over the late Pleistocene glacial-interglacial cycles by comparing the Kuroshio record to other Pacific ODP records; and (4) document the temporal and spatial variability of millennial climate changes in the Kuroshio.

The proposed drilling Site KS-1 is located at 24°48.24’N, 122°30.00’E in 1270 m deep water at the intersection of three seismic reflection profiles shot by the *R/VM Ewing* in 1995 (Fig. 11). The selection of this site is based on data collected recently during several international cooperative programs and multidisciplinary integrated programs such as Kuroshio Edge Exchange Processes (KEEP) and Southernmost Part of Okinawa Trough (SPOT) (Lee et al., 1998).

DRILLING STRATEGY

The proposed drilling program at Site MAF-4B consists of a pilot hole (A) to characterize the composition of the fluids and metamorphosed rock materials of the seamount followed by a second hole (B), which will be equipped with a reentry cone/20-in casing/conductor pipe, 16-in casing string, 10-3/4-in casing string, and the CORK instrumentation (thermistor string and an osmotic sampler). The time estimated to accomplish these objectives is 20.9 days, with coring and logging in Hole A consuming 10.8 days and the establishment of the long-term observatory in Hole B taking 10.1 days.

Coring will be conducted with the extended core barrel (XCB) and/or the motor driven core barrel (MDCB) in the first hole in an attempt to optimize core recovery and quality. The hole will be equipped with a free-fall funnel (FFF) to enable XCB bit exchange or reentry with the advanced diamond core barrel (ADCB). Plans call for Hole A to be cored to 400 mbsf, logged with a standard suite of wireline tools (see the "Logging Plan" section), and plugged with cement to prevent communication with the corked reentry hole.

A reentry cone will then be assembled and lowered to the seafloor with ~10 m of 20-in casing (actual length will be determined by a jet-in test after the 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 an 18-1/2-in tricone bit and a 22-in underreamer. Hole B will then be reentered and the hole deepened to ~220 mbsf. The drill string will again be recovered before making up ~200 m of 16-in casing. The 16-in casing string will be deployed and cemented in place before recovering the drill string. Hole B will then be reentered with a 14-3/4-in tricone bit and drilled to ~420 mbsf before installing ~375 m of standard 10-3/4-in casing with ~25 m of screened 10-3/4-in casing on the bottom. After the hole is drilled to depth, the casing will be installed and the drill string recovered. The instrument package will then be made up and attached to the deployment casing (CORK body).

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 to take 7.5 days, with the remaining time on site devoted to the installation of the instrument and battery package (Figs. 9A, 9B, 10). 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 will be determined by a jet-in test after the 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 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 penetrate ~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 (Figs. 9B, 10). Centralizers will be equally spaced on the casing string to keep it centered 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. 10). A battery package will then be lowered into the throat of the reentry cone (Fig. 10) on the logging line and acoustically released. Finally, the drill string will be released and recovered back aboard the drillship.

At the contingency site in the Southern Okinawa Trough (Kuroshio Current) we are planning to core one oriented hole with the APC to refusal and deepen it with the XCB to 410 m. This hole will be logged with standard logging instruments should time permit. Two additional APC holes will ensure complete stratigraphic recovery for the high-resolution objectives at this site.

SAMPLING PLAN

Sampling guidelines and policy are available at the following site: http://www-odp.tamu.edu/publications/policy.html. 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 ~200 m of serpentine mudflows, ~400 m of sediment, and <100 m of basalt. The volume and frequency of samples 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 or serpentine mud 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. Especially sampling at MAF-4B will require whole rounds for geotechnical experiments. Requests 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 measurements 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 objective of the Mariana portion of this leg is to core and to install a CORK at a serpentine mud volcano on the Mariana forearc in the western Pacific. Downhole measurements can be used to determine continuous in situ physical, chemical, and structural properties of the drilled formations. Downhole measurements complement observations and measurements obtained on core and allow core-log integration.

The scientific merits of logging at Site MAF-4B compared to completing the other leg objectives will be reviewed by the co-chief scientists with input from the scientific party prior to implementation of the logging program. The co-chiefs have the final decision and the responsibility to scientifically justify their decision.

Should logging at Site MAF-4B be conducted, it is planned to deploy the triple combination standard toolstring in the pilot hole (A). Physical properties such as natural radioactivity, density, porosity, resistivity, temperature and K, Th, U contents will provide a continuous characterization at high resolution of the drilled formation. The FMS (Formation MicroScanner) provides high resolution microconductance images of mud flows and clast distribution, and is particularly useful for understanding structures and lithostratigraphic variations in the mud flows. The FMS is run with the DSI (Dipole Sonic Imager) to provide sonic measurements.

A long-term seismic observatory will be installed at the West Pacific Geophysical Network site. The logging program is designed to measure physical properties, anisotropy, and hole shape in pilot hole B, objectives that are quite similar to the objectives at the Japan Trench sites drilled during Leg 186. To be effective in locating and evaluating intervals in such holes, logs must be acquired prior to installation of any downhole instrumentation. The laterolog will measure resistivity in basement intervals. Standard geophysical logs can be used to measure physical properties; hole volume can be estimated with high accuracy using the UBI log (acoustic televiewer) in the basement intervals. High-resolution temperature logs should be emphasized to identify permeable zones and in flow/out-flow from both drilling-induced and natural fractures in the holes. (Note: UBI deployment depends on the availability of funds).

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FIGURE CAPTIONS

Figure 1. Location map of the planned Leg 195 sites. Site KS-1 is planned as a contingency site that will be cored if time permits.

Figure 2. Schematic cross section through the Mariana system showing various types of associations of serpentine mud volcanoes with faulting in the forearc wedge. Strike-slip faulting associated with along-strike extension and vertical tectonics related to seamount subduction both play a part in the tectonic deformation of the forearc and provide avenues for egress of slab-derived fluids and fault gouge from both the décollement and the lithosphere of the overriding plate. Decarbonation reactions in the downgoing plate probably take place between ~15 and 20 km (Fryer et al, in press).

Figure 3. Bathymetry of the Southern Mariana forearc (250-m contour intervals). The location of all forearc seamounts sampled thus far are labeled. The South Chamorro Seamount is targeted for drilling during Leg 195. Map gives shaded bathymetric relief.

Figure 4. HMR-1 sidescan imagery of South Chamorro Seamount showing the location of six-channel seismic reflection profiles listed in the "Site Summary" section (A-A' and B-B').

Figure 5. A. Location map of seismic station coverage in the northwest Pacific showing additional stations needed. 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 6. Location map showing Deep Sea Drilling Project Sites 290, 294, 295, and 447 and proposed Site WP-1B in the Philippine Sea.

Figure 7. 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. 9A, 9B) can be removed and replaced by such a ROV. The *Kaiko* will visit Site WP-1B to activate the borehole observatory after Leg 195.

Figure 8. 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-1, 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 H1 and H2 could not be determined during installation of the instrument. dB = decibels.

Figure 9. 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 10. Schematic of the seafloor assembly with expected lithologies extrapolated from Leg 185. PAT = Power supply access terminal.

Figure 11. Approximate path of the Kuroshio Current in the area of Site KS-1. Stippled areas indicate upwelling.

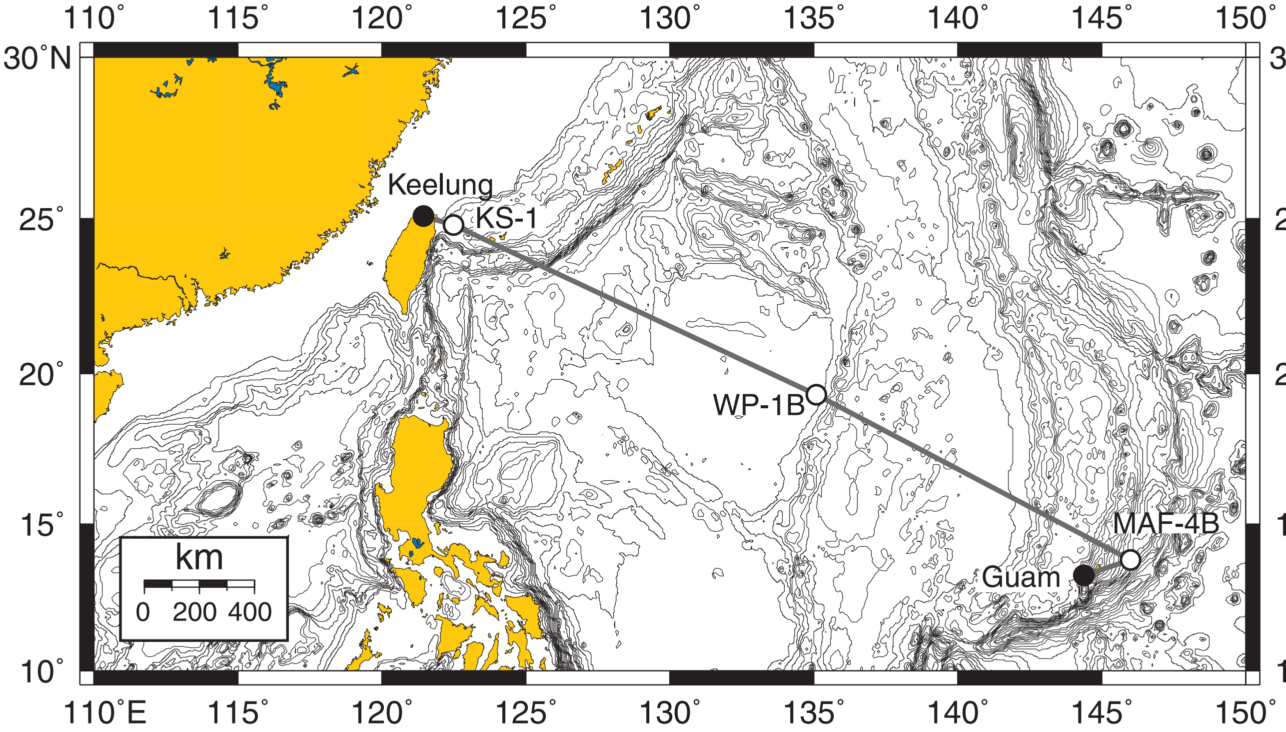

110˚
115˚
120˚
125˚
130˚
135˚
140˚
145˚
150˚
30˚N
25˚
20˚
15˚
10˚
30˚
110˚E
Keelung
KS-1
WP-1B
MAF-4B
Guam
km
0
200
400

Figure 1

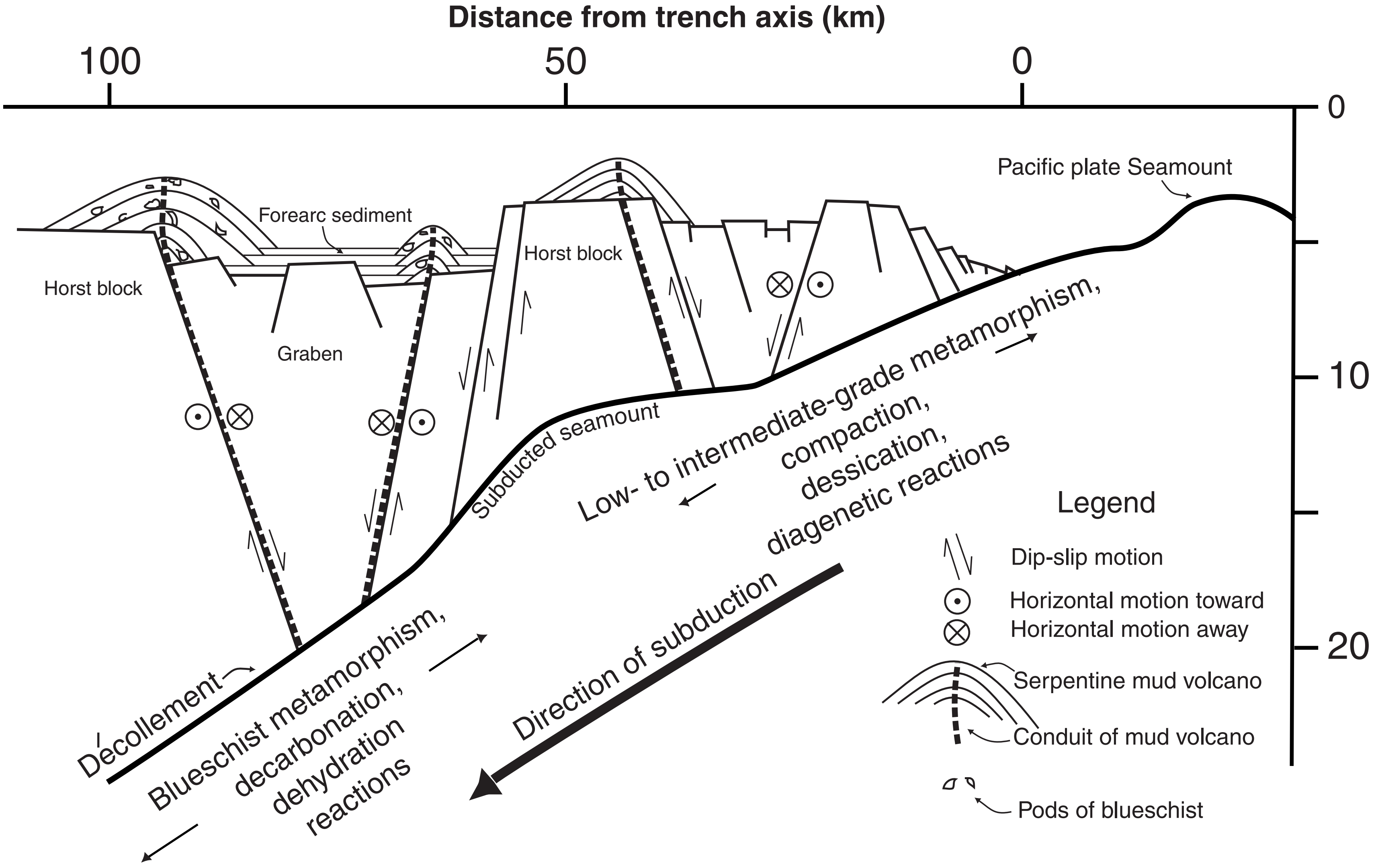

Distance from trench axis (km)
100
50
0
0
10
20
Depth (km)
Pacific plate Seamount
Forearc sediment
Horst block
Horst block
Graben
Subducted seamount
Low- to intermediate-grade metamorphism,
compaction,
dessication,
diagenetic reactions
Décollement
Blueschist metamorphism,
decarbonation,
dehydration
reactions
Direction of subduction
Legend
Dip-slip motion
Horizontal motion toward
Horizontal motion away
Serpentine mud volcano
Conduit of mud volcano
Pods of blueschist

Figure 2

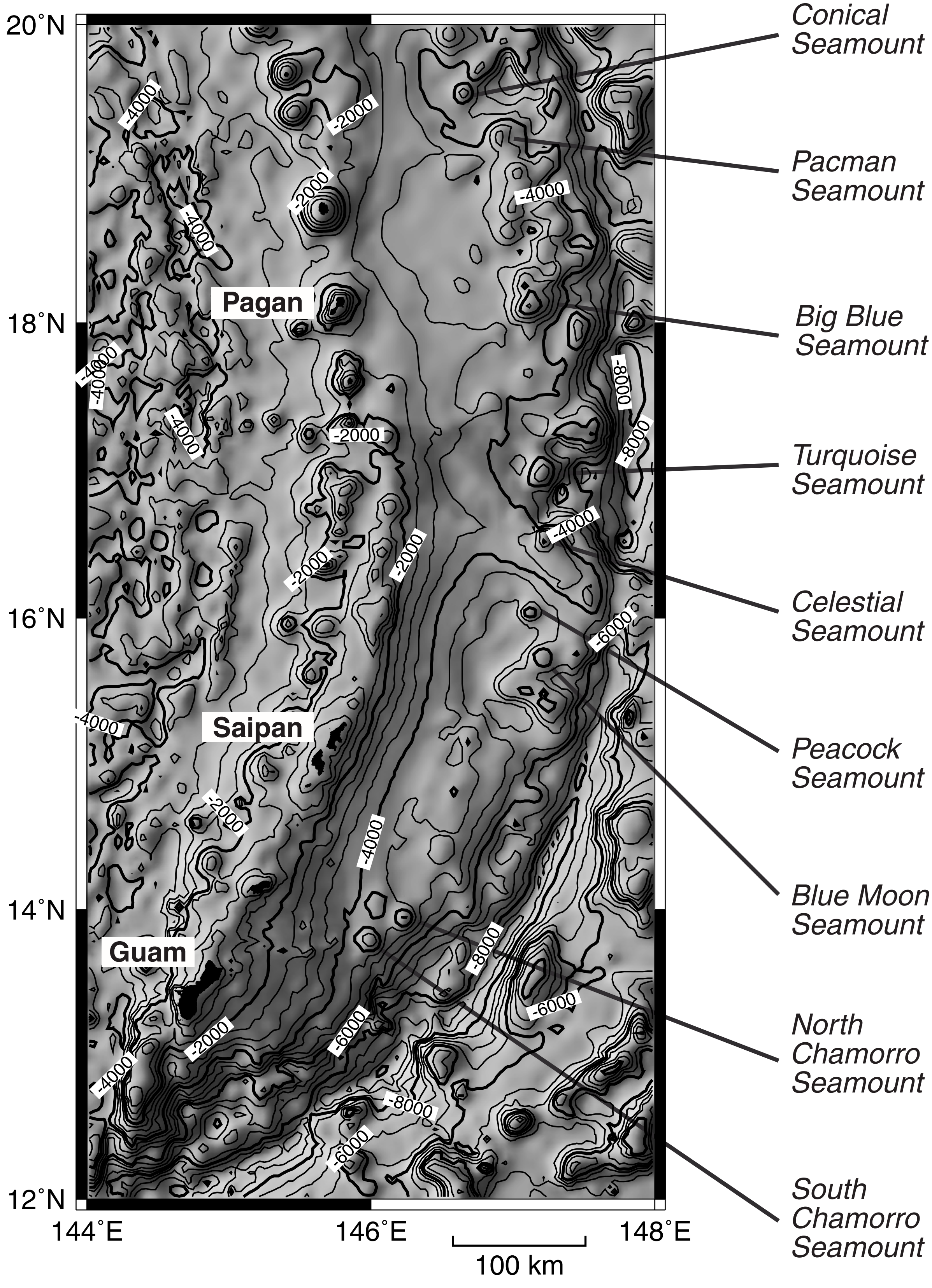

20˚N
18˚N
16˚N
14˚N
12˚N
144˚E
146˚E
148˚E
100 km
Pagan
Saipan
Guam
-2000
-4000
-6000
-8000
Conical Seamount
Pacman Seamount
Big Blue Seamount
Turquoise Seamount
Celestial Seamount
Peacock Seamount
Blue Moon Seamount
North Chamorro Seamount
South Chamorro Seamount

Figure 3

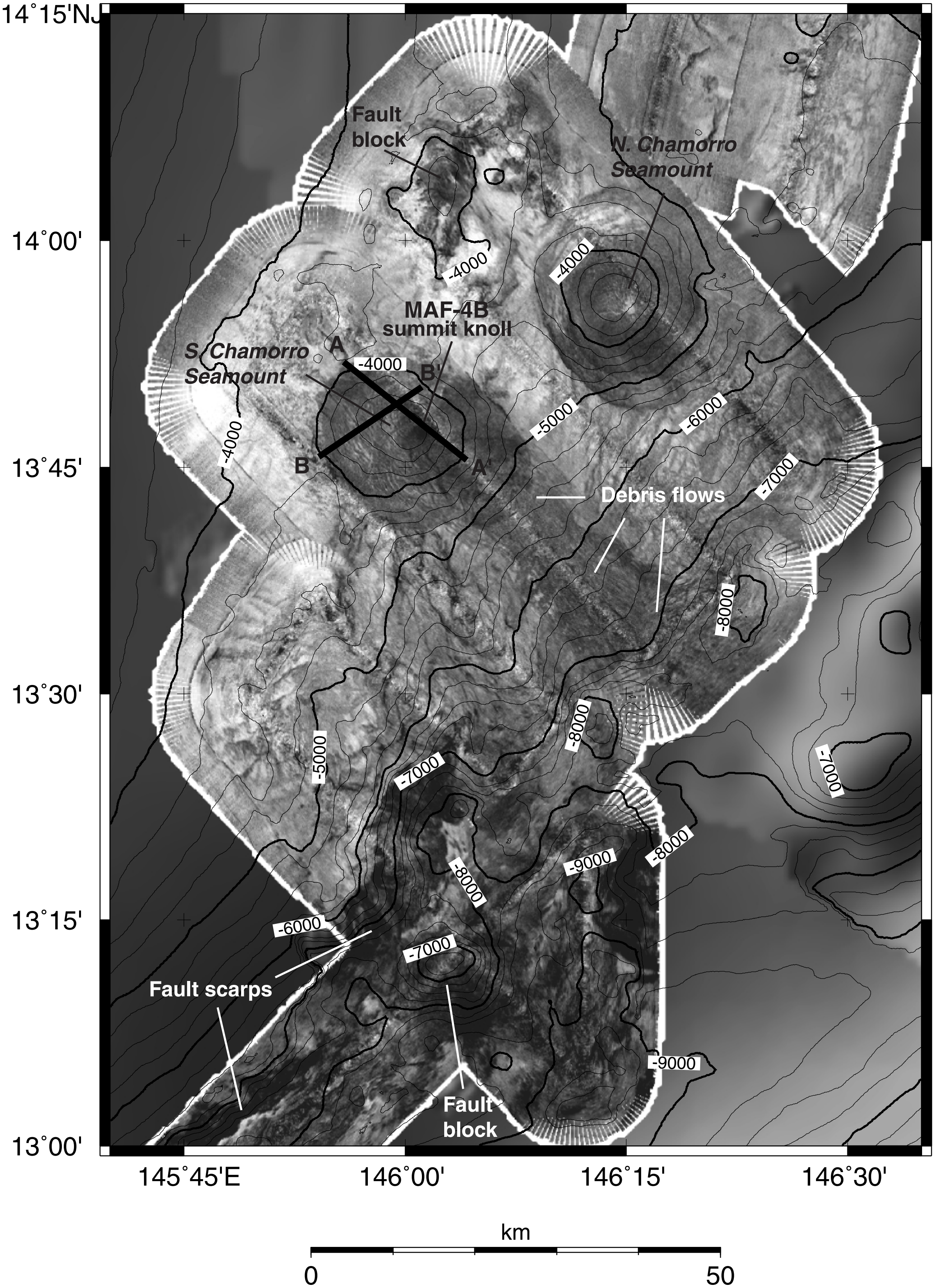

14˚15'N
14˚00'
13˚45'
13˚30'
13˚15'
13˚00'
145˚45'E
146˚00'
146˚15'
146˚30'
Fault block
N. Chamorro Seamount
-4000
-4000
MAF-4B summit knoll
S. Chamorro Seamount
A
-4000
B'
B
A'
-4000
-5000
-6000
-7000
Debris flows
-8000
-8000
-5000
-7000
-7000
-8000
-9000
-8000
-6000
-7000
Fault scarps
-9000
Fault block
km
0
50

Figure 4

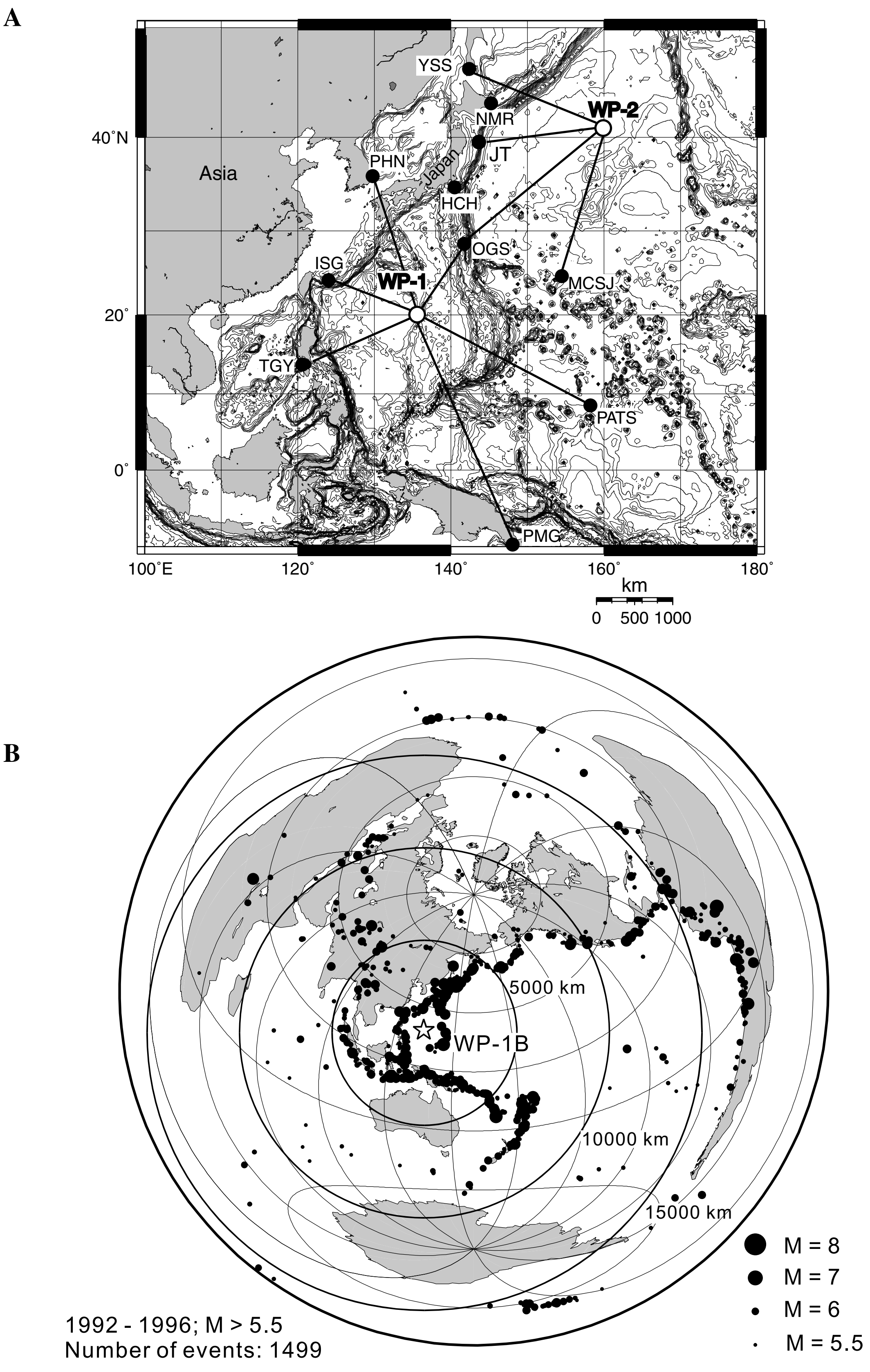

A
YSS
NMR
WP-2
40°N
JT
PHN
Asia
Japan
HCH
OGS
ISG
WP-1
MCSJ
20°
TGY
PATS
0°
PMG
100°E
120°
140°
160°
180°
km
0
500
1000
B
5000 km
WP-1B
10000 km
15000 km
M = 8
M = 7
M = 6
M = 5.5
1992 - 1996; M > 5.5
Number of events: 1499

Figure 5

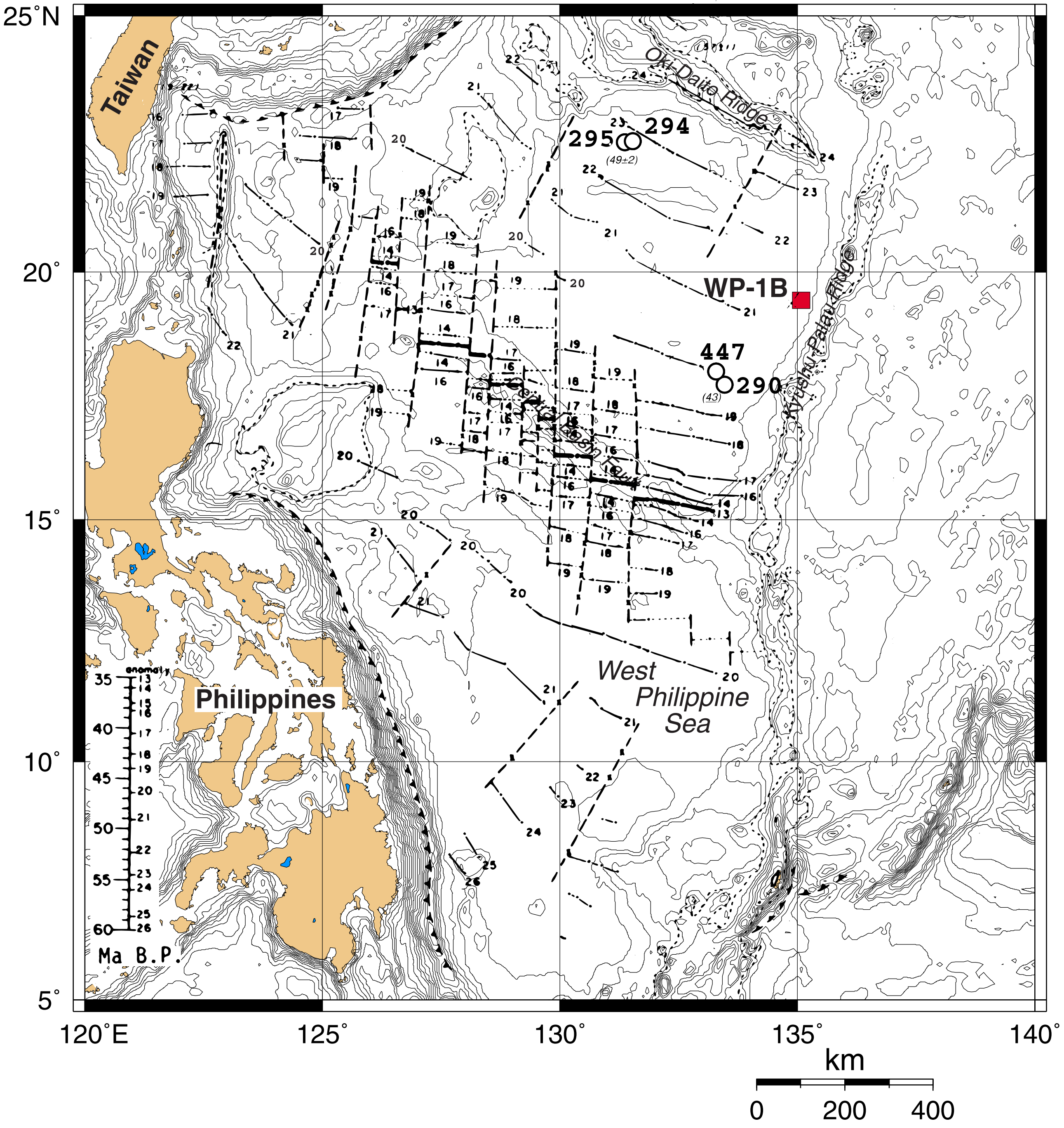

25°N
20°
15°
10°
5°
120°E
125°
130°
135°
140°
Taiwan
Philippines
Oki-Daito Ridge
Kyushu-Palau Ridge
Central Basin Fault
West Philippine Sea
WP-1B
295
294
(49±2)
447
290
(43)
anomaly
Ma B.P.
km
0
200
400

Figure 6

Figure 7

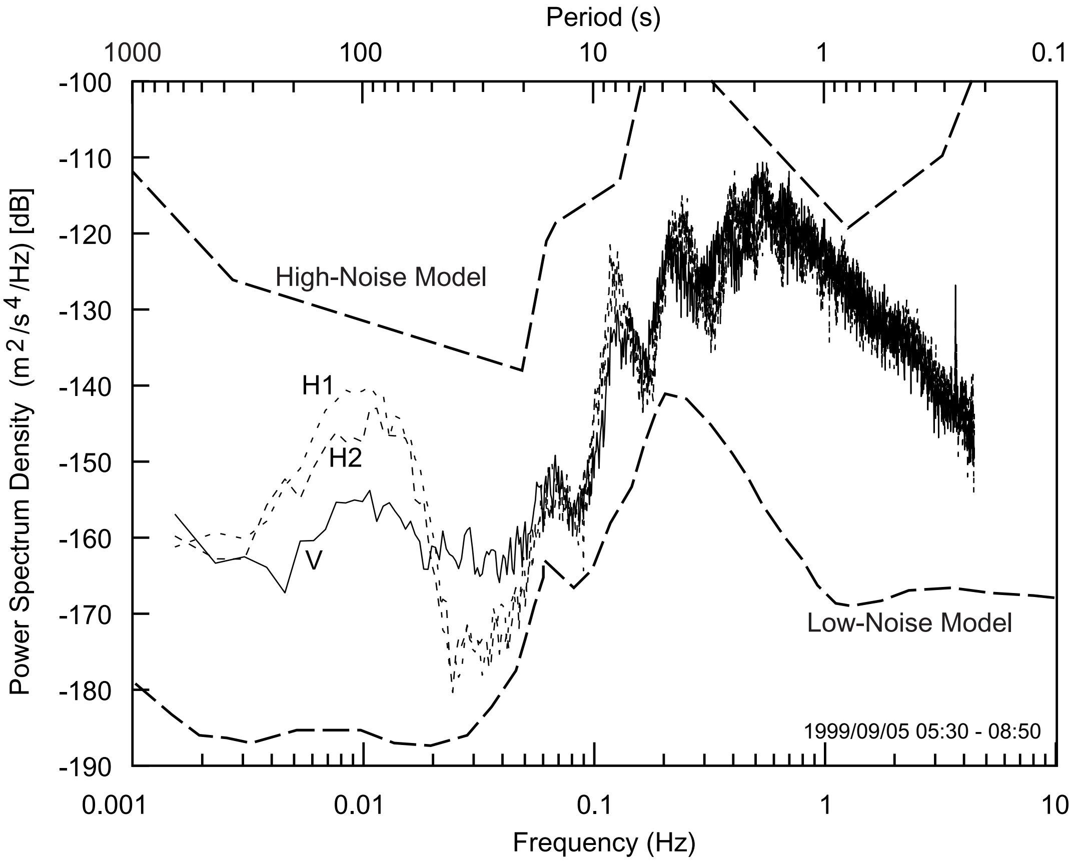

Period (s)
1000
100
10
1
0.1
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
Power Spectrum Density (m2/s4/Hz) [dB]
High-Noise Model
H1
H2
V
Low-Noise Model
1999/09/05 05:30 - 08:50
0.001
0.01
0.1
1
10
Frequency (Hz)

Figure 8

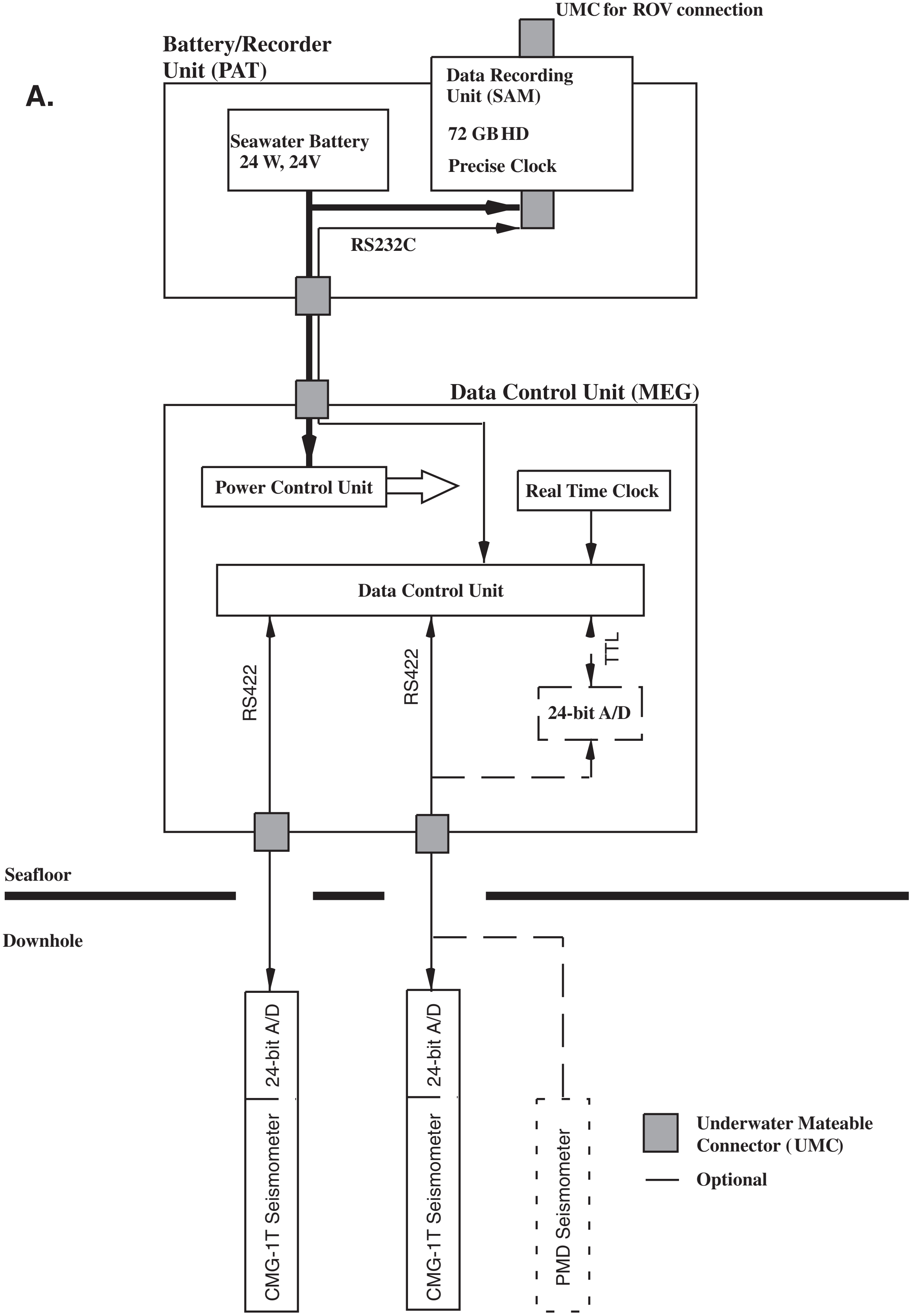

A.
UMC for ROV connection
Battery/Recorder Unit (PAT)
Data Recording Unit (SAM)
72 GB HD
Precise Clock
Seawater Battery 24 W, 24V
RS232C
Data Control Unit (MEG)
Power Control Unit
Real Time Clock
Data Control Unit
RS422
RS422
TTL
24-bit A/D
Seafloor
Downhole
24-bit A/D
CMG-1T Seismometer
24-bit A/D
CMG-1T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

Figure 9

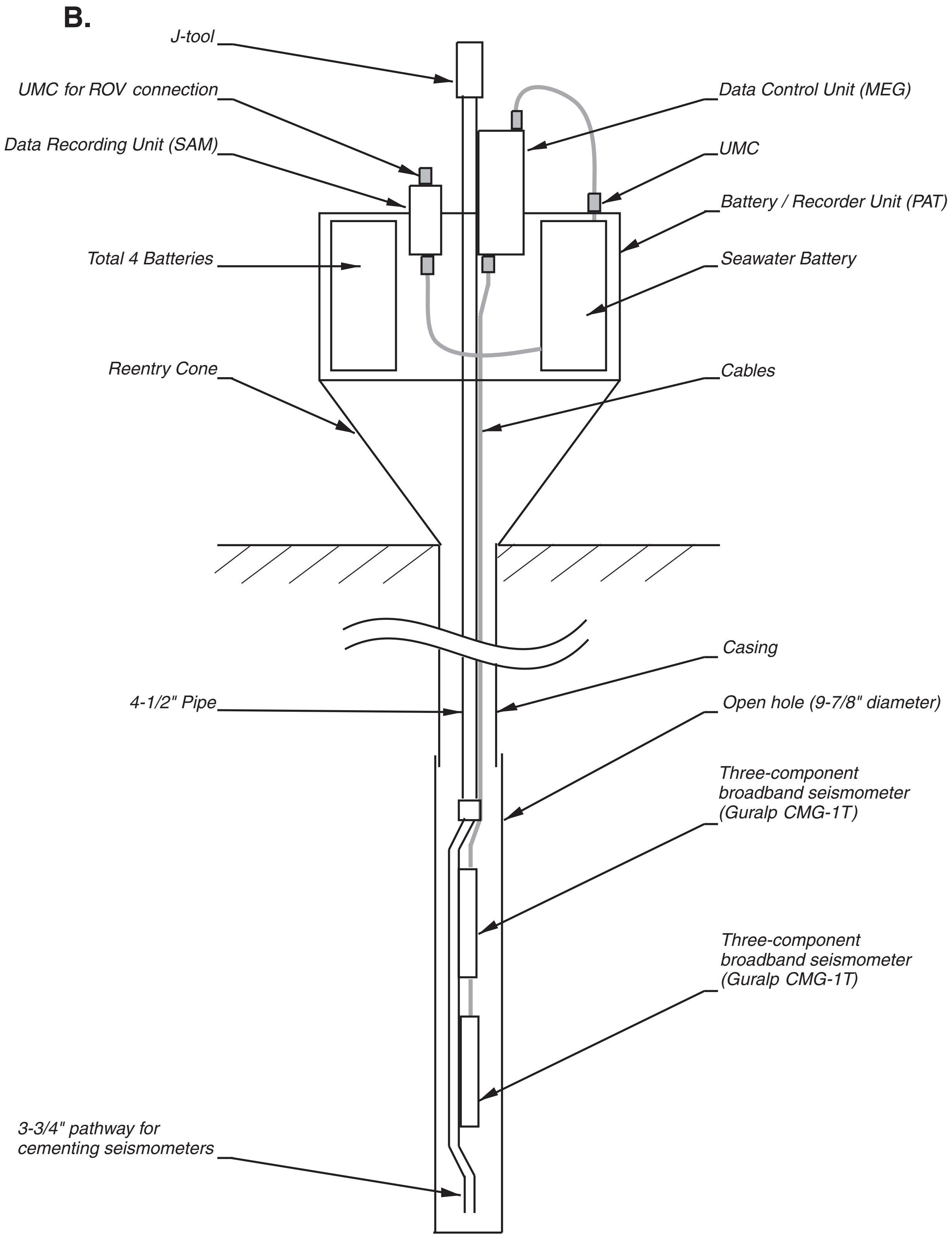


Figure 9 (continued)

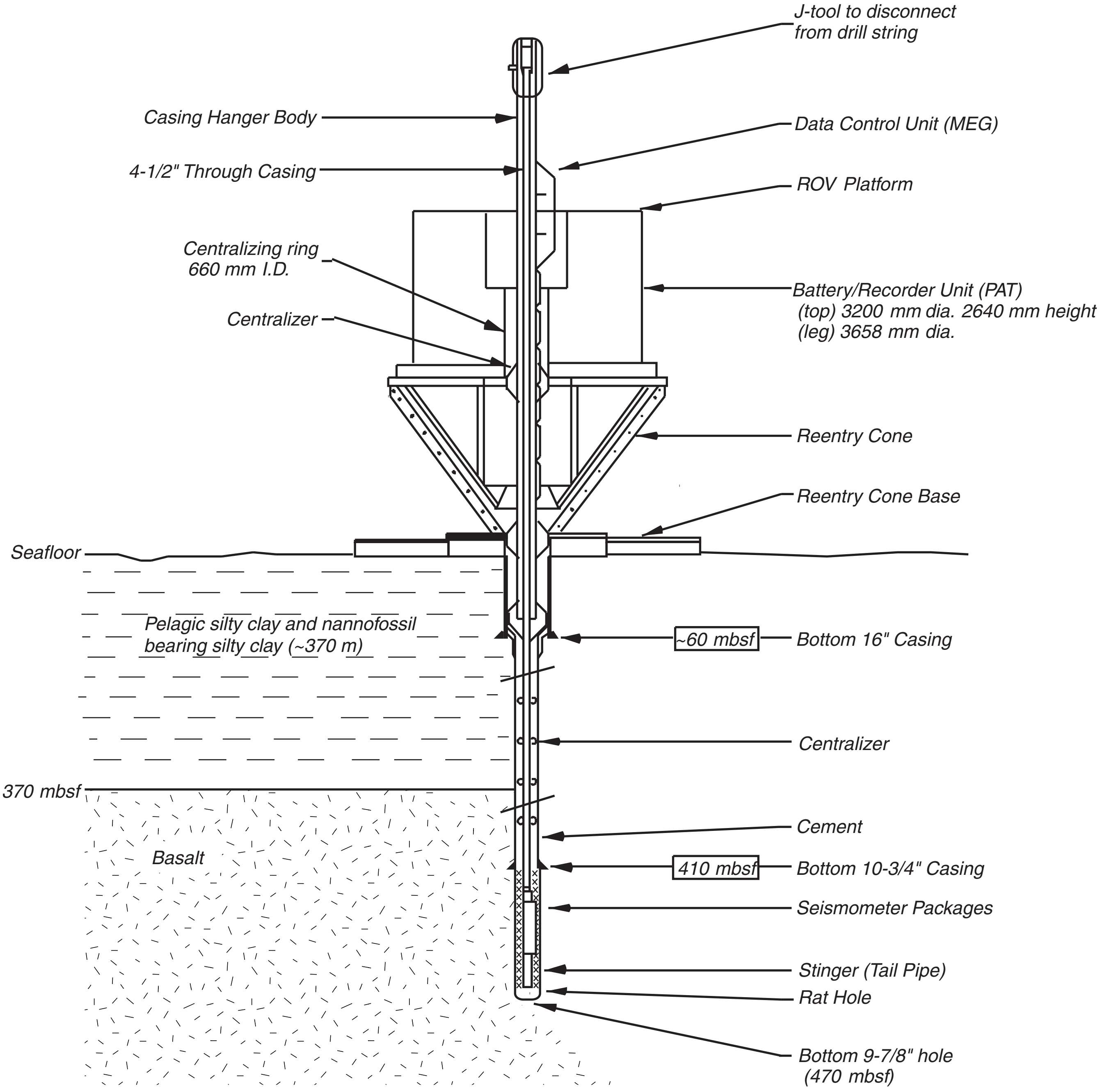

J-tool to disconnect from drill string
Casing Hanger Body
Data Control Unit (MEG)
4-1/2" Through Casing
ROV Platform
Centralizing ring 660 mm I.D.
Battery/Recorder Unit (PAT) (top) 3200 mm dia. 2640 mm height (leg) 3658 mm dia.
Centralizer
Reentry Cone
Reentry Cone Base
Seafloor
Pelagic silty clay and 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 10

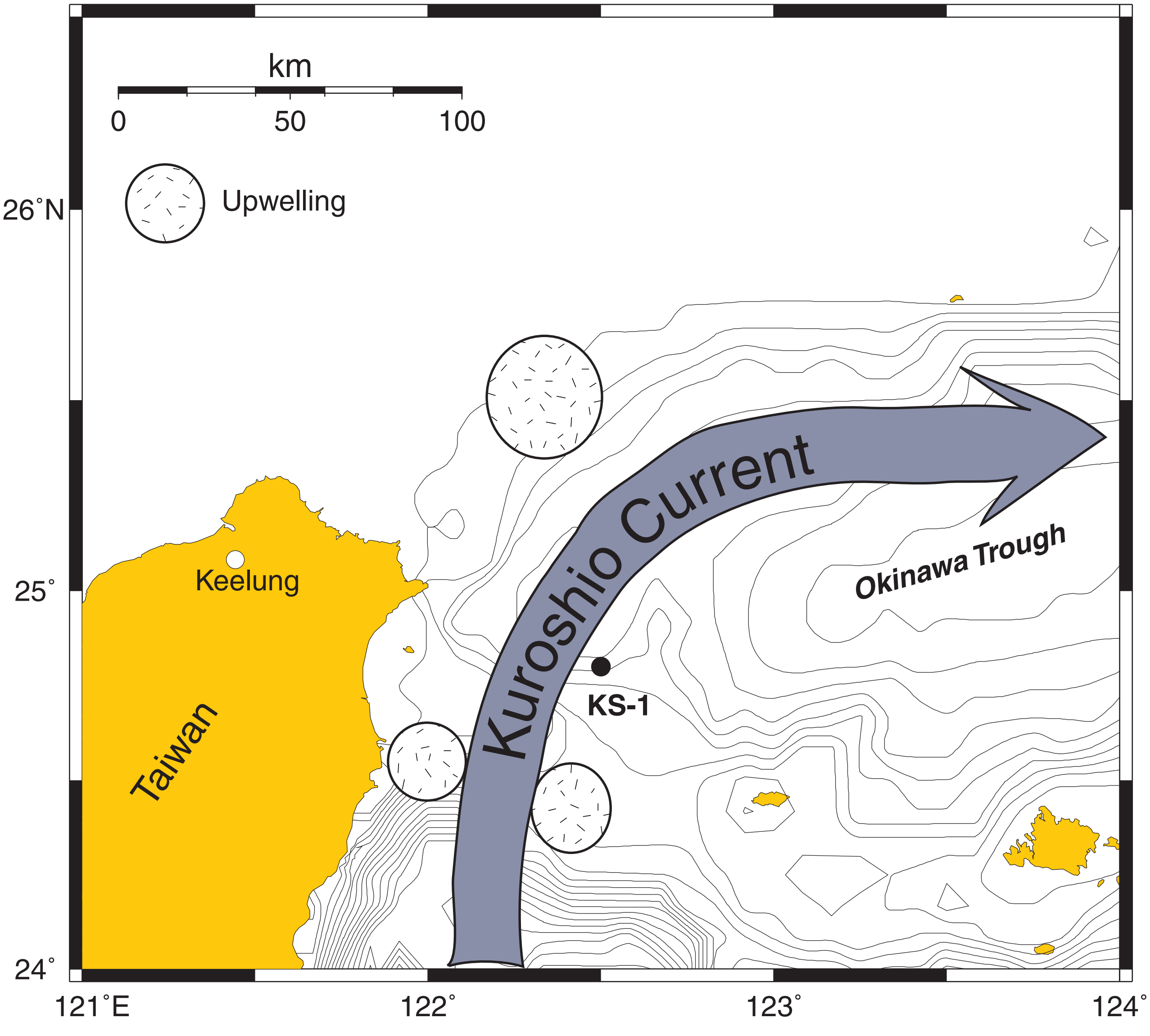

km
0
50
100
Upwelling
26˚N
25˚
24˚
121˚E
122˚
123˚
124˚
Keelung
Taiwan
Kuroshio Current
KS-1
Okinawa Trough

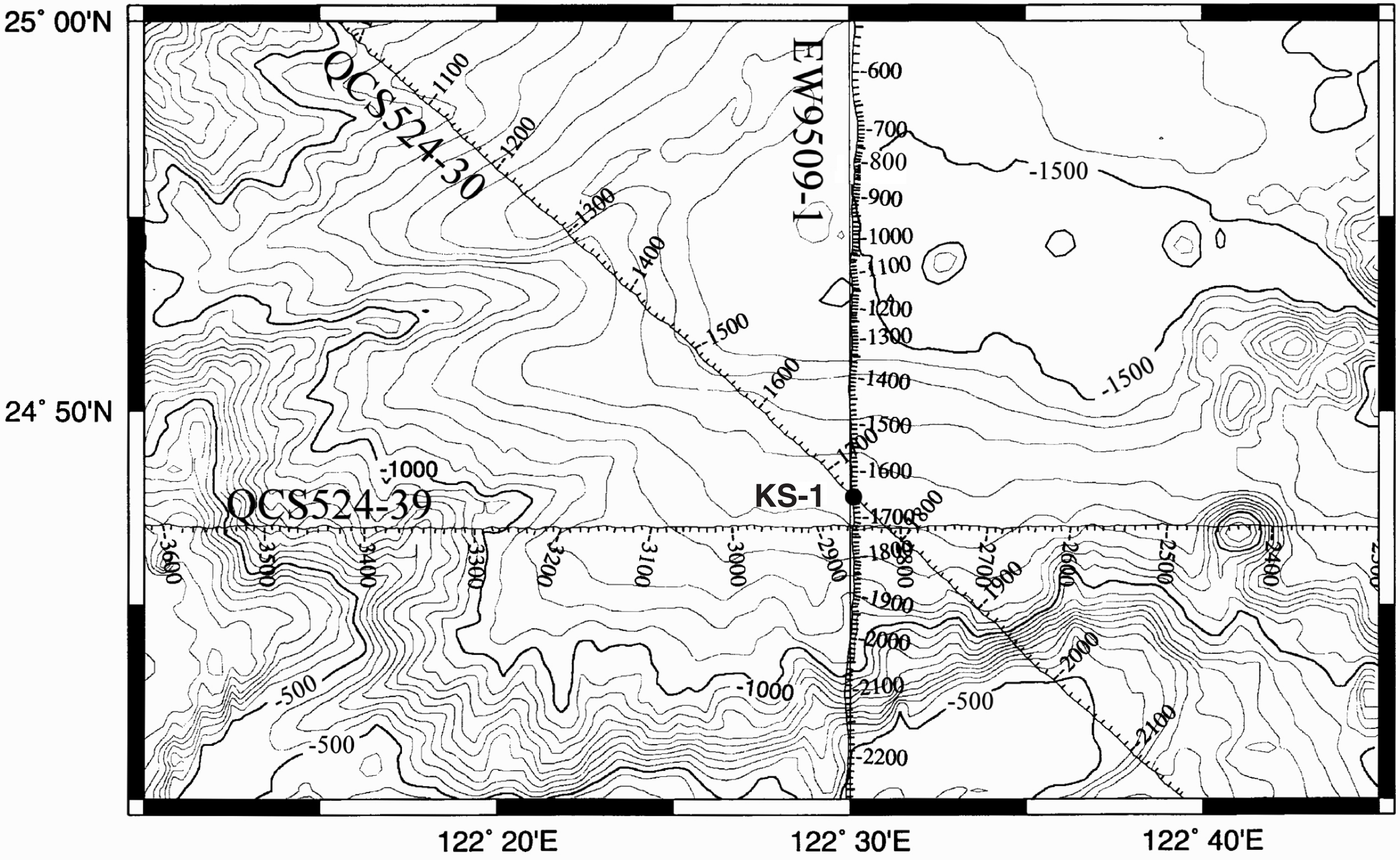
Figure 11

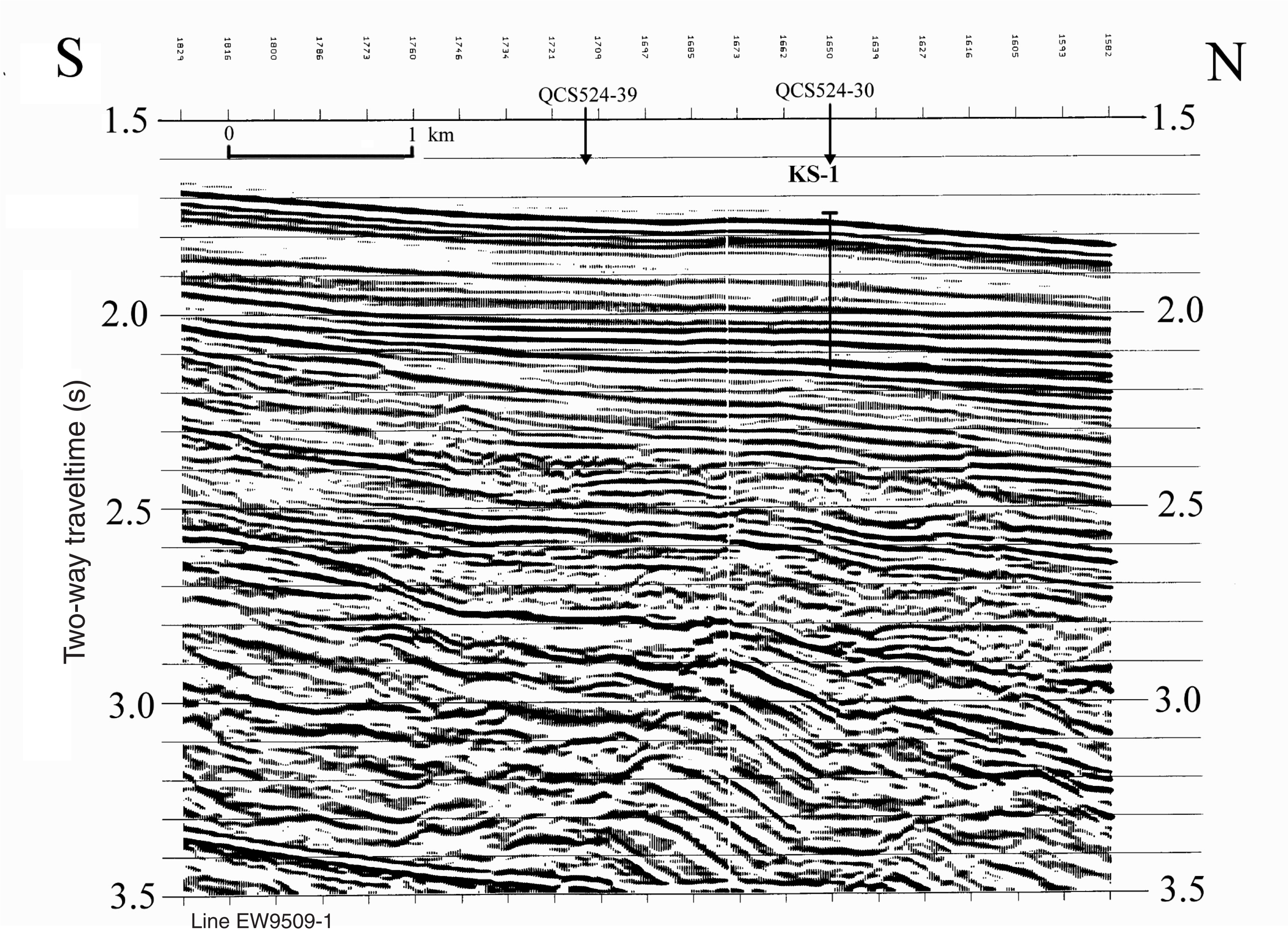
Leg 195 Operations Plan and Time Estimate

Site No.	Location (Lat/Long)	Water Depth (mbrf)	Operations Description	Transit (days)	Drilling (days)	Logging (days)	Total On-site (days)
Guam	13.27°N, 144.38°E		Transit f/Guam to MAF-4B, ~95 nmi @ 10.5 kt [9.0 hrs]	0.4			
MAF-4B	13°47.0' N	2948	A: RIH w/18-1/2" bit, TV survey (12 hr), jet-in test ~60m [130.0 hrs]		5.4	0.0	21.6
South	146°0.0'E		APC/XCB to ~420 mbsf (temperature w/Adara/DVTP)				
Chamorro							
Seamount			B. Drill to ~200 mbsf, RCB to ~420 mbsf (DVTP as req'd) [84.75 hrs]		3.5	2.0	
CORK			Need to RCB core (Hole B) is dependent upon results				
			& TD achieved in previously cored APC/XCB (Hole A)				
			Release bit/WL log dependent on co-chief decision [48.00 hrs]				
			C: Jet-in recone w/20" 94 lb/ft csg to ~25 mbsf (2 jt) [257.0 hrs]		10.7	0.0	
			Reenter/drill w/18-1/2" bit and 22" U/R to ~220 mbsf				
			M/U~200 m 16" 75 lb/ft csg (~16 jts)/RIH/RE/cmt csg				
			Reenter/drill w/14-3/4" tricone bit to ~420 mbsf				
			M/U ~400 m 10-3/4" 40.5 lb/ft csg/RIH/RE/latch csg				
			Use ~31 jts/~377 m of standard 10-3/4" csg plus 2 jts				
			or ~23 m of screened/perforated 10-3/4" csg				
			Reenter/CORK/run thermister string/osmotic sampler				
			Deploy CORK ROV/submersible platform/unlatch f/DP				
			Transit f/MAF-4B to WP-1B, ~ 712 nmi @ 10.5 kt [67.75 hrs]	2.8			
WP-1B	19°17.85'N	5658	A: APC/XCB to ~380 mbsf (basement contact) [98.25 hrs]		4.1	0.0	25.7
ION	135°5.95' E		plug hole w/cmt, APC core orientation, ~5 Adara				
seismometer							
emplacement			B: Jet-in test ~60 m/APC 2nd hole to ~150 mbsf [44.25 hrs]		1.8	0.0	
			C: Drill w/RCB c'bit to ~360 mbsf [120.25 hrs]		5.0	1.6	
			Core w/RCB to ~470 mbsf, release bit w/MBR				
			Wireline logging: rig-up, triple combo, FMS-sonic [38.0 hrs]				
			(2-passes in basement), DLL, UBI, and rig-down				
			D: Set reentry cone, jet-in 60m 16" casing [315.5 hrs]		13.2	0.0	
			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/cmt seismometer instr pkg @ ~460 mbsf				
			Deploy and release from battery platform				
			Note: Should Leg 195 primary operations be completed				
			ahead of schedule there is interest in drilling an				
			APC/XCB hole w/wireline logging at alt site KS-1				
Keelung	25.09° N, 121.44°E		Transit f/ WP-1B to Keelung, Taiwan, ~831 nmi @ 10.2 k [83.5 hrs]	3.5			
			SUBTOTAL:	**6.7**	**43.7**	**3.6**	**47.3**
			TOTAL OPERATING DAYS (Including 5 day port call):	**59.0**			

Alternate Drill Sites

Site No.	Location (Lat/Long)	Water Depth (mbrf)	Operations Description (mbsf)		Transit (days)	Drilling (days)	Logging (days)	Total On-site (days)
KS-1	24°48.24'N	1288	A: Oriented APC to ~250 mbsf, with 5 Adara	[53.75 hrs]		2.2	0.9	4.7
(Alternate	122°30.0'E		temperature measurements, XCB to ~410 mbsf					
Site off			wireline log w/triple combo, FMS-sonic, MST	[22.0 hrs]				
Taiwan)								
			B: Non-oriented APC to ~250 mbsf	[17.25 hrs]		0.7		
			C: Non-oriented APC to ~250 mbsf	[22.25 hrs]		0.9		


25° 00'N
24° 50'N
122° 20'E
122° 30'E
122° 40'E
QCS524-30
QCS524-39
EW9509-1
KS-1
-1500
-1000
-500


S
N
1829
1816
1800
1786
1773
1760
1746
1734
1721
1709
1697
1685
1673
1662
1650
1639
1627
1616
1605
1593
1582
QCS524-39
QCS524-30
KS-1
0
1 km
1.5
2.0
2.5
3.0
3.5
Two-way traveltime (s)
Line EW9509-1

SITE SUMMARY

Site: KS-1

Priority: 2
Position: 24°48.24'N, 122°30.00'E
Water Depth: 1270 meters below sea level (mbsl)
Sediment Thickness: >410 m
Target Drilling Depth: 410 mbsf
Approved Maximum Penetration: Pending PPSP approval
Seismic Coverage: Intersection of EW9509-1 and QCS524-30

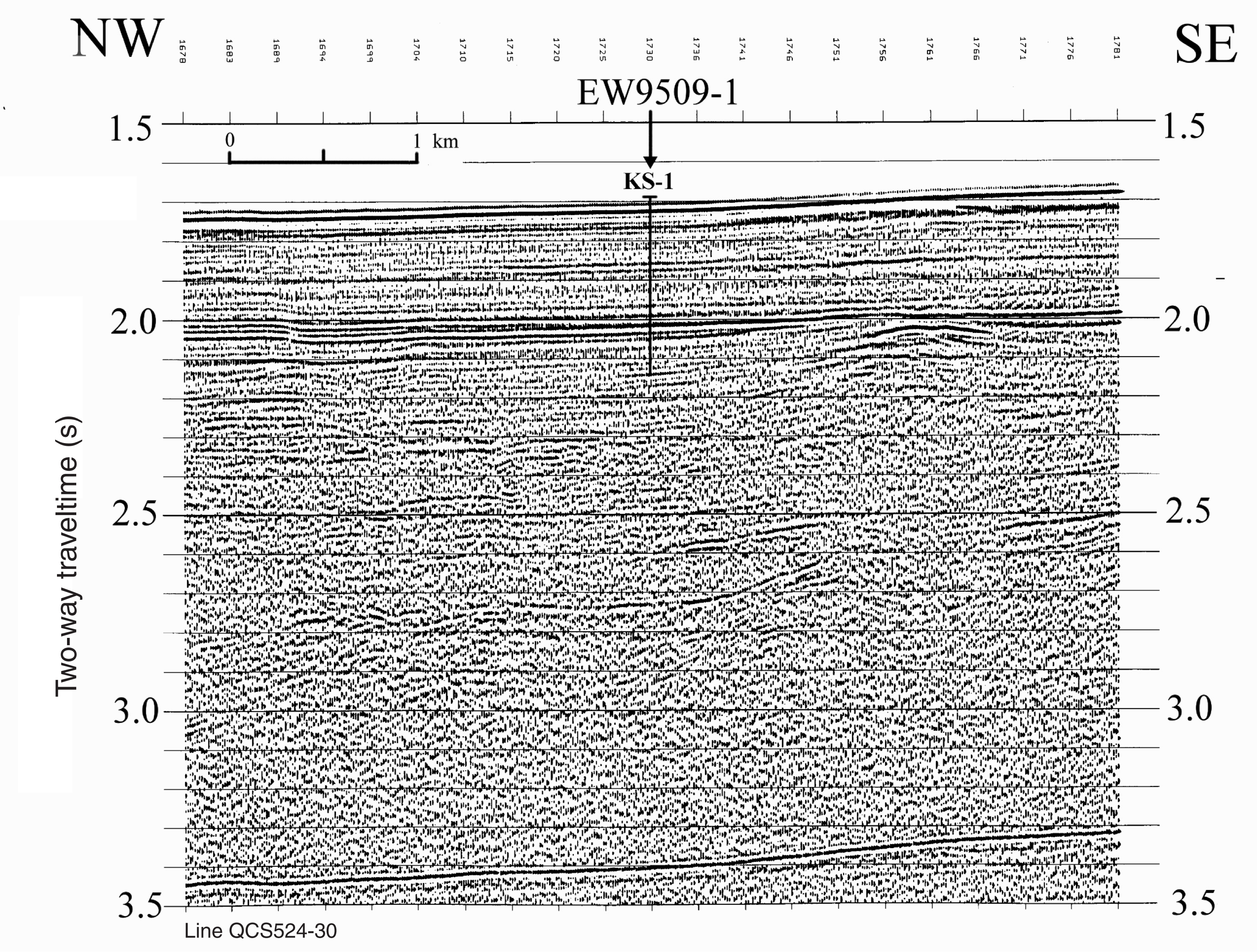
Objectives: The objectives of Site KS-1 are to sample Pleistocene high-resolution sedimentary records to obtain information about the circulation history of the Kuroshio Current by

1. Identifying patterns of long-term climate change associated with the western Pacific boundary current during the past 2.0 m.y.
2. Examining the western Pacific component of long-term changes due to orbital forcing in the mid-Pleistocene (~0.7 Ma) when Earth's climate system switched from a regime of dominant 41-k.y. cycles to 100-k.y. cycles
3. Exploring any long-term El Niño/La Niña type of climate oscillation in the low-latitude Pacific over the late Pleistocene glacial-interglacial cycles by comparing the Kuroshio record to other Pacific ODP records
4. Documenting the temporal and spatial variability of millennial climate changes in the Kuroshio Current

Drilling Program: Triple APC/XCB to 410 mbsf

Logging and Downhole Operations: Triple combo, FMS/sonic, GHMT

Nature of Rock Anticipated: Hemipelagic mud and silt


NW
SE
1678
1683
1689
1694
1699
1704
1710
1715
1720
1725
1730
1736
1741
1746
1751
1756
1761
1766
1771
1776
1781
EW9509-1
1.5
0
1 km
KS-1
2.0
2.5
3.0
3.5
Two-way traveltime (s)
Line QCS524-30

Site: MAF-4B

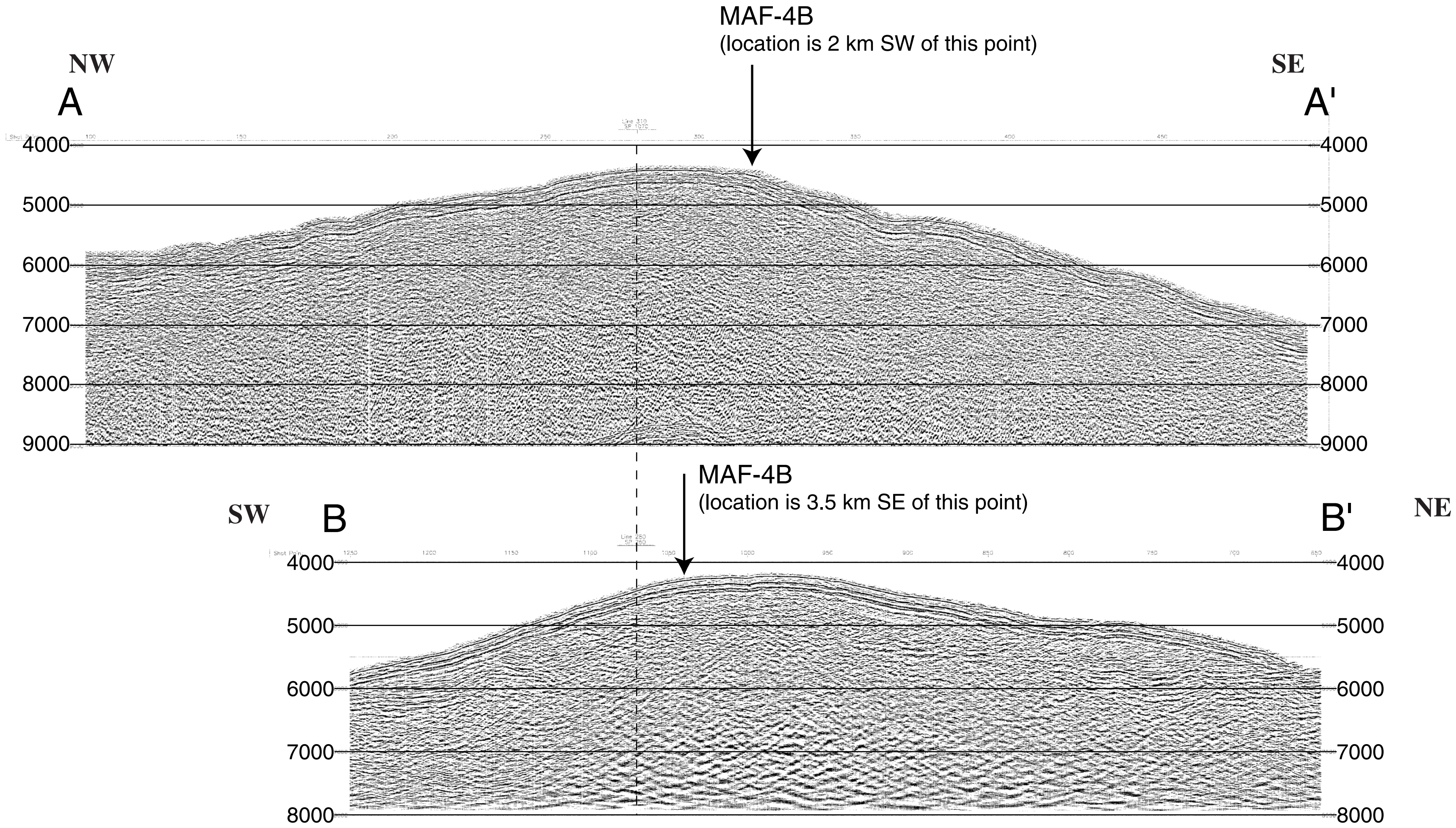
Priority: 1
Position: 13°46.99'N, 146°0.17'E
Water Depth: 2930 meters below sea level (mbsl)
Sediment Thickness: >1370 m
Target Drilling Depth: 400 mbsf
Approved Maximum Penetration: Pending PPSP approval
Seismic Coverage: Six-channel seismic reflection profiles collected during 1997; location of seismic profiles A-A' and B-B' across the seamount is indicated on Figure 4

Objective: Determine composition of slab-derived fluids and deep-derived metamorphosed rock materials. Set casing, reentry cone, and CORK the hole to establish a seafloor observatory

Drilling Program: XCB (ADCB) pilot hole to 400 mbsf. Drill instrumented borehole to ~400 mbsf, install reentry cone, casing, and CORK

Logging and Downhole Operations: Triple combo, FMS/sonic

Nature of Rock Anticipated: Unconsolidated mud flows of clay to sand-sized serpentine containing pebbles to boulders of serpentinized ultramafic rock and metabasalts


MAF-4B
(location is 2 km SW of this point)
NW
SE
A
A'
Shot Pt
100
150
200
250
Line 310
SP 1070
300
350
400
450
4000
5000
6000
7000
8000
9000
MAF-4B
(location is 3.5 km SE of this point)
SW
NE
B
B'
Shot Pt
1250
1200
1150
1100
Line 280
SP 260
1050
1000
950
900
850
800
750
700
650
4000
5000
6000
7000
8000

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

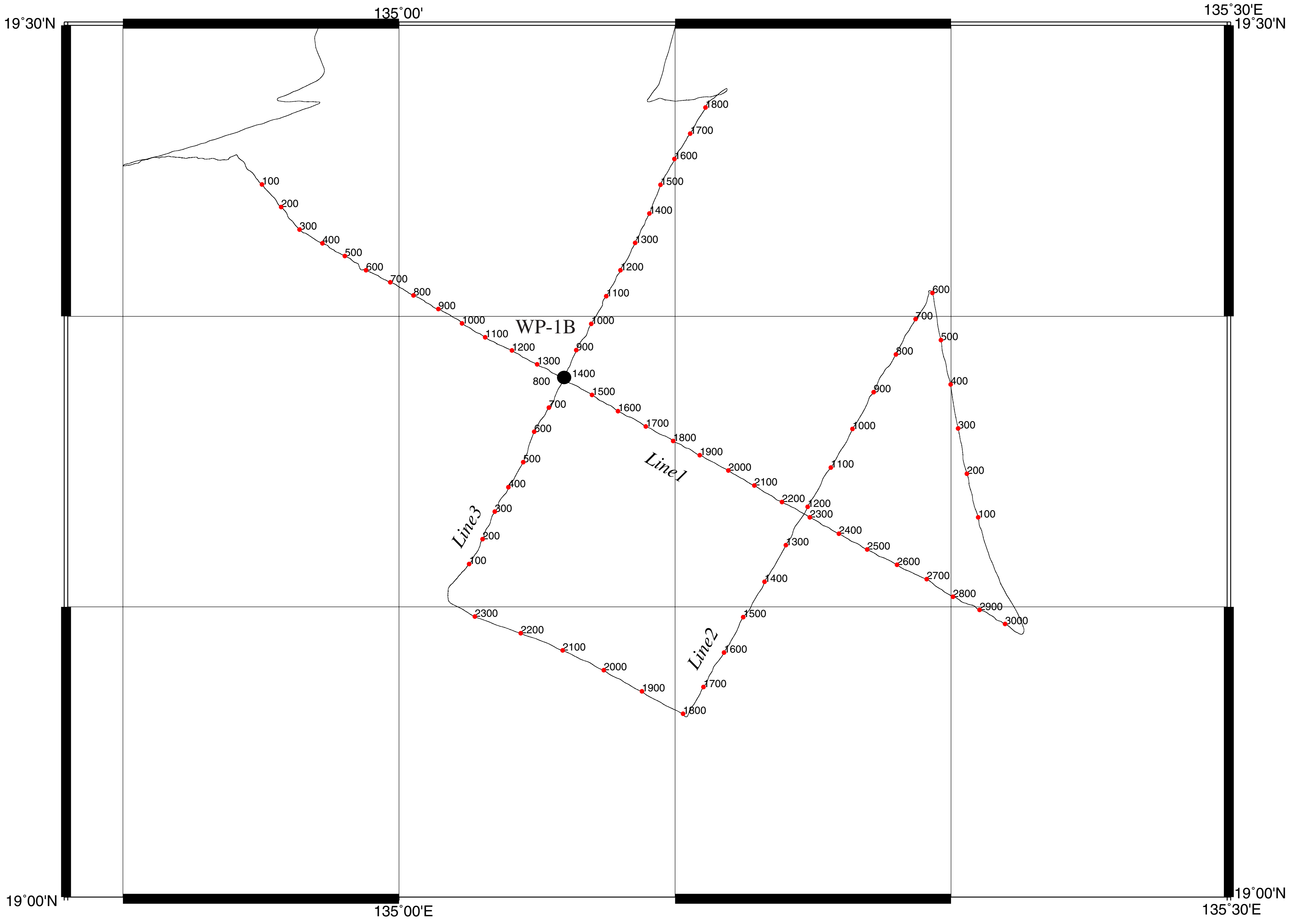
Objectives: The objectives of Site WP-1B are to

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, rotation, 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 by Eocene-Oligocene nannofossil-bearing silty clays with basal polymictic breccias and tuffs; basalt


19˚30'N
135˚00'
135˚30'E
19˚30'N
19˚00'N
135˚00'E
19˚00'N
135˚30'E
WP-1B
Line1
Line2
Line3
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
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2200
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2400
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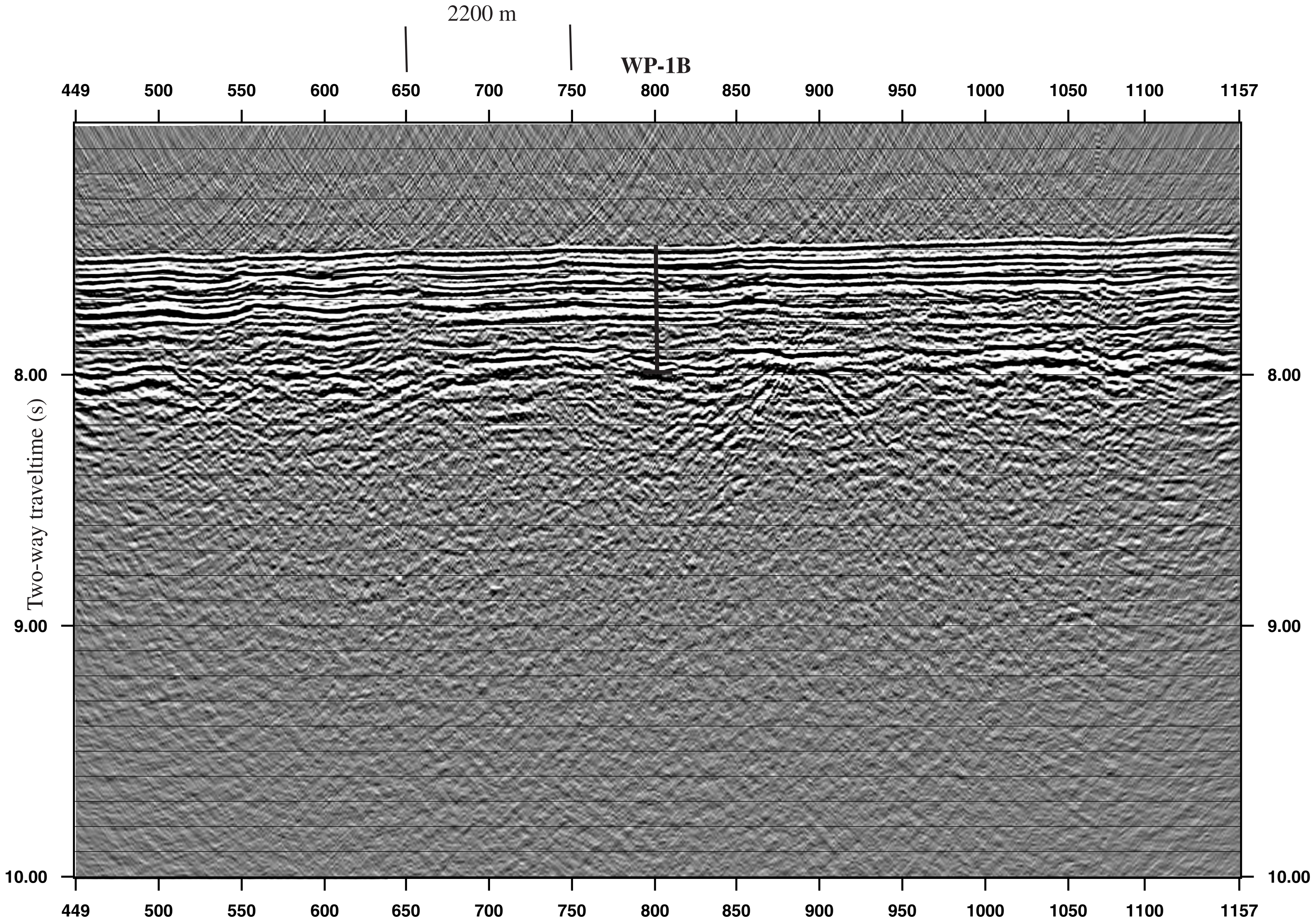
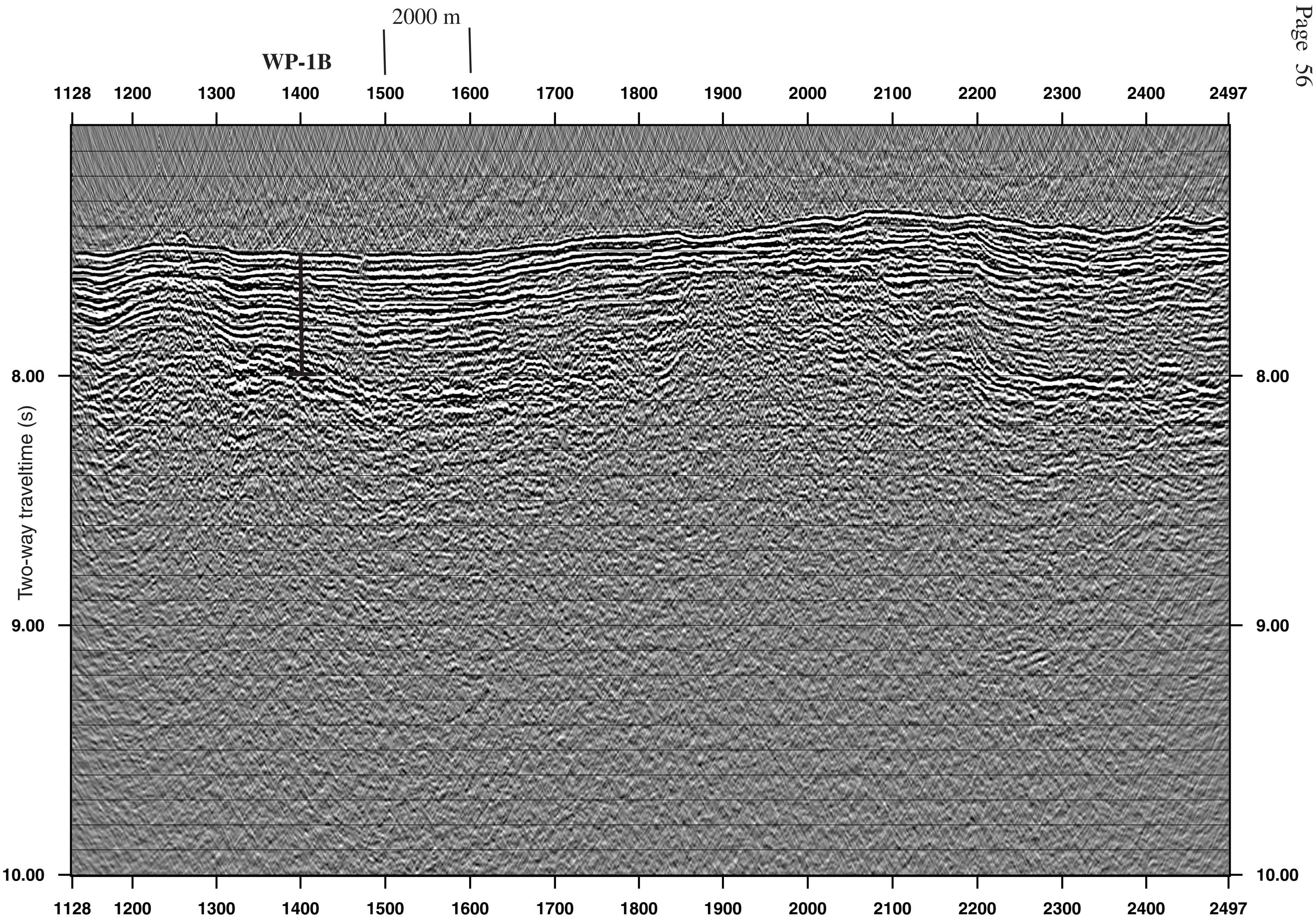
2600
2700
2800
2900
3000



OT97 Line 3 migrated



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