OCEAN DRILLING PROGRAM

LEG 186 SCIENTIFIC PROSPECTUS

WESTERN PACIFIC GEOPHYSICAL OBSERVATORIES

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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.

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ABSTRACT

During Leg 186, we will drill two sites off the northeast coast of Japan to monitor seismic and aseismic crustal deformation associated with subduction of the Pacific Plate beneath Japan. Both sites will be drilled into the deep-sea terrace on the landward side of the Japan Trench, a region that is part of the deforming edge of the overriding Eurasian plate. Borehole strainmeters, tiltmeters, and broadband seismometers will be installed at the bottom of the two holes to continuously monitor strain and seismic activity associated with plate motions. This will be the first attempt to establish long-term seafloor borehole observatories in one of the most active and most studied subduction zones in the world. These observatories will provide crucial near-field data that will quantify elastic and anelastic deformation occurring in the active plate boundary zone. Secondary objectives, which rely on coring at both sites, include (1) determining the forearc subsidence and deformation history, (2) placing constraints on tectonic erosion within the subduction zone, and (3) obtaining a record of arc volcanism over the past 3 m.y.

INTRODUCTION

The western Pacific, where plate-consuming boundaries are concentrated, is very well suited to study the dynamics of plate subductions, the formation and evolution of island arcs and marginal seas, and their relation to mantle convection (e.g., Fukao, 1992) (Fig. 1). In particular, the Japan Trench region (Fig. 2) has both high seismicity and plate convergence rates compared to other trenches. Dense regional geophysical networks have been expanded in the land area across Japan over the years. Data accumulated from these have made it possible to precisely locate the two proposed sites in seismically active (JT-1C) and inactive (JT-2G) areas about 10 km immediately above the interplate seismogenic zone (Fig. 3).

Even though the Japan Trench subduction zone is heavily monitored by dense land-based seismic and geodetic networks, it lacks near-field data that are crucial in quantifying the elastic and anelastic behavior of the active plate boundary zone. The sites we propose to drill will become observatories that will start to fill this void in data coverage. Borehole strainmeters, tiltmeters, and broadband seismometers will be installed at the bottom of the holes to continuously monitor strain and seismic activity associated with plate motions.

Secondary objectives, which rely on coring at both sites, include (1) determining the forearc subsidence and deformation history, (2) placing constraints on tectonic erosion within the subduction zone, and (3) obtaining a record of arc volcanism over the past 3 m.y.

BACKGROUND

The scientific importance of establishing long-term geophysical stations in deep oceans has been acknowledged by the earth sciences and the Ocean Drilling Program (ODP) communities and is expressed in various articles (COSOD II, 1987; Purdy and Dziewonski, 1988; BOREHOLE, 1995; Montagner and Lancelot, 1995; Ocean Drilling Program Long Range Plan, 1996). In essence, we want to understand active processes driving Earth's dynamics from a global to a regional scale, but 71% of Earth's surface is covered by oceans that can only be probed by using state-of-the-art digital sensors linked with land-based stations. Many sensors, whose locations will be carefully selected to maximize results, are needed around the world to attain the goals of the international geoscience programs. We have selected the western Pacific area for installation of ocean-bottom sensors because it is ideal for addressing problems related to plate subduction.

In the Japan Trench area, seven large (magnitude [M] > 7) interplate events occurred in the past 30 yr between 38˚ and 41˚N. Recent large events are the 1968 Tokachi-Oki earthquake (at ~41˚N with a moment magnitude [Mw] of 7.9) and the 28 December 1994 Far-off Sanriku earthquake (at ~40˚N with Mw = 7.7). These events, however, are not sufficient to account for the subducting rate of about 10 cm/yr. Thus, the seismic coupling seems much smaller along the Japan Trench (35˚-41˚N) than compared with the Kurile Trench or Nankai Trough regions, which have a higher seismic energy release rate. Subduction at the Japan Trench may be proceeding mainly by stable sliding with unstable sliding events that are either relatively small (surface-wave magnitude [Ms] <8) and occur frequently, or with truly large events that occur infrequently.

There is a third important category whereby the subduction rate is accommodated by episodic aseismic events of time constants on the order of 10 min to several days (slow earthquakes). Such events, if they exist, are presently extremely difficult to detect. Kawasaki et al. (1995) reported that an ultra-slow earthquake, estimated to have a Mw of 7.3-7.7, accompanied the 1992 Off-Sanriku (located at 39.42˚N, 143.33˚E; Mw = 6.9) earthquake based on strain records observed ~120-170 km away from the source. A postseismic strain of 10^{-7} to 10^{-8} with a time constant of about a day was observed by quartz-tube extensometers (devices that measure relative strain). Historically, in the same area, the 1896 Sanriku tsunami earthquake (Mw ~8.5 but body-wave magnitude [Mb] ~7) killed about 22,000 people. Tsunami earthquakes rupture over a much longer time than normal earthquakes (Tanioka and Satake, 1996), supporting the notion that slow earthquakes may occur off the Sanriku coast.

More recently, the Japanese global positioning system (GPS) network has revealed a postseismic motion of northern Japan after the 1994 Far-off Sanriku earthquake (M = 7.2), which can be explained by a stress diffusion model that assumes slow slip on the earthquake fault (Heki et al., 1997). A different, but previously more prevailing interpretation, is that the postseismic deformation is caused by aseismic slip at a deeper depth extending down from the seismogenic zone. If such a slow slip really occurred in the vicinity of the normal seismogenic zone, then strainmeters in the proximity would have not only recorded signals much larger in magnitude, but also would have resolved how and where the slip initiated relative to a normal earthquake, and how it proceeded. Furthermore, one can test if aseismic and episodic slips occur irrespective of normal earthquakes.

The strain waveforms of slow earthquakes are of a ramp type. The amplitudes of strain steps decay inversely proportional to the distance cubed, much more rapidly than seismic waves. It is essential, therefore, to measure the strain signatures as near to these events as possible (within 20 km for an event equivalent to Mw of 7.0; e.g., Johnston et al., 1990) to estimate how the regional tectonic stress affects earthquake occurrences.

The primary objective is to establish long-term borehole observatories, and so once the instruments are installed, they must be serviced for data analyses, distribution, and archiving. There is an ongoing national program within Japan to achieve this (Ocean Hemisphere Network Project). Initially, power will be supplied to the observatories by a battery pack and data will be retrieved by a remotely operated vehicle (ROV). Eventually, the goal is to connect the observatories to a fiber- optic cable that will supply power and allow the data to be retrieved. A new fiber-optic cable owned by the University of Tokyo already exists and currently terminates near Site JT-1C. Once Site JT-1C proves operational, connections will be made to supply power, send commands, and retrieve data in real-time on land. A 50-km cable extension is planned to connect Site JT-2G as well. These stations will make invaluable additions to the existing geophysical network over the western Pacific. The data will eventually become accessible worldwide through the Internet.

SCIENTIFIC OBJECTIVES

Dynamic Sliding of the Subducting Plate and Earthquake Process

The seismic coupling efficiency of the subduction zone off Tohoku appears to be as low as 25%. This means that, of the total Pacific plate motion expected, only one-quarter is seen as stick-slip motion leading to thrust-type earthquakes. One possibility is that three-quarters of the motion is released as slow earthquakes, which are not recorded on normal seismographs. In the past, sparse observations suggest that the slow strain release may consist of multiple episodes in which each event is rather small. For this reason, installation of an instrument of the highest achievable sensitivity is required. Any data leading to better understanding of the partitioning of strain release into damaging "fast" events and slower events will be extremely valuable and may lend further insight into the whole earthquake process.

The plate boundary off northeast Japan fulfills three important conditions for a long-term geophysical observatory:

1. Dense geophysical networks to which our proposed observatories can be optimally linked already exist on land.
2. Moderately large (M ~7) seismic events occur frequently, and aseismic slip events (slow earthquakes) with comparable or larger magnitude are expected to occur even more frequently.
3. Crustal and uppermost mantle structures have been well studied by reflection-refraction seismic surveys and tomographic inversions (Suyehiro et al., 1985a, 1985b, 1990; Suyehiro and Nishizawa, 1994; Ito, 1996).

Earthquake Source Studies

Stations at proposed Sites JT-1C and JT-2G will greatly improve source location (particularly depth), focal mechanism, and rupture process determinations of the earthquakes near the Japan Trench (Nishizawa et al., 1990, 1992; Suyehiro and Nishizawa, 1994; Hino et al., 1996).

Near-field data obtained from the stations at Sites JT-1C and JT-2G will particularly improve the resolution of the source mechanisms of very slow rupture events such as tsunami earthquakes.

High-Resolution Geometry of the Plate Boundary

The two stations at proposed Sites JT-1C and JT-2G will be linked to the network of the broadband and/or very broadband seismometers on the main Japanese islands and will become part of a dense seismic network roughly 50-km in scale. The observations of various phases of body waves from many shallow to deep earthquakes within the network will provide sufficient data to improve the structural image of the plate boundary, particularly the changes in physical properties associated with tectonic erosion and seismogenesis.

Miocene and Younger Volcanic Ash Stratigraphy in the Western Pacific (Site JT-1C)

The cores should contain an important reference section from near Japan to compare with the remote ash deposits already cored to the east. They will also provide important information about eruptive processes, volcanic hazards, and aspects of climate such as response to wind, sand, and volcanogenic input of greenhouse and related gases (J. Natland, pers. comm., 1997).

During Leg 132, a number of rhyolitic to dacitic volcanic ash beds on Shatsky Rise, east of Japan were recovered (Fig. 1). Comparison with ash stratigraphy at Deep Sea Drilling Project (DSDP) Sites 578-580, about halfway between Shatsky Rise and Japan, indicates that the Shatsky ash beds were derived either from Japan or the Kurile-Kamchatka arc systems and that they were carried far to the east on the high-speed polar and subtropical jet streams (Natland, 1993). A summary appraisal is that 25-40 eruptions produced ash that reached one or more of those sites in each of the past 3 m.y., with ~10% of these reaching Shatsky Rise in the form of discrete ash beds or pumice drops. Some of the eruptions were extremely large, resulting in deposits 5 to 15 cm thick, even on Shatsky Rise. The last drilling in this region was during DSDP Legs 56 and 57, before the advent of hydraulic piston coring. An important, but seriously incomplete and at times highly disturbed, ash record was recovered in Holes 438A and 440B (e.g., Cadet and Fujioka, 1980). Fluctuations in accumulated ash thickness through time over the 15° of latitude represented by the DSDP Leg 86 sites indicates that both the position and velocity of the jets have changed during the past 3 m.y., during the period of pronounced climatic change since the early Pliocene.

Subsidence History across the Continental Slope to Constrain the Processes of Tectonic Erosion

Quantitative estimates of the tectonic erosion process were made for the Neogene history of the Japan Trench region based on drilling and seismic records (Fig. 4; von Huene and Lallemand, 1990; von Huene et al., 1994). Key evidence came from Site 439. Evidence collected from additional drilling will further constrain the timing and erosion volumes in relation to backarc opening and the style of convergence.

Age and Nature of the Cretaceous Basement

Only one hole (Hole 439) touched the Cretaceous basement during DSDP Leg 57 (Shipboard Scientific Party, 1980). This Cretaceous unit is unconformably overlain at the drill site by a 48-m-thick breccia conglomerate, which contains 24 Ma hypabyssal dacitic to rhyolitic boulders (von Huene et al., 1994). Although, the likelihood of reaching the basement is low, if it is achieved, the age determination and areal extent of the basement could confirm the prevailing hypothesis that the now-subsided Oyashio landmass was previously above sea level (Shipboard Scientific Party, 1980).

DRILLING STRATEGY

In order to install the instrument string, the borehole needs to equipped with reentry cones and be cased through unstable sections. The instrument string should be located in a relatively homogeneous and unfractured zone, preferably in rocks older than early Miocene. Installation of borehole sensors will be made by the drillship. The sensor package consists of an 8-in diameter strainmeter, with two seismometers and a tiltmeter attached above it. Above the sensor, there will be nearly 1 km of support tubing or casing that runs from the sensor package to the seafloor. The sensor package will be secured to rock exposed at the base of the borehole by pumping cement through the drill string and support tubing. Afterwards, the drill string will be disconnected from the support tubing at seafloor level (Fig. 5).

To obtain volcanic ash records that will ensure complete recovery in the Pliocene and younger section, piston coring to refusal is preferred, ideally at least twice at one site. Below that, single extended core barrel (XCB) coring will be used to recover the Miocene section in the interval from ~250 to 450 mbsf. We will then switch to a rotary core barrel (RCB) bit and drill a new hole to ~450 mbsf and then core to ~1000 mbsf or deeper, if time permits.

LOGGING PLAN

The logging program is designed to measure physical properties using a suite of standard geophysical logs and hole shape using the borehole televiewer (BHTV) log. In particular, the BHTV will be used to characterize the shape and volume of the borehole in the vicinity of the strainmeter and seismometers. This will significantly improve grouting procedures for the instruments. The Formation MicroScanner (FMS) will provide a detailed 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 holes. Spontaneous potential (SP) log will provide in situ measurement of the streaming potential. SP changes are of electrochemical and electrokinetic origins and related to the active flow in permeable formations.

The RCB-cored pilot hole at both sites will be logged with the standard triple-combo tool string and the FMS/sonic/temperature tool string. The triple combo tool string includes the Natural Gamma-ray Sonde (NGS) to measure radioactivity, the Accelerator Porosity Sonde (APS), which measures porosity, the Hostile Environment Lithodensity Sonde (HLDS) to measure denisty, and the Dual Induction tool (DIT-E), to measure resisitivity. The triple combo tool string also measures the spontaneous potential and makes a caliper measurement. The FMS/sonic/temperature tool string includes the Formation MicroScanner, the dipole shear sonic imager (DSI), and the Lamont temperature tool (TLT) combination, along with a natural gamma-ray tool (NGT).

Following casing operations, the open part of the instrumented borehole at both sites, which includes that portion of the hole below the 10-3/4-in casing, will be logged with the BHTV at a logging speed of ~1 m/min.

We anticipate that ~1.5 days (1.2 days for the RCB hole and 0.3 days for the instrumented hole) will be required for logging operations at Site JT-1C and 1.2 days (1.0 days for the RCB hole and 0.2 days for the instrumented hole) at Site JT-2G (Table 1).

UNDERWAY GEOPHYSICS

Standard ODP practice is to collect 3.5- and 12-kHz echo-sounder data on the approach to each site. Assuming operations at the two primary sites goes as planned, no other surveys will be conducted during Leg 186.

SAMPLING PLAN

Sampling of cores will be subject to the rules described in the ODP Sample Distribution Policy (http://www-odp.tamu.edu/curation/sdp.htm). As part of this policy, any sampling to be conducted during Leg 186 or during the one year moratorium following the end of the leg must be approved by the Sampling Allocation Committee (SAC), consisting of the co-chiefs, staff scientist, and curatorial representative. At any time during the cruise, the SAC may judge that a certain interval is so unique as to be treated as a critical interval, which could result in either a sampling moratorium or solicitation of a special sampling program for the interval.

For Leg 186, we expect to recover less than 2 km of sediment and sedimentary rock. In addition, we plan to double core the upper section at one site only, with all other intervals being single cored. Given this level of recovery, it should be possible to accomplish all sampling during the cruise. Investigators may chose to sample following the leg, if such a strategy is beneficial to their research goals. Because only one working-half from single-cored sites will be available for sampling in most intervals, investigators should carefully plan their sampling strategy.

Sample requests may be submitted by shore-based investigators as well as the shipboard scientists. Based on sample requests received by 18 April 1999, the SAC will prepare a temporary sampling plan, which will be revised on the ship as needed. The SAC will also consider sample requests submitted during the leg or post-leg moratorium, but priority will generally be given to those received before 18 April 1999. In the final shipboard sampling plan, sample requests will be closely linked to proposed postcruise research, with higher priority going to research projects that fulfill the scientific goals of Leg 186 as outlined in this prospectus. The sampling plan will be subject to modification depending upon the actual material recovered and collaborations that may evolve between scientists during the leg.

PROPOSED SITES/OBSERVATORIES

Site JT-1C

Proposed Site JT-1C is located on the deep-sea terrace for observatory installation within a seismically active zone (Figs. 3, 6, 7). This zone is known to be capable of generating from micro-sized to large ($M > 7$) earthquakes. Other objectives are to (1) recover a record of the volcanic ash stratigraphy spanning the past 3 m.y.; (2) use the sedimentology, biostratigraphy, and structural fabric of cores to obtain a better understanding of the subsidence history of the forearc since the early Miocene; and (3) determine the physical properties for geologic studies and for characterizing the borehole. Time permitting, efforts will be made to reach the Cretaceous basement to determine its nature and to extend our knowledge of the subsidence and deformation history.

Site JT-2G

Proposed Site JT-2G is located on the deep-sea terrace south of Site JT-1C for observatory installation within a seismically inactive zone (Figs. 3, 6). Slip within this zone has not been accompanied by detectable earthquakes for more than a decade. No clear historical record is available that indicates seismic slips in this zone except possibly in 1678 or 1915. Other primary objectives are to (1) use the sedimentology, biostratigraphy, and structural fabric of cores to obtain a better understanding of the subsidence history of the forearc since the early Miocene and (2) determine the physical properties for geologic studies and for characterizing the borehole. Time permitting, efforts will be made to reach the Cretaceous basement to determine its nature and to extend our knowledge of the subsidence and deformation history.

Alternate Sites JT-3, 4, and DSDP-439

These are alternate sites located near the primary sites on the deep-sea terrace (Figs. 2, 6). Proposed Site JT-3 is located ~4 km north of Site JT-1C and is a contingency site should there be problems at Site JT-1C.

Proposed Site JT-4 is ~11 km south of JT-1C and is a contingency site for studying arc volcanism should there be additional time after drilling the primary sites. It will be APC/XCB cored to recover undisturbed sediments to perform a detailed study of Pleistocene/Pliocene volcanic ash, sedimentology, biostratigraphy, and subsidence history.

Site 439 was drilled and cored during DSDP Leg 57 down to the Cretaceous basement. This site is proposed as an alternate to Site JT-2G. Because this site has already been cored, it provides an alternate site in which an instrumented borehole could be completed more rapidly than the primary site. Such a contingency site could become important should difficulties arise at the primary sites.

Observatory Design

All the instruments will be third-party tools. Both sites are to be equipped with the following sensors near the bottom of the drilled holes: (1) a high-resolution volumetric strainmeter (Carnegie Institution of Washington/University of Tokyo joint development), (2) a broadband seismometer (Guralp CMG-1) and back-up sensor (PMD2023), (3) a tiltmeter (AG510), and (4) a temperature sensor. Any heat-generating instrument will be separated from the strainmeter. A pressure gauge will be placed on the seafloor to monitor pressure changes at a resolution equivalent to an ~10-cm water column.

(1) *Strainmeter*

The Sacks-Evertson borehole volumetric strainmeter has proven to have resolution of better than 10^{-11} at various locations on land, including San Andreas, California, Iceland, and Japan (Sacks et al., 1978; Linde et al., 1988, 1993, 1996). The instrument must be buried and cemented in solid contact within a competent rock section. The deepest installation so far has been at ~500 m. Because of the high dynamic range and very broad frequency response (up to 20 Hertz) of the borehole strainmeter, an ocean-bottom installation will provide valuable data for subduction zone earthquakes. For example, on-land borehole strainmeters have proven to be effective in detecting the slow initial stage of large earthquakes.

(2) *Seismic Sensor*

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 (Mb 5.4 at ~4000-km epicentral distance) clearly showing a surface wave dispersion train (Kanazawa et al., 1992). In May 1992, 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 apparent conclusion as to how we should establish seafloor seismic observatories, it is becoming clear that oceans can provide low-noise environments. In this particular case, where seismic sensors are to be installed as near to the source as possible, borehole installation should give better constraints on hypocenter depths. It is imperative that no fluid motion occur around the sensor; therefore, the seismometer and the strainmeter must be cemented at the same location in the same operation.

(3) *Tiltmeter*

Biaxial borehole tiltmeters (Applied Geomechanics Model 510) will be included to measure crustal deformation at a resolution of 10^{-8} rad with a dynamic range of 44 dB.

(4) *Temperature*

Temperature changes inside the strainmeter will be measured to compensate for the effects of temperature variation. Temperature on the seafloor will also be recorded at $5x10^{-4}$ degree sensitivity.

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von Huene, R., Klaeschen, D., Cropp, B., and Miller, J., 1994. Tectonic structure across the accretionary and erosional parts of the Japan Trench margin. *J. Geophys. Res.*, 99:22349-22361.

FIGURE CAPTIONS

Figure 1. Map of western Pacific area where at least five major plates with consuming boundaries interact. Dark gray squares are primary drill sites, light gray triangles are alternate drill sites, and gray circles are DSDP sites. Bathymetry is in meters.

Figure 2. Swath bathymetry of the Japan Trench area. The proposed sites are located on a deep-sea terrace.

Figure 3. Tectonic subsidence history (from von Huene and Lallemand, 1990).

Figure 4. Map of Japan Trench area with seismicity (R. Hino, pers. comm. 1998). The locations of proposed Sites JT-1C and JT-2G are shown.

Figure 5. A. Schematic configuration of the instrument package with multisensors for crustal strain and broadband seismometry. **B.** Strainmeter installation schemetic for Sites JT-1C and JT-2G with lithologies extrapolated from Leg 57.

Figure 6. Site survey track lines and proposed sites. Contour interval is 100 m.

Figure 7. Multichannel seismic (MCS) record section across Japan Trench near JT-2G in an east-west direction. The data is from the KH-90-1 cruise of ORI *R/V Hakuho-maru*. The location of the proposed observatories relative to the subduction geometry is shown. The strong reflector ~1.3 s below seafloor at the western edge continuing on east past the observatory site is interpreted to be Cretaceous basement. See Figure 6 for track line.

Figure 8. Seismic velocity structure across Japan Trench at about 40°N. Hatched zone is earthquake zone.

Figure 9. Prototype bottom-hole assembly about to be installed in a 200-m-deep water-filled hole south of Tokyo, Japan. The lowermost sensor is the strainmeter, followed by the Guralp broad-band seismometer, an Applied Geomechanics tiltmeter, and a PMD broad-band seismometer. The tube linking the sensors is used to transport cement from the drill pipe through the strainmeter body and up around the whole assembly, thus anchoring it firmly to bare rock at the bottom of the hole.

Figure 10. Schematic of the seafloor assembly. All the equipment in this assembly is accessible to an ROV such as the one shown in Figure 11. Cables from the sensors grouted in ~1000 mbsf terminate in a 4-way underwater-mateable connector block. The data handling and instrument control package, marked “G,” plugs into this connector block. A single output from the top of this package is coupled (by ROV) to the multiyear battery installed after the sensors are grouted. A data storage unit can be retrieved by an ROV when required.

Figure 11. Photograph of the Japan Marine Science and Technology Center's (JAMSTEC) ROV, the DOLPHIN 3K. All seafloor assembly electrical connections, the data storage unit, and the data handling and control unit (“G” in Fig. 10) can be removed and replaced by such an ROV. The top of the battery unit shown in Figure 10 is the landing base for the ROV.

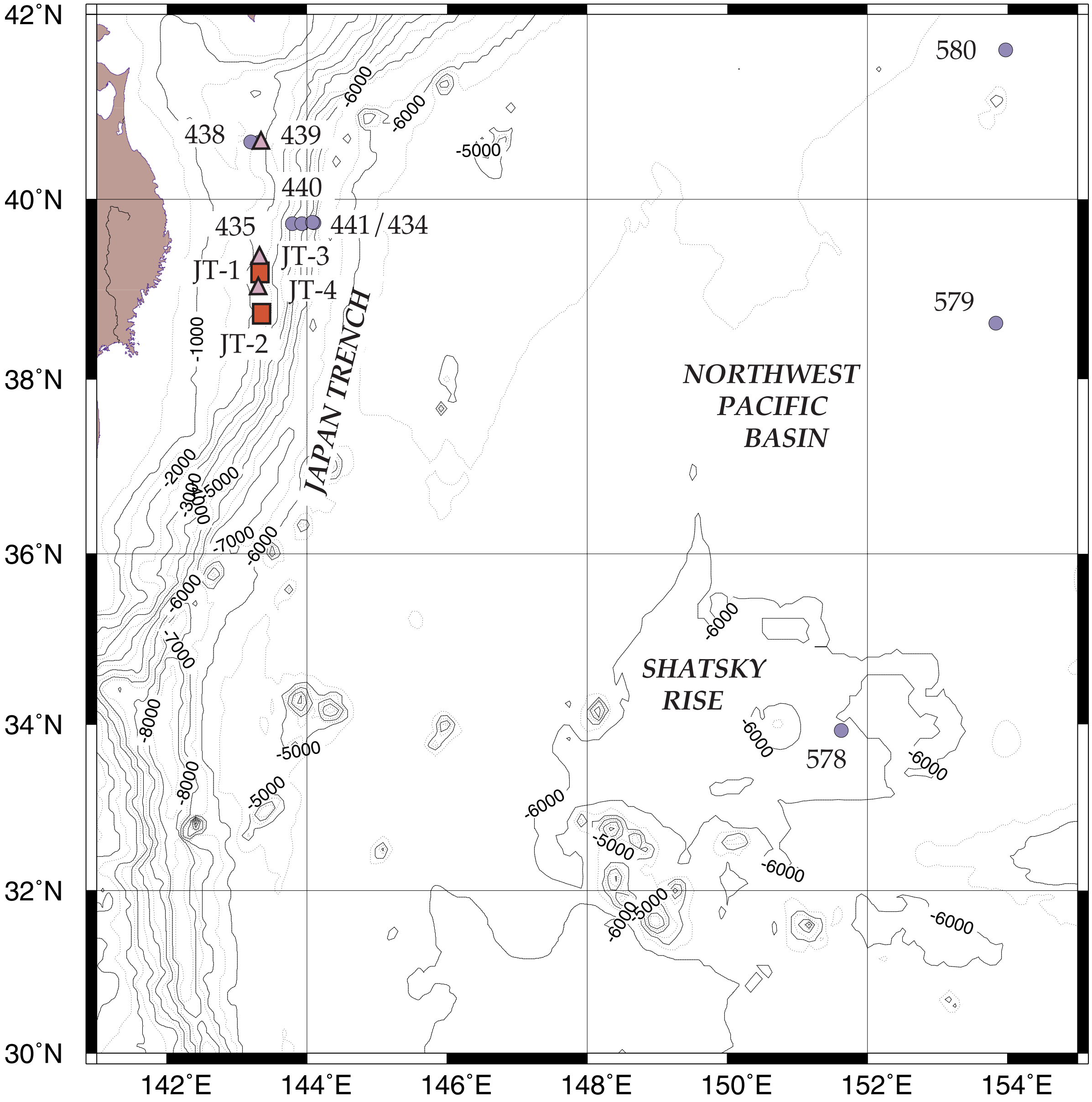
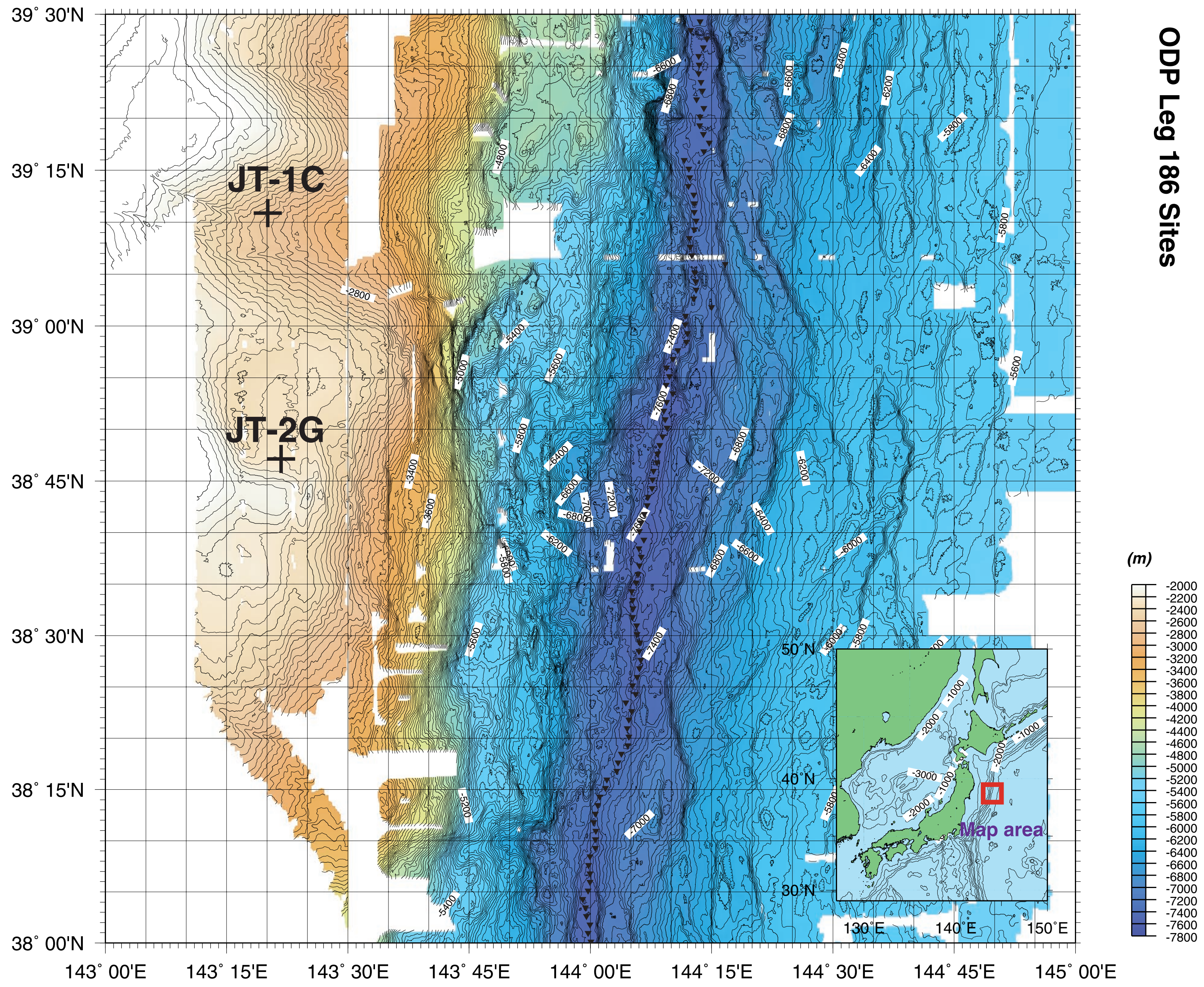

42˚N
40˚N
38˚N
36˚N
34˚N
32˚N
30˚N
142˚E
144˚E
146˚E
148˚E
150˚E
152˚E
154˚E
580
579
578
438
439
440
435
441 / 434
JT-1
JT-2
JT-3
JT-4
JAPAN TRENCH
NORTHWEST PACIFIC BASIN
SHATSKY RISE
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000

Figure 1



ODP Leg 186 Sites

Figure 2

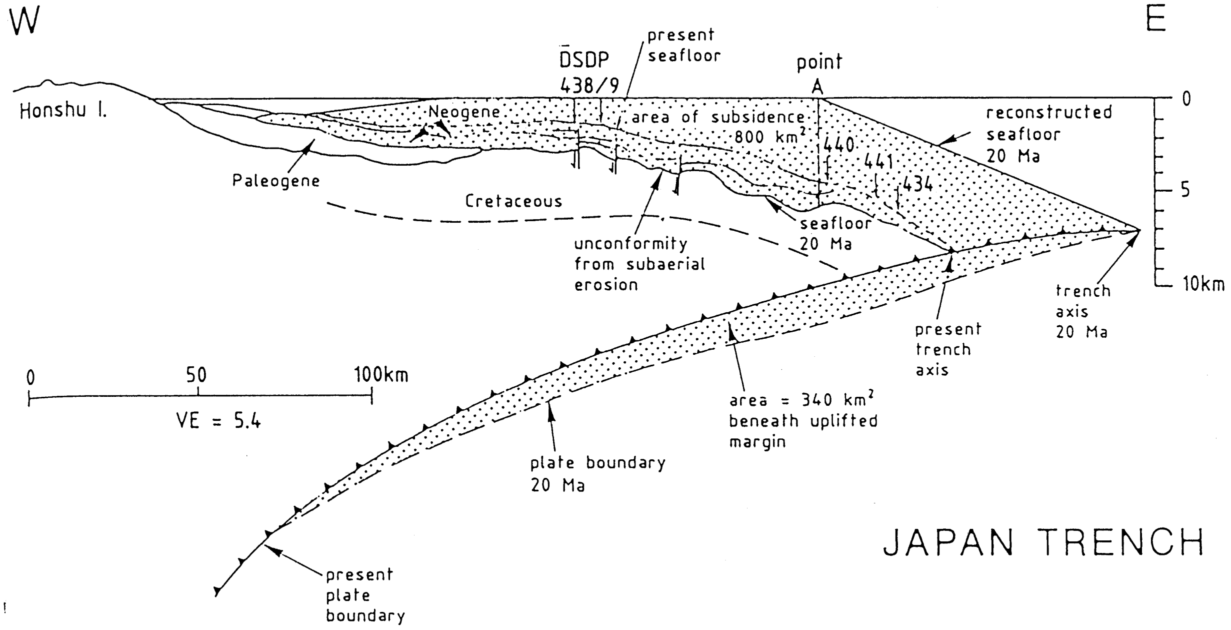

W
E
present seafloor
DSDP 438/9
point A
0
Honshu I.
Neogene
area of subsidence 800 km²
440
441
434
reconstructed seafloor 20 Ma
5
Paleogene
Cretaceous
seafloor 20 Ma
unconformity from subaerial erosion
10km
trench axis 20 Ma
present trench axis
0
50
100km
VE = 5.4
area = 340 km² beneath uplifted margin
plate boundary 20 Ma
JAPAN TRENCH
present plate boundary

Figure 3

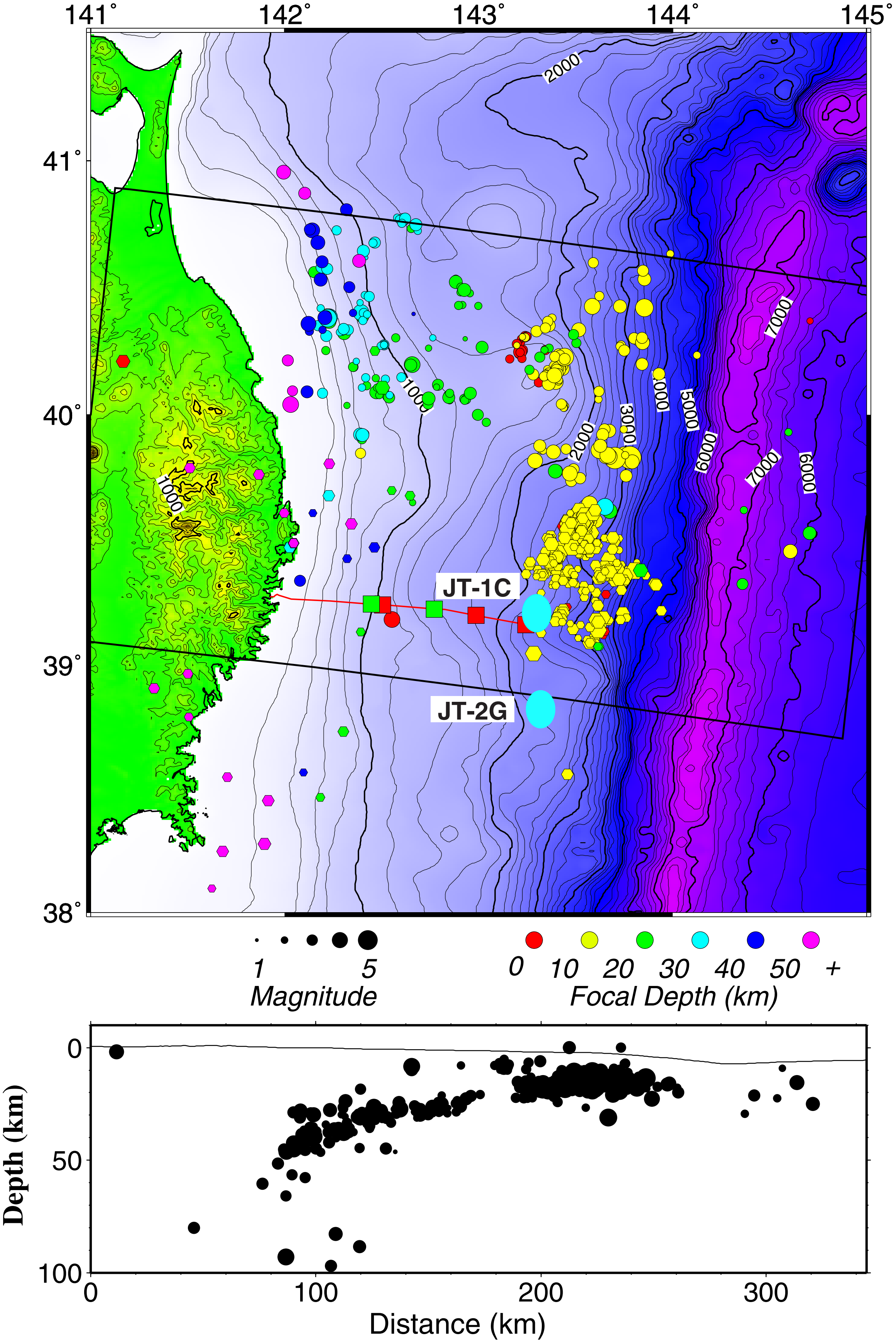

141°
142°
143°
144°
145°
41°
40°
39°
38°
2000
1000
3000
4000
5000
6000
7000
JT-1C
JT-2G
1
5
Magnitude
0
10
20
30
40
50
+
Focal Depth (km)
Depth (km)
0
50
100
Distance (km)
200
300

Figure 4

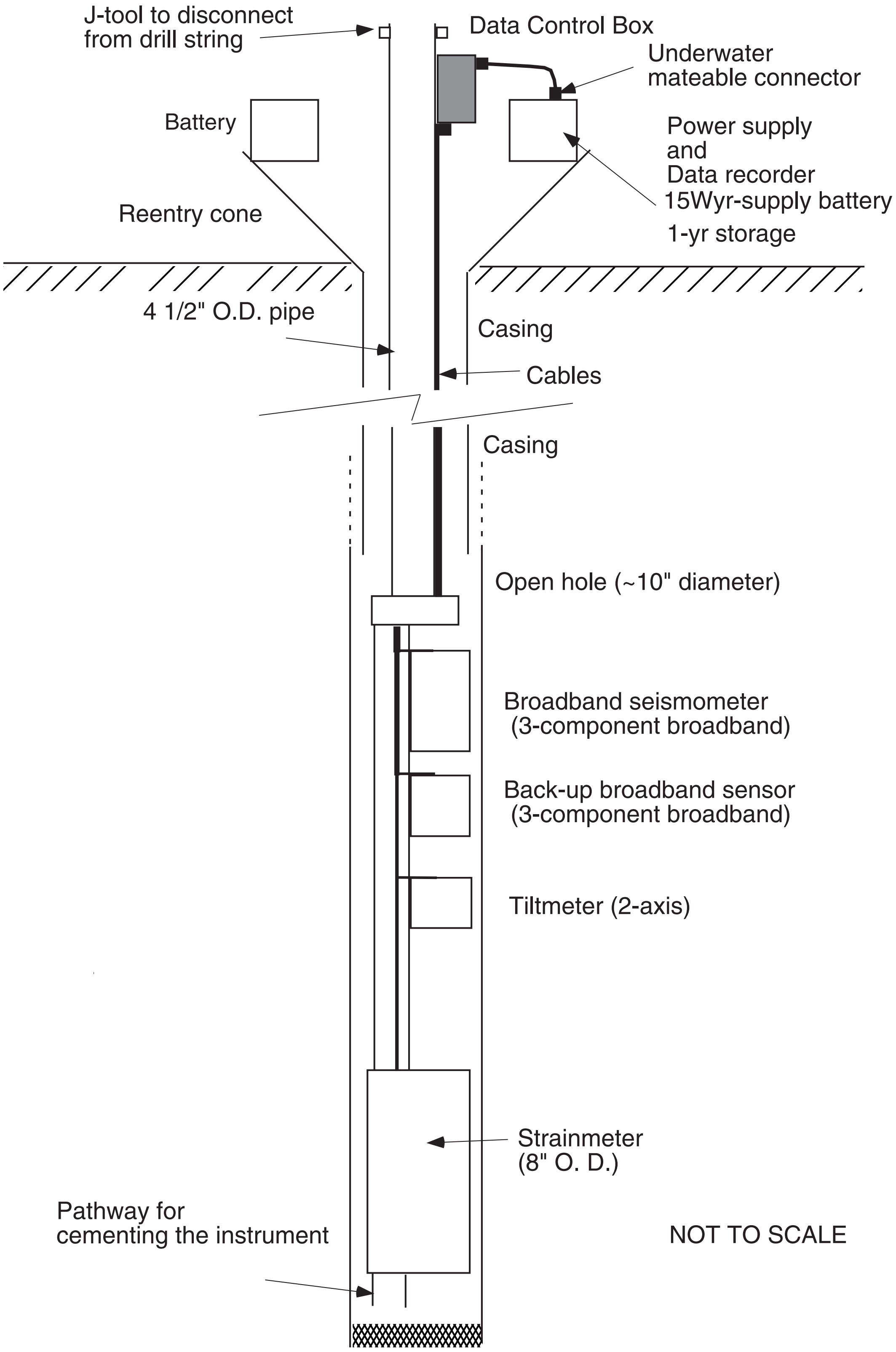

J-tool to disconnect from drill string
Data Control Box
Underwater mateable connector
Battery
Power supply and Data recorder
15Wyr-supply battery
1-yr storage
Reentry cone
4 1/2" O.D. pipe
Casing
Cables
Casing
Open hole (~10" diameter)
Broadband seismometer (3-component broadband)
Back-up broadband sensor (3-component broadband)
Tiltmeter (2-axis)
Strainmeter (8" O. D.)
Pathway for cementing the instrument
NOT TO SCALE

Figure 5A

Leg 186 Strainmeter Installation Schematic (for Sites JT-1 and JT-2)

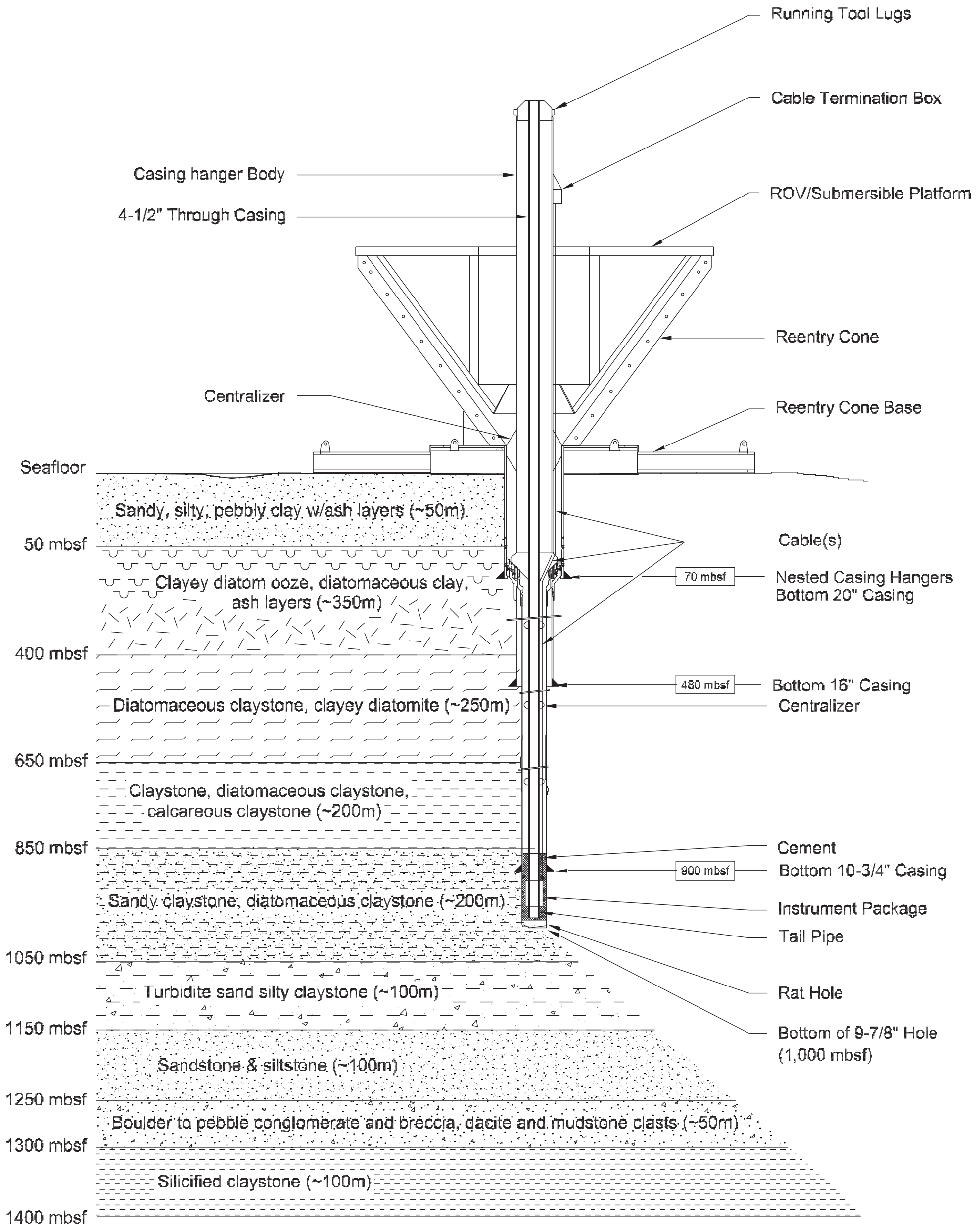


Figure 5B

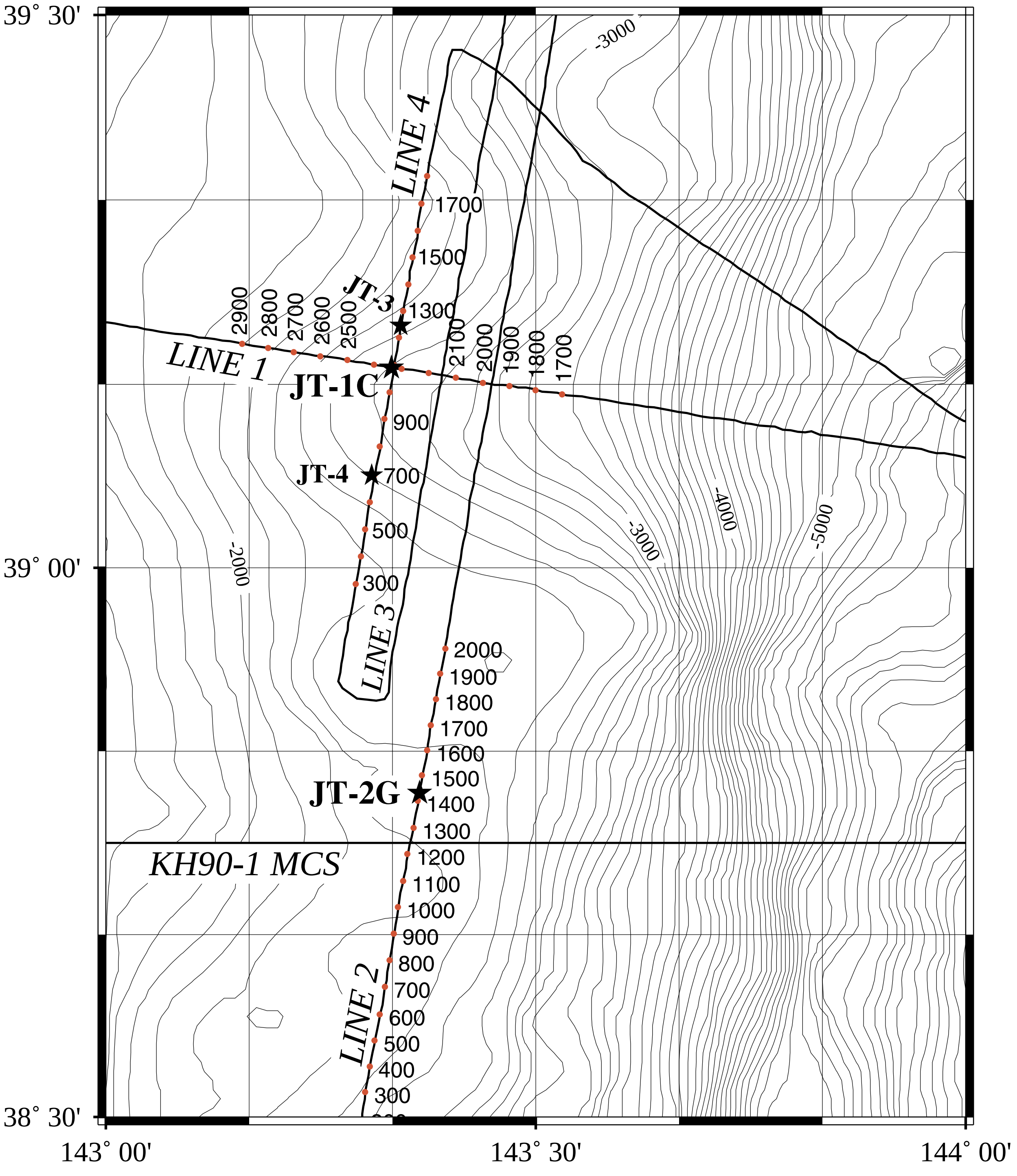

39˚ 30'
39˚ 00'
38˚ 30'
143˚ 00'
143˚ 30'
144˚ 00'
LINE 4
LINE 1
LINE 3
LINE 2
KH90-1 MCS
JT-3
JT-1C
JT-4
JT-2G
-3000
-2000
-4000
-5000
2900
2800
2700
2600
2500
2100
2000
1900
1800
1700
1500
1300
900
700
500
300
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300

Figure 6

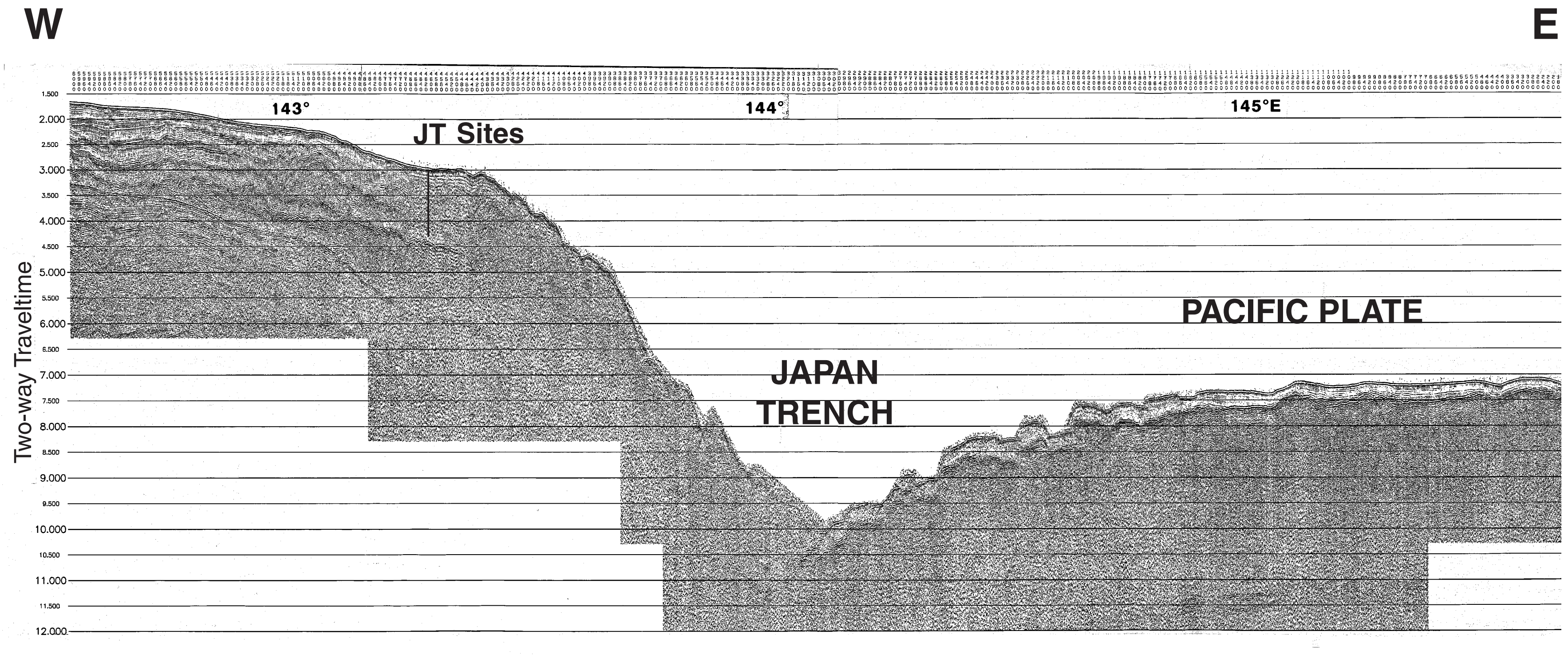

W
E
143°
144°
145°E
JT Sites
JAPAN
TRENCH
PACIFIC PLATE
Two-way Traveltime
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000
6.500
7.000
7.500
8.000
8.500
9.000
9.500
10.000
10.500
11.000
11.500
12.000

Figure 7

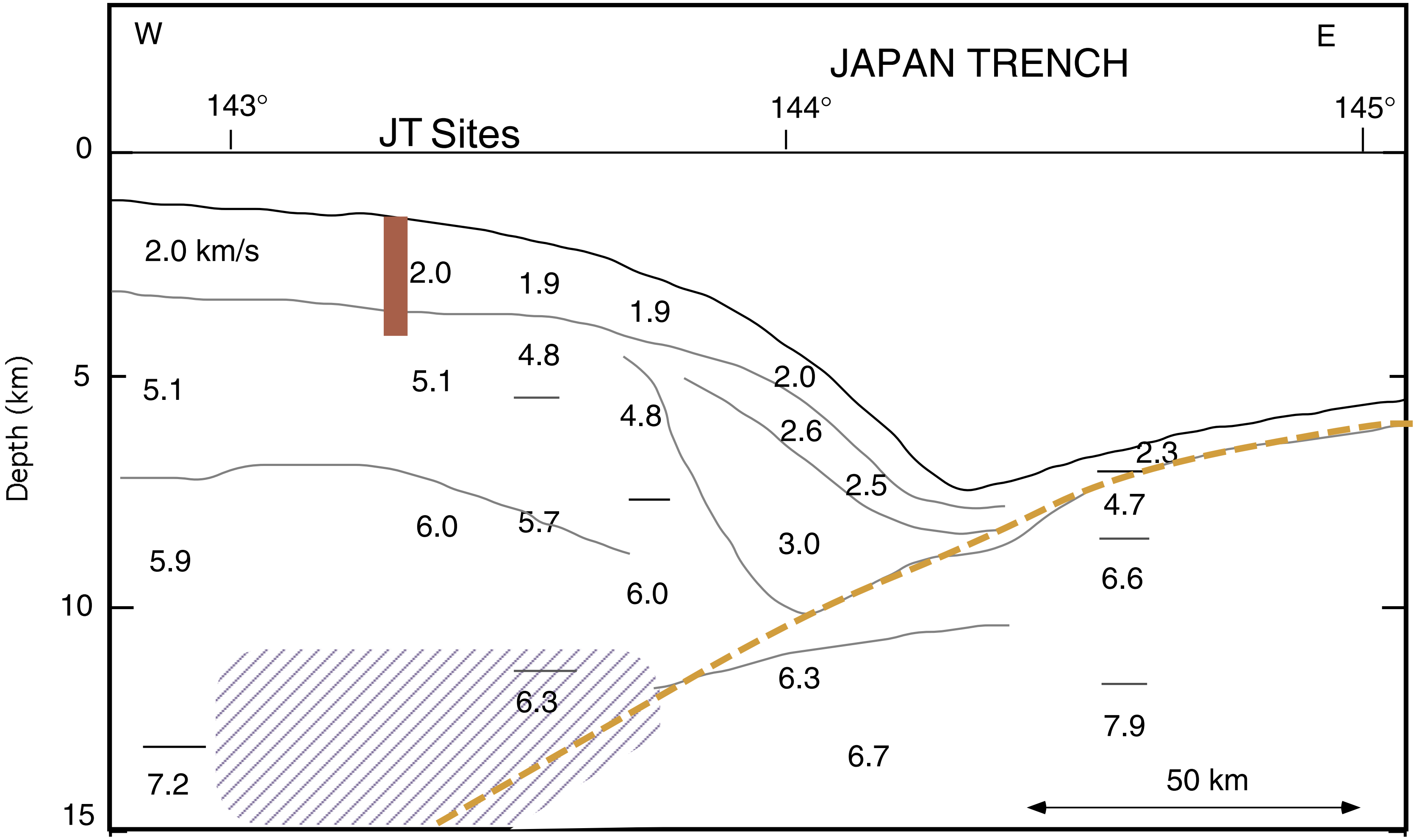

W
E
JAPAN TRENCH
143°
144°
145°
JT Sites
0
5
10
15
Depth (km)
2.0 km/s
2.0
1.9
1.9
5.1
5.1
4.8
4.8
2.0
2.6
2.5
2.3
4.7
6.6
7.9
6.0
5.7
5.9
3.0
6.0
6.3
6.3
6.7
7.2
50 km

Figure 8

Figure 9

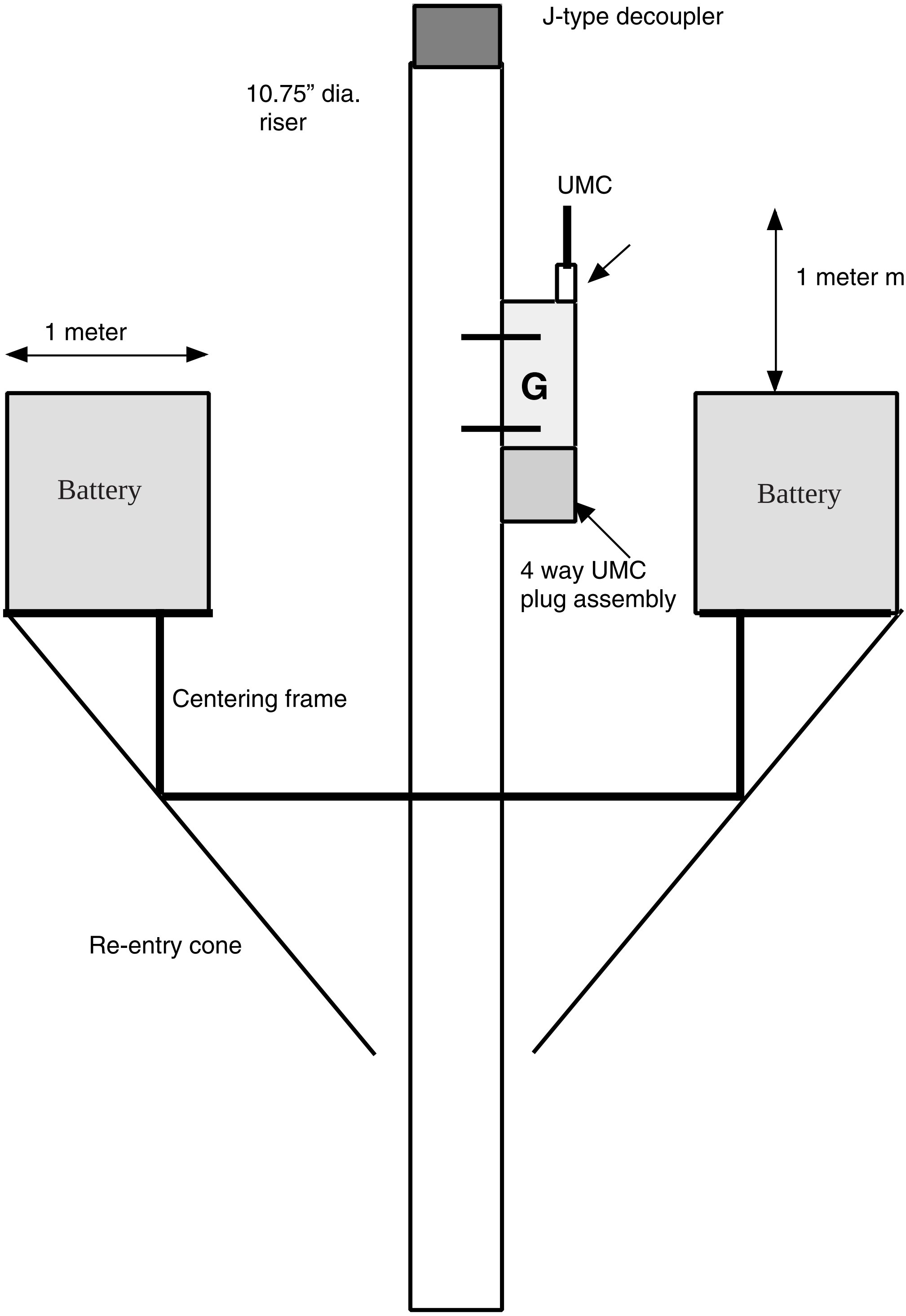

J-type decoupler
10.75" dia.
riser
UMC
1 meter max.
1 meter
G
Battery
Battery
4 way UMC
plug assembly
Centering frame
Re-entry cone

Figure 10

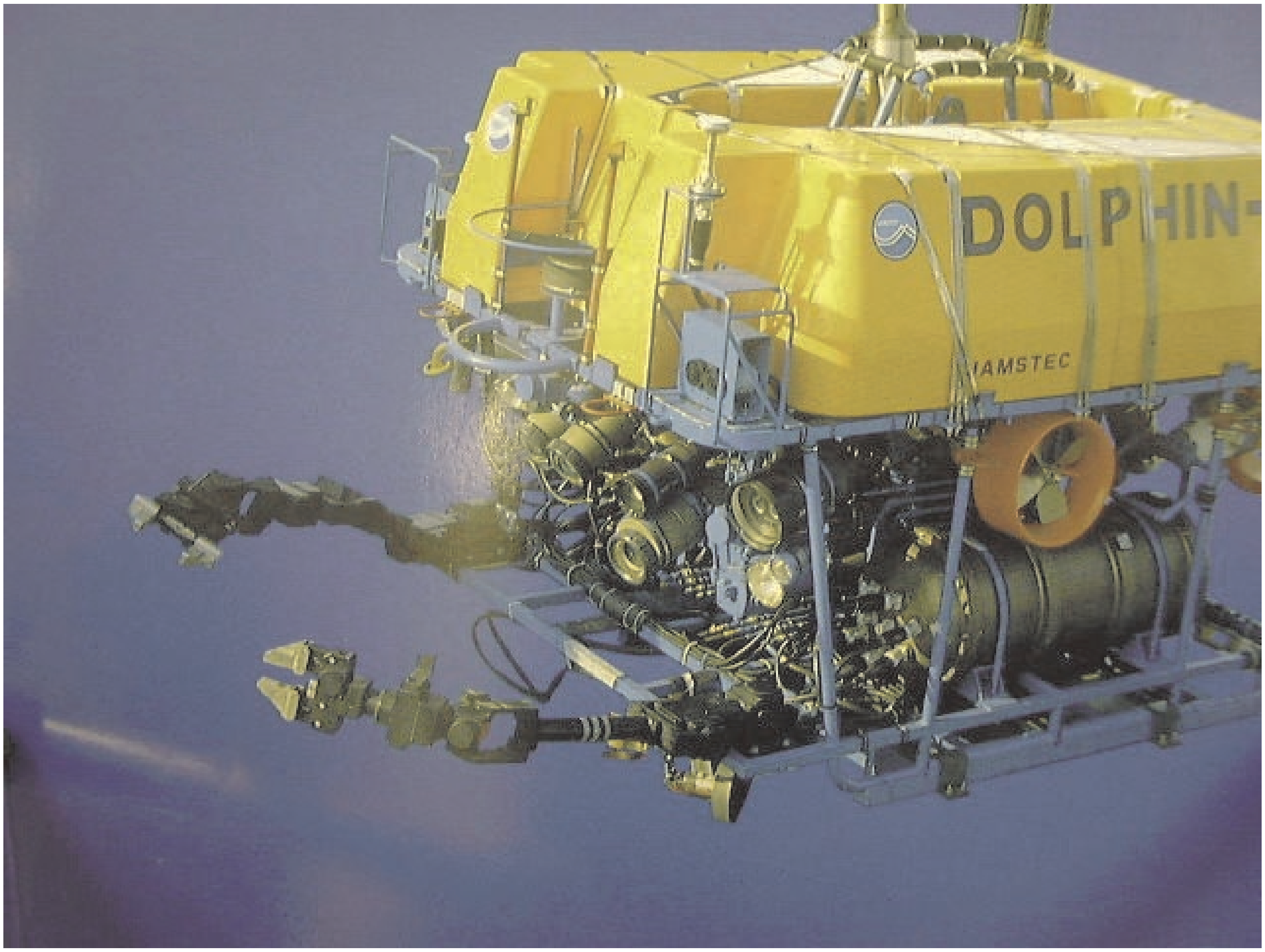


Figure 11

Leg 186 - West Pacific Geophysical Network - Japan Trench (Proposal 431A-4)

Operations Plan and Time Estimate for Primary Sites

Site No.	Location Lat/Long	Water Depth	Operations Description	Days per hole	Transit (days)	Drilling (days)	Logging (days)	Total On-site
Tokyo	36°00.0'N		**Transit 285.4 nmi from Tokyo (Yokahama) to JT-1C (28.5 hrs @ 10.0 kt)**		1.2			
	139°48.0'E							
JT-1C	39°10.911'N	2605 m	**Hole A: APC core to 250 mbsf, XCB to 450 mbsf** (81.8 hrs)	3.4		26.5	1.5	28.0
	143°19.927'E		oriented APC coring, ~6 ea Adara and ~2 ea DVTP temperature					
			measurements, and jet-in test for later reentry cone installation					
			Hole B: Second oriented APC hole only to 250 mbsf (33.3 hrs)	1.4				
			Hole C: Drill to 430 mbsf, RCB core to 1000 mbsf (139.2 hrs)	7.0				
			plus triple-combo and FMS-sonic-temperature logs (29.0 hrs)					
			Hole D: Establish seafloor installation and (321.0 hrs)	16.2				
			install/cement strainmeter/seismometer instrument package					
			deploy reentry cone w/~70 m of 20" casing, drill 18-1/2" hole to					
			~500 mbsf, set/cement ~480 m 16" csg, drill 14-3/4" hole to 920					
			mbsf, cement ~900 m 10-3/4" csg, drill 9-7/8" hole to 1000 mbsf,					
			plus BHTV wireline log ~100 m in open 9-7/8" bore hole (8.0 hrs)					
			cement strainmeter/seismometer instrument package (60.0 hrs)					
			NOTE: PPSP approved depth is 1400 mbsf					
			Transit 28.7 nmi from JT-1C to JT-2G (2.9 hrs @ 10.0 kt)		0.3			
JT-2G	38°47.75'N	2245 m	**Hole A: APC core to 250 mbsf, XCB to 450 mbsf** (71.9 hrs)	3.0		24.1	1.2	25.3
	143°21.90'E		oriented APC coring, ~6 ea Adara and ~2 ea DVTP temperature					
			measurements, and jet-in test for later reentry cone installation					
			Hole B: Drill to 430 mbsf, RCB core to 1000 mbsf (127.3 hrs)	6.3				
			plus triple-combo and FMS-sonic-temperature logs (24.0 hrs)					
			Hole C: Establish seafloor installation and (318.6 hrs)	16.0				
			install/cement strainmeter/seismometer instrument package					
			deploy reentry cone w/~70 m of 20" casing, drill 18-1/2" hole to					
			~500 mbsf, set/cement ~480 m 16" csg, drill 14-3/4" hole to 920					
			mbsf, cement ~900 m 10-3/4" csg, drill 9-7/8" hole to 1000 mbsf,					
			plus BHTV wireline log ~100 m in open 9-7/8" bore hole (5.0 hrs)					
			cement strainmeter/seismometer instrument package (60.0 hrs)					
			NOTE: PPSP approved depth is 1600 mbsf					
Tokyo	36°00.0'N		**Transit 267.4 nmi from JT-2G to Tokyo (Yokahama; 26.7 hrs @ 10.0 kt)**		1.2			
	139°48.0'E							
			Subtotal		**2.7**	**50.6**	**2.7**	**53.3**

Note[1]: This leg has been scheduled for 56 days at sea.

TOTAL DAYS: 56.0 [1]

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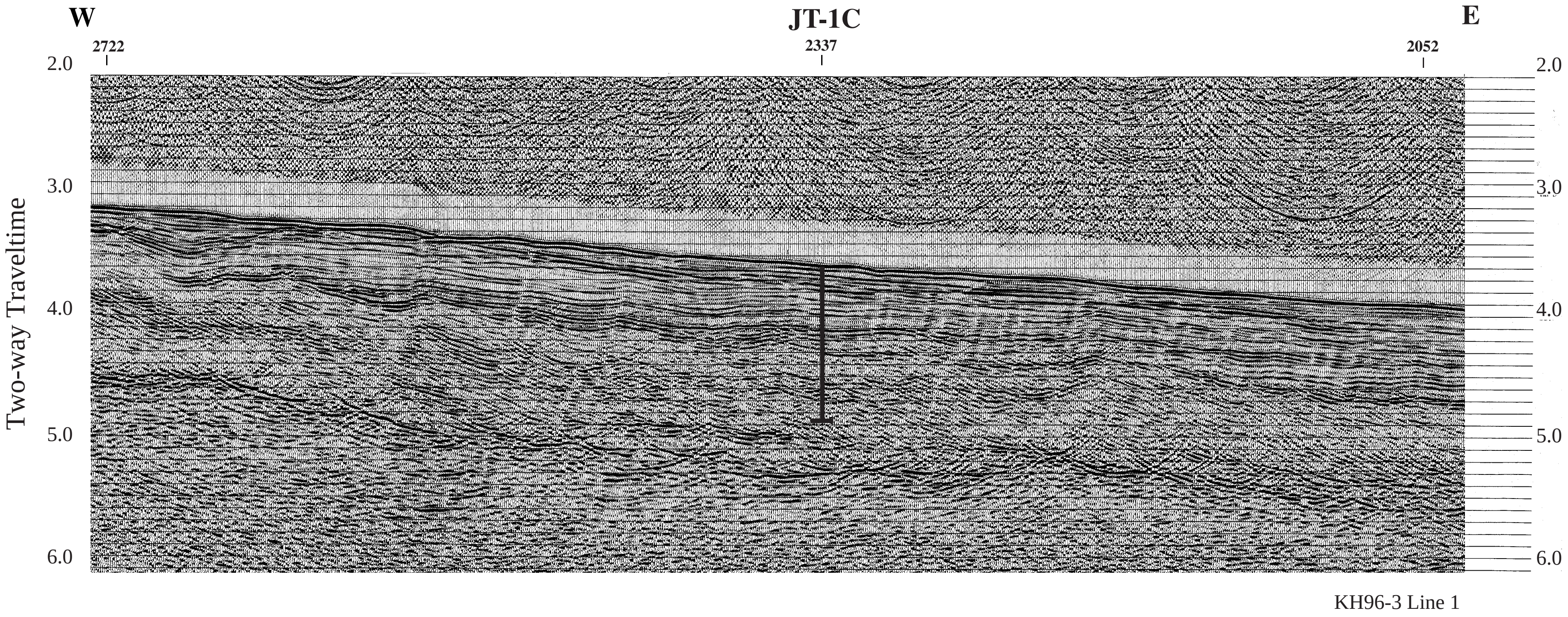
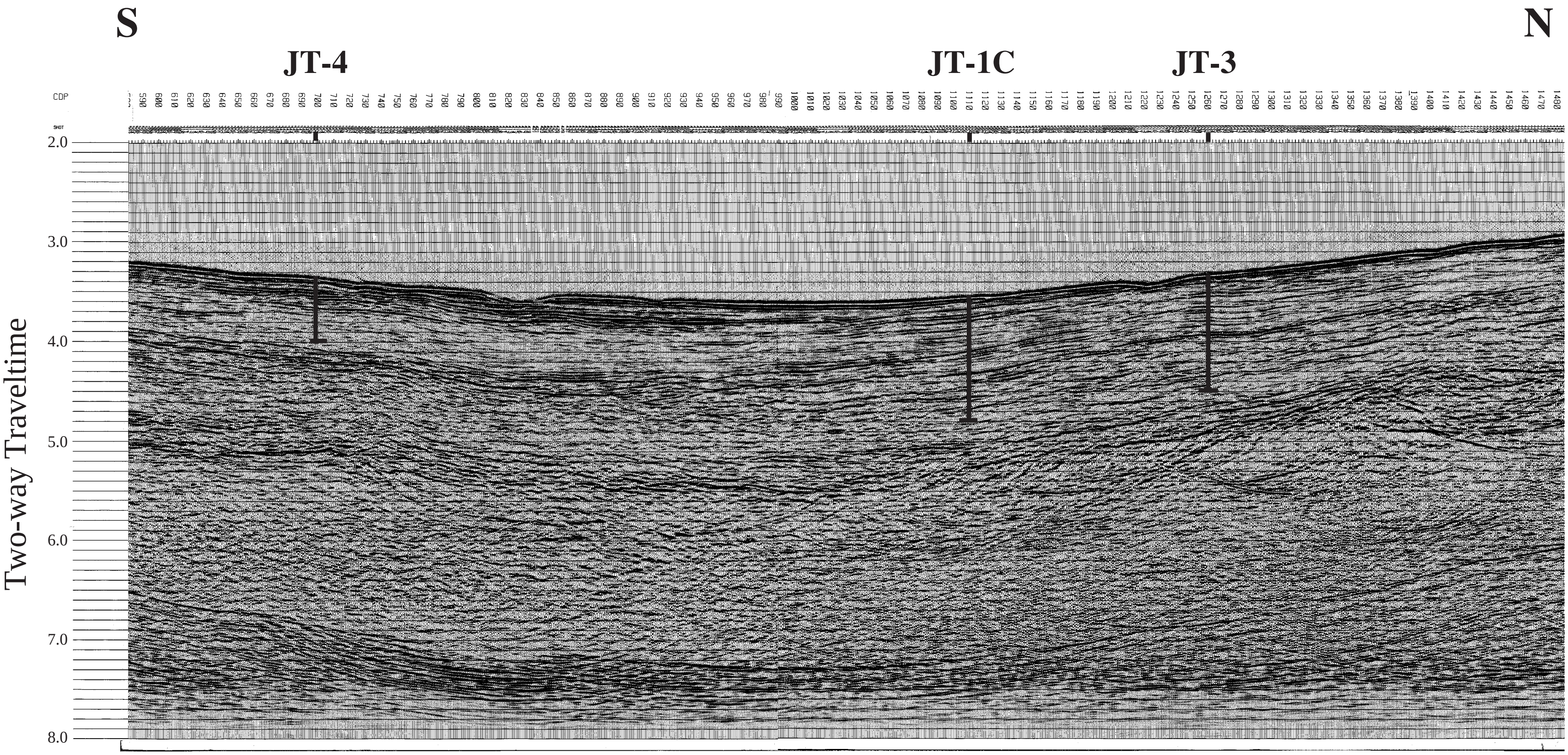
Leg 186 - West Pacific Geophysical Network - Japan Trench

Alternate Sites

Site No.	Location Lat/Long	Water Depth	Operations Description	Days per hole	Transit (days)	Drilling (days)	Logging (days)	Total On-site
JT-4	39°05.11'N	2528 m	**Hole A: APC core to 250 mbsf, XCB to 450 mbsf** (77.8 hrs)	3.2		24.8	1.3	26.1
Alt to JT-1C	143°18.77'E		oriented APC coring, ~6 ea Adara and ~2 ea DVTP temperature					
			measurements, and jet-in test for later reentry cone installation					
			Hole B: Drill to 430 mbsf, RCB core to 1000 mbsf (135.5 hrs)	6.6				
			plus triple-combo and FMS-sonic-temperature logs (24.0 hrs)					
			Hole C: Establish seafloor installation and (321.8 hrs)	16.2				
			install/cement strainmeter/seismometer instrument package					
			deploy reentry cone w/~70 m of 20" casing, drill 18-1/2" hole to					
			~500 mbsf, set/cement ~480 m 16" csg, drill 14-3/4" hole to 920					
			mbsf, cement ~900 m 10-3/4" csg, drill 9-7/8" hole to 1000 mbsf,					
			plus BHTV wireline log ~100 m in open 9-7/8" bore hc (8.0 hrs)					
			cement strain meter/seismometer instrument package (60.0 hrs)					
Site 439	40°37.61'N	1666 m	**Hole A: Jet-in test, establish sea floor installation** (320.7 hrs)	16.1		15.9	0.2	16.1
(DSDP 57)	143°18.63'E		**and install/cement strainmeter/seismometer instrument pkg.**					
Alt to JT-2G			deploy reentry cone w/~70 m of 20" casing, drill 18-1/2" hole to					
			~500 mbsf, set/cement ~480 m 16" csg, drill 14-3/4" hole to 920					
			mbsf, cement ~900 m 10-3/4" csg, drill 9-7/8" hole to 1000 mbsf,					
			plus BHTV wireline log ~100 m in open 9-7/8" bore hc (5.0 hrs)					
			cement strainmeter/seismometer instrument package (60.0 hrs)					
JT-3	39°13.44'N	2508 m	**Hole A: APC core to 250 mbsf, XCB to 450 mbsf** (72.0 hrs)	3.0		4.9	1.0	5.9
	143°20.66'E		oriented APC coring, ~8 ea Adara/DVTP temp. measurements					
			Hole B: Drill to 430 mbsf, RCB core to 500 mbsf (44.8 hrs)	2.9				
			plus triple-combo and FMS-sonic-temperature logs (24.0 hrs)					

Note: This site was initially cored during Leg 57 and therefore time is estimated only for an instrument emplacement operation.


W
JT-1C
E
2722
2337
2052
2.0
3.0
4.0
5.0
6.0
Two-way Traveltime
KH96-3 Line 1



KH96-3 Line 4

Site: JT-1C

Priority: 1
Position: 39˚10.911´N, 143˚19.927´E
Water Depth: 2605 m
Sediment Thickness: ~1300 m
Target Drilling Depth: 1000-1400 mbsf
Approved Maximum Penetration: 1400 mbsf
Seismic Coverage: Intersection of KH96-3 Lines 1 and 4 at CDP 2337 on Line 1

Objectives: The objectives of Site JT-1C are:

1. Install long-term geophysical borehole observatory to monitor strain, seismicity, tilt, pressure, and temperature. Quantify episodic plate motions within seismically active part of the interplate seismogenic zone.
2. Recover past 3-m.y. volcanic-ash stratigraphy for comparison with other western Pacific ash deposits in relation to eruptive processes and transport mechanisms.
3. Constrain subsidence history of the Japan Trench forearc.
4. Determine nature of Cretaceous basement.

Drilling Program: Double APC to 250 mbsf, XCB to 450 mbsf, RCB to 1000 mbsf and deeper, if time permits. Drill instrumented borehole to ~1000 mbsf, install reentry cone, and case through unstable section.

Logging and Downhole Operations: Triple combo, FMS/sonic/temperature, BHTV; install long-term sensor package and cement at the bottom.

Nature of Rock Anticipated: Sandy, silty, pebbly clay with ash layers (50 m); clayey diatom ooze, diatomaceous clay, ash layers (~350 m); diatomaceous claystone, clayey diatomite (~250 m); claystone, diatomaceous claystone, calcareous claystone (~200 m); sandy claystone, diatomaceous claystone (~200 m); turbidite sand silty claystone (~100 m), sandstone and siltstone (~100 m), boulder to pebble conglomerate and breccia, dacite and mudstone clasts (~50 m); and silicified claystone (~100 m).

Track lines are shown in Figure 6.

Site: JT-2G

Priority: 1
Position: 38˚47.75´N, 143˚21.9´E
Water Depth: 2245 m
Sediment Thickness: ~1300 m
Target Drilling Depth: 1000-1600 mbsf
Approved Maximum Penetration: 1600 mbsf
Seismic Coverage: North of intersection of KH96-3 Line 2 and KH90-1 Line JT90; at CDP 1430 on Line 2

Objectives: The objectives of Site JT-2G are:

1. Install long-term geophysical borehole observatory to monitor strain, seismicity, tilt, pressure, and temperature. Quantify episodic plate motions within seismically inactive part of the interplate seismogenic zone.

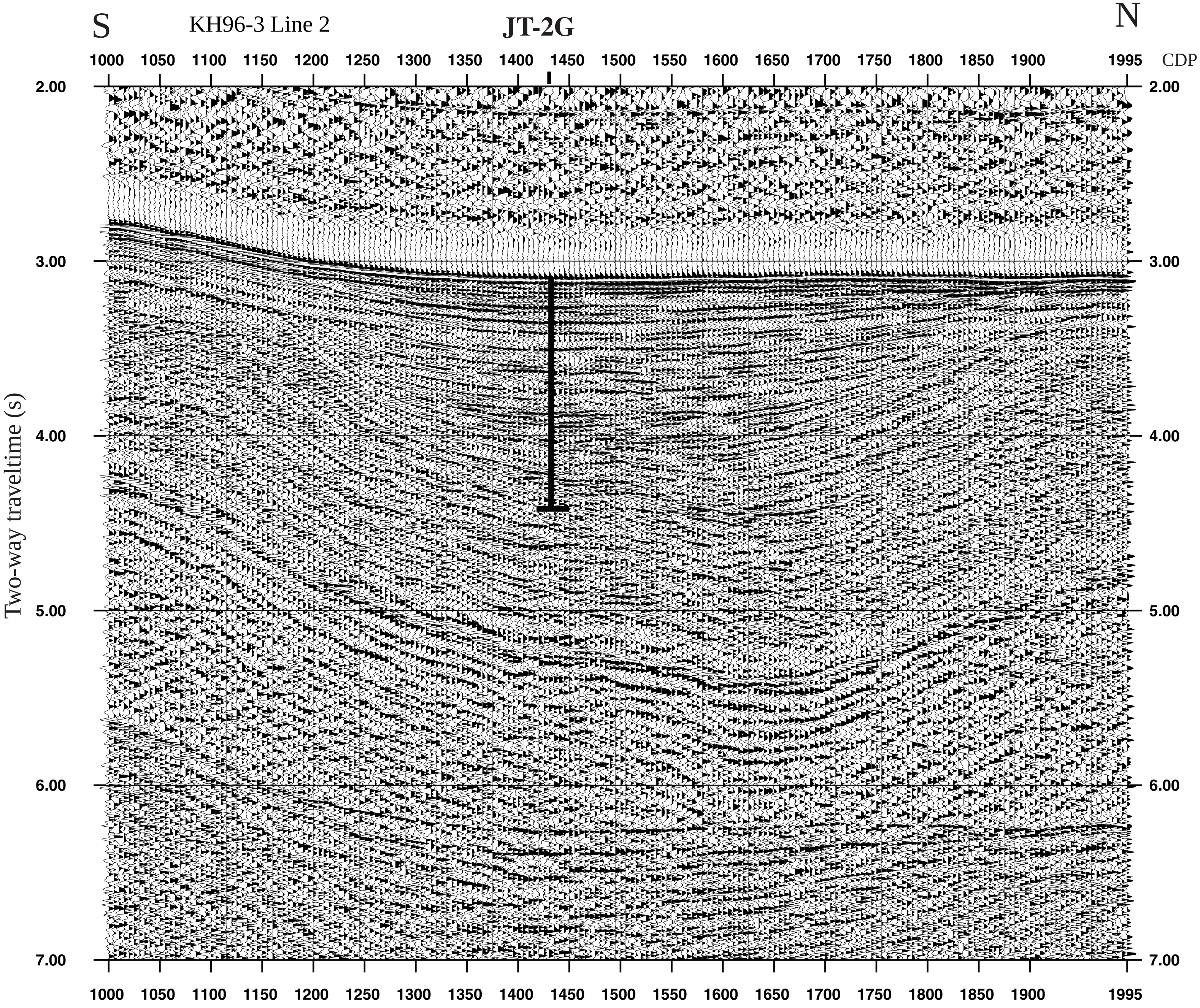
2. Constrain subsidence history of the Japan Trench forearc.

3. Determine nature of Cretaceous basement.

Drilling Program: APC to 250 mbsf, XCB to 450 mbsf, and RCB to 1000 mbsf and up to 600 m deeper, if time permits. Drill the instrumented borehole to ~1000 mbsf, install reentry cone, and case through unstable section.

Logging and Downhole Operations: Triple combo, FMS/sonic/temperature, BHTV; install long-term sensor package and cement at the bottom.

Nature of Rock Anticipated: Sandy, silty, pebbly clay with ash layers (50 m); clayey diatom ooze, diatomaceous clay, ash layers (~350 m); diatomaceous claystone, clayey diatomite (~250 m); claystone, diatomaceous claystone, calcareous claystone (~200 m); sandy claystone, diatomaceous claystone (~200 m); turbidites and silty claystone (~100 m), sandstone and siltstone (~100 m), boulder to pebble conglomerate and breccia, dacite and mudstone clasts (~50 m); and silicified claystone (~100 m).


S
KH96-3 Line 2
JT-2G
N
1000
1050
1100
1150
1200
1250
1300
1350
1400
1450
1500
1550
1600
1650
1700
1750
1800
1850
1900
1995
CDP
2.00
3.00
4.00
5.00
6.00
7.00
Two-way traveltime (s)

Site: JT-3

Priority: 2
Position: 39˚13.44´N, 143˚20.66´E
Water Depth: 2490 m
Sediment Thickness: ~1300 m
Target Drilling Depth: 500 m
Approved Maximum Penetration: PPSP approval needed
Seismic Coverage: Near KH96-3 Lines 1 and 4

Objectives: This is an alternate site for JT-1C. The objectives of Site JT-3 are:

1. Volcanic ash stratigraphy during the past 3 m.y.
2. Constrain subsidence history of the Japan Trench forearc.
3. Sedimentology, biostratigraphy, and deformation history of the forearc.

Drilling Program: Double APC, XCB to refusal, RCB.

Logging and Downhole Operations: Triple combo, FMS/sonic/temperature.

Nature of Rock Anticipated: Sandy, silty, pebbly clay with ash layers (50 m); clayey diatom ooze, diatomaceous clay, ash layers (~350 m); diatomaceous claystone, clayey diatomite (~250 m).

Please see seismic Line 4 for Site JT-1C.

Site: JT-4

Priority: 2
Position: 39˚05.11´N, 143˚18.77´E
Water Depth: 2510 m
Sediment Thickness: ~1300 m
Target Drilling Depth: 1000-1400 m
Approved Maximum Penetration: PPSP approval needed
Seismic Coverage: Near intersection of KH96-3 Lines 1 and 4

Objectives: This is an alternate site for JT-1C. The objectives of Site JT-4 are:

1. Install long-term geophysical borehole observatory to monitor strain, seismicity, tilt, and temperature. Quantify episodic plate motions within seismically active part of the interplate seismogenic zone.
2. Constrain subsidence history of the Japan Trench forearc.
3. Determine nature of Cretaceous basement if time permits.

Drilling Program: APC to 250 mbsf, XCB to 450 mbsf, and RCB to 1000 mbsf. Drill the instrumented borehole, install reentry cone, and case through unstable section.

Logging and Downhole Operations: Triple combo, FMS/sonic/temperature, BHTV; install long-term sensor package and cement at the bottom.

Nature of Rock Anticipated: Sandy, silty, pebbly clay with ash layers (50 m); clayey diatom ooze, diatomaceous clay, ash layers (~350 m); diatomaceous claystone, clayey diatomite (~250 m); claystone, diatomaceous claystone, calcareous claystone (~200 m); sandy claystone, diatomaceous claystone (~200 m); turbidites and silty claystone (~100 m), sandstone and siltstone (~100 m), boulder to pebble conglomerate and breccia, dacite and mudstone clasts (~50 m); and silicified claystone (~100 m).

Please see seismic Line 4 for Site JT-1C.

Site: 439 (DSDP Leg 57)

Priority: 2
Position: 40˚37.61´N, 143˚18.63´E
Water Depth: 1666 m
Sediment Thickness: 1140 m above Cretaceous basement
Target Drilling Depth: 1000-1200 m
Approved Maximum Penetration: PPSP approval needed
Seismic Coverage:

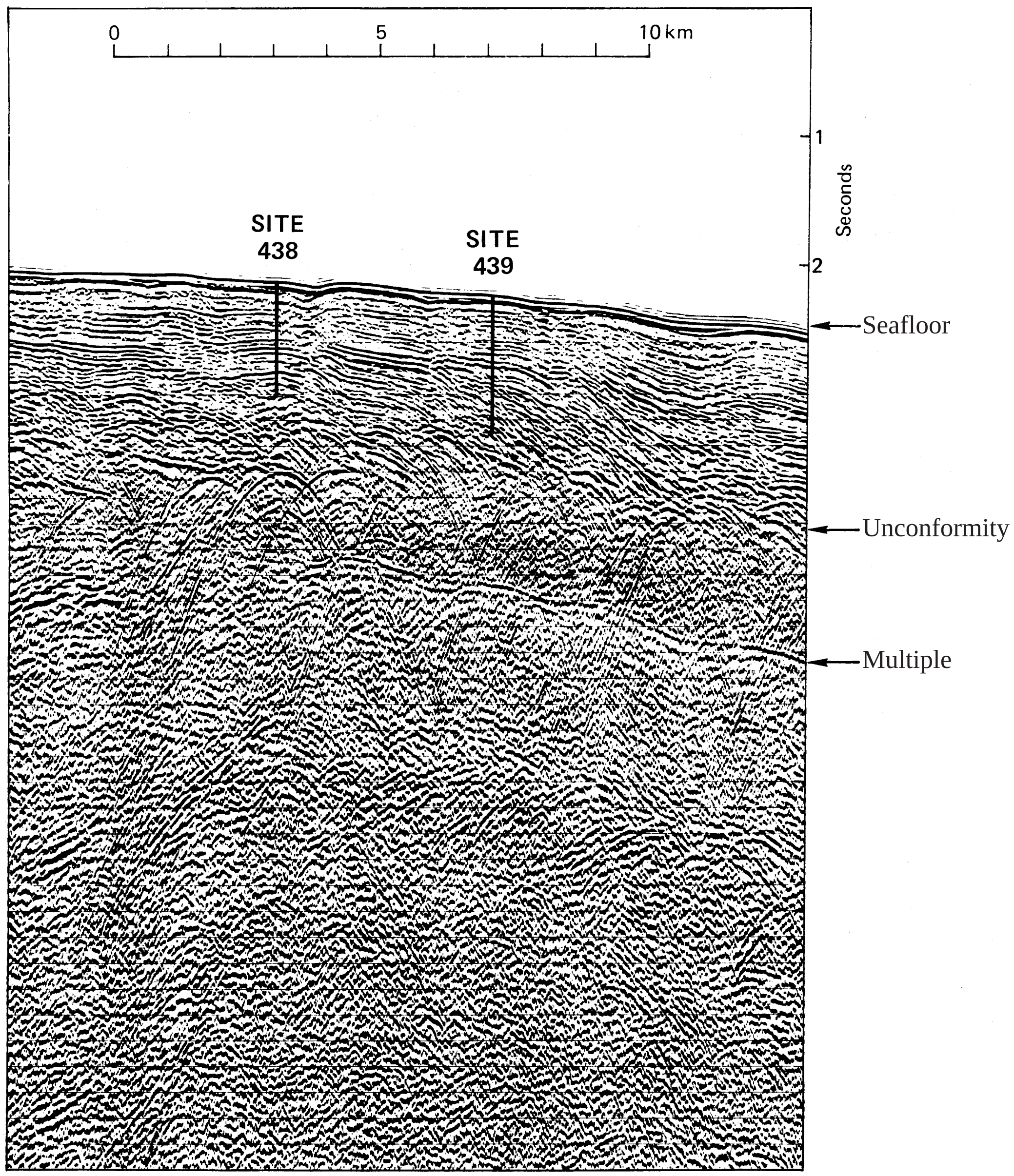
Objectives: This is a back-up site for JT-2G. The objectives of Site 439 are:

1. Install long-term geophysical borehole observatory to monitor strain, seismicity, tilt, and temperature. Quantify episodic plate motions within seismically inactive part of the interplate seismogenic zone.
2. Constrain subsidence history of the Japan Trench forearc.
3. Determine nature of Cretaceous basement, if time permits.

Drilling Program: APC to 250 mbsf, XCB to 450 mbsf, and RCB to 1000 mbsf. Coring will be done only if time permits because this site was previously cored on Leg 57. Drill the instrumented borehole to ~1000 mbsf, install reentry cone, and case through unstable section.

Logging and Downhole Operations: Triple combo, FMS/sonic/temperature, BHTV; install long-term sensor package and cement at the bottom.

Nature of Rock Anticipated: Sandy, silty, pebbly clay with ash layers (50 m); clayey diatom ooze, diatomaceous clay, ash layers (~300 m); diatomaceous claystone, clayey diatomite (~250 m); claystone, diatomaceous claystone, calcareous claystone (~200 m); sandy claystone, diatomaceous claystone (~125 m); turbidites and silty claystone (~75 m), sandstone and siltstone (~100 m), boulder to pebble conglomerate and breccia, dacite and mudstone clasts (~50 m); and silicified claystone (~100 m).


0
5
10 km
1
Seconds
2
SITE 438
SITE 439
Seafloor
Unconformity
Multiple

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