OCEAN DRILLING PROGRAM

LEG 200 SCIENTIFIC PROSPECTUS

DRILLING AT THE H2O LONG-TERM SEAFLOOR OBSERVATORY

Dr. Junzo Kasahara
Earthquake Research Institute
University of Tokyo
1-1-1 Yayoi, Bunkyo-ku
Tokyo 113-0032
Japan

Dr. Ralph Stephen
Department of Geology and Geophysics
Woods Hole Oceanographic Institution
360 Woods Hole Road MS(24)
Woods Hole MA 02543-1542
USA

____
Dr. Jack Baldauf
Deputy Director of Science Operations
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA

____
Dr. Gary D. Acton
Leg Project Manager and Staff Scientist
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA

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DISCLAIMER

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.

ABSTRACT

We intend to drill one reentry hole within 2 km of the Hawaii-2 Observatory (H2O) junction box, which is located roughly halfway between California and Hawaii in the eastern Pacific at 27°52.916'N, 141°59.504'W at a water depth of 4979 m (Figs. 1 and 2). The hole will be drilled to a total depth of about 325 m, which includes ~75 m of sediment and 250 m of basement penetration, and it will be cased to the bottom of the hole. This hole will be used to install a high-quality broadband three-component borehole seismometer (0.001-5.0 Hz, 24-bit digitizing), which can be connected to the Hawaii-2 cable for power supply and continuous real-time telemetry. The H2O site satisfies three scientific objectives of crustal drilling: (1) it is located in one of the high-priority regions for the Ocean Seismic Network; (2) its proximity to the Hawaii-2 cable and H2O junction box makes it a unique site for real-time, continuous monitoring of geophysical and geochemical experiments in the crust; and (3) it is in oceanic crust created by fast seafloor spreading (7 cm/yr half-rate), which represents one end-member for models of crustal generation and evolution and crust/mantle interaction. This is a multidisciplinary project that primarily represents the interests of the Joint Oceanographic Institutions /Incorporated Research Institutions for Seismology Steering Committee for Scientific Use of Submarine Cables, the Ocean Seismic Network group, and the International Ocean Network group. Drilling at the H2O site will also provide useful background information for the Borehole Observatories, Laboratories, and Experiments group and the oceanic lithospheric processes community.

If we gain at least one day of operation time by leaving port early, we plan to double piston core Site NU-1A on the Hawaiian Arch, ~300 km northeast of Honolulu. The upper 100 m of sediment at this site is thought to contain a record of the Nuuanu Landslide, a catastrophic event or series of events that removed ~40% (3000 to 4000 km^3) of the Koolau Volcano on the Island of Oahu. We hope to resolve whether the Nuuanu Landslide occurred as a single distinct event or multiple collapses, determine the timing of the landslide, determine the thickness of the landslide deposit at the distal site and groundtruth seismic data to better estimate the volume of the landslide, study the deposition history of the landslide, and gain insight into potential hazards related to giant landslides on the flanks of ocean island volcanoes.

BACKGROUND AND GEOLOGICAL SETTING

The H2O Program

The Hawaii-2 submarine cable system is a retired AT&T telephone cable system between San Luis Obispo, California, and Makaha, on Oahu, Hawaii (Fig. 1). The cable system was originally laid in 1964. The Incorporated Research Institutions for Seismology (IRIS) installed a long-term seafloor observatory about halfway along the cable (~142°W, 28°N) (Butler, 1995a). The cable was cut and terminated with a seafloor junction box. The location of the junction box defines the H2O seafloor observatory. The junction box has eight underwater make-break connections. About 500 W of power is available from the junction box, and there is ample capacity for two-way real-time communications with seafloor instruments. Data channels from the seafloor can be monitored continuously via the Oahu end of the cable to any laboratory in the world (the California end of the cable cannot be used because it was cut and removed from the continental shelf). There is a shallow buried broadband seismometer operating at the site. Other seafloor observatories, such as a geomagnetic observatory (Chave et al., 1995), a hydrothermal observatory (Davis et al., 1992; Foucher et al., 1995), or a broadband borehole seismic observatory (Orcutt and Stephen, 1993), can be installed at the site as funding becomes available (Chave et al., 1990; Montagner and Lancelot, 1995; JOI/USSAC, 1996).

Within the Ocean Drilling Program (ODP) and marine geology and geophysics communities, there has been considerable interest in the past few years in long-term seafloor observatories that include a borehole installation. Prototype long-term borehole and seafloor experiments almost exclusively use battery power and internal recording. Data are only available after a recovery cruise. One exception to this is the Columbia-Point Arena ocean bottom seismic station (OBSS), which was deployed on an offshore cable by Sutton and others in the 1960s (Sutton et al., 1965; Sutton and Barstow, 1990). For the foreseeable future, the most practical method for acquiring real-time continuous data from the seafloor will be over cables (Chave et al., 1990). The H2O project provides this opportunity.

On a cable like Hawaii-2, there are repeaters every 20 nmi to compensate for attenuation on the cable. The repeater boxes are ~0.2 m in outside diameter and 1 m long. The H2O junction box has been located between two of these repeater boxes. Experiments should be carried out within a kilometer or two of the junction box. The borehole should be no closer than ~500 m.

Nuuanu Landslide

The background, scientific objectives, and other details of the Nuuanu Landslide Site NU-1A are discussed in the addendum at the end of this prospectus.

Geological Setting

The Hawaii-2 cable runs south of the Moonless Mountains between the Murray and Molokai Fracture Zones (Fig. 1) (Mammerickx, 1989). Between 140° and 143°W, water depths along the cable track are typical for the deep ocean (4250-5000 m); the crustal age varies from 45 to 50 Ma (Eocene), and the sediment thickness varies to within the available resolution (~100 m or less). Prior to our cable survey cruise in August 1997, sediment thickness was not well resolved along the cable track (Winterer, 1989).

Tectonically, the cable runs across the "disturbed zone" south of the Murray Fracture Zone, between magnetic isochrons 13 and 19 (Atwater, 1989; Atwater and Severinghaus, 1989). In the disturbed zone, substantial pieces of the Farallon plate were captured by the Pacific plate in three discrete ridge jumps and several propagating rifts. To avoid this tectonically complicated region and to be well away from the fracture zone to the south of the disturbed zone, the H2O observatory was situated west of isochron 20 (45 Ma) at ~140°W. The crust west of 140°W was formed between the Pacific and Farallon plates under "normal" spreading conditions at a "fast" half-rate of about 7 cm/yr (Atwater, 1989; Cande and Kent, 1992). At the time this crust was formed, the Farallon plate had not split into the Cocos and Nazca plates, and the ridge that formed this crust was the same as the present day East Pacific Rise. The water depth at the junction box is 4979 m. The maximum relief between sites proposed for the borehole observatory is 40 m.

Between 140° and 143°W, the Hawaii-2 cable lies in the pelagic clay province of the North Pacific (Leinen, 1989). The sediments here are eolian in origin, consisting primarily of dust blown from Asia. They are unfossiliferous red clays. Deep Sea Drilling Project (DSDP) Leg 5 drilled a transect of holes in the pelagic clay province along longitude 140°W (McManus, Burns, et al., 1970). DSDP Site 39 is north of the cable at latitude 32°48.28'N with an age of 60 Ma. It has a sediment thickness of only 17 m. DSDP Sites 40 and 41 are near the same latitude at 19°50'N with an age of about 67 Ma. DSDP Site 40 was drilled in an area of ponded sediments at the base of a large abyssal hill. Basement was not reached and drilling terminated at a chert bed at 156 m. The acoustic basement, the deepest horizon identified on the seismic reflection profiles, corresponded to the chert beds. DSDP Site 41 was drilled 15 km from Site 40 but was considered to be more representative of the sediments in the general area. Basaltic basement was encountered at 34 meters below seafloor (mbsf) but there were no cherts. Site 39 is north of the Murray Fracture Zone, and Sites 40 and 41 are south of the Molokai Fracture Zone. The actual "ribbon" of crust on which the cable lies is between the two fracture zones and was not drilled during Leg 5.

Site 172 (31°32.23'N, 133°22.36'W) was drilled on DSDP Leg 18 between the Molokai and Murray Fracture Zones, penetrating basement with an estimated age of 35 Ma that lies east of 140°W and is in the "disturbed" zone (Kulm, von Huene, et al., 1973). Sediment thickness above the basaltic basement was 24 m. The sediment thickness from seismic reflection profiles had been interpreted as 90-105 m. The discrepancy was attributed to "reverberations and thin sediment cover."

Cable Survey Cruise in August 1997

In August 1997, we carried out a survey of the Hawaii-2 cable between 140° and 143°W (Stephen et al., 1997). Our survey strategy consisted of two phases. First, we collected SeaBeam bathymetry, magnetics, and single-channel seismic profiles along the cable track starting at 140°W and heading west. Our site criteria were (1) to have 100 m of sediment thickness for setting the reentry cone; (2) to be in relatively undisturbed "normal" crust in a plate tectonic sense; and (3) to optimize drilling penetration by selecting sites with well-consolidated basement, not rubble or highly altered zones. As a second phase, we carried out a survey in a 20 km by 20 km area around each of three drill sites to map bathymetry, sediment thickness, basement morphology, and magnetics in the vicinity (e.g., Fig. 3).

Figure 4 shows the H2O junction box location with respect to the tracklines for the *Revelle* during the site survey in 1997. The actual site is to the southwest of a well-surveyed block but is bracketed by two parallel single-channel seismic (SCS) lines (Fig. 5). Figures 6 and 7 show the tracklines, annotated in SCS shot numbers and Julian time, respectively, for the SCS and 3.5-kHz data. Circles at 1-, 2-, and 3-km radius from the site and the specific proposed drill locations are also indicated. Although cross-tie seismic lines are not available, the parallel seismic lines are sufficiently close together that contiguous structure can be identified across the lines.

Figures 8 and 9 are the latest 3.5-kHz examples from lines north and south, respectively, of the H2O area. This 3.5-kHz data was acquired on the *Revelle* in August 1997 at the same time as the SCS data. Unmigrated and migrated SCS profiles from this site are shown in Figures 10 and 11, respectively, for the north line and in Figures 12 and 13, respectively, for the south line. A tenth of a second two-way traveltime corresponds to about 75 m.

We know there are chert layers in this part of the Pacific from early drilling during DSDP (Legs 5 and 18). On these 3.5-kHz records, there is a clean, single pulse followed 10 ms later by a diffuse event. Our interpretation is that the clean event is the seafloor and that the diffuse event is the chert layer. Ten ms of two-way traveltime corresponds to ~8 m thickness of soft sediments. The 3.5-kHz data image nothing coherent below the "chert layer." This was also the experience in the 1960 surveys where "acoustic basement" turned out to be chert.

There is a continuous midsediment reflector at ~0.03 s below seafloor, or ~25 m depth, which does not correspond to the chert layer identified on the 3.5-kHz records. If we interpret the diffraction events at ~0.06 s below seafloor in the SCS data as occurring at the sediment/basement boundary, we get a very uniform sediment thickness of ~50 m. This may get as thick as 75 m in some areas, but in no area did we identify 100-m sediments.

SCIENTIFIC OBJECTIVES

This proposal addresses directly the second of three initiatives outlined in the ODP Long Range Plan (JOIDES Long Range Plan, 1996): "*In situ* monitoring of geological processes" (pp. 49-51). It also represents an initial step in accomplishing the oceanic crustal component of the third initiative: "Exploring the deep structure of continental margins and oceanic crust" (pp. 52-54). The drilling is intimately tied to the use of "seafloor observatories" (p. 63) and represents the partnership of ODP with the Ocean Seismic Network (OSN), International Ocean Network (ION) and Borehole Observatories, Laboratories, and Experiments (BOREHOLE) (p. 74). (Page numbers refer to pages in the Long Range Plan.)

The Ocean Seismic Network

Drilling at the H2O area would address both teleseismic, whole-Earth seismic studies, and regional studies. The site is located in a region on the Earth's surface where there is no land in a 2000-km^2

area. For uniform coverage of seismic stations on the surface of the planet, which is necessary for whole-Earth tomographic studies, a seafloor seismic observatory is required. This site is one of three high-priority prototype observatories for the OSN (Butler, 1995a; Butler, 1995b; Purdy, 1995). Global seismic tomography (GST) provides three-dimensional images of the lateral heterogeneity in the mantle and is essential in addressing fundamental problems in subdisciplines of geodynamics such as: mantle convection, mineral physics, long wavelength gravimetry, geochemistry of ridge systems, geomagnetism, and geodesy. Specific problems include the characteristic spectrum of lateral heterogeneity as a function of depth, the anisotropy of the inner core, the structure of the core/mantle boundary, the role of oceanic plates and plumes in deep mantle circulation, and the source rupture processes of Southern Hemisphere earthquakes, which are among the world's largest (Forsyth et al., 1995).

The culturally important earthquakes in California are only observed at regional distances on land stations in North America, which restricts the azimuthal information to an arc spanning about 180°. To observe California earthquakes at regional distances to the west requires seafloor stations. Regional observations are used in constraining earthquake source mechanisms. Since the Site H2O data will be available in real time, data will be incorporated into focal mechanism determinations within minutes of California earthquake events. Other problems that can be addressed with regional data from Californian and Hawaiian earthquakes are the structure of the 400-, 525-, and 670-km discontinuities in the northeastern Pacific, the variability of elastic and anelastic structure in the Pacific lithosphere from P_o and S_o and pure-path oceanic surface wave studies, and improved locations for Juan de Fuca Ridge earthquakes from T-phase arrivals (Butler, 1995a, 1995b).

In 1998 at the OSN pilot experiment site established in seafloor west of Hawaii, we deployed seafloor, buried, and borehole broadband seismometers to compare the performance of different styles of installation (Fig. 14). Figures 15 and 16 summarize for vertical and horizontal component data, respectively, the improvement that we expect to see in ambient seismic noise on placing a sensor in basement rather than on or in the sediments. Above the 0.3 Hz, the seafloor, buried, and borehole spectra at the OSN-1 site show the borehole to be 10 dB quieter on vertical components and 30 dB quieter on horizontal components (Collins et al., 2001). Shear wave resonances (or Scholte modes) are the physical mechanism responsible for the higher noise levels in or on the sediment. The resonance peaks are particularly distinct and strong at the H2O site. Note the 15-dB peak on the vertical component and the 35-dB peak on the horizontal components near 1 Hz on the

H2O spectra. By placing a borehole seismometer in basement at H2O, we expect to eliminate these high ambient noise levels.

Basement Drilling on the Pacific Plate

There are no deep boreholes (>100 m) in the Pacific plate, the largest modern tectonic plate. Table 1 summarizes the boreholes drilled on "normal" crust on the Pacific plate that have >10 m of basement penetration and crustal ages <100 Ma. Holes in seamounts, plateaus, aseismic ridges, and fracture zones were not included. Holes with crustal ages >100 Ma are not included because they would be affected by the mid-Cretaceous super plume (Pringle et al., 1993). In 30 years of deep ocean drilling and more than 1000 holes world wide, there have been only 12 holes with >10 m penetration into "normal" igneous Pacific plate: only one hole during ODP, no holes with >100 m penetration, and no holes in crust with ages between 29 and 72 Ma. Furthermore, there are no boreholes off axis in "very fast" spreading crust. At the latitude and age of the H2O area, the spreading rate was 140 mm/yr (full rate). Having a reference station in "normal" 45- to 50-Ma ocean crust will constrain geochemical and hydrothermal models of crustal evolution.

Although fast-spreading ridges represent only about 20% of the global ridge system, they produce more than half of the ocean crust on the surface of the planet, almost all of it along the East Pacific Rise. Most ocean crust currently being recycled back into the mantle at subduction zones was produced at a fast-spreading ridge. If we wish to understand the Wilson cycle in its most typical and geodynamically significant form, we need to examine ocean crust produced at fast-spreading ridges. We have also known for more than 40 yr that crust created by fast seafloor spreading is both simple and uniform, certainly so in terms of seismic structure (Raitt, 1963; Menard, 1964). Successful deep drilling of such crust at any single location is thus likely to provide fundamental information that can be extrapolated to a significant fraction of the Earth's surface (Dick and Mével 1996).

UNDERWAY GEOPHYSICS

Standard ODP practice is to collect magnetometer and 3.5- and 12-kHz echo-sounder data during transit to each site. No other surveys are planned at this time.

DRILLING STRATEGY

The specific location of the H2O junction box is 27°52.916'N, 141°59.504'W. Although it is not within any of the large 20 km by 20 km blocks that we surveyed in 1997, we do have two parallel single-channel lines that run within 1.5 km of the site. The structure is sufficiently smooth that it should be acceptable to assume that it is continuous between the lines. The whole region within 2 km of the H2O junction box is in a "contiguous block" of crust. The SCS data is laterally homogeneous over this block, and the quality of the migrated and unmigrated data is similar. At this stage, we have no new information on sediment thickness. It is no thicker than 100 m, but it is interpreted to be at least 50 m. We will not know for sure until we drill. There may be as little as 8 m of sediment above the first chert layer.

The main objective of the proposal is to drill a borehole that can be used for an OSN permanent seismic observatory. The critical issue is whether there will be enough sediment at the site to set the reentry cone. Four sites have been identified as indicated on track charts and seismic profiles. The locations are shown in Figures 6 and 7 and given in Table 2.

There are three important characteristics for a broadband borehole seismic installation:

(1) The hole should penetrate well below the sediment/basement contact so that true basement vibration is observed. The OSN Pilot Experiment hole was only drilled ~20 m into basement, and after installation the top of the sonde was still protruding out of basement and into the sediment. Therefore, it is difficult to say conclusively that the seismometer was responding to true basement motion.

(2) The sides and bottom of the hole must be sealed to hydrothermal circulation with the formation. Water circulation around the sonde generates undesirable "installation noise." If the bottom of the hole is composed of unconsolidated and fractured basalt, this means that the hole must be cased to total depth and sealed at the bottom with a cement plug.

(3) To ensure good coupling of the sonde to the Earth, the hole should be in as consolidated a section of basalt as possible and the casing should be cemented to the formation. It is impossible to predict the seismic response of rubble, and it is impossible to couple the sonde

and/or casing to rubble. When cementing in poorly consolidated rock, the cement will flow mostly into the formation rather than up the annulus around the casing, so proper coupling of the casing to the formation cannot be obtained.

Our strategy will be to probe the sediment at each site in an attempt to locate the site with the deepest sediment above the chert (Table 2). This will be accomplished by conducting a jet-in test at each site using the jets on the advanced piston corer (APC)/extended core barrel (XCB) system to wash down through the upper part of the sedimentary section. We will also attempt to wash through and possibly sample the chert layer to determine how solid it is. In some areas, chert layers are rubble zones that can be washed through when installing the reentry cone. The deepest sediment may be in a fault zone where the basement is highly fractured (e.g., Site H2O-3 in Fig. 9 or Site H2O-1 in Fig. 8), and it may be difficult to drill. The best strategy, if we have the option, may be to select a site high on the block (e.g., Site H2O-4 in Fig. 8) or a midblock site (such as Site H2O-2 in Fig. 9).

If no chert is present, we will double APC/XCB core to basement. We will then set a reentry cone with ~40-60 m of 16-in casing, followed by RCB coring from just above basement to ~325 mbsf (meters below seafloor), which will include the deeper sedimentary horizons and ~250 m of basement penetration. Alternatively, if chert is present, we will likely single APC/XCB core to about the depth of the chert. We expect that chert will be present and that there may be somewhere between 8 to 25 m of soft sediment above the first chert layer. If that is the case, we plan on setting a reentry cone with ~25 m of 20-in casing. We will then RCB core from 25 to ~325 mbsf (meters below seafloor).The core will be available for a broad spectrum of shipboard and shore-based analyses, and it will give us positive confirmation of the degree of rubble and fracturing in the upper basalts. Though we will likely encounter progressively more consolidated material down to the proposed 250 m of basement penetration, we expect that the bottom of the hole will still be fractured. If the bottom of the hole consists of unconsolidated material, we will plan to core deeper until we reach a more consolidated material or until the allotted time for coring is exhausted (see Tables 2 and 3 for time estimates). We will then run the triple combination (triple combo) tool and Formation MicroScanner/dipole sonic shear imager (FMS/sonic) in the 9-7/8-in hole to get a continuous record of the well up to the base of the casing. If 20-in casing was necessary, the hole will next be reamed to ~85 mbsf (~10 m into basement) and 16-in casing will be installed and cemented to this depth. For either the chert or no-chert scenario, the hole will then be reamed to the total depth (TD) for installation and cementing of 10-3/4-in casing. A borehole compensated sonic log (also called a cement bond log) will be run to check the integrity of the cement behind the casing.

Our original target depth was 400 m of basement penetration, which was a conservative estimate to get into consolidated basalts based on the drilling experience at Hole 504B. The allotted time for Leg 200 will unlikely be sufficient for us to reach this depth. At Hole 504B, sonic logs and resistivity measurements indicate poorly consolidated basalt down to 600 mbsf. If we are fortunate enough to set a reentry cone and casing and reach the current target depth of 250 m of basement penetration ahead of schedule, we plan to continue drilling until we are in consolidated basalt. A hole that penetrates further into basement will acquire good-quality basalt samples for geochemical studies, will provide adequate penetration into Layer 2 for paleomagnetic analyses, and will provide good hole conditions for in situ experiments.

If the reentry hole is completed before the end of the allotted time on site, there are a number of options, depending on how much time is left (Table 3). If we have less than 24 hr, we suggest repeating the vertical seismic profile (VSP) in the cased hole. If we have a few days left, we plan to APC/XCB core one or more holes at one or more of the H2O sites. The additional holes around the observatory will characterize the lateral heterogeneity of the sediment, confirm the depths to basement, and provide additional observations that can be tied to sites being cored during Leg 199, which is a Paleogene equatorial coring transect aimed at studying the evolution of the equatorial Pacific current and wind system. The information gained would also be useful in interpreting seafloor heat-flow measurements that may be made at the site in the future and provide useful background information for further drilling at the site in the future. If we have roughly a week left, we plan to core other alternate sites proposed for Leg 199 that may not be completed during that leg (e.g., Site PAT-13C, see the Leg 199 Scientific Prospectus at http://www-odp.tamu.edu/publications/prosp/199_prs/199toc.html).

Possible Coring the Nuuanu Landslide

If we complete port call activities in Honolulu at least 24 hrs early, we will double APC/XCB core at Site NU-1A. An alternate operation scenario for coring at this site is given in Table 4 and discussed below in the addendum of this prospectus.

LOGGING PLAN

Downhole logging measurements will provide in situ formation properties for the H2O observatory site. These properties include density, porosity, resistivity, temperature, K, Th, and U contents, elastic properties, and hole condition estimates. The planned logging program includes the standard geophysical string (triple combo), the FMS/sonic string, the well seismic tool (WST), and the borehole compensated (BHC) sonic string.

The triple combo tool string includes the natural gamma ray sonde (NGS) to measure radioactivity, the accelerator porosity sonde (APS) to measure porosity, the hostile environment lithodensity sonde (HLDS) to measure density, and the dual induction tool (DIT-E) to measure resistivity. The Lamont-Doherty Earth Observatory temperature tool (TLT) is also attached to the triple combo string. Temperature logs will be emphasized for identification of permeable zones and inflow/outflow from both drilling-induced and natural fractures in the holes.

The FMS/sonic string includes the Formation MicroScanner (FMS) and the dipole shear sonic imager (DSI). The high-resolution (centimeter scale) FMS image log can help to identify large- and small-scale lithologic units and tectonic features (presence of fractures and faults, their orientations, and their degree of alteration). Comparison of fractures detected from these log images could provide information on the lateral extension of the fracture system beyond the borehole and the significance of borehole-induced features vs. natural fractures. The FMS caliper log could also be used for hole size estimation. The DSI tool provides both compressional and shear wave data.

WST (or WST-3 if available) will be used to provide normal incident VSP data for the proposed objectives. However, its deployment depends upon the time constraints and the hole penetration. The BHC sonic log will be used for the cased interval of basement to obtain the acoustic properties of the formation through casing and to check the integrity of the cement.

SAMPLING PLAN

The Sample Distribution, Data Distribution, and Publications Policy is posted at: http://www-odp.tamu.edu/publications/policy.html. The Sample Allocation Committee (SAC), which consists of the two co-chiefs, the staff scientist, the ODP curator onshore, and the curatorial representative on board ship, will work with the entire science party to formulate a formal Leg 200-specific sampling plan for shipboard and postcruise sampling.

During Leg 200, we expect to recover <400 m of basalt and between 50 to 300 m of sediment. All sample frequencies and sample volumes taken from the working half of the core must be justified on a scientific basis and will be dependent on core recovery, the full spectrum of other requests, and the cruise objectives. All sample requests must be made on the standard Web sample request form and approved by the SAC. Leg 200 shipboard scientists may expect to obtain as many as 100 samples of no more than 15 cm^3 in size from basement cores. Additional samples may be obtained upon written request onshore after initial data are analyzed. Depending on the penetration and recovery during Leg 200, the number of samples taken may be increased by the shipboard SAC. For example, studies requiring only small sample volumes of 1 cm^3 or less (e.g., veins, fluid inclusions, etc.) may require >100 samples to characterize a long section of core. The SAC will review the appropriate sampling interval for such studies as the cores are recovered. Samples larger than 15 cm^3 may also be obtained with approval of the SAC. Request for large samples must be specified on the sample request form. Sample requests may be submitted by shore-based investigators as well as the shipboard scientists. Based on sample requests received two months precruise, the SAC will prepare a temporary sampling plan, which will be revised on the ship as needed. Some redundancy of measurement is unavoidable, but minimizing redundancy of measurements among the shipboard party and identified shore-based collaborators will be a factor in evaluating sample requests.

If some critical intervals are recovered (e.g., glass, fault gauge, 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.

ADDENDUM: NUUANU LANDSLIDE

Drilling at the Nuuanu Landslide Site NU-1A was added to the ODP Operations Schedule in September 2001, after the Leg 200 Prospectus had been completed. This addendum explains the science planning, background, objectives, and drilling plan for coring that may occur at Site NU-1A.

The ODP Science and Operations Committees indicated that Site NU-1A should only be cored during Leg 200 if the JOIDES Resolution is ready to leave port at least one day early. Currently, Leg 200 is scheduled for a five day port call in Honolulu, with port call activities associated with Leg 200 beginning at about 8:00 AM on 17 December 2001. Thus, if the ship is underway prior to roughly 8:00 AM on 21 December, Leg 200 will core at Site NU-1A. Otherwise the ship will cruise directly to Site H2O.

Background

The rapid growth and enormous size of Hawaiian volcanoes cause them to be gravitationally unstable and collapse. The collapse of Hawaiian volcanoes has generated some of the largest landslides on Earth and undoubtedly produced large tsunami waves (Moore, 1964; Moore and Moore, 1988; Moore et al., 1989). Deposits from dozens of major landslides, some with lengths of 200 km and volumes greater than a thousand cubic meters, have been recognized along the Hawaiian Ridge (Moore and Normark, 1994). Large landslides have also been recognized on the flanks of other ocean volcanoes such as at Reunion Island (Lenat et al., 1989) and Canaries (Carracedo, 1990).

The Nuuanu Landslide, which broke away from the northeast flank of Koolau Volcano on the Island of Oahu, is the largest Hawaiian landslide. It is a debris avalanche that contains enormous blocks such as the Tuscaloosa Seamount, which is ~30 km long, 17 km wide, and at least 2 km tall. The landslide is spread over a 23000-km^2 area (Normark et al., 1993; Naka et al., 2000), with distal portions extending up the Hawaiian Arch. To reach the upper portion of the arch (the target site for drilling), the landslide would have had to traverse the deep moat on the northeast side of Oahu and travel over 100 km uphill (Fig. 17).

Reaching the landslide deposit by gravity or piston coring has proven difficult because the deposit is overlain by a carapace of younger debris (turbidites and associated deposits). Thus, the thickness and depositional history of the landslide are poorly known. The distal portion of the landslide deposit is thought to be <10-m thick, but estimates vary from 1 to 100 m (Rees et al., 1993; Naka et al., in press). Similarly the age of the landslide is poorly constrained, though it apparently occurred near the end or after the formation of the Koolau Volcano, which has surface flows that are 1.8-2.6 Ma based on K-Ar dating by Doell and Dalrymple (1973).

Scientific Objectives

If Nuuanu Landslide Site NU-1A is cored, the core material will be used to:

(1) resolve whether the Nuuanu Landslide occurred as a single distinct event or multiple collapses,

(2) determine the timing of the landslide,

(3) determine the thickness of the landslide deposit at the distal site and groundtruth seismic data to better estimate the volume of the landslide,

(4) study the deposition history of the landslide, and

(5) gain insight into potential hazards related to giant landslides on the flanks of ocean island volcanoes.

Drilling Strategy

Site NU-1A is located along the transit route out of Honolulu to the H2O site, so no additional transit time is incurred by operations at this site. Coring operations are limited to 1.8 days with no logging. The plan is to double APC/XCB core at Site NU-1A, with the coring to ~100 mbsf in the first hole. Assuming the base of the landslide deposit has been recovered by 100 mbsf, we will core a second hole to 50 mbsf to ensure complete recovery of the sedimentary section roughly down to the top of the landslide deposit. Complete recovery of the section overlying the landslide deposit is important as it is from magnetostratigraphic and biostratigraphic studies of these sediments that a minimum age for the landslide will be established, with the minimum age likely being very close to the true age. Coring gaps are common in single cored sites and could result in large uncertainties in dating the deposit. If we have not recovered the base of the landslide deposit by 100 mbsf in the first hole, we plan to continue coring deeper until the base is recovered or the allotted time for coring at Site NU-1A has been expended. This could mean that no time will be available for a second hole. A sedimentologist will be on the catwalk monitoring cores as they are recovered to establish whether there is a need for penetration beyond 100 m.

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FIGURE CAPTIONS

Figure 1. Location of the proposed Site H2O and H2O junction box (large star), proposed Site NU-1A (small star), repeaters along the Hawaii-2 cable (crosses), major fracture zones (FZ), and previous drill sites (circles) from DSDP Legs 5 (Sites 38, 39, 40, and 41) and 18 (Site 172). Mercator map with ETOPO-5 bathymetry.

Figure 2. Hydrosweep bathymetry around the H2O area acquired from the *Thompson* in September 1999. The site is on a relatively benign ribbon of "normal" oceanic crust. Total relief varies by ~40 m across the region within 2 km of the junction box.

Figure 3. The location of the H2O junction box is shown on the SeaBeam bathymetry acquired during the site survey in August 1997. The locations of the repeaters (AT&T waypoints) on the cable are also shown (filled triangles).

Figure 4. The tracklines during the 1997 site survey cruise on *Revelle* (KIWI02) are shown with the location of the H2O junction box.

Figure 5. A detail of the track chart shows that the H2O junction box lies between two parallel tracklines southwest of a well-surveyed area.

Figure 6. The locations of the four possible drill sites (Sites H2O-1 through -4) are shown with the tracklines of the 1997 survey. The tracklines are annotated with SCS shot numbers for comparison with the seismic data in Figures 10-13. Circles were drawn at 1-, 2-, and 3-km radius from the junction box. Sites should be beyond a 1-km radius to avoid conflicts with other experiments at the observatory. They should be within a 2-km radius to minimize the effort in running cable to the junction box.

Figure 7. This figure is similar to Figure 6, except the tracklines are annotated with Julian day and time for comparison with the 3.5-kHz data in Figures 8 and 9.

Figure 8. The 3.5-kHz data for the line north of the site shows about 8-10 m of sediment above the first reflector, which we interpret to be a chert layer.

Figure 9. The 3.5-kHz data for the line south of the site shows similar sediment thickness to the north line (Fig. 8).

Figure 10. The unmigrated single-channel seismic (SCS) line north of the site shows relief of about 40 m. Site H2O-1 is at the bottom of a fault block, and Site H2O-4 is at the top.

Figure 11. The migrated SCS line north of the site does not improve the resolution of sediment thickness.

Figure 12. The unmigrated SCS line south of the site shows smooth relief within 2 km of the junction box. Site H2O-3 is at the bottom of a fault block and Site H2O-2 is in the middle of a block.

Figure 13. The migrated SCS line south of the site does not improve the resolution of sediment thickness.

Figure 14. The Ocean Seismic Network site (OSN-1) is 225 km southwest of Oahu at a water depth of 4407 m. The Hawaii-2 Observatory (H2O) is halfway between Hawaii and California on the retired Hawaii-2 telecommunications cable and is at a water depth of 4970 m.

Figure 15. Vertical component spectra from the seafloor, buried, and borehole installations at OSN-1 are compared with the spectra from the buried installation at H2O and the KIP GSN station on Oahu. H2O has extremely low noise levels above 5 Hz and near the microseism peak from 0.1 to 0.3 Hz. H2O has high noise levels below 50 mHz. Otherwise H2O levels are comparable to the OSN borehole and KIP levels. The sediment resonances at H2O near 1 and 3 Hz are very prominent.

Figure 16. Horizontal component spectra from the seafloor, buried, and borehole installations at OSN-1 are compared with the spectra from the buried installation at H2O and the KIP GSN station on Oahu. The sediment resonance peaks in the band 0.3-8 Hz are up to 35 dB louder than background and far exceed the microseism peak at 0.1-0.3 Hz. That the resonant peaks are considerably higher for horizontal components than for the vertical component is consistent with the notion that these are related to shear wave resonances (or Scholte modes).

Figure 17. Location of Site NU-1A and the debris field for the Nuuanu Landslide. Seismic reflection line 12 from Rees et al. (1993), collected on the 1988 Thomas Washington cruise, shows the stratigraphic relationship of the proximal landslide facies to the distal facies to be cored at Site NU-1A.

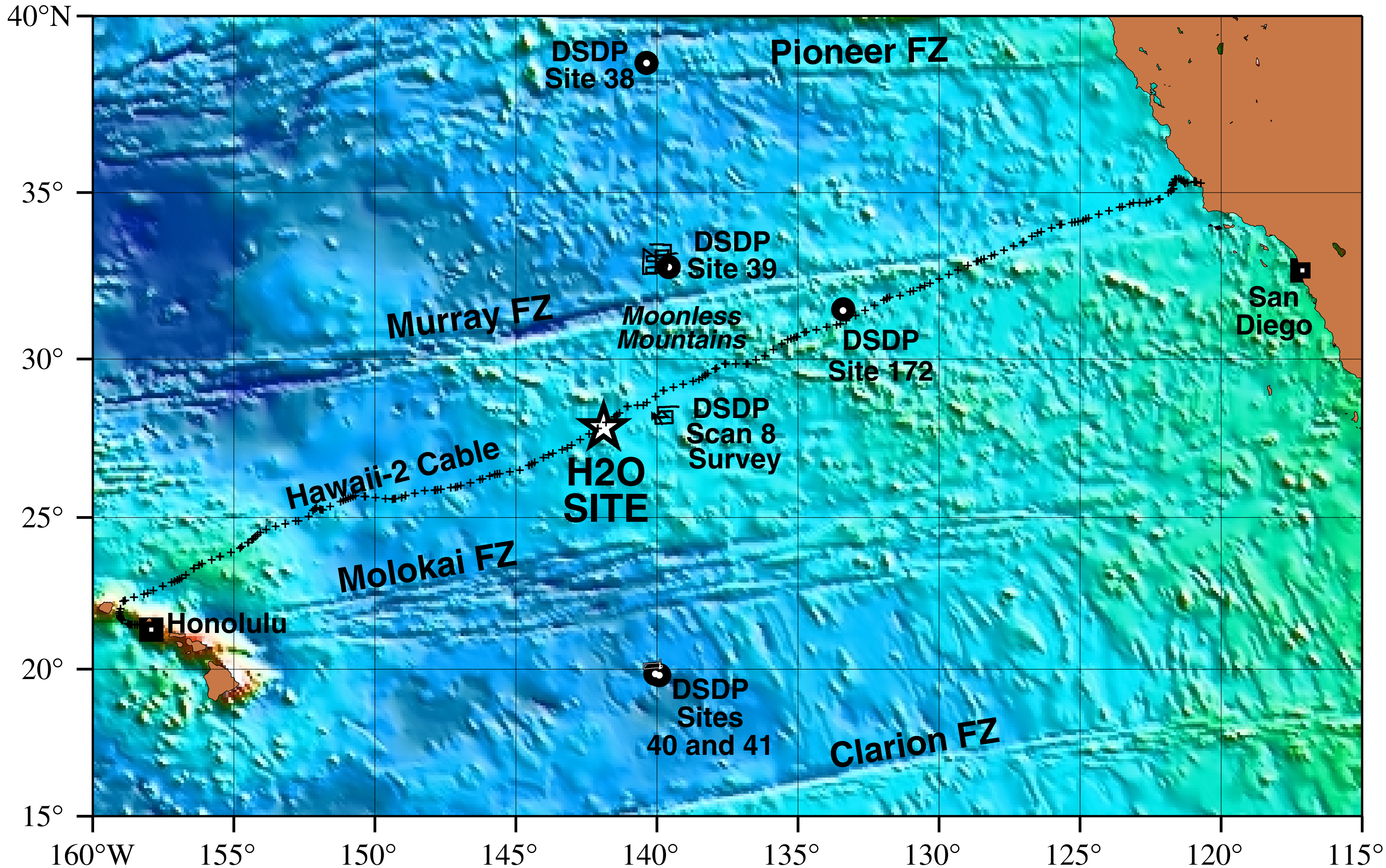

40°N
35°
30°
25°
20°
15°
160°W
155°
150°
145°
140°
135°
130°
125°
120°
115°
DSDP
Site 38
Pioneer FZ
DSDP
Site 39
Murray FZ
Moonless
Mountains
DSDP
Site 172
San
Diego
DSDP
Scan 8
Survey
H2O
SITE
Hawaii-2 Cable
Molokai FZ
Honolulu
DSDP
Sites
40 and 41
Clarion FZ

Figure 1

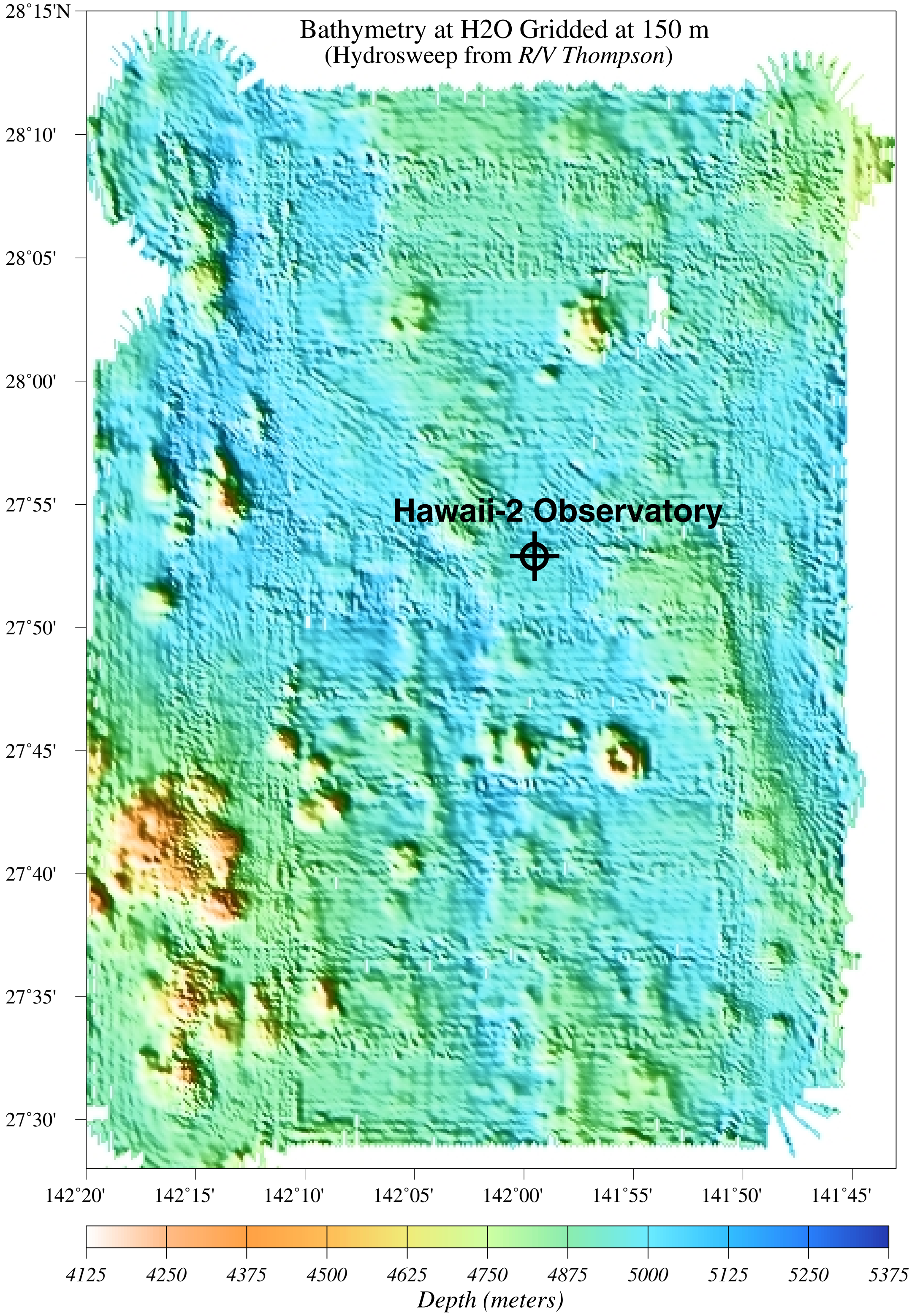

Bathymetry at H2O Gridded at 150 m
(Hydrosweep from R/V Thompson)
Hawaii-2 Observatory
28°15'N
28°10'
28°05'
28°00'
27°55'
27°50'
27°45'
27°40'
27°35'
27°30'
142°20'
142°15'
142°10'
142°05'
142°00'
141°55'
141°50'
141°45'
4125
4250
4375
4500
4625
4750
4875
5000
5125
5250
5375
Depth (meters)

Figure 2

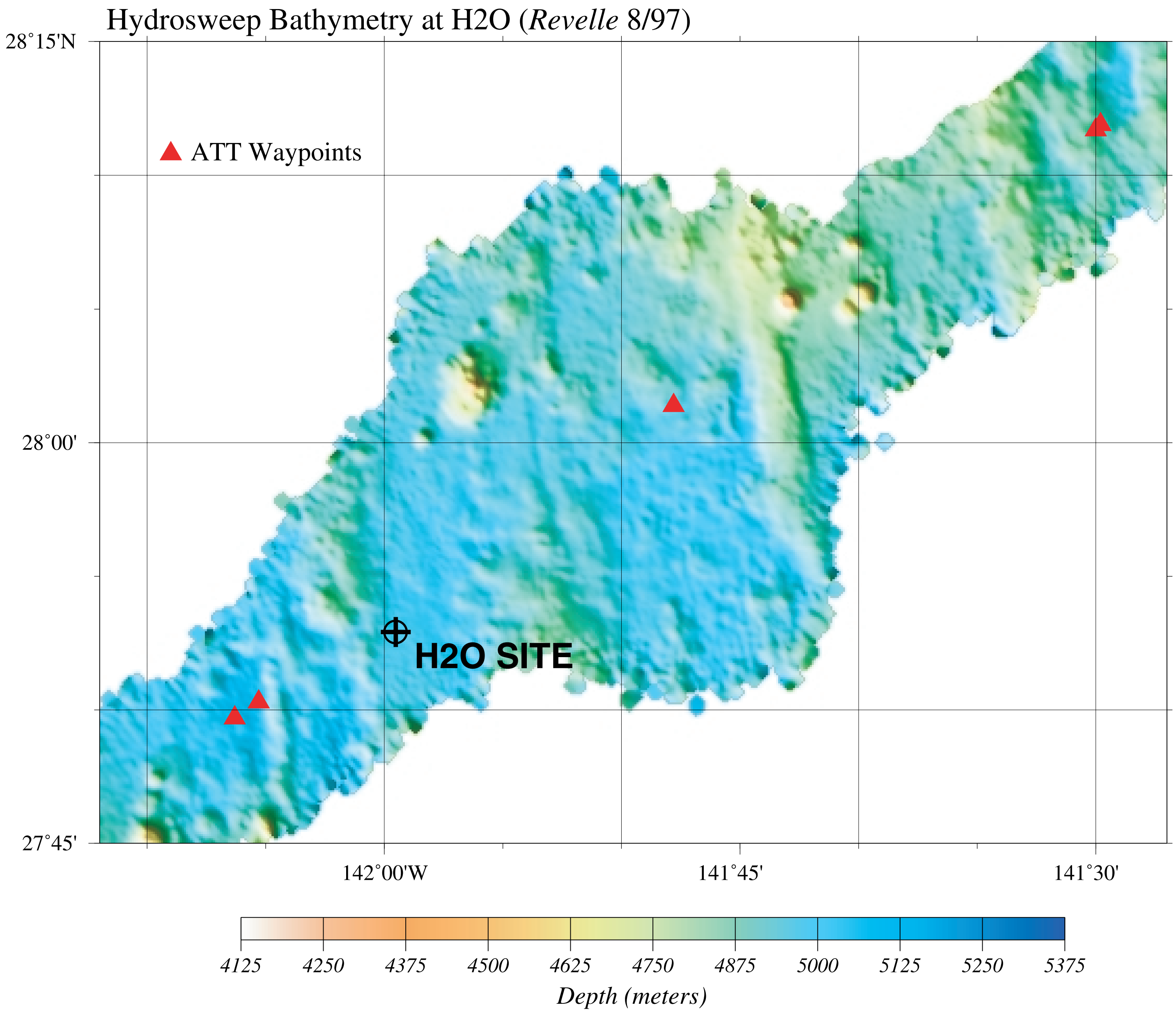

Hydrosweep Bathymetry at H2O (*Revelle* 8/97)
ATT Waypoints
H2O SITE
28°15'N
28°00'
27°45'
142°00'W
141°45'
141°30'
4125
4250
4375
4500
4625
4750
4875
5000
5125
5250
5375
Depth (meters)

Figure 3

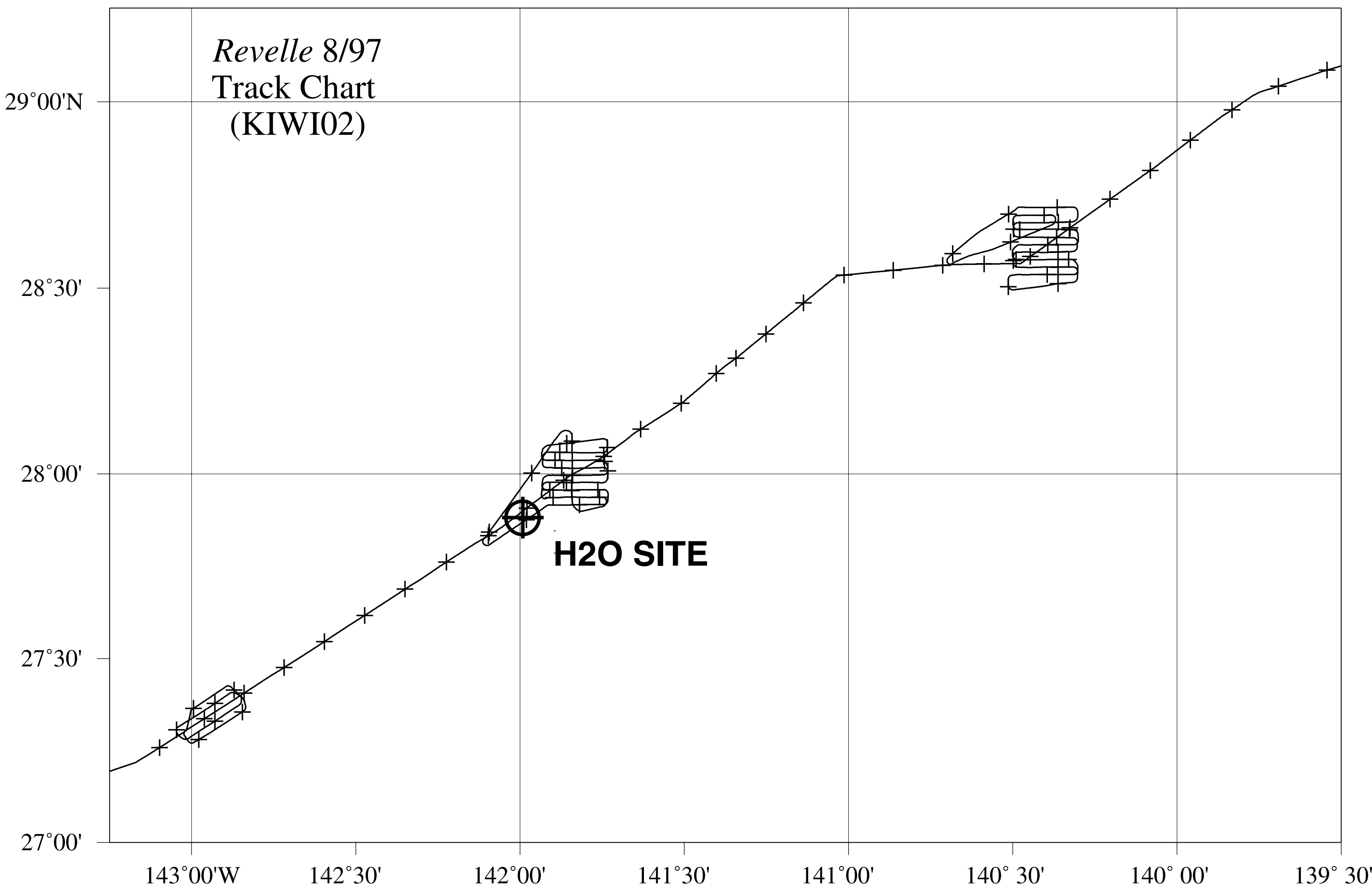
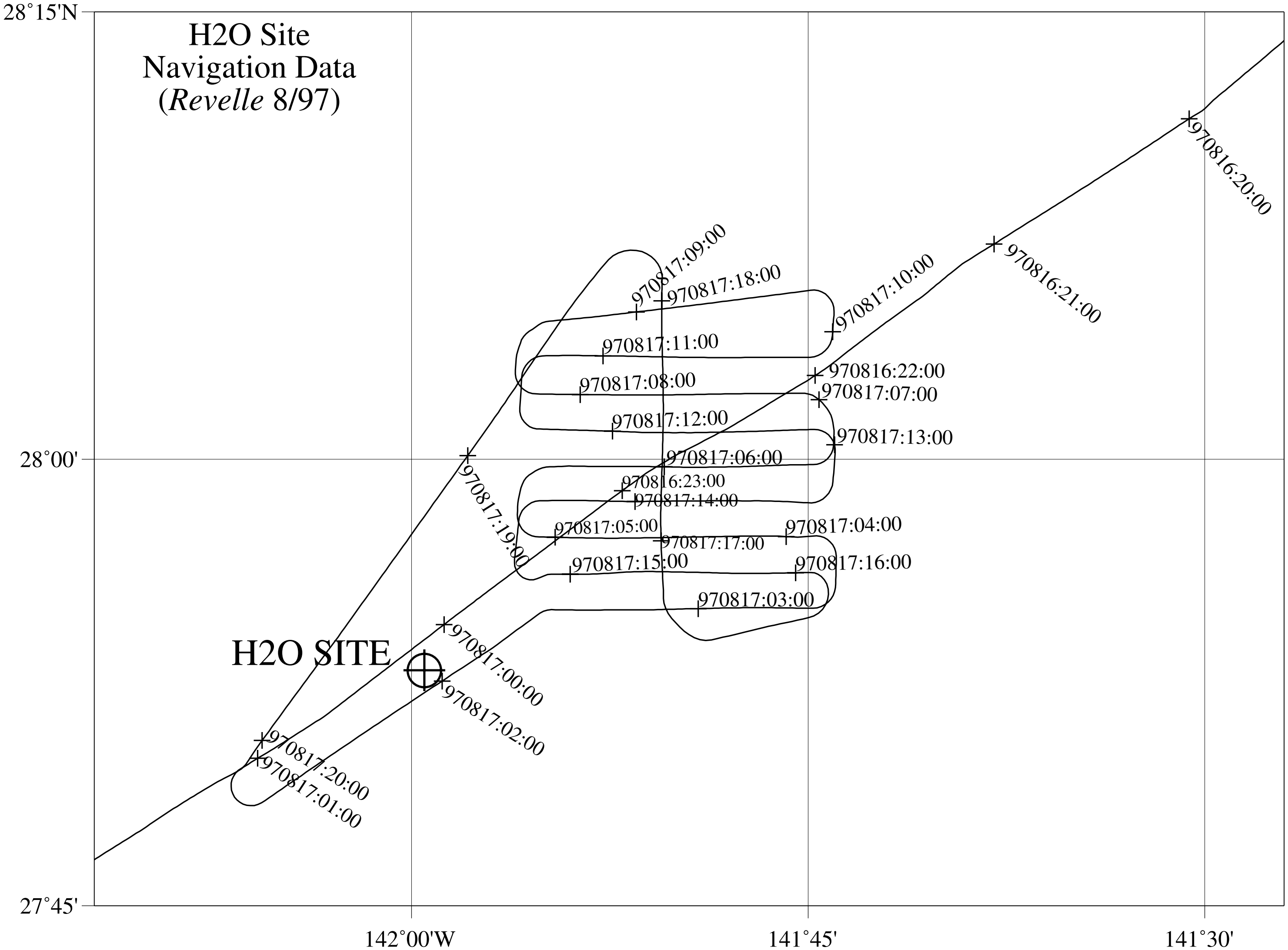

Revelle 8/97
Track Chart
(KIWI02)
H2O SITE
29°00'N
28°30'
28°00'
27°30'
27°00'
143°00'W
142°30'
142°00'
141°30'
141°00'
140° 30'
140° 00'
139° 30'

Figure 4


H2O Site
Navigation Data
(*Revelle* 8/97)
H2O SITE
28°15'N
28°00'
27°45'
142°00'W
141°45'
141°30'
970816:20:00
970816:21:00
970816:22:00
970816:23:00
970817:00:00
970817:01:00
970817:02:00
970817:03:00
970817:04:00
970817:05:00
970817:06:00
970817:07:00
970817:08:00
970817:09:00
970817:10:00
970817:11:00
970817:12:00
970817:13:00
970817:14:00
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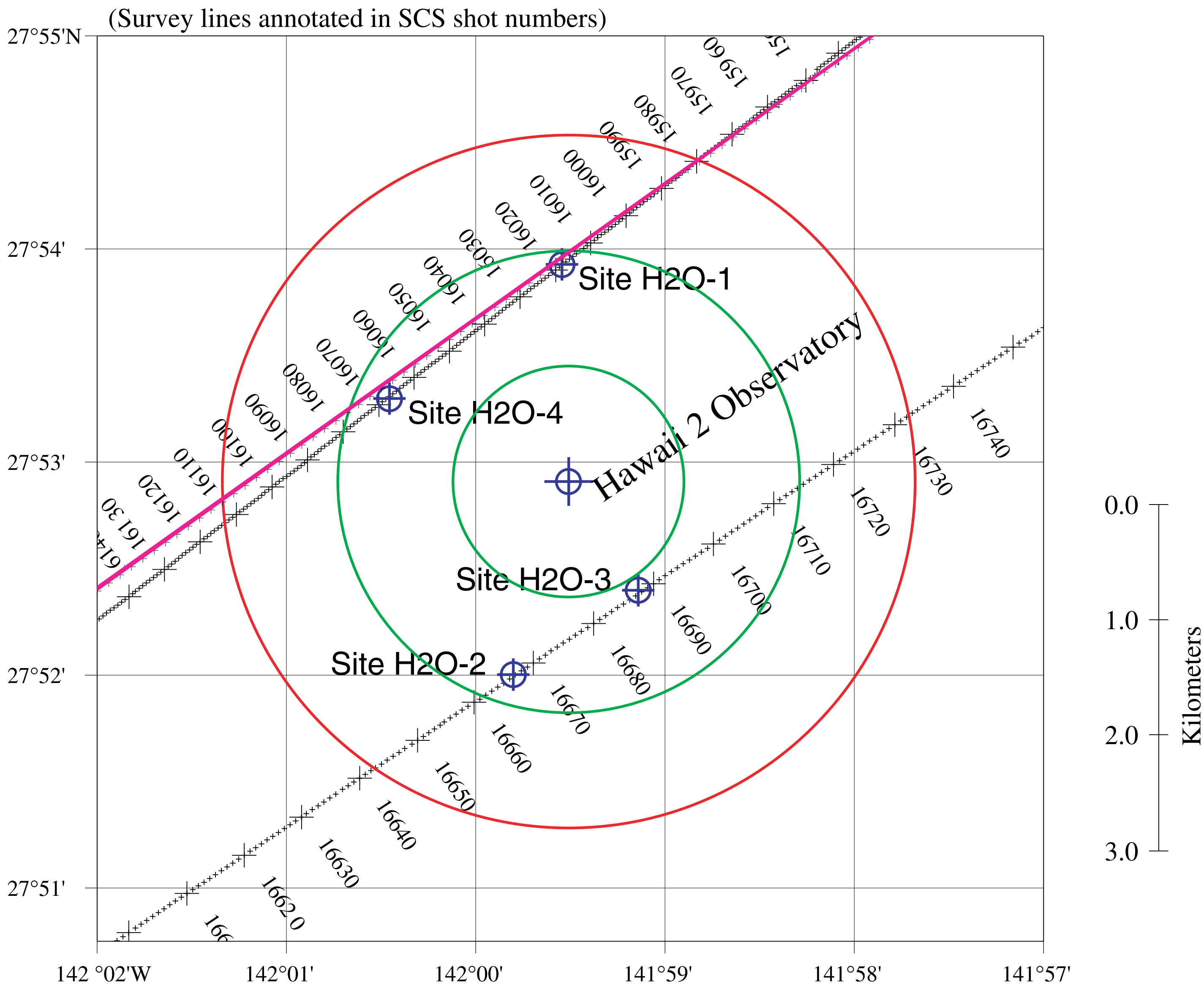
970817:20:00

Figure 5



(Survey lines annotated in SCS shot numbers)
27°55'N
27°54'
27°53'
27°52'
27°51'
142 °02'W
142°01'
142°00'
141°59'
141°58'
141°57'
Site H2O-1
Site H2O-4
Site H2O-3
Site H2O-2
Hawaii 2 Observatory
15960
15970
15980
15990
16000
16010
16020
16030
16040
16050
16060
16070
16080
16090
16100
16110
16120
16130
16620
16630
16640
16650
16660
16670
16680
16690
16700
16710
16720
16730
16740
0.0
1.0
2.0
3.0
Kilometers

Figure 6

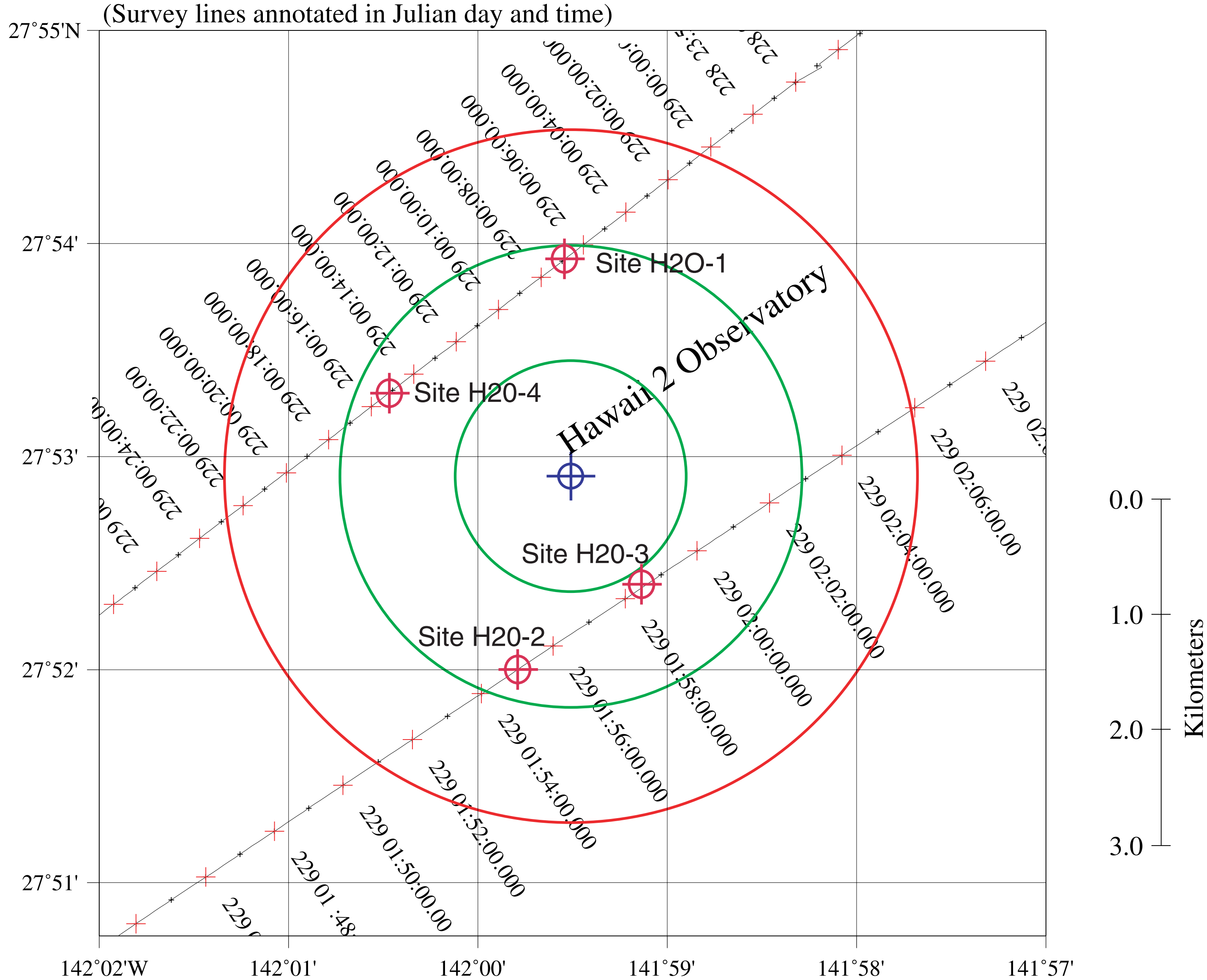
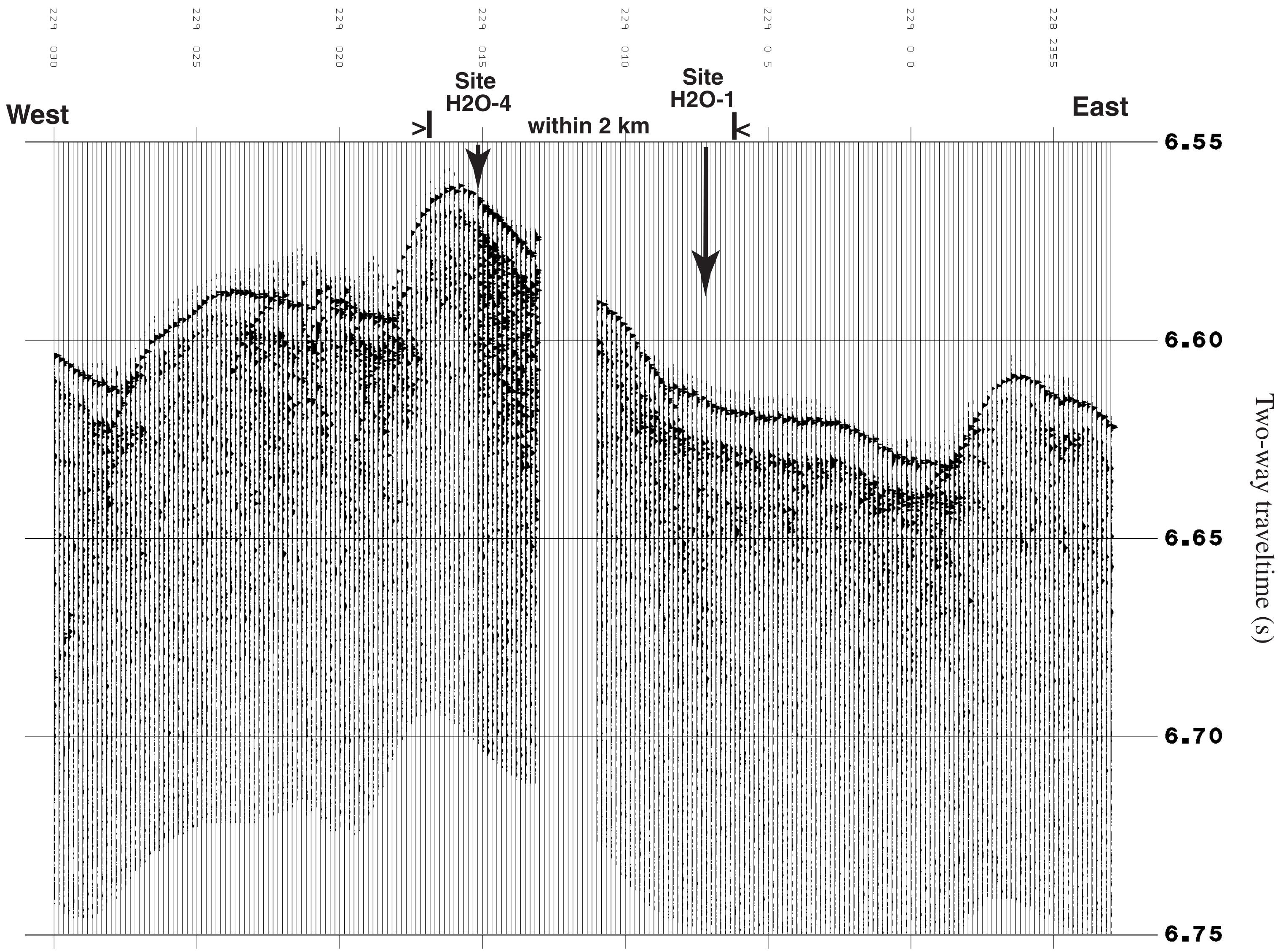

(Survey lines annotated in Julian day and time)
27°55'N
27°54'
27°53'
27°52'
27°51'
142°02'W
142°01'
142°00'
141°59'
141°58'
141°57'
Site H2O-1
Site H20-4
Site H20-3
Site H20-2
Hawaii 2 Observatory
229 00:02:00.000
229 00:04:00.000
229 00:06:00.000
229 00:08:00.000
229 00:10:00.000
229 00:12:00.000
229 00:14:00.000
229 00:16:00.000
229 00:18:00.000
229 00:20:00.000
229 00:22:00.00
229 01:50:00.00
229 01:52:00.000
229 01:54:00.000
229 01:56:00.000
229 01:58:00.000
229 02:00:00.000
229 02:02:00.000
229 02:04:00.000
229 02:06:00.00
0.0
1.0
2.0
3.0
Kilometers

Figure 7



3.5-kHz Line North of Hawaii 2 Observatory Site

Figure 8

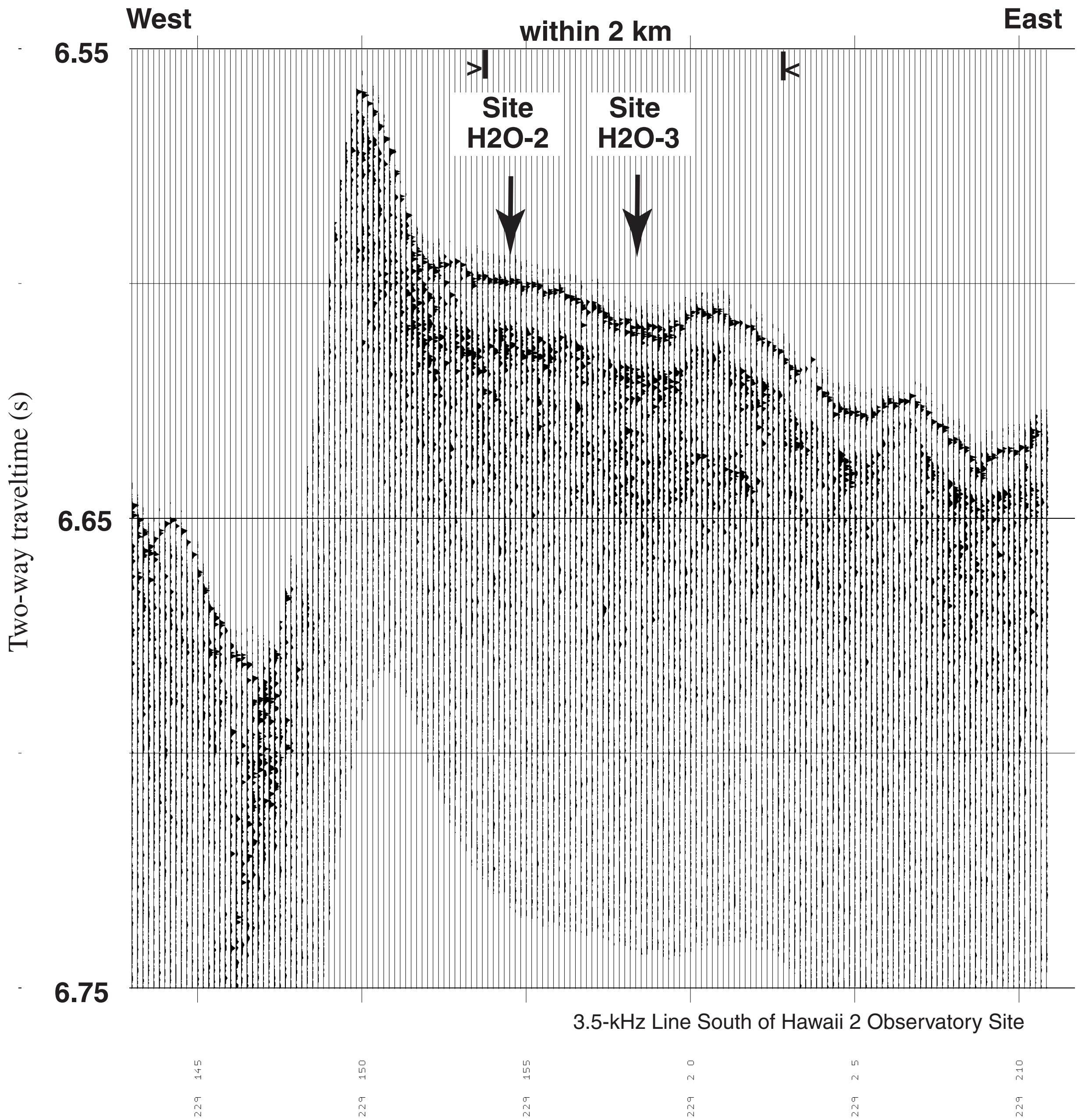

West
within 2 km
East
6.55
6.65
6.75
Two-way traveltime (s)
Site
H2O-2
Site
H2O-3
3.5-kHz Line South of Hawaii 2 Observatory Site

Figure 9

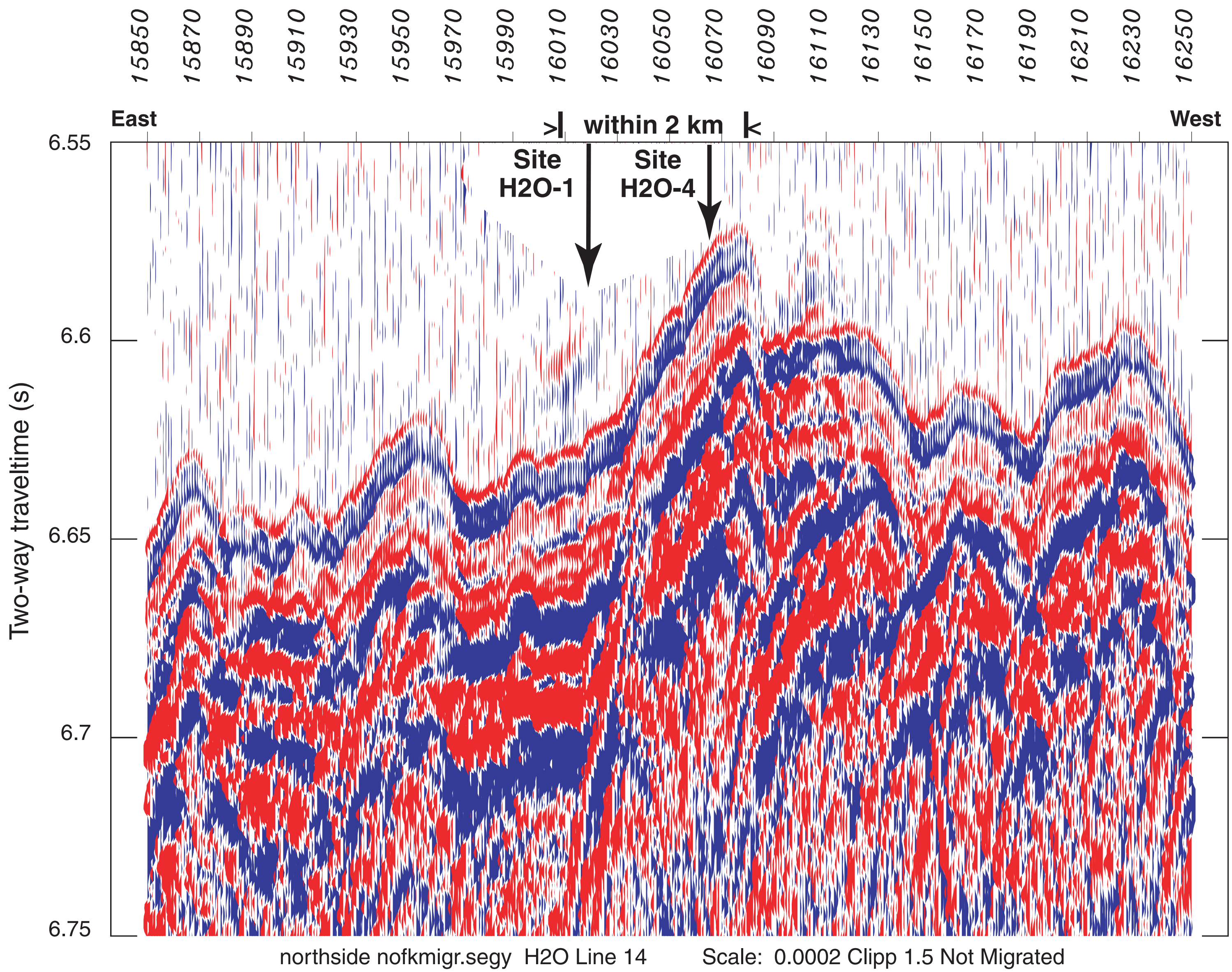

15850
15870
15890
15910
15930
15950
15970
15990
16010
16030
16050
16070
16090
16110
16130
16150
16170
16190
16210
16230
16250
East
>| within 2 km |<
West
Site H2O-1
Site H2O-4
6.55
6.6
6.65
6.7
6.75
Two-way traveltime (s)
northside nofkmigr.segy H2O Line 14
Scale: 0.0002 Clipp 1.5 Not Migrated

Figure 10

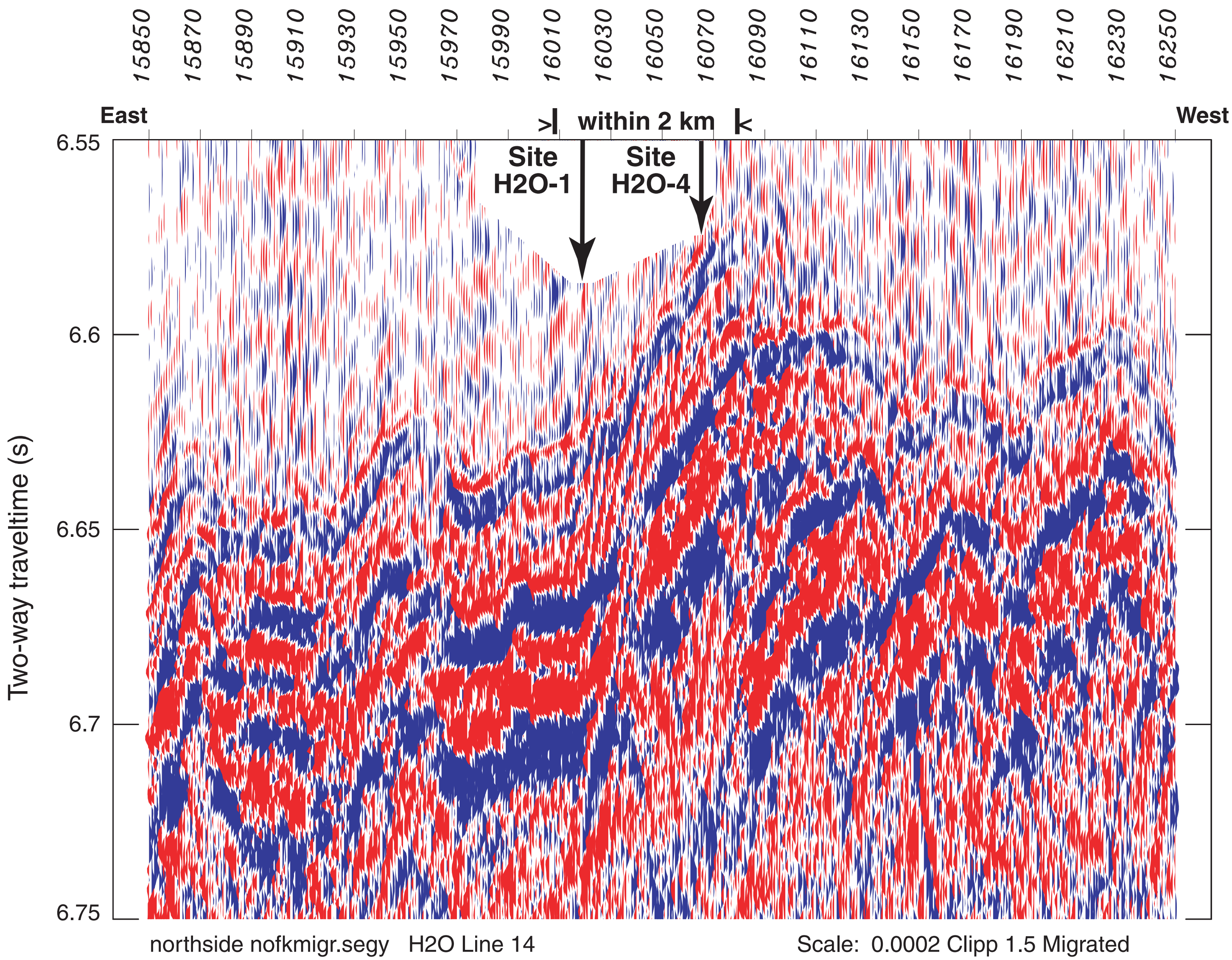
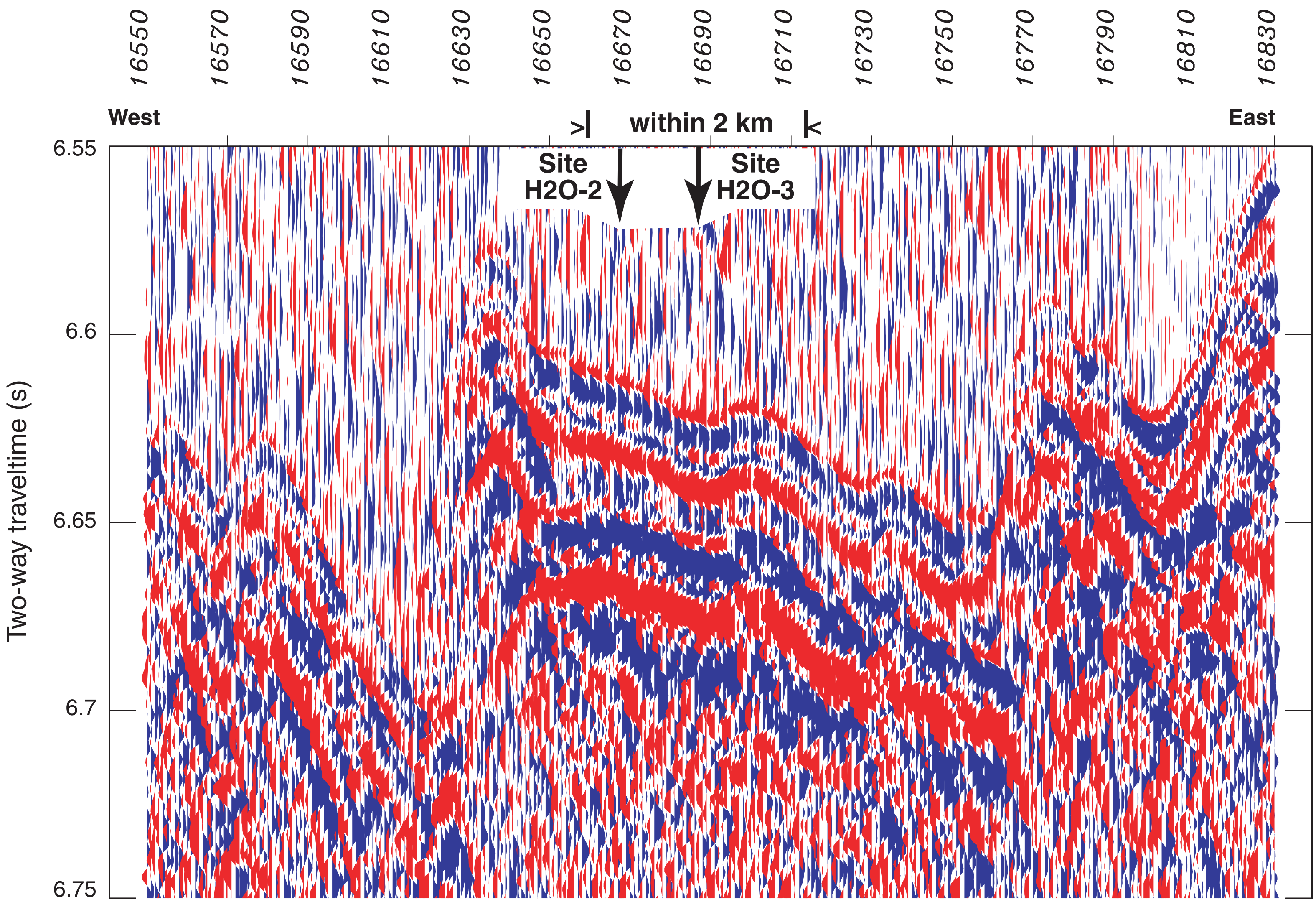

15850
15870
15890
15910
15930
15950
15970
15990
16010
16030
16050
16070
16090
16110
16130
16150
16170
16190
16210
16230
16250
East
within 2 km
West
Site
H2O-1
Site
H2O-4
Two-way traveltime (s)
6.55
6.6
6.65
6.7
6.75
northside nofkmigr.segy H2O Line 14
Scale: 0.0002 Clipp 1.5 Migrated

Figure 11



southside.segy H2O Line 14 Scale: 0.0002 Clipp 1.5 No Migration

Figure 12

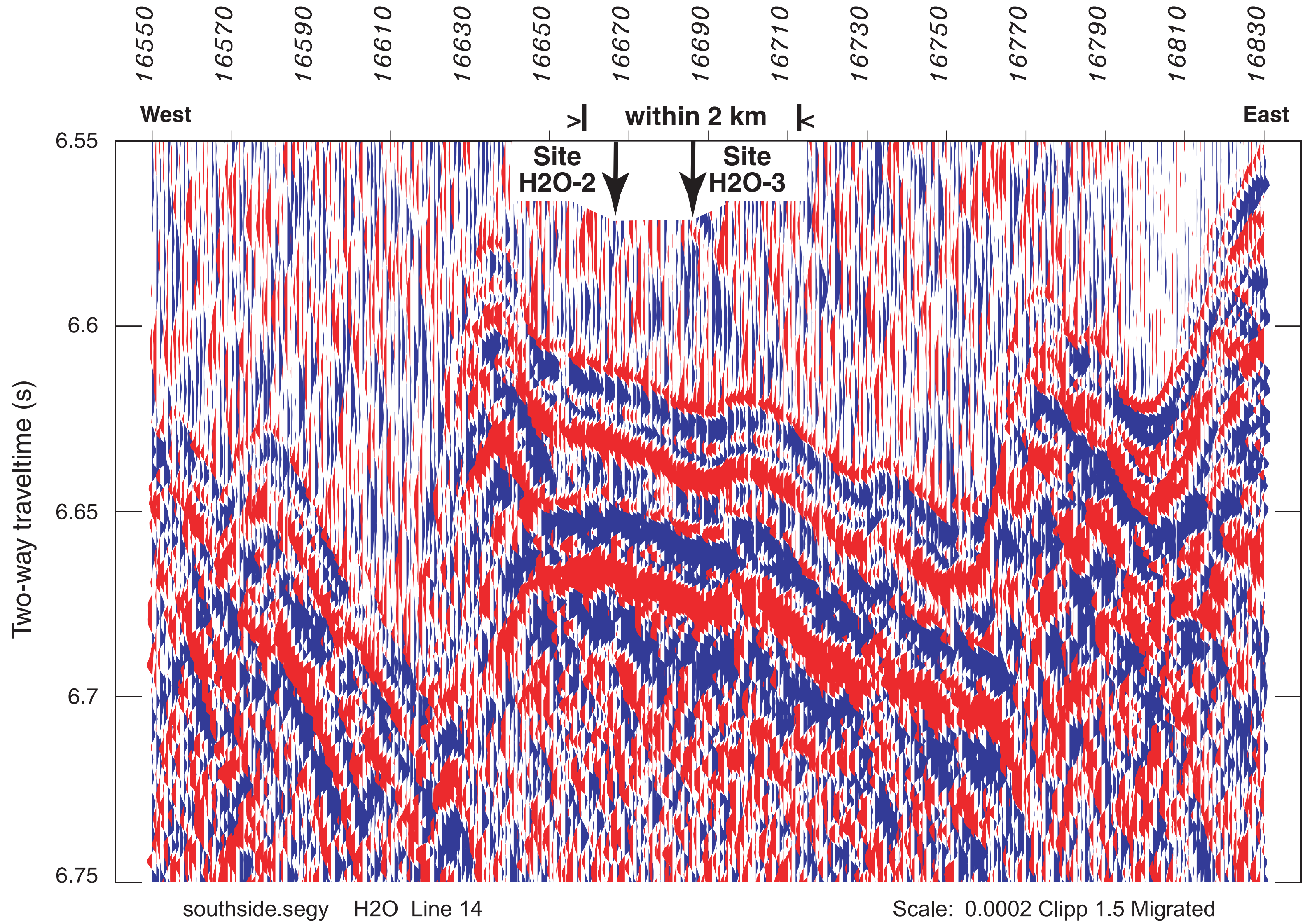

16550
16570
16590
16610
16630
16650
16670
16690
16710
16730
16750
16770
16790
16810
16830
West
within 2 km
East
Site H2O-2
Site H2O-3
6.55
6.6
6.65
6.7
6.75
Two-way traveltime (s)
southside.segy H2O Line 14
Scale: 0.0002 Clipp 1.5 Migrated

Figure 13

Locations of OSN-1 and H2O Broadband Seismic Sites

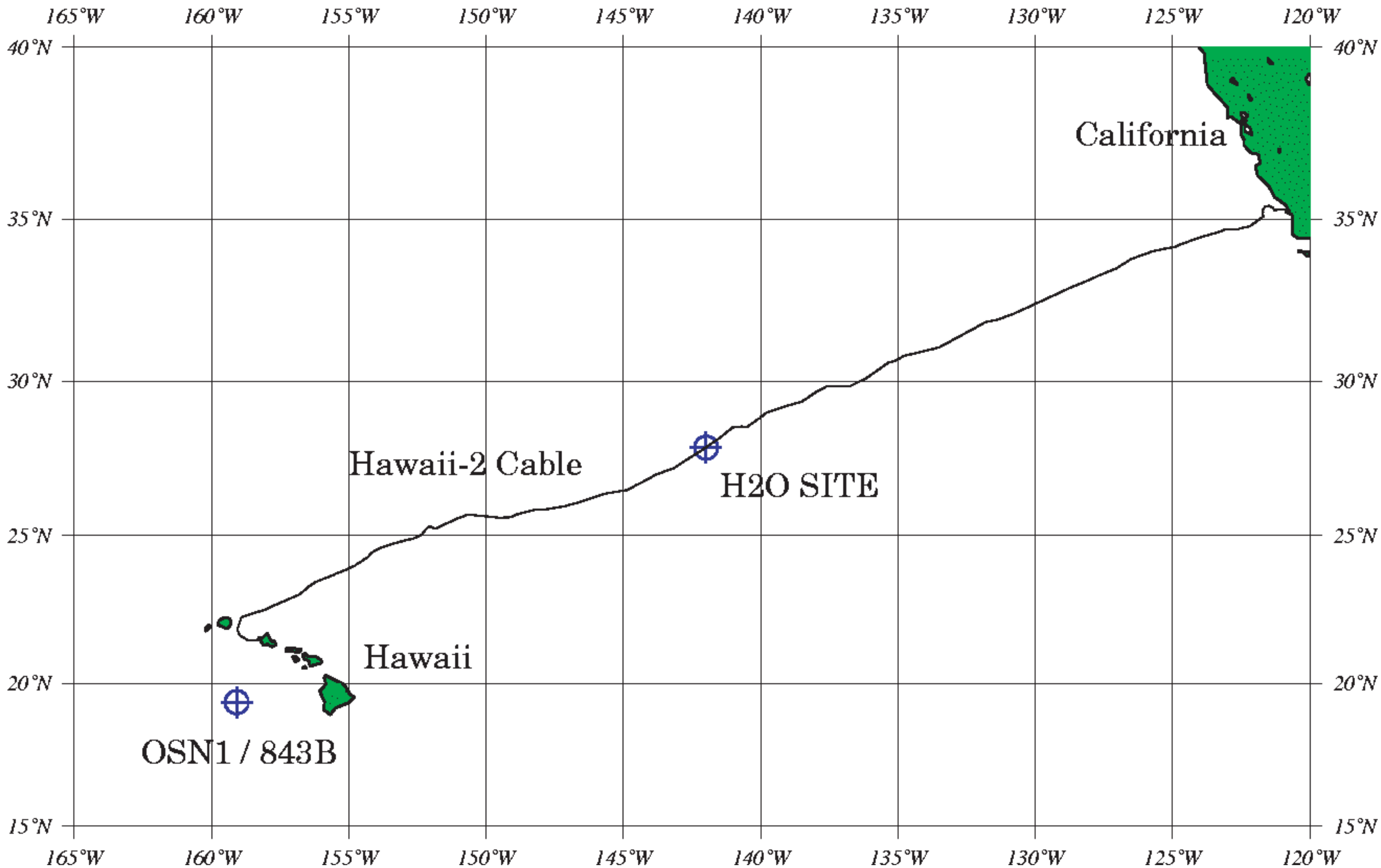


Figure 14

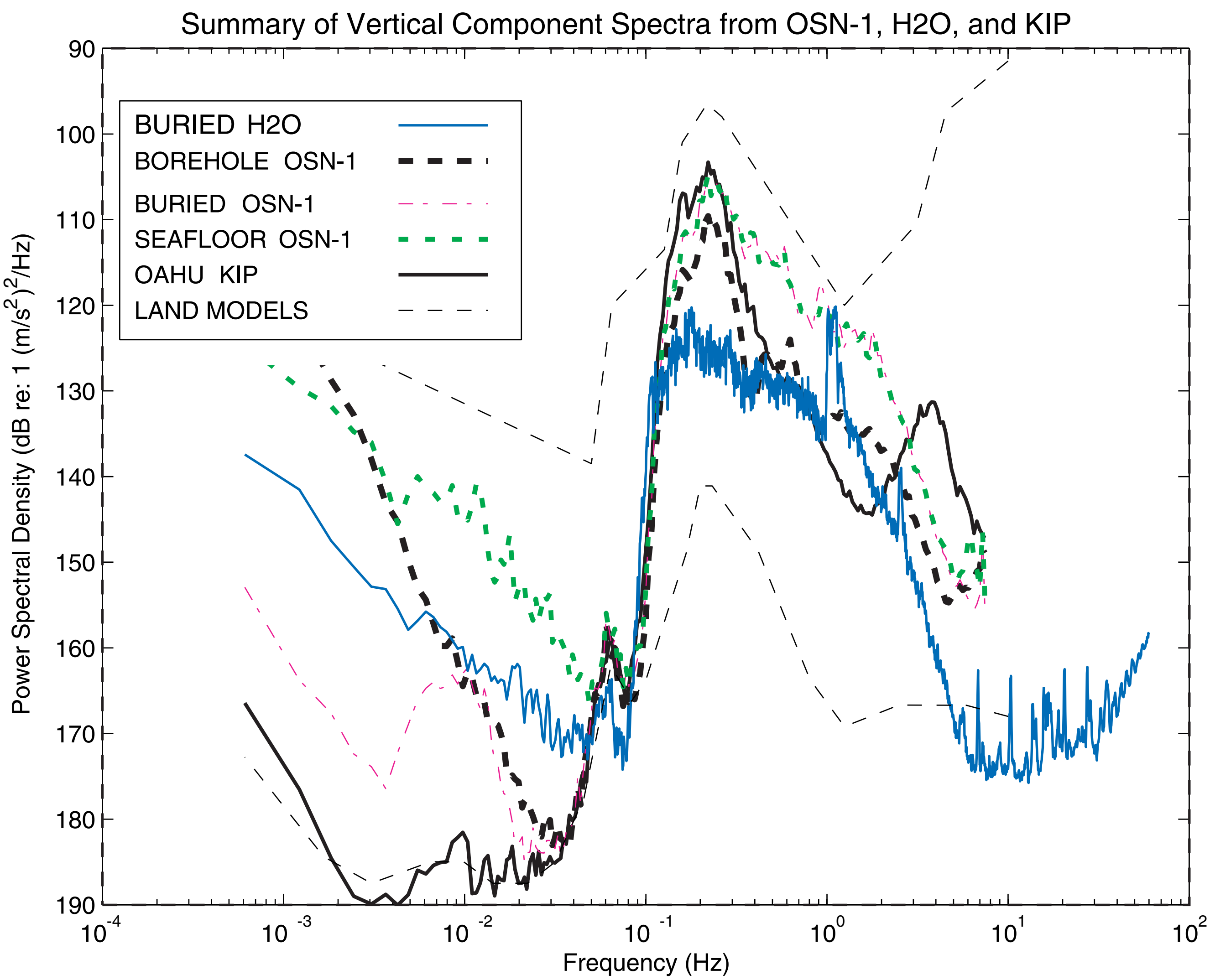

Summary of Vertical Component Spectra from OSN-1, H2O, and KIP
BURIED H2O
BOREHOLE OSN-1
BURIED OSN-1
SEAFLOOR OSN-1
OAHU KIP
LAND MODELS
Power Spectral Density (dB re: 1 (m/s^2)^2/Hz)
Frequency (Hz)
90
100
110
120
130
140
150
160
170
180
190
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}

Figure 15

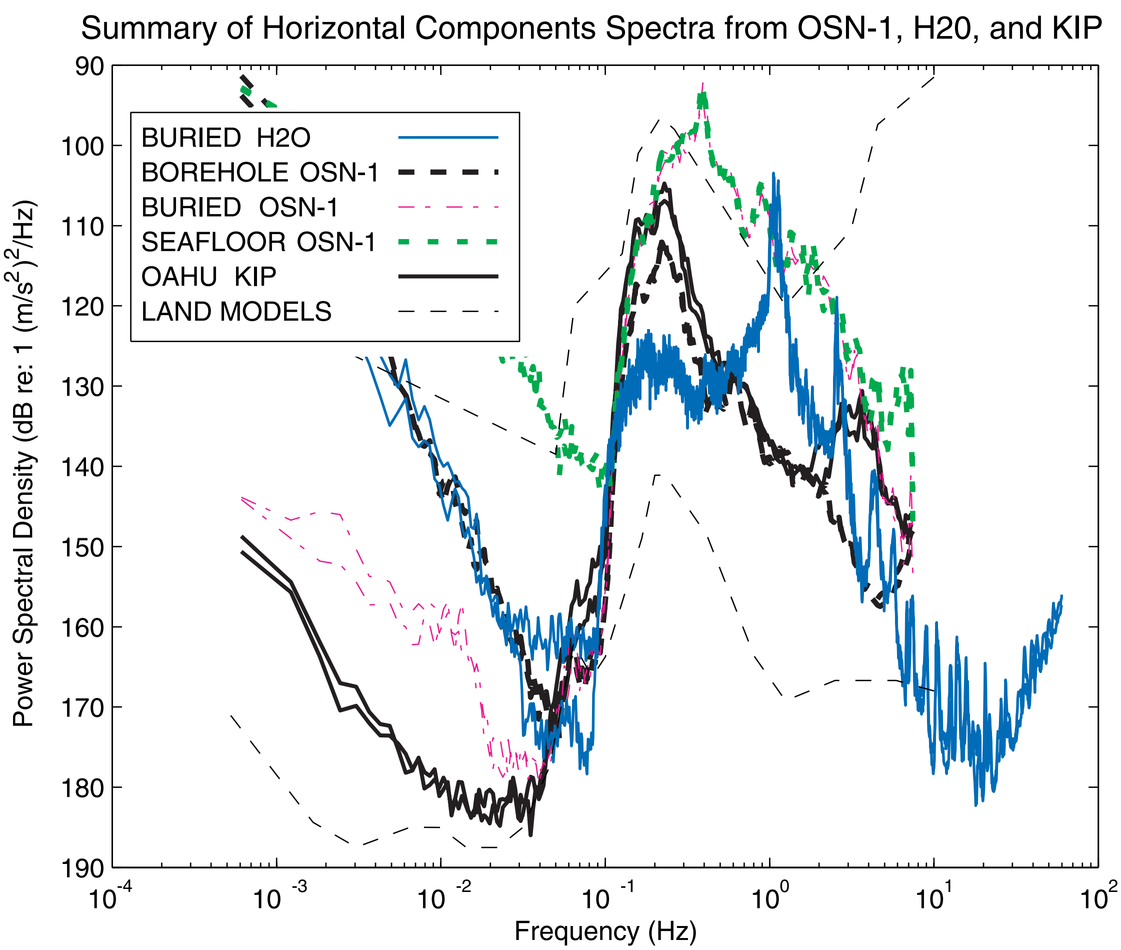

Summary of Horizontal Components Spectra from OSN-1, H20, and KIP
BURIED H2O
BOREHOLE OSN-1
BURIED OSN-1
SEAFLOOR OSN-1
OAHU KIP
LAND MODELS
Power Spectral Density (dB re: 1 (m/s^2)^2/Hz)
Frequency (Hz)
90
100
110
120
130
140
150
160
170
180
190
10^-4
10^-3
10^-2
10^-1
10^0
10^1
10^2

Figure 16

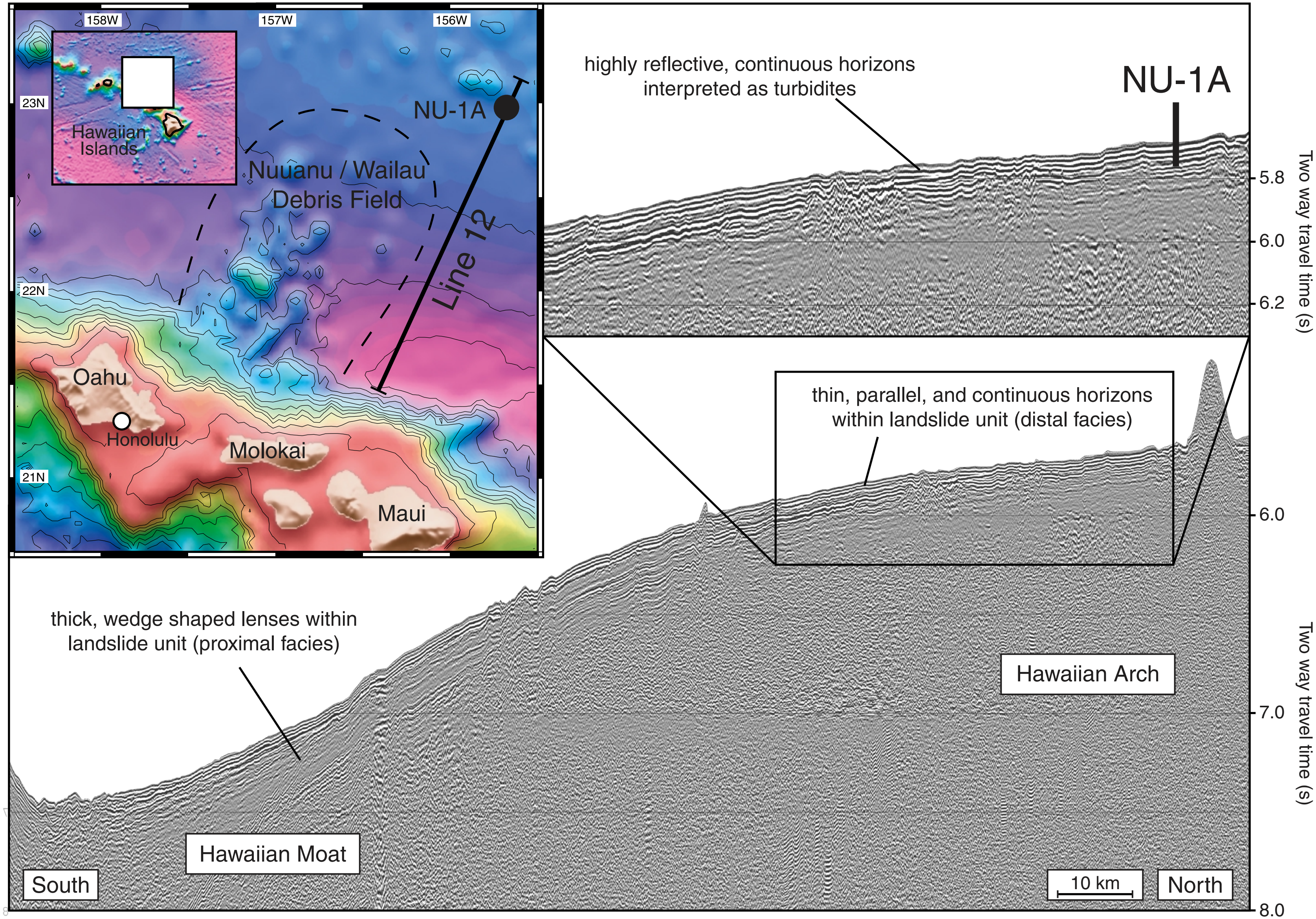

158W
157W
156W
23N
22N
21N
Hawaiian Islands
NU-1A
Nuuanu / Wailau Debris Field
Line 12
Oahu
Honolulu
Molokai
Maui
highly reflective, continuous horizons interpreted as turbidites
NU-1A
5.8
6.0
6.2
Two way travel time (s)
thin, parallel, and continuous horizons within landslide unit (distal facies)
6.0
7.0
8.0
thick, wedge shaped lenses within landslide unit (proximal facies)
Hawaiian Arch
Hawaiian Moat
South
10 km
North

Figure 17

Table 1. Summary of holes drilled in "normal crust" on the Pacific Plate with an age <100 Ma and penetration into basement >10 m.

Site/Hole	Leg	Age (Ma)	Location	Basement Penetration	Sediment Thickness
163	DSDP 16	72.0	11°N 150°W	18 m	176 m
420	DSDP 54	3.4	09°N 106°W	29 m	118 m
421	DSDP 54	3.4	09°N 106°W	29 m	85 m
429A	DSDP 54	4.6	09°N 107°W	21 m	31 m
469*	DSDP 63	17.0	33°N 121°W	58 m	391 m
470A	DSDP 63	15.0	29°N 118°W	48 m	167 m
471	DSDP 63	12.0	23°N 112°W	82 m	741 m
472	DSDP 63	15.0	23°N 114°W	25 m	112 m
597B¥	DSDP 92	29.0	19°S 130°W	25 m	48 m
597C†	DSDP 92	29.0	19°S 130°W	91 m	53 m
599B	DSDP 92	8.0	19°S 120°W	10 m	41 m
843B‡	ODP 136	95.0	19°N 159°W	71 m	243 m

* At the foot of Patton Escarpment
¥ This hole is in crust generated by fast spreading (55 mm/yr half rate)
† A reentry cone was emplaced at this site
‡ This is the location of Hole OSN-1

Table 2. Operations plan and time estimates for Leg 200.

Site	Location Latitude/Longitude	Water Depth	Operations Description	Transit (days)	On-Site (days)
Honolulu	21.19°N, 157.50°W		Transit 940 nmi Honolulu to Site H2O @ 10.5 kt	3.7	
H2O-1	27.8988°N, 141.9924°W	4980 m	Hole A (Exploratory): 30 m sediment penetration		0.6
H2O-2	27.8667°N, 141.9967°W	4980 m	Hole A (Exploratory): 30 m sediment penetration		0.2
H2O-3	27.8733°N, 141.9857°W	4980 m	Hole A (Exploratory): 30 m sediment penetration		0.2
H2O-4	27.8883°N, 142.0076°W	4980 m	Hole A (Exploratory): 30 m sediment penetration		0.6
H2O Final	To be selected from one of the above sites	4980 m	Set reentry cone, core to 325 mbsf (~250 m basement penetration), log, set casing to ~320 mbsf		25.3
San Diego	32.45°N, 117.10°W		Transit 1340 nmi H2O to San Diego @ 10.5 kt	5.3	
			Subtotal:	**9.0**	**26.9**
ODP Proposal 500-Full2: H2O Observatory			**TOTAL DAYS:**	**35.9**	

Table 3. Time estimates for secondary operations that may be conducted if extra time is available.

Scenario	Additional Time Needed (days)
1a. Bit changes necessary for coring, logging, and casing beyond 325 mbsf*	3.1
1b. Core, log, and case an extra 50 m of basement in the H2O reentry hole	1.5
1c. Core, log, and case an extra 100 m of basement in the H2O reentry hole	3.9
1d. Core, log, and case an extra 150 m of basement in the H2O reentry hole	6.3
2. Triple APC/XCB at H20 after completion of H2O reentry hole	3.6
3. Transit to PAT-13C and triple APC/XCB after completion of H2O reentry hole	7.9

* To deepen the H2O reentry hole significantly beyond the planned 325 mbsf will likely require a bit change for coring and a bit change for opening the hole for the 10-3/4-in casing.

Table 4. Alternate operations plan and time estimates for Leg 200 with Nuuanu Landslide coring.

Site	Location Latitude/Longitude	Water Depth	Operations Description	Transit (days)	On-Site (days)
Honolulu	21.19°N, 157.50°W		Transit 149 nmi from Honolulu to Site NU-1 @ 10.5 kt	0.6	
NU-1	23.00°N, 155.67°W	4500 m	Hole A: APC/XCB to 100 mbsf		1.2
			Hole B: APC/XCB to 50 mbsf		0.6
			Transit 797 nmi from Site NU-1 to Site H2O @ 10.5 k	3.2	
H2O-1	27.8988°N, 141.9924°W	4980 m	Hole A (Exploratory): 30 m sediment penetration		0.6
H2O-2	27.8667°N, 141.9967°W	4980 m	Hole A (Exploratory): 30 m sediment penetration		0.2
H2O-3	27.8733°N, 141.9857°W	4980 m	Hole A (Exploratory): 30 m sediment penetration		0.2
H2O-4	27.8883°N, 142.0076°W	4980 m	Hole A (Exploratory): 30 m sediment penetration		0.6
H2O Final	To be selected from one of the above sites	4980 m	Set reentry cone, core to 325 mbsf (~250 m basement penetration), log, set casing to ~320 mbsf		25.3
San Diego	32.45°N, 117.10°W		Transit 1340 nmi H2O to San Diego @ 10.5 kt	5.3	
ODP Proposal 500-Full2: H2O Observatory, and APL 19: Nuuanu Landslide			**Subtotal:**	**9.1**	**28.7**
			TOTAL DAYS:	**37.8**	

SITE SUMMARIES

Site: H2O-1

Priority: 1
Position: 27°53.928´N, 141°59.544´W
Water Depth: 4980 ± 40 m
Sediment Thickness: 50-75 m
Target Drilling Depth: 350 mbsf
Approved Maximum Penetration: Unlimited
Seismic Coverage: SCS with a generator-injector (GI) gun acquired on *Revelle* cruise KIWI02 (August 1997). 3.5-kHz data acquired on *Revelle* cruise KIWI02. SeaBeam bathymetry acquired on *Revelle* cruise KIWI02. Hydrosweep bathymetry acquired on the *Thompson* (September 1999).

Objectives: The objectives of Site H2O-1 if selected as the primary observatory site are to

1. Drill a reentry hole into basement for a permanent broadband borehole seismograph at the H2O area;

2. Provide a borehole at the H2O area for other long-term borehole measurements; and

3. Provide a "reference site" with in situ igneous samples in normal, fast-spreading (140 mm/yr full rate), 45- to 50-Ma ocean crust to constrain geochemical and hydrothermal models of crustal evolution.

Drilling Program: Jet-in test. If this becomes the primary observatory site, set a reentry cone with 20 in casing to ~25 mbsf, RCB core from 25 to 325 mbsf, log with the triple-combo and FMS/sonic tool strings, WST for normal-incidence VSP if time permits, open hole and set 16-in casing ~10 m into basement, open hole and set 10-3/4-in casing TD, and log hole with the BHC sonic tool.

Logging and Downhole: Triple-combo, FMS/sonic, WST for normal-incidence VSP, and BHC sonic for cement bond log

Nature of Rock Anticipated: Fractured pillow basalt

See Figure 10 for the seismic line and Figure 6 for the trackline.

Site: H2O-2

Priority: 1
Position: 27°52.002´N, 141°59.802´W
Water Depth: 4980 ± 40 m
Sediment Thickness: 50-75 m
Target Drilling Depth: 350 mbsf
Approved Maximum Penetration: Unlimited
Seismic Coverage: SCS with a GI gun acquired on *Revelle* cruise KIWI02 (August 1997). 3.5-kHz data acquired on *Revelle* cruise KIWI02. SeaBeam bathymetry acquired on *Revelle* cruise KIWI02. Hydrosweep bathymetry acquired on the *Thompson* (September 1999).

Objectives: The objectives of Site H2O-2 if selected as the primary observatory site are to

1. Drill a reentry hole into basement for a permanent broadband borehole seismograph at the H2O area;

2. Provide a borehole at the H2O area for other long-term borehole measurements; and

3. Provide a "reference site" with in situ igneous samples in normal, fast-spreading (140 mm/yr full rate), 45- to 50-Ma ocean crust to constrain geochemical and hydrothermal models of crustal evolution.

Drilling Program: Jet-in test. If this becomes the primary observatory site, set a reentry cone with 20 in casing to ~25 mbsf, RCB core from 25 to 325 mbsf, log with the triple-combo and FMS/sonic tool strings, WST for normal-incidence VSP if time permits, open hole and set 16-in casing ~10 m into basement, open hole and set 10-3/4-in casing TD, and log hole with the BHC sonic tool.

Logging and Downhole: Triple-combo, FMS/sonic, WST for normal-incidence VSP, and BHC sonic for cement bond log

Nature of Rock Anticipated: Fractured pillow basalt

See Figure 12 for the seismic line and Figure 6 for the trackline.

Site: H2O-3

Priority: 1
Position: 27°52.398´N, 141°59.142´W
Water Depth: 4980 ± 40 m
Sediment Thickness: 50-75 m
Target Drilling Depth: 350 mbsf
Approved Maximum Penetration: Unlimited
Seismic Coverage: SCS with a GI gun acquired on *Revelle* cruise KIWI02 (August 1997). 3.5-kHz data acquired on *Revelle* cruise KIWI02. SeaBeam bathymetry acquired on *Revelle* cruise KIWI02. Hydrosweep bathymetry acquired on the *Thompson* (September 1999).

Objectives: The objectives of Site H2O-3 if selected as the primary observatory site are to

1. Drill a reentry hole into basement for a permanent broadband borehole seismograph at the H2O area;

2. Provide a borehole at the H2O area for other long-term borehole measurements; and

3. Provide a "reference site" with in situ igneous samples in normal, fast-spreading (140 mm/yr full rate), 45- to 50-Ma ocean crust to constrain geochemical and hydrothermal models of crustal evolution.

Drilling Program: Jet-in test. If this becomes the primary observatory site, set a reentry cone with 20 in casing to ~25 mbsf, RCB core from 25 to 325 mbsf, log with the triple-combo and FMS/sonic tool strings, WST for normal-incidence VSP if time permits, open hole and set 16-in casing ~10 m into basement, open hole and set 10-3/4-in casing TD, and log hole with the BHC sonic tool.

Logging and Downhole: Triple-combo, FMS/sonic, WST for normal-incidence VSP, and BHC sonic for cement bond log

Nature of Rock Anticipated: Fractured pillow basalt

See Figure 12 for the seismic line and Figure 6 for the trackline.

Site: H2O-4

Priority: 1
Position: 27°53.298´N, 142°00.456´W
Water Depth: 4980 ± 40 m
Sediment Thickness: 50-75 m
Target Drilling Depth: 350 mbsf
Approved Maximum Penetration: Unlimited
Seismic Coverage: SCS with a GI gun acquired on *Revelle* cruise KIWI02 (August 1997). 3.5-kHz data acquired on *Revelle* cruise KIWI02. SeaBeam bathymetry acquired on *Revelle* cruise KIWI02. Hydrosweep bathymetry acquired on the *Thompson* (September 1999).

Objectives: The objectives of Site H2O-4 if selected as the primary observatory site are to

1. Drill a reentry hole into basement for a permanent broadband borehole seismograph at the H2O area;

2. Provide a borehole at the H2O area for other long-term borehole measurements; and

3. Provide a "reference site" with in situ igneous samples in normal, fast-spreading (140 mm/yr full rate), 45- to 50-Ma ocean crust to constrain geochemical and hydrothermal models of crustal evolution.

Drilling Program: Jet-in test. If this becomes the primary observatory site, set a reentry cone with 20 in casing to ~25 mbsf, RCB core from 25 to 325 mbsf, log with the triple-combo and FMS/sonic tool strings, WST for normal-incidence VSP if time permits, open hole and set 16-in casing ~10 m into basement, open hole and set 10-3/4-in casing TD, and log hole with the BHC sonic tool.

Logging and Downhole: Triple-combo, FMS/sonic, WST for normal-incidence VSP, and BHC sonic for cement bond log

Nature of Rock Anticipated: Fractured pillow basalt

See Figure 10 for the seismic line and Figure 6 for the trackline.

Site: NU-1A

Priority: 2
Position: 22° 58.41´N, 155°39.26´W
Water Depth: 4250 m
Sediment Thickness: ~250 m
Target Drilling Depth: 100 mbsf
Approved Maximum Penetration: ~200 m (approval pending)
Seismic Coverage: Seismic reflection line 12 from the 1988 Thomas Washington cruise; Swath bathymetry from 1998/1999

Objectives: The objectives of Site NU-1A if time permits site are to

1. Recover a complete section of the distal Nuuanu Landslide deposit;
2. Resolve whether the Nuuanu Landslide occurred as a single event or multiple collapses;
3. Determine the timing of the landslide;
4. Estimate the volume of the landslide;
5. Study the deposition history of the landslide; and
6. Gain insight into potential hazards related to giant landslides on the flanks of ocean islands.

Drilling Program: APC/XCB to 100 mbsf in Hole A and to 50 mbsf in Hole B.

Logging and Downhole: No logging or downhole measurements planned.

Nature of Rock Anticipated: Sediment

See Figure 17 for the seismic line and trackline.

SCIENTIFIC PARTICIPANTS

Co-Chief
Junzo Kasahara
Earthquake Research Institute
University of Tokyo
1-1-1 Yayoi, Bunkyo-ku
Tokyo 113-0032
Japan
Internet: kasa2@eri.u-tokyo.ac.jp
Work: (81) 3-3812-2111, ext 5713
Fax: (81) 3-3812-6979

Co-Chief
Ralph A. Stephen
Department of Geology and Geophysics
Woods Hole Oceanographic Institution
MS 24
360 Woods Hole Road
Woods Hole, MA 02543-1542
USA
Internet: rstephen@whoi.edu
Work: (508) 289-2583
Fax: (508) 457-2150

Staff Scientist
Gary D. Acton
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station, TX 77845
USA
Internet: acton@odpemail.tamu.edu
Work: (979) 845-2520
Fax: (979) 845-0876

Microbiologist
Werner Manz
Institute of Environmental Protection
Technical University Berlin
Franklinstr. 29
Berlin 10587
Germany
Internet: wernermanz@web.de
Work: (49) 303 142 5589
Fax: (49) 303 147 3460

Microbiologist
Gabriela Schumann-Kindel
Universität Göttingen
Gottinger Zentrum Geowissenschaften GZG
Goldschmidtstr. 3
Gottingen 37077
Germany
Internet: gschuma@gwdg.de
Work: (49) 551 391 2587
Fax: (49) 551 397918

Igneous Petrologist
Satoru Haraguchi
Ocean Research Institute
University of Tokyo
1-15-1, Minamidai
Nakano, Tokyo 164-8639
Japan
Internet: haraguti@ori.u-tokyo.ac.jp
Work: (81) 3-5351-6559
Fax: (81) 3-5351-6445

Igneous Petrologist
Michele Lustrino
Dipartimento di Scienze della Terra
Università La Sapienza
P.le A. Moro 5
Rome 00185
Italy
Internet: michele.lustrino@uniroma1.it
Work: (39) 6 4991 4158
Fax: (39) 6 4454 729

Igneous Petrologist
James H. Natland
Rosenstiel School of Marine and Atmospheric Science
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149-1098
USA
Internet: jnatland@rsmas.miami.edu
Work: (305) 361-4123
Fax: (305) 361-4632

Igneous Petrologist
Sarah Sherman
Department of Geology and Geophysics/SOEST
University of Hawaii at Manoa
2525 Correa Rd.

Honolulu, HI 96795
USA
Internet: macbeanur@yahoo.com
Work: (808) 956-5033
Fax: (808) 956-5512

Physical Properties Specialist
Mikako Nakamura
Earthquake Research Institute
University of Tokyo
Earth and Planetary Science
1-1-1 Yayoi
Bunkyo-ku, Tokyo 113-0032
Japan
Internet: mikako@eri.u-tokyo.ac.jp
Work: (81) 3-5841-5736
Fax: (81) 3-5689-7234

Sedimentologist
John Wilson
Royal Holloway College
University of London, Egham
Queen's Building
Egham, Surrey, TW20 0EX
United Kingdom
Internet: j.wilson@gl.rhul.ac.uk
Work: (44) 1784-443582
Fax: (44) 1784-471780

Seismologist
Hartley Hoskins
Computer and Information Services
Woods Hole Oceanographic Institution
360 Woods Hole Road
Woods Hole, MA 02543
USA
Internet: hhoskins@whoi.edu
Work: (508) 457-2011
Fax: (508) 457-2195

Logging Staff Scientist
Yue-Feng Sun
Lamont-Doherty Earth Observatory
Columbia University
Borehole Research Group
Palisades, NY 10964
USA
Internet: sunyf@ldeo.columbia.edu
Work: (914) 365-8504

Fax: (914) 365-3182

Schlumberger Engineer
Mr. Steven Kittredge
911 Center Point Rd.
Carrollton, GA 30117
Internet: kittredge1@webster.oilfield.slb.com
Work: (281) 480-2000
Fax: (281) 480-9550

Operations Manager
Brian Jonasson
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station, TX 77845-9547
USA
Internet: jonasson@odpemail.tamu.edu
Work: (979) 845-2025
Fax: (979) 845-2308

Laboratory Officer
William G. Mills
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station, TX 77845-9547
USA
Internet: mills@odpemail.tamu.edu
Work: (979) 845-2478
Fax: (979) 845-0876

Marine Lab Specialist: Yeoperson
Lisa K. Crowder
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station, TX 77845
USA
Internet: crowder@odpemail.tamu.edu
Work: (979) 845-7716
Fax: (979) 845-0876

Marine Lab Specialist: Chemistry
Timothy Bronk
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station, TX 77845-9547

USA
Internet: bronk@odpemail.tamu.edu
Work: (979) 845-9186
Fax: (979) 845-0876

Marine Lab Specialist: Chemistry
Anne Pimmel
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station, TX 77845-9547
USA
Internet: pimmel@odpemail.tamu.edu
Work: (979) 845-3602
Fax: (979) 845-0876

Marine Lab Specialist: Curator
Kim A. Bracchi
Ocean Drilling Program
Texas A&M University
1000 Discovery Dr.
College Station, TX 77845
USA
Internet: bracchi@odpemail.tamu.edu
Work: (979)
Fax: (979) 845-0876

Marine Lab Specialist: Downhole Tools, Marine Lab Specialist: Thin Sections
Edgar Dillard
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station, TX 77845-9547
USA
Internet: dillard@odpemail.tamu.edu
Work: (979) 458-1874
Fax: (979) 845-0876

Marine Lab Specialist: Paleomagnetics
Mads Radsted
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station, TX 77845
USA
Internet: radsted@odpemail.tamu.edu
Work: (979) 845-3602
Fax: (979) 845-0876

Marine Lab Specialist: Photographer
Leah Shannon Center
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station, TX 77845
USA
Internet: center@odpemail.tamu.edu
Work: (979) 845-2480
Fax: (979) 845-0876

Marine Lab Specialist: Underway Geophysics
Johanna M. Suhonen
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station, TX 77845-9547
USA
Internet: suhonen@odpemail.tamu.edu
Work: (979) 845-9186
Fax: (979) 845-0876

Marine Lab Specialist: X-Ray
Robert M. Wheatley
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station, TX 77845
USA
Internet: wheatley@odpemail.tamu.edu
Work: (979)
Fax: (979) 845-0876

Marine Electronics Specialist
Jan Jurie Kotze
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station, TX 77845
USA
Internet: kotzejj@netactive.co.za
Work: (979) 845-3602
Fax: (979) 845-0876

Marine Electronics Specialist
Pieter Pretorius
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive

College Station, TX 77845-9547
USA
Internet: pretorius@odpemail.tamu.edu
Work: (979) 845-3602
Fax: (979) 845-0876

Marine Computer Specialist
Margaret Hastedt
Ocean Drilling Program
Texas A&M University
1000 Discovery Dr.
College Station, TX 77845
USA
Internet: hastedt@odpemail.tamu.edu
Work: (979) 862-2315
Fax: (979) 458-1617

Marine Computer Specialist
Erik Moortgat
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station, TX 77845-9547
USA
Internet: moortgat@odpemail.tamu.edu
Work: (979) 845-7716
Fax: (979) 845-0876

ODP/TAMU Programmer
Dwight Hornbacher
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station, TX 77845-9547
USA
Internet: hornbacher@odpemail.tamu.edu
Work: (979) 845-1927
Fax: (979) 845-4857