Integrated Ocean Drilling Program
Expedition 301T Scientific Prospectus

Costa Rica Hydrogeology

Dr. Miriam Kastner
Chief Scientist
Scripps Institution of Oceanography
University of California, San Diego
Geoscience Research Division
9500 Gilman Drive
La Jolla CA 92093-0212
USA

Dr. Mitchell J. Malone
Expedition Project Manager
Integrated Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA

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PUBLISHER'S NOTES

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This IODP Scientific Prospectus is based on precruise Science Advisory Structure panel discussions and scientific input from the designated Chief Scientist on behalf of the drilling proponents. During the course of the cruise, actual site operations may indicate to the Chief Scientist and the Operations Superintendent that it would be scientifically or operationally advantageous to amend the plan detailed in this prospectus. It should be understood that any proposed changes to the science deliverables outlined in the plan presented here are contingent upon the approval of the IODP-USIO Science Services, TAMU, Deputy Director of Science Services in consultation with IODP-MI.

ABSTRACT

The Costa Rica hydrogeology operation proposes to replace CORK-II downhole instrument strings in holes drilled at Ocean Drilling Program (ODP) Leg 205 Sites 1253 and 1255 (September–November 2002) off Costa Rica. The CORKs are instrumented in a fractured horizon in the oceanic section of the incoming plate and in the décollement zone to investigate fluid flow across the margin and its implications for the seismogenic zone and subduction factory. During *Atlantis* cruise 11-8 (27 February–7 March 2004) the *Alvin* was unable to recover the downhole osmotic fluid samplers and miniaturized temperature loggers and was thus unable to deploy the new instrument strings. Apparently, soft debris in the borehole buried the latch, and the limited bottom time, lighter-weight running tools necessary for the *Alvin*, and limited capacity of the wellhead winch frustrated recovery efforts. These impediments present no significant obstacles to a drillship, as discussed below. Pressure data downloaded from the samplers at Sites 1253 and 1255 record two transient events; evaluation of temperature and fluid chemistry data from the downhole instruments at the two sites is critical to investigating strain or hydrological origins of the pressure events. The osmotic samplers currently installed were designed to collect a time series of samples for fluid and gas analyses over a 2 y period; after 2 y, samples and the information they contain are progressively lost. The temperature loggers will stop recovering data after 6 October 2004. The drillship work proposed here will be done during the transit following Integrated Ocean Drilling Program (IODP) Expedition 301 after the scheduled port call at Astoria, Oregon, en route to the Panama Canal.

SCHEDULE FOR EXPEDITION 301T

Expedition 301T is based on Integrated Ocean Drilling Program (IODP) ancillary program letter number 641 (available at **www.isas-office.jp/scheduled.html**). Following ranking by the IODP Scientific Advisory Structure, the expedition was scheduled by the IODP Operations Committee for the research vessel *JOIDES Resolution,* operating under contract with the U.S. Implementing Organization (USIO). The expedition is currently scheduled to depart Astoria, Oregon (USA), on 22 August 2004 and to end in St. John's, Newfoundland (Canada), on 22 September 2004 (for the current detailed schedule, see **iodp.tamu.edu/scienceops/**). A total of 3 days will be available for the installation of subseafloor observatories described in this report. Further details on the *JOIDES Resolution* can be found at **iodp.tamu.edu.**

INTRODUCTION

The character of the subducting plate at a convergent margin and the processes affecting it as it passes below the shallow forearc may be a major determining factor in the nature and extent of hazardous interplate seismicity, magnitude of volcanism, and chemistry of lavas produced in the overlying volcanic arc. Subducting sediments and ocean crust along with their associated volatile components passing through shallow subduction zones (0–50 km) profoundly affect the behavior of the seismogenic zone, which produces most of the world's destructive earthquakes and tsunamis. Fluid pressure and sediment porosity influence fault localization, deformation style, and strength and may control the updip limit of the seismogenic zone (e.g., Scholz, 1998; Moore and Saffer, 2001). Fluids contained within both fault zones and underthrust sediments at the trench affect early structural development and serve as a key agent in transport of chemical species. The mineralogy and chemistry of subducted sediments and the dehydration reactions during the subduction process may control the physical properties of the deeper subduction interface and, hence, downdip limits of the seismogenic zone.

Escape of fluids to the surface from depth (return flow) supports a deep biosphere, contributes methane for gas hydrate formation, affects seawater chemistry for selected elements, and is intimately linked to deformation, faulting, and evolution of the décollement. Distillation and partial loss of volatiles and fluid-soluble elements from the shallow slab not only record reactions and processes within the seismogenic zone but also play a central role in supplying residual volatiles to the deeper Earth and changing the composition of the slab delivered to magmatism depths beneath volcanic arcs. Processes operating in the shallow subduction zone thus affect the way the slab contributes to continent-building magmatism, explosive volcanism, ore formation, and, ultimately, evolution of the mantle through time (collectively known as the "subduction factory" in many geoscience documents). The subduction signature recorded in the chemistry of arc volcanics constrains the nature and sometimes the volume of the sediments transported through the seismogenic zone to the depths of magmatism. The arc thus acts as a flow monitor for the transport of sediments to depths greater than those that can be drilled or seismically imaged.

The Ocean Drilling Program (ODP) has identified deformation at convergent margins, fluid flow in the lithosphere, and subduction zone geochemical fluxes as important aspects of the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES) Long Range Plan (1996). The Initial Science Plan for the Integrated Ocean

Drilling Program (IODP) includes an initiative focused on the seismogenic zone. The Central American convergent margin (Fig. **F1**) is a focus area for a number of national and international programs studying the seismogenic zone and subduction factory for several reasons:

- It is one of the few modern subduction zones that is subducting a significant carbonate section and thus provides an opportunity to investigate CO_2 cycling through convergent margins.
- Along strike from Nicaragua to Costa Rica, the style and extent of seismicity and plate coupling changes.
- Along the same section, the style of arc volcanism changes, as do volumes and chemistry of arc lavas.

It has been hypothesized that changes in both seismicity and volcanic chemistry result from changes in the balance between sediment underplating, erosion, and subduction (collectively referred to here as "sediment dynamics"), perhaps related to changing bathymetry, thermal structure, and hydrological behavior along the margin.

BACKGROUND

Geological Setting

A description of the geological setting of the Costa Rica margin sites can be found in the "Leg 205 Summary" chapter (Shipboard Scientific Party, 2003) of the Leg 205 *Initial Reports* volume (Morris, Villinger, Klaus, et al., 2003).

Seismic Studies/Site Survey Data

Because the Costa Rica hydrogeology ancillary program will reoccupy previously drilled sites, no additional site survey data are required.

SCIENTIFIC OBJECTIVES

During ODP Leg 205, Cork-II observatories were installed at two sites across the Middle America Trench off the Nicoya Peninsula, Costa Rica (Fig. **F1**), drilled previously during Leg 170 (Kimura, Silver, Blum, et al., 1997; Morris, Villinger, Klaus, et al., 2003). The observatories are designed to monitor pressure and temperature changes through time in a horizon of subseafloor fluid flow and to collect a time series of fluid and gas samples for subsequent chemical analysis (Jannasch et al., 2003). One observatory was installed at Site 1253 on the incoming oceanic plate with instruments located within the fractured igneous section at 494–504 and 512–520 meters below seafloor (mbsf). Another CORK-II was installed at Site 1255, 0.4 km inboard of the deformation front, to monitor and sample the region of maximum fluid advection within the décollement at 136–144 mbsf. Downhole instrumentation in the décollement includes a flow meter, such that dilution of tracers injected at a constant rate translates to fluid flux and the four sampling ports may allow identification of anisotropy in fluid flow.

The science goals of the present operation remain those of ODP Leg 205—to investigate active fluid flow across the Costa Rica margin and its implications for the seismogenic zone and subduction factory. One specific opportunity this operation affords is combination of pressure data recovered during the *Atlantis* cruise with downhole temperature variations through time and the time series chemical data to investigate the transient pressure events recorded at Site 1253 and the overpressured décollement at Site 1255.

Incoming Plate

There is strong evidence for vigorous shallow flow of cool fluids, which may affect the updip limit of seismicity, in the oceanic section of the subducting plate at Sites 1039 and 1253. East Pacific Rise (EPR)-generated oceanic crust (~24 Ma) at the drill sites is part of a large regional low heat flow anomaly; at the Leg 170 and 205 sites, heat flow is ~15% of that expected for the plate age, implying significant advection of cool fluids (Langseth and Silver, 1996). Heat flow data collected during recent cruises show that seamounts are sites of fluid discharge and recharge (Fisher et al., 2003), and modeling suggests that lateral flow rates of 3–30 m/y in zones within the upper 600 m of high-permeability (10^{-10} to 10^{-8} m^2) basement are required to match the low heat flow on EPR-generated crust (Hutnak et al., submitted, 2003). Chemical data also suggest vigorous and recent/contemporaneous fluid flow. For example, Sr isotopic compositions measured in pore fluids squeezed from sediments show a strong mixing trend toward modern seawater ratios in the basal sediments. These basal sediment values are distinct from those appropriate for seawater contemporaneous with the sediment age or for pore fluid compositions modified by ash weathering, as seen higher in the sediment column (Silver et al., 2000). Simple modeling suggests that unless supported, the gradients, also observed for Li, Ca, and SO_4, would normalize by diffusion in ~15 k.y. Just south of the drill sites, plate reorganizations juxtapose cool EPR crust and ~22 Ma crust generated at the Cocos-Nazca spreading (CNS) center (Barckhausen et al., 2001), which is characterized by heat flow consistent with conductive lithospheric cooling models. This juxtaposition apparently corresponds to a significant change in the updip limit of the seismogenic zone. At 75 km from the trench, where cool EPR crust is subducting, this zone is at ~20 km depth; at ~60 km from the trench, where warmer CNS crust is subducting, this zone is at ~10 km depth (Newman et al., 2002). At Site 1253, the interval below 473 mbsf is packed off and two OsmoSamplers with temperature loggers are centered within fractured intervals at 500 and 516 mbsf, respectively.

Prism Site

Fluids from the décollement zone can be analyzed for a variety of chemical tracers to identify fluid sources, map fluid and element transport, constrain fluid fluxes, and possibly help constrain mineralogy at the updip limit of the seismogenic zone. At the décollement sites (1040, 1043, 1254, and 1255), pore fluid analyses across the plate boundary show strong, narrow (less than the full depth of the décollement zone) anomalous abundances of thermogenic hydrocarbons through C_{10} and other tracers (e.g., Ca, K, and Li). Taken together, the compositional anomalies indicate vigorous advection within the décollement transporting species generated at temperatures >150°C (i.e., at or near temperatures thought to exist at the updip limit of the seismogenic zone). The persistence of local compositional anomalies suggests transient flow. The OsmoSampler and OsmoFlowmeter are located within the décollement at Site 1255. Tracers such as K/Li ratios and B and Cl isotopes in the fluids may constrain the extent of smectite-illite reaction in the fluid source region; adding O and Sr isotope ratios should further constrain bulk composition and temperature of the fluid source region. Tracers of interest to geochemists investigating element recycling in volcanic arcs via subduction (e.g., U, Pb, Rb, Sr, Ba, Cs, As, B, and Li) will also be analyzed in the sampled fluids. Pumping at a constant rate, the OsmoFlowmeters inject density-compensated iodate-tagged artificial seawater, Cs, and Rb into the borehole below the OsmoSampler. Four sampling ports on a plane with the injection port collect and archive a time series of tagged fluids for subsequent recovery and analyses. Dilution of these tracers will constrain fluxes and, possibly, anisotropy (although not directionality in a geographic sense) of fluid flow. Flux rates of elements from the subducting plate carried in fluids advected from the deeper source will be useful for investigating methane fluxes and the impact of shallow slab dewatering on ocean chemistry and composition of the residual subducted slab at greater depths (ultimately to depths of magma generation).

Pressure Data from the *Atlantis* Cruise

Dive operations during the *Atlantis* cruise included downloading data from the multilevel CORKs at Sites 1253 (sampling/monitoring screens at two levels in uppermost igneous basement) and 1255 (screens at the décollement and in the overthrust section). Pressure variations are dominated by tides at the seafloor, response to seafloor tidal loading in the formation, and overpressures at Site 1255. Complete hydrologic sealing took several weeks; the most significant leakage in the first few weeks of monitoring is inferred to have been associated with the high-pressure polypack glands that seal the CORK liner and main casing. Once the seals seated, signals ranging in period from weeks to minutes are observed from barometric, oceanographic, and tectonic sources. Several observations, summarized in the records shown in Figure F2, are of particular interest from a hydrologic and geochemical perspective.

At Site 1253, basement is underpressured relative to the local geotherm hydrostat by ~7 kPa (Fig. F2A), from which it can be inferred that the basement is highly permeable and provides a close-to-hydrostatic drainage path to the ocean for the seaward part of the underthrust sediment section. The degree to which fluids squeezed from the subduction zone sediment complex influence basement fluid composition remains unknown, but it is clear that upper permeable basement provides a link to deep-sourced fluids. Thus, obtaining basement fluid samples is an important priority. Because of the subhydrostatic basement state, this fluid sampling can be done only with an in situ sampler sealed in the hole.

At Site 1255, fluid pressures in the décollement and the overlying overthrust sediments are superhydrostatic, varying with time (Fig. F2B). Maximum pressures are a significant fraction of lithostatic and decline steadily over the first few months of recording. Several events of tectonic (elastic) or hydrologic (diffusional) origin are observed at both screens. One of these (labeled “first event”) is seen at the upper screen roughly 2 days before the décollement screen. This precludes the possibility that the event is associated with motion of the packer and indicates a hydrologic source. Observations of fluid-compositional variations will be critical for determining the cause of such events and the slow pressure decline.

OPERATIONS STRATEGY

Following is a summary of Leg 205 operations at the two sites to be reoccupied during the Costa Rica hydrogeology project (Table **T1**). More complete information regarding these sites can be found in the site chapters in the Leg 205 *Initial Reports* volume (Morris, Villinger, Klaus, et al., 2003).

Site 1253

Site 1253 is located ~200 m seaward of the deformation front in the deepest part of the Middle America Trench (Figs. **F3, F4**) Operationally, the primary goal for this site was to recore the sediments immediately above the sill encountered during Leg 170, drill and core for the first time through the sediments below the sill, and core >100 m into the oceanic sections. The other major task was to install a CORK-II observatory in the deep igneous section; coring and logging information was used to identify depths to set the packer and osmotic fluid and gas samplers.

One hole was drilled at Site 1253, which was partially cored and into which we installed a long-term hydrologic borehole observatory. After setting a reentry cone and 16 1/2 inch casing into the seafloor, the hole was reentered with the rotary core barrel (RCB) and drilled without coring to ~370 mbsf. RCB coring below 370 mbsf penetrated 30 m of calcareous and locally clay rich sediments with intermittent ash layers (average recovery = 75%) before encountering a gabbro sill between 400 and 431 mbsf (average recovery = 74%). Below the sill was ~30 m of partially lithified calcareous sediments with intermittent ash layers (average recovery = 20%). This interval was followed by coring ~140 m into a second igneous unit (average recovery = 75%) with local zones of 55%–50% recovery.

After coring, operations focused on preparing the hole for downhole logging and CORK-II installation. The hole was opened to 14 3/4 inches; 10 3/4 inch casing was installed to ~413 mbsf and cemented in place to inhibit communication between the borehole and the formation. After drilling out the cement shoe and drilling a rat hole with an RCB bit, the hole was logged.

After logging, the CORK-II components were assembled, including a 4 1/2 inch casing screen, casing packer, and casing made up to the instrument hanger. The entire assembly was lowered into the hole and latched in to seal the borehole outside of the 4 1/2 inch casing. The OsmoSampler with integral temperature sensors was lowered through the center of, and latched into the bottom of, the 4 1/2 inch casing. The final operation was to inflate the packers and shift spool valves connecting the CORK-II pressure monitoring system to the formation, completely sealing the zone to be monitored. Problems with the go-devil used for this step made it difficult to determine whether the packer had inflated or the valves had turned for pressure monitoring. *Alvin* dives since then have confirmed that the installation is fully operational. Three absolute pressure gauges including a data logger are installed in the instrument hanger head. One sensor monitors pressure within the sealed-off fluid sampling zone at the bottom of the hole, one monitors pressure variations in the borehole above the sealed-off section, and the third sensor provides seafloor reference pressures. One additional sampling line extends from the CORK-II head down to the screened interval below the packer and is available for future pressure/fluid sampling purposes. The specifics of the CORK-II installation, relative to the structure and petrology of the igneous sections, are discussed in more detail below.

Details of the CORK-II installation in Hole 1253A are shown in Figure **F5,** and petrological and structural characteristics of key depths are shown in Figures **F6** and **F7.** The center of the packer was set at ~473 mbsf, with the inflatable element between 471.5 and 475.5 mbsf. Cores show this to be a high-recovery interval of massive rock with relatively few fractures. The upper OsmoSampler, inside a 7.35 m long screen, is set between 497 and 504 mbsf. A fluid sampling line runs from a 2 m pressure screen within the casing screen to the CORK-II wellhead. The lower sampler dangles in the open hole between 512.1 and 519.5 mbsf. The placement of the osmotic samplers was determined using a combination of scientific and operational constraints. Originally, the intervals 513–521 (now OsmoSampler 2) and 560–568 mbsf were targeted. However, logging tools encountered a bridge at 530 mbsf, restricting OsmoSampler deployment to shallower levels. The upper pressure screen above the packer was set between two igneous subunits, where sediments collapsing around the screen should make an effective seal. The final installation configuration for this modified CORK-II geochemical and hydrologic borehole observatory is shown in Figure **F5.**

Site 1255

Site 1255 is located ~0.4 km arcward of the deformation front in a water depth of 4311.6 m and close to the Site 1043 holes drilled during Leg 170 (Kimura, Silver, Blum, et al., 1997). Hole 1255A is ~20 m east of Hole 1043A and ~30 m northwest of Hole 1043B (Figs. **F3, F8, F9**). In Hole 1043A the complete section was cored to 282 mbsf in the underthrust sequence (Unit U3), whereas Hole 1043B was logged using logging while drilling (LWD) to 482 mbsf, the top of igneous basement. Both holes penetrated the décollement, and their results were used to plan drilling strategy and installation of the CORK-II observatory.

After setting the reentry cone in Hole 1255A, the hole was deepened to 123 mbsf with a 14 3/4 inch bit, followed by installation of 10 3/4 inch casing to 117 mbsf and cemented it in. Coring started at 123 mbsf, after drilling out the cement shoe, and stopped at 157 mbsf, when a sudden increase in penetration rate during cutting of the fourth core indicated that the underthrust sediments had been reached. Installation of the CORK-II was successful and was completed with deployment of the remotely operated vehicle (ROV) platform. The observatory configuration is shown in Figure **F10.** The center of the packer is at 129 mbsf and the center of the screen at 140 mbsf, in the middle of the geochemical anomaly determined from data from Sites 1255 and 1043. A second pressure port inside a small screen was installed just above the upper packer. A postcruise *Alvin* dive showed the installation to be fully operational, and pressure data showed a return to hydrostatic conditions within the borehole.

Alvin Operations and *JOIDES Resolution* Work Plan

Eight *Alvin* dives were planned for recovering and replacing the OsmoSamplers and temperature loggers at Sites 1253 and 1255. The intent was to place a winch on top of the wellhead, latch on to the instrument string with the running tool, and use the winch to break the seal and pull the OsmoSamplers to the wellhead, where they could be floated to the surface. Replacement samplers dropped by elevator would then be guided hand-over-hand into the 4.5 inch casing and allowed to free fall to seat. The *Alvin* and *Atlantis* crews performed superbly, but we encountered several problems. During dive 1 we installed the winch. During dive 2 we were unable to latch the running tool into the sampler despite repeated attempts; slack and additional play in the winch line suggested soft debris, possibly rust brushed from the 4.5 inch casing by passage of the tool and line atop the samplers, occluding the latch. The running tool was recovered and additional jars added in an attempt to penetrate the debris with a heavier tool. Eventually, after overcoming several other problems, the running tool latched into the OsmoSampler package, as determined from pull on the winching motor. A design incompatibility between the winch and optimal *Alvin* operations resulted in the OsmoSamplers being dropped back into the hole after being winched up 70–100 m. During penultimate dive 7, we made a brief attempt to retrieve the OsmoSamplers, but time limitations made them impossible to recover, given the need to secure the sites and recover materials on bottom.

Ultimately, pressure data were downloaded at both sites; Site 1255 was left in its original condition, and Site 1253 was left with the OsmoSamplers seated at depth, the tools and ~550 m of Spectra line attached, and a ring and float attached ~20 m above the wellhead. The impact of the engineering and borehole complications were, of course, exacerbated by *Alvin's* limited bottom time in deep water and power. Although these factors were recognized before scheduling ship time, *Jason* was fully booked through and beyond the 2 y window of the OsmoSampler and temperature logger configuration. Lessons learned from this *Atlantis* cruise benefited final engineering design and fabrication for IODP Expedition 301.

Sites 1253 and 1255 were left ready for OsmoSampler recovery and replacement by the *JOIDES Resolution* or ROV. The drillship provides heavier wireline tools and therefore more jarring action to penetrate the soft debris and latch in. Our experience suggests that it should be simple to latch in, but bailing soft debris from the hole is a possibility if necessary. Using the *JOIDES Resolution* to recover and replace the OsmoSamplers allows us to install lines to the seafloor that will make future ROV/submersible recoveries feasible without the submersible winch system, which has been problematic as presently configured. Continuous operations allow for time-efficient recovery and reinstallation.

The operations time estimate for OsmoSampler recovery and replacement is listed in Table **T1.** All operations are relatively straightforward and have been performed using the *JOIDES Resolution* in the past. The time estimate for operations at the Leg 205 sites is ~3 days (see Table **T1**). Costa Rica Sites 1253 and 1255 are conveniently located relative to the drillship transit following IODP Expedition 301, after the Astoria, Oregon, port call en route to the Panama Canal.

In addition to replacing the OsmoSamplers at Sites 1253 and 1255, we anticipate deploying a long-term current meter to record near-bottom currents close to the sites, subject to approval by Costa Rican authorities. The motivation for the experiment derives from a long-term record of bottom water temperature obtained from the first phase of borehole hydrologic monitoring, which reveals coherent variability between the two instrumented sites (ODP Sites 1253 and 1255) that is characterized by slow increases in temperature followed by abrupt decreases. Strong currents aligned with the trench axis are suspected. Bottom water temperature monitoring, along with seafloor fluid sampling, will continue throughout the current meter deployment period. Together, these data should provide new insights into deep-ocean water transport along continental margins. The current meter, which consists of a Nortek "Aquadopp" acoustic doppler sensor, two acoustic release units, a float, and a railway wheel weight, will be deployed near Site 1253. At the time of this prospectus, the approval request is pending.

SAMPLING STRATEGY

The Sample Allocation Committee (SAC; composed of co-chief scientists, staff scientist, and IODP curator on shore and curatorial representative on board ship) will work with the scientific party to formulate a formal expedition-specific sampling plan for shipboard and postcruise sampling.

Shipboard scientists are expected to submit sample requests before the beginning of the expedition. Based on sample requests (shore based and shipboard) submitted by this deadline, the SAC will prepare a tentative sampling plan, which will be revised on the ship as dictated by recovery and cruise objectives. The sampling plan will be subject to modification depending upon the actual material recovered and collaborations that may evolve between scientists during the expedition. Modification of the strategy during the expedition must be approved by the chief scientist and staff scientist on board ship.

Because the samples recovered from the **O**smo**S**amplers will consist of fluids and will be totally consumed by subsequent analysis, there will be no samples to archive from this expedition.

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Table T1. Costa Rica hydrogeology operations plan and time estimate.

Time (h)	Operations description
1.00	Drop beacon midway between Site 1253 and Site 1255.
1.00	Take up station over Site 1255 CORK-II.
8.00	Run in hole with BHA.
0.25	Run in hole with VIT.
0.50	Space out for BHA latch onto Site 1255 wellhead, load wireline into drill string.
1.00	Latch BHA onto Site 1255 wellhead.
0.50	Run in hole with wireline.
0.50	Jar/latch Site 1255 OsmoSampler.
0.75	Pull out of hole with wireline, unlatch BHA from Site 1255 wellhead.
0.50	Lay out Site 1255 OsmoSampler.
0.50	Load Site 1255 replacement OsmoSampler into drill string.
0.75	Run in hole with Site 1255 replacement OsmoSampler, latch BHA onto wellhead.
0.50	Latch Site 1255 OsmoSampler in place, release running tool.
0.75	Pull out of hole with wireline, unlatch BHA from wellhead, lay out wireline sinker bar.
0.25	Pull out of hole with VIT.
7.00	Pull out of hole with BHA (while making dynamic positioning move).
1.00	Dynamic positioning move from Site 1255 to Site 1253, take up station over Site 1253 CORK-II.
8.00	Run in hole with BHA fishing tool.
0.25	Run in hole with VIT.
2.00	Fish for Site 1253 OsmoSampler rope.
8.00	Pull out of hole with BHA fishing tool and Site 1253 OsmoSampler.
0.25	Pull out of hole with VIT.
2.00	Lay out Site 1253 OsmoSampler.
8.00	Run in hole with BHA.
0.25	Run in hole with VIT.
0.75	Space out for Site 1253 wellhead latch on, load replacement OsmoSampler into drill string.
0.50	Latch BHA onto Site 1253 wellhead.
0.25	Run in hole with Site 1253 OsmoSampler.
0.50	Jar/latch Site 1253 OsmoSampler into place.
0.75	Pull out of hole with wireline, unlatch BHA from Site 1253 wellhead.
8.00	Pull out of hole with BHA.
0.25	Pull out of hole with VIT.
0.00	Recover beacon (while pulling out of hole with BHA).
64.50	Total time (h)
2.69	Total time (days)

Note: BHA = bottom-hole assembly, VIT = vibration-isolated television.

Figure F1. Location of Leg 205 sites offshore Nicoya Peninsula, Costa Rica (Morris, Villinger, Klaus, et al., 2003). Plate boundaries and ages from Barckhausen et al., 2001. Juxtaposition of East Pacific Rise crust and Cocos-Nazca Spreading (CNS) center crust, just south of drill sites, approximately corresponds to the depth offset in the seismogenic zone updip limit. Subaerial triangles indicate volcano locations.

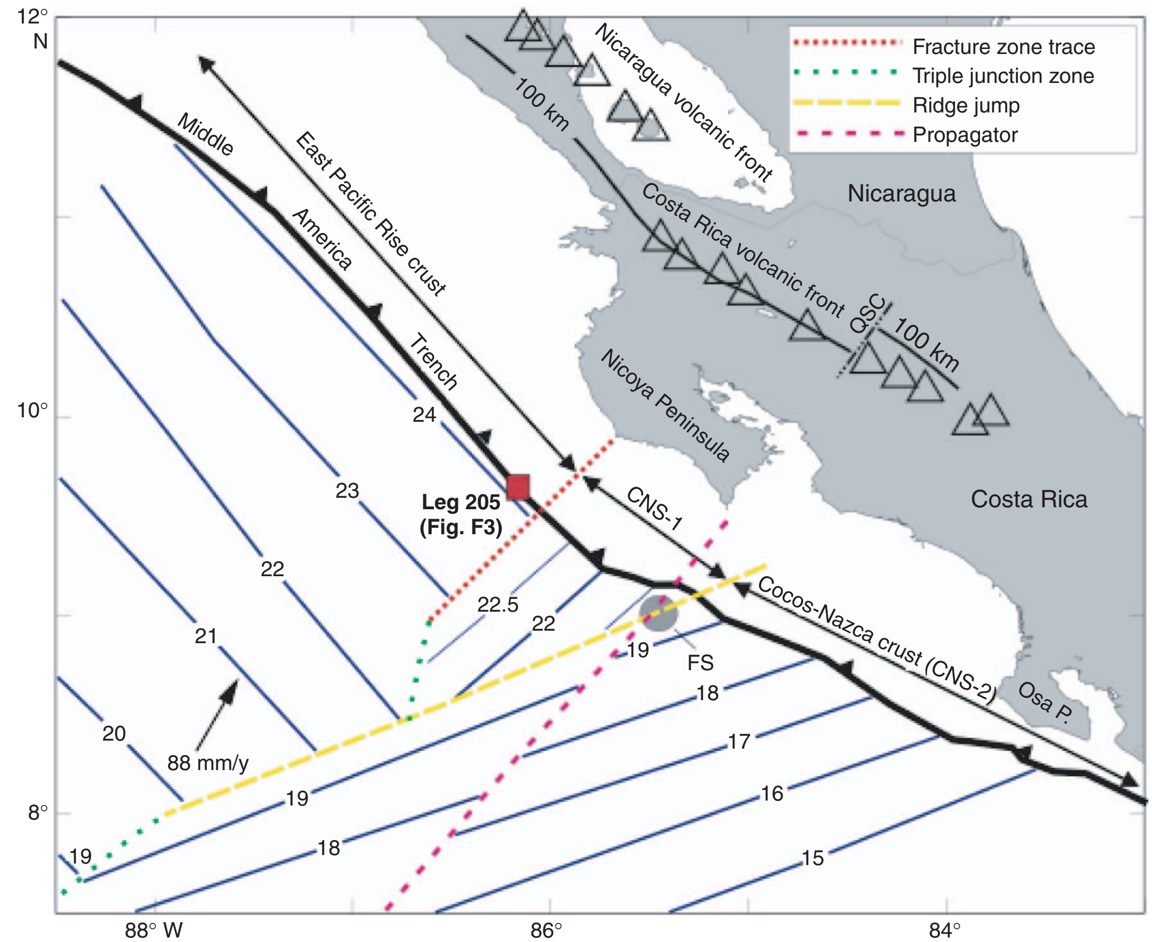


Figure F2. **A.** Pressure vs. time, Site 1253. **B.** Pressure vs. time, Site 1255. Note difference in pressure scales.

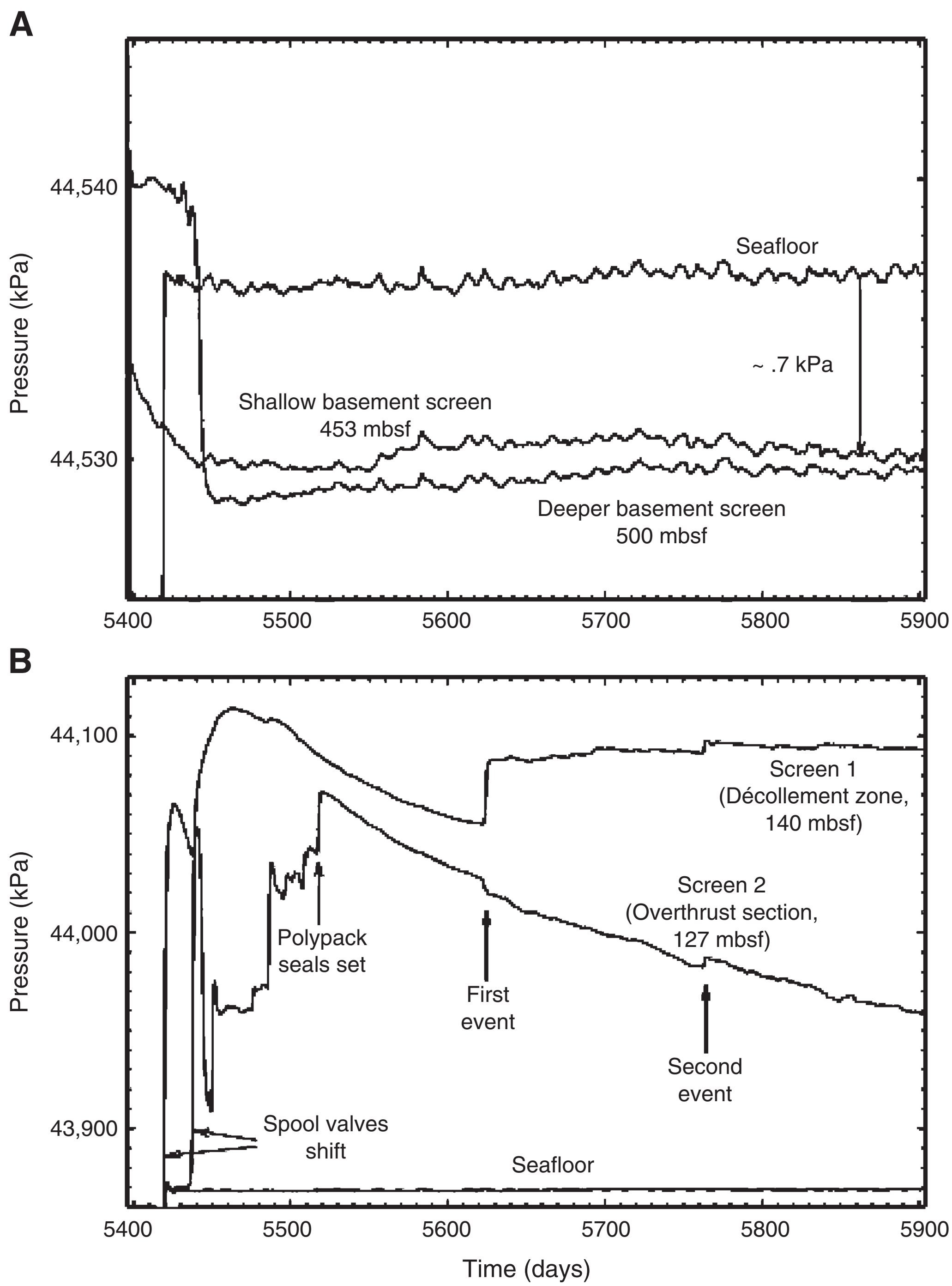


Figure F3. Bathymetric map of the Leg 205 drilling area: yellow dots = Leg 205 sites, white dots = Leg 170 sites. Seismic profiles: red = BGR 99-44 (C. Reichert and C. Ranero, pers. comm., 2001), yellow = CR-20 (Shipley et al., 1992). Leg 170 drill sites were based on seismic profile CR-20. Numbers along Line BGR 99-44 are shotpoints. White arrow = convergence direction (N30°E) and rate (88 mm/y) (DeMets et al., 1990). Bathymetric contours are in meters. (Integration of compilation by Ranero and von Huene [2000] and Simrad data from E. Flueh [pers. comm., 2000]).

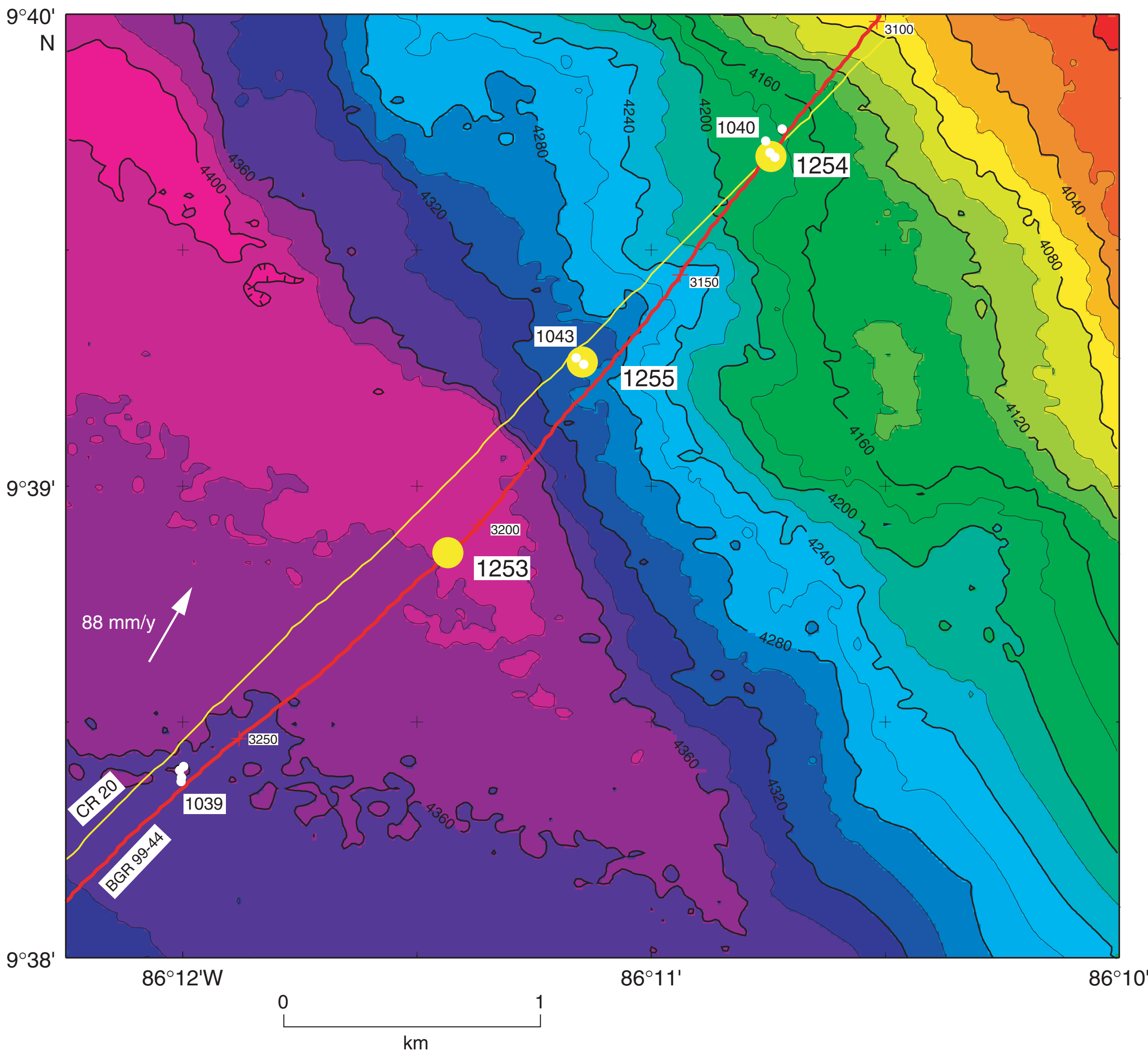


Figure F4. Portion of multichannel seismic profile BGR 99-44 across Sites 1253 and 1039. Vertical exaggeration = ~1.6.

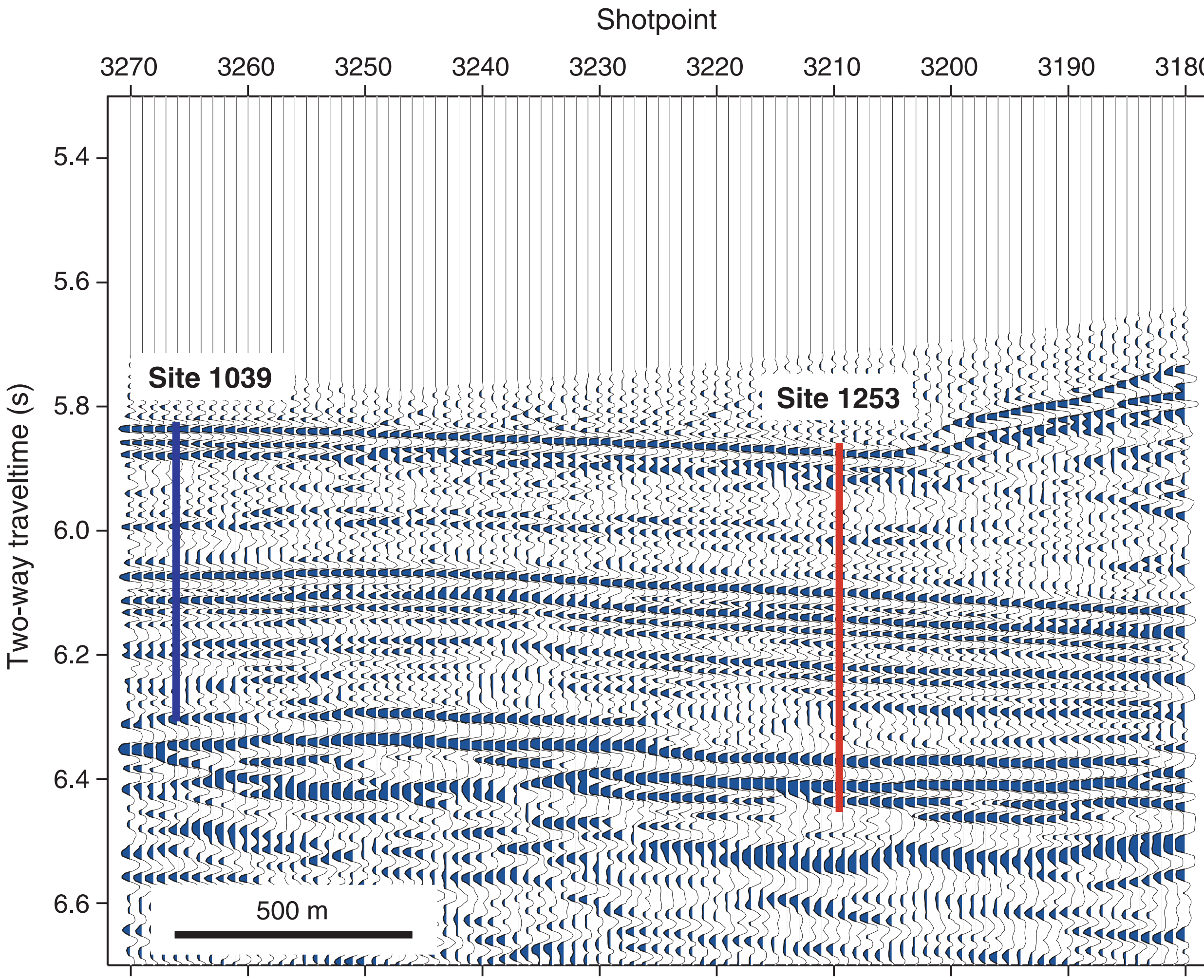


Figure F5. Hole 1253A borehole installation showing subseafloor depths for OsmoSamplers, screens, packers, and casing strings. This figure is not to scale.

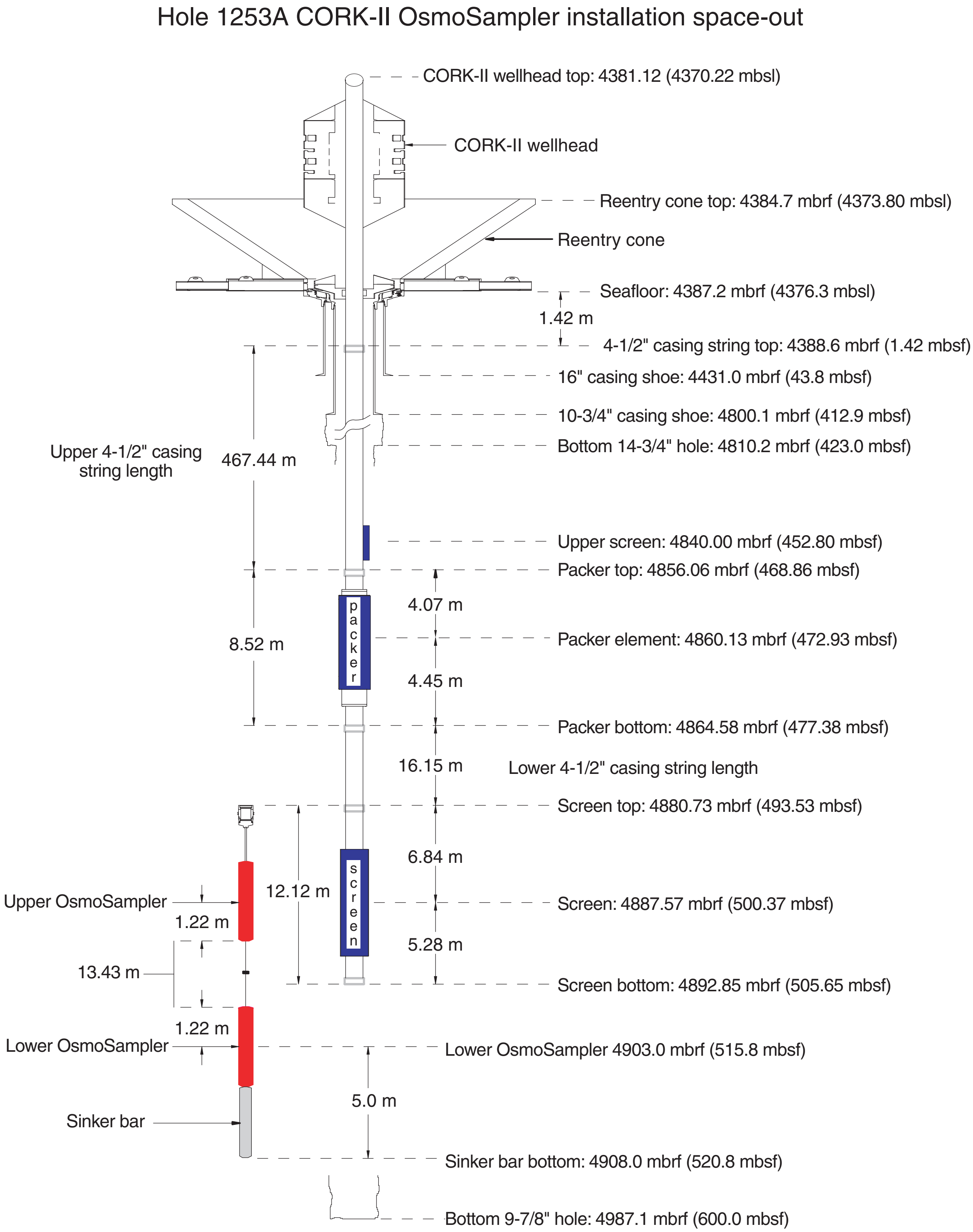


Figure F6. Composite diagram from Hole 1253A showing selected logging data annotated with physical property measurements on the cores, petrologic observations, and paleomagnetic and rock magnetic results. Correlations between core and logging intervals are shown as solid lines to indicate major boundaries or as dashed lines to indicate subunit boundaries identified petrologically. Also indicated are the positions of the two OsmoSamplers (OS #1 and OS #2).

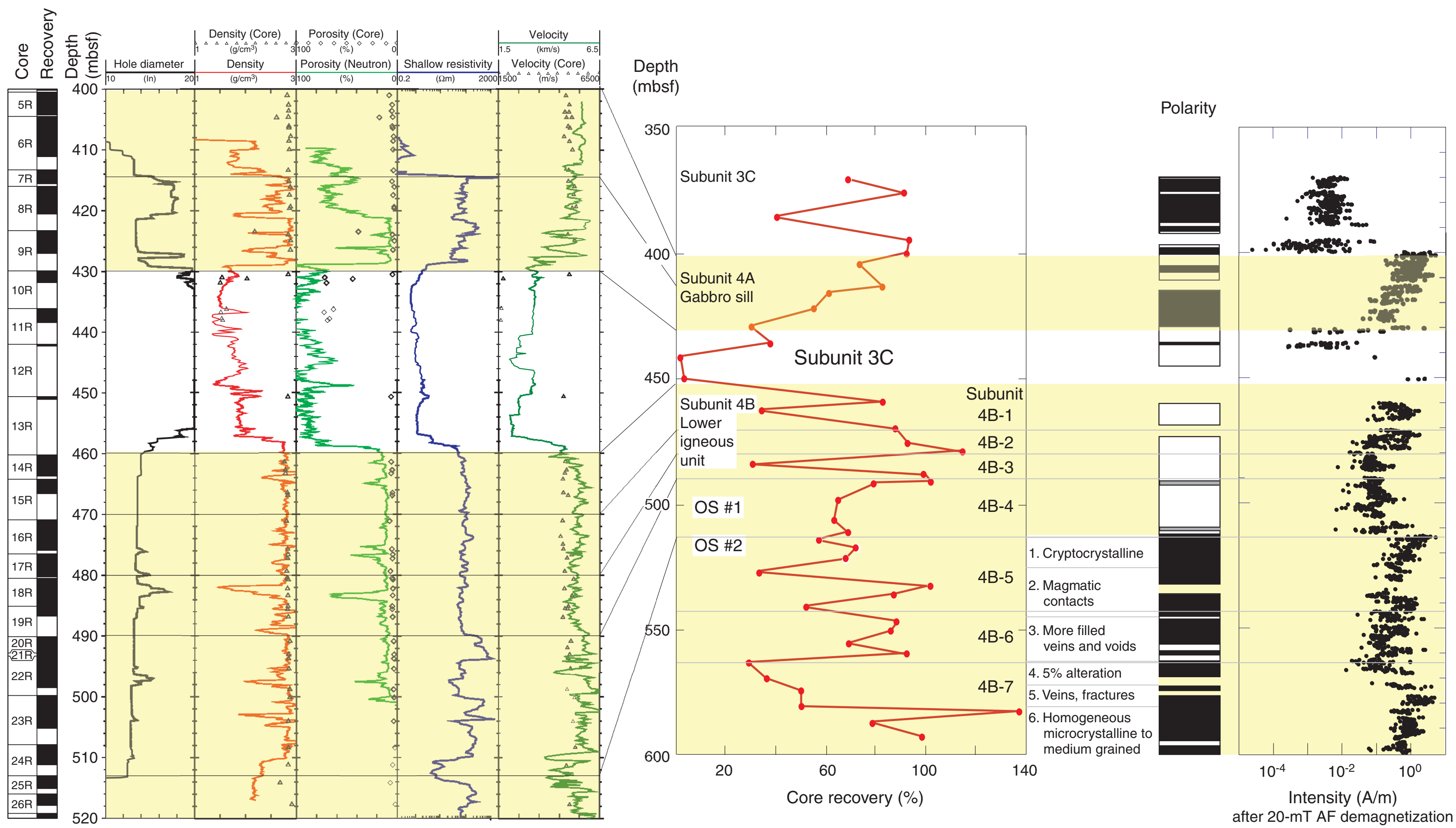


Figure F7. Composite diagram from Hole 1253A showing fracture distribution within the igneous units, a summary of petrologic observations, and detailed Formation MicroScanner images for the depths at which the OsmoSamplers (OS #1 and OS #2) were installed.

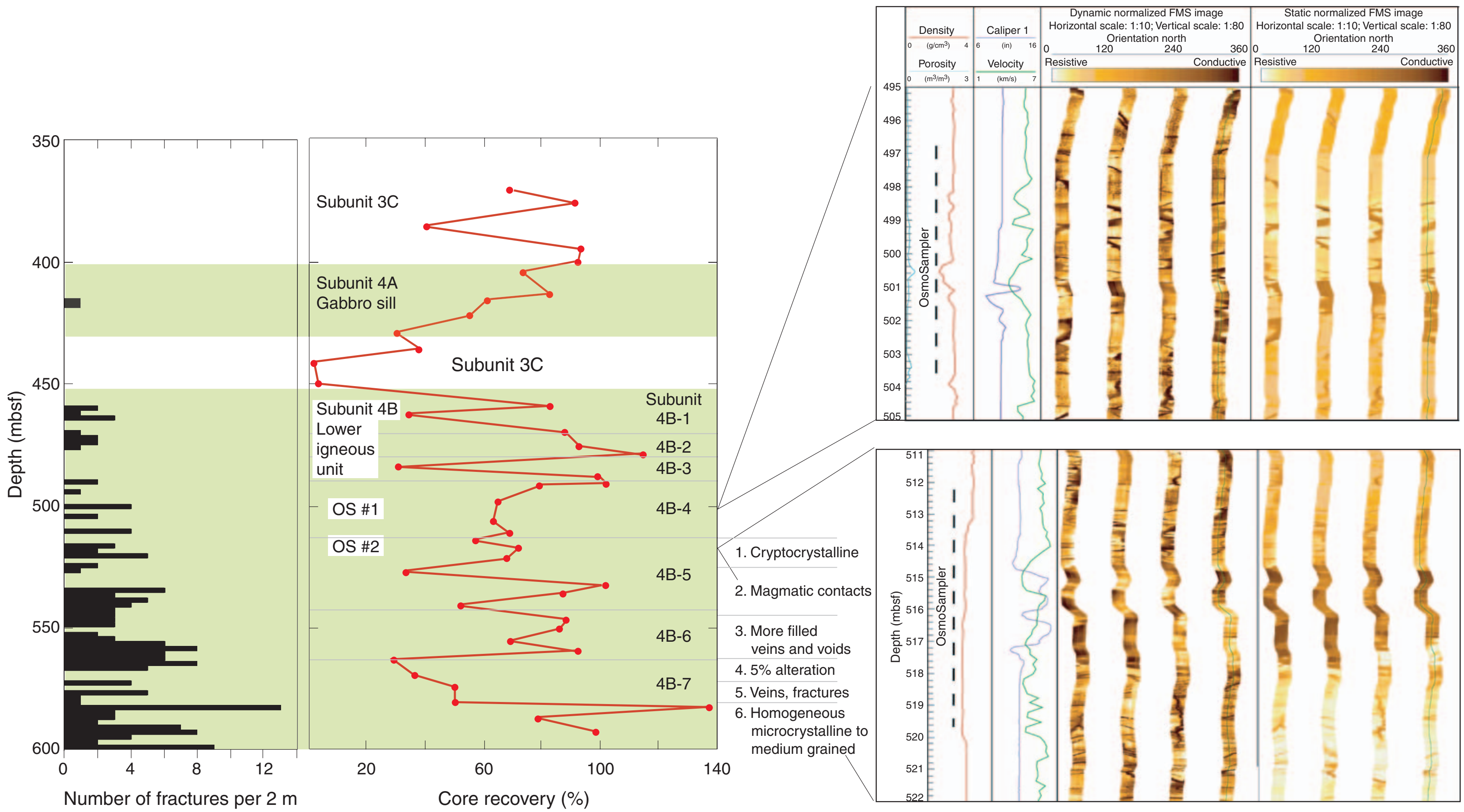


Figure F8. Location of Site 1255. Red circle = Leg 205 site, black circles = Leg 170 sites. (Integration of compilation by Ranero and von Huene [2000] and Simrad data from E. Flueh [pers. comm., 2000]).

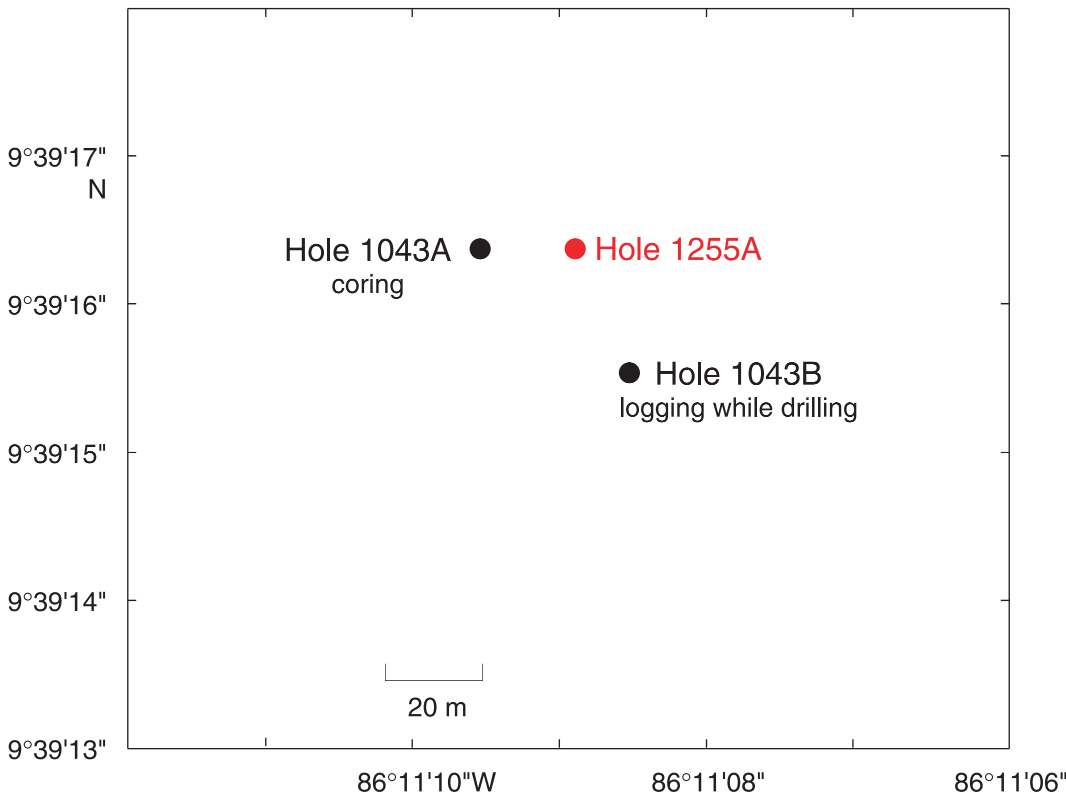


Figure F9. Portion of multichannel seismic profile BGR 99-44 across Sites 1255 and 1043. Vertical exaggeration = 1.7. CMP = common midpoint.

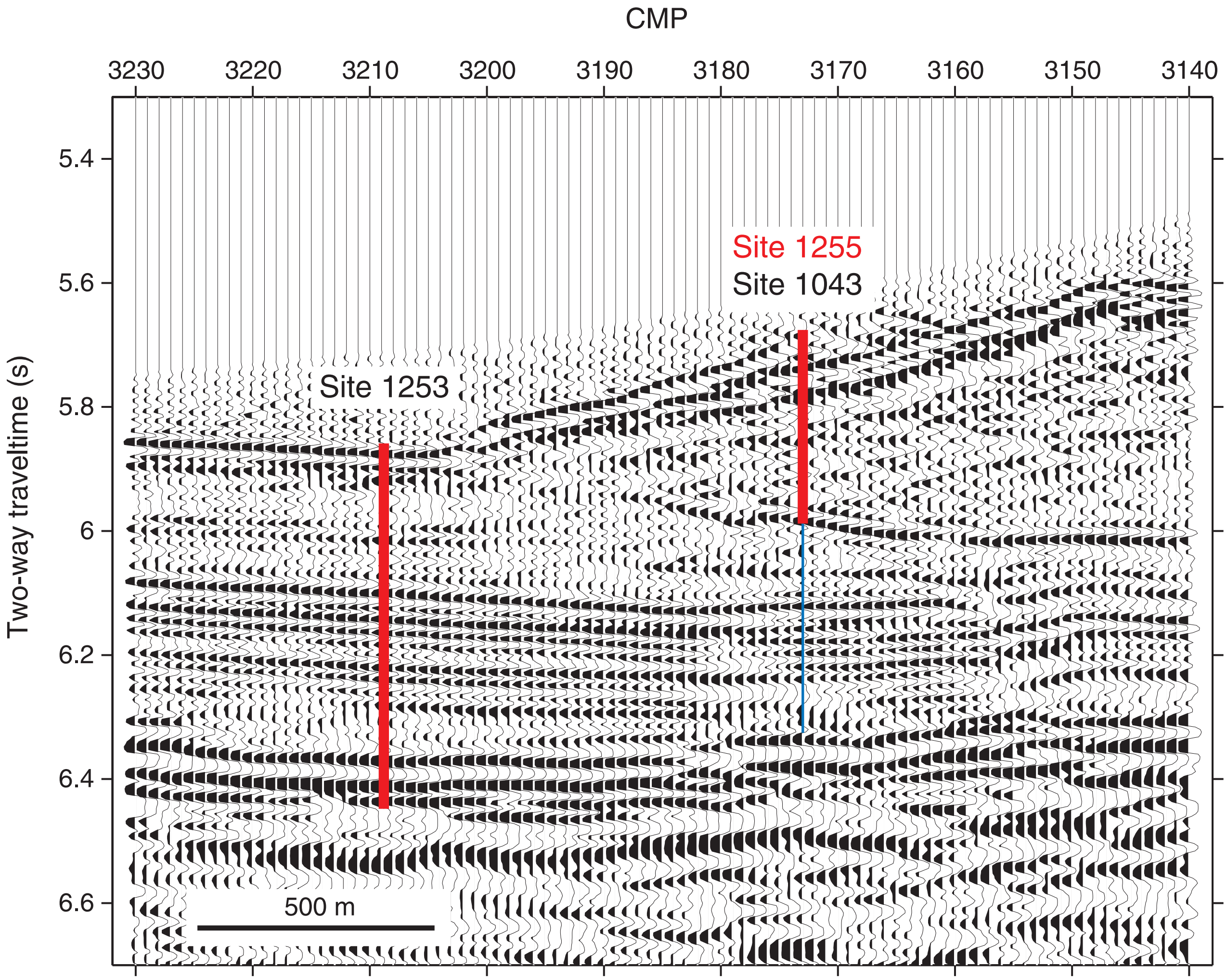
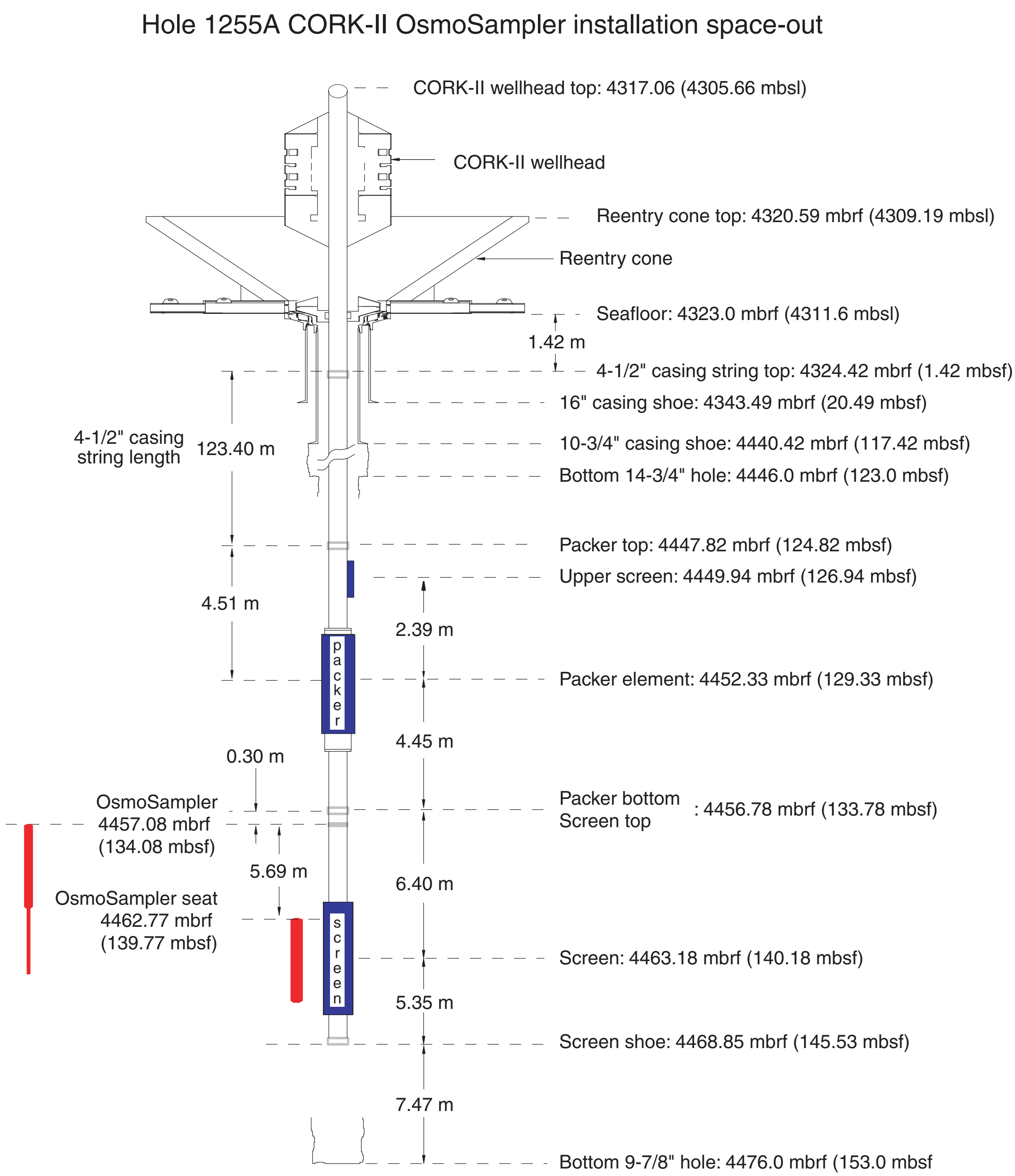


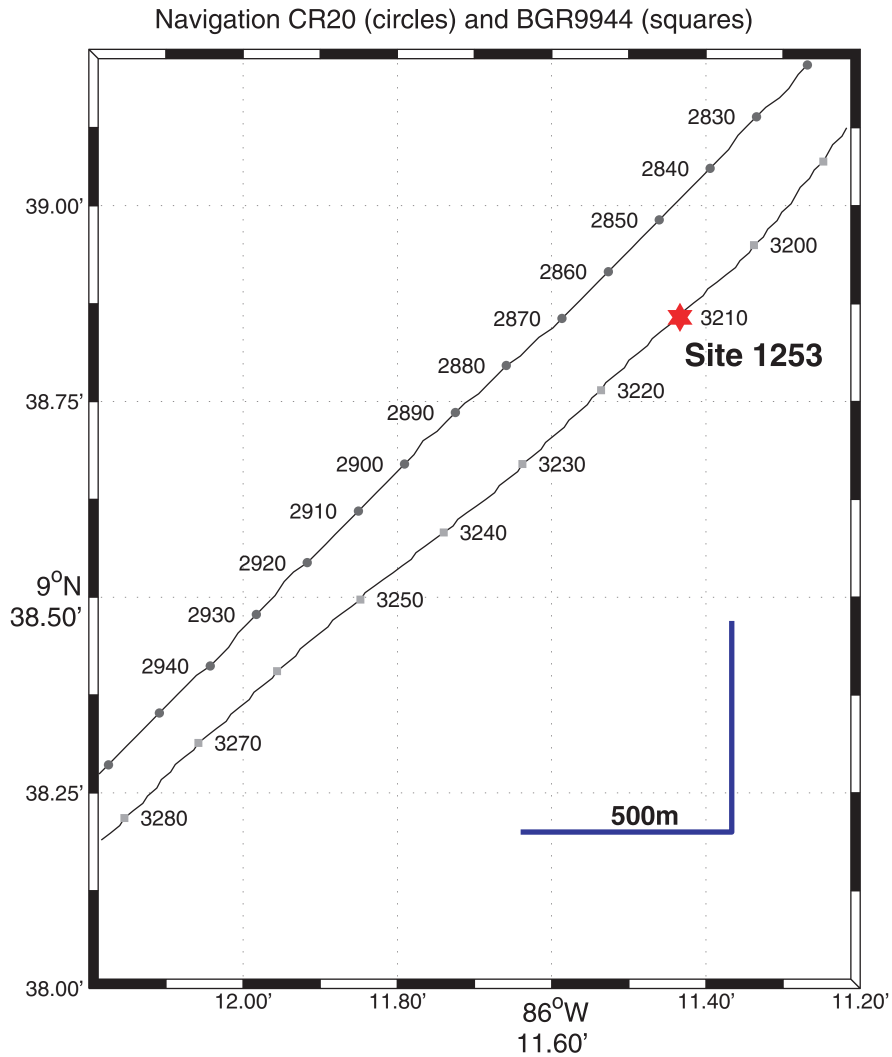
Figure F10. Hole 1255A borehole installation showing subseafloor depths for OsmoSamplers, screens, packers, and casing strings. This figure is not to scale.



SITE SUMMARIES

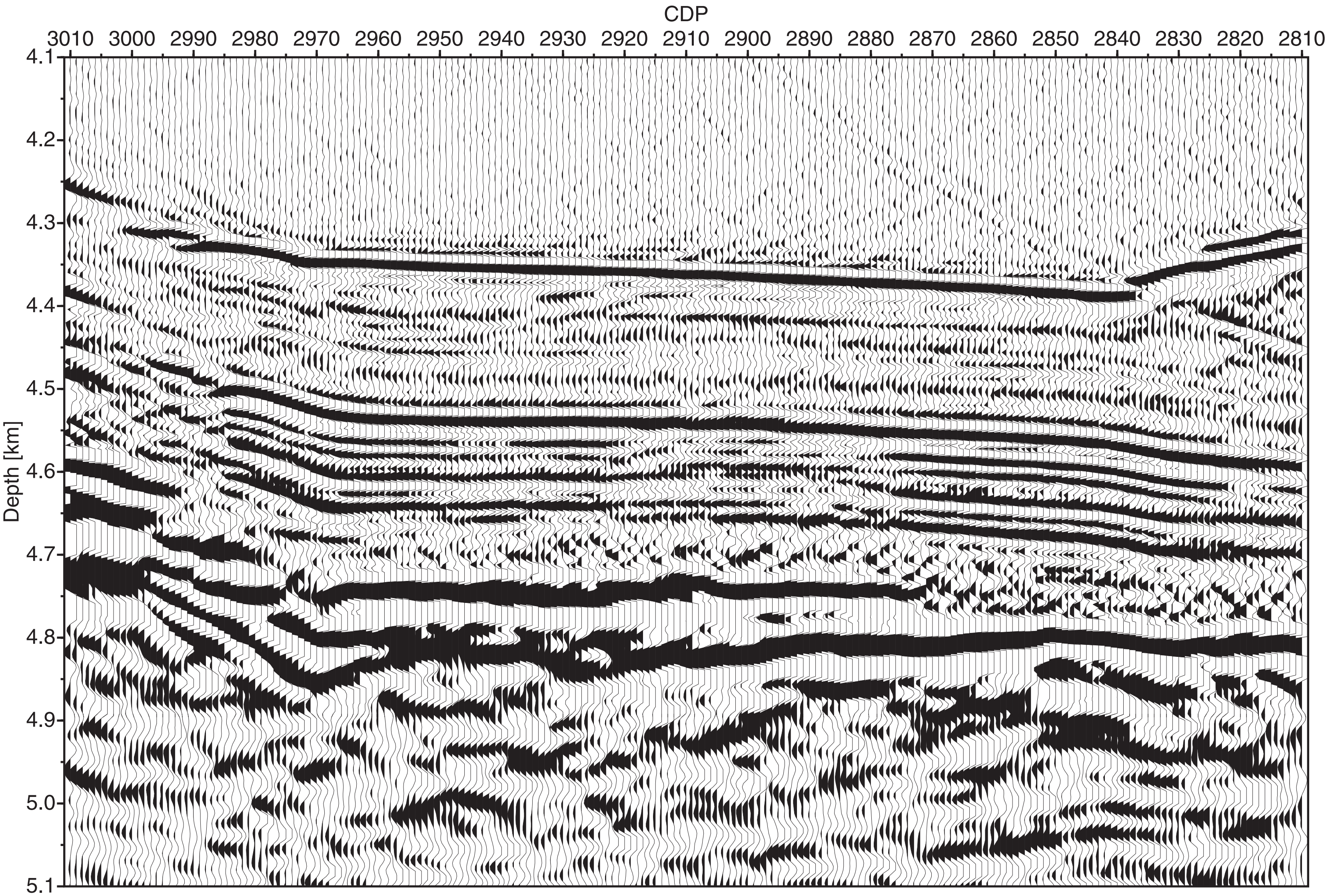
Site: 1253

Priority:	1
Position:	9°38.8583′N; 86°11.4337′W
Water depth (m):	4736
Sediment thickness:	400 mbsf is the depth to top of sill; sill thickness is not reliably resolvable from seismic records but was found by drilling to be 31 m; sediment thickness below sill and above basement is 30 m; top of basaltic basement was encountered at 460 mbsf.
Target drilling depth (mbsf):	Not applicable
Approved maximum penetration (mbsf):	Not applicable
Survey coverage:	Shotpoint 3210 on seismic Line BGR-99-44 (C. Ranero [GEOMAR, Germany], pers. comm, 2001; C. Reichert [BGR, Germany], pers. comm., 2001) Track line: seismic BGR 99-44 and CR-20
Objectives:	• Remove originally installed OsmoSamplers. • Install replacement OsmoSamplers.
Drilling program:	None
Logging program:	None
Nature of rock anticipated:	Hemipelagic and pelagic sediments, gabbro sill, and basalt.



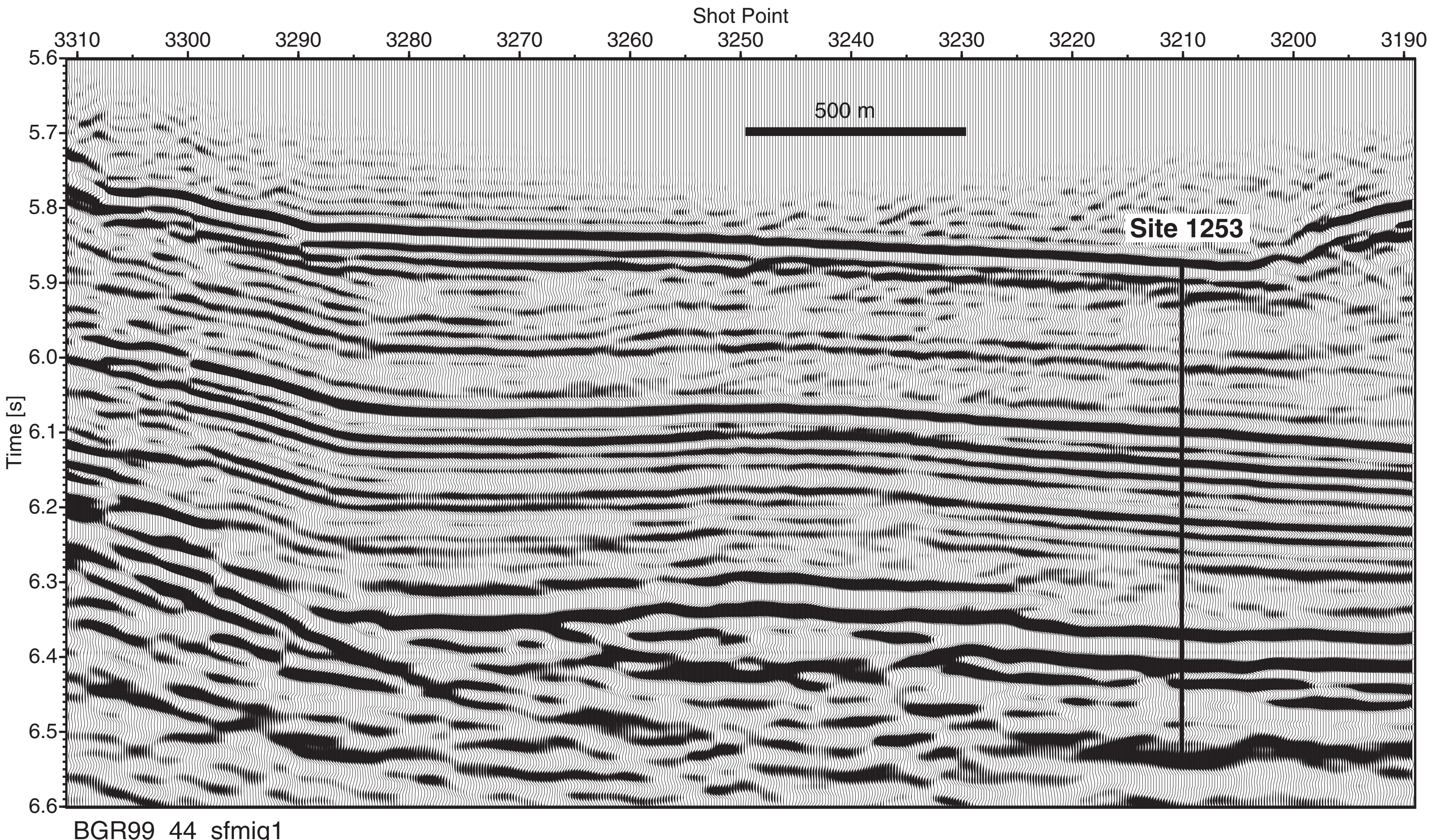
Navigation CR20 (circles) and BGR9944 (squares)
2830
2840
2850
2860
2870
2880
2890
2900
2910
2920
2930
2940
3200
3210
Site 1253
3220
3230
3240
3250
3270
3280
500m
39.00'
38.75'
9°N
38.50'
38.25'
38.00'
12.00'
11.80'
86°W
11.60'
11.40'
11.20'

Site 1253



CR20_depthmig.su

Site 1039

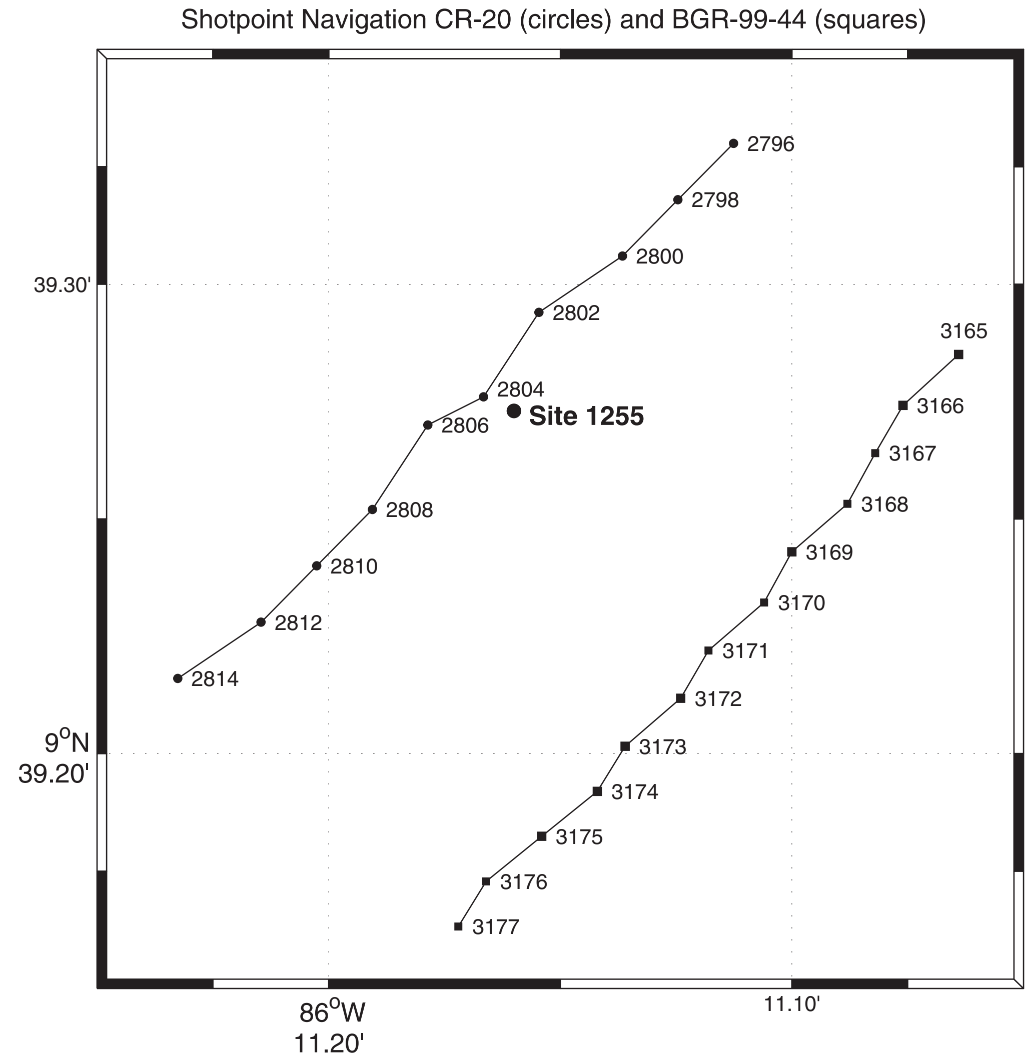

Shot Point
3310
3300
3290
3280
3270
3260
3250
3240
3230
3220
3210
3200
3190
Time [s]
5.6
5.7
5.8
5.9
6.0
6.1
6.2
6.3
6.4
6.5
6.6
500 m
Site 1253
BGR99_44_sfmig1

Site 1253

SITE SUMMARIES (CONTINUED)

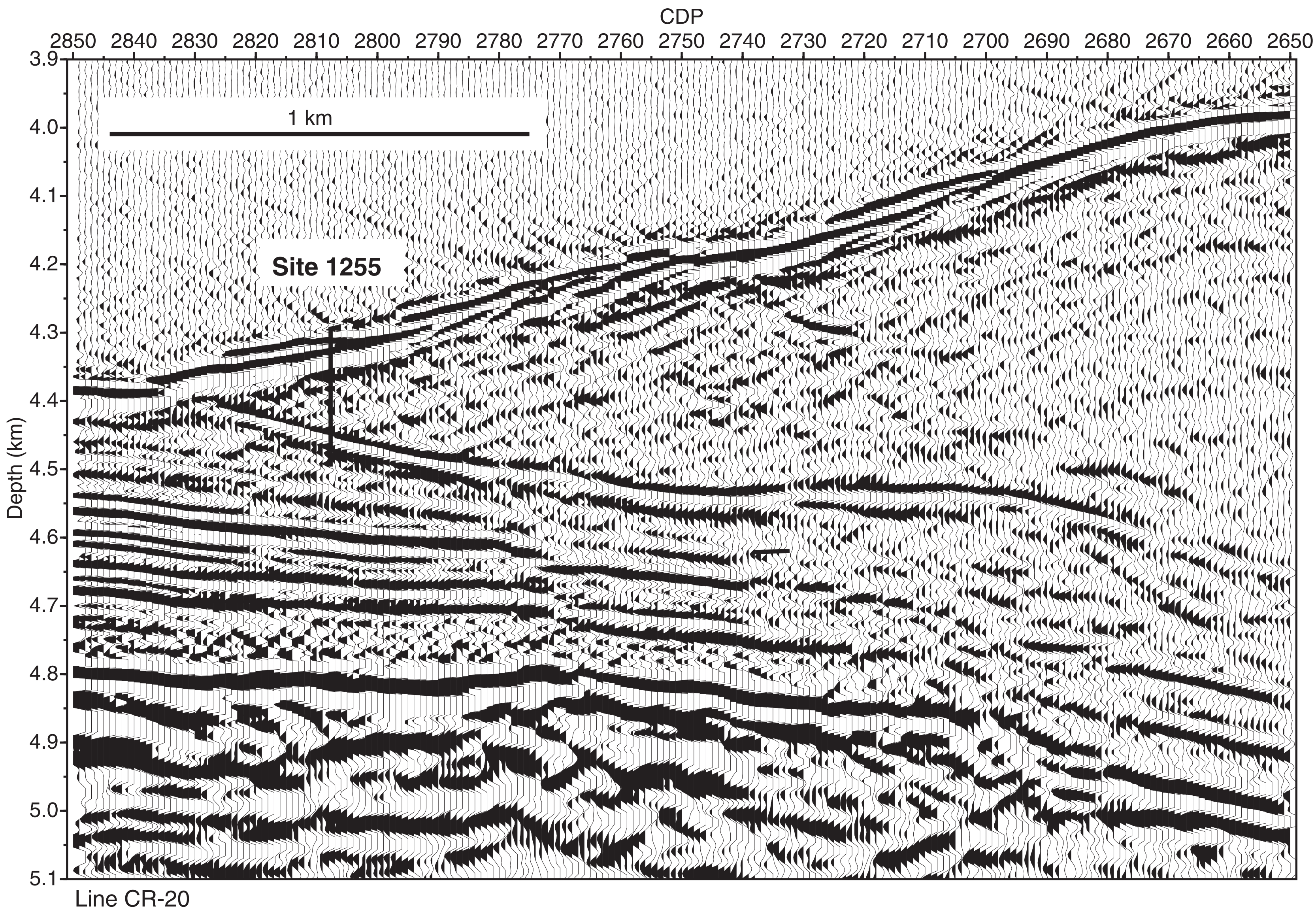
Site: 1255

Priority:	1
Position:	9°39.2716′N; 86°11.1492′W
Water depth (m):	4312
Sediment thickness: (m)	490
Target drilling depth (mbsf):	Not applicable
Approved maximum penetration (mbsf):	Not applicable
Survey coverage:	Shotpoint 2806 on seismic Line CR-20 (K. McIntosh [UTIG, USA], pers. comm., 2001) and shotpoint 3173 on seismic Line BGR-99-44 (C. Ranero [GEOMAR, Germany], pers. comm, 2001; C. Reichert [BGR, Germany], pers. comm., 2001). Track line: seismic BGR 99-44 and CR-20
Objectives:	• Remove originally installed OsmoSamplers. • Install replacement OsmoSamplers.
Drilling program:	None
Logging program:	None
Nature of rock anticipated:	Deformed claystone and hemipelagics.

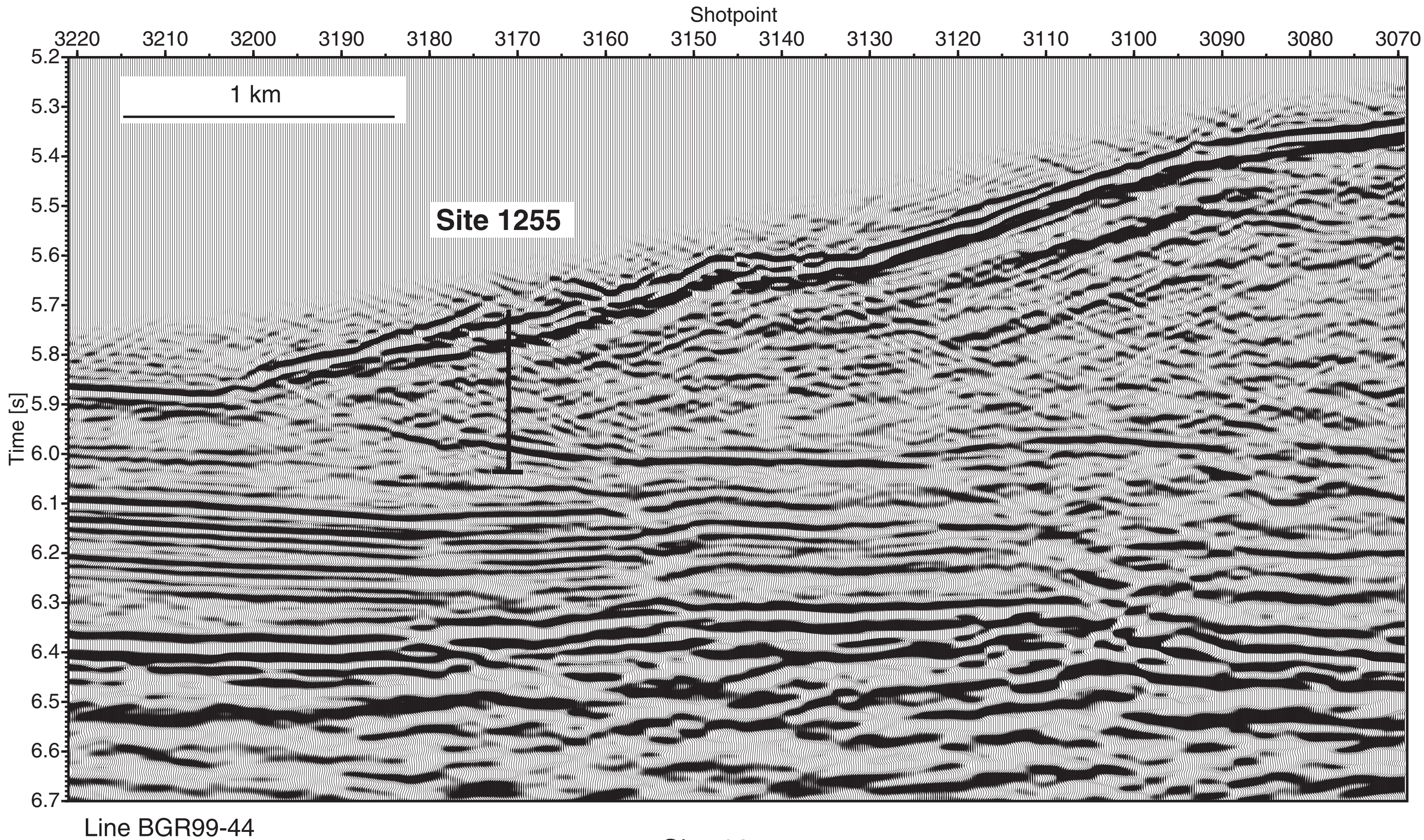


Shotpoint Navigation CR-20 (circles) and BGR-99-44 (squares)
2796
2798
2800
2802
2804
Site 1255
2806
2808
2810
2812
2814
3165
3166
3167
3168
3169
3170
3171
3172
3173
3174
3175
3176
3177
39.30'
9°N
39.20'
86°W
11.20'
11.10'

Site 1255


CDP
2850 2840 2830 2820 2810 2800 2790 2780 2770 2760 2750 2740 2730 2720 2710 2700 2690 2680 2670 2660 2650
Depth (km)
3.9 4.0 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 5.0 5.1
1 km
Site 1255
Line CR-20

Site 1255


Shotpoint
3220
3210
3200
3190
3180
3170
3160
3150
3140
3130
3120
3110
3100
3090
3080
3070
Time [s]
5.2
5.3
5.4
5.5
5.6
5.7
5.8
5.9
6.0
6.1
6.2
6.3
6.4
6.5
6.6
6.7
1 km
Site 1255
Line BGR99-44

Site 1255

SCIENTIFIC PARTICIPANTS

Miriam Kastner
Chief Scientist
Scripps Institution of Oceanography
University of California, San Diego
Geoscience Research Division
8615 Discovery Way
La Jolla CA 92093-0212
USA
mkastner@ucsd.edu
Work: (858) 534-2065
Fax: (858) 534-0784

Tabitha M. Hensley
Geochemist
Scripps Institution of Oceanography
University of California, San Diego
9500 Gilman Drive
MS 0208
LaJolla CA 92093-0208
USA
thensley@ucsd.edu
Work: (858) 534-4156
Fax: (858) 822-4945

Julie D. Morris
Geochemist
Department of Earth and Planetary Sciences
Washington University
One Brookings Drive
CB 1169
St. Louis MO 63130-4899
USA
jmorris@levee.wustl.edu
Work: (314) 935-6926
Fax: (314) 935-7361

Hideki Mukoyoshi
Geochemist
Department of Geology
Kochi University
Akebono-cho 2-5-1
Kochi-shi, Kochi 780-8520
Japan
mukoyoshi@jamstec.go.jp
Work: (81) 88-844-0111, ext 1298
Fax: (81) 88-844-8356

Gretchen A. Roberson
Geochemist
Scripps Institution of Oceanography
University of California, San Diego
9500 Gillman Drive
LaJolla CA 92093-0212
USA
garobertson@ucsd.edu
Work: (858) 534-1826
Fax: (858) 822-4945

Evan A. Solomon
Geochemist
Scripps Institution of Oceanography
University of California, San Diego
9500 Gilman Drive
MS 0208
LaJolla CA 92093-0208
USA
esolomon@ucsd.edu
Work: (858) 534-4857
Fax: (858) 822-4945

Hans W. Jannasch
Oceanographer
Monterey Bay Aquarium Research Institute
7700 Sandholdt Road
Moss Landing CA 95039
USA
jaha@mbari.org
Work: (831) 775-1717
Fax: (831) 775-1620

Martin Heesemann
Downhole Tools Specialist
Geowissenschaften 5
Universität Bremen
Postfach 33 04 40
28334 Bremen
Germany
heesema@uni-bremen.de
Work: (49) 421 218 4511
Fax: (49) 421 218 7163

Richard Dixon
Drilling Engineer—Designer
Integrated Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA
dixon@iodp.tamu.edu
Work: (979) 845-3207
Fax: (979) 845-2308

Derryl Schroeder
Operations Superintendent
Integrated Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA
schroeder@iodp.tamu.edu
Work: (979) 845-8481
Fax: (979) 845-2308

John A. Hamilton
Observer—Engineering
Research and Development Division
Monterey Bay Aquarium Research Institute
7700 Sandholdt Road
Moss Landing CA 95039
USA
hamilton@mbari.org
Work: (831) 775-1861
Fax: (831) 775-1646

Bradley Julson
Laboratory Officer
Integrated Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA
julson@iodp.tamu.edu
Work: (979) 845-5716
Fax: (979) 845-0876

Timothy Bronk
Assistant Laboratory Officer
Integrated Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA
bronk@iodp.tamu.edu
Work: (979) 845-0879
Fax: (979) 845-0876

Christopher Bennight
Marine Laboratory Specialist: Chemistry
Integrated Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA
chris@slowcar.net
Work: (979) 458-1874
Fax: (979) 845-2308

Lisa Brandt
Marine Laboratory Specialist: Chemistry
Integrated Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA
brandt@iodp.tamu.edu
Work: (979) 845-3602
Fax: (979) 845-0876

Peter Kannberg
Marine Laboratory Specialist: Downhole Tools/
Thin Sections
Integrated Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA
pk001i@hotmail.com

Paul Teniere
Marine Laboratory Specialist: Paleomagnetism
Integrated Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA
teniere@hotmail.com

Heather Paul
Marine Laboratory Specialist: Physical Properties
Integrated Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA
hjpaul@uvic.ca

Jason Deardorff
Marine Laboratory Specialist: X-Ray
Integrated Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA
jwdeardorff@hotmail.com
Work: (979) 845-9186
Fax: (979) 845-2308

Randy W. Gjesvold
Marine Instrumentation Specialist
Integrated Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA
gjesvold@iodp.tamu.edu
Work: (979) 845-3602
Fax: (979) 845-0876

Michael Meiring
Marine Instrumentation Specialist
Integrated Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA
kleinmeiring@yahoo.com
Work: (979) 845-3602
Fax: (979) 845-0876

Margaret Hastedt
Marine Computer Specialist
Integrated Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA
hastedt@iodp.tamu.edu
Work: (979) 862-2315
Fax: (979) 458-1617

David Morley
Marine Computer Specialist
Integrated Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA
morley@iodp.tamu.edu
Work: (979) 862-4847
Fax: (979) 845-4857