Integrated Ocean Drilling Program
Expedition 301T Preliminary Report

Costa Rica Hydrogeology

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Shipboard Scientific Party

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PUBLISHER'S NOTES

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The following scientists and personnel were aboard the *JOIDES Resolution* for Expedition 301 of the Integrated Ocean Drilling Program.

Shipboard Scientific Party

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

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

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

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

Thomas Pettigrew
Engineering Consultant
3300 Golden Trail
College Station TX 77845
USA

Transocean Officials

Pete Mowat
Master of the Drilling Vessel
Overseas Drilling Ltd.
707 Texas Avenue South, Suite 213D
College Station TX 77840-1917
USA

Tim McCown
Drilling Superintendent
Overseas Drilling Ltd.
707 Texas Avenue South, Suite 213D
College Station TX 77840-1917
USA

IODP Shipboard Personnel and Technical Representatives

Derryl Schroeder
Development Engineer

Michael Storms
Operations Superintendent

Stephen Midgley
Operations Superintendent Trainee

Steve Kittredge
Schlumberger Engineer

Bradley Julson
Laboratory Officer

Timothy Bronk
Assistant Laboratory Officer

Christopher Bennight
Marine Laboratory Specialist: Chemistry

Lisa Brandt
Marine Laboratory Specialist: Chemistry

Peter Kannberg
Marine Laboratory Specialist: Downhole Tools

Paul Teniere
Marine Laboratory Specialist: Paleomagnetism

Heather Paul
Marine Laboratory Specialist: Physical Properties

Jason Deardorff
Marine Laboratory Specialist: X-Ray

Randy W. Gjesvold
Marine Instrumentation Specialist

Michael Meiring
Marine Instrumentation Specialist

Margaret Hastedt
Marine Computer Specialist

David Morley
Marine Computer Specialist

Robert Burger
Associate Program Director, USSSP
Joint Oceanographic Institutions

Matthew Nimitz
Program Assistant
Joint Oceanographic Institutions

ABSTRACT

The Costa Rica hydrogeology operation was designed to replace CORK-II downhole instrument strings in holes drilled at Ocean Drilling Program 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 (Site 1253) and in the décollement zone (Site 1255) to investigate fluid flow across the margin and its implications for the seismogenic zone and subduction factory. Operations during the cruise were successfully completed in less than 4 days, and the instrument strings were retrieved and replaced; only the lower osmotic fluid sampler OsmoSampler package from Site 1253 was lost. Because of the close proximity of the two Site 1253 OsmoSampler packages, this loss will have minimal impact on the data. All recovered instruments worked as expected, and the redeployed samplers and temperature loggers are configured for approximately 3.5 y duration. OsmoSampler fluids from each site were analyzed for ephemeral properties on board ship (salinity, pH, alkalinity, and ammonium) and subdivided for further postcruise studies. Postcruise analyses will provide a high-resolution time series of fluid chemistry and temperature over a 2 y period and, at Site 1255, fluid flow rates and relative flow directions, with implications for seismogenic zone activity, chemistry of the arc volcanoes, and solute fluxes into the ocean.

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 dewatering and 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) potentially supports a chemosynthetic 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. Dehydration 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) 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 (Ocean Drilling Program, 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 it 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

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 ODP Sites 1039 and 1253. East Pacific Rise (EPR)-generated oceanic crust (~24 Ma) at the drill sites is within 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}) basement are required to match the low heat flow on EPR-generated crust (Hutnak et al., in press). 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 approximate 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; Chan and Kastner, 2000). Simple modeling suggests that unless supported, the gradients, also observed for Li, Ca, and SO_4, would dissipate 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 meters below seafloor (mbsf) is packed off and two OsmoSampler packages with temperature loggers are centered within fractured intervals at 500 and 516 mbsf to sample this subseafloor fluid flow, which cools the plate and may affect seismogenesis.

Prism Sites

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_6 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 recent flow. The OsmoSampler and OsmoFlowmeter are located within the décollement at Site 1255. Postcruise analysis of 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 sampled fluids. Pumping at a constant rate, the OsmoFlowmeters inject density-compensated artificial seawater tagged with iodate and high concentrations of Rb and Cs 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 analysis. Dilution of these tracers will constrain fluxes and, possibly, anisotropy (although not directionality in a geographic sense because the installed orientation is unknown) of fluid flow. A more complete description of the OsmoSamplers and Flowmeters is given in Jannasch et al. (2003). 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 on the composition of the residual subducted slab at greater depths (ultimately to depths of magma generation).

Installation of Observatories

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**), which had been drilled previously during Legs 170 and 205 (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 mbsf. Another CORK-II was installed at Site 1255, 0.4 km arcward 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 OsmoFlowmeters that continuously inject tracers and monitor their dilution in the natural fluid flux at four horizontally spaced sampling ports, allowing identification of anisotropy in fluid flow.

Leg 205 Operations

Complete information regarding these sites can be found in the site chapters in the ODP 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. **F2, F3**). Operationally, the primary goal for this site during Leg 205 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 section. 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 a long-term hydrologic borehole observatory was installed. After setting a reentry cone and $16\frac{1}{2}$ 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 50%–55% recovery.

After coring, operations focused on preparing the hole for downhole logging and CORK-II installation. The hole was opened to $14\frac{3}{4}$ inches; $10\frac{3}{4}$ 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 to a depth of 530 mbsf, below which a bridge was encountered. After logging, the CORK-II components were assembled, including a $4\frac{1}{2}$ 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 $4\frac{1}{2}$ inch casing. The OsmoSampler package with integral temperature sensors was lowered through the center of, and latched into a seat near the bottom of the $4\frac{1}{2}$ 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 were installed in the instrument hanger head. One sensor monitored pressure within the sealed-off fluid sampling zone at the bottom of the hole, one monitored pressure variations in the borehole above the sealed-off section, and the third sensor provided seafloor reference pressures. One additional sampling line extended from the CORK-II head down to the screened interval below the packer and is available for future pressure/fluid sampling purposes.

Details of the CORK-II installation in Hole 1253A are shown in Figure F4, and petrological and structural characteristics of key depths are shown in Figures F5 and F6. 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 package, 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 OsmoSampler package hangs 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 package 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 F4.

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 ODP 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. F2, F7, F8). 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 14¾ inch bit, followed by installation and cementation of 10¾ inch casing to 117 mbsf. 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. An OsmoSampler package with a custom pressure-neutral intake probe and self-sealing seat was installed at the décollement. The observatory configuration is shown in Figure F9. 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.

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 at the seafloor are dominated by tides, 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 **F10,** are of particular interest from a hydrologic and geochemical perspective.

At Site 1253, basement is underpressured relative to the local geothermal hydrostat by ~7 kPa (Fig. **F10A**), 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.

At Site 1255, fluid pressures in the décollement and the overlying overthrust sediments are superhydrostatic, varying with time (Fig. **F10B**). 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.

Alvin Dive Operations

Eight *Alvin* dives were planned for recovering and replacing the OsmoSamplers and temperature loggers at Sites 1253 and 1255 in February–March 2004. 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 package 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, was 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 both IODP Expeditions 301 and 301T. Sites 1253 and 1255 were left ready for OsmoSampler recovery and replacement by the *JOIDES Resolution,* submersible, or ROV. Using the *JOIDES Resolution* to recover and replace the OsmoSamplers allowed 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.

EXPEDITION 301T OBJECTIVES

The Costa Rica hydrogeology operation (301T), which took place during the transit between Expeditions 301 and 303, was designed to replace CORK-II downhole instrument strings in holes drilled at Ocean Drilling Program Leg 205 Sites 1253 and 1255 offshore Costa Rica. The CORKs are instrumented in a fractured horizon in the oceanic section of the incoming plate (Site 1253) and in the décollement zone (Site 1255) to investigate fluid geochemistry and flow across the margin and their implications for the seismogenic zone and subduction factory. This operation was necessary because during *Atlantis* cruise 11-8 (27 February–7 March 2004) the *Alvin* was unable to recover and thus redeploy the downhole OsmoSamplers and miniaturized temperature loggers. The OsmoSamplers installed during Leg 205 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 associated temperature loggers had been programmed to stop recovering data after 6 October 2004.

The primary operational objective during Expedition 301T was to successfully recover the OsmoSamplers installed during Leg 205 at Sites 1253 and 1255 and to install replacement OsmoSamplers.

The science goals of Expedition 301T 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. The specific opportunity this operation affords is the combination of pressure data recovered during the *Atlantis* cruise with downhole temperature variations through time and the time series chemical data to investigate both the transient pressure events recorded at Site 1253 and the overpressured décollement at Site 1255.

EXPEDITION 301T OPERATIONS AND PRINCIPAL RESULTS

Astoria 2 Port Call

Expedition 301T, the second part of the first expedition of IODP, officially began at the Astoria, Oregon (USA), port call with the first line tied up at 0424 h on 20 August 2004. The Astoria port call was an abbreviated port call with normal port call activities kept to a minimum. The original plan called for offloading Expedition 301 materials and samples in Astoria, taking on fuel, water, food supplies, spares, and bulk material. Shortly after arrival, the vessel was informed by customs that they had not been notified 48 h in advance of material to be offloaded in Astoria. This requirement had not been in place during the first Astoria port call. This problem could not be resolved on 20 August (Friday) and the quick departure schedule precluded a solution by departure time on the morning of 22 August (Sunday). The vessel was forced to reload all material that had already been offloaded onto the dock including all scrap iron from Expedition 301 and had to sail with all material originally scheduled for offloading in Astoria.

Transit to Site 1253

The last line was cast off from Pier 1 at 0645 h on 22 August. The forward and aft tugs were released, and the *JOIDES Resolution* proceeded down the Columbia River and across the Columbia Bar. The pilot was dispatched via helicopter, and at 0824 h the vessel was under way at full speed on a course of 183°T for Site 1253. The transit was uneventful, making the 3411 nmi transit in 314.7 h at an average speed of 10.87 kt.

After a 13 day transit from Astoria, the vessel arrived at Site 1253 in Costa Rican waters on 4 September, approximately 1 day ahead of schedule. After reducing speed upon approach to the site, the thrusters/hydrophones were lowered and the vessel was switched to dynamic positioning (DP) control.

Site 1253

After a smooth transit from Astoria, Oregon, the ship arrived at Site 1253 at 1112 h. *Alvin* operations had left the two Site 1253 OsmoSampler packages seated at depth, the tools and ~550 m of Spectra line attached, and a ring and float attached ~20 m above the CORK wellhead. Operations commenced with the attempts to retrieve the OsmoSampler packages. A sunflower-shaped fishing tool with grooves located between the petals was used to "fish" the rope suspended by a float above the CORK. After fishing for just over 3 h, we started pulling the rope that we hoped was secured to the OsmoSampler. We found that we had captured the float, some of the spectra rope, and the metal ring used to tie onto the float. The remainder of the fished components either dropped to the seafloor during the trip out or remained in Hole 1253A. The explanation is that the OsmoSampler string made it close to the surface with the line wrapped around the drill pipe and caught on the vibration-isolated television (VIT) camera frame. When the VIT frame came clear of the water, the fleet angle to the camera winch pulled on the frame, which was being held back by the Spectra rope wrapped around the drill pipe. The camera winch was capable of pulling far more than the rating on the Spectra rope (10,000 lb). During recovery the camera swings 180° to get closer to the overhead sheave, and that may be when the Spectra rope parted. The dropped components were left to be found and recovered after we completed operations in Hole 1255A.

Site 1255

After the initial attempted retrieval of OsmoSamplers at Site 1253, the ship was offset to Site 1255 in dynamic positioning (DP) mode and a new BHA was made up for connecting to the CORK in Hole Site 1255A. It was run into the hole to 4270 m, and the subsea TV camera was deployed to assist in latching onto the CORK. At midnight on 5 September, the ship was maneuvering to latch onto the CORK in Hole 1255A. The first latching attempt lasted 9 h, and erratic currents seemed to cause problems with all attempts to latch. After latching onto the CORK, the core line was run in and latched onto the OsmoSampler string inside the 4.5 inch casing. The OsmoSampler string was retrieved, the drill pipe was disconnected from the CORK, and the OsmoSampler was recovered and laid out on the core receiving platform. A new OsmoSampler string was made up and inserted into the drill pipe. It took 1.75 h to reconnect to the CORK, and then the OsmoSampler was lowered to depth. After attempts to disconnect the coring line from the OsmoSampler string, the pipe was disconnected from the CORK to discover that the OsmoSampler shear pin did not shear as intended. After two attempts the coring line was successfully disconnected from the instrument strings, with the float assembly properly deployed just above the CORK. After disconnecting from the CORK in Hole 1255A, the ship moved in DP mode back to Site 1253.

The OsmoSamplers recovered from Hole 1255A were subsampled for shipboard measurements of alkalinity, pH, ammonium, and salinity and for further postcruise chemical and isotopic time series analyses. Maximum values of 17.1 mM for alkalinity and 1828 µM ammonium are elevated relative to Site 1253 and are the result of bacterially mediated diagenesis of organic matter. Inspection indicated the osmotic pumps worked well throughout the period deployed. In addition, osmotic flowmeter fluids were subsampled for postcruise analyses to determine relative flow rates and direction. The temperature loggers recovered are in excellent shape.

Return to Site 1253

Upon completing successful operations at Site 1255, we returned to Site 1253 and reentered Hole 1253A with a fishing tool to inspect for the OsmoSampler packages and any remaining hardware. The hole was found to be completely clear. The OsmoSamplers were not found; thus, it was assumed they had been removed from the hole and dropped onto the seafloor when the Spectra line parted during initial fishing operations. Attempts to pull the coring line from the hole resulted in the realization that it was stuck. The line was worked up and down until it was freed, and the coring line was pulled from Hole 1253A. The new OsmoSampler packages (upper level within a screen and lower level in the open hole) were assembled with a new sinker bar and 500 m line to a seafloor float and deployed in Hole 1253A without incident. Visual inspection with the VIT camera confirmed that the float assembly was properly deployed just above the CORK.

After unlatching from the Hole 1253A CORK, a bottom survey was initiated to find the OsmoSampler string that was dropped during the first recovery attempt at Site 1253. The vessel was moved in DP mode on 150 m parallel lines spaced on 10 m centers. The initial track was on a course of 045°, returning on the reciprocal course of 225°T. Each pass moved 10 m farther from the CORK. After reaching 90 m northwest of the CORK, the vessel returned to the CORK/reentry cone and conducted the same search to the southeast. The OsmoSampler was located after 7.5 h, ~20 m southeast of the CORK. The vessel stabilized position over the OsmoSampler. A four-pronged grapple assembly was rigged to the underwater TV camera, and a successful pass was made with the fishing tool. The camera and VIT frame arrived at the surface with the upper OsmoSampler, wireline jars, 500 m of Spectra rope, and other miscellaneous hardware left by the submersible *Alvin*. The lower OsmoSampler was not recovered. After successful recovery of the upper OsmoSampler from Site 1253, the drill string was pulled up and beacons were recovered from Sites 1253 and 1255. Schlumberger sheaves were rigged up for a test of the active heave compensating wireline logging winch. After concluding the Schlumberger test, the sheaves were rigged down and the BHA was pulled out of the hole and laid out. All components were secured for transit to Panama.

Hole 1253A fluid coils from two of the Teflon OsmoSamplers were subsampled for shipboard measurements of alkalinity, pH, ammonium, and salinity and for a wide variety of postcruise analyses. Maximum values for alkalinity and ammonium are low: 0.8 mM and 170 µM, respectively. Two further copper coils will also be analyzed for gases and organic components postcruise. Initial salinity analyses in the two separate fluid coils have very similar profiles, suggesting two complete years of fluids were obtained.

Transit to Panama

Transit to Panama began at 1130 h on 8 September. The total transit distance was 522 nmi. First line was ashore at Berth 15, Balboa, Panama, at 1950 h on 10 September 2004.

CONCLUSIONS

The following operations were successfully accomplished during Expedition 301T:

- Successfully "fished" OsmoSampler string and miscellaneous hardware left at Site 1253. The OsmoSampler string was dropped to the seabed during the recovery operation.
- Removed the OsmoSampler string from Hole 1255A and replaced it with a new 3.5 y OsmoSampler string.
- Reentered Hole 1253A, confirmed removal of the OsmoSampler string, and reinstalled a new 3.5 y OsmoSampler string.
- Successfully located the OsmoSampler string from Hole 1253A on the seabed and "fished" the upper OsmoSampler and associated hardware. The lower OsmoSampler was lost to either the hole or the seabed.

The prime objective of this operation was to retrieve and replace the OsmoSamplers from Sites 1253 and 1255, which were installed during ODP Leg 205. Operations during the cruise were successful, and the instrument strings were retrieved and replaced; only the lower OsmoSampler package from Site 1253 was lost. Due to close proximity of the two Site 1253 Osmosampler packages, this loss will have minimal impact on the data. Operations for this transit cruise required 3.8 days, concluding 8 September 2004.

After retrieval, the Teflon coils of the OsmoSamplers were subdivided in preparation for shorebased analyses. A subset of the fluids was analyzed for ephemeral properties shipboard (alkalinity, pH, and ammonium). The alkalinity and ammonium concentrations at the two sites are distinct. They are considerably higher in the décollement fluid at Site 1255, with maximum values of 17.1 mM and 1828 µM, respectively. At

Site 1253, in the igneous complex formation fluid, maximum concentrations of alkalinity and ammonium are 0.8 mM and 170 µM, respectively. Bacterially mediated diagenesis of organic matter is responsible for the high alkalinity and ammonium observed at Site 1255.

Postcruise analyses will provide 2 y high-resolution time series of fluid chemistry and temperature and at Site 1255 also of fluid flow rates and relative flow directions, with implications for seismogenic zone activity, chemistry of the arc volcanoes, and solute fluxes into the ocean.

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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.

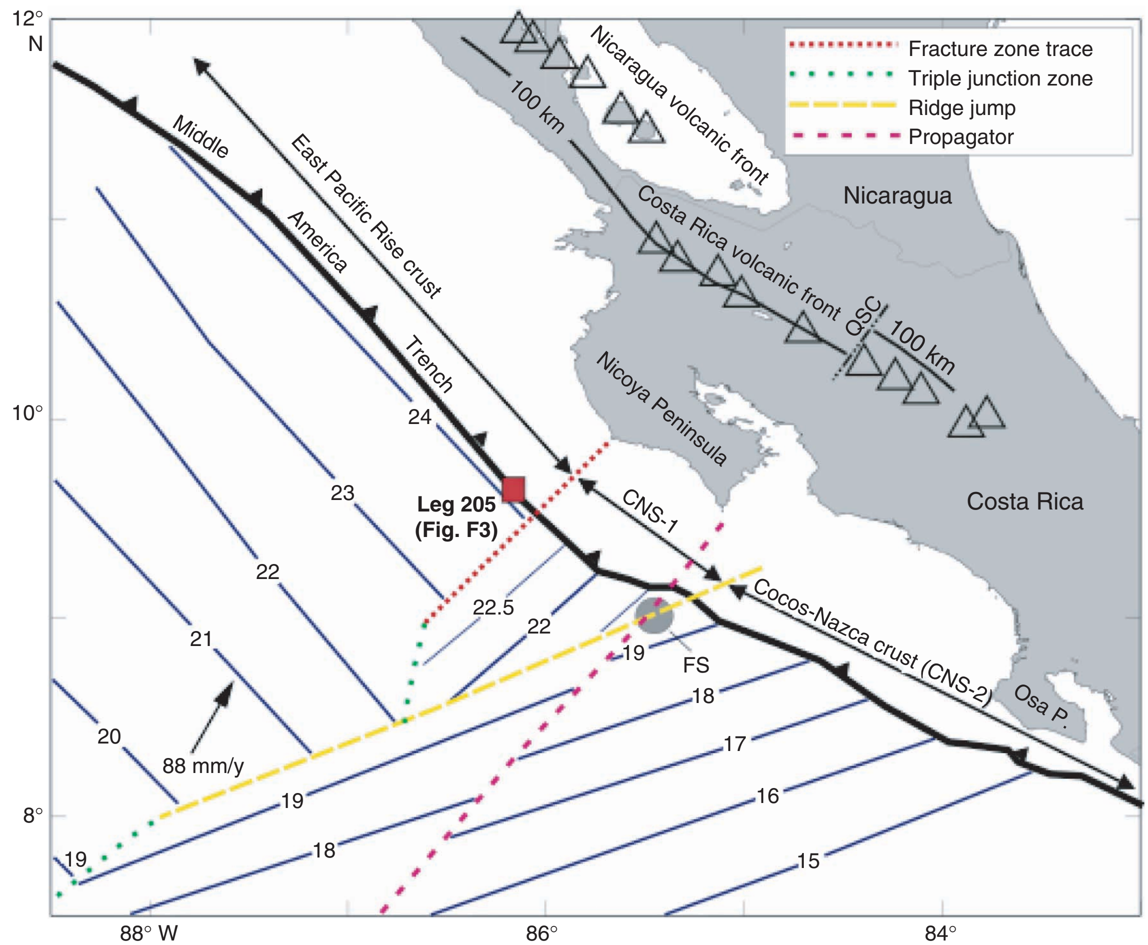

Figure F2. Bathymetric map of the Leg 205 drilling area: yellow dots = Leg 205 sites, white dots = Leg 170 sites. Seismic profiles: red = BGR 99-44 (C. Reichert and C. Ranero, pers. comm., 2001), yellow = CR-20 (Shipley et al., 1992). Leg 170 drill sites were based on seismic profile CR-20. Numbers along 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]).

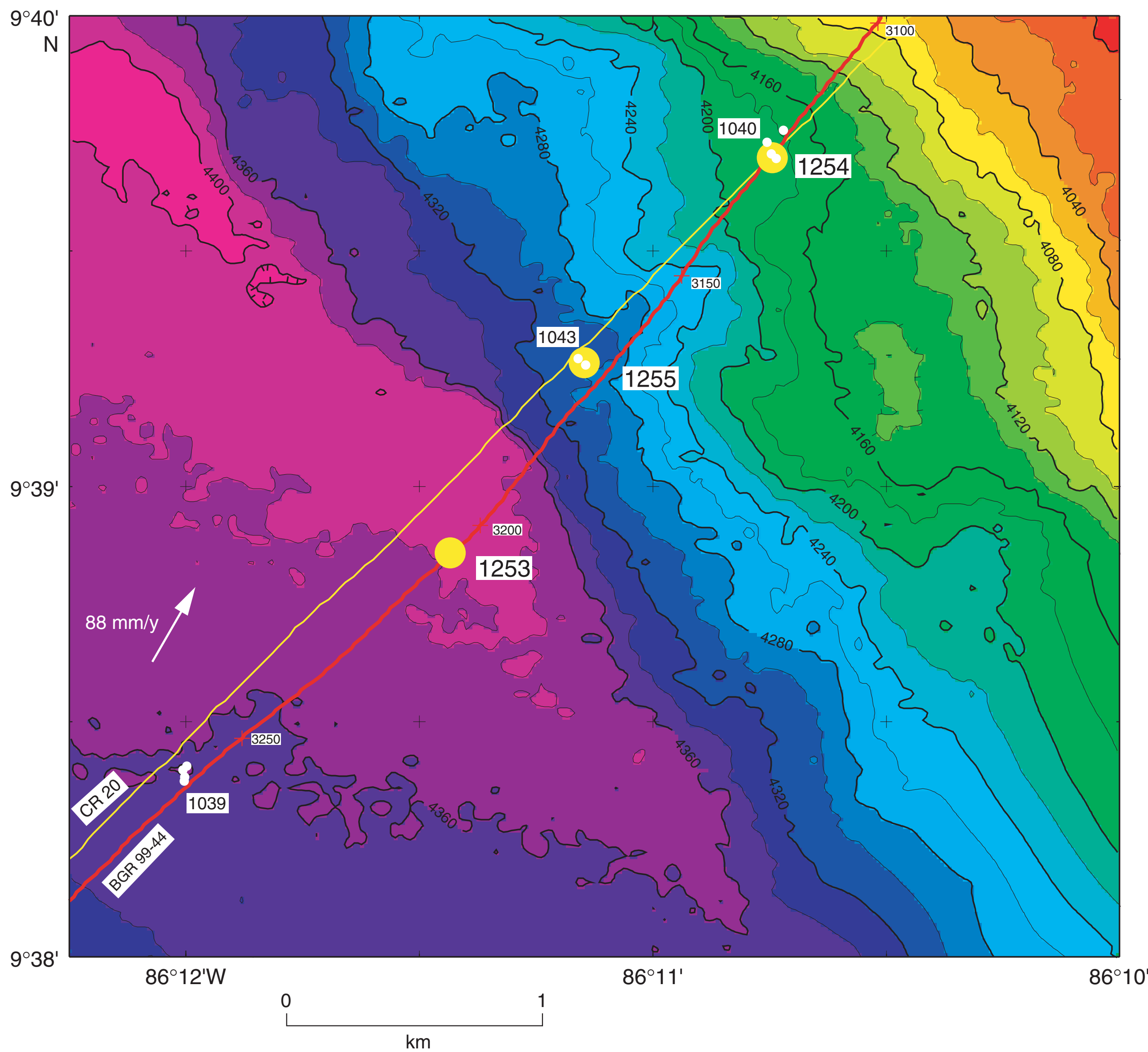

Figure F3. Portion of multichannel seismic profile BGR 99-44 across Sites 1253 and 1039. Vertical exaggeration = ~1.6.

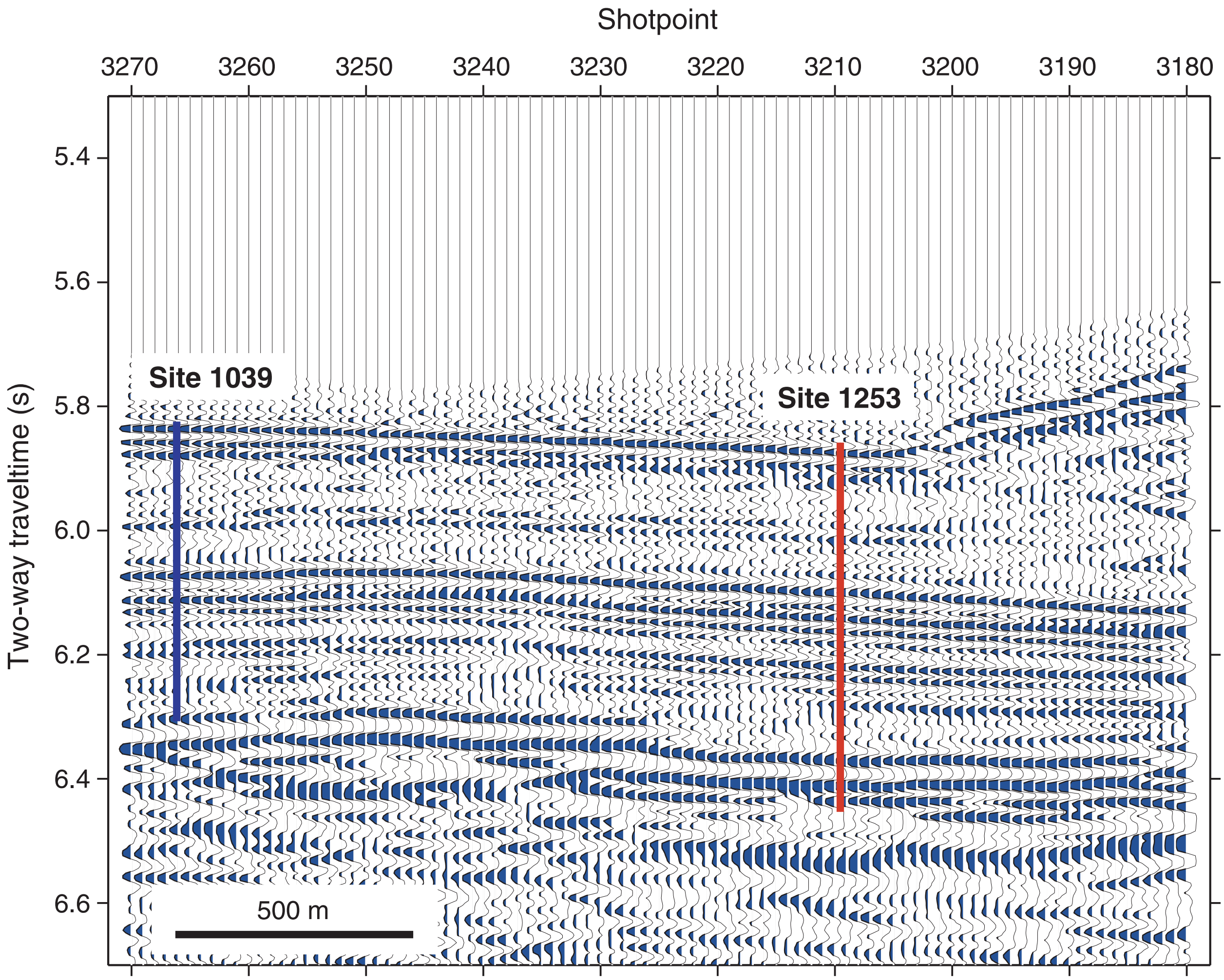

Figure F4. Hole 1253A borehole installation showing subseafloor depths for OsmoSamplers, screens, packers, and casing strings. This figure is not to scale.

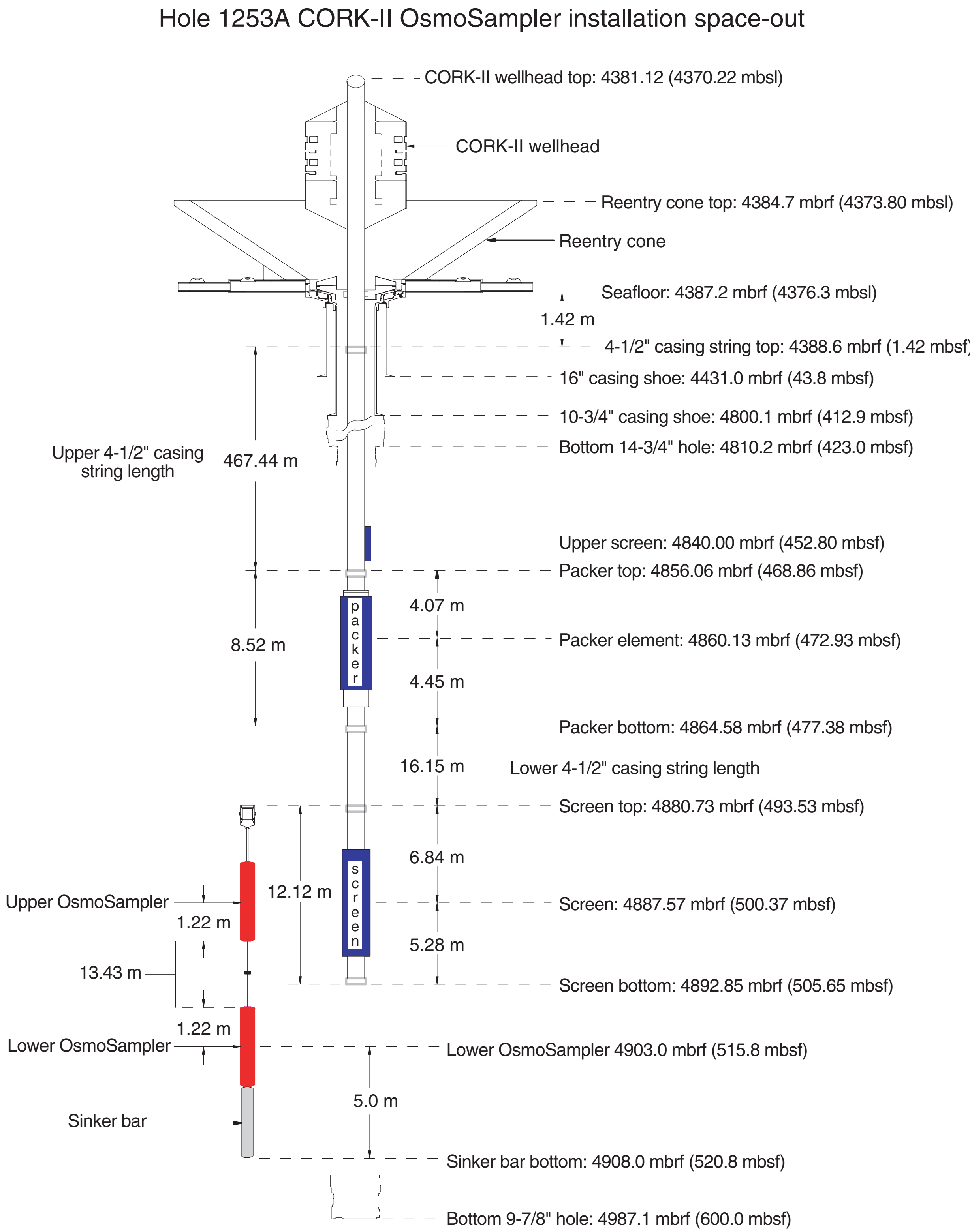

Figure F5. Composite diagram from Hole 1253A showing selected logging data annotated with physical property measurements on the cores, petrologic observations, and paleomagnetic and rock magnetic results. Correlations between core and logging intervals are shown as solid lines to indicate major boundaries or as dashed lines to indicate subunit boundaries identified petrologically. Also indicated are the positions of the two OsmoSamplers (OS #1 and OS #2).

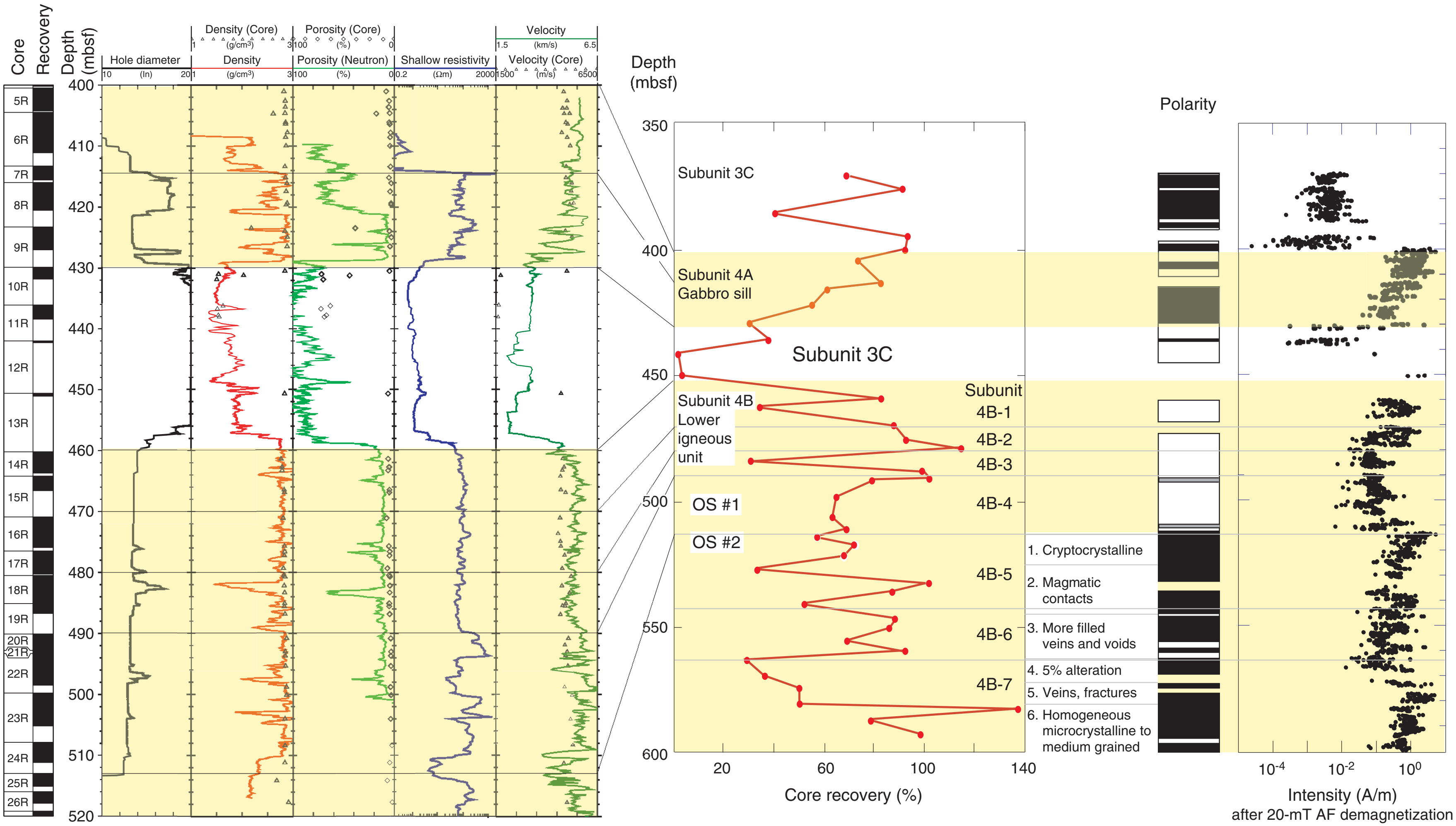

Figure F6. Composite diagram from Hole 1253A showing fracture distribution within the igneous units, a summary of petrologic observations, and detailed Formation MicroScanner images for the depths at which the OsmoSamplers (OS #1 and OS #2) were installed.

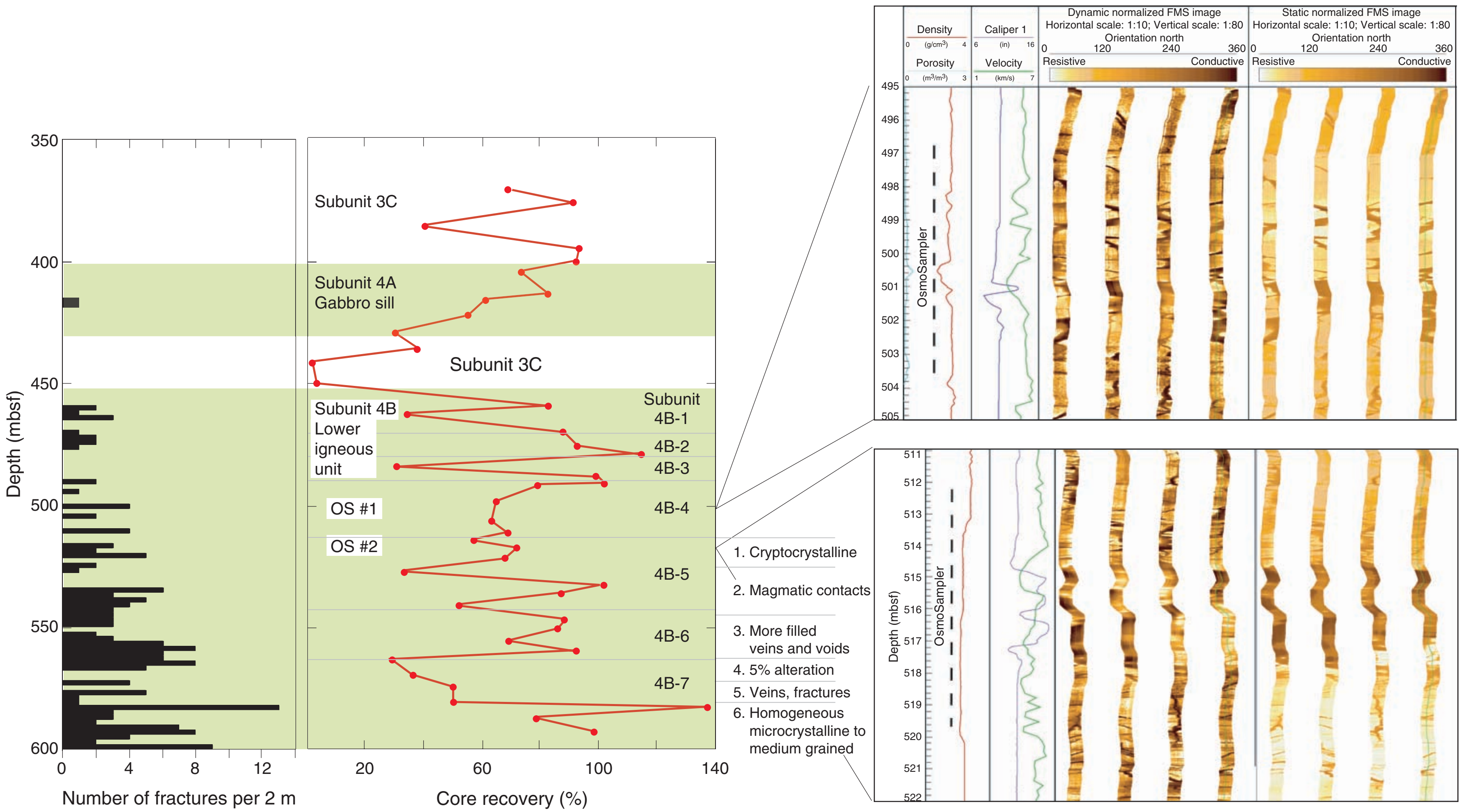

Figure F7. Location of Site 1255. Red circle = Leg 205 site, black circles = Leg 170 sites. (Integration of compilation by Ranero and von Huene [2000] and Simrad data from E. Flueh [pers. comm., 2000]).

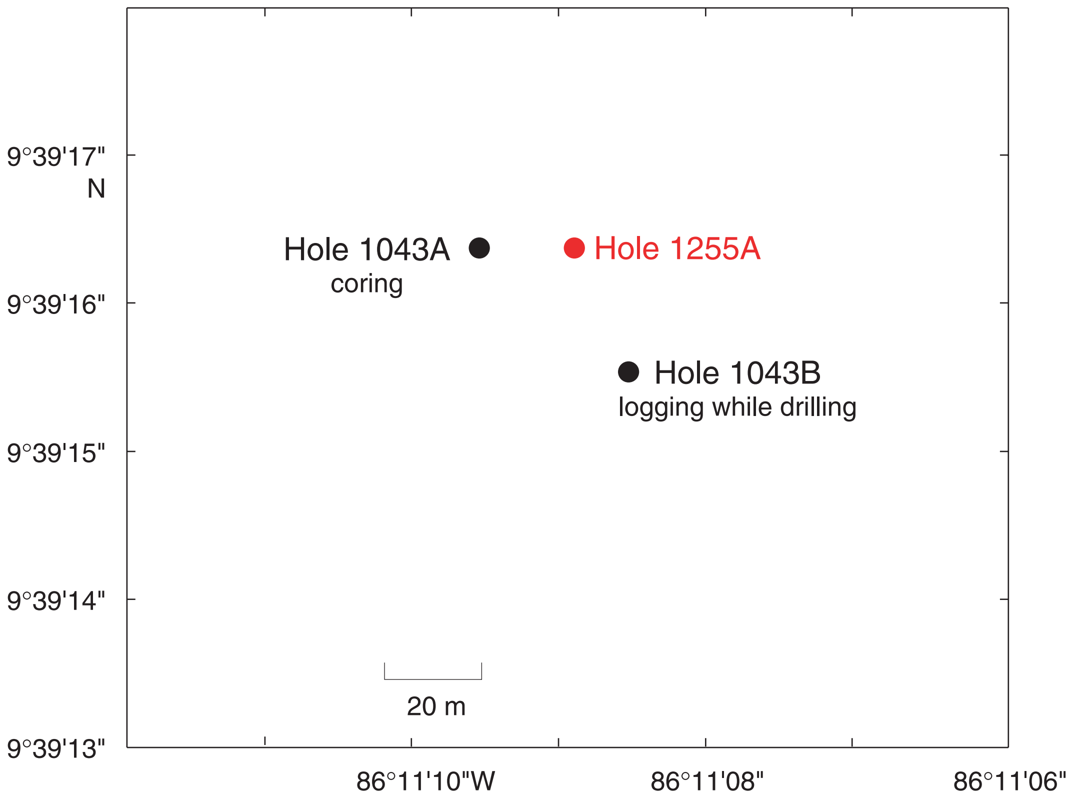

Figure F8. Portion of multichannel seismic profile BGR 99-44 across Sites 1255 and 1043. Vertical exaggeration = 1.7. CMP = common midpoint.

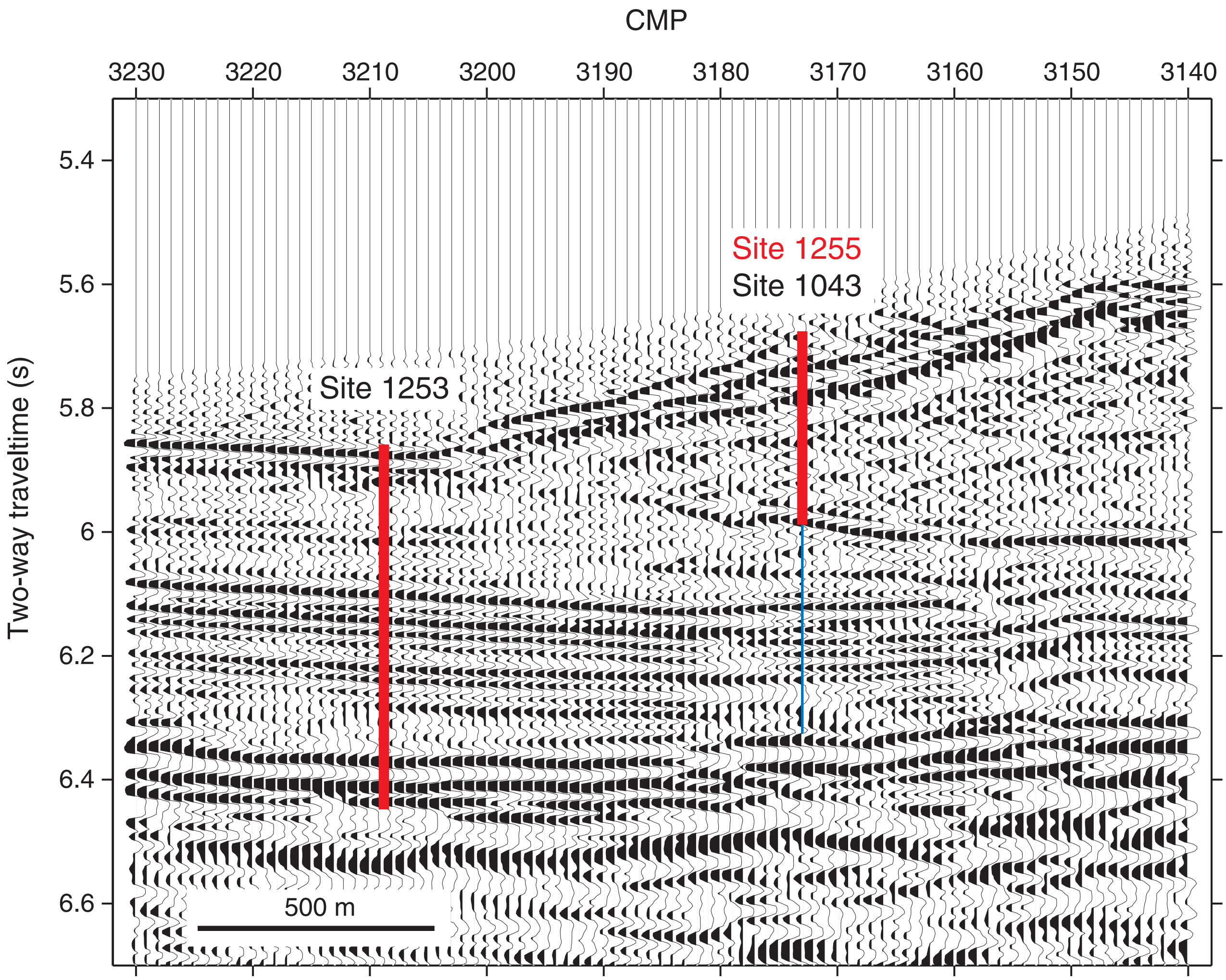

Figure F9. Hole 1255A borehole installation showing subseafloor depths for OsmoSamplers, screens, packers, and casing strings. This figure is not to scale.

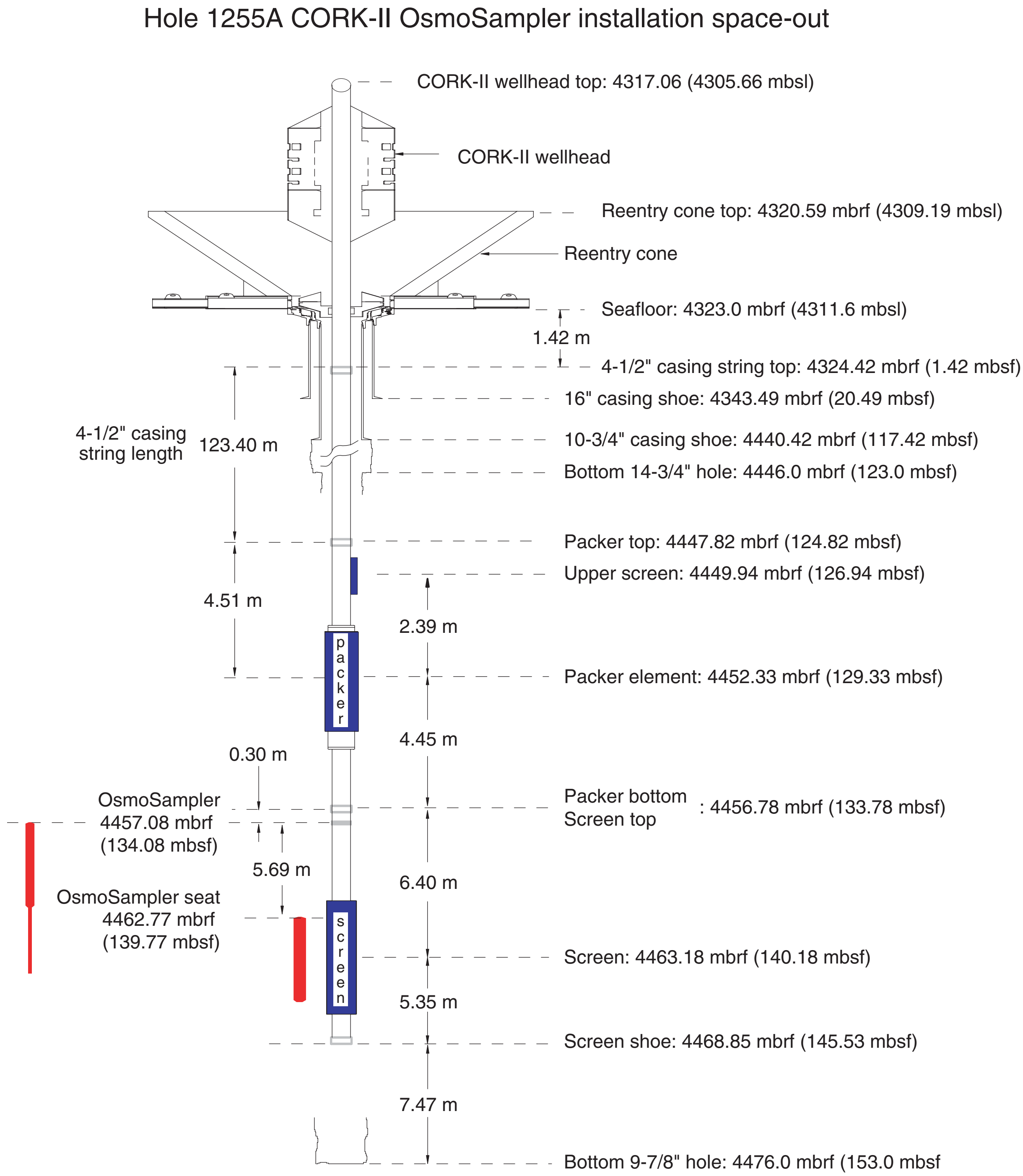

Figure F10. **A.** Pressure vs. time, Site 1253. **B.** Pressure vs. time, Site 1255. Note difference in pressure scales.