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ABSTRACT

The primary accomplishments of the JOI Cooperative Agreement with DOE/NETL in this quarter were the deployment of tools and measurement systems for testing on ODP Leg 201, which is intended to study hydrate deposits on the Peru margin as part of other scientific investigations. Additional accomplishments were related to the continuing evolution of tools and measurements systems in preparation for deployment on ODP Leg 204, Hydrate Ridge, offshore Oregon in July 2002.

The design for PCS Gas Manifold was finalized and parts were procured to assemble the gas manifold and deploy this system with the Pressure Core Sampler (PCS) tool on ODP Leg 201. The PCS was deployed 17 times during ODP Leg 201 and successfully retrieved cores from a broad range of lithologies and sediment depths along the Peru margin. Eleven deployments were entirely successful, collecting between 0.5 and 1.0 meters of sediment at greater than 75% of hydrostatic pressure.

The PCS gas manifold was used in conjunction with the Pressure Core Sampler (PCS) throughout ODP Leg 201 to measure the total volume and composition of gases recovered in sediment cores associated with methane hydrates. The results of these deployments will be the subject of a future progress report.

The FUGRO Pressure Corer (FPC), one of the HYACE/HYACINTH pressure coring tools, and two FUGRO engineers were deployed on the D/V JOIDES *Resolution* during ODP Legs 201 to field-test this coring system at sites located offshore Peru. The HYACINTH project is a European Union (EU) funded effort to develop tools to characterize methane hydrate and measure physical properties under in-situ conditions. The field-testing of these tools provides a corollary benefit to DOE/NETL at no cost to this project. The opportunity to test these tools on the D/V JOIDES *Resolution* was negotiated as part of a cooperative agreement between JOI/ODP and the HYACINTH partners.

The DVTP, DVTP-P, APC-methane, and APC-Temperature tools (ODP memory tools) were deployed onboard the R/V JOIDES *Resolution* and used extensively during ODP Leg 201. Preliminary results indicate successful deployments of these tools.

An infrared-thermal imaging system (IR-TIS) was delivered to JOI/ODP for testing and use on ODP Leg 201 to identify methane hydrate intervals in the recovered cores. The results of these experiments will be the subject of a future progress report.

This report presents an overview of the primary methods used for deploying the ODP memory tools and PCS on ODP Leg 201 and the preliminary operational results of this leg. Discussions regarding the laboratory analysis of the recovered cores and downhole measurements made during these deployments will be covered in a future progress report.

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INTRODUCTION

DOE/NETL funding was used by JOI/ODP to upgrade or modify many of the existing downhole tools onboard the D/V JOIDES *Resolution* so that they could be used to better characterize methane hydrates on ODP Leg 201, as well as on Leg 204 in July 2002.

During ODP Leg 201, several newly modified downhole tools were deployed to better characterize the subsurface lithologies and environments hosting microbial populations and gas hydrates. Methane hydrates were sampled in cores recovered from one of the sites drilled during the cruise (Site 1230) and tests of an infrared thermal imaging system were used to confirm the validity of this method for locating hydrate recovered in cores from the identification of their thermal anomaly.

The ODP Pressure Core System (PCS) was deployed 17 times during ODP Leg 201 and successfully retrieved cores from a broad range of lithologies and sediment depths along the Peru margin. Eleven deployments were entirely successful, collecting between 0.5 and 1.0 meters of sediment at greater than 75% of hydrostatic pressure. The PCS gas manifold was used in conjunction with the PCS throughout ODP Leg 201 to measure the total volume and composition of gases recovered in sediment cores, and especially in those cores associated with methane hydrate.

The HYACINTH project is a European Union (EU) funded effort to develop tools to characterize methane hydrate and measure physical properties under in-situ conditions. The FUGRO pressure corer (FPC), one of the HYACINTH pressure coring tools, was deployed on the D/V JOIDES *Resolution* during ODP Legs 201 to accomplish field-tests of this coring system at sites located offshore Peru in preparation for future deployments offshore Oregon on ODP Leg 204. The FPC was deployed 7 times with limited success in recovering pressurized cores, but much was learned about the operation of the tool with shipboard systems on the D/V JOIDES *Resolution*.

The DVTP, DVTP-P, APC-methane, and APC-Temperature tools (ODP memory tools) were used extensively during ODP Leg 201 aboard the D/V JOIDES *Resolution*, and preliminary reports indicate numerous successful deployments of all of these tools. These systems will provide a strong operational capability for characterizing the in situ properties of methane hydrates in subsurface environments on Hydrate Ridge during ODP Leg 204, as well as in other offshore sedimentary environments.

EXECUTIVE SUMMARY

The primary accomplishments of the JOI Cooperative Agreement with DOE/NETL in this quarter were the deployment of tools and measurement systems for testing on ODP Leg 201, which is intended to study hydrate deposits on the Peru margin as part of other scientific investigations. Additional accomplishments were related to the continuing evolution of tools and measurements systems in preparation for deployment on ODP Leg 204, Hydrate Ridge, offshore Oregon in July 2002.

The design for PCS Gas Manifold was finalized and parts were procured to assemble the gas manifold and deploy this system with the Pressure Core Sampler (PCS) tool on ODP Leg 201 (Task 2.0). The PCS tool and manifold was shipped to San Diego and placed onboard the JOIDES Resolution during the Leg 201 portcall. The PCS was deployed 17 times during ODP Leg 201 and successfully retrieved cores from a broad range of lithologies and sediment depths along the Peru margin. Eleven deployments were entirely successful, collecting between 0.5 and 1.0 meters of sediment at greater than 75% of hydrostatic pressure. Four other deployments were partially successful, either collecting a similar amount of sediment or returning the tool at >75% of hydrostatic pressure.

Dr. Gerald Dickens (Rice University) worked with ODP engineer Derryl Schroeder and members of the Leg 201 technical and scientific staff to operate the PCS gas manifold in concert with deployments of the PCS throughout Leg 201. The results of these deployments will be the subject of a future progress report.

The FUGRO pressure corer (FPC), one of the HYACINTH pressure coring tools, and two FUGRO engineers sailed on the D/V JOIDES Resolution during ODP Legs 201 to field-test this coring system at sites located offshore Peru. The HYACINTH project is a European Union (EU) funded effort to develop tools to characterize methane hydrate and measure physical properties under in-situ conditions. The field-testing of these tools provides a corollary benefit to DOE/NETL at no cost to this project. The opportunity to test these tools on the D/V JOIDES *Resolution* was negotiated as part of a cooperative agreement between JOI/ODP and the HYACINTH partners.

Two core logging chambers (ODP-LC) were ordered by JOI and will be fabricated for use on ODP Leg 204. These chambers will be able to accept standard ODP APC/XCB core sections in their existing core liners and will allow them to be re-pressurized and logged to collect gamma ray attenuation (bulk density) and compressional-wave acoustic velocity measurements. These measurements will be made using a vertical multi-sensor (pressure) core logging (MSCL-V) system that will be deployed on Leg 204 as part of the HYACINTH system testing. These chambers will allow physical properties data to be collected on hydrate cores recovered using conventional coring techniques and re-pressurized. These data can then be compared with similar properties measured on cores recovered at in-situ pressures by the HYACINTH corers to evaluate the similarities and/or differences among data collected using these two approaches.

The DVTP, DVTP-P, APC-methane, and APC-Temperature tools (ODP memory tools; Task 3.0) were shipped to San Diego and placed onboard the R/V JOIDES *Resolution* during portcall in San Diego in January. These tools were used extensively during ODP Leg 201 and preliminary reports indicate successful deployments of these tools.

The selection and purchase of an Infrared-Thermal Imaging System (IR-TIS) was completed during this quarter (Task 4.0) and a FLIR SC2000 system was delivered to JOI on January 14, 2002. The purchase of the second FLIR system was deferred until after the Leg 201 deployment can be evaluated to ensure flexibility in meeting the needs of the Leg 204 deployments. The second system will be ordered in early May of 2002 for delivery prior to Leg 204. ODP staff and Leg 201 scientists were trained in the theory and use of the FLIR SC2000 infrared thermal imaging system at the Infrared Training Center (ITC) in Billerica, MA to support use of this equipment on Leg 201.

Discussions continued between Leg 204 scientists and LDEO logging engineers to define the specifics of LWD and VSP experiments planned for ODP Leg 204 (Task 5.0). Tool modifications needed to integrate an ODP sample chamber with the LWD Resistivity-at-bit with coring (RAB-c) tool were identified and a plan of action was developed to meet the timetable for this deployment on ODP Leg 204 in July of 2002. In consultation with Bill Gwilliam (NETL), JOI requested authorization to re-prioritize funding to accomplish the integration of the ODP motor-driven core barrel (MDCB) inner core tube with the Schlumberger/Anadrill RAB landing sub for use on Leg 204. This activity will be accomplished at no additional cost to the NETL cooperative agreement with JOI.

Discussions were held between ODP engineers and FUGRO engineers regarding the proposed modifications to the FUGRO Piezoprobe tool for use with the ODP APC/XCB bottom hole assembly (BHA) on ODP Leg 204 (July 8 through September 6, 2002). A meeting was held in College Station, TX on February 28, 2002 to discuss the lay out, space out, and completion of crossover subs for the piezoprobe deployment and to outline possible operational scenarios for the deployment and testing of the tool on Leg 204. A second meeting was held at the FUGRO offices in Houston on March 7, 2002. Following this meeting additional drawings and technical specifications regarding the tool and the ODP BHA were exchanged.

This report will present an overview of the primary methods used for deploying the ODP memory tools and PCS on ODP Leg 201 and the preliminary operational results of this leg. Discussions regarding the laboratory analysis of the recovered cores and downhole measurements made during these deployments will be covered in a future progress report.

EXPERIMENTAL

During Leg 201, several individual downhole tools were deployed to better characterize the subsurface lithologies and environment hosting downhole microbial populations as part of the primary goals of this leg. Methane hydrate was also sampled in one of the sites drilled. DOE/NETL funding was used by JOI/ODP to upgrade or modify many of these downhole tools so that they could be used to better characterize methane hydrates on this leg, as well as on ODP Leg 204 in July 2002. The following sections of this report provide background information and operational summaries provided by the engineers and scientists who participated on ODP Leg 201 to deploy these systems and tools.

Temperature is also a key factor affecting the stability of methane hydrate deposits in the sub-seafloor. Pore pressure measurements are also important because if the pressure gradient differs from hydrostatic then fluid flow may increase the supply of dissolved substrates to subsurface microbial populations and influence the concentrations of dissolved gases and methane hydrates at in situ conditions.

In situ sediment thermal measurements were made during Leg 201 using the (Adara) APC-Temperature tool and the Davis-Villinger Temperature Probe (DVTP) (Davis et al., 1997). Formation pore pressures were measured using a DVTP that had been modified to include a pressure port and sensor that was initially tested during ODP Leg 190. Samples for dissolved gas and methane hydrates were collected with the Pressure Core Sampler (PCS). The instruments and procedures used on ODP Leg 201 are summarized below.

APC-Temperature Tool

The (Adara) APC-Temperature tool fits directly into the cutting shoe on the APC and can therefore be used to measure sediment temperatures during regular piston coring. The tool consists of electronic components, including battery packs, a data logger, and a platinum resistance-temperature device calibrated over a temperature range of 0°–30°C. A photograph of the components can be found in Fisher and Becker (1993). The thermal time constant of the cutting shoe assembly into which the Adara tool is inserted is ~2–3 minutes. The only modification to normal APC procedures required to obtain temperature measurements is to hold the corer in place for ~10 minutes after cutting the core. During this time, the Adara tool equilibrates toward the in situ temperature of the sediments. The Adara tool logs data on a microprocessor contained in the instrument. Following deployment, the data are downloaded for processing. The tool can be preprogrammed to record temperatures at a range of sampling rates. Sampling rates of 5 seconds per measurement were used during Leg 201. A typical APC measurement consists of a mudline temperature record lasting 10 min for the first deployment at each borehole and 2 minutes on subsequent runs. This is followed by a pulse of frictional heating when the piston is fired, a period of thermal decay that is monitored for 10 minutes, and a frictional pulse upon removal of the corer. Before reduction and drift corrections, nominal accuracy of Adara temperature data is estimated at 0.º C.

Davis-Villinger Temperature Probe

The temperature measurement protocol of the Davis-Villinger Temperature Probe (DVTP) is described in detail by Davis, et. al. (1997). The probe is conical and has two thermistors, one 1 centimeter from the tip of the probe and the other 12 centimeters above the tip. A third thermistor, referred to as the internal thermistor, is in the electronics package. Thermistor sensitivity is 1mK in an operating range of –5° to 20° C, and the total operating range is –5° to 100° C. The thermistors were calibrated at the factory and on the laboratory bench before installation in the probe. In addition to the thermistors, the probe contains an accelerometer sensitive to 0.98 m/s^2. The peak and mean values for acceleration of the probe are both recorded by the logger. The accelerometer data are used to track disturbances to the instrument package during the equilibration interval. In a DVTP deployment, mudline temperatures (within the drill pipe) are measured for 10 min during the first run in each hole and for 2 minutes during subsequent runs, before descent into the hole for a 10-minutes equilibration interval in the bottom. The time constants for the sensors are ~1 minutes for the probe tip thermistor and ~2 minutes for the thermistor at 12 centimeters from the tip. Only data from the probe tip thermistor were used for estimation of in situ temperatures.

Thermal Data Reduction

Similar data reduction procedures were used for the three temperature tools. The transient thermal decay curves for sediment thermal probes are known to be a function of the geometry of the probes and the thermal properties of the probe and the sediments (Bullard, 1954; Horai and Von Herzen, 1985). Analysis of data requires fitting the measurements to analytical or synthetic decay curves calculated based on tool geometry, sampling interval, and tool and sediment thermal properties.

For the DVTP tool, thermal decay data are analyzed by comparison to calculated type curves using the software program CONEFIT, developed by Davis et al. (1997). Unfortunately, it is generally not possible to obtain a perfect match between the synthetic thermal decay curves and the data collected. This is because: (1) the probe does not reach thermal equilibrium during the penetration period; (2) contrary to ideal theory, the frictional pulse upon insertion is not instantaneous; and (3) temperature data are sampled at discrete intervals, so that the exact time of penetration is uncertain. Thus, both the effective penetration time and equilibrium temperature must be estimated by applying a fitting procedure, which involves shifting the synthetic curves in time to obtain a match with the recorded data. The data collected more than 20–50 seconds beyond penetration usually provide a reliable estimate of equilibrium temperature. The thermal decay curves for the measurements were initially fit on board assuming formation thermal conductivity of 1.0 W/° K) for all of the data. Thermal conductivities measured aboard the ship were used for final estimation of in situ temperatures and for calculation of heat flow. Laboratory thermal conductivity measurements were not corrected for in situ conditions.

Davis-Villinger Temperature Probe with Pressure

Simultaneous measurement of formation temperature and pressure was achieved using modified DVTP. The probe has a tip that incorporates both a single thermistor in an oil-filled needle and ports to allow hydraulic transmission of formation fluid pressures to a precision Paroscientific pressure gauge inside. A standard data logger was modified to accept the pressure signal instead of the second thermistor signal in the normal DVTP described above. Thermistor sensitivity of the modified tool is reduced to 0.02° K in an operating range of –5° to 20° C.

Deployment of the tool consists of lowering by wireline to the mudline where there is a 10-min pause. Subsequently, the tool is lowered to the base of the hole and latched in at the bottom of the drill string, with the end of the tool extending 1.1 meters below the drill bit. The extended probe is pushed into the sediment below the bottom of the hole and pressure recorded for 30 min or as long as deemed operationally safe. If smooth pressure decay curves are recorded after penetration, then extrapolations to in situ pore pressures are possible. This pressure response is qualitatively similar to but slower than the thermal response. The model for the characteristic response of pressure to the displacement and sediment deformation associated with penetration is more complex than the model used to estimate in situ temperatures from the decay of the frictional heating pulse.

Pressure Core Sampler

Large quantities of gas can escape sediment cores when a drop in pressure or increase in temperature during recovery lowers methane saturation (Wallace et al., 2000). Based on previous drilling during Legs 112 and 138, significant gas loss was expected to occur at two or more of the proposed sites. Visible gas escape structures appeared in cores between 58 mbsf and 62 mbsf and below 30 mbsf at (ODP Leg 112) Sites 681 and 685, respectively. High headspace methane concentrations (>1000 L/L), which may signify gas concentrations approaching or exceeding saturation at depth, also were present at these two sites and at Site 684.

The pressure core sampler (PCS) is a downhole tool designed to recover a 1385-cm^3 cylindrical sediment core—including gas and interstitial water—at in situ pressure (Pettigrew, 1992). When its valves seal properly, controlled release of pressure from the PCS through a manifold (below) permits collection of gases that would otherwise escape during the wireline trip. The PCS currently provides the only proven means to determine in situ gas abundance in deep-sea sediments where gas concentrations at depth exceed saturation on the ship (Dickens et al., 1997, 2000).

To date, the PCS has only been successfully used to capture and analyze in situ gases during Leg 164 (Paull et al., 1996; Dickens et al., 1997). Consequently, interest and use of the PCS during ODP Leg 201 was driven by two objectives: (1) to quantify gas abundance at Leg 201 sites, especially along the Peru margin, and (2) to ensure that the tool was fully operational for upcoming legs targeting gas-rich sediments. One problem encountered during Leg 164 was that the tool consistently collected a longer core with a push-in (APC-style) cutting shoe instead of a rotary auger (XCB-style) cutting shoe (Paull et al., 1996; also see Rack, 2001). Thus, prior to Leg 201, there were several significant changes to the PCS design. The first was to add three optional cutting shoes for rotary coring including: (a) an auger-type shoe with carbide cutters, (b) a tapered auger with polycrystalline diamond (PDC) cutters, and (c) a PDC cutting shoe. Second, to minimize wash at the cutting shoe, it was extended to ~0.5 m ahead of the XCB bit. Lastly, the core barrel was increased to an effective 1 meter length (4.32 centimeter diameter; core = 1465 cm^3).

The PCS manifold is an assembly of pipes and valves that allows stepwise release of gas at high pressure for collection and analyses at room pressure. Many different manifold systems have been proposed for the PCS (Pettigrew, 1992; Paull et. al., 1996). Following a successful design during Leg 164 (PCS-M4) (Paull et. al., 1996, p. 25), a new PCS manifold was constructed for Leg 201. In general, gases pass from the PCS into a small chamber and then into a 1-Liter bubbling chamber consisting of an inverted graduated cylinder in a plexiglass tube filled with a saturated NaCl solution. Gas aliquots for analysis were removed from a valve at the top of the cylinder using a syringe.

Drilling Operations

Two standard coring systems were used during Leg 201: the advanced hydraulic piston corer (APC), and the extended core barrel (XCB). These standard coring systems and their characteristics are summarized in the “Explanatory Notes” chapters of various previous ODP *Initial Reports* volumes as well a number of technical notes. Most cored intervals were ~9.6 meter long, which is the length of a standard core barrel. In other cases the drill string was drilled, or “washed ahead,” without recovering sediments to advance the drill bit to a target depth where core recovery needed to be resumed.

Drilled intervals are referred to in meters below rig floor (mbrf), which are measured from the kelly bushing on the rig floor to the bottom of the drill pipe, and meters below seafloor (mbsf), which are calculated. When sediments of substantial thickness cover the seafloor, the mbrf depth of the seafloor is determined with a mudline core, assuming 100% recovery for the cored interval in the first core. Water depth is calculated by subtracting the distance from the rig floor to sea level from the mudline measurement in mbrf. This water depth usually differs from precision depth recorder measurements by a few to several meters. The mbsf depths of core tops are determined by subtracting the seafloor depth (mbrf) from the core top depth (mbrf). The resulting core top datums in mbsf are the ultimate reference for any further depth calculation procedures.

RESULTS AND DISCUSSION

ODP Leg 201 began at 0830 hours on 27 January 2002, when the first line was passed ashore at Berth 4 of the 10th Avenue Terminal in San Diego, California. After completing port call activities, the last line was cast off at 0800 hours on 1 February. The pilot and three harbor marshals were discharged at 0910 hours just off Point Loma, and the vessel assumed full speed for the voyage to the first site of Leg 201.

Transit to Site 1225

Because of excellent weather and a favorable current, the 1835-nmi voyage to Site 1225 was accomplished in just 6.6 days at an average speed of 11.7 knots. This led to an arrival on site nearly a full day earlier than scheduled. The vessel arrived on the Global Positioning System (GPS) coordinates for Site 1225 on 7 February at 2115 hours, and we commenced lowering thrusters and hydrophones. After switching into dynamic positioning mode, a positioning beacon was deployed at 2242 hours.

Hole 1225A

While tripping the pipe, a precision depth recorder (PDR) reading was taken using the 3.5-kHz recorder. The site-corrected reading of 3755 meters was adjusted for the distance to the rig-floor dual elevator stool to 3773.4 meters below rig floor (mbrf). The APC core barrel was deployed on the aft wireline, and the bit was positioned at 3767.0 mbrf. Bottom-water temperature was measured with the APC temperature tool (Adara tool). We initiated Hole 1225A at 0840 hours on 8 February. Upon recovery, Core 1H contained 4.30 meters of core, establishing a drill pipe–measured seafloor depth of 3772.2 mbrf. All cores recovered from Hole 1225A were extracted from the drill pipe and transferred as expeditiously as possible to the catwalk to minimize core warming. APC coring continued without incident through Core 19H to a depth of 175.3 mbsf. Core 20H gave a positive full stroke indication; however, because of a 70-kilopound (klb) overpull, the barrel had to be freed by drilling down and over the end of the APC shoe (drill over). Cores 21H and 22H continued with a normal, full-stroke pressure bleed off and required only 30 klb of overpull for extraction from the formation.

Tensor core orientation was initiated with Core 4H and continued through Core 33H. APC-Temperature measurements were recorded before recovery of Cores 5H (42.3 mbsf), 7H (61.3 mbsf), 9H (80.3 mbsf), and 14H (127.8 mbsf). All measurements were successful except that from 42.3 mbsf. Failure of this run was attributed to a tool software fault. The APC-Methane (APC-M) tool was installed in the coring system prior to Core 5H and was run on each core barrel through Core 14H. The tool worked well initially but stopped collecting data after Core 9H. This failure was thought to be the result of a power interrupt that caused the tool to stop logging data.

After Core 22H (203.8 mbsf), we ran the first of three deployments of the DVTP. After recovering the DVTP, we drilled without coring through the disturbed interval (nominally 1.5 meters) to a depth of 205.3 mbsf. We followed the successful temperature probe wireline run with deployment of the new Davis-Villinger Temperature-Pressure (DVTP-P) tool. The first deployment with this tool was unsuccessful, apparently as a result of a clogged filter.

APC coring continued through 27H to a depth of 243.3 mbsf. All coring runs except the last achieved full stroke of the piston, but each barrel required >80 klb overpull, requiring us to use the drill- over technique to facilitate core barrel recovery. Although the driller indicated we did not achieve a full stroke on Core 27H, we opted to drill ahead to a full-stroke length to keep our sampling strategy consistent. A second DVTP wireline run after Core 27H suffered an electronic failure, due to a broken thermistor bulkhead, and did not record a temperature.

Because of the incomplete stroke on 27H, we switched to the XCB coring system. Core 28X returned empty. Core 29P was cut using the newly modified PCS. This tool was being tested for possible use on the Peru margin sites of Leg 201 and also for Leg 204. Core 29P advanced a total of 2.0 meters. Upon recovery, the pressurized chamber was 100% full; the tool recovered 1.0 meters of core under 1200 psi pressure. Another 41 centimeters of unpressurized core was recovered in the bit extender below the ball valve.

In deference to the poor recovery with the XCB and in light of the soft sediment recovered in the bottom of the PCS core barrel, we opted to attempt to deepen the hole with the hydraulic piston core system. Cores 30H through 33H all required drill over after 80 klb overpull failed to release the barrels from the formation. In addition, Core 30H indicated only partial stroke but returned full recovery. After Core 33H, we ran a third DVTP temperature measurement, which was successful. This was followed by a second deployment of the DVTP-P tool after drilling down 1.5 meters to remove the sediment disturbed by the temperature probe. The pressure measurement again failed, and a post-deployment inspection located an internal leak in the pressure transducer line.

With basaltic basement projected at a depth of ~318 mbsf, a final APC core (Core 34H) was recovered after drilling over the shoe because of excessive overpull. Subsequently, we deployed an XCB core barrel in the hope of obtaining ~1.0 meters of basement rock. After contacting basement at ~318.6 mbsf, the driller advanced another 1.0 meters in 15 minutes. Basement was readily identifiable because of an abrupt increase in drilling torque and a significantly reduced rate of penetration. Upon recovery, the XCB core barrel contained 7.25 meters of sediment, with two cobbles of basalt embedded in sediment packed in the core catcher. Rather than deploy another barrel (since we had already drilled >1 meters into basement without recovering the sediment/basalt interface), we chose to conclude coring operations for this hole at 1930 hours on 10 February.

A wiper trip to 80 mbsf followed, sweeping the hole with a 20-bbl sepiolite mud pill. We displaced the hole with 130 bbl of sepiolite in preparation for logging and encountered only 2 m of fill in the bottom of the hole. A single wireline run with the triple combination (triple combo) tool string was completed by 1045 hours on 11 February, and the bit cleared the seafloor at 1110 hours on 11 February, ending Hole 1225A.

In support of the microbiological contamination testing protocol, whirl-pak bags containing full- concentration fluorescent microspheres were deployed with Cores 2H, 12H, 17H, 22H, and 34H. In addition, perfluorocarbon tracers (PFTs) were pumped continuously during coring operations. The rate and quantity of tracer was automatically controlled using an input signal from the Tru-Vu rig instrumentation system.

Hole 1225B

We offset 10 m north of Hole 1225A and spudded Hole 1225B at 1240 hours on 11 February. Subsequent recovery of APC Core 1H was 8.96 meters, establishing a seafloor depth of 3771.0 mbrf. Hole 1225B consisted of a single APC core to provide samples for high-resolution physical properties measurements. Hole 1225B ended with the recovery of Core 1H at 1315 hours on 11 February.

Hole 1225C

After offsetting another 10 m north, Hole 1225C was spudded at 1355 hr on 11 February. Recovery of Core 1H was 8.83 m, establishing a seafloor depth of 3771.2 mbrf. APC coring continued without incident through Core 15H (141.8 mbsf). Core 16H required 10 min to drill over after 80 klb failed to pull the barrel free of the formation. Coring continued using the drill-over technique with all barrels stroking fully through Core 25H. Drill-over time ranged from 20 to 30 min. APC coring resumed with Core 26H and continued through Core 31H (293.8 mbsf). Cores 26H, 27H, 29H, and 30H indicated partial stroke but returned full recovery. Cores 28H and 31H were recovered after indicating that a full stroke had been achieved. Tensor core orientation was initiated with Core 3H and continued through Core 31H.

Core 32P was cut using the pressure core barrel and an auger-style bit. As with the first test conducted in Hole 1225A, coring advanced a total of 2.0 meters (to a depth of 295.8 mbsf), even though the pressure core chamber was only designed to hold 1.0 m of core. Upon recovery, the pressurized chamber was once again 100% full. This time the tool recovered 1.0 meters of core under 4450 psi pressure. There was no core recovered in the bit extender below the ball valve on this deployment.

After completing the second PCS test, Core 33H indicated a full stroke, but our attempts to drill over the bit were thwarted by a bent core barrel. This resulted in a pipe trip, terminating Hole 1225C at a total depth of 305.3 mbsf, 13.3 meters short of the basement objective. Microspheres were deployed with Core 1H, and PFT was pumped continuously during coring operations. By 1930 hours on 13 February, all thrusters and hydrophones had been raised and the ship was secured for transit. Weather and sea state during the occupation of Site 1225 ranged from good to excellent. We experienced no operational difficulties that could be attributed to the environment.

Transit to Site 1226

The 1405-nautical mile transit from Site 1225 to Site 1226 required 130 hours at an average speed of 10.8 knots, arriving on the Global Positioning System (GPS) coordinates of previously occupied Site 846 (ODP Leg 112) at 1100 hours on 19 February.

Hole 1226A

The positioning beacon for Site 1226 was deployed at 1203 hours on 19 February. A pipe trip positioned the bit at 3308 mbsf, and a bottom-water temperature was recorded with the APC-Temperature tool. Core 1H returned full and did not establish a mudline depth, so Hole 1226A was abandoned.

Hole 1226B

After raising the bit to 3303 mbsf, Core 1H recovered 4.4 m of sediment, establishing the mudline at 3308.1 meters below rig floor (mbrf). Continuous APC coring from Core 1H through 29H (0.0–271.9 mbsf) returned 105% recovery. Slow drill over after Core 29H prompted us to change to XCB coring, which continued through Core 41X (271.9–378.0 mbsf), with an average recovery of 91%. Core 42P, cut with the Pressure Core System (PCS) (378.0– 380.0 mbsf) recovered a full 1-meter core, as well as ~40 centimeters in the barrel beneath the pressure chamber. XCB coring continued with Cores 43X through 47X (380.0–421.4 mbsf), with 74% recovery. Hole 1226B was terminated after coring ~1.5 meters into basement.

In addition to the mudline temperature recording, downhole operations at Hole 1226B included APC-Temperature tool measurements on Cores 5H, 7H, 10H, 13H, and 21H (42.4, 61.4, 89.9, 118.4, and 194.4 mbsf, respectively). The APC-Methane (APC-M) tool was run continuously on Cores 5H through 21H (32.9–194.4 mbsf) but stopped recording data after Core 10H. No reason for this interruption in recording could be determined. The Tensor APC orientation tool was used continuously on Cores 3H through 29H. The DVTP was deployed at 262.4 and 310.0 mbsf, and the DVTP-P was deployed at 241.9 mbsf. A single logging run with the triple combination (triple combo) tool string was completed in Hole 1226B by 1100 hours on 23 February. PFT was pumped continually for microbiological contamination testing. Fluorescent microspheres were also deployed on Cores 2H, 5H, 12H, 22H, 34X, 40X, 43X, 46X, and 47X. Operations at Hole 1226B were terminated at 1045 hours on 24 February.

Hole 1226C

Hole 1226 was a mudline core dedicated to physical properties sampling. Core 1H (0.0–7.9 mbsf; recovery = 100%) was spudded 20 meters north of Hole 1226B, and after recovery the hole was abandoned.

Hole 1226D

The vessel was offset 20-meters to the north, and Core 1H (0.0–7.6 mbsf; recovery = 100%) was collected to initiate a second attempt at deep penetration, but upon recovery we discovered that the upper 3 meters of the core was surrounded by water in the core liner and the core appeared to be either slightly under gauge or at least soupy. As an intact mudline core was required for dense interstitial water and microbiological sampling, we deemed this core inappropriate and abandoned Hole 1226D. Fluorescent microspheres and continuous PFT were used on Core 1H.

Hole 1226E

In planning this expedition, we recognized that time on site was to be a critical parameter if we were to complete all our scientific objectives. Our operations plan included the option of spot coring intervals of interest in order to conserve valuable operations time. For Hole 1226E, we determined that intervals of particular interest were the upper 100 m of the section, the top of the interval where XCB coring returned poor material for interstitial water and microbiological sampling (250–320 mbsf), and the lower 40 m of the section (380–420 mbsf). Continuous APC coring from 0.0 to 112.1 mbsf (Cores 1H through 12H) returned an average of 105% recovery.

The interval between 114 and 250 mbsf was then drilled without coring. Continuous APC coring from 250 to 326 mbsf required drilling over the bit but returned superb intact cores. The interval between 326 and 378 mbsf was also drilled without coring. At 378 mbsf, the pressure core system (PCS) was run at the same depth as deployed in Hole 1226B to test a different bit configuration. A nearly full core barrel was recovered (Core 21P), but a piece of chert was jammed in the throat of the tool, preventing recovery under pressure. Four XCB cores (Cores 22X through 25X) (380.0–418.4 mbsf; recovery = 76%) ended operations at this hole.

In order to evaluate the downhole temperature gradient, additional Adara temperature measurements were performed at 45.6, 74.1, and 102.6 mbsf in Hole 1226E. To complete the temperature profile in this hole, the DVTP was deployed at 307 and 400 mbsf, and an in situ pressure measurement was attempted with the DVTP-P at 326 mbsf. PFT was pumped continually for microbiological contamination testing, and fluorescent microspheres were deployed on Cores 1H, 15H, and 16H as part of our contamination testing protocol. Operations at Site 1226 concluded when the bit passed through the rig floor at 1615 hours on 25 February, and we began our transit to Site 1227.

Transit to Site 1227

We made the 745-nautical mile transit between Sites 1226 and 1227 in 63.7 hours at an average speed of 11.7 knots, arriving on location at ~0800 hours on 28 February. Because our drilling target was a small sediment pond, we decided to conduct a brief 3.5-kHz survey in a west-east then north-south cross pattern centered on our projected site coordinates to confirm our position. Based on our survey data, we selected a position 50 meters north of the Site 684 (ODP Leg 112) survey coordinates to begin coring operations at Site 1227. Prior to initiating coring, we affected a personnel and equipment transfer via a Peruvian Navy helicopter.

Hole 1227A

Operations at this hole began with deployment of the water-sampling temperature probe (WSTP) to collect a bottom-water sample and near-mudline water temperature. Upon recovery of the WSTP, we noticed the probe tip had mud impacted in the water sample ports, suggesting that either the tool had embedded below the mudline or the seafloor interface was turbid. Core 1H established the mudline at 438.9 mbrf.

We recognized that the drill crew could deliver cores to the core laboratory at a much faster rate than the cores could be processed, owing to the high-resolution geochemistry we required and the core handling requirements for microbiological sampling. To account for protracted laboratory handling times, we initiated a protocol of slowing core recovery, which required continual communication between the various processing laboratories and the rig floor. In short, coring operations were held in stasis by the drilling crew until word was received from both the chemistry and microbiology processing groups that they were approaching the end of a sample handling program. The rig floor crew would then respond with immediate deployment of the next core barrel. This routine prevented cores from piling up in the laboratories, enhancing our chances of meeting our science objectives.

The first five advanced piston coring (APC) cores (Cores 1H through 5H) (0.0–43.6 mbsf) returned 105% recovery. Hydrogen sulfide monitoring registered measurable quantities of H_2S on core surfaces beginning with Core 2H, and levels rose to as high as 25 parts-per-million in the first few cores. H_2S core handling protocols were initiated after Core 2H. Core flow through the physical properties and description laboratories was radically slowed, as even after perforating the cores, residue of as much as several parts per million of H_2S was detectable on core surfaces several hours after recovery.

Recovery began to deteriorate after Core 5H, as the next several APC barrels (Cores 6H through 8H; 43.6–72.1 mbsf) returned an average of 40%. Through this interval, recovery ranged from as little as 4% to as much as ~70%. In addition, starting with Core 8H, we were required to drill over the APC shoe when we encountered elevated tension when trying to extract core barrels via wireline (overpull). However, we chose to continue to attempt APC coring to as deep as possible, since the extended core barrel (XCB) cores we had recovered from previous sites were so disturbed and XCB coring during Leg 112 had experienced such poor recovery (averaging <15% at this location). After Core 8H and continuing through the bottom of the hole (Cores 9H through 18H; 72.1–151.1 mbsf) recovery improved to average 60%, which allowed us much improved core recovery and quality as compared to operations during Leg 112. Hole 1227A was terminated after impacting a hard layer at 151 mbsf in Core 18H.

Several downhole tool measurements were accommodated by our slowed recovery pace in Hole 1227A. The APC-Temperature (Adara) shoe was deployed on Core 4H. Because the core liner from Core 4H shattered, possibly as a result of the measurement protocol, we abandoned APC-Temperature tool measurements in lieu of DVTP runs for the remainder of the hole. The DVTP was deployed at 81.6 and 110.1 mbsf, and the DVTP-P was deployed at 132 mbsf. Both the PCS and the (HYACE) Fugro pressure corer (FPC) tool were deployed between 128 and 132 mbsf, but neither run was particularly successful, as the only material recovered was a handful of pebbles and shell hash.

Holes 1227B, 1227C, 1227D, and 1227E

Holes 1227B, 1227C, and 1227E were all three-core holes (mudline plus two subsequent penetrations) dedicated to shipboard and shore-based high-resolution sampling. Hole 1227D was drilled to provide high-resolution microbiological and geochemistry sampling and to attempt to improve on recovery records in certain intervals cored in Hole 1227A. Our target depth for this hole was to reach the interval at ~70 mbsf, where recovery improved while APC coring in Hole 1227A. Cores 201-1227D-1H through 5H (0.0–45.5 mbsf) returned 96% recovery. Core 201-1227D-6H (45.5– 55.0 mbsf) was nearly full (recovery = 96%), but a shattered core liner resulted in severe core disturbance in the lower two- thirds of the core. Core 201-1227D-7H also returned with a shattered core liner and only a handful of pebbles and shell hash. In addition, the end of the APC cutting shoe showed evidence of impact with a hard ground. Coring operations were terminated in Hole 1227D when Core 201-1227D-8H (64.5–74 mbsf) delivered an incomplete stroke and returned only 1.7 m of core. The APC-Methane (APC-M) tool was deployed on Cores 201-1227D-1H through 7H.

After recovering three cores from Hole 1227E (Cores 201-1227E-1H through 3H) (0.0–25.9 mbsf; recovery = 101%) that were not split and that were end-capped without acetone but with tape, we deployed the FPC tool. This strategy allowed a test of the HYACE tool in an interval where we were confident that the lithology contained more abundant clay and less abundant sand and pebbles. Operations at Site 1227 concluded when the bit passed through the rig floor at 0245 hours on 3 March, and we began a short transit to Site 1228.

Transit to Site 1228

The 167-nautical mile transit between Sites 1227 and 1228 took 15.8 hours at an average speed of 10.6 knots. A positioning beacon was deployed at 1900 hours on 3 March, ~75 meters north of the Global Positioning System (GPS) coordinates of Site 680 (ODP Leg 112) in 273.6 meters water depth (below rig floor). The vessel was moved to a position 50 meters north of these coordinates to begin operations at Site 1228.

Hole 1228A

Continuous APC coring was initiated with Core 1H, which arrived on deck at 2155 hours on 3 March. Coring continued through Core 23P (0.0–200.9 mbsf) with 68% recovery. Cores 1H through 8H (0.0– 71.4 mbsf) had average recovery in excess of 100%, with the exception of Core 5H (recovery = 80%). Core 6H had a full core barrel, but the liner was shattered, resulting in a severely disturbed core. Cores 9H through 23P (71.4–200.9 mbsf) were variably successful in terms of recovery, ranging from empty barrels (Core 17H), to poor recovery intervals with soupy cores (Cores 11H, 12H, 15H; all <20% recovery), to cores with as much as 95% recovery of intact sediment. Core 10H did not advance and returned to the rig floor with the shear pins scored but not broken. We interpreted this to suggest that the bit was resting on a hard layer, obstructing penetration of the barrel. The core barrel was deployed again with the bit raised to 1 m off bottom so as to provide momentum for the piston core prior to penetration. The barrel still would not extend beyond the bit, indicating that there was an obstruction inside the throat of the BHA. An extended core barrel (XCB) was deployed to dislodge the obstruction, but the subsequent APC barrel (still identified as Core 10H) only pushed a short distance out of the bit and returned an intensely disturbed, low-recovery core. We drilled to the equivalent depth of a full piston stroke (9.5 meters) and deployed Core 11H, which also misfired because of impact with a hard interval, and returned a core in much the same condition as the previous one comprising a mixture of mud, sand, and gravel. While discussing our operational strategy, we deployed the Hydrate Autoclave Coring Equipment (HYACE) FPC tool (Core 13M) (109.4–110.4 mbsf; recovery = 40%), which returned a collapsed core barrel partially filled with gravel at ambient pressure.

Since our science objectives would be better served with a few meters of intact APC recovery than with any partial recovery the XCB might return, we chose to continue APC advancement, recovering what material we could and drilling down through multiple hard intervals. Recovery was sporadic (Cores 14H through 22H; 110.4–194.9 mbsf), but in most cases we recovered sufficient intact core to meet our microbiological and geochemical objectives. Hole 1228A was terminated when the Pressure Core System (PCS) cutting shoe dislodged and stuck in the bottom of the hole.

The DVTP tool was deployed at 42.9, 80.9, 147, and 194.9 mbsf and the Davis-Villinger Temperature Probe with Pressure (DVTP-P) tool at 99.9 and 196.9 mbsf. We attempted to collect bottom-water samples with the water sampling temperature probe (WSTP) just above the mudline before beginning operations and after Core 1H, but both attempts suffered mechanical failure. A mudline temperature was measured with the Adara temperature tool before collecting Core 1H. A logging run with the triple combo tool string was completed in Hole 1228A. PFT was pumped continually during all coring operations at Site 1228 as part of our microbiological contamination testing protocol. In addition, fluorescent microspheres were deployed on Cores 2H, 5H, 11H, and 12H to help assess the potential of contamination in cores where heavy microbiological sampling was planned.

Holes 1228B, 1228C, 1228D, and 1228E

Since the location of the positioning beacon was ~20 meters due north of the location of Hole 1228A and we were operating in shallow water, we were required to arrange our subsequent occupations relatively close to the beacon, while avoiding drilling into it. Offsets of 22 meters north-northeast, 13 meters north- northwest, 12 meters northwest, and 20 meters north were chosen for Holes 1228B, 1228C, 1228D, and 1228E, respectively.

Hole 1228B comprised six continuous APC cores (Cores 201-1228B-1H through 6H; 0.0–54.3 mbsf) and returned 107% recovery. The upper five cores were sampled for shipboard high-resolution paleooceanography and paleomagnetics objectives. In addition, Core 201-1228B-6H was taken to fill in gaps in the continuous geochemical and microbiological profile from Hole 1228A. The HYACE tool was deployed at the bottom of Hole 1228B (Core 201-1228B-7P; 55.3–55.0 mbsf) and recovered 0.42 meters of sediment.

The last three holes drilled at this site were cored for high-resolution shorebased sampling (Hole 1228D: Cores 201-1228C-1H through 3H [0.0–27.0 mbsf; recovery = 101%]) and shipboard geochemistry and microbiology (Hole 1228C: Core 201-1228C-1H [0.0–7.5 mbsf; recovery = 100%], and Hole 1228E: Core 201-1228E-1H [0.0–7.3 mbsf; recovery = 100%]). A WSTP sample was collected above the mudline in Hole 1228E. The Fugro pressure corer (FPC) was deployed at the bottom of Hole 1228E (Core 201-1228E-2M; 7.3–8.3 mbsf). In addition to continuous PFT contamination monitoring, fluorescent microspheres were deployed on Core 201-1228E-1H. Operations at Site 1228 ended when the bit passed through the rig floor at 1200 hours on 6 March, and we began our short transit to Site 1229.

Transit to Site 1229

Sites 1228 and 1229 are 9 nautical miles apart, so the transit between them only required an hour, and a positioning beacon was deployed at 1330 hours on 6 March.

Hole 1229A

Our first operation at Site 1229 was deployment of the water sampling temperature probe (WSTP) to collect a bottom-water sample. A short in the electronics prevented the tool from functioning properly, and an in-line capacitor was installed in the tool to prevent similar failures in future deployments. Continuous advanced piston coring (APC) through Core 4H (0.0–33.4 mbsf) returned 98% recovery. The signal from a DVTP temperature measurement at this depth appears noisy, but a severe current was rattling the drill pipe and the formation may have been unsuitable to sufficiently seal the tool in the sediment. APC coring continued to 58.9 mbsf (Cores 5H through 7H), where we intended to make another DVTP measurement, but poor recovery in the last two cored intervals above this depth prompted us to delay this effort. Recovery improved on the next two cores (Cores 9H and 10H) (58.9–77.9 mbsf; recovery = 98% recovery), so the DVTP and the DVTP-P were deployed after Cores 9H and 10H, respectively.

As we experienced significant overpull while extracting Cores 9H and 10H, mud pills were pumped after each subsequent core to clean the hole, and we began operating in a drill-over mode. High recovery continued through Core 12H (77.9–107.9 mbsf; recovery = 96%), followed by a third DVTP temperature measurement. Cores 13H and 14H (107.9–126.9 mbsf) had somewhat poorer results (average recovery = 75%). The next three cores (Cores 15H through 17H; 126.9–155.4 mbsf) returned only severely disturbed cores comprised of gravel and mud. Based on this result, we aborted a planned deployment of the FPC tool. Since our goal was improved recovery in the lower part of the section as compared to Leg 112, we drilled through this interval and attempted two APC barrels (Cores 18H and 19H; 155.4–174.4 mbsf), which returned an interval satisfactory for geochemical and microbiological sampling. Core 20M was a deployment of the FPC tool. Cores 21H and 22H took us near our depth objective (194.4 mbsf), but we again experienced poor and disturbed recovery in muddy gravel, so we opted not to perform planned pressure and temperature measurements at this interval and aborted an additional run of the FPC tool as well. Operations at Hole 1229A concluded with logging the entire cored interval using the triple combo tool string.

Perfluorocarbon tracers were pumped continuously in all holes at Site 1229 as part of our contamination monitoring protocol. In addition, fluorescent microspheres were deployed on Cores 2H, 3H, 4H, 6H, 9H, 16H, 17H, 19H, and 22H. Elevated H_2S (as high as 50 ppm) was measured with handheld detectors at the rig floor and on the catwalk for the upper part of the cored interval, although H_2S was undetectable below 30 mbsf. Nevertheless, alert precautions were maintained throughout coring at this site.

Hole 1229B

Using the dynamic positioning system, we offset 5 meters north from Hole 1229A to initiate Hole 1229B. We were restricted in offset distance and direction in order to maintain a reasonably clean signal from the positioning beacon in shallow water. The upper three cores from this hole (Cores 1H through 3H) (0.0–24.4 mbsf; recovery = 102%) were dedicated to shore-based paleooceanography studies, so the cores were not split and the end caps were sealed with tape rather than acetone. Operations at Hole 1229B were concluded with a deployment of the FPC tool at 24.4 mbsf. During this deployment, the tool was damaged beyond our capacity to repair at sea, so no more deployments were planned.

Holes 1229C and 1229D

After an offset of 20 meters west from Hole 1229B, operations began at Hole 1229C with a WSTP deployment, which returned a bottom-water sample. High-resolution sampling of the upper few meters of the sediment column was one of our objectives for this hole, so when Core 201-1229C-1H returned with the upper end of the core liner collapsed and the mudline disturbed, we terminated the hole. A second mudline attempt, offset by 5 meters west-northwest (Core 201-1229D-1H) (0.0–6.8 mbsf; recovery = 100%), was suitable for our sampling plan and initiated Hole 1229D.

Continuous APC coring continued through Core 201-1229D-9H (to 77.8 mbsf) with 81% average recovery. The core liner on Core 201-1229D-8H was shattered, resulting in a severely disturbed core. A PCS deployment on Core 201-1229D-10H returned under hydrostatic pressure and contained a mixture of air and methane. An interval between 85 and 90 mbsf that fell at the junction between cored intervals in Hole 1229A was determined by geochemical analysis to be of particular interest, so we asked the drilling crew to optimize our chances of complete recovery of this interval in Hole 1229D. Core 201-1229D-11H was shot from 5 m above the bottom of the hole, thus advancing only 4.5 m to 84.3 mbsf. The subsequent Core 201-1229D-12H bridged the interval of interest, and although the core was partially disturbed, sufficient intact material was recovered to sample for geochemistry and microbiology. Cores 201-1229D- 13H through 15H (0.0–115.8 mbsf; recovery = 72%) completed operations at Hole 1229D.

Hole 1229E

For our final penetration at Site 1229, we offset 20 meters west of Hole 1229D. Continuous APC coring from Core 1H through 13H (0.0–121.5 mbsf; recovery = 82%) was interrupted only by a short deployment of the DVTP at 83 mbsf to augment our thermal profile at this site. Operations at Site 1229 concluded when the bit passed through the rig floor at 0700 hours on 10 March, and we began our transit to Site 1230.

Transit to Site 1230

The 187-nautical mile sea voyage between Sites 1229 and 1230 lasted 16.6 hours at a speed of 11.3 knots. We arrived on the Global Positioning System (GPS) coordinates for Site 685 (ODP Leg 112), just after midnight on 11 March. After a positioning beacon was deployed, the pipe trip to bottom in 5097 meters water depth required 11 hours.

Hole 1230A

We began operations at Hole 1230A, offset 50 meters north of the Site 685 coordinates, with a water sampling temperature probe (WSTP) deployment to collect a water sample. The APC-Temperature shoe was included on the core barrel assembly for Core 1H to measure the temperature at the mudline. The first core at Site 1230 (Core 1H) (0.0–4.8 mbsf; recovery = 100%) arrived on deck at 1645 hours on 11 March. Continuous advanced piston coring (APC) operations through Core 6H returned an average of 103% recovery. Low levels of H_2S were measured with handheld detectors on the first three cores, and H_2S safety protocols were observed. H_2S was not detected in cores recovered from below 33 mbsf. Cores recovered from below 33 mbsf all showed evidence of gas expansion, which appeared to increase in severity downhole, so precaution against explosive core liner rupture (perforating the core liners with a handheld drill) was continued through the rest of our coring operation.

The PCS was deployed on Core 7P (52.3 mbsf) and returned a full barrel under pressure. Continuous APC coring followed through Core 15H (to 127.3 mbsf). We were able to advance much farther with piston coring than was achieved during Leg 112 because of our technological advancements in APC operations. Recovery in this interval was in excess of 100%, despite an apparent less than full stroke on the piston coring system (measured by drill-over depth), due to core expansion. Core 16P (PCS) (127.3–129.3 mbsf) also returned a full core barrel under pressure. Cores 17H through 19H (129.3–156.8 mbsf) returned progressively poorer recovery (recovery = 54%–34%) in expanded cores. Core 20P (156.8–158.8 mbsf) recovered 65 centimeters of poorly consolidated core under pressure.

Cores 21H through 24H (158.8–196.8 mbsf) suffered incomplete stroke and poor recovery (recovery = 7%–44%), but we continued our strategy of drilling through 9.5-meter intervals. Another PCS deployment (Core 25P; 196.8–198.8 mbsf) recovered 18 cm of core under pressure. Four more APC cores (Cores 26H through 29H; 198.8–226.3 mbsf) were also interpreted as incomplete deployments, with the APC shoe coming free after only a meter or so of drill-over. These cores returned an average of <1.5 meters of core. After deployment of Core 28H, we decided to use a center bit while drilling to the full- stroke depth in order to avoid clogging the bottom-hole assembly (BHA). The subsequent Core 29H returned only 0.5 meters of core, so to supplement recovery for pore water analysis we chose to core to the next APC deployment depth with the extended core barrel (XCB). Only 3.3 meters of advancement was possible with Core 30X, which returned 1.78 meters of core. Another XCB barrel was deployed to determine if the reason for poor penetration was due to clay buildup on the XCB bit or if the main bit was not capable of further penetration. After cutting though a hard layer (part which was recovered in the top of Core 31X; 229.6–234.1 mbsf), we decided to continue the approach of APC coring and advancing by recovery, followed by XCB coring of the underlying interval. Two short APC strokes returned <1 meters each of core, but Core 35X was nearly full (recovery = 99%) of semisoft sediment. The PCS was deployed as Core 36P (254.6–256.6 mbsf), followed by two XCB cores (Cores 37X and 38X; 256.6–276.8 mbsf). Based on the results of the Core 36P (reduced pressure and gas content as compared to shallower deployments), we deployed the pressure core barrel as our final coring tool in Hole 1230A (Core 39P; 276.8–278.8 mbsf).

PFT was pumped continuously during all coring operations at Site 1230 as part of our contamination testing, and fluorescent microspheres were deployed on Cores 1H, 2H, 8H, 13H, and 38X. The DVTP was deployed at 33, 80, 148, 178, and 256 mbsf. Only the deployments at 33 and 256 mbsf returned data consistent with a reasonable thermal profile. All other deployments either failed to return any data or provided low temperatures indicative of poor penetration of the probe tip into stiff sediment. The Davis-Villinger Temperature-Pressure (DVTP-P) tool was deployed at 258 mbsf. A wireline logging program consisting of two runs, one with the triple combo tool string and a second with the Formation MicroScanner (FMS)-sonic tool string, completed operations at Hole 1230A. Logging was completed by 2200 hours on 16 March.

Hole 1230B

After an offset of 20 meters north, Hole 1230B was initiated at 2300 hours on 16 March. The interval from about 3 mbsf to 11 mbsf was of the most intense interest to shipboard scientists, so we wanted this interval recovered in a single core barrel. Core 1H returned 5.4 meters, but we used this information to place the bit at 3 mbsf (resulting in a recorded recovery for Core 1H of 179%). The interval between 3.0 and 5.8 mbsf is thus represented twice in our recovery.

Our operations plan for this hole included three deployments of the PCS to complete the shallow portion of the gas profile initiated in Hole 1230A. Coring continued with Core 3H (12.5–22 mbsf; recovery = 105%) and pressure core barrel Core 4P (22.0–24.0 mbsf). APC coring to 71.5 mbsf (Cores 5H through 9H) returned 107% recovery. Core 10P (71.5–73.5 mbsf) returned 99 cm of core under pressure. APC coring to 100 mbsf reached our depth objective for this hole, and coring operations ended with a final deployment of the PCS (Core 14P; 102.0–104.0 mbsf). The DVTP was deployed at 73.5 and 100.0 mbsf and the DVTP-P at 101.5 mbsf.

Holes 1230C, 1230D, 1230E

Three shallow holes were cored (two APC cores each in Holes 1230C and 1230D, and four APC cores in Hole 1230E), to provide samples for dense microbiological sampling

(Hole 1230C), paleoceanography and paleomagnetics studies (Hole 1230D), and to ensure that material representing the shallow part of the interval cored at Site 1230 was preserved in the Ocean Drilling Program (ODP) archive (Hole 1230E).

Fluorescent microspheres were deployed on Cores 201-1230C-1H and 2H. The Adara tool measured a mudline temperature before Core 201-1230E-1H and a temperature at 33 mbsf on Core 201-1230E-4H. A final PCS deployment was completed at the base of Hole 1230E (34.0–36.0 mbsf). Operations at Site 1230 concluded when the bit passed through the rig floor at 0820 hr on 19 March, and we began our transit to our final site for Leg 201.

Transit to Site 1231

The 191-nautical mile sea voyage between Sites 1230 and 1231 lasted 18.2 hours at an average speed of 10.2 knots. A positioning beacon was deployed over the Global Positioning System (GPS) coordinates of Deep Sea Drilling Project (DSDP) Site 321 in 4824.9 mbrf water depth.

Holes 1231A and 1231B

Hole 1231A was initiated at 0300 hours on 20 March. When Core 201-1231A-1H returned full, we could not determine the mudline so the hole was abandoned. The first core from Hole 1231B (Core 201- 1231B-1H) (0.0–3.4 mbsf; recovery = 100%) was initiated by pulling the bit ~5 meters above the bit depth of Core 201-1231A-1H. Recovery established the mudline at 4824.0 mbrf. Continuous advanced piston coring (APC) through Core 201-1231B-12H (3.4–107.9 mbsf) returned 102% recovery.

After a final deployment attempt of the DVTP-P at 107.9 mbsf, we drilled out the interval disturbed by the probe tip (to 109.4 mbsf) and fired Core 201-1231B-13H, which only returned 5 meters of core with small chips of basalt in the core catcher. Fearing we had struck basement (some 9.5 meters shallower than reported in the core summary table for Leg 34) we deployed the extended core barrel (XCB), which immediately showed indication of hard basement (slow penetration and high, erratic torque). After 2 hours, we had advanced <3 meters, so we recovered the core barrel (Core 201-1231B-14X; 114.4–117.3 mbsf), which returned only a few pieces of basalt. Having reached our basement target, we terminated Hole 1231B.

Perfluorocarbon tracers (PFT) were pumped continuously during all coring operations at Site 1231. In addition, fluorescent microspheres were deployed on Cores 201-1231B-1H and 201-1231B-1H, 2H, 6H, 12H, and 14X. The (Adara) APC-Temperature tool was deployed at the mudline and at 41.4, 50.9, 88.9 and 114.4 mbsf.

Hole 1231C and 1231D

Two cores were recovered to support high-resolution paleoceanographic and paleomagnetic studies (Cores 201-1231C-1H and 2H; 0.0–15.1 mbsf). Because heavy microbiological and geochemical whole-round core sampling depleted a significant part of the recovery at Hole 1231B, we chose to recover a complete section (Cores 201-1231D-1H through 13H and 14X [0.0–121.9 mbsf; recovery = 92%]) at this site in support of shipboard and shorebased solid phase sampling. The APC-Temperature tool was deployed at 74.3 and 102.8 mbsf in Hole 1231D.

We noted an interval in the DSDP Site 321 lithostratigraphic column that reported 9.5 meters (between 96.5 and 106.0 mbsf) as uncored. The sediments above and below this interval in our recovery are similar in appearance to those described in the DSDP Leg 34 site report. The time on deck between cores surrounding the reported uncored interval is recorded as 1.5 hours, which was similar to our wireline time in this water depth, suggesting little time was spent on drilling without coring. We can only surmise that there was a recording error in the coring summary table that was accounted for in the lithostratigraphic column as a coring gap, but that the basement contact at Site 321 is at the same depth as at Site 1231.

Hole 1231E

Our final operation for Leg 201 was recovery of a complete section to sample specific intervals for high-resolution microbiology and geochemistry. Cores 1H through 14H (0.0–119.0 mbsf; recovery = 100%) ended with a final penetration into basement. The APC-Temperature tool was deployed at 98 mbsf. Operations for Leg 201 ended when the bit passed through the rig floor at 1600 hours on 23 March, and we began our ~5-day transit to Valpariso, Chile to end the leg.

CONCLUSION

The primary accomplishments of the JOI Cooperative Agreement with DOE/NETL in this quarter were the deployment of tools and measurement systems for testing on ODP Leg 201, which was designed to study the deep subsurface biosphere and investigate gas hydrate deposits on the Peru margin. Additional accomplishments were related to the continuing evolution of the required tools and measurements systems that will be needed for future deployments on ODP Leg 204, Hydrate Ridge, offshore Oregon in July 2002.

The ODP Pressure Core System (PCS) was deployed 17 times during ODP Leg 201 and successfully retrieved cores from a broad range of lithologies and sediment depths along the Peru margin. Eleven deployments were entirely successful, collecting between 0.5 and 1.0 meters of sediment at greater than 75% of hydrostatic pressure. The PCS gas manifold was used in conjunction with the PCS throughout ODP Leg 201 to measure the total volume and composition of gases recovered in sediment cores, and especially in those cores associated with methane hydrate.

The DVTP, DVTP-P, APC-Methane, and APC-Temperature tools (ODP memory tools) were used extensively during ODP Leg 201 aboard the D/V JOIDES *Resolution*, and preliminary reports indicate numerous successful deployments of all of these tools. These systems will provide a strong operational capability for characterizing the in situ properties of methane hydrates in subsurface environments on Hydrate Ridge during ODP Leg 204, as well as in other offshore sedimentary environments.

The deployment of modified downhole measurement tools and pressure core sampling systems on ODP Leg 201 provides a wealth of experience for meeting the challenges of a dedicated hydrate coring program on ODP Leg 204 on Hydrate Ridge, offshore Oregon during July through September of 2002.

REFERENCES

Bullard, E.C., 1954. The flow of heat through the floor of the Atlantic Ocean. *Proc. R. Soc. London A,* 222:408–429.

Davis, E.E., Villinger, H., MacDonald, R.D., Meldrum, R.D., and Grigel, J., 1997. A robust rapid- response probe for measuring bottom-hole temperatures in deep-ocean boreholes. *Mar. Geophys. Res.,* 19:267–281.

Dickens, G.R., Paull, C.K., Wallace, P., and the ODP Leg 164 Scientific Party, 1997. Direct measurement of in situ methane quantities in a large gas-hydrate reservoir. *Nature,* 385:427–428.

Dickens, G.R., Wallace, P.J., Paull, C.K., and Borowski, W.S., 2000. Detection of methane gas hydrate in the pressure core sampler (PCS): Volume-pressure-time relationships during controlled degassing experiments. In: Paull, C.K., Matsumoto, R., Wallace, P.J., and Dillon, W.P., Proceedings of the ODP, Scientific Results. 164: College Station, TX (Ocean Drilling Program), p. 113-126

Fisher, A.T., and Becker, K., 1993. A guide to ODP tools for downhole measurements. *ODP Tech. Note,* 10; College Station, TX (Ocean Drilling Program).

Horai, K., and Von Herzen, R.P., 1985. Measurement of heat flow on Leg 86 of the Deep Sea Drilling Project. *In* Heath, G.R., Burckle, L.H., et al., *Init. Repts. DSDP,* 86: Washington (U.S. Govt. Printing Office), 759–777.

Paull, C.K., Matsumoto, R., Wallace, P.J., et al., 1996. *Proc. ODP, Init. Repts.,* 164: College Station, TX (Ocean Drilling Program).

Pettigrew, T.L., 1992. The design and operation of a wireline pressure core sampler (PCS). *ODP Tech. Note,* 17.

Rack, F. R., 2001. Task 1.1: - “Preliminary Evaluation of Existing Pressure/Temperature Coring Systems”. Technical Report submitted to DOE/NETL on October 22, 2001 (Joint Oceanographic Institutions, Washington, DC 20036), 739 pp.

Wallace, P.J., Dickens, G.R., Paull, C.K., and Ussler III, W., 2000. Effects of core retrieval and degassing on the carbon isotope composition of methane in gas hydrate– and free gas–bearing sediments from the Blake Ridge. *In* Paull, C.K., Matsumoto, R., Wallace, P.J., and Dillon, W.P. (Eds.), *Proc. ODP, Sci. Results,* 164, 101–112 [CD-ROM]. Available from: Ocean Drilling Program, Texas A&M University, College Station, TX 77845-9547, U.S.A.

LIST OF ACRONYMS AND ABBREVIATIONS

APC	Advanced Piston Corer
BHA	Bottom Hole Assembly
DOE	Department of Energy
DSDP	Deep Sea Drilling Program
DVTP	Davis Villinger Temperature Probe
DVTPP	Davis Villinger Temperature Probe with Pressure
EU	European Union
FMS	Formation MicroScanner
FPC	Fugro Pressure Corer
GPS	Global Positioning System
HRC	HYACE Rotary Corer
HYACE	Hydrate Autoclave Coring Equipment
HYACINTH	Deployment of HYACE tools In New Tests on Hydrates
IODP	Integrated Ocean Drilling Program
IR-TIS	Infrared Thermal Imaging System
ITC	Infrared Training Center
JOI	Joint Oceanographic Institutions
JOIDES	Joint Oceanographic Institutions for Deep Earth Sampling
KHz	Kilohertz
Klb	Kilopound
LDEO	Lamont Doherty Earth Observatory (Columbia University)
L/L	Liters per Liter
LTC	Laboratory Transfer Chamber
MBRF	Meters Below Rig Floor
MBSF	Meters Below Sea Floor
MCDB	Motor Driven Core Barrel
MSCL-V	Multi-Sensor Core Logger - Vertical
NETL	National Energy Technology Laboratory
NSF	National Science Foundation
ODP	Ocean Drilling Program
ODP-LC	Ocean Drilling Program – Logging Chamber
PCS	Pressure Core Sampler
PFT	Perfluorocarbon Tracer
PSI	Pounds per Square Inch
RAB	Resistivity at the Bit
RAB-c	Resistivity at the Bit with Coring
R/V	Research Vessel
TAMU	Texas A&M University
WOB	Weight on Bit
WSTP	Water-Sampling Temperature Probe
XCB	Extended Core Barrel

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