"In-Situ Sampling and Characterization of Naturally Occurring Marine Methane Hydrate Using the D/V JOIDES Resolution."

DOE COOPERATIVE AGREEMENT: DE-FC26-01NT41329

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DISCLAIMER

ABSTRACT

The primary accomplishments of the JOI Cooperative Agreement with DOE/NETL in this quarter were the implementation of a scientific ocean drilling expedition to study marine methane hydrates along the Cascadia margin, in the NE Pacific as part of Integrated Ocean Drilling Program (IODP) Expedition 311 using the R/V JOIDES Resolution and the deployment of all required equipment and personnel to provide the required services during this expedition.

IODP Expedition 311 shipboard activities on the JOIDES Resolution began on August 28 and were concluded on October 28, 2005. New ODP Pressure Coring System (PCS) aluminum autoclave chambers were fabricated prior to the expedition. During the expedition, 16 PCS autoclaves containing pressure cores were X-rayed before and after depressurization using a modified Geotek MSCL-P (multi-sensor core logger-pressure) system. These PCS cores were density scanned using the MSCL-V (multi-sensor core logger-vertical) during depressurization to monitor gas evolution. The MSCL-V was set up in a 20-foot-long refrigerated container provided by Texas A&M University through the JOI contract with TAMRF. IODP Expedition 311 was the first time that PCS cores were examined before (using X-ray), during (using MSCL-V gamma density) and after (using X-ray) degassing to determine the actual volume and distribution of sediment and gas hydrate in the pressurized core, which will be important for more accurate determination of mass balances between sediment, gas, gas hyrate, and fluids in the samples collected.

Geotek, Ltd was awarded a contract by JOI to provide equipment and personnel to perform pressure coring and related work on IODP Expedition 311 (Cascadia Margin Gas Hydrates). Geotek, Ltd. provided an automated track for use with JOI's infrared camera systems. Four auxillary monitors showed infrared core images in real time to aid hydrate identification and sampling. Images were collected from 185 cores during the expedition and processed to provide continuous core temperature data.

The HYACINTH pressure coring tools, subsystems, and core logging systems were mobilized to Astoria, Oregon. Both HYACINTH pressure coring tools, the HRC (HYACE Rotary Corer) and the FPC (Fugro Pressure Corer) were mobilized and used during the expedition. Two HYACINTH engineers supervised the use of the tools and five good pressure cores were obtained. Velocity, density and X-ray linear scanning data were collected from these cores at near *in situ* pressure using the MSCL-P system. Dr. Barry Freifeld from Lawrence Berkeley National Laboratory provided an X-ray source and detector for X-ray imaging of pressure cores and helped Geotek with the design and mobilization of the MSCL-P system. Pressure core handling, transfer, and logging was performed in a refrigerated 20-foot container supplied by Geotek, Ltd. After scanning, the pressure cores were stored for on-shore analysis in aluminum barrels. Additional studies were conducted at the Pacific Geoscience Center (PGC), where a shorebased laboratory was established after Expedition 311.

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INTRODUCTION

The primary accomplishments of the JOI Cooperative Agreement with DOE/NETL in this quarter were the implementation of a scientific ocean drilling expedition to study marine methane hydrates along the Cascadia margin, in the NE Pacific as part of Integrated Ocean Drilling Program (IODP) Expedition 311 using the R/V JOIDES Resolution and the deployment of all required equipment and personnel to provide the required services during this expedition.

The statement of work for this project included three primary tasks: (1) research management oversight, provided by JOI; (2) mobilization, deployment and demobilization of pressure coring and core logging systems, through a subcontract with Geotek Ltd.; and, (3) mobilization, deployment and demobilization of a refrigerated container van that will be used for degassing of the Pressure Core Sampler and density logging of these pressure cores, through a subcontract with the Texas A&M Research Foundation (TAMRF).

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EXECUTIVE SUMMARY

Integrated Ocean Drilling (IODP) Expedition 311 (Cascadia Margin Gas Hydrates) shipboard activities on the JOIDES Resolution began on August 28 and were concluded on October 28, 2005. Five sites formed a cross-margin transect. Pressure coring and core logging was conducted at each site in addition to many other activities.

Site U1325 (Prospectus Site CAS-02C) is located near the southwestern end of the margin perpendicular transect established during IODP Expedition 311. Four holes were occupied at Site U1325. Pressure coring tools were deployed seven times at Site U1325, including two PCS cores, two HRC cores and one FPC core. Pressure coring proved to be extremely difficult at Site U1325, with only the deepest PCS (Core 311-U1325C-10P, 256.5 mbsf) recovered successfully under pressure.

Site U1326 (Prospectus Site CAS-03C) is located on an uplifted ridge of accreted sediments at the southwest end of the multi-site transect established during Expedition 311. At Site U1326, only one PCS core (Core 311-U1326C-12P) was successfully recovered under pressure at a depth of 84.2 mbsf.

Site U1327 (Scientific Prospectus Site CAS-01B) is located near ODP Site 889/890 approximately at the mid-slope of the accretionary prism over a clearly defined BSR, estimated to be at a depth of 223 mbsf. Five holes were occupied at Site U1327. The PCS was deployed eight times at Site U1327 (three in Hole U1327C, three in Hole U1327D, two in Hole U1327E), five of which recovered sediment under pressure. In addition to the PCS deployment, the HRC was used four times (with three core recoveries under pressure) and the FPC was used twice, but only one of the FPC cores was recovered under pressure.

Site U1328 (Scientific Prospectus Site CAS-06A) is located within a seafloor cold-vent field, with dimensions 2 km by 4 km, consisting of at least four vents associated with nearsurface faults. Site U1328 is different than all of the other sites visited during this expedition in that it represents an area of active, focused fluid flow. Five holes were occupied at Site U1328. The PCS was deployed six times at Site U1328 (twice in Hole U1328B, once in Hole U1328C, and three times in Hole U1328E), five of which recovered sediment under pressure. The HRC was used two times and the FPC was used three times, but none of these cores were recovered under pressure.

Site U1329 (Scientific Prospectus Site CAS-05D) is at the eastern end of the southwest-northeast trending, margin-perpendicular, transect of sites occupied during this expedition and is located closest to shore (65 km) at a water depth of 946 mbsl. The location of this site is interpreted to be at the eastern limit of gas hydrate occurrence on the Northern Cascadia Margin. Five holes were occupied at Site U1329. In total six PCS deployments were made, three in Hole U1329C and three in Hole U1329E. Out of the six deployments, two runs did not recover sediment under pressure and all other runs retrieved sediments under pressure, although at measured surface pressures approximately half the expected in-situ hydrostatic pressure. It was concluded that the tool is sealing only when a certain differential pressure is reached, not at the in-situ pressure of the cored interval. One HRC and one FPC were deployed in Hole U1329E. The HRC recovered a full core at near in situ pressure. The FPC deployment recovered a core without pressure.

As part of this cooperative agreement, three aluminum PCS inner core barrels and three aluminum PCS outer core barrels were fabricated to allow X-ray imaging of these cores under pressure. During the expedition, 16 PCS autoclaves containing pressure cores were X-rayed before and after depressurization using a modified Geotek MSCL-P (multi-sensor core logger-pressure) system and were density scanned using the MSCL-V (multi-sensor core logger-vertical) during depressurization to monitor gas evolution. The MSCL-V was set up in a 20-foot-long refrigerated container provided by Texas A&M University through the JOI contract with TAMRF.

Geotek, Ltd. provided an automated track for use with JOI's infrared camera systems. This track was mounted on plywood sheets attached to the catwalk stantions. Four auxillary monitors showed infrared core images in real time to aid hydrate identification and sampling. Images were collected from 185 cores during the expedition and processed to provide continuous core temperature data.

Geotek also provided the HYACINTH pressure coring tools, subsystems, and core logging systems. Both HYACINTH pressure coring tools, the HRC (HYACE Rotary Corer) and the FPC (Fugro Pressure Corer) were mobilized to Astoria, Oregon and used during the expedition. Two HYACINTH engineers supervised the use of the tools and five good pressure cores were obtained. Velocity, density and X-ray linear scanning data were collected from these cores at near *in situ* pressure using the MSCL-P system. Dr. Barry Freifeld from Lawrence Berkeley National Laboratory (LBNL) provided an X-ray source and detector for X-ray imaging of pressure cores and helped Geotek with the design and mobilization of the MSCL-P system. Pressure core handling, transfer, and logging was performed in a refrigerated 20-foot container supplied by Geotek, Ltd. After scanning, the pressure cores were stored for on-shore analysis at the Pacific Geoscience Center (PGC), where a shorebased laboratory was established after Expedition 311. Additional costs were incurred as a result of establishing the shorebased laboratory and shipping pressure core samples internationally. These additional costs were discussed with the DOE-NETL Program Manager for the cooperative agreement and project costs were reassigned by JOI to compensate for these new requirements.

All tasks outlined in the original statement of work were accomplished except for the deployment and use of the X-ray CT system under Subtask 2-2. This reduction in scope provided resources that were applied to other activities to support the overall project. Post-expedition analysis of results and report writing will continue beyond this reporting period, however, all field deployments associated with this project have been successfully concluded as of this writing.

EXPERIMENTAL

The primary accomplishments of the JOI Cooperative Agreement with DOE/NETL in this quarter were the implementation of a scientific ocean drilling expedition to study marine methane hydrates along the Cascadia margin, in the NE Pacific as part of Integrated Ocean Drilling Program (IODP) Expedition 311 using the R/V JOIDES Resolution and the deployment of all required equipment and personnel to provide the required services during this expedition.

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Additional studies were conducted at the Pacific Geoscience Center (PGC), where a shorebased laboratory was established after Expedition 311. The LBNL X-ray CT system was not mobilized to the PGC north of Victoria, B.C., Canada following the expedition to take part in post-expedition experiments. Therefore, Geotek personnel set up the MSCL-V and performed depressurization experiments on hydrate-bearing cores while also collecting gamma density data during core scans. Geotek personnel, assisted by TAMU staff, organized and distributed samples from pressure cores extracted at PGC following the expedition. Additional costs were incurred for these activities and other costs were incurred by the cooperative agreement related to establishing the shorebased laboratory and the logistics of shipping pressure core samples internationally. These additional costs were discussed with the DOE-NETL Program Manager for the cooperative agreement and costs were reassigned internally at JOI to compensate for these new requirements.

All tasks outlined in the original statement of work were accomplished except for the deployment and use of the X-ray CT system under Subtask 2-2. This reduction in scope provided resources that were applied to other activities to support the overall project. Post-expedition analysis of results and report writing will continue beyond this reporting period, however, all field deployments associated with this project have been successfully concluded as of this writing.

RESULTS AND DISCUSSION

OPERATIONAL SUMMARY

IODP HOLE U1329A (Proposed Site CAS-05D)

Hole U1329A was spudded at 18:30 hr on 25 September. LWD/MWD drilling progressed without incident and within the prescribed protocol guidelines reaching the total depth of 220 mbsf at 08:00 hr on 26 September. After displacing the hole with 10.5 pounds per gallon (ppg) mud, the arrival of the last of the tools and the bit on deck at 13:30 hr officially ended operations in Hole U1329A, and we offset 15 m to the north to Hole U1329B.

IODP HOLE U1329B

On the morning of 26 September, we learned that the LWD/MWD-transfer boat had to return to Coos Bay, Oregon twice; once to drop off a sick passenger and the second time because of engine problems. However, the engine problems were not serious and the transfer boat was quickly repaired and left Coos Bay at 10:25 hr. The exchange boat arrived at 16:30 hr on 27 September. Offloading of the tools and personnel transfer was completed and the boat was away at 21:25 hr. While waiting for the boat and during transfer operations, the drill string was tripped to near the seafloor. Hole U1329B was spudded with first core on deck at 21:05 hr, recovering 10.02 m, indicating we did not recover the mudline.

IODP HOLE U1329C

We picked the bit up 5 m higher than for the Hole U1329B spud position, and without offsetting, spudded Hole U1329C. Core U1329C-1H recovered 8.19 m, providing an estimated seafloor depth of 946.4 mbsl (957.4 mbrf), which indicated the bit was over 6 m below the seafloor for the first core in Hole U1329B. APC coring in Hole U1329C continued to 140.2 mbsf (106% recovery) where we switched to XCB coring system and advanced the hole to 188.5 mbsf (82% recovery). Two PCS cores (U1329C-7P and 14P) were collected at 55.6 and 114.6 mbsf, respectively, with Core U1329C-14P recovered without pressure. The third PCS core deployment, Core U1329C-23P, returned to the rig floor at 02:10 hr on 29 September without the bit, which was left in hole. Attempts to drill past it were unsuccessful. Hole U1329C coring was terminated at 189.5 mbsf, ~30 m shy of target depth.

Swell from a nearby low pressure system (> 5 m heave) made conditions too rough to attempt wireline logging or expect quality piston cores from a new hole. Thus, we decided to wait on the weather to improve to continue operations. After four hours of waiting on weather, the morning forecast predicted continued poor conditions throughout the day, but improvement for the following day, so we decided to pull out of Hole U1329C and drill a dedicated logging hole.

IODP HOLE U1329D

We offset 15 m south of Hole U1329A and spudded Hole U1329D at 11:15 hr on 29 September. At 19:55 hr, after drilling Hole U1329D to 165.6 mbsf, ship heave had increased enough (>6 m heave) that we needed to suspend operations again. By 21:30 hr improving conditions allowed us to resume drilling Hole U1329D. After relatively slow drilling (~5 m/hr) in the lower ~35 m, we decided to take a single XCB core (Core U1329D-1X; 1.03 m recovered) at the bottom of Hole U1329D, which was completed to a total depth of 210.5 mbsf at 10:15 hr on 30 September. After reaching total depth in Hole U1329D, we switched over to the wireline logging program. The first tool deployed was the standard triple-combo, which was able to reach a depth of 209 mbsf and the hole was logged without incident. The second logging run consisted of two passes of the FMS-sonic tool. On the first lowering the FMS-sonic tool reached a depth of 209 mbsf, but on the second lowering the FMS-sonic tool only reached a depth of 171 mbsf. The caliper log showed that parts of the hole were severely enlarged. The wireline tools were recovered, the hole was displaced with 10.5 ppg mud, and we pulled out of the hole, clearing the seafloor at 00:20 hr ending Hole U1329D.

IODP HOLE U1329E

After offsetting 15 m to the north, Hole U1329E was spudded at 02:35 hr on 1 October. The hole was advance with the APC system to 33.5 mbsf, followed by deployment of the PCS (Core U1329E-5P), which was recovered without pressure. After washing down to 54.5 mbsf, an APC core (U1329E-6H) was taken to obtain an APCT temperature measurement, returning with almost no recovery. The DVTP was deployed immediately after Core U1329E-6H to provide a calibration point with the ACPT. The rest of the hole was devoted to pressure coring runs with intervening washed intervals. The PCS was deployed two more times at 73.5 and 125.0 mbsf, both successful runs. The Fugro pressure corer (FPC) was deployed at 104.0 mbsf; however, the tool returned without pressure. The HYACE rotary corer (HRC) was deployed at 114.5 mbsf and retrieved a full core under pressure. After displacing the hole with 10.5 ppg mud, the BHA was pulled clear of the seafloor at 22:32 hr on 1 October, ending Hole U1329E. The drill string was tripped to the rig floor in preparation for the short transit to Site U1327.

IODP HOLE U1327B

After concluding coring and logging operations at Site U1329, the drill string was tripped to the rig floor and we transited 9.2 nmi to Site U1327, arriving at 04:15 hr on 2 October. We spudded Hole U1327B, retrieving a full core, which indicated we did not recovery the mudline. Therefore, we terminated operations in Hole U1327B to obtain a mudline core from a new hole, which is important for shallow geochemical and microbiological studies.

IODP HOLE U1327C

The bit was picked up 5 m and Hole U1327C was spudded returning a 6.1 m mudline core, providing an estimated seafloor depth of 1304.5 mbsl (1315.4 mbrf). With the APC system, the hole was advanced to 92.9 mbsf (104% recovery), below which the hole was cored to 300 mbsf with the XCB (81% recovery). Four APC temperature measurements were made with the APCT. Additional temperature measurements were made using the DVTPP probe at 170.4, 218.5, and 300.0 mbsf. Three PCSs were deployed at 44.1, 121.8 mbsf, and 197.3 mbsf; the shallowest was returned without pressure. After reaching total depth, the hole was displaced with weighted mud, and the bit was pulled clear of the seafloor at 15:45 hr on 4 October, ending Hole U1327C.

IODP HOLE U1327D

After completing operations in Hole U1327C, we offset 15 m to the northeast to spud a dedicated tool hole, which focused on pressure coring and wireline logging. Additional conventional APC and XCB spot coring was conducted in targeted zones of specific interest. Zones between pressure cores that were not targeted for spot coring were washed or drilled. The coring phase of Hole U1327D was interrupted for 20 hr on 5 October by adverse heave conditions (>4.5 m), which made it impossible to keep pressure core systems on the bottom of the hole. Ultimately, seven total pressure core deployments were conducted in Hole U1327D with five containing cores under pressure (2 PCS, 2 HRC, 1 FPC). The two cores that returned without pressure were the PCS at 83.0 mbsf and the FPC at 132.0 mbsf. The HRC at 126.3 mbsf was recovered under pressure, but during the transfer for core logging measurements, the transfer system lost pressure. Two APC cores were taken to 16.4 mbsf for ultra-high resolution sampling for geochemical and microbiological analyses. Seven XCB spot cores also were taken within the presumed gas hydrate stability zone: one core at 126.0 mbsf; three from 133.0-155.1 mbsf, one at 157.1 mbsf, and two in an interval (218.7-237.9 mbsf) with equivalent depths across the BSR.

At 16:15 hr on 7 October, Hole U1327E had been drilled to a total depth of 300 mbsf, but adverse ship heave conditions, > 3.0 m, were not conducive to logging so the hole was conditioned with a wiper trip and the bottom 20 m was reamed out, which was followed by a mud sweep. By 23:30 hr, the heave conditions had improved so the pipe was pulled up to logging depth and the triple combo was rigged up and lowered to 295.4 mbsf. The hole was logged without incident until near the top of the log run. The combination of a ship heave event (>3.0 m) and the oversized borehole apparently caught and tore off the density tool caliper arm. The damaged triple-combo tool string was returned to the ship without further incident. The VSP logging program in Hole U1327D began at 07:20 hr on 8 October with the pre-shooting, one-hour marine mammal observation period, followed by ramping up the firing pressure for the GI gun. The WST was lowered to 276.4 mbsf and the VSP program began. We moved in 5 m increments up the hole and had completed sixteen positions at ~11:00 hr. Around 136 mbsf the WST was unable to clamp although the caliper log from the triple-combo run showed that the hole should have been suitable for clamping. It was decided to pull the WST back to the ship for inspection. Unfortunately the tool could not be pulled back into the drill pipe. Attempts to clamp the logging wireline with two Kinley crimpers were unsuccessful; however, the WST was finally worked back into the drill pipe and pulled to the surface by 23:00 hr on October 8.

IODP HOLE U1327E

Because of the critical nature of the downhole acoustic log data to achieve the goals of the expedition, it was decided to drill a dedicated wireline logging hole (Hole U1327E) and to acquire additional PCS, HRC, and FPC pressure cores from several critical intervals not successfully cored in the two previous holes at this site. Hole U1327E was started by drilling to 3.0 mbsf and then taking a single APC core for high-resolution geochemical and microbiological sampling. An earlier attempt to sample across the sulfate-methane interface (SMI) in Hole U1327C was unsuccessful; Hole U1327E presented us with an opportunity to resample the SMI at this site. The hole was then advanced by drilling to 40.0 mbsf and the PCS was deployed to obtain a pressure core (Core 2P), which yielded a complete core but it was not pressurized. The hole was advanced by drilling to 80.0 mbsf and a second PCS core (Core 3P) was acquired, this time with a full core and at pressure. Core 3P was X-rayed and moved into the PCS van for degassing. The hole was drilled to 128.0 mbsf, the HRC was deployed, and Core 4E was recovered with sediment but the flapper valve failed to completely seal. A deployment of the FPC was planned at 134.0 mbsf, but was canceled because of growing ship heave conditions that had exceeded 3.5 m near the end of the HRC deployment. We decided to drill Hole U1327E to the target total depth of 300 mbsf and make ready for wireline logging.

IODP HOLE U1328B

After completing operations at Site U1327, the ship was relocated ~1.9 nmi to Site U1328. Prior to coring, we conducted a 120 m long camera survey along the proposed coring transect across the vent site to inspect the seafloor for the occurrence of chemosynthetic communities. We did not observe any living clam colonies; however, widespread carbonate outcrops were observed. Hole U1328B was spudded with the APC system at 13:10 hr on October 11, returning a successful mudline core. The estimated seafloor depth is 1267.8 mbsl. Core recovery in the second APC core was only 1.7 m with an incomplete stroke. The next core was taken with the XCB system to the target depth of the first PCS (Core U1328B-4P) at 14.5 mbsf. The APC taken after Core U1328B-4P was again an incomplete stroke with only 1.89 m of core recovered. We switched back to XCB coring and advanced the hole to the target depth for the second PCS deployment (Core U1328B-7P) at 20 mbsf. Both PCS deployments yielded core under pressure. Three more APC cores ware taken to 56.5 mbsf when operations were suspended at 03:15 hr on 12 October because of strong winds and severe ship heave conditions. By 07:45 hr conditions had deteriorated to a level (heave > 8 m) necessitating pulling out of Hole U1328B.

IODP HOLE U1328C

After waiting on the weather for a total of 16 hours, the sea conditions had improved to the point to allow drilling and coring operations to continue. We offset the ship 15 m and spudded Hole U1328C at 20:30 hr on 12 October, drilling down to the maximum depth of Hole U1328B (56.5 mbsf) to resume APC coring. Hole U1328C was advanced to 75.5 mbsf with three APC cores, where we switched to the XCB coring system. A pressurized PCS core was recovered from a depth of 92 mbsf. The rest of the hole was cored to 300 mbsf with the XCB. The total average recovery for Hole U1328C was 80.3%.

Two APC temperature measurements were made with the APC3, and two DVTP temperature measurements were carried out at ~150 and ~197 mbsf, but the data from both runs were degraded by an apparent electronic problem in the tool. After reaching total depth (TD), the hole was prepared for wireline logging. A successful single pass was made of the triple combo from 294 mbsf. Two passes of FMS-sonic tool were completed from 294 mbsf without incident. After rigging up for the VSP, the marine mammal watch began at 07:30 hr, followed by the 30 minute ramp-up of the GI gun at 08:30 hr. The start of the VSP log run began at 09:00 hr with the first clamping position at 286 mbsf. The VSP was run successfully to the shallowest clamping position of 106 mbsf. After pulling the tool back to the rig floor and rigging down logging, the drill string was pulled clear of the seafloor at 16:15 hr on 15 October, ending Hole U1328C.

IODP HOLE U1328D

The ship was offset 35 m to Hole U1328D for a high-resolution microbiology and geochemistry study of the sulfate/methane interface. The first two deployments of the APC resulted in bent core barrels and we switched to the XCB coring system. Hole U1328D was spudded with XCB at 19:55 hr on 15 October, followed by a second XCB core, and then deployment of the FPC pressure core at 14 mbsf, which did not recover core. The drill string was pulled clear of the seafloor at 23:45 hr on 15 October, ending Hole U1328D.

IODP HOLE U1328E

After offsetting 50 m from Hole U1328D, Hole U1328E was spudded with the XCB at 00:40 hr on 16 October. The primary focus of Hole U1328E was pressure coring, with XCB spot cores to recover gas hydrate from the upper ~ 35 mbsf. XCB coring advanced the hole to 8.5 mbsf, where the FPC was deployed (Core U1328E-3E), which did not return under pressure. An XCB core was taken, followed by a PCS run at 15.1 mbsf (Core U1328E-5P), which did not return pressurized. Another XCB core was taken and then the HRC was deployed (Core U1328E-7Y), which also failed to return a core under pressure. Two XCB cores advanced the hole to 46.0 mbsf, followed by the deployment of the center bit to drill the hole to 92.0 mbsf. The PCS Core U1328E-10P was deployed, returning under pressure, followed by a DVTP temperature measurement. The center bit was redeployed and the hole was drilled to 197.0 mbsf and the FPC pressure core system was deployed, but the core failed to retract into the autoclave. An additional DVTP survey was conducted at 199 mbsf. The hole was drilled to 215.3 mbsf and the HRC (Core U1328E-12E) was deployed but failed to return a core under pressure. The hole was drilled to 233.0 for a PCS run (Core U1328E-13P), which returned with a core under pressure. With ship heave conditions increasing to as high as 7 m, the planned DVTP deployment at the bottom of the hole was cancelled, ending the hole at 234 mbsf. The hole was displaced with weighted mud and the drill string was pulled out of the seafloor in preparation for the transit to Site U1325.

IODP HOLE U1325B

After pulling the drill pipe back to 1,000 mbrf, the ship was moved 5.5 nmi in DP mode from Site U1328 to Site U1325, arriving at 14:30 hr on 17 October, 2005. Hole U1325B was spudded with the APC system. When trying to recover Core U1325B-2H, the inner core barrel became stuck near the drill bit and it took several hours to work the core barrel loose. The second APC core contained a relatively large amount of fine sand, which probably contributed to the problem. After replacing part of the barrel assembly and re-terminating the coring wireline, an XCB core barrel was deployed to work the hole below the sand section identified in the second APC core. The hole was advanced by combination of APC, XCB, and pressure coring to a depth of 206.5 mbsf. At 71.5 mbsf we had an incomplete stroke of the APC for Core U1325B-8H and switched to XCB coring. Interspersed with the XCB cores was a DVTP run at 140.5 mbsf, which yielded high quality temperature data. Five pressure cores were deployed in Hole U1325B.

The first pressure core (PCS) was taken at 82.4 mbsf but did not return with a pressurized core. An HRC was deployed at 129.9 and 197.4 mbsf but both did not return core under pressure. We also deployed the FPC at 169.4 mbsf, but it did not retrieve a pressurized core. The last PCS was deployed at 206.1 mbsf but the tool became jammed in the BHA after penetrating just 40 cm into the formation. We were unable to retrieve the tool despite four attempts and we had to terminate Hole U1325B and trip the pipe back to the surface clearing the seafloor at 21:25 hr on 19 October, ending Hole U1325B.

IODP HOLE U1325C

After extracting the stuck PCS and checking for potential problems with the BHA, the drill string was tripped back to the seafloor, and Hole U1325C was spudded at 08:20 hr on 20 October. The hole was drilled to a depth of 188 mbsf where coring recovery in Hole U1325B began to deteriorate. Coring operations resumed with the deployment of the XCB system at 21:15 hr. XCB coring operations, interspersed with two pressure coring runs and a DVTP deployment, deepened the hole to TD of 304.3 mbsf with the last core on deck at 07:15 hr on 22 October. The FPC pressure core was deployed at a depth of 217.6 mbsf, but it did not return with sediment under pressure. The PCS pressure core was successfully taken at a depth of 256.1 mbsf.

During the previous evening and early morning hours of 22 October, sea state had severely deteriorated resulting in a sustained ship heave of 5 m. After reviewing the weather forecast and discussing options, we decided that two separate logging runs would be attempted with tools without calipers to reduce the potential risk of damage to the tool strings. The first run included the phasor Dual Induction Tool (DIT) and the Hostile Environment Gamma Ray Sonde (HNGS). The second run included the Dipole Sonic Imager, (DSI), the Scintillation Gamma Ray (SGT) tool and the Temperature/Acceleration/Pressure (TAP) tool. We were only able to lower the first tool string to 259.8 mbsf, which is 44.5 m shallower than total depth for coring, and the hole was successfully logged followed by some difficulty reentering the drill pipe. The second tool string (sonic without the FMS) was deployed and was only able to reach a TD of 185.8 mbsf and the available hole was logged successfully. The repeat pass of the sonic tool string reached 183.0 mbsf. After rigging down logging, the bit was pulled clear of the seafloor at 02:00 hr on 23 October, ending operations in Hole U1325C.

IODP HOLE U1325D

To ensure that a mudline core was obtained at this site, one APC core was taken with the bit at 2200.0 mbrf. Core U1325D-1H recovered 4.69 m, indicating a seafloor depth of 2193.2 mbsl (2204.8 mbrf). This suggested that Hole U1325B did not recovery the mudline and was initiated ~1.4 m below the seafloor. The drill pipe was pulled clear of the seafloor at 04:30 hr on 23 October, ending operations at Site U1325.

IODP HOLE U1326B

After completing Hole U1325D, we pulled the drill pipe back to ~1600 mbrf and transited ~2.8 nmi in DP mode to Site U1326. We spudded Hole U1326B at 12:05 hr on 23 October, but the core contained only 1.55 m of sediment, which was not ideal for planned shallow microbiological and geochemical studies, hence we terminated Hole U1326B.

IODP HOLE U1326C

The bit was set at 1834 mbrf (two meters lower than Hole U1326B), and without offsetting, Hole U1326C was spudded at 12:45 hr. The first core recovered 3.93 m of sediment, indicating a seafloor depth of 1828.0 mbsl (1839.6 mbrf). On the fourth APC core (~ 30 mbsf), we unexpectedly hit APC refusal and switched to XCB coring. XCB coring advanced the hole to a depth of 82.7 mbsf, which was followed by three consecutive pressure core deployments within a high electrical resistivity zone identified on LWD/MWD downhole logs. The first pressure core system deployed was the FPC, which recovered a partial core (15 cm) at less than full pressure. The second system to be deployed was the PCS, which recovered a partial core under pressure. The third pressure core system deployed was the HRC, which was damaged at the bottom of the hole because of excessive ship heave (>4 m) and formation sands packing around the outer barrel. The HRC cutting shoe had unscrewed and was left behind in the hole, which resulted in the termination of Hole U1326C at a total depth of 86.7 mbsf.

IODP HOLE U1326D

After tripping the BHA back to the seafloor, the ship was moved 30 m to the southwest. Hole U1326D was spudded at 11:30 hr on October 24 and drilled to a depth of 78.8 mbsf in preparation for continued coring operations. Because of problems associated with the heave state, which continued to grow through the day, we decided to suspend all pressure coring operations for the remainder of the expedition to avoid the risk to the tools and potentially losing the last hole with little remaining operational time remaining. XCB coring deepened the hole to 271.4 mbsf with an average recovery of 63.3%. With forecasts of deteriorating weather conditions on the morning of 26 October, it was decided to stop coring at a depth of 271.4 mbsf and deepen the hole to a total depth of 300 mbsf by drilling, which allowed us to gain time and complete logging, rigging down, and securing the rig floor before the expected arrival of the forecasted storm. Despite the conditions, we did attempt three deployments with the DVTP tool (at 252.2 mbsf, 271.4 mbsf, and 300 mbsf), which yielded marginally useful data.

We then conducted a single downhole log run with a non-standard IODP tool string, which included the Scintillation Gamma Ray (SGT) Tool, Phasor Dual Induction (DIT) tool, and the Dipole Sonic Imager (DSI). The tool was lowered to 298.4 mbsf, and two successful passes were made from this depth, and the tool was back on deck at 03:45 hr. The drill string was pulled clear of the seafloor at 05:30 hr on 27 October, ending operations in Hole U1326D.

TRANSIT TO VICTORIA

After tripping the drill string to the rig floor, recovering two beacons, and securing the ship for transit, we departed under deteriorating sea state (with 40-45 kt sustained winds gusting to >50 knots) at 13:20 hr on 27 October. We made the 157 nmi transit to Victoria, B.C. at an average speed 6.8 kts. Expedition 311 officially concluded with the first line ashore at 12:25 hr on 28 October, 2005.

CONCLUSION

IODP SITE U1325 SUMMARY

Site U1325 (Prospectus Site CAS-02C) is located near the southwestern end of the margin perpendicular transect established during Expedition 311 and is within a major slope basin that developed eastward of the deformation front behind a steep ridge of accreted sediments. Bathymetry data show that the seafloor in the western part of this slope basin is relatively flat with water depths around 2200 m. Around Site U1325 the seafloor becomes gradually shallower before it rises rapidly to the east to form the plateau of the second main accreted ridge at water depths around 1200 m, on which Sites U1327 and 889 are located. A bottom-simulating reflector (BSR) is clearly visible in the eastern part of the slope basin, but it fades to the west (CDP 1180 – 1280 along MCS line 89-08). The BSR also shows the typical frequency dependent reflection strength pattern as observed at all other sites. At Site U1325 the BSR is less strong than at the core of a buried ridge of accreted sediments, which is located about 700 m west of this Site.
The primary research objectives for this site are linked to the transect-concept of this expedition. The objectives include (a) studying the distribution of gas hydrates, (b) defining the nature of the BSR, (c) developing baseline geochemical and microbiological profiles, and (d) obtaining data needed to ground-truth remotely acquired imaging techniques such as seismic or controlled-source EM. The slope basin is expected to show a different geochemical regime and related geophysical properties than the uplifted ridges of accreted sediments.

Four holes were occupied at Site U1325. Hole U1325A was dedicated for the LWD/MWD program to a total depth of 300 mbsf. Hole U1325B was spudded with the APC system but problems arose due to thick sand accumulation causing a switch to XCB core barrel for one core section and a switch back to APC. The hole was then advanced by combination of APC, XCB, and pressure coring to a depth of 206.5 mbsf. Interspersed with the XCB cores was a DVTP run at 140.5 mbsf, which yielded high quality temperature data. Five pressure cores were deployed in Hole U1325B but all attempts failed to retrieve sediments under pressure. The last run with a PCS resulted in a stuck tool, which lead to the abandonment of the hole. Hole U1325C was drilled to a depth of 188 mbsf where core recovery in Hole U1325B began to deteriorate. Coring operations resumed with the XCB system, interspersed with two pressure coring runs (one failed FPC run, one successful run with the PCS) and two DVTP deployments, deepening the hole to a TD of 304.3 mbsf.

Pressure coring tools were deployed seven times at Site U1325, including two PCS cores, two HRC cores and one FPC core in Hole U1325B. Hole U1325C included one FPC core from above the projected depth of the BSR and a PCS core from well below the estimated depth of the BSR. Pressure coring proved to be extremely difficult at Site U1325, with only the deepest PCS (Core 311-U1325C-10P, 256.5 mbsf) recovered successfully under pressure, which was investigated by a controlled shipboard degassing experiment. All other attempts to deploy pressure cores failed for various reasons, partially due to difficult lithologic conditions (the presence of unconsolidated fine sand) and the potential effect of adverse ship heave conditions. The degassing of Core 311-U1325C-10P yielded 2.07 liters of methane gas and may have contained small amounts of gas hydrates (0.4%) or free gas (0.3%) depending where the base of gas hydrate stability (BGHS) is situated (see uncertainty in temperature-derived BGHS above).

Infrared (IR) imaging of the recovered APC/XCB cores was routinely carried out on the catwalk to detect and characterize the nature of gas hydrates in the cores. A large number of IR imaged cold spots were detected in the cores from Holes U1325B and U1325C and were partially subsampled for focused interstitial water analyses and microbiology studies. In many cases the IR imaged cold temperature anomalies correlated with layers of high resistivity and low interstitial water salinities and chloride concentrations, which have been shown to be associated with the occurrence of gas hydrate.

IODP SITE U1326 SUMMARY

Site U1326 (Prospectus Site CAS-03C) is located on an uplifted ridge of accreted sediments at the southwest end of the multi-site transect established during Expedition 311. Recently acquired bathymetry data reveals a collapse structure near the originally proposed primary site CAS-03B. We decided to switch the former alternate location CAS-03C to the primary site to avoid coring directly into the slump feature, which may have complicated the recent geologic history of this site.

The objectives of coring and logging this site are tied to completing the transect of scientific research holes across the Northern Cascadia Margin near Vancouver Island. Site U1326 is the closest location to the deformation front and it probably represents the tectonically youngest occurrence of gas hydrate on the Northern Cascadia Margin, as such our primary research objectives include (a) studying the distribution of gas hydrates, (b) defining the nature of the BSR, (c) developing baseline geochemical and microbiological profiles, and (d) obtaining data needed to ground-truth remotely acquired imaging techniques such as seismic.

Hole U1326B was spudded 15 m NE of Hole U1326A at 12:05 hr on 23 October, but the first core failed to establish the depth of the mud line and it was decided to start a new hole. Without offsetting from the location of Hole U1326B, Hole U1326C was spudded at 12:45 hr on 23 October. The first core established a seafloor depth of 1828.0 mbsl (1839.6 mbrf). On the fourth APC core (~30 mbsf), we unexpectedly hit APC refusal and switched to XCB coring. Hole U1326C was advanced by XCB coring to a depth of 82.7 mbsf, which was followed by three consecutive pressure core deployments within a high electrical resistivity zone identified on LWD/MWD downhole logs. In this case, the FPC and HRC pressure core runs were added to the traditional continuous core hole to increase the total number of pressure core runs at this site.

The FPC was the first pressure core system deployed at this site, it recovered a partial core (15 cm) at less than full pressure. The second system to be deployed was the PCS, which recovered a partial core under pressure. The third pressure core system deployed was the HRC, which was "packed off" with a sand and the cutting shoe and the lower part of the autoclave was unscrewed and left behind in the hole, resulting in the termination of Hole U1326C at a total depth of 86.7 mbsf. After tripping the BHA back to the seafloor, the ship was moved 30 m to the southwest (15 m from Hole U1326A). Hole U1326D was spudded at 11:30 hr on October 24 and drilled to a depth of 78.8 mbsf in preparation for continued coring to a target depth of 300 mbsf. Because of problems associated with the heave state and schedule limitations, all pressure coring operations were suspended for the reminder of the hole. XCB coring deepened the hole to 271.4 mbsf, with the forecast of deteriorating weather conditions on the morning of 26 October, it was decided to stop coring and complete the hole by drilling to 300 mbsf. After completing coring and drilling operations, we then decided to conduct a single downhole log run with a non-standard IODP tool string, which included the Scintillation Gamma Ray (SGT) Tool, Phasor Dual Induction (DIT) tool, and the Dipole Sonic Imager (DSI). At 23:15 hr on 26 October the logging tool was lowered to a logging depth of 298.4 mbsf; two successful logging passes were made with tool string back on deck at 03:45 hr. The drill string was pulled clear of the seafloor at 05:30 hr on 27 October, ending operations in Hole U1326D.

Cold temperature anomalies were observed at a wide range of depths from 70-250 mbsf, and catwalk sampling was conducted based on these scans. Many IW samples were taken based on IR data to extend the chlorinity anomaly database available for calibrating IR data as a proxy for gas hydrate saturation. We note that the maximum depth of observed IR anomalies is deeper than the anticipated BSR depth of 230 mbsf.

At Site U1326, only one PCS core (Core 311-U1326C-12P) was recovered successfully under pressure and investigated by controlled shipboard degassing experiments. This core was taken at a depth of 84.2 mbsf. The degassing of this single PCS core yielded 21.0 liters of gas, which was determine to be equivalent to a pore space gas hydrate saturation of 40%, which is in close agreement with the gas hydrate saturations estimated from the Archie resistivity calculations in the same interval.

IODP SITE U1327 SUMMARY

Site U1327 (Scientific Prospectus Site CAS-01B) is located near ODP Site 889/890 approximately at the mid-slope of the accretionary prism over a clearly defined BSR, estimated to be at a depth of 223 mbsf. The primary research objectives for this site are linked to the transect-concept of this expedition.

Five holes were occupied at Site U1327. Hole U1327A was dedicated to LWD/MWD measurements to a total depth of 300 mbsf. Initially we had planned to drill to a depth of 350 mbsf, but tight time constraints during the LWD/MWD operations made it necessary to reduce the depth of the planned deepest penetrations at this site. The first APC in Hole

U1327B missed mudline with a full core, the core was curated and a new hole was spudded without offsetting the ship. Hole U1327C was then cored (10 APC, 22 XCB, 3 PCS cores; 88.3% recovery) to 300.0 mbsf. The PCS was deployed three times in Hole U1327C and four APCT temperature measurements were made (Cores 311-U1327C-3H, 5H, 7H, 9H). In Hole U1327D, which was drilled and cored as a special tools hole, two APC cores were also taken from the surface to a depth of 16.4 mbsf for a high resolution microbiological and geochemical study of the sulfate/methane interface (SMI). In this hole, the PCS was deployed three times, together with four deployments of the HRC and two deployments of the FPC pressure coring system. The last pressure core was taken at a depth of 246.5 mbsf and the hole was advanced to a TD of 300 mbsf for the logging program.

Hole U1327E was advanced to 3 mbsf and a single 9.5 m long APC core was taken for high resolution microbiological and geochemical sampling of the SMI, which was partially missed during an earlier attempt. Two additional PCS pressure cores and one HRC core were taken, out of which only the second PCS at ~80 mbsf recovered sediment under pressure. Excessive heave over 3.5 m forced the termination of pressure coring operations and the hole was advanced by drilling to a completion depth of 300 mbsf to prepare the second wireline logging run.

Infrared (IR) imaging of the recovered cores was routinely carried out on the catwalk to detect and characterize the nature of gas hydrates in the cores. A large number of IR identified cold spots were detected in the cores from Holes U1327C and U1327D; however, an apparent depth mismatch in the occurrence of major cold core sections between the holes indicated significant intra-site geologic variability. Apparent mismatches between the IR inferred gas hydrate occurrences in Hole U1327C with the LWD/MWD resistivity inferred gas hydrate occurrences in Hole U1327A further documents the lack of lateral continuity at this site.

The PCS was deployed eight times at Site U1327 (three in Hole U1327C, three in Hole U1327D, two in Hole U1327E), five of which recovered sediment under pressure. In addition to the PCS deployment, the HRC was used four times (with three core recoveries under pressure) and the FPC was used twice, but only one of the FPC cores was recovered under pressure. The degassing of the five PCS cores from this site that were recovered under pressure showed variable gas concentrations with depth. The deepest PCS core was taken at a depth of 246.5 mbsf, which is ~25 m deeper than the seismically inferred BSR depth. The other four PCS cores were taken from within the predicted depth interval of the methane hydrate stability zone. Core 311-U1327E-3P is the shallowest PCS core taken at this site, which was from a depth of ~80 mbsf.

Three PCS Cores 311-U1327C-15P, 311-U1327D-10P, and 311-U1327C-24P were taken at 122.3, 155.6, and 197.8 mbsf, respectively. Out of these three cores, only Core 311-U1327D-10P yielded enough gas to infer the occurrence of a significant amount of gas hydrate; with an estimated gas hydrate pore-space concentration of ~8%. The other two PCS cores yielded gas hydrate pore-space concentrations of less than 1%.

Three HRC cores (311-U1327D-4E from 125.3 mbsf, 311-U1327D-12E from 170.5 mbsf, 311-U1327D-14E from 217.7 mbsf) and one FPC core (311-U1327D-13Y from 203.6 mbsf) were successfully recovered and transferred under pressure to storage chambers for shorebased analyses. All of these cores were X-ray imaged, P-wave velocity and density logged within their storage vessels. Some of the recovered pressure cores exhibited evidence of gas hydrate, including high P-wave velocities and anomalous low density readings.

IODP SITE U1328 SUMMARY

Site U1328 (Scientific Prospectus Site CAS-06A) is located within a seafloor cold-vent field, with dimensions 2 km by 4 km, consisting of at least four vents associated with nearsurface faults. The cold vents are characterized by near-vertical seismic blank (or wipe-out) zones that are between 80 and several 100 m wide, and show a clear E-W trend as identified from 3D seismic imaging. The most prominent vent in the field, referred to as Bullseye vent, is the target of this site and has been the subject of intensive geophysical and geochemical studies since 1999. Site U1328 is different than all of the other sites visited during this expedition in that it represents an area of active, focused fluid flow.

Five holes were occupied at Site U1328. Hole U1328A was dedicated to LWD/MWD measurements to a total depth of 300 mbsf. Hole U1328B was continuously cored (6 APC, 2 XCB, 2 PCS cores; 72.8 % recovery) to a depth of only 56.6 mbsf, and was terminated after strong winds and severe ship heave conditions required us to pull out of the hole. After waiting on weather for 16 hours, conditions had improved to the point to allow drilling and coring operations to continue. Hole U1328C was drilled from the seafloor to the maximum depth of Hole U1328B (56.5 mbsf). Hole U1328C was then continuously cored (4 APC, 22 XCB, 1 PCS cores; 80.7 % recovery) to a total depth of 300 mbsf. Hole U1328D was cored as a special high-resolution combined microbiology and geochemistry research hole with two XCB cores and a single FPC taken at the bottom of the hole. Hole U1328E was a special tool hole, which also included the deployment of six XCB cores within the upper 46.0 mbsf to recover additional samples of gas hydrate. Seven pressure cores were taken (3 PCS, 2 HRC, and 2 FPC) separated by XCB cores and drilled intervals.

All cores from this site were systematically scanned upon arrival on the catwalk to detect infrared (IR) anomalies indicative of gas hydrate dissociation during core recovery. Strong cold anomalies were detected in the shallowest cores from this site.

At Site U1328 we attempted 11 deployments of the three different pressure coring tools. The PCS was deployed six times at Site U1328 (twice in Hole U1328B, once in Hole U1328C, and three times in Hole U1328E), five of which recovered sediment under pressure. In addition to the PCS deployment, the HRC was used two times and the FPC was used three times, but none of these cores were recovered under pressure. The degassing of the five successful PCS cores from this site showed variable gas concentrations with depth. Two PCS cores were taken within the near-surface gas-hydrate-bearing section from 0 to 46 mbsf (Core U1328B-4P at 14.5 and Core U1328B-7P at 26 mbsf). The X-ray images of Core U1328B-4P under pressure show 2-6-mm-thick low-density structures that disappeared after degassing and are interpreted as gas hydrate veins. This core showed large amounts of gas expansion and sediment extrusion during depressurization, as did Cores U1328B-7P and U1328E-10P to a lesser extent. The two PCS cores taken in Holes U1328C and U1328E at 92.0 mbsf (Cores U1328C-5P, U1328E-10P) yielded each quite different amounts of methane gas. One PCS core was taken from a depth of 233 mbsf, very close to the seismically inferred BSR depth.

IODP SITE U1329 SUMMARY

Site U1329 (Scientific Prospectus Site CAS-05D) is at the eastern end of the southwest-northeast trending, margin-perpendicular, transect of sites occupied during this expedition and is located closest to shore (65 km) at a water depth of 946 mbsl. The location of this site is interpreted to be at the eastern limit of gas hydrate occurrence on the Northern Cascadia Margin. The objectives of coring and downhole logging at this site are tied to completing the transect of scientific drill sites across the Northern Cascadia Margin to further constrain models for the formation of marine gas hydrate in a subduction zone acretionary prism.

Five holes were occupied at Site U1329 (CAS-05D). Hole U1329A was dedicated to LWD/MWD measurements to a total depth of 220 mbsf. Hole U1329B consisted of only one missed mudline APC core to 9.5 mbsf. Hole U1329C was continuously cored (17 APC, 5 XCB, 3 PCS cores; 99.3 % recovery) to 189.5 mbsf, and was terminated before the target depth of 220 mbsf when the PCS cutting shoe broke off and was left in the bottom of the hole. With a forecast for improving weather the following day, we decided to abandon Hole U1329C to drill a dedicated logging hole. Hole U1329D was drilled from the seafloor to 201.0 mbsf, which included another 1.5 hr of suspended operations due to excessive ship heave, and a single XCB core was taken to 210.5 mbsf. Hole U1329D was wireline logged with the triple-combo and FMS-sonic tool strings. Hole U1329E was a special tool hole to 127.1 mbsf where five APC cores were taken for high resolution microbiological and geochemical studies. Five pressure cores were taken (3 PCS, 1 HRC, and 1 FPC) separated by drilled intervals.

Infrared (IR) imaging of the recovered core was used to assist in immediate gas hydrate detection on the catwalk. At this site, core IR temperatures did not show any significant cold-spot anomalies from gas hydrate dissociation that could be related to the presence of gas hydrate in the recovered core.

In total six PCS deployments were made, three in Hole U1329C and three in Hole U1329E. Out of the six deployments, two runs did not recover sediment under pressure and all other runs retrieved sediments under pressure, although at measured surface pressures approximately half the expected in-situ hydrostatic pressure. It was concluded that the tool is sealing only when a certain differential pressure is reached, not at the in-situ pressure of the cored interval. All PCS cores that were successfully retrieved under pressure were degassed and subsamples of the recovered gas were analyzed on the ship and additional subsamples were taken for shore-based isotope studies. In addition to the PCS, one HRC and one FPC were deployed in Hole U1329E. A full core at near in situ pressure was recovered by the HRC that revealed 10 cm high velocity zones indicative of gas hydrate. The FPC deployment recovered a core without pressure. The degassing of the four PCS cores from this site that were recovered under pressure showed variable gas concentrations with depth.

PROJECT SUMMARY AND CONCLUSIONS

The primary accomplishments of the JOI Cooperative Agreement with DOE/NETL in this quarter were the implementation of a scientific ocean drilling expedition to study marine methane hydrates along the Cascadia margin, in the NE Pacific as part of Integrated Ocean Drilling Program (IODP) Expedition 311 using the R/V JOIDES Resolution and the deployment of all required equipment and personnel to provide the required services during this expedition.

The statement of work for this project included three primary tasks: (1) research management oversight, provided by JOI; (2) mobilization, deployment and demobilization of pressure coring and core logging systems, through a subcontract with Geotek Ltd.; and, (3) mobilization, deployment and demobilization of a refrigerated container van that will be used for degassing of the Pressure Core Sampler and density logging of these pressure cores, through a subcontract with the Texas A&M Research Foundation (TAMRF).

IODP Expedition 311 shipboard activities on the JOIDES Resolution began on August 28 and were concluded on October 28, 2005. New ODP Pressure Coring System (PCS) aluminum autoclave chambers were fabricated prior to the expedition. Three aluminum PCS inner core barrels and three aluminum PCS outer core barrels were fabricated to allow X-ray imaging of these cores under pressure. During the expedition, 16 PCS autoclaves containing pressure cores were X-rayed before and after depressurization using a modified Geotek MSCL-P (multi-sensor core logger-pressure) system. These PCS cores were density scanned using the MSCL-V (multi-sensor core logger-vertical) during depressurization to monitor gas evolution. The MSCL-V was set up in a 20-foot-long refrigerated container provided by Texas A&M University through the JOI contract with TAMRF. This was the first time that PCS cores were examined before (using X-ray), during (using MSCL-V gamma density) and after (using X-ray) degassing to determine the actual volume and distribution of sediment and gas hydrate in the pressurized core, which will be important for more accurate determination of mass balances between sediment, gas, gas hyrate, and fluids in the samples collected.

Geotek, Ltd was awarded a contract by JOI to provide equipment and personnel to perform pressure coring and related work on IODP Expedition 311 (Cascadia Margin Gas

Hydrates). Geotek, Ltd. provided an automated track for use with JOI's infrared camera systems. This track was mounted on plywood sheets attached to the catwalk stantions. Four auxillary monitors showed infrared core images in real time to aid hydrate identification and sampling. Images were collected from 185 cores during the expedition and processed to provide continuous core temperature data.

The HYACINTH pressure coring tools, subsystems, and core logging systems were mobilized to Astoria, Oregon. Both HYACINTH pressure coring tools, the HRC (HYACE Rotary Corer) and the FPC (Fugro Pressure Corer) were mobilized and used during the expedition. Two HYACINTH engineers supervised the use of the tools and five good pressure cores were obtained. Velocity, density and X-ray linear scanning data were collected from these cores at near *in situ* pressure using the MSCL-P system. Dr. Barry Freifeld from Lawrence Berkeley National Laboratory (LBNL) provided an X-ray source and detector for X-ray imaging of pressure cores and helped Geotek with the design and mobilization of the MSCL-P system. Pressure core handling, transfer, and logging was performed in a refrigerated 20-foot container supplied by Geotek, Ltd. After scanning, the pressure cores were stored for on-shore analysis in aluminum barrels.

Additional studies were conducted at the Pacific Geoscience Center (PGC), where a shorebased laboratory was established after Expedition 311. The LBNL X-ray CT system was not mobilized to the PGC north of Victoria, B.C., Canada following the expedition to take part in post-expedition experiments. Therefore, Geotek personnel set up the MSCL-V and performed depressurization experiments on hydrate-bearing cores while also collecting gamma density data during core scans. Geotek personnel also organized and distributed samples from pressure cores extracted at PGC following the expedition. Additional costs were incurred for these activities and other costs were incurred by the cooperative agreement related to establishing the shorebased laboratory and the logistics of shipping pressure core samples internationally. These additional costs were discussed with the DOE-NETL Program Manager for the cooperative agreement and costs were reassigned internally at JOI to compensate for these new requirements.

All tasks outlined in the original statement of work were accomplished except for the deployment and use of the X-ray CT system under Subtask 2-2. This reduction in scope provided resources that were applied to other activities to support the overall project. Post-expedition analysis of results and report writing will continue beyond this reporting period, however, all field deployments associated with this project have been successfully concluded as of this writing.

LIST OF ACRONYMS AND ABBREVIATIONS

APC	Advanced Piston Corer
APC-M	Advanced Piston Corer-methane tool
APC-T	Advanced Piston Corer-temperature tool
BHA	Bottom Hole Assembly
BSR	Bottom Simulating Reflector
DOE	Department of Energy
DVTP	Davis Villinger Temperature Probe
DVTP-P	Davis Villinger Temperature Probe with Pressure
FMMG	Fugro-McCleland Marine Geosciences
FMS	Formation Micro-Scanner
FPC	Fugro Pressure Corer
GHSZ	Gas Hydrate Stability Zone
GI	Generator-Injector (seismic source)
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
JOI	Joint Oceanographic Institutions
JOIDES	Joint Oceanographic Institutions for Deep Earth Sampling
LDEO	Lamont Doherty Earth Observatory (Columbia University)
LTC	Laboratory Transfer Chamber
LWD	Logging While Drilling
MBRF	Meters Below Rig Floor
MBSF	Meters Below Sea Floor
MBSL	Meters Below Sea Level
MH	Methane Hydrate
MPa	Mega-Pascals
MSCL-V	Multi-Sensor Core Logger – Vertical
MWD	Measurements While Drilling
NETL	National Energy Technology Laboratory
NSF	National Science Foundation
ODP	Ocean Drilling Program
PCS	Pressure Core Sampler
PPG	Pounds Per Gallon
PSI	Pounds per Square Inch
RAB	Resistivity at the Bit
RCB	Rotary Core Barrel
R/V	Research Vessel
TAMU	Texas A&M University
VSP	Vertical Seismic Profile
WST	Well Seismic Tool
XCB	Extended Core Barrel

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