IODP Expedition 344: Costa Rica Seismogenesis Project (CRISP-A2)

Week 4 Report (11–17 November 2012)

Operations

Week 4 of Expedition 344 (Costa Rica Seismogenesis Project, Program A Stage 2) began with RCB coring from 787 to 800 mbsf in Hole U1380C. A total of 362.0 m was cored and 202.4 m was recovered for a recovery of 56%. At the conclusion of coring, the hole was swept clean with a 40-barrel sweep of high viscosity mud.

In preparation for logging, the drill string was pulled out of the hole to a depth just above the seafloor, clearing the reentry cone at 0720 h on 11 November 2012. The subsea camera was deployed and the bit was successfully released on the seafloor at 0855 h. Hole U1380C was reentered at 1005 h, the subsea camera was recovered, and the end of the drill pipe was placed at 336 mbsf. After holding a safety meeting on the rig floor, the triple combination-Ultrasonic Borehole Imager (UBI) logging string was rigged up and run into the hole at 1530 h. However, the logging tools were unable to advance past 398 mbsf, which coincided with the estimated depth of the casing shoe. The tools were pulled from the hole and the drill pipe was advanced to 467 mbsf without difficulty. The drill pipe was then pulled back to 394 mbsf, and a reconfigured triple combo string without the UBI was picked up and run into the hole at 2310 h. This time the logging tools made it to 458 mbsf before encountering an obstruction. A review of the logs showed that the casing might have slipped down inside the hole. The logging tools were pulled back to the surface and the hole was checked down to 496 mbsf with the end of the pipe, where an obstruction was encountered. The pipe was pulled back to 457 mbsf with 20 klbs of overpull. In order to better clean the hole for logging, the drill string was pulled all the way out of the hole, reaching the rig floor at 0725 h on 12 November. A bottom-hole assembly (BHA) with a used RCB bit was deployed. The subsea camera was deployed and Hole U1380C was reentered at 1015 h. The drill pipe was advanced to 65 mbsf, where it encountered a slight obstruction. This depth was recorded as the new possible top of the 10-3/4 inch casing string, which would place the casing shoe at 455 mbsf. The pipe was eventually run in the hole to 496 mbsf and the hole was washed down from 496 to 781 mbsf in 15.75 h. The hole was swept clean with a 40-barrel sweep of high viscosity mud and a second sweep of 20 barrels was pumped. The RCB bit was released in the hole at 768 mbsf and the hole was again displaced with 230 barrels of heavy mud. In preparation for logging, the end of the drill string was placed at 443 mbsf. The triple combo logging tool string was rigged up for the third time and run into the hole at 1310 h on 13 November. However, the logging tools encountered a similar obstruction as before at 462 mbsf. After several attempts to get the tools to reenter the open hole, the tools were pulled back to the surface and rigged down. The drill pipe was lowered into the hole for one last depth check but encountered an obstruction at 438 mbsf. At that point all attempts to log Hole U1380C were abandoned, and the hole was plugged with a 10-barrel cement plug. The acoustic beacon was released and recovered at 2310 h on 13 November. The drill string was pulled from the hole, clearing the rig floor at 0055 h on 14 November. The rig floor was secured for transit, ending Hole U1380C and operations at Site U1380. A total of 17.3 days were spent on Site U1380 compared with 16.0 days budgeted in the original plan.

After a 7-nmi transit to Site U1412, the thrusters and hydrophones were lowered and the vessel shifted from cruise mode to dynamic positioning mode at 0200 h on 14 November. During the 1-h transit, the drill line was slipped and cut. On arrival, an APC/XCB BHA was assembled and lowered to 1876 m below sea level. After three unsuccessful attempts at recovering the mudline, Hole U1412A (8°29.3294'N, 84°7.6686'W) was spudded at 1520 h on 14 November at a water depth of 1920 mbsl. The FlexIt orientation tool was used with Cores U1412A-1H to 15H and non-magnetic core barrels were used with all cores. APCT-3 formation temperature measurements were taken with Cores 3H, 5H, 7H, and 8H. All cores after Core U1412A-3H were partial stroke cores and APC refusal was reached at a depth of 108.2 mbsf with Core 15H. After APC refusal was reached, the XCB coring system was deployed and coring continued through Core 25X to a final depth of 200.3 mbsf. At that time the hole had become too unstable to continue coring. The hole was plugged with 49 barrels of heavy mud and abandoned. The drill string was pulled from the hole, cleared the seafloor at 1410 h on 16 November and ending Hole U1412A. Fifteen APC cores and ten XCB cores were recovered at Hole U1412A. The cored interval for the APC system was 108.2 m with 108.8 m recovered. The cored interval for the XCB system was 92.1 m with 61.3 m recovered. The overall recovery for Hole U1412A was 85%.

After clearing the seafloor, we attempted to recover the last XCB core barrel that had been deployed. A previous attempt had resulted in the aft coring line parting above the core barrel. Two wireline runs were made before eventually bringing the core barrel and sinker bars back to the surface. The vessel was offset 350 m to the south-southwest in the hope that the formation would be more suitable for a deeper hole. Hole U1412B (8°29.1599'N, 84°7.7512'W) was spudded at 2350 h on 16 November at a water depth of 1964 m. Recovery of the mud line core was slightly problematic as remnants of wireline from the previous wireline failure were obstructing the overshot. After successfully clearing up the debris, an XCB core barrel with a center bit attached was dropped and Hole U1412B was drilled down from 6.7 mbsf to 155.8 mbsf. The center bit was replaced with an XCB core barrel and coring began at 1700 h on 17 November. Cores U1412B-3X and 4X were recovered to a depth of 175.2 mbsf.

Science Results

Hole U1380C

After finalizing the core description, smear-slide evaluation, and XRD analyses from Hole U1380C, the lithology has been divided into three major units. Unit I comprises a massive, dark greenish gray silty clay with three sandstone-rich horizons with centimeter to decimeter-thick sandy layers. Unit II is composed of a greenish gray clayey siltstone with intercalated sandstone and conglomerate layers that has been subdivided into two subunits based on compositional and depositional variations. Subunit IIA is characterized by poorly to weakly consolidated sand beds that contain abundant to common shell fragments. Subunit IIB is a very dark greenish gray clayey siltstone characterized by two fining-upward sequences of centimeter to decimeter-thick, medium to coarse-grained sandstones and fine conglomerates, as well as two intervals rich in fine-grained reddish-brown tuffs. Finally, Unit III is a fine-grained silty claystone sequence with rare but thick intercalated fine to coarse-grained sandstones.

The biostratigraphy of the Hole U1380C sediments was constrained by their nannofossil content because there were no radiolarians present in core catcher samples. Four biostratigraphic Zones

have been identified. The interval from Sample 344-U1380C-2R-CC to 4R-CC is assigned to nannofossil Zones NN19-NN21. The second interval, between Samples 344-U1380C-5R-CC and 8R-CC, is assigned to Zone NN19. The third Zone, NN18, is defined by the first downhole occurrence of *Discoaster brouweri*, which appears in Sample 344-U1380C-9R-CC. The fourth biostratigraphic zone encompassed Samples 344-U1380C-51R-CC to 52R-CC (791-797 mbsf) and is assigned to Zones NN15-NN17, based on the LO of *Discoaster pentaradiatus*, the FO of *Pseudoemiliania lacunosa* in Sample 51R-CC, and the FO of *Discoaster asymmetricus* in Sample 52R-CC. Therefore the oldest sediments found at this hole are older than 2.4 Ma.

Benthic foraminifers were studied in 44 of the 52 core catcher samples collected. Benthic foraminifers vary from "few" (Samples 344-U1380-2R-CC to 9R-CC) to "present" (Samples 31R-CC to 52R-CC) and preservation ranges from moderate, where abundance is higher, to poor, where foraminifera are present or rare. Overall benthic foraminifer assemblages are characterized by species generally associated with organic carbon–rich environments and low bottom water oxygenation such as *Uvigerina peregrina*, *Epistominella smithi*, *Brizalina* spp. and *Hansenisca altiformis*. Benthic foraminifer assemblage changes are relatively subtle downhole.

We completed the chemical analyses of 25 interstitial water samples from Hole U1380C. The most significant finding is the presence of fluid flow through a shear zone that extends from ~480 to 550 mbsf, at the lithologic Unit I/II boundary. The Cl, Li, and hydrocarbon data indicate that this fluid originated from a source depth where temperatures are >90°C. Below this horizon, there is a marked increase in C_1/C_{2+} ratios towards a more biogenic signature of the gases, which is consistent with pore water data (Sr, Mg, Ca and K) that indicate lower temperature volcanic tephra alteration reactions within the sediments of lithologic Unit II. Both the inorganic and organic carbon concentrations are distinctly higher in lithologic Unit I than in the sediments underlying the 550 mbsf unconformity.

All Hole U1380C physical properties measurements were completed.

We completed measurements of natural remanent magnetization (NRM) on all archive-half sections and on 60 discrete samples taken from the working halves in Hole U1380C. We subjected archive-half cores to alternating-field (AF) demagnetization up to 30 mT and subjected discrete samples to stepwise thermal and AF demagnetization up to 475°C and 120 mT, respectively, to establish a reliable magnetostratigraphy at this site and to observe the magnetic properties of each lithology in the lithostratigraphic units recovered.

Several relatively well-defined polarity intervals have been identified in downhole magnetostratigraphic records in spite of the presence of some samples showing unstable and ambiguous magnetization. Based on biostratigraphic data, we were able to tentatively correlate certain parts of the magnetic polarity interval recorded in the sediments with the geomagnetic polarity timescale. The Matuyama/Gauss Chron boundary (2.581 Ma) is tentatively placed at ~770 mbsf, based on both discrete sample and pass-through results.

Downhole logging was attempted three times between November 11 and 13 (see "Operations"). Hole obstructions, however, prevented us from lowering the wireline tool string below the base of the 10-3/4 inch casing, and we were not able to collect useful measurements. Caliper, density, and natural gamma ray measurements taken within the casing were useful in determining the extent of the cased interval in Hole U1380C.

Hole U1412A

Lithology at Hole U1412A is dominated by dark greenish to greenish gray clay with some smaller variations in grain size to silty clay. Seven ash layers have been found and the sediments show strong indications for gas expansion. From Core U1412A-8H down to 25X some horizons in the surprisingly well-consolidated sediments experienced strong textural destruction as is common when gas hydrate–bearing sediments are exposed to lower pressures and the hydrate becomes unstable. The more carbon rich sediments in the lower part of the hole are heavily disturbed by drilling disturbance.

Radiolarians and nannofossils are present throughout Hole U1412A. Radiolarian abundances decrease markedly after Sample 344-U1412-12-CC and the assemblages do not contain any important biostratigraphic markers. Consequently, biostratigraphy for this hole was constrained from nannofossils. Marker species indicate that the older sediments (Samples 344-U1412A-22X-CC to 25X-CC) correspond to Zone NN19 and are older than 0.4 Ma and younger than 1.9 Ma. Benthic foraminifers are common in the upper section (Samples 344-U1412A-2H to 9H-CC) and range from rare to present downhole from Sample 344-U1412A-10H-CC to 24X-CC.

Hole U1412A has subhorizontal to gently dipping bedding at the very top of the drilled section. Steeply dipping normal faults are common in the lower part of the section.

We collected 29 pore fluids samples from the APC cores of Hole U1412A. Although the XCB cores were too disturbed for adequate pore fluid sampling, we were able to obtain small pore fluid volumes from four of the XCB cores (344-U1412A-16X, 20X, 22X, and 23X). The chemical composition of these samples will be corrected for drill fluid contamination where the sulphate data indicates that contamination is <5%. The upper section of the sediments reflects changes associated with organic matter diagenesis. The sulphate/methane transition occurs at 14.73 mbsf, and high-resolution headspace samples were collected below this depth for shore-based microbiology studies. The presence of gas hydrate in the sediment was inferred from discrete Cl anomalies and excursions to low C_1/C_{2+} ratios between 60 and 85 mbsf, consistent with the recovery of sediment with a mousse-like texture.

All Hole U1412A physical properties measurements have been completed. At Hole U1412A, natural gamma ray counts and magnetic susceptibility show some variability indicative of lithologic variations. Hole U1412A porosities decrease between the seafloor and 20 mbsf, below which they fluctuate around 60%. *P*-wave measurements were not possible due to the effects of gas expansion on the sediments. Four successful temperature measurements were taken.

Paleomagnetic measurements were conducted on Site U1412 sediments. We have finished pass-through magnetometer measurements on all archive-half cores from Hole U1412A and are measuring the discrete samples from Hole U1412A as well as archive-half sections from Hole U1412B. Overall, the paleomagnetic data at Site U1412 are reasonably robust to provide magnetic information about the recovered sediments.

Education and Outreach

Blogs and photos were added to joidesresolution.org, Facebook, and Twitter. Video conferences were held with 300 Oceanography students at Colorado State University in Fort Collins, as well as 123 high school students in Dover, New Hampshire, Portland, Oregon, and Lincolnton, North Carolina, and 19 middle school students in Orland Park, Illinois. Work continued on the first of four video episodes on CRISP science.

Technical Support and HSE Activities

The following technical support activities took place:

- Labs processing core
- Rebuilt Carver hydraulic unit tested and installed on press setup in core reefer for helium free sampling

The following HSE activities took place:

- Eyewash stations tested