IODP Expedition 355: Arabian Sea Monsoon

Week 3 Report (12–18 April 2015)

Operations

Hole U1456A (IND-03C)

Coring with the Half-Length Advanced Piston Corer (HLAPC) continued in Hole U1456A through Core 70F to 389.5 m below seafloor (mbsf). The coring system was changed to the Extended Core Barrel (XCB) system and at 0615 h (UTC + 5.5 h) on 13 April 2015, the first XCB core (71X) was on-deck, recovering 7.10 m. Coring continued through Core 74X. When that core barrel was retrieved on-deck, the XCB cutting shoe was missing. Further examination revealed that it had broken off at the last engaged thread of the inner barrel connection, terminating Hole U1456A at 426.6 mbsf. Although short of the planned depth of ~600 mbsf, discussions had been underway to possibly terminate the hole at a depth of 450 to 460 mbsf due to the consistently fine grained lithologies encountered below 400 mbsf. We decided to defer wireline logging in Hole U1456A in favor of logging Hole U1456C, which would likely be deeper and open for a shorter period of time. The drill string was tripped back to the seafloor with the top drive in place in case any hole problems were encountered due to the unconsolidated sands. Although a fair amount of sand was evident in the cores, the driller did not experience any difficulty recovering the drill string. The bit cleared the seafloor at 1805 h, ending Hole U1456A and beginning Hole U1456B.

Hole U1456B (IND-03C)

The ship was offset 15 m to the east of the original site coordinates, with the bit positioned at 3647 m below rig floor (mbrf), 2 m lower than for Hole U1456A. Hole U1456B was started at 1955 h on 13 April 2015. A seafloor depth of 3655.8 mbrf (3645.0 m below sea level [mbsl]) was established based on APC core recovery, which was ~7 m deeper than the previous hole located 30 m to the west. Based on discussions with the coring technician on watch, we determined that a significant amount of material was lost due to the soupy nature of the core, which led to an inaccurate seafloor depth. This hole was planned as a dedicated microbiology hole to consist of three cores; however, because the recovery was only 0.69 m in Core 1H, we decided to take an additional core. APC coring continued through Core 4H to 29.1 mbsf where the hole was terminated. The bit was pulled clear of the seafloor at 2355 h on 13 April 2015, ending Hole U1456B and beginning Hole U1456C.

Hole U1456C (IND-03C)

The ship was offset 15 m north of the original site coordinates, with the bit positioned at 3647 mbrf. Hole U1456C was started at 0050 h on 14 April 2015. The seafloor depth for this hole was established based upon APC core recovery as 3649.2 mbrf (3638.4 mbsl). Oriented

APC coring continued through Core 17H to 134.3 mbsf. Core 18H was a partial stroke advancing only to 137.0 mbsf with limited recovery of 2.72 m, apparently hitting a significant sand layer. The bit was advanced by recovery and the coring system was changed to the HLAPC. Cores 19F through 36F were recovered to 221.6 mbsf with Core 36F on-deck at 1155 h on 15 April 2015. During HLAPC coring, each interval was advanced 4.7 m regardless of recovery. After Core 36F was retrieved, coring was suspended and an XCB center bit assembly deployed to drill down to 408.0 mbsf. Drilling of the 186.4 m interval required 12.25 h to complete. We suspect that the drilling was slowed by bit balling of the polycrystalline diamond compact (PDC) bit in the soft clay formation. In addition, hard layers were occasionally encountered, requiring a longer amount of time to penetrate because of the limited weight-on-bit that could be applied due to presence of the XCB center bit. The net rate of penetration (ROP) achieved (including connection time, mud sweeps, etc.) was 15.2 m/h. Thirty barrel sea gel mud sweeps were pumped every 30 m to proactively avoid sand build-up in the annulus and to hopefully prevent any recurrences of the stuck wireline barrels that occurred in Hole U1456A.

After reaching 408.0 mbsf, the center bit was recovered, an XCB core barrel deployed, and at 0230 h on 16 April 2015, XCB coring resumed in Hole U1456C. Cores 38X and 39X were cut and recovered to 418.0 mbsf. Core 39X was on-deck at 0745 h. While Core 39X was being recovered, a notification came from the bridge (at ~0700 h) that they were observing an unknown vessel located ~3.5 nmi away from the drill site. Soon after, the bridge instructed the drill floor to suspend coring operations and begin to pull out of the hole to near the seafloor when the vessel began to approach. The vessel began deploying fishing line in the vicinity of the *JOIDES Resolution* and also motioned to personnel onboard that they wanted food. After being instructed that we were a research vessel and that they needed to standoff a minimum of 3 nmi from our drilling location, the vessel departed. At 0845 h, the drill crew began tripping pipe back to the bottom of the hole. XCB coring then resumed, with Cores 40X through 46X cut and recovered to 465.2 mbsf. At this point we determined that this depth would make a reasonable casing point and that the material being cored was recoverable with the Rotary Core Barrel (RCB) coring system. Coring operations were terminated in Hole U1456C and we began to prepare the hole for wireline logging operations.

A 40-barrel sea gel mud sweep was circulated out of the hole, and at 0215 h on 17 April 2015, a wiper trip was conducted to 56.3 mbsf. There was no overpull, excessive drag, or fill on the bottom detected by the driller. At 0645 h on 17 April, the Lockable Float Valve (LFV) go-devil was deployed, another 40-barrel sea gel mud sweep pumped, and after chasing the sweep with 500 strokes of seawater, the hole was displaced with 171 barrels of 10.5 lb/gal heavy mud. The drill string was then positioned with the end-of-pipe (EOP) at a logging depth of 81.1 mbsf. We started assembling the first wireline logging tool string (triple combo without the source) and it was deployed at 1155 h on 17 April. This suite of logging tools reached the total borehole depth of 465.2 mbsf, and after an up-log was collected, the tool string was retrieved to the rig floor at 1740 h. The second suite of tools, the FMS-sonic tool string, was deployed at 1810 h and also was able to reach bottom. Two up-passes were collected with the FMS-sonic, and the tool string

was retrieved to the surface at 0315 h on 18 April. The third and final logging run was made with the triple combo tool suite, this time with the source after the hole was determined to be in good condition. The tool string was deployed at 0445 h, reached the total depth of the hole, and was then retrieved to the rig floor at 1150 h on 18 April. After rigging down from logging, the subsea camera was deployed and the drill string was pulled out of the hole, clearing the seafloor at 1440 h on 18 April. This officially ended Hole U1456C and started Hole U1456D. The vessel was offset in dynamic positioning (DP) mode to 15 m south of the original site coordinates. A drill string tag of the seafloor was observed on the subsea camera, establishing a seafloor depth adjusted to the rig floor dual elevator stool of 3648.0 mbrf. The subsea camera was then returned to the surface while we began to trip the drill string back to the seafloor. As of midnight on 18 April, the drill string had been tripped up to 513.7 mbrf.

Science Results

The sedimentologists finished describing cores from Hole U1456A (Cores 15H through 74X), Hole U1456B (1H through 4H), and Hole U1456C (1H through 46X) using a combination of visual core description, microscopic inspection of smear slides, core imaging, spectral color scanning, and magnetic susceptibility. The stratigraphy in these three holes is tentatively divided into three lithostratigraphic units. The uppermost unit (Unit I) consists mostly of nannofossil ooze, nannofossil-rich clay, and nannofossil ooze with clay, with common bioturbation. Graded beds marked by sharp, erosional contacts at their bases also occur. A distinct change from finer grained lithologies above to coarser lithologies below occurs between Cores U1456A-15H and 17H and within Core U1456C-17H. The dominant lithology in Unit II is soupy sand containing some interbeds of nannofossil-rich clay and clay with nannofossils, as well as graded silt and clay beds. The boundary between Units II and III is identified in Core U1456A-65F. In Hole U1456C, it occurs within the interval drilled without coring from 221.6 to 408.0 mbsf. Unit III marks a return to finer grained lithologies and is comprised primarily of calcareous-rich clay and claystone with some pyrite concretions. Drilling disturbance is high in many of the cores, particularly in the sandy intervals and in the deeper parts of Holes U1456A and U1456C. Smear slide analysis supports the lithologies identified through macroscopic core description and verifies the occurrence of biogenic components, particularly nannofossils, throughout the recovered interval. Abundant detrital minerals occur in most samples, including quartz, feldspar, mica, and a heavy mineral assemblage that is consistent with input of Indus River sediments derived from the Himalayas.

The biostratigraphers completed analysis of all core catcher samples and additional samples from split cores for Holes U1456A and U1456C. Diatoms and radiolarians are common in the mudline water sample, but rare or absent below. Calcareous nannofossils occur throughout the sampled section in both holes, but are most abundant and well preserved in the nannofossil ooze of Lithostratigraphic Unit I. Nannofossils are generally sparse and moderately preserved in the sandy sediment of Unit II. Reworked specimens are particularly abundant over this interval. The abundance of nannofossils increases slightly in Unit III, with somewhat better preservation.

Planktonic foraminifers are abundant and generally well preserved in Unit I, but almost absent in Unit II. Samples from the interbedded clay of Unit II yielded rare to abundant foraminifers. Abundance increases slightly in Unit III; however, the preservation decreases near the base of the section. Integrated biostratigraphy indicates that the bottom of Holes U1456A and U1456C is late Pliocene in age. Linear sedimentation rates were ~10 cm/k.y. during the late Pliocene to early Pleistocene (Unit III) and ~14 cm/k.y. during the Pleistocene (Unit I). Sedimentation rates during deposition of Unit II were approximately four times higher, with a significant thickness of sand deposited over a few hundred thousand years.

Stratigraphic correlation among Holes U1456A, U1456B, and U1456C is ongoing, but sufficient data have been collected to composite the data into a continuous section for Unit I. Despite heavy sampling for microbiology and interstitial waters, enough section remains in Hole U1456B to be correlated to the other holes. The sedimentary records for Holes U1456A and U1456C have been used to reconstruct and splice a continuous section for the seafloor to the top of Unit II (through the base of Core U1456A-15H at ~134 mbsf).

The geochemists collected samples for shipboard analysis of headspace gas, interstitial water chemistry, and bulk sediment geochemistry analyses from all holes. Headspace gas was measured on samples from Cores U1456A-38F to 73X and samples from Hole U1456C below 419 mbsf. At this site, C_1/C_2 ratios are all >1000 ppmv, an order of magnitude more than the levels for thermogenic gases. Bulk sediment geochemistry analysis for carbon, nitrogen, and sulfur was completed on samples from Hole U1456A. Above 140 mbsf, calcium carbonate and total carbon values are generally high, consistent with the lithology. Calcium carbonate and total carbon abundance decrease below 140 mbsf. Nitrogen concentration is low throughout the hole, and sulfur was not detected above 170 mbsf and is only present in low concentrations below.

Interstitial water chemistry including pH, alkalinity, salinity, major ions (anions and cations), phosphate, ammonium, and minor ion measurements have been completed for all samples from Holes U1456A and U1456B. Salinity decreases, possibly due to clay dehydration, in the upper 60 mbsf and then remains relatively uniform. The pH declines slightly in the top portion of the hole, which may be due to microbial anaerobic sulfate reduction evident by rapid sulfate depletion in the top 50 mbsf. It also results in increase of the alkalinity, which is consumed by calcium and magnesium in the top 50 mbsf to possibly precipitate dolomite. Phosphate and ammonium, byproducts of microbial degradation, increase in the upper 50 mbsf. Once sulfate reduction is complete, methanogenesis becomes an important process below 50 mbsf. Major cation concentrations show gradual decrease with depth, suggesting their removal to solid phase by ion exchange, and for potassium and magnesium, through formation of clay minerals. Higher strontium content in the upper 100 mbsf suggests dissolution of biogenic carbonate (rich in Sr) and deposition of inorganic carbonate (poor in Sr). Dissolved silica concentrations are high in the top 100 mbsf, which may be due to release from biogenic silica.

Hole U1456B is a dedicated microbiology and geochemistry hole cored to 29.03 mbsf. Fluorescent microspheres were deployed in the core catcher sub of each core for contamination testing. Microbiology samples were collected every ~1.5 m, with a total of 18 whole-round samples collected on the catwalk under aseptic conditions. These whole rounds were then subsampled under strict anoxic conditions in an anaerobic chamber and stored at either 4ºC or –80ºC, depending on planned shore-based analyses. Samples were taken from the exterior, interior, and a location in between (termed "intermediate") from each whole round for microsphere analysis. No microspheres were found in the samples from the interior of each core, although microspheres were detected in both the exterior and intermediate samples, indicating that contamination of the interior of each whole-round sample is negligible.

The paleomagnetists completed paleomagnetic and anisotropy of magnetic susceptibility (AMS) analyses for Hole U1456A, producing a preliminary magnetic polarity stratigraphy in which the Brunhes, Matuyama, Olduvai, and Gauss Chrons are recognized. Analyses for Hole U1456C are ongoing, but preliminary data are consistent with the magnetostratigraphy of Hole U1456A. Continuous paleomagnetic analyses of archive-half sections have been suspended because it has not been possible to retrieve reliable directions for the characteristic magnetization due to the presence of a magnetic overprint not fully resolvable after demagnetization in an alternating field of 20 mT, together with the abundant occurrence of sands that display a modern field magnetization. Magnetostratigraphy of Site U1456 is now based on the complete step-wise demagnetization of discrete samples collected from the working-half sections.

Physical properties measurements continued on samples from Holes U1456A to U1456C to provide basic information for characterizing the cored section using whole-round cores, split cores, and discrete samples. Unlike cores from Hole U1456A, the whole-round sections from Holes U1456B and U1456C were run immediately after curation on the Special Task Multisensor Logger (STMSL), at a resolution of 2.0 or 5.0 cm, to help the stratigraphic correlators guide drilling in order to ensure coring of a complete composite section. Those cores were then allowed to equilibrate and were then run on the Whole-Round Multisensor Logger (WRMSL) at 2.0 cm interval and the National Gamma Radiation Logger (NGRL). Thermal conductivity measurements were conducted on the Hole U1456A whole-round sections before splitting, approximately once per core (or every 9.5 m); however, it was difficult to reliably measure thermal conductivity on sandy sections. *P*-wave velocities measured on the WRMSL are erratic, especially in the sandy intervals, because of poor acoustic coupling, with some cores partially filled with water and air trapped inside the core liner. Moisture and density measurements were completed on discrete samples from Hole U1456A, with a few additional samples taken from Hole U1456C to fill in missing stratigraphic intervals. Discrete *P*-wave and shear strength measurements were also completed on the working halves from Hole U1456A and through Core U1456C-26F. A manual penetrometer was used to measure compressional strength for Cores U1456A-34F to 74X because the automated vane shear could not be used due to the indurated nature of the sediments. Magnetic susceptibility variations correlate with the alternation between the coarser graded beds that we interpret as turbidites, and the nannofossil-

rich hemipelagic sediment. Variation in natural gamma radiation also correlates well with lithologic changes. Density measurements are correlated with changes in porosity and lithology, and thermal conductivity is also generally correlated to porosity.

Logging operations at Site U1456C began at 1000 h on 17 April after completion of coring operations to a total depth of 465.2 mbsf. The end of pipe was set at 81.13 m drilling depth below seafloor (DSF) for logging. Two tool strings were deployed in Hole U1456C: the triple combo (gamma ray, resistivity, magnetic susceptibility, borehole temperature, and caliper) and the FMS-sonic tool string. The source was left out of the first logging run with the triple combo because of the potential for unstable borehole conditions due to the abundant unconsolidated sand in Lithostratigraphic Unit II. However, the borehole was determined to be in good condition with no tight pulls, therefore we decided to deploy the triple combo with the source to measure porosity and density during a third logging run. During all three runs, the tool string reached the total depth of the hole (~464 m wireline depth below seafloor [WSF]). The data generated matched well between repeat runs and initial analysis shows good correlation to measurements on the cores.

Education and Outreach

We hosted our first ship-to-shore live video events this week, with connections to an elementary school in Kentucky (USA), a middle school in Texas (USA), and a STEM mentoring and leadership camp for Grades 3–8 in Washington, DC (USA). In addition, several scientists are regularly posting to the JR Facebook (https://www.facebook.com/joidesresolution) and Twitter (https://twitter.com/TheJR) accounts, and others are blogging about the expedition on the *JOIDES Resolution* website (http://joidesresolution.org/).

Technical Support and HSE Activities

The following technical support activities took place during Week 3.

Laboratory

- The laboratories continued processing cores from Holes U1456A, U1456B, and U1456C.
- The Special Task Multisensor Logger (STMSL) is occasionally dropping data points from the magnetic susceptibility loops. We are running experiments to determine the cause; however, the dropped data issue is not enough to halt analysis of core sections.
- A cooling fan on the natural gas analyzer (NGA) needs servicing. This will have to be done after shutting down the system at the end of our expedition.
- We have replaced the coulometer in the Chemistry Laboratory and are preparing the old coulometer to be sent back to shore.

HSE Activities

- Tested safety shower and eye wash stations.
- An abandon ship drill was held on 14 April.