IODP Expedition 354: Bengal Fan

Week 5 Report (22–28 February 2015)

During the fifth week of the IODP Bengal Fan Expedition 354, we finished retrieving the drill string after pulling out of Hole U1451A (MBF-3A) and then spent the rest of the week conducting the following operations in Hole U1451B: (1) installed a reentry cone along with 402 m of 10.75 inch casing, (2) XCB cored from 542.0 to 600.2 m, and (3) RCB cored from 645.8 to 704.6 m. As the week ends, we are continuing to RCB core in Hole U1451B.

Operations

Hole U1451B (MBF-3A)

After pulling out of Hole U1451A, we retrieved the drill string and the bit arrived back on the rig floor at 0600 h on 22 February. We then started preparing and assembling the Hole U1451B reentry system to facilitate our deep coring and logging objectives at this site. The pre-assembled reentry cone was moved over the moonpool and 401.75 m of 10.75 inch casing was assembled and latched into the reentry cone. So that we could drill this casing into the seafloor, our next task was to make up a drilling assembly. This consisted of a 9.875 inch tricone bit, underreamer set to 12.75 inches, mud motor, two stands of drill collars, and 328.57 m of drill pipe. The casing running tool was attached to the top of the drilling assembly and then latched into the reentry system. At 0315 h on 23 February, we opened up the moonpool and started lowering the reentry system to the seafloor. After deploying the camera system at 1000 h, we started to drill the reentry system into the seafloor at 1205 h.

At 0430 h on 24 February, we finished drilling in the 401.76 m of 10.75 inch casing with the reentry cone. The reentry cone landed ~1 m above the seafloor on a mound of cuttings from drilling the hole, so the bottom of the casing is at ~400.76 m below the seafloor. The casing running tool was detached from the reentry system and we started to retrieve the camera system and drilling assembly. By 1600 h on 24 February, all parts of the drilling assembly had arrived back on the rig floor and had been taken apart, cleaned, and stored. We assembled an APC/XCB bottom-hole assembly (BHA) with a 9.875 inch polycrystalline diamond compact (PDC) bit and started lowering it to seafloor at 1830 h on 24 February. We planned to drill without coring to ~540 m (Hole U1451A cored to 582.1 m), and then XCB as far as possible. We decided on the APC/XCB system so that we could have the option to deploy the APC to recover any loose sands (a high priority science objective) not likely to be recovered by our other coring systems (XCB/RCB).

We reentered Hole U1451B at 0255 h on 25 February, retrieved the camera system, lowered the bit to 396 m (~5 m above the bottom of the casing), dropped a center bit, and then washed to

404.7 m. At 0645 h on 25 February, we started drilling ahead without coring from that depth to 542 m; the previous hole had cored to 582.1 m, and we wanted to attempt to recover core from this overlapping interval. We retrieved the center bit and started XCB coring. Eleven XCB cores, and a single 6.7 m interval drilled without coring, penetrated from 542.0 to 640.8 m (98.8 m). Cores U1451B-2X to 13X sampled 92.1 m of section and recovered 19.05 m of core (21%).

Several failures of XCB cutting shoes occurred during this coring. When Core 7X arrived back on the rig floor, the lower part of the XCB cutting shoe was missing; it had been left in the hole. The inner flow diverter was still in place, so it was inferred that the bit became overheated and failed after coring as the bit was pulled off the bottom of the hole. We deployed an XCB barrel with a center bit, advanced 6.7 m to push the pieces of the broken XCB bit out of the path of our coring bit, and then resumed XCB coring (Cores 9X–12X). On the last of these cores (12X), the XCB cutting shoe was recovered with substantial cracks in it; it fell apart on deck when the core was hydraulically extracted from the throat of the cutting shoe. Once again, we inferred that the bit was overheating. For the next core, we decided to reduce the weight on the bit, lower the rotation rate, and increase fluid being pumped. However, when cutting Core 13X the penetration was substantially reduced, so we retrieved it after only a 3 m advance. When Core 13X was recovered on the rig floor, the lowermost part of the XCB cutting shoe was missing and we decided that further XCB coring was no longer viable. At 1930 h on 26 February, we started pulling out of the hole so we could switch to an RCB coring assembly, reenter Hole U1451B, and continue coring to our target depth.

After the APC/XCB bit arrived back on the rig floor at 0340 h on 27 February, we started assembling an RCB bit and BHA. After this was spaced out, we picked up three additional drill collars, finished assembling the BHA, and started lowering it to the seafloor at 0800 h on 27 February. We deployed the camera and reentered Hole U1451B at 1642 h. The bit was lowered through the 10.75 inch casing that extends to 400.76 m and then into the open hole below. At 578 m, the bit encountered an obstruction in the hole, so it was raised up to 569 m to install the top drive. At this time, the drill string became stuck in the hole. The drill string was freed after 2 h of working the drill string by applying overpull, torque, and circulation. We raised the bit back up to 549 m, installed two knobbies beneath the top drive, and started washing and reaming back to the bottom of the hole (at 640.8 m). After reaching the bottom of the hole, we drilled ahead 5 m (640.8–645.8 m) with a center bit to ensure any pieces of the failed XCB cutting shoe were cleared to the side of the hole. Two wireline runs were needed to retrieve the center bit as the first run came up without the core barrel and center bit. We started RCB coring at 0645 h on 28 February and Cores U1451B-15R to 20R penetrated from 645.8 to 704.6 m (63.8 m) and recovered 11.53 m of core (18%). As the week ended, we were continuing to RCB core in Hole U1451B.

Schlumberger wireline logging activities:

- Routine security inspection of supplies and storage facilities; all found in good order.
- Prepared logging software and hardware for U1451B; standby for hole to be drilled.

Science Results

Overview

Site U1451 represents the easternmost location of the 8°N transect, with the deepest targeted drilling depth down to a seismic unconformity, which is believed to indicate the onset of fan deposition at this latitude. This site also contributes to the Miocene–Pliocene transect of three 900 m deep holes and the Pleistocene coverage at six locations. This site targets a maximum penetration of 1500 m in order to recover the oldest fan deposition at 8°N. It is anticipated that this site will be occupied during about one third of the total drilling time of Expedition 354, including downhole logging to the total depth.

Lithostratigraphy

Coring in Hole U1451A was completed this week to a total depth of 582.1 m DSF with 86% recovery. The lithology is dominated (63%) by micaceous siliciclastic sediments, with relatively coarse material (i.e. silty sand and sandy silt) common near the top of the hole (13.61 to 59.04 m CSF-A), and relatively fine material (i.e. silty clay and clay) occurring more frequently in the lowermost units (449.30 to 578.45 m CSF-A). Intervals of fine sand, silty sands and silty clays are interspersed throughout and frequently contain plant fragments. Clastic units are interspersed with mottled and bioturbated hemipelagite sequences (37% of recovered material) that occasionally contain pyritized burrows. Also observed were five glassy volcanic ash layers. Coring in Hole U1451B was initiated at 542 m DSF. Thus far, silty clay and clayey silt containing plant fragments is the most commonly observed lithology in Hole U1451B. One 17 cm thick ash layer composed of amorphous particles was identified at ~687.92 m CSF-A.

Biostratigraphy

This week, calcareous nannofossil and foraminiferal biostratigraphic analyses were conducted at Site U1451. We completed processing and observing samples from Hole U1451A and presented the preliminary biostratigraphic results at the Hole U1451A meeting.

The initial draft of our Site U1450 report was submitted for review. Samples from Hole U1451B were processed, and initial nannofossil biostratigraphy places Sample U1451B-18R-CC in the middle Miocene.

Paleomagnetics

We completed preliminary paleomagnetic studies on 41 Hole U1451A APC cores with minor to no visible coring deformation, focusing our analysis on hemipelagic intervals. In addition to archive half measurements, which we measured at four alternating field demagnetization steps (0, 10, 15, and 20 mT). We measured 82 discrete samples from selected lithologies at eight demagnetization steps up to 60 mT. The increase in demagnetization steps is intended to investigate the stability of remanence (both NRM and drilling overprint) in these Bengal Fan sediments, and to assess the reliability of section half measurements. In spite of challenges including deformation, discontinuous recovery, and noisy inclinations, we identified 13 reversals and worked closely with biostratigraphers to match all but one to the GPTS. Our interpretation spans the upper 178 m (CSF-A) and includes the Gauss-Gilbert chron (3.596 Ma) boundary and subchrons of the Matuyama and Gilbert chrons (covering 0–6.022 Ma). Cores U1451A-1H to 9H (all normal) and 28H–30H (28 reversed) were oriented with the Icefield and Flexit tools. Based on the reversal magnetostratigraphy and biostratigraphy, orientation allowed us to confidently place these cores in the Bruhnes and Gilbert Chrons, respectively.

Physical Properties

Physical property data were acquired on Site U1451 cores, including density, magnetic susceptibility, *P*-wave velocity, natural gamma radiation, and thermal conductivity. The data are mostly of good quality, but the results from disturbed and partially filled sections are less reliable, as described below. The physical properties in Hole U1451A principally reflect lithological variations, with downcore compaction having a relatively minor effect until lithification starts below ~570 mbsf. In the sections measured this week from Hole U1451B lithification is more apparent, for example in *P*-wave velocities sometimes exceeding 2100 m/s. Using the principal lithological name from the core description to assign six lithologies, we calculated their average physical properties. From the 275 m total core recovery from Hole U1451A, sand accounts for 131 m (48%), silt for 39 m (14%), clay for 61 m (22%), and calcareous ooze or chalk for 43 m (16%), with additional thin ash layers and siliceous oozes. In general, sands and silts have the highest density, and *P*-wave velocity; sands have the highest magnetic susceptibility, clays have the highest natural gamma radiation, and calcareous oozes generally have the lowest values in all of the measurements. Some of the sand-rich intervals were difficult to recover and were often fluidized, which sometimes resulted in incompletely filled core liners; this had the effect of giving anomalously low GRA density, magnetic susceptibility, and NGR values. Cores that had inflow of core material ("suck in") also likely have lower than expected values in these physical properties.

Downhole Measurements

In Hole U1451A, we conducted seven formation temperature measurements with the APCT-3 tool at 28.9, 46.3, 60.3, 74.4, 188.0, 301.9 and 406.4 m DSF (while taking Cores 4H, 7H, 10F, 13F, 29H, 52F, and 74F). The last of these measurements beat last week's record to become the

deepest APC formation temperature measurement ever obtained. The geothermal gradient at this site is about 40°C/km.

Geochemistry

The chemistry laboratory spent the week finalizing their report for Hole U1449A, and completing the process of analyzing samples from Holes U1450A and U1451A for headspace gases, pore water and sediment geochemistry. In Hole U1451A, methane concentrations revealed remarkably low values (<8.5 ppmv) down to 578 m CSF-A. Analyses of interstitial waters from Hole U1450A are complete for alkalinity, chlorinity, pH, major elements, and anion chemistry, nearly complete in Hole U1451A, and begun in Hole U1451B. Bulk sediment geochemistry characterization by ICP has been completed for Hole U1449A (12 samples) and Hole U1450A (28 samples), and is in progress for Hole U1451A. Analyses for total inorganic carbon (TIC), total carbon (TC), and total nitrogen (TN) are complete in Hole U1450A (78 samples) and nearly complete for Hole U1451A (81 samples). TIC in Hole U1451A varies from 2 to 13 wt% eq. $CaCO_3$ in lithologies where carbonate is mainly detrital in origin, and from 15 to 50 wt% in lithologies dominated by hemipelagic carbonates. Total organic carbon content (TOC) varies from <0.1 to 1.1 wt%. Sample preparation, processing, and analysis has begun on Hole U1451B samples for pore water and sediment geochemistry.

Summary

Operations so far conducted at Site U1451 revealed a Pliocene–Pleistocene sedimentary record that is much more dominated by hemipelagic carbonate rich ooze deposition than at the two other sites drilled to the west. The Miocene record covers the Upper Miocene down to ~12 Ma. Turbidite deposition is more frequent with alternation of silt to mud sequences frequently associated to macroscopic organic debris deposition. Recovery was very low in the upper part of Hole U1451B due to the overall low compaction and loose sand lithologies for which XCB was inadequate. Lithification clearly increases below 700 m DSF at Hole U1451B and recovery tends to improve while progressing with RCB. So far, in spite of low recovery in the interval between 580 and 650 m, the cores collected provide an excellent record of both turbidite and hemipelagic sedimentation that will allow Himalayan-derived sediments with low diagenetic overprint to be investigated for the source evolution, erosion rates, weathering conditions, carbon burial, and photosynthetic plant evolution during the Upper Miocene and Pliocene. The numerous hemipelagic sequences intercalated in the turbiditic successions will allow a reliable chronostratigraphy.

Education and Outreach Activities

As part of our Education and Outreach activities for the Bengal Fan Expedition, we posted daily updates and photos on our official social media outlets (Facebook [https://www.facebook.com/

joidesresolution] and Twitter [https://twitter.com/TheJR]). We launched a contest to increase our Instagram followers and a crowd-sourcing campaign for a new video. We figured out the problem with the Instagram account, and have been posting there again. We continued compiling activity metrics from these websites, and will be using these analytics to improve future posts and increase our reach. We wrote numerous blogs, and edited scientist blogs, for http://joidesresolution.org/ as well as for the AGU GeoSpace Blog and Munsell Color Blog.

To prepare for our live video interactions with schools and museums around the world, we continued to communicate with shore-based educators to schedule broadcasts and carried out several test connections, including testing the connection and the design/layout of a Ship Chat on the nine-screen media wall with the Exploratorium. We tested the extent of the ship's Wi-Fi to see how far forward we could go before failure (surprisingly far) and reported our findings to the IT staff on board. We held live broadcasts with Los Alamos High School, San Diego Mesa College, Commonwealth Connections Academy, Christina School District, University of British Columbia, Hawaii Academy of Arts and Sciences, and Super Science Saturday.

We interviewed scientists for the "Source-to-Sink" video in production. The videographer started shooting 4K footage for a future UHD media wall museum exhibit, shot video of out-of-the-ordinary drilling operations, including an attempted time-lapse of the drill floor. She created a sequence of the subsea camera system going into the moonpool for a Facebook post. We made two more sediment settling time-lapse videos, changing the mixture of sediments to try and make a better turbidite for a science party crowd-sourced video.

Technical Support

Technical staff are fully engaged supporting coring and science operations at Sites U1450 and U1451. Laboratories are fully operational with no major issues to report that impact this expedition's objectives.

Laboratory Activities

- **Liquid Nitrogen Generator:** We are fairly certain that the N_2 level gauge's zero setting has changed. The generator has been secured while we wait for instructions from the vendor.
- **Whole Round Multisensor Logger:** The Galil amplifier that drives the positioning system failed and was replaced. Cause of the amplifier's failure is unknown but the system is fully operational.

Developer Activities

- ***P*-wave Logger (Whole Round Multisensor Logger):** Updated code to accept velocity constraints based on the user's input into the configuration file. All values are still

displayed on the computer screen but only the values that meet the user's criteria are saved to the LIMS. The WRMSL's code was recompiled and fully tested.

MCS Activities

- **HP Tape Drive:** New issues with this system occurred, and after a discussion with HP technical support it has been decided to replace the unit.
- **Macintosh file access:** Users were unable to access or manipulate files on our servers. The Apple file protocols were reset and the issues cleared.
- **User Room PC Upgrades:** Hard drive upgrades for the User Room PC have been completed.

HSE Activities

- The weekly fire and abandon ship drill was held.