IODP Expedition 354: Bengal Fan

Week 7 Report (8–14 March 2015)

This week we conducted operations in Holes U1450B, U1452A, and U1452B. In Hole U1450B (7–11 March), we drilled without coring to 608.0 m (Hole U1450A cored to 687.4 m) and then RCB cored 203.9 m of section to a depth of 811.9 m. Downhole logging was attempted, but the tool strings could not pass a bridge in the hole ~50 m below the end of the pipe. Hole U1452A (12 March) consisted of a single APC mudline core dedicated to high-resolution studies surrounding the Toba ash. In Hole U1452B (11–13 March), we used a combination of full-length APC, half-length APC (HLAPC), and 4.8 m advances without coring to penetrate to 217.7 m. Hole U1452C (13 March) consisted of continuous coring from the seafloor to 41.3 m to obtain a more complete sampling of the uppermost levee sequence. After a short transit from Hole U1452C, we ended the week preparing to APC core at Hole U1453A (MBF-4A) on 14 March.

Operations

Site U1450, Hole U1450B

We continued drilling without coring in Hole U1450B from 25.7 to 465.0 m. Due to the low penetration rate, at 1945 h on 8 March we retrieved the center bit for inspection and then redeployed it. Drilling resumed at 2100 h and by midnight on 8 March the bit had reached 530.7 m. At 0414 h on 9 March, we finished drilling down without coring to 608.0 m (Hole U1450A was cored to 687.4 m). After retrieving the center bit, RCB coring started at 0515 h. Cores U1450B-2R to 11R penetrated from 608.0 to 705.1 m (97.1 m) and recovered 15.77 m of core. Due to poor recovery for Cores 3R–6R (3.72 m; 8%), slow penetration rate, and sediment jammed in those core catchers, we ran a bit deplugger after Core 6R to clear the bit; subsequent core recovery improved. Cores U1450B-12R to 22R penetrated from 705.1 to 811.9 m (106.8 m) and recovered 15.77 m of core (29%). After Core 22R was recovered (1715 h, 10 March), we decided our primary coring objectives had been mostly achieved, so we started to prepare the hole for downhole logging. RCB coring penetrated 203.9 m of formation (608.0–811.9 m) and recovered 46.66 m of core (23%).

We circulated 35 barrels of mud to clear cuttings out of the hole (while cutting the last core), deployed the rotary shifting tool (RST) to release the bit in the bottom of the hole, filled the hole with 250 barrels of weighted (11.0 ppg) mud, and raised the bottom of the drill string up to 82.7 m. After assembling and testing the first logging tool string (triple combo), we lowered it through and out of the open end of the drill string. The bottom of the tool string encountered an obstruction in the hole at 133.7 m. The tool string was raised and lowered a few times in an attempt to pass through this obstruction, but the tool became stuck in the hole. After applying

nearly the maximum amount of force (just under 8,000 lb) to the logging wireline, the tool string was freed from the formation at 0330 h on 11 March. We decided logging was not possible due to the hole conditions. After the rig floor was cleared of the logging setup, the driller started to pull the string out of the seafloor. However, the pipe had become stuck and the drillers had to apply 40 klb of overpull to extract the bottom-hole assembly out of the seafloor. After the drill string was retrieved, the rig floor secured, the thrusters raised, and the seafloor positioning beacon recovered, we departed for Site U1452 at 1430 h on 11 March.

Site U1452, Hole U1452A

After a 29 nmi transit, we arrived at Site U1452 (MBF-5A) at 1700 h on 11 March, prepared an APC/XCB bottom-hole assembly, and lowered it to the seafloor. After lowering the drill string to the seafloor, we attempted to take the mudline APC core in Hole U1452A at 0315 h on 12 March, but the system would not fire (shear pins did not fail). After recovering the APC core barrel and diagnosing and repairing the problem, we redeployed the APC core barrel and started coring in Hole U1452A at 0540 h (12 March). Core U1451A-1H penetrated 8 m. This core is dedicated to high-resolution studies around the Toba ash layer, so it was only run through the whole-round track systems and then stored for postcruise splitting and sampling.

Hole U1452B

We then offset the ship 20 m to the east and started coring in Hole U1452B at 0700 h. Core U1452B-1H to 5H penetrated to 41.4 m and recovered 8.21 m of sediment (80%). All of these cores were orientated. Core 5H was a partial stroke and inferred to have only penetrated ~4.7 m based on the amount of competent material recovered in the top of the core. We then switched to the HLAPC system. Cores 6F to 12F penetrated from 41.4 to 71.1 m (29.7 m) and recovered 23.32 m of core (79%). Based on evidence on the outside of the core barrel (rusty steel that had been scrubbed clean by the formation), Core 6F only penetrated 1.5 m into the formation, so it was advanced this amount; all other cores were advanced 4.7 m. From 71.1 to 142.4 m, we started alternating 4.7 m long HLAPC cores with 4.8 m intervals drilled without coring. The seven HLAPC cores (14F–26F) penetrated 32.9 m and recovered 21.41 m of core (65%). The eight 4.8 m advances without coring penetrated 38.4 m. Nearly continuous HLAPC coring (Cores 28F to 43F, except for a single 4.8 m advance without coring) penetrated from 142.4 to 217.7 m and recovered 62.49 m of core (89%). We decided our primary deep coring objectives at this site had been achieved, so we pulled out of Hole U1452B and the bit cleared the seafloor at 0030 h on 14 March. Hole U1452B penetrated a total of 217.7 m; 174.5 m of the formation was cored and recovered 140.33 m of core (64%).

Hole U1452C

After the ship was offset 20 m to the south of Hole U1452B, Hole U1452C was continuously cored from the seafloor to 41.3 m to obtain a more complete sampling of the uppermost levee sequence. APC coring in Hole U1452C started at 0245 h on 14 March. After a successful

mudline core (U1452C-1H), we used the XCB system to core from 7.0 to 11.0 m; in Hole U1452B, this interval had poor recovery and appeared to be a hard layer. Unfortunately, this core came back empty. APC coring resumed and Cores 3H–6H extended from 11.0 to 41.3 m (30.3 m) and recovered 30.3 m of core (87%). All of the APC cores were orientated. When the last core recovered sand, our objective for this hole had been reached (we had passed below the targeted levee section) so we pulled out of the hole and recovered the drill string. After the bit was back on board, we secured the rig floor, raised the thrusters, and departed for Site U1453 (MBF-4A) at 1900 h on 14 March.

Site U1453 (MBF-4A)

After a short 23 nmi transit, we arrived at Site U1453 at 2145 h. As the week ended, we were lowering the drill string to start APC coring in Hole U1453A.

Science Results

Overview

Site U1450 was deepened this week. This is one of the three deep penetration sites intended to record erosion of the Himalaya and fan evolution during the Neogene. Earlier in the expedition, this site was cored to 687 m (Hole U1450A) and this second hole (U1450B) was cored to extend the section and obtain downhole log data. The second site of this week (Site U1452), located ~50 km west of Site U1450, was drilled to a comparatively shallow 218 m depth below seafloor and is part of the six-hole transect targeting Quaternary fan construction.

Lithostratigraphy

This week we completed descriptions of cores recovered from Hole U1451B and worked on our lithostratigraphic summaries for the Site U1451 report during logging and transit back to Hole U1450B. In Hole U1450B, Cores 2R–22R are mostly silty clay and clayey silts containing plant fragments to 658.5 m CSF-A; below this depth to the hole base (804.76 m CSF-A), mottled and bioturbated clayey limestones, limestones and claystones interbedded with occasional silt layers are more commonly observed. At Site U1452, Cores U1452B-1H to 6F contain nannofossil-rich calcareous ooze with a volcanic ash layer, clayey silt, silty clay, and silty fine sand.

Biostratigraphy

This week, calcareous nannofossil and foraminiferal biostratigraphic analyses were conducted at Sites U1450 and U1452. At Hole U1450B 24 samples were prepared for foraminifer analyses and 26 samples were prepared for nannofossil biostratigraphy. A total of 18 biomarkers were identified at this site. The first occurrence of *Amaurolithus primus* and the lowest common occurrence of *Discoaster surculus* were tentatively identified in Hole U1450B and suggest that the sediments recovered extend back to the Late Miocene.

At Site U1452 a total of 43 samples were prepared and observed for foraminiferal biostratigraphic analyses and a further 48 were prepared and observed for nannofossil biostratigraphy. Three nannofossil and two foraminiferal biozones were identified, with both confirming a Pleistocene age for the sediments at this site.

Paleomagnetics

We completed preliminary paleomagnetic studies on archive section halves of all 21 cores collected from Hole U1450B (2R through 22R). Remanent magnetization was measured at 2.5 cm spacing after alternating field demagnetization in peak fields of 0, 10, 15, and 20 mT. All cores were unoriented and were collected with RCB, so declinations of remanent magnetization are difficult to interpret in terms of polarity. Noise and bias in the magnetic data from Hole U1451B made it difficult to identify magnetic polarity from inclination alone. We applied the technique developed, with some success at Hole U1451B, which uses the local tectonic deformation of the site to reorient the cores. However at Hole U1450B, the apparent dip of the formation was very small if any. Eleven discrete samples were collected and demagnetized in alternating fields between 0 and 80 mT as well, allowing further exploration of the causes of anomalously high inclinations in many of the cores from Expedition 354.

In addition, we began paleomagnetic analyses at Site U1452. A mudline core was collected from Hole U1452A for detailed study of the Younger Toba Tuff and sediments overlying it. Some of the work to be done on Core U1452A-1H will address environmental magnetic questions. The core was not measured, but has been archived for postcruise splitting and u-channel sampling at the Kochi Core Repository; the first core of Hole U1452B covered this same interval. We have completed paleomagnetic measurement of 14 APC and HLAPC cores from Hole U1452B, of which five are oriented (Cores U1452B-1H to 5H). To increase the speed of core flow, we demagnetized archive half sections from Hole U1452B at three alternating field demagnetization steps (0, 15, and 20 mT). Information from these cores suggests that at least the upper ~140 m of Hole U1452B likely correspond to the Brunhes Chron.

Physical Properties

Physical property data were acquired on cores from Hole U1450B and Site U1452, including density, magnetic susceptibility, *P*-wave velocity, natural gamma radiation, and thermal conductivity. The measurements in Hole U1450B extend these data to 805 m, and continue the downhole trend of low magnetic susceptibility seen in the lower part of Hole U1450A, particularly below 550 m; we interpret this as a trend to lower abundances of sand and silt in the older sediments. At Site U1452, the physical property values are mainly controlled by lithology, as at the equivalent uppermost 200 m of our previous Bengal Fan sites. The Toba ash, at about 1.8 m, has distinct physical properties compared to the background clayey calcareous ooze, having wet bulk densities of 1.65 g/cm^3, standing out against the background density of about 1.3 g/cm^3. The ash is also identified by jumps to higher values of magnetic susceptibility (to 45 instrument units) and natural gamma radiation (to 60 cps).

Downhole measurements

Downhole temperature: In Hole U1452B, we conducted one formation temperature measurement with the APCT-3 tool at 184.7 m DSF, while taking Core 36F. The geothermal gradient at this site is about 38°C/km, based on the single APCT-3 measurement and the seafloor temperature.

Logging measurements: The modified triple combo tool string, consisting of magnetic susceptibility, natural gamma radiation (NGR), and resistivity tools, was run in Hole U1450B on 11 March 2015. The density tool was also run in the tool string for the caliper (borehole diameter) measurement, but without the source because of concerns about hole stability. The bottom of the tool string encountered an obstruction in the hole at about 130 m WSF, only about 50 m into the open hole below the pipe. The tool string was raised and lowered a few times in an attempt to pass through this obstruction, but then the formation started to close in and overpull was required to extract the tool, and we decided to stop logging in this hole due to the adverse hole conditions. However, some open-hole NGR, magnetic susceptibility, and resistivity data were acquired, and NGR in top 80 m of the hole through the pipe could be corrected for attenuation and correlated to the NGR measurements made on core.

Geochemistry

We spent the week completing analysis of samples from Hole U1451B for pore water and bulk sediment geochemistry, and began analyzing samples from Hole U1450B. Processing of samples from Hole U1452B was also started. Headspace gases in Hole U1450B revealed low concentrations of methane (<1105 ppmv). In Holes U1452A and U1452B methane concentrations were variable with a maximum value of 33,761 ppmv. Two samples had quantifiable amounts of ethane (0.7 ppmv). Analysis of interstitial waters for alkalinity, chlorinity, pH, and cation and anion concentration are in progress for Holes U1450B and U1452B. Bulk sediment geochemistry characterization by ICP has been completed for Hole U1451B (46 samples) and is in progress for Hole U1450B. Analyses for total inorganic carbon (TIC) and total carbon (TC) are complete in Hole U1451B (153 samples) and Hole U1450B (96 samples) and in progress for Hole U1452B (19 samples). Carbonate content in Hole 1450B varies from 1 to 63 wt%. Total organic carbon (TOC) calculated by difference between TC and TIC varies from <0.1 to 1.2 wt%. Handheld XRF measurements were conducted on selected sections of cores from Holes U1452A, U1452B, and U1452C.

Summary

Operations in Hole U1450B allowed deepening the Neogene record by more than 200 m down to 812 mbsf and extending the record at this site to the Late Miocene. Overall this site provides an extended record of turbiditic deposition throughout the Pliocene and Late Miocene. Sedimentation in this central segment of the fan appears more sand-rich and turbiditic than the comparable depth section of Site U1451 on the flank of the Ninetyeast Ridge. The base of the

hole dates back to ~8 Ma, which should provide a detailed record of the expansion of C_4 photosynthetic plants (savana type) to the detriment of C_3 plants (forest) in the Himalayan paleo-floodplain. This event is already well recorded on continental sections of the Siwaliks (uplifted foreland basin series) and this new Bengal Fan record will allow more accurate dating of the expansion at the regional scale, thanks to the number of hemipelagic intervals interlayered with turbidites. Shore-based studies of these sediments will also probe the potential links between climate, erosion processes, and plant evolution. Hole U1450B was also drilled with the intention of logging that is part of our primary objectives to capture a more complete image of the sand/silt/clay proportion and alternations. Probably due to collapse of sandy portions of the borehole, this objective could not be accomplished. The lack of any consolidation of sand layers even at greater depth makes coring, and logging in particular, especially challenging in this environment.

The second site drilled this week, Site U1452 is intended to complement our six-site east–west transect to document the Quaternary fan architecture and depocenter migration. The site was cored to 217.7 mbsf with excellent recovery. Like the three other sites already drilled to the east of Site U1452, the top section is covered by hemipelagic deposition with a distinct Toba ash layer and transition to clay and then to turbiditic deposition with depth. This sequence reveals that turbidites did not reach most of the central and eastern fan since at least the last 200 k.y. As a particularly important feature, a levee sequence of about 40 m thickness located beneath the Toba Ash sequence was cored twice to provide high-resolution studies of deposition from the Himalaya, document the duration of levee construction, and provide a high-resolution record of turbidite sediment delivery to the fan at 8°N.

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], Twitter [https://twitter.com/TheJR], and Instagram [http://instagram.com/joides_resolution]). We launched a crowdsourcing campaign to solicit ideas from our followers for the next video. We continued compiling activity metrics from these websites, and we are using these analytics to improve posts and increase our reach. We also wrote blogs for the http://joidesresolution.org/ website and the AGU GeoSpace 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. The Education Officers switched from night shift to day shift to accommodate audiences in different time zones. We held live broadcasts with Cours Bastide (France), Lycée Audiberti (France), Lycée L.Barthou (France), Lycée Xavier Marmier (France), Lycée Descartes (Morocco), Colorado State University (Fort Collins, CO) and the Multidisciplinary Applied Geochemistry Network (six universities across Canada). A special

Nepali broadcast was held with attendees who included a popular Nepalese blogger and a cameraman for a Nepalese national television network. Lastly, we organized a third “Friends & Family” broadcast for members of the Science Party.

The “Source to Sink” video was completed and distributed through various social media channels and to teachers as part of our pre-broadcast resource package. Footage of turbidity currents in a custom-built tank was shot for the turbidite demonstration video that is now in production.

Technical Support

Technical staff are still fully engaged supporting coring and science operations at Sites U1452 and U1453. Laboratories are fully operational. Bathymetric data was collected on all transits.

Laboratory Activities

- **SRA (Source Rock Analyzer):** Still no success in resolving issues. Vendor now believes it is the communication board drivers.
- **Liquid Nitrogen Generator:** The generator was purged and the fill gauge was zeroed. This appears to have fixed the earlier issues with the system.

Developer Activities

- **MSL (Multisensor Logger application):** MSL 5.1 completed offline testing on the SHMSL and was deployed to the WRMSL for use on the current site. MSL 5.1 contains the Bartington corrections from v5.0 and the recent updates to the PWL code. Both tracks are now running on the same software versions.

MCS Activities

- **Sun Servers:** Started planning for decommissioning and service migration to new server platforms.

HSE Activities

- The weekly fire and abandon ship drill was held.