

IODP Expedition 354: Bengal Fan

Week 4 Report (15–21 February 2015)

During the fourth week of the IODP Bengal Fan Expedition 354 we finished coring in Hole U1450A (MBF-2A; 15–17 February), had a short 64 nmi transit to the east, and then spent the rest of the week coring to 582.1 m in Hole U1451A (MBF-3A).

Operations

Hole U1450A

Based on our experiences in the upper portion of this hole and those at Site U1449, we continued deepening Hole U1450A by an alternating series of 4.7 m long half-length APC cores (HLAPC) followed by 4.8 m advances without coring. This was due to the fact that the full APC coring system could not sufficiently penetrate/recover this formation, and the XCB system, although it could penetrate it, would not recover core from this type of formation. In addition, the science objectives required deep penetration sampling at multiple sites, which could not be accomplished in time if the HLAPC was used continuously. This alternating pattern penetrated 428.4 m of formation from 132.9 to 561.3 m DSF (Cores U1450A-28F to 119F). The only exception to this pattern occurred in a few intervals where HLAPC cores were taken consecutively (Cores 80F–84F, 114F–115F, and 117F–119F). The HLAPC cores taken from this interval (28F to 119F) penetrated 226.8 m of formation and recovered 176.7 m of core (77%). Forty-two 4.8 m advances without coring penetrated 201.6 m of formation.

Since we had some difficulty getting Core 119F to penetrate into the formation, we cored the rest of the hole with the extended core barrel system (XCB), except for five HLAPC cores and three 4.8 m advances without coring. Cores 120X–123X cored 37.7 m (561.3 to 599.0 m) and recovered 8.89 m (24%). Since the penetration rate substantially increased while cutting the last part of Core 123X, we inferred that the formation had likely changed back to sandy turbiditic material. We switched back to HLAPC coring, as it was the system most likely to be able to recover poorly consolidated sediments and sands. We then cored an alternating series of HLAPC cores (124F, 126F, 128F) and 4.8 m advances without coring that penetrated 11.2 m of formation and recovered 8.89 m (85%).

The lowermost section of the hole consisted of mostly of XCB cores with two HLAPC cores. Cores 129X (619.8–628.2 m) and 132X–136X (637.7–686.3 m) penetrated 57.0 m and recovered 6.47 m of core (11%). Two half-length APC cores (130F, 628.2–632.9 m; 137F, 686.3–687.4 m) penetrated 5.8 m and recovered 4.05 m (70%). The deepest core at this hole, HLAPC Core 137F, set the record for the deepest penetration piston core in scientific ocean drilling.

We decided to terminate operations in Hole U1450A after this last HLAPC core. We felt that recovering core down to the 900 m target objective and obtaining good wireline logs would be better achieved by drilling a new RCB hole at this site later in the expedition. We pulled the drill string out of Hole U1450A, and the bit cleared the seafloor at 2035 h on 16 February and was back on the rig floor at 0235 h the next day. After the drill floor was secured and the thrusters raised, we started the transit to Site U1451 at 0418 h on 17 February.

A total of five APCT-3 formation temperature measurements were conducted in Hole U1450A at 86.3, 118.7, 156.6, 175.6, and 318.1 m DSF (while taking Cores 17F, 24H, 32F, 36F, and 66F). The last of these measurements is the deepest APC formation temperature measurement ever obtained.

In Hole U1450A, we cored a total of 444.7 m and recovered 282.73 m of core (64%). This included 71 HLAPC cores (318.3 m cored, 245.39 m recovered, 77%), five APC cores (31.7 m cored, 21.98 m recovered, 69%), and 10 XCB cores (94.7 m cored, 15.36 m recovered, 16%).

Site U1451 (MBF-3A)

After a 64 nmi transit at 10.7 kt, we arrived at Site U1451 (MBF-3A) at 1018 h on 17 February. We assembled the APC/XCB bottom-hole assembly (BHA), lowered it to the seafloor, and started coring in Hole U1451A at 1810 h. Cores U1451A-1H to 9H extended to 55.6 m and were advanced by recovery; each of these was also oriented. The last of these cores recovered only 3.3 m, so we switched to half-length APC (HLAPC) cores. Cores 10F–21F extended from 55.6 to 112.0 m (56.4 m) and recovered 58.78 m of core (104%).

Based on the nature of the core material recovered, we decided to switch back to full-length APC coring. Cores 22H–30H extended from 112.0 to 197.5 m (85.5 m) and recovered 73.99 m of core (74%). Each of these was not advanced by recovery, but by the full 9.5 m barrel length. Core orientation was conducted on Cores 23H–30H. The core liner of the last two APC cores failed, so we switched back to the HLAPC system.

The rest of the week was spent deepening the hole from 197.5 to 573.7 m with an alternating series of HLAPC cores and 4.8 m advances without coring. The 41 HLAPC cores from this interval (31F–110F) cored 189.0 m of section and recovered 144.3 m (76%); thirty-nine 4.8 m long intervals were drilled without coring. The majority of the HLAPC cores in this section were partial strokes. Recovery for the last four HLAPC cores was poor (only from 0.55 to 1.30 m) and up to 40 klbs of pressure was required to pull the core barrel out of the formation, despite only having penetrated a short distance into the formation. We decided further HLAPC coring would not work. Before stopping coring operations in Hole U1451A, we took one XCB core (Core 111X, 573.7–582.1 m, 4.75 m recovered, 57%). After this last core from Hole U1451A arrived on deck at 1750 h on 21 February, we started pulling the drill string out of the hole. The bit cleared the seafloor at 2130 h, and just before midnight we took a break from tripping pipe to slip and cut the drill line.

Formation temperature measurements (APCT-3) were made while taking Cores 4H, 7H, 10H, 13H, 29H, 52F, and 74F (28.9, 46.3, 60.3, 74.4, 188.0, 301.9, and 406.4 m). The latter of these broke the record for the deepest piston core formation temperature measurement ever obtained; the previous record had been set at our last site.

Schlumberger wireline logging activities:

- Met with client to discuss logging for Hole U1450A; logging plan confirmed, then 3 h later was cancelled until later in expedition.
- Met with Co-chiefs/scientists to discuss possible logging plans for Site U1451 and to confirm details for seismic operations during the leg.
- Completed routine security inspection of storage facilities for hazardous materials used for pipe severing and logging tools; all found in good order.
- Prepared logging software for Hole U1451B; standby for hole to be drilled.

Science Results

Overview

Site U1450, the second of our six site transect, targets a 900 m thick late Miocene to Recent sedimentary section. In addition to addressing the shallow late Pleistocene section to study the architecture and evolution of the middle Bengal Fan, this site also provides insight into long term changes in the delivery mechanism of the fan and the climatically and tectonically influenced sediment supply from the Himalaya. The deeper portion of Site U1450 will be compared with two complementary sites on our east–west transect on top of Ninetyeast Ridge and 85°E Ridge, respectively (proposed sites MBF-3A [now Site U1451] and MBF-1A).

Site U1451 (proposed site MBF-3A) is the easternmost site of the transect. It is located on the western flank of the Ninetyeast Ridge on a somewhat uplifted position compared to the central part of the fan transect (i.e. Site U1450). This site targets a maximum 1500 m penetration in order to recover the oldest fan deposition at 8°N in addition to the Neogene and Pliocene–Pleistocene objectives described for Site U1450. The deep objective is an unconformity clearly imaged on the seismic data, which marks a fan prograding phase of possible Eocene age. The objective there is to document the early stage of Himalayan erosion.

Lithostratigraphy

One hole was drilled (U1450A; MBF-2A) to a total depth of 687.4 m DSF, with a core recovery of 64%. The lithology is similar to that of Site U1449A, dominated by siliciclastic material, comprised of intervals of mica-rich quartz-dominant fine sand separated by silty-clay and clayey-silt intervals. Drilling disturbances are common in clastic layers, which results in structureless intervals of mixed sand and silt. Where structure of clastic beds is preserved, both mud- and

sand-turbidites of varying thickness are present. Siliciclastic intervals are separated by mottled and bioturbated pelagic and hemipelagic sequences containing foraminifera. Three glassy volcanic ash layers occur within the upper 246 m CSF-A.

Lithological differences between siliciclastic units, grain size and bed thickness reflect cycles of proximal turbidity current channel activity. Bioturbated pelagic and hemipelagic oozes likely represent times of channel-levee inactivity and hence reduced deposition through the settling of suspended sediment from the pelagic zone.

Coring at Site U1451A (MBF-3A) recovered predominantly mottled pelagic and hemipelagic sequences with bioturbation and frequent pyritized burrows. Mica-rich fine sand, silt and clay intervals are also present, displaying varying levels of turbiditic structure, beside the degree of drilling disturbance observed in the lower portions of most cores. Volcanic ash layers have also been identified.

Biostratigraphy

This week, calcareous nannofossil and foraminiferal biostratigraphic analyses were conducted at Sites U1450 and U1451. Ten nannofossil and three foraminiferal biozones were identified at Site U1450, with the oldest extending back to the Upper Miocene. At Site U1451, we have processed and observed 100 core catcher samples. Foraminifera are highly variable in their abundance and preservation and are dominated by dissolution resistant species. Nannofossil assemblages observed in the most recent core catcher of Core 100F suggest a Middle Miocene (NN9–NN7, 9.5–12 Ma) depositional age.

Paleomagnetism

We completed a preliminary paleomagnetic study on 31 of the 76 APC cores and three out of 10 XCB cores collected from Hole U1450A, avoiding deformed or sandy intervals. Most cores were unoriented, so we relied on inclination data as well as declination data within each core, both from discrete samples and archive section halves. As with Site U1449, we observed that hemipelagic sediments are the most useful for magnetostratigraphy. Despite the lack of long cores due to spot coring, the few hemipelagic sections retrieved allowed us to identify only the Jaramillo (0.988–1.072 Ma) and Cobb Mountain (1.173–1.185 Ma) subchrons, both in a hemipelagic interval in Core 36F.

We also analyzed 28 cores from Hole U1451A. We measured the magnetization of all retrieved hemipelagic sections at four demagnetization steps (0, 10, 15, and 20 mT). So far, we identified both the Upper and Lower Jaramillo transitions in Core 15H and observed a reversal from reversed polarity to normal in Core 23H. We have not yet matched the latter transition to the GPTS, but work is in progress in conjunction with the biostratigraphers.

Physical Properties

In the lower part of Holes U1450A and U1451A, physical property data were acquired on almost all cores and allow three general lithological categories to be distinguished, similar to Site U1449 and the upper portion of Site U1450. Sand-dominated lithologies reveal high acoustic velocity, high wet bulk density, generally high magnetic susceptibility, and intermediate to high levels of natural gamma radiation (NGR). Occasional very high levels of NGR and magnetic susceptibility (e.g. at 490 m CSF-A) could indicate elevated concentrations of heavy minerals in the sediment. Silty-clay lithologies show intermediate values of acoustic velocity, wet bulk density and susceptibility, and the highest NGR levels. Hemipelagic calcareous lithologies are easily distinguished by their low acoustic velocity, low wet bulk density, very low magnetic susceptibility, low NGR, and the lightest color. A long interval dominated by (hemi)pelagic sediment occurs between 135–187 m CSF-A. A series of four or five broad alternations between sand-dominated and clay-dominated lithologies occur between 200 and 600 m CSF-A. In cores that have fluidized sand and/or gaps between the core and core liner, physical property measurements typically underestimate the expected true values for these sediments.

Geochemistry

The chemistry laboratory spent the week finalizing results from Holes U1449A and U1449B, and processing and analyzing samples from Holes U1450A and U1451A for headspace gases, pore water, and sediment geochemistry. In Hole U1450A, methane concentrations reached 34,500 ppmv while ethane concentrations stayed below 1 ppmv. In Hole U1451A methane concentrations consistently reveal remarkably low values (<8.5 ppmv) down to 578 m CSF-A. Analysis of interstitial waters for Holes U1449A and U1449B are complete for alkalinity, chlorinity, pH, major elements, and anion chemistry, nearly completed in Hole U1450A, and begun in Hole U1451A. Bulk sediment geochemistry characterization by ICP has been completed for Hole U1449A (12 samples) and is in progress for Hole U1450A (19 samples analyzed). Analyses for total inorganic carbon (TIC), total carbon (TC) and total nitrogen (TN) are complete in Holes U1449A (37 samples) and U1450A (78 samples). TIC in Hole U1450A varies from 0.1 to 1.2 wt% in lithologies where carbonate is mainly detrital in origin, and from 1.2 to 7.6 wt% in lithologies dominated by hemipelagic carbonates. Total organic carbon (TOC) calculated by difference between TC and TIC varies from <0.1 to 1.2 wt%. Sample preparation, processing and analysis have begun on Hole U1451 samples for pore water and sediment geochemistry.

Summary

Operations conducted at Site U1450A allowed us to core with very decent recovery down to the Upper Miocene. The HLAPC coring combined with 9.5 m advance allowed us to core difficult lithologies such as loose sand and mud turbidite alternations while maintaining a rate of penetration sufficient to advance in depth within the planned schedule. The lithification remained moderate down to more than 630 m CSF-A. Below that, despite increasing lithification, XCB

recovery was low, which triggered the decision to stop Hole U1450A at 687.4 m DSF. However, drilling the remaining 200 m below this depth is planned for later in the expedition with the rotary drilling technique would allow to complete the sedimentary record back to ~10 Ma and achieve complete logging in the best hole condition possible. Lithologies sampled are quite similar to those cored at Site U1449. Sequences of 50 to 150 m thick high accumulation rate turbidites composed of variable proportions of mica-rich fine sand, silt, and clay are separated by comparatively thin, hemipelagic and carbonate rich intervals. The latter represent intervals of abandonment of the turbiditic input to this portion of the fan. Dating and estimating the duration of these intervals as well as testing their continuity across the transect will reveal the fan construction dynamics as well as the long-term detrital sedimentary input. Given the challenge of coring complex successions of alternating lithologies throughout the whole section, we view the approach of HLAPC “spot” coring as an appropriate compromise between recovery and drilling time, and the recovered material appears more than adequate to achieve our scientific objectives.

At our third site, we completed Hole U1451A down to 582.1 m DSF. This again was principally achieved using HLAPC throughout most of the section. The upper 202 m of the section were cored continuously, returning a total recovery close to 100% and a detailed record of the Pleistocene and Upper Pliocene section. This will be particularly useful to correlate between the sites along our transect, as pelagic sections seem to be more prevalent and more complete at this site.

Below, and down to 573 m, the alternating pattern of 4.7 m HLAPC cores with 4.8 m intervals drilled without coring was again chosen in order to fulfill the overall expedition objectives. The overall lithology at Site U1451 is comparable to that of other sites, although hemipelagic and carbonate rich sedimentation is more represented in the section. The base of Hole U1451A reached turbiditic sequences of Middle Miocene age. Operations are continuing at Site U1451 where we are preparing to core the deeper section after installing a reentry cone and 400 m casing to enhance hole stability so that we can achieve these high priority objectives.

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 continued compiling activity metrics from these websites, and will be using these analytics to improve future posts and increase our reach. Since the start of the expedition we have engaged over 4500 people, including ~200 new followers. We wrote blogs for <http://joidesresolution.org/> and began updating the website’s glossary. 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. We held live broadcasts with 1st/2nd year students at the University of New England (Australia) and Utah

Valley University (USA) and with high school students at Lycée Jules Haag (France), Lycée du Val d'Argens (France) and Lycée Anna de Noailles (Romania). Finally, we completed a pilot study on a time-lapse video showing how a turbidite is deposited, and began shooting interviews and preparing animations for a "Source to Sink" expedition mission video.

Technical Support

Technical staff are fully engaged supporting coring and science operations at Sites U1450 and U1451. Bathymetric data were collected on the transit between the two sites. The laboratories are fully operational with no major issues to report.

Laboratory Activities

- **Liquid Nitrogen Generator:** The system appears mechanically sound but the dial indicator may have unknown issues. The investigation continues.
- **Section Half Imaging Logger (SHIL):** Occasional transient issues of the frame grabber failing to acquire an image have occurred. The SHIL system will be moved to the back-up hardware to see if the issue is hardware specific.
- **Thermal Conductivity:** The new mini-pucks are in the process of being tested.

Developer Activities

- **HLAPC cores/Drilled interval:** Initial mistakes made in the entry applications are requiring manual intervention to correct.
- **Thermcon Uploader:** We are investigating an issue with the thermcon uploader.

MCS Activities

- **McAfee Repository:** Issues with the McAfee antivirus repository updates from shore were finally resolved.
- **Personal Computer Upgrades:** Hardware upgrades to our PCs have started in the user room.
- **Etna (Sun Server):** Oracle support was contacted regarding the failed fan assembly and concluded that it is dead. A new fan has been ordered and delivered to IODP for the Expedition 355 air freight.

HSE Activities

- The weekly fire and abandon ship drill was held.