

IODP Expedition 354: Bengal Fan

Week 8 Report (15–21 March 2015)

This week we (1) cored to 215.7 m at Site U1453 (MBF-4A) and collected downhole logging data with two tool strings, (2) cored one deep (161.8 m) and three shallow holes at Site U1454 (MBF-7A), and (3) started coring at our last location of Expedition 354, Site U1455 (MBF-1A, DSDP Site 218).

Operations

Hole U1453A

After a short 23 nmi transit, we arrived at Site U1453 at 2145 h on 14 March. We assembled an APC coring bottom-hole assembly (BHA) and started lowering it to the seafloor. We used a 9.875 inch PDC coring bit with a lockable float valve (LFV) so that we would have a smaller diameter hole for improved log data if hole conditions would allow. Non-magnetic hardware was used for all cores (drill collar, core barrels). We finished lowering the drill string to the seafloor and started coring in Hole U1453A at 1020 h on 15 March. Except for one 5 m interval advanced without coring, APC and HLAPC coring penetrated from the seafloor to 172.9 m (Cores U1453A-1H to 34F) and recovered 148.84 m of core (89%). The HLAPC system was used except for the full-length APC system that was used for the first four cores (1H–4H) and one deeper core (29H, 142.4 to 149.4 m) that attempted to recover a hemipelagic layer in a single core. The rest of the coring in Hole U1453A (172.9 to 215.7 m) consisted of four HLAPC cores alternating with five 4.8 m advances without coring. Cores U1453A-36F to 42F penetrated 18.8 m and recovered 15.94 m of sediment (85%). The majority of piston cores at this site were partial strokes. Orientation was attempted on all of the full-length APC cores.

Since the primary coring objectives were achieved, at 0715 h on 17 March we started preparing the hole for downhole logging. We circulated 25 barrels of mud to clean cuttings out of the hole. To ensure the lockable float valve was functioning properly for logging, we also activated it with a go-devil and an XCB barrel. After filling the hole with 180 barrels of 12.0 ppg mud, we raised the bit up to logging depth (78.5 m). The triple combo logging string was assembled and we began lowering it down the drill string at 1200 h on 17 March. At ~2170 m DRF within the drill pipe well above the seafloor, the string began losing weight. We inferred it had encountered the weighted mud, so we circulated the mud down to the seafloor and resumed lowering the logging tool string. Log data were collected to the full depth of the hole and indicated good hole conditions. After the triple combo was recovered, we ran the FMS-sonic tool string, which also reached the bottom of the hole in two passes. The tool string was back on the rig floor just before midnight on 17 March and the rig floor was cleared of all equipment by 0055 h on 18 March. We

then spent 45 min getting the pipe free from the formation with the bit clearing the seafloor at 0200 h on 18 March. We retrieved the drill string, secured the rig floor, raised the thrusters, and departed for Site U1454 (MBF-7A) at 1135 h.

Site U1454 (MBF-7A)

After a 56 nmi transit, we arrived at Site U1454 at 1706 h on 18 March, assembled an APC/XCB BHA, and lowered it to the seafloor. At 0115 h on 19 March, we took a single mudline core in Hole U1454A (1H, 0 to 7.5 m) for microbiological and geochemical studies. We offset the ship 20 m to the east and started coring in Hole U1454B at 0255 h on 19 March. The full-length APC penetrated from the seafloor to 32.1 m (Cores U1454B-1H to 4H, 30.28 m recovered, 94%). We switched to the HLAPC and cored from 32.1 to 161.8 m. This 129.7 m interval included three 4.8 m advances without coring. Cores U1454B-5F to 32F sampled 129.7 m of formation and recovered 99.23 m of sediment (86%). Coring was interrupted for 2 h on 19 March when a broken strand on the coring line snagged in the top drive; ~1500 m of coring line had to be cut off and the coring line re-terminated. A single temperature measurement was obtained during Core U1454B-30F. Having achieved our depth objectives, we decided to core two more holes to obtain a more complete section in the upper ~37 m. We pulled the bit out of Hole U1454B, offset the ship 20 m to the south, and started coring in Hole U1454C at 1650 h on 20 March. Cores U1454C-1H to 6F penetrated to 37.2 m and recovered 30.16 m (81%). We pulled the bit out of Hole U145C, offset the ship 20 m to the west, and started coring in Hole U1454D at 0020 h on 21 March. Cores U1454D-1H to 5F penetrated to 37.1 m and recovered 24.46 m (66%). We pulled the bit out of the seafloor (0630 h) and retrieved the drill string. Once the bit was back on the rig floor, we secured the rig floor, raised the thrusters, and departed for Site U1455 (MBF-1A) at 1336 h.

Site U1455 (MBF-1A, DSDP Site 218)

After the 26 nmi transit, we arrived at Site U1455 at 1640 h. We assembled an APC BHA with a 9.875 inch PDC bit and an LFA (to allow for logging) and started lowering it to the seafloor. At midnight on 21 March, the bit was just above the seafloor and we were preparing to start coring in Hole U1455A.

Science Results

Overview

Coring and wireline logging this week contributed important pieces of information to our seven-site east–west transect of the middle Bengal Fan. At Site U1453, we were finally able to collect wireline log data. The previous attempts to log the deep-penetration Sites U1450 and U1451 failed because of bad hole conditions (loose sands, bridging). Wireline logging was an important objective for our expedition since it was intended to provide information where we expected that

unconsolidated core material would be poorly recovered, a complete inventory of stratification and turbidite successions, and in situ properties of the formations. When sand layers are thick they are typically not fully penetrated by piston coring (partial stroke) and the sands often lose their original structure and become liquefied during the coring process and retrieval. In order to characterize the different lithofacies types—including thicker sand intervals—we opted for logging a short and shallow interval to measure the in situ physical properties (density, *P*-wave velocity, resistivity) and image the sedimentary structures with the FMS. This was performed successfully at Site U1453 between 210 and 80 m DSF. These data provide an important basis for the interpretation of the composition of the turbidites cored during this expedition at other sites.

Site U1454 (MBF-7A) is the westernmost of the seven-site transect of >200 m penetration locations drilled in the Bengal Fan at 8°N during Expedition 354. This 300 km east–west transect is intended to provide an overview of Pleistocene fan architecture and evolution. The site was introduced during the expedition as an alternate site to better document the recent and upper Pleistocene fan deposition. This complements the other Expedition 354 sites because drilling in the eastern and central parts of the transect revealed that fan deposition above and below the Toba ash layer (~70 ka) was remarkably low, marking the abandonment of channels supplying this part of the fan between the Ninetyeast and 85°East Ridges for probably the last 300 ka. Site U1454 is located ~50 km west of Site U1455 (DSDP Site 218) on the western levee of a channel-levee system that is believed to be the modern active channel of the fan. Coring at Site U1454 successfully recovered a full section of this recent levee that will be dated by ¹⁴C and δ¹⁸O so that it can be related to global climatic and sea level cycles as well as other proxies for sediment flux and weathering. Multiple turbidite units were recovered including one with impressive centimeter-size tree fragments at its base. Deeper in the cores at this site, we recovered a hemipelagic unit that contains the Brunhes/Matuyama boundary, as well as the Jaramillo and Cobb Mountain subchrons. This allows magnetostratigraphic correlation of mid-Pleistocene sediments across the other 8°N transect sites.

We are presently starting to core the last site of Expedition 354. Site U1455 is a reoccupation of DSDP Leg 22 Site 218, which was the first attempt to drill the Bengal fan and was the only spot cored to 773 m. The site is above the eastern flank of the 85°East Ridge at 8°0.42'N and 86°16.97'E at 3743 m water depth. Together with the 8°N seismic surveys in 1997 and 2006, DSDP Site 218 was the basis to establish the Expedition 354 transect strategy. Site U1455 is one of the three deep penetration sites of the transect aimed to model the Neogene fan evolution and to record Himalayan erosion. The site will also document the Pleistocene fan architecture when integrated into the complete seven-site transect of the expedition. Coring to 900 m is planned to determine Miocene–Pliocene accumulation rates and changes related to Himalayan erosion and environment. The deeper part of the site will extend the existing record in the middle Miocene.

Lithostratigraphy

This week we completed descriptions of cores recovered from Holes U1452B and Sites U1453 and U1454. We began description of the cores recovered from Hole U1455A.

At Site U1453, cores are Pleistocene in age and document a buried channel-levee system as imaged by seismic profiles. Cores 1H to 4H from this site are light gray calcareous clay. A light brown ash layer, gray clay, and dark gray fine sand were also described. From Core 5H to 22F downwards, a succession of clays with silt interbeds and intervals of homogenous silty sand with mica occur. Finally, Cores 23F to 42F display a succession of dark gray sand, gray clay with silt interbeds, and calcareous clay.

In Hole U1454B, Cores 1H to 8H are middle to early Pleistocene in age and contain gray clay with silt interbeds and dark gray fine sands with mica. Cores 8F to 32F are early Pleistocene gray clay with silt interbeds, dark gray sand, and grayish white to light brown nannofossil-rich calcareous clay. Cores of Site U1454 document the levee buildup of the recently active channel.

At Site U1455, Core U1455A-1H is Late Pleistocene in age and contains light brown nannofossil-rich calcareous clay with minor dark gray silt and fine sand.

Biostratigraphy

This week, calcareous nannofossil and foraminiferal biostratigraphic analyses were conducted at Sites U1453 and U1454. The sediments at Site U1453 contain a Recent to Early Pleistocene sequence. Four biomarkers were identified at this site, with three nannofossil and two foraminiferal biozones defined. Three holes were drilled at Site U1454. The sediments here represent an expanded Holocene to Early Pleistocene sequence of levee sediments deposited adjacent to the active channel.

Paleomagnetism

We completed preliminary paleomagnetic studies at Sites U1452, U1453, and U1454, and reran all cores of magnetostratigraphic importance at all previous sites due to common SRM position errors ranging from a few centimeters to 20 centimeters between runs. We are very thankful for the hard work the shipboard science technicians in finding a solution to this combined mechanical and software problem.

At Site U1452, we measured archive half sections of 22 cores from Hole U1452B and three cores from Hole U1452C along with five discrete samples. At Site U1453, we measured the archive section halves from 18 cores along with 14 discrete samples. At Site U1454 we measured 19 cores and 10 discrete samples. Only NRM before AF demagnetization was measured on archive halves from the upper 50 m at Site U1454 to preserve sediment magnetization for shorebased analysis. NRM after AF demagnetization was measured for some cores with good recovery below 50 m.

The Brunhes/Matuyama boundary (C1n–C1r) was identified at Sites U1452, U1453, and U1454, as well as the Jaramillo and Cobb Mountain subchrons, allowing for magnetostratigraphic correlation of mid-Pleistocene sediments along the 8°N transect.

Physical Properties

Physical property data were acquired on cores from Holes U1453A, U1454A, U1454B, U1454C, and U1454D, and included density, magnetic susceptibility, *P*-wave velocity, natural gamma radiation (NGR), and thermal conductivity. Maximum values of magnetic susceptibility (up to 300 instrument units) along with high values of NGR are observed in Cores U1453A-22F and 25F, and they correspond to thick sand layers. These layers appear to be distinct from other sand-rich lithologies in the core, which have magnetic susceptibility around 100 units. At Sites U1453 and U1454, the physical property values are mainly controlled by lithology, as at the equivalent top 200 m of the previous Expedition 354 sites.

Downhole measurements

Downhole temperature: In Hole U1453A, we conducted one formation temperature measurement with the APCT-3 tool at 177.7 m DSF while taking Core 36F. The geothermal gradient at this site is about 33°C/km, based on the single APCT-3 measurement and the seafloor temperature.

In Hole U1454B, we conducted one formation temperature measurement with the APCT-3 tool at 152.4 m DSF while taking Core 30F. The geothermal gradient at this site is about 39°C/km, based on the single APCT-3 measurement and the seafloor temperature.

Wireline logging: The modified triple combo and the FMS-sonic tool strings were run in Hole U1453A on 17 March 2015. The density tool (without the source due to hole conditions) was included in the triple combo for the caliper (borehole diameter) measurement. Barite-weighted mud, 12 ppg, was used to stabilize the borehole walls. Both strings reached almost the depth of the bottom of the hole, about 220 m WSF. The borehole was in good condition for logging, averaging 10 inches wide in the bottom 50 m of the hole, and about 13 inches wide in the 50 m below the pipe, which was set at 79 m WSF, with some m-scale washouts to wider diameters. The good logging conditions were likely due to both the heavy mud and drilling with a PDC bit, which at 9.875 inches is narrower than the APC roller-cone bits. Additionally, it appears to wash-out the borehole less than the roller-cone bits.

The logged values mainly depend on lithology, and the hole is too shallow for compaction effects to be evident in the data. The hemipelagic interval between 155–158 m WSF has relatively low velocity, resistivity, magnetic susceptibility, and NGR. The in situ downhole velocity measurements are higher than the equivalent PWC and PWL measurements in the lab, reflecting core expansion. Downhole magnetic susceptibility measurements have been corrected for temperature drift and they match quite well to the core magnetic susceptibility measurements.

Geochemistry

The Chemistry Laboratory spent the week processing and analyzing samples from Sites U1452, U1453, and U1454, for headspace gases, pore water, and bulk sediment geochemistry. Methane concentrations at Sites U1452 and U1453 are similar, with values sharply increasing at ~40 m CSF-A from background level to higher and more variable values (maximum 33,762 ppmv). In contrast, methane concentrations at Site U1454 remain very low (background level) down to ca. 100 m CSF-A. Analysis of interstitial waters for alkalinity, chlorinity, pH, major elements, and anion chemistry are in progress for these sites including the mudline core U1454A for high resolution pore water and microbiological studies. Bulk sediment geochemical analysis by ICP is in progress at Sites U1452, U1453, and U1454. Analyses for total inorganic carbon (TIC) and total carbon (TC) are complete for Sites U1452 and U1453 (41 samples) and in progress for Site U1454 (15 samples). Carbonate content at Sites U1452 and U1453 varies from 0.6 to 51.1 wt%. Total organic carbon content (TOC) calculated by difference between TC and TIC varies from <0.1 to 2.5 wt%. Handheld XRF measurements were conducted on selected core sections including Pleistocene ash layers and paleomagnetic reversal stratigraphy in the 1.2 Ma to 0.8 Ma age range.

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 wrapped up the crowd-sourcing campaign, which included testing Facebook's poll feature, to solicit ideas from our followers for the next video. We continued compiling activity metrics from these websites, and are using these analytics to improve posts and increase our reach. We also wrote blogs for the <http://joidesresolution.org/> website.

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 Sunnyside Elementary School (San Francisco CA), Centre International Valbonne (France), Cours Bastide (France), Lycée Amiral de Grasse (France), Lycée Descartes (Morocco), Lycée Français Jean-Monnet (Belgium), Lancaster University (UK), Escola Secundaria de Loule (Portugal), Presidency University (India), and Nexus International School (Malaysia). Of special note was a live broadcast with students from two schools in Nepal, Adarsa Vidhya Griha and Ram Jyoti Secondary School. Lastly, we organized a fourth "Friends & Family" broadcast for members of the Science Party.

The turbidite transport video is in final production. The social media crowd-sourced video "A Day in the Life of a JR Scientist" and a video with music "Tripping Pipe" are now in production. A presentation on student opportunities with IODP and ECORD is also being prepared.

Technical Support

Technical staff are still fully engaged supporting coring and science operations at Sites U1453, U1454, and U1455. Laboratories are fully operational. Bathymetric data was collected on all transits.

Laboratory Activities

- **SRA (Source Rock Analyzer):** After working with the vendor over the last week, we believe the issues are resolved. Testing is in progress.
- **Cryogenic Magnetometer:** Discovered and resolved positioning issues with the software (SRM-Section) by changing the position method from relative incremental to absolute. This eliminated positioning errors from accumulating when the drive motor failed to reach the instructed position.

Developer Activities

- **Sample Master:** Issues with null values in the core catcher affecting the display of data in the application remain unresolved.
- **SRM Software:** A test version of the software was released to correct accumulated errors in the position data.

MCS Activities

- **SHIL-B (Imaging Track Computer):** Was reconfigured to use the 1TB RAID drives as boot drives.
- **Sun Servers:** Started planning for decommissioning and service migration to new server platforms.
- **Tape Drive 1:** Problems have continued with this drive, requiring it to be disabled until the replacement is delivered.
- **Computer Upgrades:** Finished upgrading all Userroom PCs to 1TB disk drives.

HSE Activities

- The weekly fire and abandon ship drill was held.