

## **IODP Expedition 354: Bengal Fan**

### **Site U1455 Summary**

#### **Background and Objectives**

Site U1455 is the last site drilled by Expedition 354 in the Bengal fan. It is a reoccupation of DSDP Leg 22 Site 218 (von der Borch and Sclater, 1974), which was the first attempt to drill the Bengal fan and was only spot cored with RCB to 773 m. The site is above the eastern flank of the 85°E Ridge at 8°0.42'N, 86°16.97'E, at 3743 m water depth. Site U1455 is one of the three deep penetration sites of the Expedition 354 transect aimed to reveal Neogene fan evolution and 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 was planned to determine Miocene to Pliocene accumulation rates and changes related to Himalayan erosion and environment. The deeper part of the site will extend the existing Site 218 record back into the Middle Miocene. Due to time constraints at the end of Expedition 354, we focused coring on three objectives: Pleistocene (0–122 m), Late Miocene terrestrial vegetation (C<sub>3</sub>- to C<sub>4</sub> plants) transition (360–431 m), and Middle Miocene (773–949 m) to extend the existing core record of Site 218.

Because Site U1455 is above the 85°E Ridge that is undergoing deformation since the Miocene (Schwenk and Spiess, 2009), accumulation rates at this site are lower than at Site U1450 in the axial part of the fan transect, and are similar to those at Site U1451. The overall thickness of the fan is less than 4 km in this location according to Curray et al. (2003). These lower accumulation rates offer the possibility to capture a longer stratigraphic range within an achievable depth of penetration. Site U1455 is intended to help to establish a representative accumulation history from Middle Miocene to Recent, which is essential to complete the 8°N transect of the Bengal fan.

#### **Principal Results**

Site U1455, located above 85°E Ridge, is a key location for the transect approach—particularly for investigating Miocene fan deposition. A comparison between the easternmost Site U1451 and this site should elucidate whether depocenter migration occurred in a similar manner as in the Pliocene and Pleistocene. Due to the absence of major channel-levee systems, addressing these objectives can only be achieved by

integrating core and seismic data. This will require good chronostratigraphic control to be able to compare the same time periods. This has to await post-expedition work.

Site U1455 also cored critical intervals that will address different objectives. In the upper section, Core U1455C-1H, the Toba ash layer is found at 5.6 m instead of being consistently around 2 m deep like at the other eastern Expedition 354 sites. The vicinity of the most recently active channel (see Site U1454, ~50 km to the west) is the likely explanation for this increased sedimentation, and indeed discrete turbiditic deposition is observed above the Toba Ash layer at this site. This will further document deposition of clay and silt in the context of a distant channel.

Second, the deeper Late Miocene interval cored between 360 and 431 m returned a relatively continuous record across the terrestrial vegetation change from the C<sub>3</sub> to C<sub>4</sub> photosynthetic type of plants which was known to occur around 380 m at Site 218. A number of short hemipelagic intervals are present in this section and should provide a good chronological constraint for this transition and may document variability on shorter timescales.

Coarser-grained deposition has been found below 770 m, even though recovery of sand is limited. Coarser-grained material suitable to study Himalayan erosion became available whereas it was not recovered at Site U1451 for the same period. In this particular depth interval, further detailed sedimentologic analyses may shed light on the causes for the depositional facies being different from Pliocene and Pleistocene times, and whether the absence of levees originates from a change in sediment supply, in the lifetime of transport pathways or other factors.

### ***Operations***

We cored three holes at Site U1455 (MBF-1A, DSDP Site 218). Holes U1455A and U1455B each consisted of single mudline core penetrating to 0.9 m and 6.9 m, respectively. Hole U1455C consisted of coring in three intervals: from 0 to 122.3 m (APC, HLAPC), 359.8 to 431.4 m (HLAPC), and 773.0 to 949.0 m (RCB). The uppermost interval consisted of APC and HLAPC coring and four 4.8 m advances without coring (19.2 m). Cores U1455C-1H to 24F cored 103.1 m in this interval and recovered 89.82 m of sediment (87%). We drilled 237.5 m without coring from 122.3 to 359.8 m and then resumed continuous HLAPC coring. Cores 26F–41F penetrated from

359.8 to 431.4 m (71.6 m) and recovered 48.82 m of sediment (68%). After retrieving the drill string to switch to the RCB system, we reentered Hole U1455C and drilled ahead without coring from 431.4 to 773.0 m. We RCB cored from that depth to 949.0 m. Cores 43R to 60R penetrated 176.0 m and recovered 59.36 m of sediment (34%). Coring ended on 28 March at 1435 h when the operational time for the expedition expired.

### ***Lithostratigraphy***

Similar to the other Expedition 354 sites, lithological differences between units and variations in grain size and bed thickness reflect cycles of proximal turbidity current channel activity and abandonment. Sand intervals may represent inter-levee “sheet flows” (e.g., Curray et al., 2003), while finer-grained fractions are more likely preserved in leveed sections. Calcareous clay units reflect cessation of proximal channel activity, but the intervals also resemble episodes of minor increase in siliclastic deposition.

Site U1455 corresponds to DSDP Site 218 (Leg 22). Coring in Hole U1455C was divided into three segments. The uppermost segment (from 120.51 m CSF-A to the seabed) is principally comprising micaceous quartz rich siliclastic sediments, many containing turbiditic structures and/or parallel laminations. In this segment, sand units are overlain by 13.5 m of calcareous clay, which are covered by a 45.86 m thick section of sand and mud turbidites. There are two glassy volcanic ash layers at 5.68 to 5.75 m CSF-A, and from 82.80 m to 82.89 m CSF-A. The second recovered segment of Hole U1455C (431.39 m to 359.80 m CSF-A) is also predominantly micaceous and quartz-rich sand, silt, and clay, though fewer turbiditic structures are present. Calcareous clay units alternate with siliclastic sediments. The lowermost segment (773.0 m to base of the hole at 942.35 m CSF-A) contains claystone and siltstone intervals with preserved turbiditic structures, and a ~4 m thick unit of calcareous claystone. Organic fragments were prevalent in this lower section.

Overall, siliclastic units (silt, clay, and sand) at Site U1455 are compositionally classified as micaceous (muscovite and biotite) and quartz-rich. Sand occurs mostly in fine to medium grain size ranges, with rare occurrence of coarse-grained particles. Feldspars and heavy minerals (e.g. amphibole, garnet, clinozoisite, zoisite, tourmaline, zircon, rutile, sphene, epidote, sillimanite, chloritoid, pyroxene, staurolite, and opaque minerals) are common in silt and sand layers, and occasionally contain euhedral carbonate minerals and carbonate aggregate grains. Lithic fragments (e.g. biotite-gneiss,

amphibole-mica schist, sillimanite-biotite-gneiss, and phyllite fragments) appear in sand. From previous sites (see report from Site U1450), it is known that siliciclastic sediments in the fan contain between ~3–10% of detrital carbonate as well. Calcareous clays contain clay minerals, foraminifers, diatoms, and radiolarians.

### ***Biostratigraphy***

Calcareous nannofossil and planktonic foraminiferal biostratigraphic analyses were conducted at Site U1455 on 113 samples and resulted in the identification of 14 biomarker events. These events were used to construct three foraminiferal and 10 nannofossil biozones, providing good age control extending back to the Middle Miocene. The age model reconstruction is limited as to the drilled intervals from 120 m to 360 m and between 430 and 770 m, as well as by the very low abundance and barren intervals from 360 m to the bottom of Hole U1455C. Foraminifera species diversity decreased with depth, which could be due to preservation changes in the sediments, or could reflect a change in environmental conditions of the above lying water column.

### ***Paleomagnetism***

We identified the Brunhes/Matuyama boundary as well as the Jaramillo subchron in a calcareous clay interval at Site U1455 that can be correlated with similar intervals in other holes within the Expedition 354 transect based on both magnetostratigraphy and seismic stratigraphy. The Brunhes/Matuyama boundary occurs at 82.83 m (CSF-A) below seafloor in Core U1455C-6F and, as like all other sites where the Brunhes/Matuyama boundary is identified, the transition is associated with an ash layer. Core U1455C-17F contains the Jaramillo subchron (86.40–87.92 m CSF-A). Unlike all other sites, the Cobb Mountain Subchron was not recorded at Site U1455 and is likely located between Cores U1455C-17F and 18F.

### ***Physical Properties***

Physical property data were acquired on all Hole U1455C cores, including density, magnetic susceptibility, *P*-wave velocity, natural gamma radiation, and thermal conductivity. The physical property data at Site U1455 are mostly of good quality. For Hole U1455C, the average physical property values are as follows: GRA densities are 1.88 g/cm<sup>3</sup>, *P*-wave velocities are 1697 m/s for PWL and 1712 m/s for PWC, magnetic susceptibilities are  $53 \times 10^{-5}$  SI for whole-round, and  $62 \times 10^{-5}$  SI for point sensor measurements. Average natural gamma radiation is 61 cps, and average thermal

conductivity is highest in sand (1.64 W/[m·K]). The physical property data reflect lithological variations, compaction, and lithification with depth. The following unlithified principal lithologies are present: the most common is sand (~56 m), followed by claystone (~38 m), calcareous clay (~40 m), silt (~22 m), clay (21 m), calcareous claystone (~10 m), and siltstone (~6 m), with volcanic ash occurring in traces.

### ***Geochemistry***

Interstitial water chemistry in the upper section of the Hole U1455 suggests active biotic processes releasing dissolved phosphate, ammonium, and influencing pore water alkalinity and sulfate concentrations. Phosphate and ammonium contents co-vary and the rise in alkalinity in the upper section of the core is associated with the drop in calcium and magnesium contents.

Bulk sediment major, minor, and trace element concentrations correspond closely to sediment lithology, and are consistent with observations made at other sites cored during Expedition 354 and within the Ganga–Brahmaputra (G–B) river system. The increase in carbonate content in turbiditic sediments below 360 m CSF-A is consistent with a similar increase at Sites U1450 and U1451, and DSDP Leg 22 Site 218, and indicate a regional change in the delivery of detrital carbonate to the fan. Total organic carbon content in Pleistocene turbiditic sediments co-vary with Al/Si, a proxy for grain size and mineral composition reflecting preferential association of organic matter with clay. This behavior is consistent with similar observations in G–B river system and modern (18 ka) fan deposits, and in all sites along the 8°N transect across the Bengal Fan. The organic carbon content of pelagic and hemipelagic sediments broadly decreases with depth consistent with organic carbon concentrations observed at DSDP Leg 22 Site 218.

### **References**

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