

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

### **Site U1452 Summary**

#### **Background and Objectives**

Site U1452 is located in the center of the seven-site transect drilled during Expedition 354 with the objective to study the Pleistocene fan architecture and evolution of the middle Bengal Fan at 8°N. When integrated with the seismic data across this transect, these sites will establish a complete inventory of Pleistocene fan architecture and evolution spanning 300 km across the Bengal Fan. Site U1452 is located in a relatively flat environment with a smooth morphology. Topographic expressions of channels are absent in the vicinity of the site. The seismic profile at this site reveals a prominent, >20 km wide and up to 40 m thick levee, the top of which is only ~5 m below the seafloor.

At this site, we focused on coring the upper levee to provide a detailed record of this type of depositional system. Two holes were cored through this levee to allow high-resolution sedimentological, geochemical, and micropaleontological investigations. A single mudline core in Hole U1452A was devoted to the detailed study of the hemipelagic deposition during the last glacial cycle and to the Toba ash. Hole U1452B was cored down to 217.7 m for the study of the Upper Pleistocene section. Finally, Hole U1452C was cored down to 41.3 m to provide a more complete record of the levee and to allow more extensive sampling.

#### **Principal Results**

Coring at Site U1452 contributed to the Pleistocene transect of seven sites, which is one of the primary Expedition 354 objectives. The levee sequence recovered will allow detailed integrated sedimentological and geochemical investigations. On such rapidly accumulated sediments,  $\delta^{18}\text{O}$  measurements on planktonic foraminifer are expected to document the evolution in the sediment source region on glacial-interglacial time scales. This section is also important for the understanding of channel and levee formation. Site U1452 cored the fine-grained levee, as was done deeper in Site U1449, but also penetrated the coarser basal unit. Physical properties seem to indicate a progradation and the transition from sand deposition, through erosion, to levee construction.

The successful interpretation of seismic facies types with respect to grain size allowed coring strategies to target specific horizons. Hemipelagic layers, after being identified in several previous sites, were used to establish a preliminary Pleistocene seismic stratigraphy. Also, coring targeting these layers was successful and provided an improved chronology even when half-length APC (HLAPC) coring was alternating with short 4.8 m advances without coring.

A hemipelagic unit deposited from ~0.8 and ~1.2 Ma between 166 and 190 m marks a period when fan deposition was diverted to other parts of the fan and only clays were supplied to this area; this was also observed at our other sites to the east (Sites U1449, U1450, and U1451). Fan sedimentation intensified between 800 ka and 300 ka as represented by sheeted sands and the levee. These sheeted sands and levee grew by 100 m in 500 k.y., equivalent to an average sedimentation rate of 20 cm/k.y. The end of this intense period of fan sedimentation at 300 ka is constrained by the basal age of the surficial hemipelagic unit.

### ***Operations***

Hole U1452A was a single APC mudline core that recovered 8 m of sediments including the mudline. Hole U1452B consisted of oriented APC coring down to 41.4 m then continued with the HLAPC system. From 71.1 to 142.4 m, we started alternating 4.7 m long HLAPC cores with 4.8 m intervals drilled without coring. In this interval, 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 continued down to 217.7 m. Nine 4.8 m advances without coring were intercalated with cores in units predicted to be sandy. Overall recovery is 79% for this hole.

Hole U1452C was continuously cored from the seafloor to 41.3 m to obtain a more complete record of the uppermost levee sequence down to the sand layer at the base of the levee. All of the APC cores were orientated and core recovery in this hole was 81%.

### ***Lithostratigraphy***

Drilling at Site U1452 intentionally targeted a Pleistocene-aged levee identified in the pre-expedition seismic data. The lithology and structures of sediments recovered indicate we captured the initiation and cessation of an entire levee sequence (8–40 m), from pre-levee sand sheets (40–167 m) to calcareous clays (>167 m) marking the initiation of

turbiditic deposition levee-building at this location. The pre-levee sand sheets are turbiditic sands dominated by mica- and quartz-rich sand characteristic of sediments found in Himalayan Rivers. These sands were likely deposited as inter-levee sheet flows originating from a nearby channel. The hemipelagic calcareous clay unit extends to 190 m and overlies inter-levee sand-rich turbidites.

The sediments at this site document channel system shifting across the fan. Initially the proximal channel sand deposition reduced and was succeeded by increased deposition of hemipelagic nannofossil-rich calcareous clays. Above this calcareous interval, a very thick (~160 m) section of levee deposits (i.e. sand and mud turbidites) reflect activation of a nearby channel and the associated levee building that forms the top of the section. The levee deposits are overlain by a relatively thin unit of bioturbated calcareous clay, representing the end of proximal channel activity and in turn a decrease in siliciclastic input. The surficial calcareous clay unit at the top of the levee contains a glassy volcanic ash layer, presumably from the Toba eruption that occurred at ~75 ka.

### ***Biostratigraphy***

Biostratigraphic control at Site U1452 is limited, but four tie-points were observed and help to constrain levee development during the Pleistocene. Although the foraminifera biomarker *Globorotalia tosaensis* (0.61 Ma) was found in Holes U1452B and U1452C (at 8.97 m and 23.29 m, respectively), its FO was found at a shallower depth than the nannofossil biomarkers *Emiliana huxleyi* (0.29 Ma) and *Pseudoemiliana lacunosa* (0.44 Ma), indicating that this foraminifera was either reworked or has a longer extent in the Indian Ocean. Cores U1452B-33F to 37F are dominated by hemipelagic calcareous clay, are abundant in nannofossils, and contain abundant to barren foraminifera.

Interestingly, fragmentation of planktonic foraminifera was higher in the hemipelagic sediments than in the turbiditic sediments. The nannofossil biomarkers agree well with the magnetic polarity reversals found at Site U1452.

### ***Paleomagnetism***

As was observed in the upper parts of Sites U1449 through U1451, sediments at Site U1452 record the Brunhes/Matuyama boundary (184.10 m CSF-A) as well as both boundaries of the Jaramillo and Cobb Mountain subchrons (186.00–187.20 m CSF-A and 188.33–188.61 m CSF-A, respectively). Relative to the seafloor, these are the deepest instances of these polarity transitions identified on our transect to date. Also similar to

Sites U1449 to U1451, the Jaramillo and Cobb Mountain subchrons occur within an interval of hemipelagic sedimentation at Site U1452. The Brunhes/Matuyama boundary is associated with an ash layer, believed to be from Toba. Microtektites, likely from the Australasian Microtektite Event dated at 790 ka, have been found below the level of the Brunhes/Matuyama boundary, further supporting the identification of this polarity transition.

### ***Physical Properties***

Physical property data were acquired on all cores from Holes U1452A and U1452B, including density, magnetic susceptibility, *P*-wave velocity, natural gamma radiation, and thermal conductivity. The physical property data are mostly of good quality and reflect lithological variations. Using the principal lithological name from the core description to assign five lithologies (sand, ~46 m; silt, ~27 m; clay, ~33 m; calcareous clay, ~26 m; volcanic ash), we calculated their minimum, maximum, and average physical properties. Average wet-bulk densities are rather uniform for terrigenous sediment (sand, silt, and clay), ranging from 1.89 to 2.03 g/cm<sup>3</sup>, calcareous clay has lower average densities (1.72 g/cm<sup>3</sup>), and volcanic ash has substantially lower wet-bulk densities (1.54 g/cm<sup>3</sup>). Average *P*-wave velocities are highest in sand (1697 m/s) and lowest in clay and in calcareous clay (~1525 m/s). Average magnetic susceptibilities are also highest in sand ( $107 \times 10^{-5}$  SI), followed by silt ( $80 \times 10^{-5}$  SI) and clay ( $58 \times 10^{-5}$  SI). The lowest values occur in calcareous clay ( $22 \times 10^{-5}$  SI). Average natural gamma radiation is high throughout the terrigenous components sand, silt, and clay (around 65 cps) and lower in calcareous clay (45 cps). Average thermal conductivity is highest in silt (1.63 W/[m·K]) and lowest in calcareous clay (1.18 W/[m·K]).

### ***Geochemistry***

Detailed pore water measurements show that two hydrological units can be distinguished based on sulfate, phosphate, silica, magnesium, potassium, calcium, and alkalinity content. Carbonate contents of turbiditic sediments vary from 0.6 to 7.4 wt% CaCO<sub>3</sub>. Similar carbonate contents were measured in Upper Pliocene and Pleistocene turbiditic sediments recovered at Sites U1449, U1450, and U1451. A 4.6 m thick hemipelagic interval at 184 m was analyzed at high resolution with XRF scanning. It reveals that carbonate content varies between 18% and 60% with an average ~40%. Sr/Ca ratio and

carbonate content variations suggest a single binary mixing between marine biogenic carbonate and a clay endmember of supra-crustal composition.