

IODP Expedition 354: Bengal Fan

Site U1454 Summary

Background and Objectives

Site U1454, proposed Site MBF-7A, is the westernmost site of the transect of seven shallow penetration holes 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 capture the most recent and upper Pleistocene fan deposition. Expedition 354 sites in the eastern and central part of the transect revealed that fan deposition above and below the Toba ash layer (~75 ka) was remarkably low, marking the migration of turbidite channel activity to the west of the 85°East Ridge for probably the last 300 k.y.

Site U1454 is located ~50 km west of Site U1455 (DSDP Site 218) at 8°0.39'N, 85°51.00'E, in a water depth of 3721.4 m. It is situated on the western levee of a channel-levee system that is believed to be the modern active channel of the fan (Hübscher et al., 1997). The levee surface rises ~50 m above the thalweg of the meandering channel that is well imaged with multibeam bathymetry. Site U1454 is intended to provide a sequence through a channel-levee system, which can be dated by ^{14}C and $\delta^{18}\text{O}$, and thereby be related to global climatic and sea level cycles as well as other proxies for sediment flux and weathering. The general objective of the Pleistocene transect at 8°N is to document depocenter migration and overall accumulation rates since the Pliocene, and Site U1454 completes this approach by focusing on the Late Pleistocene and Holocene fan deposition. Obtaining a high-resolution levee record that could extend into the Holocene will allow comparison of this middle fan deposition to an upper fan levee likely constructed across the same channel levee at 16°N since 18 ka (Hübscher et al., 1997; Weber et al, 1997). The levee at 16°N recorded consistent changing weathering and vegetation conditions since the last glacial maximum (Galy et al. 2008, Lupker et al. 2013), which can be further correlated at Site U1454.

Principal Results

Site U1454 provides a key expanded section to the overall understanding of depositional processes in the Pleistocene Bengal Fan. This site was added during the expedition because of the inferred Holocene age of the channel with sediments suitable for dating

with oxygen isotopes and radiocarbon on foraminiferal tests as well as on terrestrial organic, in addition to high-resolution nannofossil biostratigraphic work. Accordingly, we will be able to determine the time spans over which the levee units have formed. Also, the surficial calcareous clay unit will shed light on the episodicity and absence of turbidites at this location. Furthermore, we expect to be able to link channel activity with sea level and glacial-interglacial climatic cycles.

Beneath the levee unit, coring recovered a sand-rich section, which is comparable to Site U1452, likely representing the progradational facies of early channel formation and erosion. Several other smaller channel systems in the vicinity contributed to sediment accumulation at Site U1454, and it will be interesting to investigate their temporal relationships with the active channel. Mud turbidites, silt, and sand beds are intercalated between hemipelagic units, indicating rare episodic activity.

An organic rich turbidite was recovered at ~34 m in the sand-rich section. It comprises an 18 cm thick layer of organic debris deposited at the base of a sand layer. The base of the organic layer contains centimeter-sized pieces of wood. Unlike the Miocene and Pliocene, organic debris is not frequently found in Pleistocene turbidites, and this one represents certainly an unusual transport from delta or floodplain to the fan. Identification of wood species may allow relating this deposit more precisely to an event and a vegetation zone.

Site U1454 also completes the recovery of the mid-Pleistocene hemipelagic interval to the westernmost position, and allows detailed study of the transition to intensified fan activity over a lateral distance of 300 km. This will shed light on the distances over which the active channel can deliver particularly the fine particles and contribute to the dilution of pelagic accumulation.

Operations

Four holes were cored at Site U1454. Hole U1454A was a single mudline core to 7.5 m for microbiological and geochemical studies. Hole U1454B was cored with the APC and HLAPC systems to 161.8 m and recovered 129.51 m of sediment (88%). This hole also included three 4.8 m advances without coring. The four top cores utilized full APC with orientation tool and non-magnetic hardware. Holes U1454C and U1454D were shallow penetrations (37.2 and 37.1 m, respectively) and recovered 30.16 and 24.46 m of sediment (81% and 66%). The latter were cored in order to fully record the topmost levee

and to provide sufficient samples for high-resolution studies and to avoid gaps. Cores from Holes U1454C and U1454D were not split.

Lithostratigraphy

Coring at Site U1454 recovered a full levee sequence that is thought to be associated with the modern active channel of the Bengal Fan, and is well represented by the 25 m sequence of mud turbidites in Unit II. Intervals of calcareous clay occur in the top 20 cm of Hole U1454B and are rare to about 110 m CSF-A. Below this depth, calcareous and clastic units alternate to 139.14 m, where an 18 m thick interval of mottled calcareous clay with occasional color banding appears. Plant fragments occur in several silt intervals, including large (~2 cm) woody pieces. In the lower hemipelagic interval, one 8 cm thick volcanic ash layer is present at 145.5 m. It is much thinner than the shallowest ash layers recovered at other Expedition 354 sites (~20 cm), and is likely related to the Toba eruption before the Brunhes/Matuyama boundary (790 ka).

Overall, siliciclastic units (silt, clay, and sand) at Site U1454 are compositionally classified as mica- (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, epidote, sillimanite, chloritoid, pyroxene, staurolite, and opaque minerals) are common in silt- and sand-rich 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. These minerals are consistent with a general provenance from Himalayan river sands (e.g. Garzanti et al. 2010).

Biostratigraphy

The levee system targeted for drilling at Site U1454 was expected to be of Pleistocene age. Biostratigraphic age control within the Pleistocene is limited to three nannofossil zonations and two foraminifera biomarkers (one at 0.61 Ma and one at 1.88 Ma).

Calcareous nannofossil assemblages were observed in a total of 44 samples from Site U1454, and the sediments were found to contain a Recent to Early Pleistocene sequence. Foraminifera assemblages were observed in 19 samples, and 19 samples were barren of foraminifera due to the recovery of turbidite sands in the core catcher samples. Postcruise

work on nannofossils may further constrain sediment ages, as there are an additional potential 20 biostratigraphic markers that can be used to refine the Pleistocene age model.

Paleomagnetism

We identified the Brunhes/Matuyama boundary as well as the Jaramillo and Cobb Mountain subchrons in hemipelagic calcareous clay at 145–151 m at Site U1454 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 145.83 m (CSF-A) below seafloor, roughly similar to the depth of the same transition at Site U1453; as at Site U1453, the transition is associated with an ash layer. The upper boundary of the Jaramillo subchron is likely in an interval that was not recovered between Cores U1454B-29F and 30F. Core U1453B-30F contains the lower boundary of the Jaramillo subchron (148.63 m CSF-A) and both boundaries of the Cobb Mountain subchron (149.86–150.20 m CSF-A).

Physical Properties

Physical property data were acquired on all Hole U1453A cores, including density, magnetic susceptibility, *P*-wave velocity, natural gamma radiation, and thermal conductivity. The physical property data at Site U1453 are mostly of good quality, and reflect lithological variations. For five principal lithologies based on visual core description, average physical properties were determined: the most common principal lithology is sand (~73 m), followed by clay (~45 m), calcareous clay (~23 m), silt (~11 m), with volcanic ash occurring in traces. The physical property average values show the following. Wet-bulk densities are rather uniform for terrigenous sediment (sand, silt, and clay), ranging from 1.89 to 1.96 g/cm³. Calcareous clay has the lowest densities (1.62 g/cm³), followed by volcanic ash (1.68 g/cm³). *P*-wave velocities are highest in sand (1666 m/s on average) and lowest in silt and clay (~1530 m/s). Magnetic susceptibilities are also highest in sand (109×10^{-5} SI), followed by silt (90×10^{-5} SI) and clay (56×10^{-5} SI). The lowest values occur in calcareous clay (20×10^{-5} SI). Natural gamma radiation is high throughout the terrigenous components sand, silt, and clay (around 70 cps) and low in calcareous clay (43 cps). Thermal conductivity is highest in sand (1.82 W/[m·K]) and lowest in calcareous clay (1.17 W/[m·K]).

Geochemistry

At Site U1454, interstitial water measurements have been conducted only in the top 7 m. Like at other sites studied during this expedition, the hydrochemistry in this upper section is dominated by biogenic processes that release dissolved phosphate, ammonium, and CO₂ (leading to a rise in alkalinity) and consume sulfate.

Carbonate content of turbidites analyzed throughout Site U1454 have CaCO₃ contents between 2 and 5 wt% eq., except for four samples from the upper 16 m of the levee that have 6 to 7.4 wt% eq. These higher values are significantly higher than all turbidite carbonate contents measured in the seven Pleistocene sections cored during Expedition 354 (0.5 to 6 wt%). It is however identical to carbonate content recorded in the levee sediments at 17° N during the last deglaciation stage (Lupker et al. 2013). This could indicate a match between the 17° and 8° levee records, however the pattern of K/Al appears different at these Site U1454 and 17°N.

References

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