

## **IODP Expedition 353: Indian Monsoon Rainfall**

### **Site U1446 Summary**

#### **Background and Objectives**

Site U1446 is located within the Mahanadi Basin, on the eastern margin of India. This location, ~70 km offshore, offers the opportunity to drill sediments underlying the low salinity waters of the Indian margin, a result of summer-monsoon rainfall and runoff from the peninsular rivers of India, including the Ganges/Brahmaputra and Mahanadi.

Objectives at this site are to recover Late Pleistocene to Holocene sediment sections in order to reconstruct changes in the Indian summer monsoon at orbital to suborbital timescales.

#### **Operations**

At Site U1446, Holes U1446A, U1446B, and U1446C were drilled to total depths of 180.0 m, 27.1 m, and 182.0 m DSF, respectively. In Holes U1446A and U1446C, the APC system (9.5 m long) and the half-length (4.7 m long) APC (HLAPC) were deployed. In Hole U1446B, the only the APC system was used. Overall, 47 cores were recovered for the site. A total of 344.95 m of core over a 342.3 m cored interval were recovered using the APC system (101% recovery). The cored interval with the HLAPC system was 46.8 m with a recovery of 49.43 m of core (106%). The overall recovery percentage for Site U1446 was 101%. The total time spent on Site U1446 was 2.3 days.

#### **Principal Results**

##### ***Lithostratigraphy***

The sediments recovered from Site U1446 are Holocene to mid-Pleistocene in age, and are typical of continental margin settings, falling within the hemipelagic classification as a mixture of a dominant lithogenic fraction diluting a minor biogenic fraction. They are primarily composed of dark gray to gray clay with nannofossils, nannofossil-rich clay, clay with foraminifers, clay, clay with biosilica, and biosilica-rich clay. Due to the homogeneous clayey nature of the sediments, only one lithostratigraphic unit (Unit I) is recognized at this site. Visual core description and smear slide observations were used with supporting information from physical properties (primarily natural gamma radiation) and geochemical parameters (wt% CaCO<sub>3</sub>) to evaluate the varying abundances of the siliciclastic fraction (clays, silts, and occasionally sands) versus the biogenic fraction

(calcareous and siliceous). Turbidites are rare at Site U1446, with only occasional thin quartz-rich or shallow water carbonate-rich intervals indicative of transported sediments. Overall, drilling disturbance is generally slight to moderate due to the fact all cores have been retrieved using the APC system, and is characterized by voids and gas expansion cracks.

### ***Biostratigraphy***

Calcareous microfossils are continuously present in the sediments of Hole U1446A, whereas siliceous microfossils are sporadically present. Calcareous nannofossils show abundances ranging from few to abundant in the smear slides studied, and their preservation is generally very good to good, and occasionally moderate. Foraminifers are dominant to abundant in Hole U1446A in 19 of 21 core catcher samples. Preservation is good to moderate in all foraminifer samples. Diatoms are present in the lower and upper part of the Hole U1446A record. Valve preservation ranges from good to poor, and tends to be better whenever abundance is higher.

All Late Pleistocene calcareous nannofossil events are identified. Late to Middle Pleistocene assemblages are typical of tropical/subtropical paleoenvironments. All core catcher samples from Hole U1446A contain Pleistocene planktonic foraminifer assemblages. Planktonic assemblages are dominated by tropical to warm-subtropical species. The diatom community is highly diverse and resembles that at Site U1445. The diatom assemblage consists of species typical of warm to temperate, low-to-mid latitude ocean waters.

The age model for Site U1446 was established by combining nannofossil, planktonic foraminifer, and diatom datums with paleomagnetic reversal datums. The combined biostratigraphy/magnetostratigraphy age model indicates a mean sedimentation rate of ~16 cm/k.y. from 0 Ma to just over 1 Ma. The oldest planktonic foraminifer datum encountered is the last occurrence of *Globorotalia tosaensis* (0.61 Ma) in Sample U1446A-12H-CC, while the combination of nannofossils and diatoms datums constrains the basal age of Hole U1446A to between 0.90–1.0 Ma and 1.26 Ma.

### ***Geochemistry***

The organic carbon content at Site U1446 ranges from 0.8 wt% to 1.6 wt% (average 1.2 wt%) and the geochemistry of the site mainly reflects the anaerobic processes of

sulfate reduction and methanogenesis associated with microbial degradation of organic matter. Sulfate declines rapidly from 28 mM at the sediment/water interface to nearly zero at approximately 20 m CSF-A. Alkalinity peaks at 20 m depth, consistent with the production of bicarbonate during the sulfate reduction. Sulfate reduction appears to continue throughout the hole, as suggested by the gradual increase in dissolved Ba concentration with depth as this Ba is likely derived from barite. Changes in the concentration of other cations and anions (Fe, Mg, Ca, ammonia, and Sr) in interstitial water can be readily explained by the microbial induced chemical reactions and their effects on pH, alkalinity, and mineral dissolution and precipitation. Methane concentrations in sediment are generally low above 30 m CSF-A, but rise between 30 m to 70 m CSF-A, peaking at ~50 m CSF-A, with a moderate concentration of 1000 ppm. High methane/ethane ratios suggest that the methane is mostly of biogenic origin (methanogenesis). Carbonate content varies significantly between 2 wt% to 20 wt% within the scale of a few meters, with the low content intervals corresponding to high NGR (terrestrial, clay rich materials).

### ***Paleomagnetism***

Paleomagnetic measurements were conducted on archive half sections for all three holes at Site U1446, with alternating field (AF) demagnetization up to 10 mT. Discrete samples taken from the working half sections of Holes U1446A ( $N = 53$ ) and U1446C ( $N = 9$ ) were also analyzed, with AF-demagnetization up to 40–80 mT. Characteristic remanent magnetizations (ChRMs) of these discrete samples were calculated using the principal component analysis (PCA) technique. The paleomagnetic signal was generally good down to ~120 m CSF-A, but poor below. A magnetostratigraphy is constructed from 0–1.173 Ma (~170 m CSF-A) in Hole U1446A with certain degree of ambiguity for some of the chrons. In addition, anhysteretic remanent magnetization (ARM) was acquired and measured on a selection of Hole U1446A discrete samples. A significant decrease in ARM due to diagenetic reduction at 30 m CSF-A was observed for Hole U1446A. Below this depth, ARM intensity increases slightly from 40–60 m CSF-A, and decreases from 100–130 m CSF-A.

### ***Physical Properties***

The physical properties data collected at Site U1446 were found to be in good agreement with the lithostratigraphic data. However, based on density and porosity changes with

depth, Hole U1446A is divided into three subunits (Ia, Ib, and Ic). The changes in bulk density and porosity is possibly due to change in sediment composition. We observe similar trends in all physical properties data between Holes U1446A and U1446C. We observe cyclic variability in NGR values possibly due to changes in lithogenic input.

### ***Stratigraphic Correlation***

A composite scale (CCSF-A) and a splice were constructed for Site U1446 from Holes U1446A and U1446C using magnetic susceptibility, natural gamma ray and RGB data. Splicing between these holes enabled us to construct a continuous stratigraphic sequence down to ~108 m CCSF-D. Due to data quality and time availability issues, correlation should be viewed with caution below ~78 m CCSF-A.

### ***Highlights***

Site U1446 recovered ~180 m of section ranging from the Late Pleistocene to the Holocene, with a mean sedimentation rate of ~16 cm/k.y. The entire interval was APC cored with excellent recovery. The Toba ash was recovered at ~14 mbsf. Although the site is within the hydrate stability zone and in the same general vicinity as Site U1445, no indications of gas hydrates were found, possibly due to the finer-grained nature of the sediments.