

## **IODP Expedition 359: Maldives Monsoon and Sea Level**

### **Week 7 Report (9–15 November 2015)**

#### **Overview**

This week we completed scientific coring operations at Sites U1468 (MAL-3A) and U1469 (MAL-08A) and started operations at Site U1470 (MAL-05A).

At Site U1468, two holes were drilled to 874.7 mbsf. Hole U1468A was cored using the full- and half-length APC and the XCB coring systems. Hole U1468B was drilled as a dedicated hole for downhole logging. Total core recovered at Site U1468 was 458.7 m (53%).

At Site U1469 we cored two holes, Hole U1469A (0–161.1 mbsf) and Hole U1469B (0–151.4 mbsf). Coring at Site U1469 was challenging from the start, as the loosely cemented skeletal grainstone and reefal carbonates caused excessive drill string torque, increased pumping pressures, poor circulation, and difficulty cleaning the holes. Only 4.86 m of core was recovered from these two holes.

#### **Operations**

For Site U1468, we obtained an extension for the total EPSP approved penetration depth to 1000 mbsf to ensure the achievement of the site's main scientific objective of coring through the Oligocene–Miocene boundary. Ultimately, coring with the XCB system terminated with Core U1468A-111X at a total depth of 874.7 mbsf, when the biostratigraphers confirmed the Oligocene age of the recovered core. Hole stability was maintained throughout by circulating 20-barrel high-viscosity mud sweeps every other core. This resulted in little or no fill on connections, normal drilling torque, and no overpull or drag with the drill string. After laying out the final core barrel, the bit was raised up to 795.5 mbsf and the top drive was set back. The drill string was pulled out of the hole, clearing the seafloor at 2215 h, and the bit arrived back on the rig floor at 2400 h on 11 November. We offset the ship 20 m east of Hole U1468A and started assembling the tri-cone drill bit with a mechanical bit release (MBR) to drill the dedicated logging hole. An extra stand of 8¼ inch drill collars was added to the existing drilling BHA to be able to place the bit at ~130 mbsf or slightly deeper to allow the end of the pipe to be below a potentially problematic sand layer. We lowered the bit to the seafloor and started drilling without coring in Hole U1468B at 0810 h on 12 November. During the course of drilling the dedicated logging hole, the driller noted elevated drilling torque and hole cleaning problems at 131.7 mbsf. At 1345 h, we spent nearly 2 h conducting a wiper trip by raising the bit up to 43.5 mbsf and then running it back to the bottom of the hole. At 1530 h, drilling resumed and continued without incident until the bit reached a total depth of 874.7 mbsf at 2030 h on 12 November. We circulated a high-viscosity mud sweep, released the bit in the bottom of the hole, and at 0115 h

on 13 November the end of the pipe had been positioned at 140.5 mbsf in preparation for wireline logging. We rigged up the triple combo tool string and ran it into Hole U1468B at 0240 h. The tool string reached ~835 mbsf where it tagged bottom, indicating ~40 m of infill in the hole. A short pass was logged from the bottom of the hole up to ~735 mbsf, showing reasonable hole diameter. The tool string was run back to total depth and the main pass started at 835 mbsf, recording gamma ray, density, porosity, electrical resistivity, and magnetic susceptibility. Borehole diameter varied smoothly, ranging from ~17 to 12 inch, until a narrow section (<6 inch) was encountered at ~465 mbsf. Significant overpull was required to continue pulling the tool string up to ~290 mbsf. This suggested that the borehole had deteriorated in this interval. Above ~290 mbsf, hole diameter increased and the main pass continued up to the base of the drill pipe at 140 mbsf. Logging data were recorded continually throughout the main pass with the triple combo tool string, but further logging operations could not be carried out due to the state of the borehole. The tool string was returned to the rig floor and rigged down, and logging operations in Hole U1468B were complete by 0915 h on 13 November.

After rigging down from wireline logging the pipe was pulled out of the hole, clearing the seafloor at 0935 h. Hole U1468B ended when the bit arrived back on the rig floor at 1125 h.

Site U1469 was only a 4 nmi transit away, so the dynamic positioning system was used to move the ship. During the transit, the drill string was recovered, and a new RCB bottom-hole assembly (BHA) was assembled and lowered to the seafloor. We tagged the seafloor with the drill bit establishing a seafloor of 427 mbsl. RCB coring in Hole U1469A started at 1825 h on 13 November. Coring was extremely challenging, and high torque and overpull occurred when pulling the bit off the bottom of the hole; however, we were able to penetrate to 122.1 mbsf before making a wiper trip up. At 0245 h on 14 November, with the bit back on bottom again, RCB coring continued; however, hole conditions continued to be problematic. We suspected that the drilling had encountered a zone of high-permeability within the buried reefal carbonate rocks, causing a loss of circulation uphole that was required to clean the drilled cuttings from the hole. At 0630 h we decided to abandon the hole and try again after offsetting the ship 40 m to the west. The drill string was pulled clear of the seafloor at 0810 h on 14 November, ending Hole U1469A. Drilling in Hole U1469B started at 0850 h after using the bit to tag the seafloor (427 mbsl). Hole U1469B was drilled without coring to 122 mbsf without incident and it appeared that this hole would be considerably better than the previous hole. This optimism was short-lived as the same hole cleaning problems occurred again after cutting just three RCB cores to 151.4 mbsf. Convinced that the hole could not be deepened any further due to lost circulation, we also abandoned Hole U1469B. The drill string was retrieved back aboard, the positioning beacon was picked up, the thrusters were raised, and we started the transit to the next site at 2045 h on 14 November.

After a 17.8 nmi transit, we arrived at Site U1470 at 2306 h on 14 November. We assembled an APC/XCB BHA and lowered it to the seafloor. The first APC core barrel recovered 2.17 m of core, establishing a seafloor depth of 400 mbsl. APC coring continued through Core U1470A-

17H to 148.4 mbsf before a lithological change in the formation to hard reef material led to a switch to the XCB coring system. Cores U1470A-18X and 19X had very poor recovery (0.17 m and 0 m, respectively). The material was hard but very friable and rock pieces would break and jam in the core catcher. The HLAPC system was then deployed for Cores U1470A-20F and 21F, recovering 1.76 m and 1.90 m, respectively. The improved recovery was welcome; however, the time required to deepen the hole was of concern and therefore another XCB core was attempted. This time we used an “extended” XCB cutting shoe, placing the cutting structure even further out ahead of the main drill bit. Recovery with the extended XCB shoe was no better, and because of the higher risk associated with the longer extension of the XCB shoe, it was not run again. Coring was terminated after Core U1470A-24X at 190.0 mbsf in favor of starting a new hole using the rotary coring system. The drill string was pulled clear of the seafloor at 1910 h and the bit arrived back on the rig floor at 2055 h on 15 November, ending Hole U1470A. By the end of the week (2400 h, 15 November), we had finished assembling an RCB BHA up and spacing-out the core barrels in preparation for lowering the drill string back to the seafloor.

## **Science Results**

### ***Overview***

Site U1469 lies 2.87 km SSW of Site U1465, which is the westernmost site of the northern transect in the western part of Kardiva Channel. The site was selected to document and reconstruct the carbonate bank depositional system of the drowned Miocene bank and to link the seismic sequences to facies. This link is possible because the drowning unconformity does not mask underlying geometries at this site. The target depth was 700 mbsf, which is the base of the platform sequence PS07 and the first sequence after the Kardiva Platform went from a mostly aggrading growth to progradation.

Site U1470 is located south of Goidhoo atoll and is the westernmost site of the southern transect. This site was selected to provide a detailed reconstruction of the predrowning, drowning, and postdrowning evolution of the carbonate bank by linking the seismic stratigraphic record to the sedimentary record. The geologic setting is similar to that at Site U1469: the drowned Middle Miocene platform is overlain by a sheeted drift. However, the seismic stratigraphy indicates that the drowning of this platform occurred later than the one in the Kardiva Channel. One objective was to test this seismic interpretation that, if true, would provide evidence for a successive drowning of the platforms.

### ***Sites U1468 and U1469 Initial Results***

#### ***Lithostratigraphy***

One hole was cored at Site U1468 through a series of drift deposits, underlying hemipelagic deposits and into an Oligocene shallow-water platform. Eight lithostratigraphic units were

identified based on core description, four units within the drift package and four in the distal platform. From top to bottom: Unit I is a coarse-grained planktic foraminifera grainstone. Unit II is a coarse to granular-grained large benthic foraminifera grainstone to rudstone, devoid of planktic foraminifera. Unit III and Unit IV consist of partially lithified (Unit III) to lithified (Unit IV) fine-grained planktic foraminifera wackestone to packstone. Unit V is characterized by a massive homogenous planktic foraminifera wackestone. Unit VI is a basinal nannofossil chalk with distinctive black (organic) and white (nannofossil chalk) intervals. Unit VII is a lithified benthic foraminifera wackestone to floatstone. Finally, Unit VIII is a completely lithified bioclastic floatstone from the Oligocene platform.

At Site U1469 two holes were cored through a succession of hemipelagic drift deposits into the Kardiva Platform (Hole U1469A [0–161.1 mbsf] and Hole U1469B [0–151.4 mbsf]). Despite the remarkable low recovery (4.14 m in Hole U1469A and 0.7 m in Hole U1469B), it was possible to define two preliminary lithostratigraphic units based on visual core descriptions. This includes a planktic foraminifera-rich bioclastic grainstone to packstone (Unit I) and a dolomitized coral-algal floatstone (Unit II).

### *Biostratigraphy*

All the core catcher samples from Sites U1468 and U1469 were analyzed for biostratigraphy and paleoenvironmental reconstruction. Calcareous nannofossils and planktonic foraminiferal analyses indicate a late Oligocene for the basal succession at Site U1468 and provide a robust age model for the entire Neogene. Moderately preserved benthic foraminifera and ostracods were observed throughout the ~865 m sedimentary succession at this site and indicate a transition from reefal and neritic conditions from the late Oligocene to upper bathyal during the Plio–Pleistocene. All samples were barren of radiolarians. Analyses of samples from Site U1469 and U1470 are ongoing.

### *Geochemistry*

Geochemical analyses of interstitial waters and sediments were completed for Site U1468. At this site, the effects of recrystallization and dolomitization are recorded in the interstitial water geochemistry of the non-conservative elements throughout the cored interval (alkalinity, sulfate, magnesium, calcium, and strontium). Variations in the concentration of aragonite at Site U1468 in the upper 50 mbsf reflect variations in input, but below 50 mbsf the decrease in aragonite concentration is a result of diagenesis. Below 200 mbsf, concentration of Sr and Ca increase while Mg decreases. Despite some sulfate reduction, the pore waters were saturated with respect to  $\text{SrSO}_4^{2-}$  and the mineral celestite was detected. The Mn/Ca ratio of the sediments increases below 400 mbsf (from Unit IV to Unit V), suggesting a change in the oxygen content of the waters at the time. The concentration of  $\text{Cl}^-$  shows a steady increase from seawater values of ~550 mM at the seawater-sediment interface to between 580 and 585 mM at ~90 mbsf, similar to Site U1467, and it might be related to the salinity increase during the last glacial maximum.

In Hole U1469A, no interstitial water samples were obtained as a result of poor recovery. Headspace samples were obtained from a total of 11 cores for analysis of gases. The concentrations of methane remained between 1.40 and 2.28 ppmv.

### *Paleomagnetism*

All cores from Hole U1468A were measured for natural remanent magnetization. The paleomagnetists are working on the paleomagnetic interpretation of the stepwise demagnetized magnetization of APC and XCB sections in order to recognize a geomagnetic signal that might allow the recognition of normal and reversal polarities.

### *Physical Properties*

Whole-round core measurements of velocity, density, magnetic susceptibility, natural gamma radiation, and thermal conductivity, as well as moisture and density (MAD) measurements on discrete samples from Sites U1468 and U1469, have been completed. Changes in trends of physical properties correlate well with the lithostratigraphic units, indicating that the variable facies also have distinctive petrophysical signatures. Measurements of cores and samples from Hole U1470A are underway. Variability in sediment physical properties are related to changes in lithification, bioturbation, and water content of the material and compaction and diagenetic processes.

### *Downhole Logging and Sequence Stratigraphy*

Downhole logging was partially completed in Hole U1468B using the triple combo tool string. The tool string reached ~835 mbsf where it tagged bottom, indicating ~40 m of infill in the hole (originally drilled to 874.5 mbsf). A short pass was logged from the bottom of the hole up to ~735 mbsf, showing reasonable hole diameter. The tool string was run back to total depth and the main pass started at 835 mbsf, recording gamma ray, density, porosity, electrical resistivity, and magnetic susceptibility. Borehole diameter varied smoothly, ranging from ~17 to 12 inch, until a narrow section (<6 inch) was encountered at ~465 mbsf. Significant overpull was required to continue pulling the tool string up to ~290 mbsf because the borehole had deteriorated in this interval. Above ~290 mbsf, hole diameter increased and the main pass continued up to the depth of the drill pipe at 140 mbsf; however, further logging operations could not be carried out due to the state of the borehole.

The logging scientists are working on integration of downhole and core logs, as well as core photos of Sites U1468 and U1469, into our Petrel seismic data project.

Comparisons of well data with seismic facies and mapped sequences, and on-the-fly correlation of core samples and drilling depth with seismic data and depositional model, are continuously being used for further site planning.

## **Education and Outreach**

This week we conducted 14 education events with a total of 424 students from high schools in France, Italy, Denmark, Germany, Belgium, United Kingdom, Turkey, and Uruguay, one university in Brazil, and one in the Netherlands. We also conducted a live exchange with the French embassy in Colombo to share an event in support of the COP21 in Paris. In addition, we posted daily updates and photos on our social media outlets (Facebook [<https://www.facebook.com/joidesresolution>], Twitter [<https://twitter.com/TheJR>], and Instagram [[http://instagram.com/joides\\_resolution](http://instagram.com/joides_resolution)]), in personal blogs from the expedition scientists, and in blogs on the *JOIDES Resolution* website (<http://joidesresolution.org/>).

## **Technical Support and HSE Activities**

### *Laboratories*

- Processing of cores and samples from Holes U1468A, U1469A, U1469B, and U1470A.
- Water samples collected daily with the Wildco Beta Water Sampler at approximately 15 m water depth for analysis of plankton.
- Serviced numerous laboratory vacuum pumps.
- A transducer on the *P*-wave logger on the Whole-Round Multisensor Logger (WRMSL) broke during routine maintenance. The set of transducers were replaced and tested with no interruptions to shipboard measurements.

### *HSE Activities*

- A fire and boat drill was conducted on 10 November.
- The eyewash stations and safety showers were tested.