IODP Expedition 359: Maldives Monsoon and Sea Level

Week 4 Report (19–25 October 2015)

The fourth week of IODP Expedition 359 (Maldives Monsoon and Sea Level) consisted of coring operations in one hole at Site U1465 (MAL-01A; 19–20 October) and the transit to and coring in two holes at Site U1466 (MAL-02A; 20–25 October).

Operations

The sea passage from Malé, Republic of Maldives, to Site U1465 ended at 0418 h on 19 October. The 65 nmi transit was completed in 6.6 h at an average speed of 9.9 kt. Thrusters/hydrophones were lowered, and by 0456 h full control of the vessel was shifted to the dynamic positioning system operator. A positioning beacon was deployed at 0611 h. The bottom-hole assembly (BHA) and the outer core barrel assembly were made up, and the APC/XCB space out was checked. A precision depth recorder (PDR) depth reading was taken, indicating the seafloor was at ~514.4 m below the rig floor (mbrf). The sinker bars were made up and an APC core barrel was run in the hole, with the bit positioned at 509.4 mbrf or 5.0 m above the PDR depth. This core barrel was recovered empty so the pipe was lowered an additional 9.0 m for a second attempt. This time the barrel was again recovered empty; however there was evidence that the core barrel may have hit the seafloor as the gap at the base of the core liner contained a small amount of coarse sand. At this point the drill string compensator was opened and the bit was lowered until it hit something hard at ~524.4 mbrf and again at ~528.0 mbrf. A third attempt at starting Hole U1465A was successful at 1405 h with the bit positioned at 523.4 mbrf. Core U1465A-1H recovered 7.3 m, establishing a seafloor depth of 525.8 mbrf. It was later determined that the original PDR measurement had contained a 10 m error.

Coring in Hole U1465A continued to a total depth of 76.6 m below the seafloor (mbsf). A total of nine APC cores were obtained, recovering 77% of the 64.4 m penetrated. One half-length APC (HLAPC) core was taken, recovering 71% of the 4.7 m advance, and a single XCB core was cut at total depth advancing 7.5 m and recovering a mere 0.42 m or 6%. Coring was problematic from the start due primarily to the highly sandy formation and a few interspersed hard layers. The APCT3 temperature shoe was deployed three times; however analysis indicated that all measurements were suspect. The formation conditions were not good for core recovery or formation temperature measurement. Coring was halted when the depth objective, the ancient carbonate platform, was reached. Overall recovery for the hole was 70%. The drill string was pulled clear of the seafloor and secured for a move in dynamic positioning mode to the next site. At 0230 h on 20 October the ship began moving with thrusters down. After the ~1 nmi transit to Site U1466, the ship was positioned over the new location by 0430 h and rig floor activities began. The top drive was picked up and the drill string was spaced out. At 0625 h on 20 October,

Hole U1466A was started, recovering 5 m of core and establishing a seafloor depth of 528.9 mbrf. Coring was equally problematic in this hole as there continued to be a great deal of sand in the surface layers of the formation. Coring with the full-length and half-length APC coring systems proceeded to 100.5 mbsf (Core U1466A-12F). Three formation temperature measurements (APCT3) were attempted; however, all the values were considered suspect. At this point we decided to make a wiper trip because of high drilling torque. At 1730 h on 20 October the drill string was pulled back to a depth of 63.1 mbsf and then washed back to bottom. With all drilling parameters back to normal, coring resumed at 1930 h and continued through Core U1466A-20F to 155.0 mbsf. Once again high drilling torque necessitated a second wiper trip. At 0100 h on 21 October, the drill string was recovered back to 63.1 mbsf and then washed back to the bottom of the hole at 155.0 mbsf. As on the first wiper trip, the hole again cleaned up, and all drilling parameters returned to normal. Coring resumed at 0400 h and continued through Core U1466A-50X to a total depth of 326.2 mbsf. All three coring systems (APC, HLAPC, and XCB) were used interchangeably and with great effectiveness during this cored interval. Coring was terminated at 0400 h on 22 October as the depth objective had been achieved and it was felt the formation could be cored at that point with the RCB coring system. The drill string was recovered and pulled back to the rig floor at 1000 h on 22 October, officially ending Hole U1466A and initiating Hole U1466B. An RCB bottom-hole assembly was lowered to the seafloor, and with the compensator open the driller physically tagged the seafloor with the bit at a depth of 528.0 mbrf. Drilling without coring in Hole U1466B started at 1620 h on 22 October at the seafloor and continued to 158 mbsf. A wiper trip to 61 mbsf and back to bottom was conducted with no overpull or drag experienced and no fill noted on bottom. Drilling resumed and a depth of 313.9 mbsf was reached by 0600 h on 23 October. A second wiper trip was conducted and again there was no overpull or drag noted. Two meters of fill were found on bottom and were circulated out with a high viscosity mud sweep. At 1045 h, we started RCB coring at 314.0 mbsf. Coring continued using nonmagnetic core barrels. Poor recovery through the highly interbedded hard/soft formation led to the taking of a combination of full and half RCB cores. As the depth of the hole progressed and the scientific data built up, the scientists decided that the scientific objectives had essentially been reached and terminated the hole earlier than planned. The value of the logging data was also taken into consideration given the sparse core recovery. We thought it was prudent to stop coring while the hole was still in good condition and initiate wireline logging sooner. At 1150 h on 25 October, the last RCB core, U1466B-57R, was recovered from 809.7 mbsf. Hole conditions continued to remain good. The bit was released, and the hole was displaced with heavy mud. The drill string was pulled up and the end of the pipe was placed at 106.0 mbsf. At 1800 h, rig-up of the first wireline logging tool string was initiated. The triple combo, without the source installed, was run in the hole; however, the tools would not pass 894.0 mbrf (366.0 mbsf). Log data was collected up from there, however constant tool drag indicated the hole was rapidly deteriorating. The triple combo was back on deck at 2100 h and the decision was made to abandon any further logging attempts in Hole U1466B. The drill string was pulled out of the hole, clearing the seafloor at 2250 h. As of midnight on 25 October, the pipe had been recovered to a depth of 171.0 mbrf.

Science Results

Overview

This week we initiated scientific coring operations at Site U1465 (MAL-1A) and completed operations at Site U1466 (MAL-02A). Site U1465 is the westernmost site of the northern transect that runs from west to east in the Kardiva Channel between the Goidhoo and South Maalhosmadulu Atolls in the Maldives. The site is situated above the margin of a drowned platform that is overlain by 70 m of sediment. Within the platform, 10 sequences were identified and are interpreted to relate to sea level changes because lowstand and highstand units are recognized in the last five sequences. Site U1465 penetrates the topset of the youngest of these sequences, and below the foresets of older sequences. Site U1466 is located only 1880 m east of Site U1465, in about the same water depth (518 m), but it is situated above completely different strata. It is in front of the last prograding clinoform of the drowned carbonate platform that is the target at Site U1465. In this basinal position, a thick prograding drift succession first overlays the bottomsets and foresets of the prograding platform and finally buries the platform. These deposits contain the best biostratigraphic information to date the sequences and the sea level changes. The specific objectives of Site U1465 are to provide detailed reconstruction of the age and processes for the predrowning, drowning and postdrowning evolution of the carbonate bank by linking the seismic stratigraphic record to the sedimentary record. The main objective at Site U1466 is to retrieve and date the first drift sequence and the subsequent changes in the current evolution.

Lithostratigraphy

At Site U1465, one hole (U1465A) was cored to 76.6 m (70% recovery). Two lithostratigraphic units were identified in Hole U1465A: Unit 1 (from the seafloor to 65.5 mbsf) consists of poorly to well sorted unlithified grainstone to rudstone, dominated by skeletal grains and planktic foraminifera, with pteropods, echinoderms, bryozoans, *Halimeda,* and benthic foraminifera as minor components. Unit 2 (from 65.5 to ~70 mbsf) consists of a lithified medium- to coarse-grained floatstone, with corals and fragmented bivalves as common components.

At Site U1466, two holes were cored: Hole U1466A (0–326 mbsf; 75% recovery) and Hole U1466B (316–822 mbsf; 18% recovery). The upper unit, recovered only in Hole U1466A (0–82.51 mbsf) consists of mainly unlithified grainstone with massive to normal grading. This unit is equivalent to Unit 1 in Hole U1465A, and it is underlain by a sedimentary unit that increases in lithification downhole from partially lithified to lithified, bioturbated fine- to medium-grained dolomitic packstone and wackestone. Interbedded chert nodules and thin chert layers are common from 465 mbsf and 654 mbsf. Large slumps and calciturbidites occur from 731 mbsf down to ~800 mbsf in the described cores.

Biostratigraphy

Micropaleontological analyses have been performed in sediment samples from Sites U1465 and U1466. Planktic foraminifers and calcareous nannofossils have been studied in order to obtain a biostratigraphical age model for both sites. In addition, radiolarians, benthic foraminifers, and ostracods have also been studied. Samples for biostratigraphy were mainly collected from the core catchers, although additional samples have been taken from the sediment cores, particularly for nannofossil analysis. The biostratigraphic results suggest that the sequence recovered in Hole U1465A spans from the Middle Pliocene to the late Pleistocene. At Site U1466, the base of Hole U1466A is of Middle Miocene age (foraminiferal Zones M8–M9 and calcareous nannofossil Zone NN6). In Hole U1466B, the top of the cored sequence is of Middle Miocene age (foraminiferal Zones M7–M8, calcareous nannofossil Zone NN5) and the base of the hole is estimated to correspond to the Oligocene–Miocene boundary (calcareous nannofossil Zone NN1).

Geochemistry

Interstitial water (IW) samples were taken at an interval of one per core in Holes U1465A and U1466A by squeezing and approximately one per section in Cores 1H–5H of Hole U1466A using Rhizons. Although no further IW recovery was believed to be possible in Hole U1466B, an interval of semi-consolidated sediment in Core U1466B-25R was encountered. Upon squeezing, a 10 cm interval yielded 20 cm^3 of fluid. Analyses of alkalinity, chlorinity, pH, and major and minor ions have been completed on all IW samples (both squeezed samples and Rhizons) with the exception of the deeper semiconsolidated sediment sample. The IW major element chemistry is generally similar to seawater, with a slight increase in Cl and Ca with depth, and a slight decrease in Mg. For the minor elements, the concentrations of Sr and Si increase with depth. The Sr/Ca ratios increase and the Mg/Ca ratios decrease in the lower portion, suggesting reaction involving the precipitation of calcite and dolomite.

Analysis of sediment by XRD revealed changes in carbonate mineralogy in Holes U1465A and U1466A. In Hole U1466A, aragonite is present in the upper 90 m, and to a lesser degree between 150 and 300 m. Dolomite is abundant from 100 to 120 m (throughout the interval where aragonite is absent), and is present in lower concentrations down to 300 m. The aragonite/dolomite transition occurs where Sr concentrations in the IW begin to increase, marking the onset of significant aragonite recrystallization. In Hole U1466B, XRD analyses will be performed on splits from the headspace samples. Coulometry measurements are underway to quantify percent carbonate.

Headspace gas analyses reveal low methane abundances (<4 ppm) and an absence of heavier hydrocarbons (C_+).

Physical Properties

Whole-round core measurements of velocity, density, magnetic susceptibility, and natural gamma radiation, as well as measurements of moisture and density in discrete samples, were conducted for the upper sections of Holes U1465A (Cores U1465A-1H to 9H, 0–64.8 m), U1466A (Cores U1466A-1H to 50X, 0–317.8 m) and U1466B (Cores U1466B-2R to 50R; 314–741 m). Velocity measurements in whole-round cores did not give good results for the upper ~65 m of Hole U1465A and the upper 81 m in Hole U1466A due to high water content, which caused poor sediment-to-liner coupling and deterioration of the acoustic signals, hence producing inconsistent compressional velocity values. Therefore, *P*-wave velocity measurements on the split cores were considered more reliable. Additionally, 40 thermal conductivity measurements have been performed in cores from Holes U1465A and U1466A.

Stratigraphic Correlation

The Stratigraphic Correlator continued to work with WRMSL, L*, and NGR data from Holes U1466A and U1466B to determine what records may provide the best correlation and compositing for sites where triple coring will occur.

Sequence Stratigraphy and Downhole Logging

Hole U1465A was dedicated to reach the top of a drowned carbonate platform via APC and XCB coring. In the seismic data, the platform is expressed by a flat, continuous high-amplitude reflection with toplap termination. As proposed by the sequence stratigraphic model, the platform top was drilled at 69 mbsf. This showed that the estimated velocity model for depth conversion of the seismic data is in good agreement with the cored depths.

Education and Outreach

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]), in blogs on the *JOIDES Resolution* website (http://joidesresolution.org/), and in personal blogs from members of the science party. We held a number of live ship-to-shore videoconferences with schools in Chile, Belgium, France, Germany, Ireland, Colombia, Italy, and the United States.

Technical Support and HSE Activities

Technical staff continued to provide guidance and assistance to the scientific party as they become familiar with laboratory equipment, software, and procedures and prepare the laboratories for coring activities.

Laboratories

- Processing and sampling of Cores from Holes U1465A, U1466A, and U1466B.
- Water samples collected daily with the Wildco Beta Water Sampler at approximately 15 m water depth for analysis of plankton.
- The liquid nitrogen generator was drained and purged in order to defrost it. The system is currently running normally.
- The seismic source was assembled and prepared for upcoming logging operations.

HSE Activities

- A fire drill was conducted on 20 October.
- The eyewash stations and safety showers were tested.