

IODP Expedition 359: Maldives Monsoon and Sea Level

Week 8 Report (16–22 November 2015)

Overview

This week we completed scientific coring operations at Site U1470 (MAL-05A) and started operations at Site U1471 (MAL-07A). At Site U1470, we drilled two holes. Hole U1470A was cored with the APC and XCB coring systems to 190 mbsf, with a total core recovered of 139.8 m (74%). Hole U1470B was cored with the RCB system to 343.7 mbsf, with a total core recovered of 7.35 m (4%). At Site U1471, we have cored four holes using the APC and XCB systems. Hole U1471A was penetrated from 0 to 685.1 mbsf. Total core recovered was 366.1 m (53%). Hole U1471B was penetrated from 0 to 6.7 mbsf with a recovery of 99%. Hole U1471C was extended from 0 to 178.8 mbsf with a recovery of 170.2 m (95%). Hole U1471D was extended from 0 to 58 mbsf with a recovery of 100%.

Operations

By midnight on 15 November, we had finished making up an RCB bottom-hole assembly (BHA) and spacing out the core barrels in preparation for returning the drill string to the seafloor. The ship was offset 20 m west of Hole U1470A, and Hole U1470B was started at 0230 h on 16 November. An offset seafloor depth of 410.8 mbsf was utilized from the adjacent Hole U1470A. Drilling proceeded to a depth of 150.0 mbsf before the formation stiffened up enough to warrant deploying an RCB center bit. Drilling continued to 168.9 mbsf, and at 0930 h on 16 November RCB coring was initiated. Only a single core was cut to 178.6 mbsf before high torque and overpull forced the need for a wiper trip. The drill string was pulled back to 90.2 mbsf, placing the top of the tapered drill collar above seafloor before drilling parameters returned to normal. The hole was washed and reamed back to total depth, and at 1345 h on 16 November RCB coring resumed. Cores U1470B-3R through 8R to 227.1 mbsf were cut before, once again, high torque and overpull indicated cuttings were not being properly flushed from the hole, perhaps aggravated by zones of lost circulation within the cavernous reefal limestone. Another 3 h long wiper trip was made and at 2030 h RCB coring resumed. Coring continued through Core U1470B-19R to 343.7 mbsf when coring was terminated shortly after 0400 h because we needed to wireline log the hole. Downhole logging was considered to be of greater importance than deepening a challenging hole. The shifting tool was run in the hole, but there were problems shifting the mechanical bit release (MBR) sleeve to release the bit. Repeatedly jarring on the sleeve with the wireline jars eventually knocked the sleeve loose, and the bit was released at 0530 h. The sleeve was reverse shifted without incident and the drill string was pulled to logging depth at 100.2 mbsf.

Due to uncertainty about the hole conditions and stability, a single logging run was planned with a tool string designed to measure the highest priority data (gamma ray, sonic velocity, electrical resistivity, and borehole diameter). Rig up for wireline logging began at 0730 h on 17 November. We ran this sonic-resistivity tool string into the hole without installing the nuclear source; unfortunately, resistance was encountered almost immediately as the tools reached 10 m below the end of the pipe (EOP), and we were not able to pass a collapsing section of the borehole securely just 52 m below EOP at 100.2 mbsf. The winch operator eventually pulled the tool string back into the pipe and up to the rig floor where it was rigged down, and logging operations in Hole U1470B were concluded by 1215 h on 17 November. The drill string was pulled clear of the seafloor at 1230 h, and the drill string was recovered back aboard ship with EOP clearing the rig floor rotary table at 1355 h. The positioning beacon was recovered on deck at 1410 h. Thrusters were pulled and the rig was secured for transit to the next site.

At 1448 h on 17 November we started the transit to Site U1471. We covered the short 9.1 nmi distance in 1 h and at 1548 h the transit ended. Thrusters were lowered and heading control was switched over to dynamic positioning at 1636 h. This process took a little longer than usual because the captain had to turn the ship around and change heading prior to getting back on the location coordinates. The APC/XCB bottom-hole assembly (BHA) was built and at 1707 h we deployed the same positioning beacon recovered from Site U1470. We lowered the drill string to the seafloor, picked up the top drive, and spaced out the bit at 414.6 mbsl. At 2050 h we started Hole U1471A, cutting Core U1471A-1H and recovering 4.62 m of sediment, thus establishing a seafloor depth of 419.5 mbsl. Continuous APC coring continued without incident through Core U1471A-32H to 295.1 mbsf where high overpull and incomplete stroke with the full-length APC led us to switch coring systems to the half-length APC (HLAPC). We continued to core with the HLAPC through Core U1471A-37F to 318.6 mbsf. All HLAPC cores were incomplete strokes and penetration continually decreased. Therefore, we switched to XCB coring and continued through Core U1471A-44X to 384.0 mbsf, but because of poor XCB recovery, we attempted another HLAPC core. Core U1471A-45F recovered only 0.51 m, indicating the formation had become more lithified and therefore too hard for piston coring. In addition, the driller noticed that the wash pipe assembly on top of the top drive was leaking seriously, leading to an impromptu wiper trip to condition the hole and position the tapered drill collar above the seafloor. The standpipe assembly was replaced and the bit was washed back to bottom. At 0030 h on 19 November, we resumed XCB coring and continued through Core U1471A-59X to 515.1 mbsf. Recovery was extremely poor, averaging just 8.6% (1.5%–27.2%). Only two of 14 cores were recovered with more than 1 m of sediment. Cores U1471A-60F and 61F were HLAPC cores in an attempt to improve recovery. These cores recovered 1.91 m and 1.16 m, respectively. However it was deemed too high a risk to drill out the rat hole with the pipe open ended and no core barrel in place. Core U1471A-63F was the final HLAPC attempted, recovering 1.74 m. Continuous XCB coring began with Core U1471A-64X at 531.5 mbsf and continued through Core 82X to 685.1 mbsf. XCB coring the interbedded hard/soft material was difficult and recovery was marginal because the lithified limestone jammed in the XCB cutting

shoe and the softer material washed away. The high content of sand in the formation caused the flapper valve in the core barrel to lock up, leading to occasional misfires of the APC/HLAPC coring systems. Although hole conditions remained good throughout, and core recovery had improved significantly over the last 100 m interval (averaging 44.5% and ranging between 19% and 88%), we decided to stop coring before reaching our depth and age objectives because of the slow rate of penetration (<8 m/h). Our plan was to reach our target depth in an RCB hole to be drilled after completing two more APC holes to 180 and 140 mbsf. Therefore, at 2300 h on 20 November, we stopped coring Hole U1471A and pulled the drill string back, clearing the seafloor at 0155 h.

After offsetting the ship 20 m to the west, we started coring Hole U1471B at 0440 h on 21 November. The mudline core recovered 6.62 m, but this was considered questionable and ineffective for stratigraphic correlation because the core liner was shattered and much of the material was lost. Therefore, we terminated the hole and Hole U1471C was started another 20 m to the west at 0555 h. Core U1471C-1H recovered 7.85 m, establishing a seafloor depth of 419.3 mbsl. Full-length APC coring continued through Core U1471C-19H to a total depth of 178.8 mbsf. Successful temperature measurements were made using the APCT3 temperature tool at depths of 26.8, 45.8, 64.8, 83.8, and 169.3 mbsf, defining a very low temperature gradient of 26°C/km. In addition, as a result of an APCT3 cutting shoe arriving late to the rig floor, the shoe was inadvertently installed without core catchers resulting in Core U1471C-5H (from 36.3 to 45.8 mbsf) being recovered empty. The drill string was pulled clear of the seafloor at 2000 h, ending Hole U1471C.

The ship was moved another 20 m west and we initiated Hole U1471D at 2105 h on 21 November. For this hole, to optimally position the core breaks to allow for a reliable stratigraphic correlation, the bit was advanced to 1.0 m below seafloor before taking the first core. Cores U1471D-2H through 7H were recovered to 59.0 mbsf with the last two cores oriented.

After completing coring operations in Hole U1471D, the planned test of the motion decoupled hydraulic delivery system (MDHDS) took place with mixed results. Handling of the tool at the rig floor was vastly improved, reducing deployment time from 1.5 h required during the first test at Site U1467 to 30 min. The Electrical Release System (ERS) tool was opened and closed numerous times, working flawlessly each time. The Sediment Temperature Tool (SET2) functioned as designed and successfully recorded data, although it was not inserted into the formation because the MDHDS became stuck in the lockable float valve (LFV). A round trip of the drill string was completed with the bit clearing the rig floor at 0545 h on 22 November, ending Hole U1471D.

The MDHDS tool was removed without incident at the rig floor and the LFV was discovered packed with sand. It appeared that entrained sand was restricting removal of the MDHDS tool

downhole and this was flushed from the system during the pipe trip, which also explained several unusual piston core sequences where the pressure profile was atypical.

After making up a new RCB coring bit with a mechanical bit release (MBR) and a four-stand bottom-hole assembly, the drill string was once again lowered to the seafloor. The ship was offset another 20 m west, and at 1110 h on 22 November we started drilling Hole U1471E. Our goal is to drill this hole down to ~610 mbsf and then continuously RCB core to ~950 mbsf. Finally, we will conduct downhole logging with the three suites of wireline tools: the triple-combo, FMS-sonic, and Versatile Seismic Imager (VSI). As of midnight on Sunday, 22 November, Hole U1471E had been drilled down to 421.4 mbsf.

Science Results

Overview

This week we processed 42 cores (147 m) from Site U1470 and 108 cores (600 m) from Site U1471 for lithologic description, sediment physical properties, and biostratigraphic and geochemical analyses. The scientific objectives and preliminary results for Site U1470 were introduced in the Week 7 report of the expedition. Below are the introduction, scientific objectives, and very preliminary results for Site U1471.

Site U1471 is the easternmost site of the southern transect, located 16.8 km east of Site U1470 and 16.4 km southwest of Site U1467, at a water depth of 419.3 m. It is located well within the Inner Sea part of the Kardiva Channel, where the seafloor is an overall flat surface. Sediments of the Inner Sea are hemipelagic carbonates consisting of an admixture of components exported from the atolls and pelagic components (“periplatform ooze”). Therefore, the cores from Site U1471 are expected to provide a complete and uninterrupted record of the sedimentary and paleoceanographic changes in the Maldives from the Miocene throughout the Pleistocene.

Lithostratigraphy

Two holes were cored at Site U1470. Hole U1470A was cored using a combination of the APC, HLAPC, and XCB coring systems to 190 mbsf. The top of the buried platform was reached at 150 mbsf, and from there downhole the lithology we found was of a reefal limestone. Hole U1470B was drilled without coring to 168.9 mbsf and then rotary cored to 343.7 mbsf. All cores from Site U1470 were split and described. Both holes represented a succession of partially lithified to lithified, gray-brown to pale yellow, coarse-grained grainstones to packstone with abundant bivalve molds and fragments, benthic foraminifera, and echinoderm spines. This was underlain by lithified dolomitic coral-rich grainstone to rudstone, with a very fine-grained crystalline matrix and lithified bioclastic floatstone. The main components of this succession are common to abundant red algae (as nodules and encrustations) and coral fragments (massive and branching). Serpulids and mollusks are also common (as molds). Moldic porosity is pervasive

with abundant casts of bioclasts, commonly partially to totally infilled by calcite cement. Crystalline structures are observed on the walls of the molds, with botryoidal-like geometries. Fine crystals of dolomite are present as well-developed large euhedral dolomite crystals.

At Site U1471, four holes have been cored so far with the APC, HLAPC, and XCB coring systems. Cores from the first three holes were split and described. The upper part of this succession consisted of a grayish brown, fine- to medium-grained, unlithified to partially lithified planktonic foraminifera-rich packstone. Benthic foraminifera, gastropods, and pteropods are common. Downhole (as of 80–90 mbsf), decimeter thick layers of partially lithified packstone are present. Preservation of calcareous microfossils deteriorates below Core U1471A-10H with most shells showing pervasive calcite overgrowth. This was underlain by a fine- to medium-grained interlayered partially lithified and lithified planktonic foraminifera-rich wackestone to packstone. Planktonic foraminifera are abundant and benthic foraminifera are few to rare. Bioturbation is moderate to intense. *Thalassinoides* and *Chondrites*, *Planolites*, and *Zoophycos* are present to common.

Biostratigraphy

At Site U1470, a fairly clear age model could be established based on planktonic foraminifera biostratigraphic events identified in the upper part of the sequence, ranging from the Quaternary to early Pliocene. For the lower part of the cored section of Site U1470, which corresponds to the early Pliocene and possibly topmost Miocene, only a single planktonic foraminiferal event was identified.

At Site U1471, a complete age model based on marker species from calcareous nannofossils and planktonic foraminifera is being developed. Our preliminary results suggest that the base of Hole U1471A (at 685 mbsf) is of late Miocene age. The record will be extended once Hole U1471E is cored.

Geochemistry

Interstitial water (IW) sampling was limited at Site U1470 by lithification and poor recovery. Sixteen IW samples were taken in addition to a bottom water (mudline) sample, with little variation observed in any geochemical properties in the pore fluids. Bulk sediment analyses were conducted on squeeze cakes or headspace samples, depending on availability. Carbonate content is high, generally above 90 wt%, and aragonite is abundant in the upper ~140 mbsf. At greater depths the sediments consist largely of low-Mg calcite.

A total of 39 IW samples were taken from Hole U1471A, in addition to a bottom water (mudline) sample. Alkalinity increases by ~5 mM with a maximum at ~150 mbsf, which also corresponds to minima in sulfate and magnesium and a maximum in calcium. These trends suggest that sulfate reduction and dolomitization are occurring in the sediment column. Sediment analyses at Site U1471 are underway and will be continued when Hole U1471E is cored.

Paleomagnetism

We completed measurements of all the cores recovered from Sites U1469 and U1470, and we started measuring Site U1471 cores in the cryogenic rock magnetometer. Paleomagnetic data continued to be hampered by magnetic overprint, and the data were analyzed and interpreted whenever possible. In addition, the internal field of the cryogenic rock-magnetometer was inspected in search of possible causes for biased paleomagnetic directions obtained from the cores at Site U1470. No problems were found with the instrument.

Physical Properties

We finished whole-round core measurements for Holes U1470B and U1471A–U1471D. PWL velocity, GRA density, MSL, and NGR measurements were performed on each section of cores from these holes. PWC velocity was measured on split cores and discrete samples from Holes U1470B and U1471A. MAD analysis was also conducted on discrete samples from these two holes. Thermal conductivity and shear strength were only performed on samples from Hole U1471A. Similarly to previous sites, physical properties exhibit variability along depth, indicating significant effects of lithification, bioturbation, compaction, and diagenetic alteration. The most interesting finding is the alternating high and low velocity layers at >600 mbsf in Hole U1471A, which may be related to aragonite diagenetic cycles.

Downhole Logging and Sequence Stratigraphy

Logging operations were attempted in RCB Hole U1470B. Given the possibility of deteriorating hole conditions following coring operations, a single logging run was planned. A sonic-resistivity tool string measuring gamma ray, sonic velocity, electrical resistivity, and borehole diameter was run into the hole on 17 November 2015. Unfortunately, the tool string was not able to pass a blocked section of the hole just 52 m below the pipe depth (155 mbsf). Logging operations could not continue and the tool string was returned to the rig floor and rigged down.

Education and Outreach

This week we conducted 12 education events with a total of 643 students from high schools in France, Belgium, United States, and Portugal, and one university in Israel. 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]), 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 Sites U1470 and U1471.
- Water samples collected daily with the Wildco Beta Water Sampler at approximately 15 m water depth for analysis of plankton.
- The *P*-wave sensor was disabled briefly due to inability to obtain a good calibration even after servicing the transducers. It is unclear exactly what the issue was but further maintenance by the electronic technicians and the addition of Olympus Coupling B to the transducers solved the issue. All available sections were measured with no further problems.

HSE Activities

- A fire and boat drill was conducted on 17 November.
- The eyewash stations and safety showers were tested.