IODP Expedition 359: Maldives Monsoon and Sea Level
Site U1466 Summary

Background and Objectives

Site U1466 is positioned at 4°55.9880′N, 73°1.6894′E, in a water depth of 518 m and 1880 m east of Site U1465. The site is in front of the last prograding clinoform of the drowned carbonate platform that was the target at Site U1465. In this basinal position, a thick drift succession overlays the bottom- and foresets of the drowned Kardiva Platform. The pulses of progradation are related to the sea level changes while the overlying drift succession is a current controlled system that is likely related to the Indian monsoon. The main goals of this site were 1) to date the transition from the sea level-controlled platform system to the current-controlled drift deposition, and 2) to establish an age model for the early and middle Miocene sea level changes in the Indian Ocean and the changes in the current evolution since the middle Miocene. The Mid-Miocene to recent drift succession contains several sequences that are caused by fluctuations in the current system. Dating these sequence boundaries will provide the ages of the changes in strength and direction of the currents and potentially serve as a proxy for changes in the monsoon intensity. Dating of the platform sequence boundaries will provide ages of the sea level lowstands in the Indian Ocean that together with data sets from the Bahamas (ODP Leg 166) and offshore eastern Australia (ODP Leg 133 and Leg 194) will allow testing the global synchroneity of Neogene sea level changes. In addition, the age of the last platform sequence will provide the age of the platform drowning that potentially is linked to the onset of the current system. The cores recovered at Site U1466 will also allow addressing another objective of Expedition 359. The periplatform sediments deposited at this site offer the opportunity to retrieve a complete record of $\delta^{13}C$ through the Lower and Middle Miocene that together with the other sites drilled during Expedition 359 will provide another data set of the carbon isotopic record that is needed to calibrate the periplatform platform margin record against the pelagic record.

Principal Results

Site U1466 is located in the Kardiva Channel, which connects the Inner Sea of the Maldives with the open Indian Ocean. Two holes were cored at Site U1466 using the full and half-length advanced piston corer (APC, HLAPC) and the extended core barrel (XCB) systems, as well as the rotary coring barrel (RCB). Hole U1466A was cored to

317.9 mbsf (50 cores) and recovered 243.8 m of sediment (74% recovery). Hole U1466B was cored down to 803.1 mbsf and recovered 88.5 m (17%). Three formation temperature measurements (APCT3) were attempted, however all the values were considered suspect.

The sedimentary succession at Site U1466 penetrated 803.6 m of carbonates, which are early Miocene to Pleistocene in age. Seismic stratigraphy shows that this succession consists of a 254 m thick package of drift deposits which overlays a 549 m thick succession which consists of the bottomsets and foresets of the middle Miocene prograding platform.

Seven lithostratigraphic units were identified in the drift and slope/basin deposits. The Lithostratigraphic Units I–IVC (0–248.3 mbsf) are from the sediment drift succession, Units IVD–VI (248.3–715.34 mbsf) contain the lithological record of the prograding tongues of the Kardiva Platform, and lithostratigraphic Unit VII (715.34–803.61 mbsf) is composed of early Miocene basinal carbonates from the Inner Sea. Lithostratigraphic Unit I is Pleistocene to Recent in age and consists of unlithified coarse-grained grainstone succession. The grey-brown to pale yellow carbonate sands consists almost exclusively of bioclasts with planktic foraminifera being the most abundant component with admixtures of benthic foraminifera, pteropods, otoliths, *Halimeda* plates, echinoid spines, bryozoa, and bivalves. The bioclasts are generally broken and show signs of abrasion indicative of current transport.

Lithostratigraphic Unit II is an alternation of unlithified packstone and grainstone. The sediment ranges in grain size from very fine in the grainstone intervals to coarse-grained in the packstone. The main components are planktonic foraminifera and minor benthic foraminifera, pteropods, red algae, *Halimeda* plates, bivalves, and echinoid fragments and spines, as well as otoliths. Aggregate grains, yellow to brown stained grains, and black grains occur throughout the entire unit.

Lithostratigraphic Unit III consists of very pale brown medium- to coarse-grained grainstone to packstone that is variably lithified. The main components are planktonic foraminifera, with common to present benthic foraminifera (e.g. *Lepidocyclina*), encrusting red algae, *Halimeda* plates, and bryozoan fragments. Lithification increases down to lithified rocks at 99.53 mbsf; below unlithified and lithified intervals alternate again. Lithostratigraphic Unit IV consists of four subunits based on the occurrence of

textural changes from wackestones to packstones and/or grainstones. The overall lithology is very comparable throughout the entire unit and consists of skeletal and foraminiferal wackestone to packstone. Lithostratigraphic Unit V is marked by the occurrence of large benthic foraminifera in light gray to light brownish gray colored, lithified, medium- to coarse-grained, dolomitic grainstone and packstone. Lithostratigraphic Unit VI is characterized by a significant increase in the bioturbation degree. It consists of an alternation of decametric intervals of lithified fine- to medium-grained packstones and wackestones with common planktonic and benthic foraminifera and echinoid fragments, as well as bioclasts. Lithostratigraphic Unit VII consists of a recurrent alternation of well-laminated black intervals with white massive white chalk and grey-green colored intervals with moderate to abundant bioturbation. The top of the unit contains intervals with gravity-induced deposits, e.g. slump sediments, soft sediment deformation features, and turbidites.

Combining planktonic foraminifers and calcareous nannofossils provided the age model for Site U1466. The estimated sedimentation rate for the Plio–Pleistocene sequence is ~1.41 cm/k.y. Most of the late Miocene is absent from the sedimentary record at this site. The hiatus occurs between the LO of *Coronocycus nitescens* (11.9 Ma) and the LO of *Globoquadrina dehiscens* (5.92 Ma). The Middle Miocene is divided into three intervals: the basal one presents high sedimentation rate (~7.83 cm/k.y.), the sedimentation rate decreased during the second interval (~2.52 cm/k.y.), and the third interval presents very high sedimentation rate (~17.12 cm/k.y.). The Early Miocene is divided into two intervals: the lower interval presents low sedimentation rate (~1.40 cm/k.y.) and during the upper one sedimentation rate increased to ~6.13 cm/k.y.

Pore water studies at Site U1466 in the upper 85 mbsf indicate either relatively low rates of organic matter remineralization, or rates of advection by bottom seawater that are faster than the rates of decomposition of organic matter. XRD analysis shows that the concentration of aragonite in the sediments remains relatively high throughout the Pleistocene and Pliocene (0–85 mbsf), reflecting either variations in the input from adjacent platforms during changes in sea level or diagenetic change to LMC. While the hypothesis that aragonite is not being neomorphosed in the upper 85 mbsf is supported by the absence of large increases in the concentration of Sr^{2+} in the pore fluids, the possibility also exists that relative high rates of fluid advection are removing evidence of

dissolution and precipitation reactions. Below 85 mbsf, the concentration of aragonite disappears and at 97.7 mbsf the sediment contains up to 70% dolomite. Below ~150 mbsf the concentration of dolomite decreases again and up to 20% aragonite is present, and below 320 mbsf the dolomite disappears and is only barely detectable in trace concentrations through the remainder of the core.

The determination of paleomagnetic polarity based only on inclination data for Site U1466 is extremely weak because of the very low paleolatitude, possible inclination anomalies due to nondipole field, and the poor data quality. Nevertheless, paleomagnetic studies allow recognizing 21 magnetozones using the inclination data. These magnetozones are tentatively attributed to the lower Miocene and middle Miocene (C5A–E series and C6).

The variability of values in the downhole logs and the measured petrophysical properties in the pure carbonate strata of Site U1466 reflects changes in diagenesis/lithification and the amount of organic carbon rather than mineral composition. Downhole logging was limited to a one run with the modified triple combo tool string to 345 m WSF (wireline below the seafloor) where the hole had collapsed. In the pure carbonate, the natural gamma radiation is low with two higher peaks related to increased content of organic carbon. The resistivity most likely records the degree of cementation with better-cemented intervals having higher resistivity. The petrophysical properties are also reflecting the pure carbonate composition. Magnetic susceptibility is very low throughout the section. Grain density is similar in the entire section. Velocity does not correlate well to porosity and displays abrupt increases and decreases downcore as is typical in pure carbonates. Gamma ray peaks in the logs appear to be related to an increase in organic matter.

The correlation of the lithostratigraphy and the age model from biostratigraphy to the seismic stratigraphy confirms and refines the predrilling interpretation. The continuous seismic reflections of the distal clinoforms of the sea level-controlled Kardiva Platform is lithologically a regular alternation of intervals of lithified fine- to medium-grained packstones and wackestones. These alternations most likely are the result of the high-frequency sea level changes. The turnover to the drift succession is recorded by a change in seismic and lithologic facies. The seismic reflection amplitudes decrease and the

lithology is dominated by coarse-grained packstone and grainstone reflecting the current dominated sedimentation pattern.