IODP Expedition 359: Maldives Monsoon and Sea Level
Site U1465 Summary

Background and Objectives

One goal of IODP Expedition 359, in addition to retrieving the record of the Neogene sea level changes in the prograding Kardiva platform and the onset of the monsoon related currents in drift deposits, was to establish the time and cause of the drowning of the Kardiva Platform during the middle Miocene. The platform drowning related questions were the focus of Site U1465, which is situated above the margin of the drowned Kardiva Platform that is overlain by 70 m of sediment.

Carbonate platforms are the only depositional system that can cease to exist. The mechanism of the platform demise is usually drowning but the reason(s) for the drowning is still an unresolved question. Many processes have been proposed such as global anoxic events, tectonic breakup, and excess nutrients. The close relationship between platform drowning and intensification of ocean currents has been proposed for the demise of the Miocene platforms on the Marion Plateau. Previous studies documented the partial platform drowning in the Maldives and proposed that in the Maldives, the drowning of the platforms is the combined product of current activity and nutrient supply. Examining the drowning unconformity and the pre- and post drowning succession in regards to age, composition, and diagenetic overprint was intended to provide evidence to link drowning directly to the onset of the monsoon-related current system and the concomitant excess nutrient supply from upwelling.

Principal Results

Site U1465 is located at 4°55.9873′N, 73°0.6786′E and a water depth of 512 m in the Kardiva Channel between the Goidhoo and South Maalhosmadulu Atolls. It is the westernmost site of a transect that runs from west to east in the Kardiva Channel, which is the main passage connecting the Inner Sea of the Maldives with the Indian Ocean.

In Hole U1465A we APC cored 76.6 m mainly in the drift sequence overlying the drowned platform and recovered 53.24 m (70% recovery). Hole U1465B was washed down to 65.9 m and then RCB cored between 65.9 and 213 mbsf with a recovered length of 9.41 m (6% recovery) in the platform succession. Hole U1465C was washed down to

55 mbsf and then cored with the half-length APC, and the XCB coring systems in the drift, and in the platform succession with a recovery of 24.6 m (14% recovery).

Three lithostratigraphic units were identified in the mostly unlithified drift deposits and the underlying lithified platform and slope-sediments of the Kardiva Platform. Lithostratigraphic Unit I contains unlithified white/light grey to grey-brown and pale-yellow packstone to grainstone and locally rudstone. The components are planktic foraminifera together with benthic foraminifera, pteropods, red algae, *Halimeda* plates, bivalves, echinoid fragments and spines, otoliths, and rare solitary corals. Aggregate grains, and yellow to brown and black grains occur throughout the entire unit. All lithoclasts and some bioclasts are abraded, which is to be expected in this drift deposit. The underlying Lithostratigraphic Unit II is comprised of a shallow-water platform margin facies with a diverse coral fauna. The top of Lithostratigraphic Unit I is a well-lithified floatstone with corals, red algae, large benthic foraminifera, bivalves, and serpulid fragments that show evidence of exposure and subsequent submarine hardground formation. This thin drowning layer is partly dolomitized and silicified and contains large molds with two generations of dark-colored geopetal infillings that are likely phosphatic. Below this top layer exists an alternation of coral boundstone and floatstone that can be rich in algal nodules. The matrix of the floatstones is generally a bioclastic grainstone with abundant benthic foraminifera. Pervasive meteoric diagenesis is indicated by moldic porosity, and marine diagenesis is seen in multiple stages of cements and partial dolomitization. Lithostratigraphic Unit III consists of an alternation of lithified, very pale brown, coarse-grained dolomitic grainstone to packstone with varying cementation degree. The composition is similar to the matrix of the overlying floatstone but there is a decrease in the amount of coral fragments and an increase of red algae and large benthic foraminifera. The main components are large benthic foraminifera (*Heterostegina* sp., *Lepidocyclina* sp. (*Nephrolepidina*), *Operculina* sp., *Amphistegina* sp., *Miogypsina* sp., and *Nummulites* sp.), bivalves, *Halimeda* plates, red algae, minor coral fragments (massive and branching), bryozoa, echinoid spines, gastropods, and abundant bioclasts. A characteristic of Lithostratigraphic Unit III is the repetitive alternation of hard cemented layers with abundant moldic porosity and layers of loosely cemented grainstone to packstone with interparticle porosity. Lithostratigraphic Unit III displays all the characteristics of a proximal slope facies, which fits the seismic facies consisting of steeply inclined reflections.

A robust age model was produced by combining the biostratigraphic data of the planktonic foraminifers and the calcareous nannofossils in the ~70 m thick drift sediment succession recovered at Hole U1465A, above the drowned platform. In the platform and the underlying slope section, the occurrence of planktonic foraminifers and nannofossils was not sufficient for biostratigraphic purposes. The 70 m thick drift sediments range in age from Late Pleistocene to Early Pliocene. The large benthic foraminifer assemblage within the platform points to a middle Miocene age, indicating a long hiatus of ~10 m.y. on the platform top.

Benthic foraminifers and ostracods were studied in selected samples above and within the platform to evaluate the paleoenvironmental conditions. The Plio–Pleistocene benthic fauna in the drift samples generally indicates middle neritic to upper bathyal water depths (most likely less than 500 m) based on the presence of benthic foraminifera such as *Borelis melo, Cycloclypeus mediterraneus, Planulina ariminensis*, *Planulina subtenuissema*, *Cibicidoides dutemplei*, *Sphaeroidina bulloides*, *Cibicidoides bradyi,* and small *Miliolids*; and ostracod genera such as *Bairdopillata*, *Lankacythere*, *Loxocorniculum*, *Bradleya*, and *Krithe.* Below 35.8 mbsf, a sand layer is mainly composed of reworked reefal material (large benthic foraminifers, fragments of corals, and *Halimeda*). The Late Pliocene portion of the drift section also had abundant coral fragments, well-preserved echinoderm spine fragments, fish teeth, and planktic foraminifera, but no ostracods were observed. All samples contain reworked shallow water taxa, ranging from reefal to middle neritic environments.

Interstitial water (IW) sampling was limited at Site U1465 to the top 70 m because of lithification and poor recovery in the platform succession below the drift sediments. The concentrations of major anions and cations generally remain constant and close to the mean seawater value throughout the sampled interval. For example, the concentrations of Na^+ and K^+ range between 422–433 mM and 10.9–11.2 mM with no trends visible with increasing depth. Similarly stable values are reflected in Ca^{2+} and Mg^{2+} concentrations and salinity also remains relatively constant at 34.5–35.0 throughout the measured interval. This general lack of variation could result from three possible situations: no significant diagenesis, high rates of advection, or contamination by seawater.

This is in contrast to the mineralogical changes shown by the X-ray diffraction data that reflect carbonate diagenesis during the burial of sediments at Site U1465. Above 45 mbsf,

the sediment consists of 30%–80% aragonite, 6%–18% high-Mg calcite (HMC), and the remainder low-Mg calcite (LMC). From 45–85 mbsf, dolomite is present up to 7 wt% while aragonite and HMC continue to make up 30%–60% of the sediment. Thus, it is possible that the rate of advection dilutes the geochemical signal of diagenesis in the IW. In the carbonate platform portion the carbonate mineralogy is variable. Below 90 mbsf, the rocks are essentially composed of low magnesium calcite and dolomite. Dolomite peaks at 57% at 143.5 mbsf and is otherwise present mostly <20%. Below 160 mbsf, aragonite is again present at abundances of <10%, with dolomite constituting less than 1 wt% and the remainder (>90%) consisting of LMC. Quartz is often present in the X-ray diffraction spectra but is never a significant component of the sediments (<1%).

Petrophysical analyses allow differentiating two different units. The first unit encompasses the loose Plio–Pleistocene drift sediments and shows high porosities. The lower unit corresponds to the platform carbonates characterized by higher *P*-wave velocities and higher densities. *P*-wave velocities reflect a variety of pore types, which possibly result from complex diagenetic processes in response to the diagenetic processes linked to the platform drowning.

Seismic stratigraphy at Site U1465 shows an excellent correlation with lithostratigraphic units. The APC cores from Hole U1465A recovered the drift sequences DS7–DS9 and the platform top, while the cores of Hole U1465B and U1465C retrieved platform sequence PS11 and parts of platform sequence PS10. The hiatus separating the platform top from the drifts encompasses drift sequences DS1 to DS6, which biostratigraphically was dated at Site U1466 as Middle Miocene to middle Pliocene, i.e., ~12 to 3.5 m.y. and corresponds to the boundary between Lithostratigraphic Units I and II. The upper part of PS11 at Site U1465 consists of a package of gently basinward reflections that can be laterally traced over a distance of around 600 m. The lower boundary of the packages coincides with sequence boundary PS11, which corresponds to the base of Lithostratigraphic Unit II. The deepest hole at Site U1465 (Hole U1465C) has been abandoned approximately 9 m above the basal boundary of PS10.