IODP Expedition 359: Maldives Monsoon and Sea Level
Site U1469 Summary

Background and Objectives

Site U1469 lies 2.87 km (1.57 nmi) SSW of Site U1465, which is the westernmost site of the northern transect in the western part of Kardiva Channel. It is located at 4°54.41′N and 73°0.48′E at a water depth of 427 m. The Kardiva Channel is a wide W–E oriented passage, which dissects the N–S running double row of the Maldives atolls. The Kardiva Channel formed as a result of the demise of larger carbonate banks during the Miocene. The northern transect, including Site U1469, is in the approximately 12 km wide northwestern branch of the Kardiva Channel between the Goidhoo Atoll and the Maalhosmadulu Atoll. At present this passage accommodates a seasonally reversing and monsoonal driven water throughflow. Currents affect the water column down to the sediment surface and trigger erosion at the seafloor as well as the migration of large-scale carbonate sand and mud waves. This depositional regime persists since the Miocene, and the hypothesis to test is that the onset of current and partial drowning of the carbonate banks were intimately linked. Seismic stratigraphy and facies indicate that the onset of this current was a rapid process, and that the intensity of the currents varied through time.

Site U1469 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 (i.e., the surface that forms the top of the last growth episode of the carbonate bank) does not mask underlying geometries at this site. The target depth was 700 mbsf, which is the base of the platform sequence PS07; the first sequence after the Kardiva Platform went from a mostly aggrading growth to progradation.

The specific objectives of Site U1469 were (1) 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 (i.e., depositional facies); (2) to constrain the timing of this evolution thus allowing age assignments of unconformities, sedimentary interruptions, sedimentary turnovers, and onset of drift deposition; and (3) reconstruction and dating of bank-to-drift turnover.

Principal Results

The sedimentary succession expected at Site U1469 was comparable to Site U1465, with a package of loose drift carbonate sands overlying the limestones of the drowned platform. Although recovery was expected to be low, this site was cored with the rotary core barrel (RCB) coring system, because only faulty sleeves for extended core barrel (XCB) coring were available at the time of drilling.

Three lithostratigraphic units were defined at Site U1469 based on visual core descriptions and thin sections analysis. Unit I (0–93.0 mbsf) represents the youngest hemipelagic deposits, which consist of partly-lithified to lithified, gray-brown to pale yellow, coarse-grained very well sorted grainstones to packstone. Bioclasts are typical open marine pelagic fauna, and minor proportions of skeletal benthic fauna that may have originated close to the active atolls and were transported by the currents to the Kardiva Channel.

During deposition of Lithostratigraphic Unit II (93.0–141.7 mbsf), the coarse-grained grainstones to rudstones contained an increased amount of benthic foraminifera and admixtures of corals, bivalves, *Halimeda,* and echinoderm spines. The coarser grain size and the microfaunal assemblage indicate a shallower and higher energy current-dominated environment compared to Lithostratigraphic Unit I. These deposits cover the top of a drowned carbonate platform that makes up Lithostratigraphic Unit III (141.7–153.4 mbsf). The lithologies of Unit III consist of dolomitized coral-rich floatstone with massive and branching coral fragments, rhodoliths, gastropods, and other encrusting organisms that are interpreted as a shallow marine reef to fore reef depositional setting.

Because of the poor recovery no continuous record of core catchers could be obtained. As a result the biostratigraphic age model for this site is limited, but both the planktonic foraminifera and the calcareous nannofossils indicate a Quaternary to Early Pliocene age for the sediments above the drowned platform. Planktonic foraminifer biostratigraphy identified two Pleistocene biohorizons, the LOs of *Globigerinoides fistulosus* (1.88 Ma) and *Globorotalia limbata* (2.39 Ma), which were found at 44.57 mbsf and 63.96 mbsf, respectively. The Pliocene events LO of *Dentoglobigerina altispira* (3.47 Ma) and LO of *Globorotalia margaritae* were found at 63.96 mbsf and 73.7 mbsf, respectively. The occurrence of nannofossils was sparse and of poor preservation. Thus, no assemblages were unambiguously datable. However, the presence of small *Gephyrocapsa* specimens

in the upper part of the sequence (25–93 mbsf) indicated that these samples are Quaternary to middle Pliocene in age (Zones NN21 to NN14). Similarly the consistent presence of *Sphenolithus* specimens in the lower part of the site (73.6–122.1 mbsf) suggested that this part of the sequence is middle Pliocene or older (NN15 or older), although they could be reworked. No Miocene marker species were seen. The drowned platform did not contain any age diagnostic benthic foraminifers, but seismic stratigraphic evidence placed a middle Miocene age at the drowning surface.

At Site U1469, no interstitial water (IW) samples were obtained. The carbonate content in seven sediment samples above the platform yielded carbonate contents between 94.95 and 97.95 wt%, and their TOC was between 0.04 and 0.15 wt%. The mineralogy of the sediment consists of aragonite, high-Mg calcite (HMC), low-Mg calcite (LMC), and dolomite. High-Mg calcite was present only to a depth of 25 mbsf and reached a maximum of 8.9%. Aragonite occurred at concentrations between 10.7%–49.0% from the surface to 73.6 mbsf. Below this depth, most of the aragonite and all of the HMC neomorphosed to LMC. Dolomite is present with a low abundance of <3.3% above 93 mbsf. Below 93 mbsf dolomite increases to concentrations between 4.4% and 30.9% while the concentration of aragonite decreases. The C/N ratios of the samples collected for headspace analyses suggest organic matter with a marine origin. The platform carbonates, at 153.22 msbf, are completely dolomitized. The Sr/Ca ratios are high (1.26 to 3.32 mmol/mol) above 80 mbsf. Below that depth, they decrease to <1.2 mmol/mol.

Paleomagentic measurements of intensity, declination, and inclination on the platform carbonates below 151 mbsf yielded some magnetostratigraphic information. One reversal was recognized at 153.8 mbsf and a normal below. In addition, a possible short reversal occurred at 153.9 mbsf.

The physical properties fall into two groups that correspond to the Pliocene–Pleistocene drift sediments (Unit 1) and the carbonate platform succession (Unit 2). The slightly lithified grainstone to rudstone facies of the drift sediment display low natural gamma radiation (NGR), increasing downhole. As in the drift sediments of the other sites, bulk density is low (1.5–2.0 g/cm^3) and porosity is very high, ranging from 42% to 52%, and the *P*-wave velocity reaches 2562 m/s in these drift sediments. The dramatic facies change to the platform carbonates at 141.7 mbsf is also reflected in the physical properties. The dolomitized limestone has high NGR values. Bulk density averages

2.5 g/cm^3 whereas the grain density was 2.84 g/cm^3, confirming the complete dolomitization of this interval. Porosity was between 15.4% and 22.8%. Despite the relatively high porosity, the velocities were over 5000 m/s. This can be explained by the dominance of the moldic pore types that produced a rock with a stiff framework.

The time depth conversion for correlating the seismic sequence to the lithology relied on the velocity model from Site U1465 that had a similar lithology. Similar to Site U1465, Site U1469 is at the margin of the drowned Kardiva Platform that is overlain by drift deposits. At this location, however, the sequence stratigraphic interpretation indicates a younger age of the top of the Kardiva Platform. Additionally, the overlying drift sequences above DS4 are more complete. The seismic facies of the drowned Kardiva Platform displays a series of prograding clinoforms with slightly basinward inclined topsets and steep foresets that flatten out basinward. The overlying drift deposits are horizontal semi-continuous medium amplitude reflections of drift sequences DS4–DS10 and were interpreted to be Late Miocene to Recent in age. The drifts succession consists of coarse-grained grainstone that is early Pliocene to Recent in age in the upper part, but no age diagnostic fossils were found in the portion directly overlaying the drowned platform. The drowned platform top is part of platform sequence PS11 that was interpreted to be Middle Miocene in age. Shore-based radiometric dating will be needed to assess the exact age.