IODP Expedition 361: Southern African Climates
Site U1477 Summary

Background and Objectives

Site U1477 is located in the western Mozambique Channel on the upper continental slope (19°21.29′S; 36°54.90′E), ~65 nmi east of the Zambezi River delta region, at a water depth of 429.2 mbsl.

Site U1477 receives fluvial material exported from the Zambezi River Catchment, which is situated in the southernmost reach of the African monsoonal precipitation belt and drains multiple subbasins. Collectively these subbasins span around 1.385 million km^2 and the river itself extends over 2500 km. Annual precipitation across the Zambezi River Catchment varies spatially with ~150 cm in the northern catchment region, ~85 cm in the southern region, and 60–70 cm in the central region (Ronco et al., 2006). Peak precipitation in the Zambezi catchment occurs during the austral summer (December–February), when the Intertropical Convergence Zone (ITCZ) is located at its most southerly position.

The mean outflow of the Zambezi River is 3000 m^3/s (Gammelsrød, 1992), which transports an annual sediment load of around 51 Mm^3, making it the largest single source of suspended sediment supply to the Mozambique margin (Walford et al., 2005). These fluvial sediments mix with current-transported and biogenic material and are a major component of the extensive current-controlled sedimentary deposits that characterise the Mozambique margin. These sediments have the potential to provide comprehensive proxy records of regional oceanographic changes as well as changes in hydrological conditions of the African precipitation belt in southeastern Africa (e.g. Just et al., 2014; Schefuß et al., 2011; Schulz et al., 2011; Wang et al., 2013; Weldeab et. al. 2013, 2014; van der Lubbe et al, 2014, 2015).

Site U1477 is situated on a contourite drift deposited under the influence of the eddy-dominated water flow through the Mozambique Channel. The drift displays packages of parallel and laterally continuous subseafloor reflectors. Site U1477 is immediately southwest of the 6.51 m long sediment core GeoB9307-3 (18°33.99′S, 37°22.89′E, 542 m water depth; Schefuß et al., 2011) which is located in an area with elevated sedimentation during the deglacial period to the Holocene. The existing core data from GeoB9307-3

suggest the great potential of Site U1477 for providing a centennial-scale paleoceanographic record.

The Site U1477 primary objectives are to: (i) recover a complete and high resolution sedimentary succession that spans the last 2 my, including the mid-Pleistocene transition, from the Mozambique Margin close to the Zambezi River delta; (ii) generate a high-resolution Pleistocene profile of southern African continental climate changes on orbital and suborbital timescales; (iii) establish linking between southern African terrestrial climates and southwest Indian Ocean heat budgets, notably warm water transport along the southeast African margin and associated ocean-atmosphere heat and moisture transfer; (iv) examine the relationship between such climate variability and early human evolution; and (v) reconstruct upstream control on Agulhas leakage through headwater variability during periods of orbitally modulated and suborbitally accelerated climate changes. Specific questions that will be addressed include: Did the long-term climatic developments of the Pleistocene, through their impact on atmospheric circulation, alter the rainfall patterns over southeast Africa, notably in conjunction with far-field responses to East African uplift, monsoon dynamics, and migration of the ITCZ (Johnson et al., 2002; Schefuß et al., 2011; Trauth et al., 2009)? Did variable Agulhas Current warm water transport contribute to and modulate the impacts of shifting air boundaries and rainfall patterns over southeast Africa, and possibly offset these patterns from those over southwest Africa and the Namib (Dupont et al., 2005; 2011; Maslin et al 2012)?

The stratigraphic extent of Site U1477 was considerably shorter than anticipated, with a maximum age of ~200 ka. As a result, the paleoclimate site objectives will require adjustment to focus on high temporal timescale variability (centennial-decadal) over the last glacial cycle. The remarkably high sedimentation rates at Site U1477 promise an unprecedented opportunity to investigate hydroclimate variability in Southeastern Africa and its potential links to changes in the Greater Agulhas Current System.

Operations

Site U1477 consists of three holes that penetrated from 119.4 to 181.2 m DSF. The advanced piston coring (APC) system penetrated a total of 296.2 m and recovered 308.07 m of core (104%). The half-length APC (HLAPC) recovered 174.00 m of sediment over a 169.2 m interval (103%). The XCB was deployed for one core resulting in 7.96 m of sediment (97%). One interval was advanced 1.0 m without coring to adjust

coring gaps to provide a continuous stratigraphic sequence. The total time spent at Site U1477 was 1.9 d.

Principal Results

Sedimentology

The sediments at Site U1477 consist of two lithologic units:

Unit I is composed of very dark gray to dark greenish gray sandy clay with foraminifers and nannofossils.

Unit II is composed of very dark gray to dark greenish gray silty clay with intermittent to frequent occurrences of sand layers. These sand layers contain quartz and clay and thicknesses range between centimeter to meter scale.

Bioturbation is not apparent in either unit. Macrofossils, including bivalve and echinoderm fragments, are present throughout the cores. Many of the cores show disturbance related to gas expansion.

Physical Properties

Despite the relatively homogenous lithology, different physical parameters at Site U1477 show a complex pattern of high amplitude changes that are likely caused by climate related variations in terrigenous sediment supply or current sorting effects. However, some excursions to lower values in natural gamma radiation (NGR) and gamma ray attenuation (GRA) bulk density data may be due to the voids caused by gas expansion. Also, the collection of reliable *P*-wave data below 16.9 m CSF-A at all of the holes was inhibited by strong signal attenuation due to the frequent occurrence of gas expansion voids. The porosity profile at Site U1477 shows a decreasing trend downhole and average porosities are significantly lower when compared to the previous sites (U1474, U1475, and U1476).

Micropaleontology

Site U1477 spans the Holocene to the Late Pleistocene. Two biostratigraphic datums are observed: the abundance crossover from *Gephyrocapsa caribbeanica* to *Emiliana huxleyi* at ~90 ky and the top occurrence of *Globigerinoides ruber* (pink) at ~120 ky. Sedimentation rates, based on biostratigraphic datums as well as radiocarbon ages tied in from a nearby piston core, suggest deposition rates of ~1.5 m/ky from 0 to ~30 m CSF-A

in Hole U1477A that decrease to ~83 cm/ky from ~30 m CSF-A to the base of the hole. Calcareous microfossils are generally well preserved, although abundance is typically low. Planktonic foraminifer tests compose less than 1% of sediment particles in most samples, while less than 50 nannofossils per field of view are observed throughout most of the section. The planktonic assemblage, which includes the regular occurrence of pteropods, is joined by benthic foraminifers, ostracods, sponge and gorgonian spicules, molluscs, echinoderm plates, and fish otoliths. Siliceous microfossils make up a minor component of the mudline and core catcher samples. Marine and freshwater diatoms, phytoliths, and sponge spicules are present, providing indications of both terrestrial and marine sources.

Paleomagnetism

Paleomagnetic measurements from Site U1477 show a clear magnetic signal. For all holes, inclinations center around −50° during the Brunhes chron, which is expected for the site location. Rock-magnetic data acquired on discrete samples reveal phases of high ferrimagnetic mineral content that largely match magnetic susceptibility (MS) data collected on archive section halves and whole cores. Variations in magnetic minerals present reflect either a change in the composition of the terrigenous fraction or preferential mineral dissolution.

Stratigraphic Correlation

Real-time stratigraphic correlation was possible at Site U1477 using magnetic susceptibility (MS) data. Holes U1477A, U1477B, and U1477C were used for the splice from 0 to ~85 m CCSF-A. Below ~85 m CCSF-A, the splice consists primarily of sediment from Hole U1477B, with a couple of exceptions where intervals of Hole U1477A were used. A continuous stratigraphic splice was not possible at this site due to substantial gas expansion that led to core fracturing and variable core stretching between holes.

Geochemistry

Interstitial water chemistry and headspace gas concentrations show relatively intense early sediment diagenesis at Site U1477. The sulfate–methane transition appears at ~16 m CSF-A, below which sulfate is completely consumed and methane concentrations increase rapidly to a peak of ~75,500 ppmv at ~35 m CSF-A. Other redox sensitive elements, including iron, manganese, and barium, show enrichments due to

remobilization. Terrigenous sediment dominates the core. Carbonate contents average 5%, with a few intermittent layers of shell material with carbonate contents as high as ~20%. The average total organic carbon content is 0.61 wt%.

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