IODP Expedition 361: Southern African Climates
Site U1478 Summary

Background and Objectives

Site U1478 is located in the Delagoa Bight on the Inharrime Terrace (25°49.26′S; 34°46.16′E), around 75 nmi east of the Limpopo River at a water depth of 488 mbsl.

The Delagoa Bight is a distinct indentation of the continental margin (Lamont et al., 2010), into which the Limpopo River, the second largest east-draining river in Africa, is depositing sediment. Its hydrography is influenced by the southerly flowing waters from the Mozambique Channel and the East Madagascar Current (Lutjeharms, 2006a, b), the confluence of which forms the Agulhas Current. The Limpopo catchment is a little over 410,000 km^2—considerably smaller than that of the neighboring Zambezi. The Limpopo River has as mean annual discharge of ~170 m^3/s and delivers annual sediment loads of 33 Mt/yr (Milliman and Meade 1983) to the Delagoa Bight.

The Site U1478 primary objectives are to: (i) recover a complete and high-resolution sedimentary succession that spans the last 2 my; (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 transports 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? Did variable Agulhas Current warm water transports 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; Maslin et al 2012)?

Operations

Site U1478 consists of four holes that penetrated from 216.0 to 248.4 m DSF. The advanced piston coring (APC) system penetrated a total of 698.9 m and recovered

708.66 m of core (101%). The half-length APC (HLAPC) recovered a total of 213.4 m of sediment over a 206.8 m cored interval (103%). Five intervals were advanced 54.3 m without coring to adjust coring gaps to provide a continuous stratigraphic sequence. The total time spent at Site U1478 was 2.7 d.

Principal Results

Sedimentology

The sediments in Site U1478 consist of one lithologic unit:

Unit I (0 to 248.59 m CSF-A) is composed of dark olive gray and dark greenish gray sand with foraminifera and nannofossils that alternates with clayey or sandy silt with foraminifera and nannofossils. The sand is predominantly composed of quartz.

Bioturbation is rare; however, the coarser-grained sediment in Site U1478 may obscure sedimentary structures, such as bioturbation and diagenetic alterations. Macrofossils, including bivalves, gastropods, and echinoderms, are present throughout the cores.

Physical Properties

The physical properties measured at Site U1478 show a complex pattern of amplitude changes and trends. All high-resolution records derived by the physical properties core logging (magnetic susceptibility, natural gamma radiation, bulk density, RGB color, and spectral reflectance) show cyclic changes that are likely related to the variable lithological alternations between silt-rich and sand-rich intervals. These cyclic changes are pervasive throughout the sequence and probably reflect complex interactions between ocean circulation, sea level fluctuations, and fluvial discharges recorded at Site U1478. Two zones of very low magnetic susceptibility (MS) values at ~89 to 92 m CSF-A and ~164 to 168 m CSF-A depth may be related to sediment diagenesis as indicated by elevated iron and manganese concentrations in the interstitial waters. Porosity decreases down the section and average porosities are similar to those at Site U1477 but are significantly lower compared to our deeper water Sites U1474, U1475, and U1476.

Micropaleontology

Biostratigraphy of calcareous nannofossils and planktonic foraminifera indicates that Hole U1478A spans the Late Pleistocene to the middle Pliocene with a basal age of ~4 Ma. Calcareous microfossil assemblages include warm subtropical to tropical species in combination with coastal to slope water taxa. Planktonic foraminifers and calcareous

nannofossils are abundant throughout Site U1478. Foraminifers dominate sandy beds while calcareous nannofossils are typically more abundant in silty and clay-rich intervals. Glassy and translucent foraminifera are found throughout most of the recovered sequence although there is an increase in fragmentation in the oldest parts of the sequence. Calcareous nannofossils are mostly well preserved but the *Discoaster* group commonly exhibits fragmentation of the delicate arms. Diatoms are present only in the surface sediments and sponge spicules and phytoliths are scarce in the lower parts of the sequence. Low levels of reworking are evident in planktonic foraminifer records. The biochronology for both calcareous microfossil groups reveals sedimentation rates of ~9 cm/ky between the Late Pleistocene and ~2.1 Ma and lower rates of 2.9–5.3 cm/ky older than 2.1 Ma. Planktonic foraminifers and calcareous nannofossils give diverging age-depth relationships between 1.9 and 3 Ma, possibly linked to sedimentological processes. The two fossil groups are in agreement in the lowest ~25 m of Site U1478 and predict a basal age of 4–4.1 Ma.

Paleomagnetism

Rock magnetic and paleomagnetic analyses were carried out on discrete samples from Hole U1478A and archive half sections from Holes U1478A through U1478D. Saturation and hard isothermal remanent magnetization (SIRM and HIRM) measured on discrete samples largely follow the downcore patterns in MS. The S-Ratio is mostly stable; however, distinct minima at ~90, 165, and 245 m CSF-A indicate a strong depletion of low-coercivity minerals. These intervals coincide with minima in the MS and SIRM records. The minimum in MS at ~90 m CSF-A lies below the sulphate-methane transition and the minimum at ~165 m CSF-A is located just below an interval of elevated dissolved Fe and Mn concentrations, suggesting that in these zones early diagenetic processes affected the magnetic mineral record.

The inclination data appear to be of good quality, and the Brunhes/Matuyama boundary and the Jaramillo subchron were identified. According to biostratigrahy, the sedimentary sequence dates back to ~4 Ma; however, the Matuyama/Gauss transition was not identified in the paleomagnetic data.

Stratigraphic Correlation

Four holes were drilled at Site U1478 using the APC and HLAPC. Generally good core quality and clear MS signals resulted in robust and unambiguous stratigraphic ties

between holes. We have high confidence that these holes constitute a nearly complete section spanning the full length of the longest hole (244 m CSF-A recovered in Hole U1478A), with the exception of one probable gap at ~195 m CSF-A. The objective of obtaining a complete section was aided by the fact that the MS from whole-round physical properties tracks could be used for real-time correlation in Holes U1478B, U1478C, and U1478D; adjustments to the drilling depth were made in these holes for the purpose of avoiding potential core gap alignment. A continuous splice has been constructed for the uppermost ~200 m composite depth, and a floating splice of another ~50 m of section is appended below the coring gap. In general, the clarity of the stratigraphic ties and the multiple cross-checks available from several different data sets gives us high confidence in the integrity of these two separate spliced sequences.

Geochemistry

Interstitial water chemistry and headspace gas concentrations show relatively intense early sediment diagenesis at Site U1478. The sulfate-methane transition zone occurs at ~70 m CSF-A, below which sulfate is completely consumed and methane concentrations increase rapidly. Several methane peaks occur below the sulfate-methane transition, with the largest at ~65,000 ppmv at ~214 m CSF-A. Other redox sensitive elements, including iron and manganese also show multiple peaks at depth. These pulses of iron and manganese and associated lows in MS, are interpreted as paleo-redox horizons related to repeated fluctuations in sedimentation. Detrital material is the most important sedimentary component. Carbonate contents average 28 wt% and total organic carbon content average 0.5 wt%; neither show any trend with depth.

References

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