IODP Expedition 361: Southern African Climates
Site U1479 Summary

Background and Objectives

Site U1479 is located on a 30 km wide morphological high, rising ~200 m above the regional seafloor, on the mid-to-lower western slope of the Agulhas Bank in the Cape Basin (35°03.53′S; 17°24.06′E), ~85 nmi southwest of Cape Town, South Africa, at a water depth of 2615 mbsl.

This region has been the focus of numerous oceanographic and a growing number of paleoceanographic studies (e.g., Beal et al., 2011, and references therein), to describe the present hydrography within the so-called "Agulhas ring corridor" (or "Cape Cauldron"; Gordon, 2003) and also to gain a better understanding of past oceanographic variation in the area and how they may be related with global climate changes. Several studies have highlighted the Agulhas Current's sensitivity to climate changes and reorganizations of atmospheric and the ocean circulation at large.

As the Agulhas Current separates from the Agulhas Bank at the southern tip of Africa, it retroflects, shedding rings, eddies, and filaments to the South Atlantic. This leads to a leakage of between 2 and 20 Sv of Indian Ocean waters into the Atlantic, and affects the water column to depths of more than 2,000 m (Gordon et al., 1987; de Ruijter et al., 1999; Richardson, 2007).

The Agulhas ring corridor is an area in which retrieval of high-quality sediment cores suitable for paleoceanographic studies is difficult. The southeast African margin has a very narrow shelf and a steep continental slope, leading to frequent sediment instability and slumping. Furthermore, the vigorous Agulhas Current and its variability can cause sediment redistribution because meanders and eddies frequently reach the seafloor. However, a number of published studies and emerging work demonstrate that paleoceanographic records of excellent quality are in fact achievable for reconstructing both surface and deepwater variability in the region (e.g., Rau et al., 2002, 2006; Peeters et al., 2004; Martínez-Méndez et al., 2010; Dickson et al., 2010; Caley et al., 2011, 2012, 2014; Marino et al., 2013; Dyez et al., 2014; Petrick et al., 2015).

The primary objectives at Site U1479 are to (i) recover a complete Pliocene–Pleistocene sedimentary succession (including the early Pliocene warm period, mid-Pliocene expansion of northern hemisphere ice sheets, and the mid-Pleistocene transition) from a high-accumulation site located within the Agulhas Ring Corridor; (ii) reconstruct Agulhas Current warm-water transports during orbitally modulated and suborbitally accelerated climatic changes; (iii) assess the linking between Antarctic climate variations, circumpolar ocean front instability, and connections with the Agulhas leakage into the South Atlantic; (iv) assess the vigor and hydrography of North Atlantic Deep Water (NADW), or its precursors, exported to Circumpolar Deep Water and the southwest Indian Ocean; and (v) evaluate the possibility of advective salinity feedbacks between Agulhas Leakage and Atlantic Meridional Overturning Circulation variability, notably the possible role of the leakage in modulating surface-to-deep ocean coupling in the North Atlantic during the transition between climatic states.

Operations

Site U1479 consisted of nine holes, ranging in depth from 1.0 to 300.7 m DSF. Overall, 105 cores were recorded for the site. A total of 963.21 m of core over a 975.3 m interval was recovered using the advanced piston coring (APC) system (99% recovery). Seven intervals advanced without coring penetrated a total of 175.7 m. The total time spent at Site U1479 was 6.0 d.

Principal Results

Sedimentology

The sediments in Site U1479 consist of one lithologic unit:

Unit I is composed of light greenish gray, greenish gray, and light olive gray nannofossil ooze with or without foraminifers.

Moderate to strong bioturbation is widespread throughout the sequence. Discrete ichnofossil burrows are commonly observed, that are often surrounded by thin darker bands. The occurrence of intervals rich in sand-size quartz and foraminifers suggests the contourite and/or turbidite deposition.

Physical Properties

At Site U1479 the lithology is quite homogenous and has been classified as one lithological unit. All high-resolution physical property records derived by core logging

show cyclic changes that are likely related to varying amounts of terrigenous content within this nannofossil ooze and thus may reflect changes in ocean circulation and/or terrigenous supply. A slump in the lowermost part of Site U1479 is characterized by physical properties that are distinctly different from the rest of the cored section.

Micropaleontology

Biostratigraphy of calcareous nannofossils, planktonic foraminifers, and diatoms indicates that Hole U1479B spans the Late Pleistocene to the late Miocene with a bottom age of ~7 Ma. Calcareous microfossils include primarily subtropical convergence and coastal to slope water taxa with minor abundances of warm subtropical and subpolar taxa. Diatoms are mostly composed of subtropical taxa with a minor presence of Southern Ocean taxa in the Pleistocene and subtropical taxa in the early Pliocene and latest Miocene. Planktonic foraminifers and calcareous nannofossils are abundant throughout Site U1479 while diatoms make episodic appearances, particularly in the upper and lower parts of the record. Preservation is good to moderate for the calcareous taxa and moderate to poor for diatoms. The biochronology for both calcareous microfossil groups and diatoms provides an average sedimentation rate of ~4.9 cm/ky.

Paleomagnetism

Paleomagnetic analyses were carried out on archive halves from Site U1479 and on discrete samples from Hole U1479B. The inclination and declination data from the archive halves are relatively noisy, which might be partially explained by the alteration of magnetic minerals as is suggested by downhole records of various rock magnetic parameters including the Sr-ratio, HIRM, and SIRM. Additionally, the magnetic susceptibility is very low for most of the record. The inclination and declination show an interval of normal polarity in the uppermost ~55 m CSF-A, the Brunhes paleomagnetic chron, although the lower boundary is deeper than would be anticipated from the biostratigraphy. A distinct interval of reversed polarity situated between ~55 m and ~125 m CSF-A depth is probably the Matuyama polarity chron, which spans from ~2.6 to 3.6 Ma. Unlike the Brunhes/Matuyama boundary, the inferred Matuyama/Gauss boundary is in agreement with the biostratigraphic ages. Additional paleomagnetic analyses on rock magnetic properties and directional data are necessary to constrain and eventually refine the Site U1479 magnetostratigraphy.

Stratigraphic Correlation

Stratigraphic correlation of Holes U1479B through U1479I was complicated by the very low magnetic susceptibility and adverse weather conditions. The poor weather resulted in several partial core recoveries in all the holes, as well as soupy top sections of individual cores that rendered them generally unusable for stratigraphy. Notwithstanding, the records of natural gamma radiation (NGR) and color (e.g. RGB green) displayed clear variability in all the undisturbed core sections, making the alignment of cores relatively straightforward once all scanning was complete. Furthermore, comparatively constant offsets between cores in Holes U1479B and U1479C led to the development of a robust and nearly complete spliced section from just below the mudline to the bottom of Hole U1479B at ~300 m CSF-A. The generally clear stratigraphic relationship between Holes U1479B and U1479C only needed refinement and addition of intervals from other holes in scattered, discrete intervals.

Geochemistry

Interstitial water chemistry and headspace gas concentrations indicate moderate early sediment diagenesis. Major element concentrations show some evidence of uptake into clay minerals and precipitation of authigenic carbonates. There is no clear sulfate-methane transition zone in Hole U1479B; sulfate concentrations go to zero at ~185 m CSF-A, but methane concentrations never go above ~50 ppmv. Other redox-sensitive elements, such as iron and barium, show more dramatic enrichments, with iron reaching ~15 µM at ~60 m CSF-A and barium reaching ~600 µM at ~150 m CSF-A. Calcium carbonate ranges from ~51 to 91 wt% (average of 67 wt%) and shows no distinct downhole trend. Organic carbon ranges between 0.15 and 1.93 wt% with an average of 0.62 wt%.

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