IODP Expedition 361: Southern African Climates
Site U1475 Summary

Background and Objectives

Site U1475 is located on the southwestern flank of Agulhas Plateau (41°25.61′S, 25°15.64′E), ~450 nmi south of Port Elizabeth, South Africa, in a water depth of 2669 mbsl. The Agulhas Plateau, which was formed during the early stages of the opening of the South Atlantic about 90 Ma (Parsiegla et al., 2008), is a major bathymetric high that is variably coated with sediments (Uenzelmann Neben, 2001). The 230,000 km^2 plateau, which ascends up to ~2500 m above the adjacent seafloor, is bounded on the north by the 4700 m deep Agulhas Passage and is flanked by the Agulhas Basin in the west and the Transkei Basin in the northeast. The northern part of the plateau is characterized by rugged topography, while the central and southern part of the plateau exhibits a relatively smooth topography (Allen and Tucholke, 1981) and has greater sediment thickness (Uenzelmann Neben, 2001).

A strong water mass transport flows across the Agulhas Plateau region (Macdonald, 1993), which involves the water column from the surface down to Upper Circumpolar Deep Water. The hydrography of the upper ocean is dominated by the Agulhas Return Current, which comprises the component of the Agulhas Current that is not leaked to the South Atlantic Ocean but rather flows eastwards from the retroflection (Lutjeharms and Ansorge, 2001). Antarctic Intermediate Water, below the Agulhas Return Current, also follows the same flow path near South Africa as the Agulhas Current showing a similar retroflection (Lutjeharms, 1996). During its return to the southwest Indian Ocean the Agulhas Return Current crosses the Agulhas Plateau, which deflects the deep-reaching current towards the Equator (Harris, 1970).

Site survey data collected during a seismic cruise with R/V *Petr Kottsov* in 1998 (Uenzelmann-Neben, 1998) and R/V *Marion Dufresne* in 2002 show that Site U1475 is located on a sediment drift (Uenzelmann-Neben, 2001; 2002) that is deposited on the southwestern flank of Agulhas Plateau by North Atlantic Deep Water (NADW) exiting the South Atlantic to the Indian Ocean. The wedge-shaped sediment drift thickens to the west, reaching a water depth of ~2510 m at its crest. The wavy character of the seafloor topography and the subsurface seismic reflection pattern are interpreted as sediment

waves that document sedimentation by active deep-water flow. Site U1475 is located at a water depth of 2669 m, near the drift crest where minor buried depressions create a locally expanded sequence.

Millennial-scale multi-proxy records covering the past 350 k.y. previously collected at this location highlight the synchrony of the regional ocean climatology and Antarctic climate variability. Evidence for regional ocean paleoclimatology includes latitudinal migrations of the regional Southern Ocean fronts and deposition of ice rafted debris that document expansion of Subantarctic conditions to the plateau. These data serve as evidence for possible meridional shifts in the Subantarctic frontal zone that borders the Agulhas leakage corridor and influence Agulhas leakage.

Paleoceanographic studies spanning the past 350 k.y. combined with seismic refelction data support the suitability of Site U1475 to achieve our primary objectives, which are to: (i) recover a complete Pliocene–Pleistocene sedimentary succession from a high-accumulation sediment drift located within the southern Agulhas Return Current sector of the Indian–Atlantic ocean gateway, (ii) assess the linking between Antarctic climate variations, circumpolar ocean front instability, and connections with the Agulhas leakage into the South Atlantic, (iii) assess the vigor and hydrography of NADW (or its precursors) exported to Circumpolar Deep Water and the southwest Indian Ocean at a location proximal to the entrance of NADW to the Southern Ocean and South Indian Ocean, and (iv) 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 U1475 consists of six holes that penetrated from 1.5 to 277.0 m DSF. The advanced piston coring (APC) system penetrated a total of 987.9 m and recovered 1015.92 m of core (103% core recovery). Six intervals were advanced without coring to provide a continuous stratigraphic sequence which penetrated a total of 86.0 m. The total time spent at Site U1475 was 5.7 d.

Principal Results

Sedimentology

The sediment recovered at Site U1475 consists of two lithologic units.

Unit I (0–4.75 m CSF-A) is composed of pale brown, light greenish or olive gray, and white gray nannofossil-rich foraminifera ooze.

Unit II (4.75–277.22 m CSF-A) is composed light greenish or pale gray to white gray nannofossil ooze. Alternations between foraminifera-bearing or foraminifera-rich nannofossil ooze and nannofossil ooze with fine sand (foraminifera, quartz, and occasionally diatoms) are observed.

Sediments in both units include dark gray molting that we interpret as bioturbation (ichnofossil burrows: *Planolites*). Thin darker bands commonly surround burrows, and macroscopic pyritized burrows are also common. Dropstones (displaying coarse sand to granule grain sizes) were observed in three different cores, which we interpret to represent ice rafted debris. Sediments in both units also include green layers that predominantly consist of pyrite and glauconite representing diagenetic alteration.

Physical Properties

Despite the homogenous lithology, different physical parameters show downhole trends as well as cyclic variations. There is a marked change in physical sediment properties at ~110 m CSF-A. Above this depth a change from quasiregular short and lower amplitude variations to longer, higher amplitude, and more irregular cyclic variation is observed. This change is most clearly displayed in the natural gamma ray (NGR) and color reflectance (a*) data. In addition, *P*-wave velocity decreases and bulk density increases at this depth indicating a change in the compaction trend. Prominent changes in *P*-wave velocity at Site U1475 can be clearly linked to seismic reflectors present in the site survey profiles.

Micropaleontology

Analysis of calcareous nannofossils, planktonic foraminifers, and diatoms from core catchers and working-half core samples of Holes U1475B, U1475C, and U1475E reveals that the ~277 m section recovered at Site U1475 spans the latest Miocene (~6.91 Ma) to Recent. Calcareous nannofossils show moderate to good preservation in all the sequences with the consistent presence of well-preserved Eocene to middle Miocene (reworked)

species. The nannofossil chronostratigraphy of Site U1475 spans from Biozones NN21 and CN15 to Biozone NN11 and the CN9d/CN9c boundary. The calcareous nannofossil assemblages are characterized by species typical of tropical to subtropical and temperate environments. Planktonic foraminifer biota in Site U1475 are moderately- to well-preserved and are mostly composed of subtropical convergence species mixed with polar species. The Pleistocene foraminifer assemblage is dominated by *Globorotalia inflata*, which typically constitutes 30%–50% of each sample. Diatoms show poor to moderate preservation and have a mixed assemblage of subtropical and Southern Ocean taxa. Diatom markers from both environmental settings are used to define datums; however, the Southern Ocean assemblage abundance is greatly reduced below 101.62 m CSF-A. Overall the diatom chronostratigraphy spans from NTD 17 to NTD 12.

The sedimentation rates for Site U1475, based on biostratigraphy and paleomagnetic reversals, during the Pleistocene and latest Pliocene are nearly linear at 2.8 cm/k.y. between 0 and 3.9 Ma. A notable increase in sedimentation rates to 9.6 cm/k.y. occurs between 3.9 Ma and 5.3 Ma. Finally, below 5.3 Ma, sedimentation rates decrease to 2.5 cm/k.y.

Paleomagnetism

All archive halves of Holes U1475B, U1475C, and U1475F, and Cores U1475E-1H to 15H were analyzed for their natural remanant magnetization (NRM) and demagnetized at 15 and 25 mT. In total, 98 discrete cube samples were taken from Holes U1475A, U1475B, and U1475D, and subjected to NRM demagnetization. Cores from Site U1475 were not oriented because of the relatively high-latitude of the site means inclination data provide a reliable record of magnetic reversals. For most of the recovered interval, the magnetic susceptibility (MS) indicates that the sediments are diamagnetic in character and below the detection limit of the whole-round and point MS instruments. Nonetheless, taken together the inclination records of all individual holes provide a consistent and detailed magnetostratigraphy for Site U1475. The boundaries of the Brunhes, Matuyama, Jaramillo, Olduvai, Gauss, Keana, and Mammoth paleomagnetic chrons and subchrons constrain the chronology of the sediments, and are in general agreement with the biostratigraphic data.

Stratigraphic Correlation

Select sequences from Holes U1475B, U1475C, U1475E, and U1475F were spliced together to create the most complete and representative section possible using RGB blue, b* color reflectance, and natural gamma radiation (NGR) data. Sedimentological logs were consulted meticulously in the process of constructing the splice to avoid inclusion of any obviously disturbed sections or sections with completely unique features (relative to the other adjacent holes). The splice constitutes a continuous sequence with a total length of ~292 m CCSF. However, confidence in the splice is low surrounding occasional problematic intervals, and further work on shore will be required to improve confidence.

Geochemistry

Interstitial water chemistry shows a moderate degree of early sediment diagenesis at Site U1475. The nitrate profile indicates suboxic conditions in the upper 0.25 m CSF-A. Sulfate concentration decreases throughout the sediment column and is never completely consumed. Methane concentrations remain at background levels. Carbonate is the dominant sedimentary component, ranging from 75–85 wt% with terrigenous material dominating the remaining fraction. Organic carbon contents range from 0.3 to 0.6 wt%, decreasing slightly downhole. Together, carbonate, organic carbon, and elemental biogenic indicator profiles suggest that export production increased into the Late Pleistocene.

References

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