IODP Expedition 361: Southern African Climates
Site U1476 Summary

Background and Objectives

Site U1476 is located on Davie Ridge at the northern entrance of the Mozambique Channel (15°49.25′S; 41°46.12′E) at a water depth of 2165 mbsl. It is 3 nmi northwest of DSDP Site 242.

The Mozambique Channel is considered to be one of the most turbulent areas in the world ocean (Ternon et al., 2014). It is bordered by Madagascar to the east and Mozambique to the west. At its southern end flow through the channel feeds into the greater Agulhas Current system. The Mozambique Channel is characterized by complex and variable surface and subsurface circulation. Several water masses converge within the Mozambique Channel and the circulation is dominated by activity related to the inflow of both Indonesian Throughflow and Tasman Strait Throughflow as well as the strength of the tropical and subtropical surface gyres in the Indian Ocean (Penven et al., 2006; Palastanga et al., 2006; Ridderinkhof et al., 2010; Schott et al., 2009; Backeberg and Reason, 2010). Satellite observations (e.g., Schouten et al., 2003; Quartly and Srokosz, 2004) and ocean models (Biastoch and Krauss, 1999) have shown that mesoscale anticyclonic eddies generally form as the channel narrows close to the Davie Ridge (at about 16°S), between the northern and central basin of the Mozambique Channel. These eddies typically maintain a high rotational velocity, often >1.5 m/s (Schouten et al., 2003; Ullgren et al., 2012), as they migrate southwards through the channel at a mean rate of about 4–7 eddies per year. Accordingly, processes in the Mozambique Channel have downstream implications for the Agulhas Current including leakage into the South Atlantic Ocean (e.g., Bryden et al., 2005; Biastoch et al., 2008, 2009). The Mozambique Channel eddies may also be linked with interannual modes of Indian and Pacific Ocean variability, implying a connection with the Indian Ocean Dipole and Pacific La Niña/El Niño phases (Schouten et al., 2002; Palastanga et al., 2006).

Limited paleoceangraphic evidence currently exists regarding the longer-term linkage between variability in the northern source waters of the Agulhas Current and its eventual leakage into the South Atlantic Ocean. The primary objectives at Site U1476 are to: (1) recover a complete Pliocene–Pleistocene sedimentary succession including the early

Pliocene warm period, the mid-Pliocene expansion of Northern Hemisphere ice sheets, and the mid-Pleistocene transition; (2) reconstruct Mozambique Current warm-water transports during periods of orbitally modulated and suborbitally accelerated climate changes; and (3) assess the influence of remote upstream forcing on southeast African warm water transport. Specific questions that will be addressed include: Did the restriction of the Indonesian Seaway and the associated reduction of the Indonesian Throughflow in the Pliocene affect the Agulhas Current source region in the western tropical Indian Ocean and subsequently impact warm and saltwater transports along the southeast African margin? Did the Agulhas Current, by way of far-field controls on tropical-subtropical wind forcing, respond to the long-term development of tropical climates and the associated weakening of the monsoons in the course of the global cooling of the Pliocene?

Operations

Site U1476 consists of five holes that penetrated from 5.7 to 234.8 m DSF. The advanced piston coring (APC) system penetrated a total of 841.1 m and recovered 873.85 m of core (104%). 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 U1476 was 4.1 d.

Principal Results

Sedimentology

Two lithologic units were described at Site U1476:

Unit I (0–34.57 m CSF-A) is composed of light brown to greenish gray foraminifera ooze with nannofossils alternating with foraminifera-rich nannofossil ooze.

Unit II (34.57–235.41 m CSF-A) is composed of greenish gray foraminifera-rich nannofossil ooze and nannofossil ooze with foraminifera, silt, and clay.

Sediment in both units includes dark gray mottling that we interpret as bioturbation. Thin darker bands commonly surround burrows and macroscopic pyritized burrows are common. Sediments also include green layers that predominantly consist of pyrite and glauconite, which are diagenetic alterations. Only minor coring disturbance is observed in the cores.

Physical Properties

Despite the relatively homogenous lithology, different physical parameters show significant trends downhole as well as cyclic variations along the sediment column. High amplitude cyclic changes occur in the uppermost 16 m CSF-A of all holes. These cyclic changes continue downward to the bottom of the holes with lower amplitude and higher frequency. Variations in the color reflectance indicate sediment compositional changes and the RGB data broadly correspond with the color reflectance L*. The bulk density increases downsection due to compaction but there are large variations in the top 16 m CSF-A, which are also seen in the other physical properties.

Micropaleontology

Calcareous nannofossil and planktonic foraminifera biostratigraphy indicates that Hole U1476A spans the Late Pleistocene to the late Miocene. Diatoms are not included in the biostratigraphy as the record is barren of diatoms throughout, except for tropical diatoms present in minor amounts in the mudline sample. Calcareous microfossils show very good preservation in Pliocene to Pleistocene age sediments; however, the late Miocene is characterized by an increase of fragmented planktonic foraminifera. Assemblages in both microfossil groups include tropical to subtropical forms with the periodic appearance of species typical of temperate environments. Sedimentation rates, based on calcareous nannofossil and planktonic foraminifera datums, increase from 2.3 to 3.5 cm/k.y. downhole. No hiatuses are observed; however, diachronous events are observed within the planktonic foraminifer biochronology. These events might suggest that microfossil datums from the tropical western Indian Ocean need a refined calibration.

Paleomagnetism

Paleomagnetic and rock magnetic analyses were carried out on sediment cores from Holes U1476A, U1476B, U1476D, and U1476E. Altogether, the rock magnetic data imply that the concentration of high-coercivity minerals (e.g. hematite and titano-magnetite) is relatively stable, while magnetite concentrations decrease below ~150 m CSF-A. Demagnetization of natural remanent magnetization (NRM) carried out on discrete samples and archive halves shows that the directional record carries a strong coring overprint. The uppermost two sections of each core reveal steep downward inclinations after demagnetization at maximum levels of 25 mT, suggesting that the applied field was too weak to remove the overprint. More detailed demagnetization

experiments on discrete samples show changes in inclination after demagnetization of 40 mT, suggesting that sediments have an early diagenetic overprint, which might be removed by demagnetization at higher fields. Because the IceField orientation tool malfunctioned, the declination data could not be corrected for core orientation and can therefore not be used for assigning polarity zones. A more detailed investigation of demagnetization behavior will be needed to establish a more confident paleomagnetic stratigraphy for Site U1476.

Stratigraphic Correlation

Ideal coring conditions and good signal in the magnetic susceptibility (MS) measurements allowed for near real-time correlation at Site U1476. Coring offsets were applied on Holes U1476A and U1476D such that no gaps were present down to the full depth of the holes (229.0 m CSF-A). Hole U1476E provided similar offsets to Hole U1476A so that a splice could be constructed primarily between Holes U1476D and U1476E. The splice was constructed using MS data and confirmed using natural gamma ray (NGR) and RGB (blue) data.

Geochemistry

Interstitial water chemistry shows mild early sediment diagenesis at Site U1476. Nitrate and sulfate, two species that disappear with progressively more intense microbial respiration, persist deeper into the sediment column and at higher concentrations than was documented at Sites U1474 or U1475. Methane concentrations remain at or near background levels. Decreasing concentrations of major elements, such as potassium and sodium, reflect uptake by clay minerals. Carbonate is variable (45–75 wt%) with terrigenous sediment making up the remainder of the sediment. The sediment is organic-carbon poor, with average concentrations of 0.24 wt% total organic carbon.

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