IODP Expedition 361 – Southern African Climates and Agulhas LGM Density Profile

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IODP Expedition 361 drilled six sites (U1474 – U1479) on the southeast African margin and the Indian-Atlantic ocean gateway from 30 January to 31 March 2016. The sites, situated in the Mozambique Channel, Natal Valley, Agulhas Plateau, and Cape Basin, were targeted to reconstruct the history of the Greater Agulhas Current System over the past ~5 Ma (Fig. 1). More specifically, the main objectives of Expedition 361 were: (i) to establish the sensitivity of the Agulhas Current to climate change during the Plio-Pleistocene in association with transient to long-term changes of high-latitude climates, tropical heat budgets, and the monsoon system; (ii) to determine the dynamics of the Indian-Atlantic gateway circulation in association with changing wind fields and migrating ocean fronts; (iii) to examine the connection of the Agulhas leakage and the Atlantic Meridional Overturning Circulation; (iv) to address the influence of the Agulhas Current on African terrestrial climates, notably rainfall patterns and river runoff, and potential links to hominid evolution. Additionally, the expedition set out to fulfill the needs of the Ancillary Project Letter, consisting of high-resolution interstitial water samples aiming at constraining the temperature and salinity profiles of the ocean during the Last Glacial Maximum.

In total, 5175 m of core was recovered (average recovery 102 %) from a region poorly represented in the database of drill sites for scientific purposes. Physical property records derived from core-logging of the recovered sequences allowed complete spliced stratigraphic sections to be generated that span the interval of 0 to between ~0.13 and 7 Ma (Fig. 2). A high-resolution program of interstitial water samples was carried out at Sites U1474, U1475, U1476, and U1478. The expedition made major strides toward fulfilling the scientific objectives despite of ~11 days of lost operational time due to weather conditions, a medical evacuation, and delays in attaining the necessary permissions to operate in Mozambique exclusive economic zone waters.

Site U1474 (3034 meters below sea level [mbsl]; Fig. 1), located in the northernmost Natal Valley, consists of eight holes ranging in penetration depth from 3.1 to 254.1 m drilling depth below seafloor (dsf). A total of 910.8 m of sediment was recovered, predominantly consisting of foraminifer-bearing clay with nannofossils. Based on the shipboard bio- and magnetistratigraphic datums, the sedimentary sequence extends back to the late Miocene (~6.2 Ma; Fig. 2). This record represents the only site situated beneath the main flow of the fully constituted Agulhas Current and therefore provides the opportunity for high-resolution climate reconstructions of Agulhas Current warm-water transports and upstream variability that may allow the identification of connections between Agulhas leakage and its headwater variability. It also holds significant potential to investigate the connections between southern African terrestrial climates and southeast Indian Ocean heat budgets and the links to the cultural evolution of early modern humans.

Site U1475 (2669 mbsl; Fig. 1), located on the southwestern flank of the Agulhas Plateau, consists of six holes ranging in penetration depth from 1.5 to 277.0 m dsf. A total of 1015.9 m of sediment was recovered, predominantly consisting of nannofossil ooze. Shipboard bio- and magnetistratigraphic data suggest that the sedimentary sequence extends back to the late Miocene (~7 Ma; Fig. 2). This record provides the opportunity for high-resolution climate reconstructions of the Agulhas Return Current and connections with the Sub-Tropical Front, productivity, and deep-water circulation.

Site U1476 (2165 mbsl; Fig. 1), located at the northern entrance of the Mozambique Channel, consists of five holes ranging in penetration depth from 5.7 to 234.8 m dsf. A total of 873.8 m of sediment was recovered, predominantly consisting of foraminifer-rich nannofossil ooze. The sedimentary sequence extends back to the late Miocene (~6.9 Ma; Fig. 2)), as inferred from the shiboard bio- and magnetostratigraphic data. The site boasts excellent biostratigraphy and notably cyclic physical properties. It therefore provides the opportunity for high-resolution reconstructions of tropical faunal assemblages, which will allow identification of connections between Agulhas leakage and its headwater variability. It also holds significant potential to investigate the connections between southern African terrestrial climates and southeast Indian Ocean heat budgets and thermocline and deep-water variability with likely links to the development of the Indonesian Throughflow as well as aridification of east Africa. Because of the excellent preservation of foraminifers, this an ideal site for a long record of surface-ocean pH from boron isotopes.

Site U1477 (429 mbsl; Fig. 1), located in the western Mozambique Channel east of the Zambezi River delta, consists of three holes ranging in penetration depth from 119.4 to 181.2 m dsf. A total of 490.0 m of sediment was recovered, predominantly consisting of sandy clay with foraminifers and nannofossils. Based on correlations to a nearby ^{14}C dated cores and two biostratigrahic markers, the sedimentary sequence extends back to the Late Pleistocene (~0.13 Ma; Fig. 2). The extreme accumulation rate (~1 m/ky) at this site provides the opportunity for exceptionally high resolution reconstructions of terrestrial climate and thermocline characteristics during the last glacial cycle.

Site U1478 (488 mbsl; Fig. 1), located in the western Mozambique Channel east of the Limpopo River delta, consists of four holes ranging in penetration depth from 216.0 to 248.4 m dsf. A total of 922.1 m of sediment was recovered, predominantly consisting of sand or clayey/sandy silt with foraminifers and nannofossils. The shipboard age-model suggests that the sedimentary sequence extends back to the Pliocene (~4 Ma; Fig. 2). This record provides the opportunity for high-resolution climate reconstructions of faunal, biogeochemical, and terrigenous tracers that are characteristic of the upper

reaches of the Agulhas Current warm-water transports that will allow connections between Agulhas leakage and its headwater variability. The site also holds significant potential to investigate the connections between southern African terrestrial climates and southeast Indian Ocean heat budgets, and examine the relationship between such climate variability and early human evolution.

Site U1479 (2615 mbsl; Fig. 1), located in Cape Basin, consists of nine holes ranging in penetration depth from 1.0 to 300.7 m dsf. A total of 963.1 m of sediment was recovered, predominantly consisting of nannofossil ooze with or without foraminifers. According to the shipboard bio- and magnetostratigraphy-based age model, the sedimentary sequence extends back to the late Miocene (~7 Ma; Fig. 2). This record represents the only site situated in the immediate Agulhas leakage pathway. It will therefore provide the opportunity for high-resolution climate reconstructions of the leakage and temporal comparisons with deep-water circulation.

Reference:

Hall, I.R., Hemming, S.R., LeVay, L.J., and the Expedition 361 Scientists, 2016. *Expedition 361 Preliminary Report: South African Climates (Agulhas LGM Density Profile).* International Ocean Discovery Program. http://dx.doi.org/10.14379/iodp.pr.361.2016

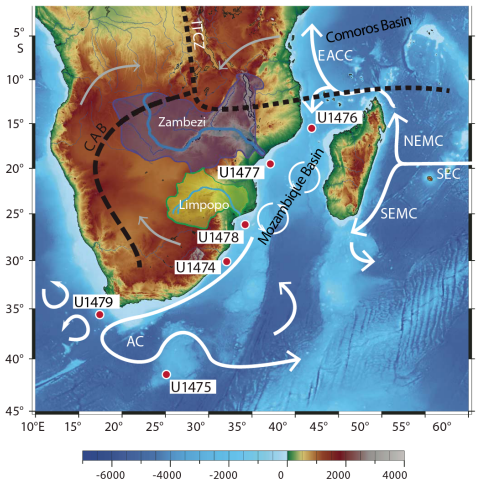

Figure 1: Expedition 361 site locations. Yellow and orange arrows: main surface ocean currents; gray arrows: main pathways of moisture supply to the African continent from the northwest Atlantic (via Congo) and the northwest and southwest Indian Ocean; dashed lines: approximate position of the Intertropical Convergence Zone (ITCZ) and Congo Air Boundary (CAB); purple shaded area: Zambezi Catchment; green shaded area: Limpopo Catchment. AC: Agulhas Current; SEC: South Equatorial Current; SEMC: South East Madagascar Current; NEMC: North East Madagascar Current; EACC: East Africa Coastal Current (modified from Hall et al., 2016).

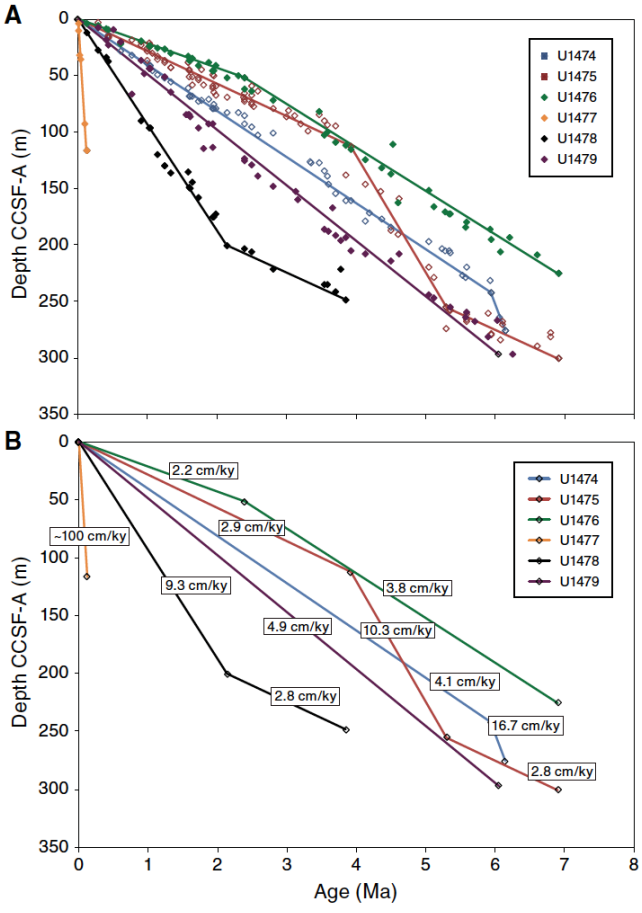

Figure 2: Age-depth relationships, IODP Sites U1474–U1479. A. Time estimates based on a mixture of major planktonic foraminifer, calcareous nannoplankton, diatom, and paleomagnetic datums. B. Implied sedimentation rates (adapted from Hall et al., 2016).