Abstract

Closure of the East Tethyan and Indonesian Gateways and development of the Indian monsoon or South Asian monsoon (SAM) wind system had profound control over Indian Ocean circulation. However, the dynamics of the Indian Ocean surface hydrography since the late Oligocene have hitherto been poorly documented. This study documents planktic foraminiferal abundances and stable oxygen and carbon isotope data from ODP Hole 758A and DSDP Site 241 in the eastern equatorial Indian Ocean (EEIO) and western equatorial Indian Ocean (WEIO), respectively. Planktic foraminiferal abundance from ODP Hole 758A reveal a conspicuous thick mixed layer during ~ 25.6-14.7 Ma, except for a short-lived thinning during 20.7-19.4 Ma. It is speculated that the existence of a thick mixed layer and perhaps higher sea surface temperatures in the EEIO increased convection and moisture transport to the southern hemisphere via the upper troposphere, which contributed to the expansion of Antarctic ice volume. The East Tethyan Gateway closure and constriction of the Indonesian Gateways cooled the surface and deep waters at ~14.7 Ma when the mixed layer thickness began to decrease and thermocline began to shoal. Seasonal fluctuations between mixed layer and thermocline were secular during 25.6-12.9 Ma which became more intense and frequent in the younger interval. A shift in surface hydrography at 12.9 Ma was driven by the onset of the SAM wind system, leading to the development of the modern summer monsoon surface circulation in the Indian Ocean. In the younger periods, thermocline shoaling was observed at 9.9 Ma, 5.5 Ma and 1.2 Ma, corresponding to intensification of the SAM. Surface and subsurface dynamics of the WEIO significantly impacted the East African climate, and played an important role in hominin evolution and dispersal. Planktic foraminiferal abundance and stable isotope data from Site 241 helped to ascertain cool subsurface and thermocline shoaling in the WEIO, along with a strong zonal subsurface $\delta^{18}O$ gradient in the equatorial Indian Ocean between 2.3 and 0.4 Ma. This east-west contrast triggered an intensification of equatorial westerlies, which enhanced the subsidence of air convection over WEIO and hampered the moisture transport to East Africa, and thus the expansion of C_4 grassland during the Pleistocene. The intensification of the East African monsoon was governed by positive wind-evaporation feedback during ~ 1.9–1.7 Ma, 1.2–0.9 Ma, and 0.14–0.09 Ma, where increasing wind intensity of Findlater Jet enhanced the evaporation over WEIO. The wind-evaporation feedback drove short-lived wet-dry phases that influenced hominin speciation, adaptation, and dispersal.

Keywords: western Indian Ocean; East African monsoon; thermocline; mixed-layer; C_4 grassland; moisture transport; Indian Ocean circulation; Australasian monsoon; Heat budget; eastern equatorial Indian Ocean; MMCT; MCO.