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Decoding the sedimentary responses to the monsoon seasonality and ocean circulation in the southeast Arabian Sea during the last 50 ka☆

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ABSTRACT

The Indian Monsoon System, an integral part of the Asian Monsoon, is intricately linked to the global climate system through solar forcing, abrupt warming or cold events in the Northern Hemisphere, and deep ocean circulation. This study reconstructs the sedimentation history and its linkages to monsoon seasonality and intermediate-to-deep ocean circulation over the last 50 ka using well-dated sediment core SK-257/02 from the southeastern Arabian Sea (SEAS). Environmental magnetic parameters (concentration, mineralogy, and grain size) combined with the end-member analysis reveal three dominant sedimentary components. The fine-grained fluvial suspension-driven fraction (EM1- mean size 3.46 μm) reflects intensified Indian Summer Monsoon (ISM) precipitation during the interglacial periods (MIS 3 and 1) and warmer phases of Dansgaard-Oeschger (D–O) cycles, associated with precession-driven changes in solar insolation. In contrast, the Northeast Monsoon (NEM) wind-driven aeolian silt fraction (EM2, mean size 5.59 μm) dominates during glacial stages (especially the last glacial maximum; LGM) and Heinrich events (HS). The co-occurrence and compensatory depositional behavior of EM1 and EM2 demonstrate the seasonal occurrence of the South West Monsoon (SWM) and NEM during the glacial-interglacial cycle. The fractional abundance of the coarsest fraction (EM3, mean size 15.92 μm) shows coherence with enhanced southern component waters (SCW)- Antarctic Bottom Water: AABW and/or Pacific Deep Water: PDW), admixed intermediate-to-deep circulation across the Arabian Sea, Equatorial Indian Ocean, and the Bay of Bengal, particularly during glacials and stadials. This signifies that the resuspension of fine-to-medium silt-sized sediment is associated with stronger circulation at intermediate water depths, temporally synchronizing with colder Antarctic and Southern Ocean episodes, promoting the advent of more SCW admixed Circumpolar Deep Water (CDW) into the Northern Indian Ocean. This suggests a teleconnection with the SEAS through altered intermediate and deep-water circulation, linked to the deep-water mass structure and global overturning circulation changes in the glacial deep ocean.

1. Introduction

The Indian Summer Monsoon (ISM) is a vital component of the larger Asian Monsoon system (ASM), which is a dominant climatic system shaping the hydrography, sedimentation and biogeochemical cycles of the Arabian Sea (AS) and the adjoining Indian continental margin (Clemens et al., 1991; Rostek et al., 1997; Zhisheng, 2000; Gadgil, 2003). Although the ISM is a regional component of the broader ASM, several studies have shown that ISM variability can be asynchronous or incoherent with East Asian monsoon behavior on glacial–interglacial and millennial timescales, highlighting the importance of considering regional dynamics when interpreting monsoon-driven sedimentary records (Fleitmann et al., 2003; Gupta et al., 2003; Cheng et al., 2016). ISM variability is primarily driven by changes in Northern Hemisphere summer insolation, land-sea thermal gradients, and the amplifying effect of the Tibetan Plateau, which acts as an elevated heat source

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