

Initiation and intensification of Indian Summer Monsoon inferred from stable isotopes and trace element geochemistry

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The Miocene epoch marks the most salient interval in the Cenozoic era, characterized by several major climatic events. An important aspect of Miocene epoch is related to the initiation and intensification of Indian summer monsoon (ISM), believed to have occurred during Miocene. While most researchers agree that the Asian monsoon systems intensified at around 8 Ma ^[1,2,3], however this view has been contested by few researchers^[4,5], who suggested that the intensification occurred during the early Miocene and the late Eocene^[6]. Therefore, in order to better understand the timing of ISM initiation and intensification we focused our attention to reconstruct the paleoceanography of the Northeast Indian Ocean through stable carbon and oxygen isotopic ratios of foraminifera and geochemistry of marine sediments. The $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values on *Globigerinoides quadrilobatus* (planktonic) and *Cibicidoides wuellerstorfi* (benthic foraminifera) indicates initiation of ISM at 12 Ma and its intensification at 10 Ma. We have correlated our stable isotopic data with trace element geochemistry of marine sediments. The Ba data shows increased productivity at ~ 12 Ma which bloomed at 10 Ma to give rise to nearly suboxic condition at ~ 10 Ma leading to dissolution of planktonic foraminifera. The Ba geochemistry is supported by $\Delta\delta^{13}\text{C}_{\text{Pl-Ben}}$ for an increased productivity event at 12 Ma and productivity bloom at 10 Ma. The moderately high U/Th ratio at ~ 10.2 Ma also points at near suboxic condition in the study area. Elemental ratios Rb/Al and K/Al also increases at ~ 12 Ma indicating higher concentration of feldspar and illite^[7,8]. High concentration of feldspar and illite from ~ 12-8 Ma could be possibly due to intense mechanical weathering ^[9,10]. Increase in physical erosion is often linked with stronger summer monsoon ^[11]. Hence our isotopic and trace elemental record from ODP 758 suggests initiation of ISM at 12 Ma and its intensification at 10 Ma.

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