ABSTRACT

Many significant climatic, tectonic and biotic changes characterize the Neogene period, which shaped the modern Earth. The phased uplift of the Himalaya and Tibet, which led to initiation/intensification of the Indian monsoon is one such event. The Indian monsoon is one of the most compelling tropical features marked by seasonally reversing wind system with southwesterly winds in summer (June-September) and northeasterly winds in winter (December-February). The monsoon driven primary productivity changes are observed in the Arabian Sea. The Indian summer monsoon (ISM) plays an important role in the socio economic conditions of the south Asian countries. The ISM causes an ocean upwelling that affects primary productivity in the Arabian Sea and also the fauna and flora on land. The effect of Indian monsoon variability and Himalayan uplift can be seen in numerous proxy records across the region. The Arabian Sea is one of the most productive regions in the world, and it is used as natural laboratory to carry out paleoclimatic studies on marine sediments. Multiproxy studies such as planktic/benthic foraminifera, stable isotopes and elemental geochemistry have been carried out over the last three decades to understand ISM evolution, variability and its relation to Himalayan tectonics. The present research work is focused towards understanding of Indian monsoon variability, evolution of wind system, ocean upwelling history, paleoproductivity and weathering records during the Neogene. In this study new data sets with high resolution and longer record of planktic foraminiferal abundances, Total organic carbon (TOC wt.%) and major and trace elemental variations in deep-sea sediments has used as multi-proxy records from Ocean Drilling Program (ODP) Hole 722B, Leg 117, Owen Ridge (northwestern Arabian Sea; water depth 2028m depth) to address the above (mentioned) issues.

Paleoclimatically and paleoceanographycally important planktic foraminiferal species such as upwelling indicators *Globigerina bulloides*, *Globigerinita glutinata*, mixed layer species (MLS) *Globigerinoides ruber*, *Globigerinoides sacculifer*, *Globigerinoides obliquus*, *Globigerinoides extremus*, and thermocline species *Globorotalia menardii* and *Neogloboquadrina dutertrei* have been studied to understand the Indian monsoon variability during the Neogene. The planktic foraminiferal census counts were carried on >150μm size fraction. At least 300 specimens were picked, identified and counted from the residues. The relative abundance of open-ocean upwelling species *G. glutinata*, increased during ~9.23 – 7.7 Ma. Decrease in *G. bulloides* abundance and increase in TOC wt.% during late Miocene cooling (~7.7 to 6 Ma) and indicates that the SW monsoon decreased and the NE monsoon strengthened. The *G. bulloides* population increased from 5.6 to 3.6 Ma, indicating enhanced coastal upwelling. A significant drop in *G. bulloides* and TOC wt.% increased from 3.5 to 1.8 Ma indicates reduced coastal upwelling linked to northern hemisphere glaciation and a weaken summer monsoon and strengthening winter monsoon. An abrupt change occurred during the late Quaternary (~0.07 Ma), when the abundance of both the upwelling species remarkably increased. Abrupt changes and dominance of the MLS occurred since ~3.5 Ma, which indicates development of a thick mixed layer due to deep convective mixing ~3.5 Ma onwards.

Multi-proxy records from ODP holes in the western Arabian Sea, off Oman margin and on the Owen Ridge, show that *G. bulloides*, which is a proxy for SW monsoon, began to appear in planktic foraminiferal population at ~12.9 Ma and its abundance increased significantly at ~7 Ma. A significant increase in TOC (wt.%) and a negative shift in stable carbon isotope record of *Cibicides* spp. is also noted at ~ 12.9 Ma. These proxies indicate that the present day South Asian monsoon wind system began to develop during the late Middle Miocene (~ 12.9 Ma) and summer monsoon reached its full strength in the late Miocene (~ 7 Ma). From 11 to 7 Ma, the summer monsoon was weaker and winter monsoon was stronger.

The geochemical records of the present study provide insights into the effects of productivity, paleoceanographic changes and weathering history during the Neogene. The TOC values began to increase at ~15.2 Ma with fluctuations ranging from 0.01 to 7.84 (wt.%). The results of lower TOC (wt.%), $CaCO_3$ (%) and elemental ratio suggest low productivity during the early Miocene, and cold conditions and increased productivity since the middle Miocene (~15.2 Ma). New records of Ba/Al, P/Al, $CaCO_3$, Ti/Al, terrigenous (%), K/Al, K/Rb, and Mg/Al have been correlated together with previously published global data. The present study suggests that the Owen Ridge initially received huge amount of terrigenous input from the Indus River (23.03 to 15.2 Ma). Pelagic deposits began to influence the study site ~15.2 Ma onwards, which could be due to the uplift of the Owen Ridge, strengthening of the South Asian Monsoon (SAM) wind system, changes in the ocean circulation, and global cooling.

Keywords: Neogene; Himalayan uplift; Indian monsoon; upwelling; planktic foraminifera; total organic carbon; major and trace elements.