Auer, Gerald[1]; Bialik, Or M.[2]; Puentes Jorge, Xabier[1]; Hechemer, Tamara[1]; Piller, Werner E.[1]

New multiproxy approaches in paleoenvironmental reconstruction – An example from a Late Miocene upwelling cell in the northwestern Indian Ocean

[1]University of Graz, Department of Earth Sciences, NAWI Graz Geocenter, Heinrichstraße 26 8010 Graz; [2]University of Muenster, Institute of Geology and Palaeontology, Corrensstr. 24, 48149 Münster, Germany; gerald.auer@uni-graz.at

Accurate paleoenvironmental reconstructions require high-resolution, high-precision analysis of proxy data. In recent decades, it has also become common practice to apply multi-proxy approaches to best characterize all potential controlling factors that may have influenced past changes. Here, we present new high-precision data based on micropaleontological (nannoplankton, planktonic foraminifer assemblages, and diatom abundances) proxies coupled with geochemical proxy data. Geochemical datasets include C and N elemental concentrations and ratios, as well as bulk $\delta^{13}C_{org.}$ $\delta^{15}N_{org.}$ stable isotope data, coupled with habitat-specific planktonic and benthic foraminifer $CaCO_3$ $\delta^{13}C$ and $\delta^{18}O$ data.

This multi-proxy approach was necessary to fully disentangle the dynamic changes that occurred within a Miocene Monsoon wind-driven upwelling cell in the Western Arabian Sea (WAS) along the Oman Margin. In the WAS upwelling cell, nutrient-rich waters fuel productivity, providing a key example of how the global thermohaline circulation transports nutrients through the intermediate waters of the ocean. Today, these nutrient-rich intermediate waters form within the Antarctic Divergence – located at present around 55° S latitude – before expanding into the middle and lower latitudes where they can upwell, fertilizing upwelling cells throughout the global oceans.

Our data spanning the Middle to Late Miocene at Ocean Drilling Program (ODP) Site 722 details the inception and history of upwelling-derived primary productivity in the Oman Margin. Our data confirms that monsoonal upwelling in the WAS has persisted since the emergence of the Arabian Peninsula after the Miocene Climatic Optimum (MCO) ~ 14.7 Ma. Although fully monsoonal conditions were only detected after the end of the Middle Miocene Climatic Transition (MMCT) at ~ 13 Ma.

Crucially, however, the application of multivariate statistical methodologies based on the multi-proxy bases revealed that upwelling did not simply intensify after the MCO. Changing nutrient fluxes through Antarctic Intermediate and sub-Antarctic Mode Waters (AAIW/SAMW) further influenced paleoenvironmental conditions by ~12 Ma. These changes culminated ~11 Ma, when diatom abundance increased significantly, leading to alternating diatom blooms and high-nutrient-adapted nannoplankton taxa. These changes in primary producers are also well reflected in geochemical proxies with increasing $\delta^{15}N_{org.}$ values (> 6 ‰) and high organic carbon accumulation. These proxies provide further independent evidence for high productivity and the onset of denitrification simultaneously.

Foraminifer $\delta^{13}C$ and $\delta^{18}O$ subsequently compound the evidence for a stepwise evolution of Middle to Late Miocene productivity in the western Arabian Sea. The absence of a clear correlation with existing deep marine climate records suggests that both local wind patterns and intermediate water nutrient changes likely modulated productivity in the western Arabian Sea during the Middle to Late Miocene. Our multi-proxy records, therefore, provide novel insights into how plankton responded to changing nutrient conditions in the monsoon-wind-driven upwelling zone in the WAS during the Miocene after the MMCT.

Session: *Classical Session: Analytical Advances*
Keywords: *nutrient cycling, paleoclimate, micropaleontology, stable isotope geochemistry*