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Millennial-Scale Redox Instability in a Shallow OMZ: A 20 kyr Mo–U–Re Reconstruction from the Eastern Arabian Sea

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The Arabian Sea continental margin is a dynamic land–ocean interface where monsoon-driven terrigenous input, biological productivity, and oxygen minimum zone (OMZ) intensity are tightly coupled. Building on prior work documenting late Quaternary OMZ variability in the Arabian Sea, we revisit the redox state of the eastern margin with a focus on distinguishing persistent oxygenation from transient anoxic states characterized by weak sulfide availability. We present a multi-proxy geochemical reconstruction of redox conditions over the past 20 kyr from sediment core AAS-VI/GC-03, retrieved off the Goa coast (eastern Arabian Sea) within the mid-depth of the present-day OMZ.

Using redox-sensitive trace metals (Mo, U, Re), enrichment factors, Re/Mo ratios, and their covariation with productivity and carbon-cycle indicators ($CaCO_3$, TOC, $\delta^{13}C$), we resolve three principal redox modes and their transitions: (1) predominantly suboxic–ferruginous conditions during the last deglaciation (~18–14 ka), expressed by elevated authigenic U and moderate Re/Mo ratios; (2) a prolonged interval of strengthened oxygen depletion during ~14–4.5 ka, with peak Mo enrichment and Re/Mo ratios approaching seawater, consistent with episodic pore-water sulfide development and a weakly sulfidic, anoxic overprint rather than sustained euxinia; and (3) near-oxic conditions in the late Holocene (~4.5 ka–present), indicated by minimal trace-metal enrichment. The combined proxy behavior points to fluctuating redox conditions near the ferruginous–weakly sulfidic boundary, likely paced by millennial-scale changes in monsoon-driven productivity and ventilation.

These results refine constraints on the temporal persistence and intensity of anoxia in a shallow OMZ setting and underscore how modest shifts in oxygen supply and organic-matter flux can drive short-lived excursions into weakly sulfidic conditions on the eastern Arabian Sea margin during post-glacial climate transitions.