Sensitivity of Redox Proxies to Rapid Variability in Oxygen Minimum Zones

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Our ability to track the sensitivity of major Oxygen Minimum Zones (OMZs) to rapid perturbations in climate and productivity can be compromised by (1) global sea level change, (2) insufficient temporal resolution, (3) inadequate age models, and (4) strong microbially mediated transformations and diagenetic overprints. As a consequence, short-term proxy trends are often deemphasized in favor of the major pattterns despite having the potential to capture environmental shifts in the OMZs. To address this problem we reconstruct variations in oxygenation over the last 100 kyr in a major OMZ—the Eastern Tropical North Pacific (ETNP). Specifically, we analyzed sediments collected from basinal settings with diverse levels of restriction and nutrient availability in the Gulf of California and Eastern Pacific: Alfonso, La Paz, Pescadero, and Carmen basins. We emphasize a broad range of paleoredox proxies (e.g., Mo, Ni, V, U, detailed Fe speciation, and C and S concentrations and isotope ratios) and productivity indicators with a centennial-to-millenial temporal resolution. Our comprehensive data reveal that long-term redox changes on glacial-interglacial time scales are largely controlled by global sea level, which lowered the OMZ more than 100 meters below its present-day depth during the LGM and MIS 4, exposing marine basins to oxygenated waters (revealed by low U, Mo, V, and Fe_{HR}/Fe_{T} values). Sea-level highstands, by contrast, return anoxic and even euxinic conditions to shallower regions, especially when primary productivity is boosted by enhanced upwelling. At the same time, Heinrich, Dansgaard-Oeschger, Bond, and short-term cold events enhanced the ventillation of the ETNP, as fingerprinted in low Mo, V, and U. These events were also accompanied by productivity variations, evinced not only by trends in organic carbon, biogenic silica, P, and excess-Ba but also as a strong correlation to U content. Such links reveal the potential for U as a paleoproductivity proxy prehaps related to authigenic-U enrichments in settling particles consistent with data from modern sediment traps.