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Spatiotemporal redox variability enveloping an Oceanic Anoxic Event

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Understanding and constraining redox conditions surrounding "Oceanic Anoxic Events" (OAEs), as they represent recent intervals of major climate upheaval, are of significant interest as they provide insight into the cascade of events and timeframe leading to natural deoxygenation variability during climate perturbation. These ancient events bury a significant portion of organic matter and are recorded by large carbon isotope excursions ($\delta^{13}C$). The enhanced burial of organic matter contributes to the consumption of oxygen, global cooling, and hydrocarbon reserves.

The term OAE suggests that the dominant and pervasive global marine redox conditions during these events were anoxia. Additionally, it suggests that these reducing conditions were restricted to these intervals as defined by $\delta^{13}C$. Here, we have utilized two new geochemical redox proxies, vanadium (V) and thallium (Tl) isotopes, to better constrain the local and global redox variability during OAE-2 (~94 million years ago). Recently, V isotopes have been shown to be a reliable proxy to record changes in low oxygen conditions, particularly at concentrations important for biota. Importantly, V isotopes document local stratigraphic redox variability at a site with laminated, organic-rich mud deposition – more consistent with previous biological evidence. This is likely recording a vacillation between the result of the expansion and contraction of the oxygen minimum zone (OMZ).

Thallium isotopes provide a global record of marine oxygenation through the burial of manganese oxides, which require the presence of dissolved oxygen. Thus, perturbations in seawater Tl isotopes provide a record of the earliest changes in global marine oxygenation. Two long-term Tl isotope records surrounding OAE-2 suggest progressive deoxygenation well before the OAE. Thus, the OAE represents the culmination of the maximum extent of deoxygenation. Using a combination of redox proxy data suggest that OAEs represent the punctuation of a longer-term climate scenario, and also that local redox conditions are more variable and dynamic – i.e., expansion/contraction of OMZs. The wealth of data during this time interval provides a unique window to constrain the impacts affecting marine oxygen conditions. The utility of combining redox proxies provides unique spatiotemporal records that can differentiate aspects of the redox ladder.