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Characterizing Permian Ocean Oxygenation Through a Fossil Reef

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The Capitan Reef Complex in the Guadalupe Mountains of western Texas ranks among the best-preserved ancient reefs known in the geologic record. Its Permian-age (~260 Ma) carbonate and siliciclastic rocks were later exhumed as structurally intact outcrops that preserve a record of the reef from the shallow-water platform to the deep-water basin. The reef has been the subject of extensive geochemical studies aimed at revealing the diagenetic history of its rocks and reconstructing middle Permian seawater chemistry. Middle Permian seawater redox conditions are of particular interest because ocean anoxia has been associated with both the Capitanian mass extinction (~262 Ma) and the Permian-Triassic mass extinction (~252 Ma). In this study, we apply geochemical proxies to Yates, Tansill, and Bell Canyon formation samples from the Capitan Reef Complex to investigate how redox conditions may be preserved through early marine diagenesis, burial, and exhumation. We sample microfacies representing a diversity of grains and cements of varied mineralogy and include rocks from near-shore, slope, and basin deposits. We leverage existing C, O, S, Ca, and Mg isotope data of a petrographically and sedimentologically characterized suite of diagenetic alteration to identify those samples that best preserve reliable records of seawater chemistry. We then apply two paleoredox proxies: uranium isotopes ($\delta^{238}U$) and iodine-calcium-magnesium ratios (I/(Ca+Mg)). The I/(Ca+Mg) ratio in carbonate rocks tracks local iodate abundance and is generally controlled by redox conditions in the local water column during deposition. Carbonate $\delta^{238}U$ tracks the extent of global seafloor anoxia and thus yields information on broader ocean redox state. Coupled measurements of I/(Ca+Mg) and $\delta^{238}U$ may thus yield insights on oxygenation at both local and global scales. Our data shed light on seawater oxygenation during a period marked by repeated climatic and biotic crises.