Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.19106

Searching for signals of oxygenation in Ediacaran microbial reefs

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Geochemical data suggest that atmospheric oxygen levels in the Proterozoic Eon were between 0.1–10% of the present day. While surface waters were oxygenated, the deep ocean remained largely anoxic–suboxic. The first animals appeared at the end of the Proterozoic, in the Ediacaran Period, pre-dating the rise to stable, modern-like atmospheric oxygen and fully ventilated oceans in the mid-Palaeozoic Era. However, the precise distribution, stability and amount of oxygen in Ediacaran oceans is poorly constrained. We investigate redox signals in the Nama Group, South Africa, an Ediacaran carbonate-ramp system deposited around 550 to 538 Ma. During this interval, global records suggest that oxygen levels fluctuated dramatically on ~1 myr timescales. Regional data suggest that anoxic waters impinged on the outer ramp, and animal fossils were confined to local oxygen oases. We targetted microbial reef systems, which grew in shallow, sunlit surface waters and were generated by a microbial community that likely included oxygenic cyanobacteria. They are therefore prime targets to search for signals of oxygenation. We micro-drilled microbial horizons, used sequential digestion techniques, and analysed rare earth elements + Y via solution and laser ablation ICP-MS. The samples preserve pristine primary seawater signals, but we found no evidence for Ce fractionation. This suggests that either oxygen levels were too low to trigger Ce oxidation or that microbial fabrics are not reliable recorders of ambient conditions. These data deepen a puzzling pattern of “missing” negative Ce anomalies throughout the Nama Group, despite clear evidence for fractionation, as indicated by abundant positive Ce anomalies recorded in non-microbial samples.