Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.23064

A place in our world: what the iron cycle in ferruginous lakes can teach us about past ferruginous oceans

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Some meromictic lakes have chemical and some biological analogy to past ferruginous oceans conditions that are now extinct. Studying these lakes and comparing with others around the world can fill in the range of biogeochemical possibilities for settings in past ferruginous oceans. I will discuss two examples.

Ferruginous oceans had greater hydrothermal iron supplies than modern, but terrestrial iron was not insignificant and could have been supplied through surface or submarine groundwater discharge. Our work indicates that groundwater is a major source of water and iron directly into the anoxic zone of these lakes, circumventing initial encounters with oxygen. Despite different geological and hydrologic settings, this is common to other meromictic and ferruginous lakes around the world. Groundwater injection into deeper anoxic waters increases the residence time of iron. As iron encounters oxic waters it is rapidly scavenged into mineral particles that are reductively dissolved upon sinking, regenerating dissolved iron. For discharge directly into oxic waters, whether from ground or surface waters, it would be more likely to be quickly deposited in near-shore sediments. This results in extreme enrichment of iron the anoxic layer relative to the oxic layer in comparison to conservative elements, and a longer residence time of iron.

Despite the large reservoirs of Fe in these lakes, phototrophs in the oxic layer show indications of being Fe limited, adding nuance to the discussion of what nutrient limited Earth's early primary producers. Consequently, phototrophs sink deeper to access iron in zones of low light and oxygen and high biomass. Biological uptake of iron seems to enrich light iron isotopes in biomass. Such a biological fractionation within phototrophs has been difficult to measure in the modern Fe limited oceans but has a clear signal in productive lakes that could be a biosignature for primary producers relevant to ferruginous oceans.