Mo isotope evidence for a global expansion in marine euxinia ~ 2.5 billion years ago

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The ~2.5 billion year old (Ga) organic-rich Mt. McRae Shale contains higher molybdenum (Mo) concentrations and heavier Mo isotopic values than typical Archean sedimentary rocks[1,2]. Such anomalous values have been interpreted as evidence for a mild "whiff" of O_2 at ~ 2.5 Ga. Iron (Fe) speciation evidence for local water column euxinia indicates that enhanced oxidative weathering increased the pool of seawater sulfate for microbial sulfide production[3]. However, it remains unknown whether euxinic conditions were primarily a local phenomenom or more widespread. To address this question, we obtained higher-resolution Mo concentration and isotopic data from the Mt. McRae Shale to better constrain ocean redox dynamics during the whiff interval.

These higher-resolution analyses show a sharp drop to lower Mo concentrations and lighter Mo isotope values coincident with the onset of Fe speciation evidence for persistent local euxinic conditions. This pattern is not consistent with the development of euxinia at a local scale only, as local euxinia should result in higher Mo concentrations and heavier Mo isotope values—the opposite of what we observe. Instead, our results are best explained by a more widespread expansion of marine euxinia that depleted the global oceanic Mo reservoir and reduced the area of seafloor preferentially incorporating isotopically light Mo from seawater.

Global expansion of marine euxinia may have been a natural consequence of the liberation of sulfate by oxidative weathering during Mt. McRae Shale deposition.

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