Evolution of the sulfur cycle in the late Paleoproterozoic

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A significant transition period in the Earth's sulfur cycle came at the end of banded iron formation (BIF) deposition in the late Paleoproterozoic, when widespread sulfidic ocean conditions are thought to have been initiated. This transition is thought to mark a large-scale shift in Earth's surface oxidation state, and may have been a biological threshold that drove either innovation or relocation of biological activity. In this study, we examine the sulfur isotopic composition (^{32}S, ^{33}S, ^{34}S, ^{36}S) of sulfides from BIF and shales across part of this transition (represented by the Gunflint and Rove formations, Ontario, Canada) to determine the state, and potential response, of the surface sulfur cycle and the biology it supports.

Our results suggest that biological sulfate reduction was limited to marine sediments during BIF deposition and that pore-water sulfate (which would be reduced to sulfide) adopted its initial isotopic composition from the overlying seawater sulfate reservoir. During deposition of the overlying Rove shale, we suggest that a sulfate stratified ocean was ultimately established, with a surface ocean sulfate reservoir that fed a deeper ocean sulfate reservoir in which the sulfate may have been largely consumed by water-column sulfate reduction. Further, the relationship between ^{33}S and ^{36}S allows for the definitive exclusion of weathering/detrital contributions from Archean environments, and places a lower limit on the level of atmospheric oxygen during this time interval.