Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.21249

Mass Independent Signals from Sulfur and Oxygen in Constraining Atmospheric Oxygen since the Great Oxidation Event

JINGJUN LIU[1], DR. AOSHUANG JI, PHD[2], JAMES KASTING[2], JORDAN WOSTBROCK[1], CHRISTOPHER T. REINHARD[3] AND NOAH J. PLANAVSKY[1]

[1]Yale University

[2]Penn State

[3]Georgia Institute of Technology

Presenting Author: jingjun.liu@yale.edu

There persists a three-order of magnitude uncertainty for the estimated partial pressure of atmospheric oxygen(pO_2) derived from various geochemical proxies during the mid-Proterozoic (1.8 Ga ~ 0.8 Ga) [1]. To reconcile this difference requires deciphering geochemical signals of direct and distinct atmospheric origin. The Sulfur Mass-independent fractionation (S-MIF) signature in sedimentary sulfur provides definitive estimates on the maximum pO_2 [2] before the Great Oxidation Event (GOE, 2.45-2.32 Ga), but cannot be used to infer pO_2 after the GOE under the current conceptual framework. Similarly, Oxygen-MIF in sedimentary sulfate carries distinct atmospheric signature [3-5], however its utility [6-7] in inferring atmospheric oxygen has been recently questioned by a more accurate photochemical framework [8]. Recent data compilation of Oxygen-MIF in Phanerozoic marine sulfate [9] also seems to suggest that a direct atmospheric signal from oxygen was missing.

We revitalize ancient sulfate as a direct proxy of atmospheric oxygen since the GOE through tracking the life cycles of atmospheric sulfur and oxygen. By developing a TIPO model (three isotopes photochemical model for oxygen) coupled with an existing S-MIF model, we are able to infer atmospheric oxygen levels since the GOE by examining both the oxygen-MIF and sulfur-MIF signal in geologic records. Considering uncertainties involving diagenesis, microbial recycling, SO_2 outgassing and pCO_2 levels, this new framework shows the potency of deciphering mid-Proterozoic pO_2 and demonstrated that the Phanerozoic sulfur and sulfate record also reflect a direct signal from atmospheric oxygen.

Reference

1. Lyons *et al*. (2021), *Astrobiology* 21, 906-923.
2. Pavlov & Kasting (2002), *Astrobiology* 2, 27-41.
3. Krankowsky *et al.* (2007), *Journal of Geophysical Research-Atmospheres* 112, D0831.
4. Anderson, Hulsebusch & Mauersberger(1997), *Journal of Chemical Physics* 107, 5385-5392.
5. Fruchtl *et al.* (2015), *Geophysical Research Letters* 42, 8711-8718.
6. Cao and Bao (2013), *Proceedings of the National Academy of Sciences of the United States of America* 110, 14546-14550.
7. Crockford *et al.* (2018), *Nature* 559, 613.
8. Liu *et al. (2021), Proceedings of the National Academy of Sciences of the United States of America* 118, 51.
9. Waldeck et al. (2022), *Proceedings of the National Academy of Sciences of the United States of America* 119, 31.