Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.10253

# Controlling factors for atmospheric $O_2$ during the mid-Proterozoic

**AOSHUANG JI** AND JAMES KASTING

Penn State

Presenting Author: azj64@psu.edu

The mid-Proterozoic (1.8 – 0.8 Ga), also known as the 'Boring Billion', is generally regarded as a transitional time between the anoxic Archean and the well-oxygenated late Neoproterozoic. The subsequent emergence of multicellular animals around 0.55 Ga suggests an atmospheric $O_2$ level ($pO_2$) above 0.5 – 4% times the Present Atmospheric Level (PAL), based on an analogy to demosponges [1], and above 10% PAL for other centimeter-scale animals that appeared shortly thereafter [2]. Capturing how mid-Proterozoic $pO_2$ evolved and what mechanism could stabilize is the key to the coevolution of Earth's life and its environment. However, it remains one of the most challenging puzzles because different proxies and methods show variable $pO_2$, from < 0.1% to 40% PAL.

We have constructed a new model to help constrain $pO_2$ during the mid-Proterozoic, along with the processes and feedbacks that were controlling it. This model considers cycling of carbon, oxygen, sulfur, and iron in the atmosphere-ocean-sediment system, combining an ocean-sediment box model with an updated one-dimensional photochemical model modified from Liu et al. [3]. We also take air-sea $O_2$ exchange into account, recognizing that it is complicated because it varies spatially and temporally on the modern Earth. This new treatment has already been applied in interpreting O-MIF signal produced from ozone photochemistry and preserved in mid-Proterozoic sulfates [3,4]. Part of our motivation is to better understand biogenic methane fluxes and atmospheric methane concentrations, both of which were predicted to have been small in a recent study by Cooke et al. [5]. We will argue that Cooke et al. underestimated the methane lifetime in the low-$pO_2$, mid-Proterozoic atmosphere.

References

[1] Knoll, A.H. and Sperling, E.A. 2014. *Proceedings of the National Academy of Sciences*. 111 (11), 3907–3908.

[2] Catling, D.C. and Kasting, J.F. 2017. Cambridge University Press.

[3] Liu et al. 2021. *Proceedings of the National Academy of Sciences*. 118 (51), e2105074118.

[4] Crockford et al. 2018. *Nature*. 559 (7715), 613–616.

[5] Cooke et al. 2022. *Royal Society Open Science*. 9 (1), 211165.