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Revisiting ancient seawater molybdenum concentrations with mass balance models

ETHAN EDMANS[1], ALEISHA C. JOHNSON[2] AND ARIEL D. ANBAR[1]

[1]Arizona State University
[2]University of Arizona

Molybdenum (Mo) has received significant recent attention in geobiology due to the apparent paradox of ancestral Mo use by biology despite a presumed scarcity of Mo in ancient seawater inferred from its abundance and isotope systematics in Archean sedimentary rocks [1]. The scarcity of Mo in ancient oceans is linked to the lack of atmospheric oxygen before the Great Oxidation Event (GOE), because Mo transport and accumulation in surface waters are redox-sensitive. On today's oxic Earth, riverine input dominates the marine Mo budget. This input would have been much smaller before the GOE. However, recent experimental and field studies suggest that high-temperature deep-sea hydrothermal systems may be a net source of Mo to seawater today [2]. While this source is small relative to today's large riverine input, it could have been a dominant source in pre-GOE oceans.

We are exploring the possible consequences of this new source of Mo for ocean Mo concentrations throughout Earth's history, using a mass balance model originally developed by Johnson et al. [3]. The model runs a Monte Carlo simulation to generate a series of outputs across the uncertainties in parameter space. Important parameters of the Mo cycle, such as Mo burial rates, are calibrated using data from modern settings. The generated outputs are then filtered to exclude mass balance results that are inconsistent with Mo concentrations and isotopic abundances measured in ancient shales. We have modified this model to include potential hydrothermal sources, and have also revised previous model parameters. In particular, we consider the effects of recent experimental work showing that the presence of dissolved silica - which was abundant in Precambrian oceans - reduces the incorporation of Mo into manganese and iron oxides [4,5]. These oxides, when they accumulate in sediments, are important sinks for Mo today. Here, we review the revised model and present initial findings.

References:

[1] Rico et al. (2024), *Treatise on Geochemistry (Third Edition)*: 337-364

[2] Evans et al. (2023), *GCA* 353: 28-44

[3] Johnson et al. (2021), *Science Advances* 7.40: eabj0108

[4] Edmans et al., in prep

[5] Hao et al., in prep