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Oceanic redox state in the lead-up to Neoproterozoic oxygenation: insights from REEs and Mo isotopes of microbial carbonates

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The Neoproterozoic Oxygenation Event (NOE), identified as the second major rise in oxygen towards modern atmospheric levels, is proposed to have occurred progressively between ca. 850-550 Ma. Although the NOE is closely associated with the emergence of the Ediacaran fauna at ca. 640-540 Ma, the controversial evidence for the existence of large metazoans at ca. 1000 Ma questions the exact timing, magnitude and causes of the increase in oxygen. This study aims to evaluate the link between oxygenation, tectonics and biological evolution during this critical period by using the REE and Mo isotopic composition of pre-NOE open-marine microbial carbonates to explore the redox state of the ocean in the lead-up to the event.

The microbial reefs of the Little Dal Group, Mackenzie Mountains Supergroup, Northwest Territories, provide a unique snapshot of the trace element signature of open-ocean water between ca. 1000-740 Ma. The microbialites grew in a virtually detritus-free environment, maintaining their growth surfaces within the photic zone. Samples of each growth phase of several reefs along with their corresponding off-reef deep-water carbonate and black shale facies were collected. A subset of samples from several reefs were analysed for REEs by ICP-MS. Samples for Mo isotope analysis were prepared using a modified version of the method outlined by Voegelin et al. (2009) and Eroglu et al. (2015) and analysed by MC-ICPMS.

Here we discuss the implications of the observed REE patterns and present the first estimates of the Mo isotopic composition of the ocean water in the period immediately prior to the NOE. The Mo isotopic data, combined with REE data, is used to constrain the relative influence of Mo sinks on the global ocean signature during this time, for successful mass balance modelling of the pre-NOE ocean. Preliminary normalised REE compositions display patterns typical of oxygenated seawater. Positive La anomalies and slightly negative Ce anomalies suggest that the microbialites developed in an at least partially oxygenated surface environment. In contrast, the deep-water off-reef microbial carbonate samples display a strong positive Ce anomaly, suggesting the prevalence of deep-water anoxia at this time.