Glacial oxygen delivery in the Neoproterozoic: Fe isotope evidence

M. LECHTE*[1], M. WALLACE[1], A. HOOD[1], N. PLANAVSKY[2], W. LI[3], G. JIANG[4], S. MCCOLL[1] AND D.ASAEL[2]

[1]School of Earth Sciences, University of Melbourne, Parkville VIC 3010, Australia (*correspondende: maxwell.lechte@unimelb.edu.au)
[2]Department of Geology and Geophysics, Yale University, New Haven CT 06511, USA
[3]School of Earth Sciences and Engineering, Nanjing University, Nanjing 210093, China
[4]Department of Geoscience, University of Nevada, Las Vegas, Nevada 89154, USA

Episodes of extreme glaciation share a broad temporal association with oxygenation of the Earth's surface environments and biological innovation. The Neoproterozoic Era experienced global glaciation, a stepwise shift in atmospheric oxygen, and the proliferation and diversification of marine life. However, the mechanism by which these processes are linked lacks consensus. Here we show geochemical evidence for the direct delivery of oxygen from the Earth's atmosphere to the oceans during the Neoproterozoic. We examine glacial sediments containing iron formations from the Cryogenian Period (~720 – 665 Ma) deposited in a range of depositional environments, from ice-proximal to ice-distal glaciomarine settings.

Iron formations deposited in ice-proximal glaciomarine environments are interbedded with massive diamictites and feature highly fractionated, negative Fe isotope contents, negative Ce anomalies and Mn-oxide enrichment. By contrast, iron formations deposited more distally from the ice sheet grounding line are interbedded with turbidites and shales and feature highly positive Fe isotope values, and lack negative Ce anomalies and Mn enrichment. These data suggest a redox gradient from an oxic, ice-proximal setting to an anoxic, ice-distal setting and imply a subglacial oxygen source. We propose that atmospheric oxygen trapped in glacial ice was delivered to the anoxic marine environment via subglacial meltwater outwash. We suggest that such a mechanism was likely also active during the extreme glaciations of the Paleoproterozoic and Ediacaran, and that oxygen delivery from the atmosphere to the oceans may have facilitated biotic diversification during these times.