Atmospheric oxygen regulation at low Proterozoic levels

S. J. DAINES[1*], B. MILLS[1] AND T. M. LENTON[1]

[1]College of Life and Environmental Sciences, University of Exeter, Exeter EX4 4QE, UK (*s.daines@exeter.ac.uk)

Multiple lines of proxy evidence suggest that following the Great Oxidation Event ~2.4 Ga, atmospheric oxygen remained ~1–10% of present atmospheric level (PAL) for most of the Proterozoic Eon [1]. However, the controls on atmospheric oxygen during this >1.5 Gyr interval remain poorly understood [2] [3].

We show [4] that a stable low atmospheric oxygen state was an inevitable result of the tectonic recycling of previously accumulated sedimentary reduced matter, combined with the oxygen sensitivity of oxidative weathering. Prior to the Great Oxidation, in the absence of oxidative weathering, a large reservoir of reduced organic carbon accumulated in sedimentary rocks. Following the Great Oxidation, the tectonic supply of this accumulated organic carbon to weathering environments exceeded the burial of 'new' organic carbon in marine sediments. Hence atmospheric oxygen levels were regulated by the consumption of oxygen in oxidative weathering of organic carbon, which depended strongly on oxygen concentration. To increase atmospheric oxygen to modern levels required a large increase in the source of oxygen from organic carbon burial, which did not occur until the Neoproterozoic-Paleozoic Eras.

Our quantitative model for Proterozoic atmospheric oxygen regulation provides a new interpretation of the Precambrian carbonate carbon isotope ($\delta^{13}C$) record, in which changes in organic carbon burial do not alter $\delta^{13}C$, because they generate counterbalancing changes in the weathering of organic carbon with the same isotopic composition.

[1] Canfield (2014) in *Treatise on Geochem*. Vol 6, pp 197-216. [2] Laakso & Schrag (2014) *EPSL* **388**, 81-91. [3] Reinhard. *etal* (2013) *PNAS* **110**, 5357-5362. [4] Daines, Mills & Lenton (2015) *submitted*.