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Evolution of Oxidative Continental Weathering

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The Great Oxidation Event (GOE) is currently viewed as a protracted process during which atmospheric oxygen levels increased above 10-5 times the present atmospheric level. This value is based on the loss of sulphur isotope mass independent fractionation (S-MIF) from the rock record, beginning at 2.45 Ga and disappearing by 2.32 Ga. However, a number of recent papers have pushed back the timing for oxidative continental weathering, and by extension, the onset of atmospheric oxygenation several hundreds of million years earlier despite the presence of S-MIF (e.g., Crowe et al., 2013). This apparent discrepancy can, in part, be resolved by the suggestion that recycling of older sedimentary sulphur bearing S-MIF might have led to this signal's persistence in the rock record for some time after atmospheric oxygenation (Reinhard et al., 2013). Here we suggest another possibility, that the earliest oxidative weathering reactions occurred in environments at profound redox disequilibrium with the atmosphere, such as biological soil crusts, riverbed and estuarine sediments, and lacustrine microbial mats. We calculate that the rate of O_2 production via oxygenic photosynthesis in these terrestrial microbial ecosystems provides largely sufficient oxidizing potential to mobilise sulphate and a number of redox-sensitive trace metals from land to the oceans while the atmosphere itself remained anoxic with its attendant S-MIF signature. These findings reconcile geochemical signatures in the rock record for the earliest oxidative continental weathering with the history of atmospheric sulphur chemistry, and demonstrate the plausible antiquity of a terrestrial biosphere populated by cyanobacteria.

Crowe, S.A., Dossing, L.N., Beukes, N.J., Bau, M., Kruger, S.J., Frei, R. & Canfield, D.E. Atmospheric oxygenation three billion years ago. Nature 501, 535-539 (2013).

Reinhard, C.T., Planavsky, N.J. & Lyons, T.W. Long-term sedimentary recycling of rare sulphur isotope anomalies. Nature 497, 100-104 (2013).