Benthic O_2 factories and Earth's earliest oxidative weathering

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The Great Oxidation Event (GOE) is currently viewed as a protracted process during which atmospheric oxygen increased above ~10–5 times the present atmospheric level (PAL) sometime around 2.5–2.3 Ga. However, an increasing number of studies have suggested that the timing for oxidative continental weathering, and by conventional thinking the onset of atmospheric oxygenation, was hundreds of millions of years earlier than previously thought (see [1] for review). We suggest that this apparent discrepancy can be resolved by the earliest oxidative weathering reactions occurring in benthic and soil environments at profound redox disequilibrium with the atmosphere, such as biological soil crusts and freshwater microbial mats covering riverbed, lacustrine, and estuarine sediments. We calculate that oxygenic photosynthesis in these millimeter-thick O_2 factories provides sufficient oxidizing equivalents to mobilize sulfate [2] and redox-sensitive trace metals (e.g, [3]) from land to the oceans while the atmosphere itself could have remained anoxic with its attendant S-MIF signature. Our observations [4] help reconcile evidence for pre-GOE oxidative weathering with the history of atmospheric chemistry, and support the plausible antiquity of a terrestrial biosphere populated by cyanobacteria well before the GOE.

[1] Lyons *et al*. (2014) *Nature* **506**, 307-315. [2] Stuëken *et al*. (2012) *Nature Geoscience* **5**, 722-725. [4] Lalonde and Konhauser (2015) *PNAS* **112**, 995-1000.