Benthic Oxygenic Photosynthesis on the Archean Landmass

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A remarkably coherent ensemble of evidence point to a significant accumulation of atmospheric oxygen for the first time in Earth's history beginning ca. 2.45 Ga, the so-called Great Oxidation Event (GOE). This includes, amongst many, the loss of sedimentary sulfur isotope mass-independent (S-MIF) anomalies from the rock record. However, several trace element and isotopic proxies have recently suggested oxidative weathering hundreds of millions of years earlier[1]. This apparent discrepancy has been addressed by two models: (1) that pre-GOE oxidative weathering is the result of transient oxygenation events driven by 'oxygen oases' in the marine realm, and (2) that oxidative weathering proceeded at atmospheric O_2 concentrations below 10^{-5} present atmospheric level. We propose here a third model - intense O_2 generation at sub-meter scales by benthic oxygenic photosynthesis in the terrestrial realm. Despite the absence of a UV-protective ozone layer in the Archean, a terrestrial phototrophic biosphere may have existed in various sheltered environments, including biological soil crusts and freshwater microbial mats covering riverbed, lacustrine, and estuarine sediments. We calculate that the rate of O_2 production via oxygenic photosynthesis in these ecosystems provides 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 demonstrate the plausible antiquity of a terrestrial biosphere populated by cyanobacteria.

[1] Crowe *et al* (2013), *Nature* **501**, 535-539