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Progressive Planetary Oxygenation: Multiple Lines of Evidence Confirm an Archean Oxidation Event at 2.5 Ga

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Accumulating evidence suggests that the timing of the Great Oxidation Event (GOE) was affected by geological processes bringing reductants from Earth's interior, such as crustal growth and mantle mixing [1-4]. These processes affect the flux and composition of metamorphic and volcanic gases, and hence atmospheric redox [5]. The emergence of Earth's aerobic biosphere likely depended on the evolution of the solid planet as much as on the evolution of life.

These scenarios are predicated on geochemical evidence that O_2 production began long before the GOE. Transient "Archean Oxidation Events" (AOE) have been identified at 2.5 Ga and 2.65 Ga [6 and references within]. Additional compelling evidence of pre-GOE O_2 extends to at least 2.95 Ga [7, 8].

The most well-studied AOE intersects the 2.5 Ga Mt. McRae Shale, Western Australia, where correlated enrichments of TOC, Mo, and Re are interpreted as indicating oxidative weathering due to a "whiff" of pre-GOE O_2 [9]. An alternative interpretation invokes igneous sourcing and post-depositional remobilization of Mo [10]. We find this hypothesis inconsistent with multiple lines of evidence, including: sedimentary Fe and S systematics [11)]; the stable isotope compositions of Mo, N, U, Se, Tl, Hg, and Fe [summarized in 6; see also 12, 13]; and Re-Os systematics [14]. An AOE at 2.5 Ga remains the most parsimonious interpretation [15], consistent with emerging perspectives on planetary oxygenation.

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