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Subaerial volcanism linked to contemporaneous ocean oxygenation 2.65 billion years ago

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The Great Oxidation Event (GOE) ~2.4 billion years ago (Ga) is widely recognized as the first permanent rise of molecular oxygen (O_2) in Earth's atmosphere. Growing evidence supports multiple transient ocean oxygenation events before the GOE, but the trigger of these events remains under constrained. It is hypothesized that brief episodes of enhanced subaerial volcanism could have stimulated pre-GOE ocean oxygenation by introducing SO_2 to the surface environment. Conversion of SO_2 to H_2S by reaction with photosynthetically produced organic carbon enhances the burial of pyrite, leaving photosynthetically produced O_2 behind. We tested this hypothesis by measuring mercury (Hg) concentration and isotope compositions in ~2.65 Ga organic-rich shales of the Jeerinah Formation from the Hamersley Basin, Western Australia. We found abnormally high Hg enrichment alongside positive mass independent fractionation of Hg isotopes indicative of extensive subaerial volcanism during an interval of increased pyrite burial. The Hg isotope evidence of subaerial volcanism appears synchronous with independent inorganic geochemical evidence of transient ocean oxygenation and with sulfur isotope evidence of an atmospherically processed source of pyrite sulfur. These correlations imply intimate coupling between subaerial volcanism, pyrite burial, and pre-GOE ocean oxygenation. Our results highlight the pivotal role of subaerial volcanism in triggering contemporaneous ocean oxygenation via pyrite burial. The emergence of widespread subaerial volcanism due to accelerated continental growth in the late Archean could mark a key transition in Earth's redox history and implications for exoplanet life.