Oxygenating a planet: Astrobiological implications

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Oxygen formed through photosynthesis is arguably the biosphere's greatest resource. In addition to the aeroic respiration that powers all complex eukaryotes, it is the ultimate source of oxidants for bacterial sulfate reduction and the bacterially-generated organic matter that lies at the base of the food chain in all hot vent and cold seep communities. Thus, the origin and growth of the oxygen fraction of Earth's atmosphere, and the positive and negative feedbacks on it that are imposed by the global biosphere, remain one of the most central problems of historical biogeochemistry. This talk will attempt to integrate recent discoveries and theories that bear on this problem. It is being actively explored at present (2003) through the Archean Biosphere Drilling Project of the NASA Astrobiology Institute's Astrobiology Drilling Program.

Mass-dependent and mass-independent sulfur isotopic effects in Archean and Paleoproterozoic sulfides and sulfates

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Measurements of the ratios of the four stable isotopes of sulfur (^{32}S, ^{33}S, ^{34}S, and ^{36}S) were made on a wide variety of sulfides and sulfates ranging in age from early Archean to Miocene using a Cameca 120 ims ion microprobe in multi-collection and mono-collection modes. Results confirm the observations of Farquhar et al. (2000) that, in general, samples older than about 2 Ga exhibit small to pronounced mass-independent offsets from the terrestrial fractionation line whereas those younger than about 2 Ga do not show this effect. However, there are exceptions. For example, pyrite clasts in an early Archean sedimentary breccia exhibit mass-dependence ($\Delta^{33}S = 0$) over a range of almost 50‰ in $\delta^{34}S$. This is excellent evidence for a magmatic source as any mass-independent signature, once acquired, may only be lost by dilution. Conversely, the retention of a small but significant mass-independent signature in dacitic sills associated with the Panorama volcanic-hosted massive sulfide deposits of the Pilbara craton, Western Australia, implicates meteoric fluids in the ore-forming processes.

The longevity of the mass-independent sulfur isotope signature in geological settings means that it may be recycled into younger deposits. This complicates the problem of timing its disappearance at or near the Paleoproterozoic "Great Oxidation Event". Preliminary data from secondary barite in the 1.88 Ga-old Negaunee Iron Formation of northern Michigan suggest that the primary sulfide had a small mass-independent signature. If so, this is one of the youngest records of this effect.

Reference

Farquhar, J.F., Bao, H. and Thiemens, M., (2000), *Science* **289**, 756-758.