A new marine arsenic ecosystem stable state 2480 million years ago

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Arsenic, a ubiquitous metalloid in the biosphere, may have played a part in the shaping of Earth's early biosphere through its redox-dependent toxic properties and organic matter synthesis via arsenic-dependent anoxygenic photosynthesis. It is shown that the concentration and redox state of arsenic varied dramatically through Earth history, controlled by climate, weathering fluxes and atmospheric oxygen content. Arsenate and arsenic sulfides rose to global prominence in seawater 2480 million years ago, coincident with the first permanent rise of oxygen in the atmosphere. At this time, the modern arsenic cycle was first established, triggering the onset of severe arsenate toxicity and competition with phosphate for uptake into cells. Phytoplankton would have been stressed by arsenate, while rapid precipitation of arsenic sulfides provided a refuge against severe arsenic toxicity in sulfidic continental margins. These sulfide-rich habitats would have been relatively enriched in phosphate compared to the chemocline where Fe(III) minerals precipitated phosphate and enhanced arsenate toxicity. The Great Oxidation event resulted in distinct arsenic niches that promoted differential arsenic cycling and oxidation states, and in turn influenced the assemblage of distinct microbial communities.