Cryptic Oxygen Oases: Hypolithic oxygenic photosynthesis in hydrothermal areas as a model for continental oxidation before the GOE

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Mounting geochemical evidence suggests microorganisms capable of oxygenic photosynthesis (e.g., Cyanobacteria) colonized Archean continental surfaces, driving oxidative weathering of detrital pyrites prior to the 2.5 Ga great oxidation event. However, terrestrial life during the Archean would have had to contend with high UV radiation, erosion, and dessication. Hydrothermal areas maybe be ideal locations as analogs of ancient continental surfaces, as they produce areas of reletively high moisture content that preclude vascular plants. Furthermore, recent work indicates terrestrial hydrothermal systems date back at least as far as 3.5 Ga. Here, we explore phototrophic communities in hypolithic (sub-sinter) and hydrothermal (subaqueous) and associated proximal microbial mat (subaerial) environments in Yellowstone National Park as potential analogs to Archean continental surfaces.

Hydrothermal sub-sinter environments provide ideal conditions for phototrophic microbial communities, including blocking of harmful UV radiation, trapping and retention of moisture, and protection from erosion by rain and surface runoff. Hypolithic communities in both acidic and circum-neutral to alkaline geothermal settings were characterized for carbon uptake, geochemistry, and microbial community composition. Hypolithic (sub-sinter) mats were found to be similar to hot spring communities. We hypothesize that hydrothermal area hypolithic communities represent modern analogs of phototrophic microbial communities that colonized Archean continental surfaces, producing oxygen locally and facilitating microbially-mediated pyrite oxidation prior to the presence of free oxygen in the global atmosphere. These results have implications for oxidation of the early Earth surface, the search for biosignatures in the rock record, as well as for potential harbors of past life on Mars and the search for life on Exoplanets.