The Biogeochemical Aftermath of 'Snowball Earth' Conditions

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Under 'Snowball Earth' conditions the global network of oceans may have been blanketed for millions of years under thick sea ice. In the darkness beneath this extended cover photosynthesizing organisms would have perished and the oceans would have become anoxic. Under such conditions sulfate-reducing bacteria would likely dominate microbial life, assuming utilizable substrates were available. Intense sulfate reduction would have ultimately drawn down seawater sulfate concentrations during the ice age. Residual sulfate would have been driven to positive S-isotopic extremes through the formation and burial of ^{34}S-depleted sulfides. In post-glacial times, sulfide isotopic compositions could have exceeded seawater sulfate due to the slow diffusion of sulfate into sediments and closed system fractionation. The carbonate alkalinity necessary for rapid cap carbonate formation may have been partly supplied from intense sulfate reduction during the ice age, and subsequent upwelling in the post-glacial world. Delivery of nutrients, like P and Fe, from the deep anoxic ocean in the aftermath of the 'Snowball' winter would have stimulated intense photosynthetic blooms, consistent with a marked decrease in carbon isotope fractionation in organic-rich cap carbonates.