Geochemical Markers of Anoxygenic Photosynthesis in Modern-Day Piermont Marsh Samples and 3.4-Billion-Year-Old South African Rock Samples

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Photosynthesis played a major role in shaping Earth's surface, but its earliest forms, like anoxygenic photosynthesis, remain difficult to trace in the rock record. This study investigates geochemical markers of microbial redox activity by comparing modern samples from the Piermont Marsh in Rockland County, New York to 3.4-billion-year-old sedimentary rocks from the Moodies Group in South Africa. We used X-ray absorption spectroscopy (XAS) and X-ray fluorescence (XRF) microscopy to analyze the oxidation state and speciation of sulfur, iron, and arsenic across both environments. Piermont Marsh samples showed a mixture of organic and inorganic sulfur species, with more oxidized compounds near the ground's surface. In contrast, Moodies samples were dominated by reduced inorganic sulfur, primarily pyrite, with small amounts of oxidized or organic sulfur detected. Preliminary iron and arsenic data also suggest the presence of both reduced and oxidized forms in both environments, indicating redox variability. The presence of even small amounts of oxidized and organic sulfur in the ancient Moodies samples may point to localized microbial redox activity, possibly linked to anoxygenic photosynthesis. These findings support the idea that microbial processes can leave behind preserved chemical signatures, even under low-oxygen conditions, and that modern analog environments can help us interpret biosignatures in the early rock record.