Nanophase Iron Oxides as an Ultraviolet Sunscreen for Ancient Photosynthetic Microbes: A Possible Link Between Early Organisms, Banded-Iron Formations, and the Oxygenation of the Atmosphere

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We propose that nanophase iron oxide-bearing materials provided important niches for ancient photosynthetic microbes on the early Earth that ultimately led to the oxygenation of the Earth's atmosphere and the formation of iron oxide deposits. Atmospheric oxygen and ozone attenuate UV radiation on the Earth today providing substantial protection for photosynthetic organisms. With ultraviolet radiation fluxes likely to have been even higher on the early Earth than today, accessing solar radiation was particularly risky for early organisms. Yet, we know that photosynthesis arose then and played a critical role in subsequent evolution. Of primary importance was protection at ~250-290 nm, where peak nucleic acid (~260 nm) and protein (~280 nm) absorptions occur. Nanophase ferric oxide/oxyhydroxide minerals absorb, and thus block, the lethal UV radiation, while transmitting light through much of the visible and near-infrared regions of interest to photosynthesis (400 to 1100 nm). Further, they were available in early environments, and are synthesized by many organisms. Based on ferric oxide/oxyhydroxide spectral properties, likely geologic processes, and the results of experiments with the photosynthetic organisms, *Euglena sp.* and *Chlamydomonas reinhardtii*, we propose a scenario where photosynthesis, and ultimately the oxygenation of the atmosphere, depended on the protection of early microbes by nanophase ferric oxides/oxyhydroxides. The results of this study are also applicable to other potentially habitable iron-bearing planetary bodies because of the evolutionary pressure to utilize solar radiation when available as an energy source.