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Microbial oxidation of pyrite: Experiments using microorganisms from an extreme acidic environment

KATRINA J. EDWARDS,[1,*] MATTHEW O. SCHRENK,[1] ROBERT HAMERS,[2] AND JILLIAN F. BANFIELD[1]

[1]Department of Geology and Geophysics, University of Wisconsin-Madison, Madison, Wisconsin 53706, U.S.A.
[2]Department of Chemistry, University of Wisconsin-Madison, Madison, Wisconsin 53706, U.S.A.

ABSTRACT

Surface colonization and microbial dissolution of pyrite were studied in the laboratory and by in situ surface colonization experiments conducted at Iron Mountain, California. Laboratory experiments involved organisms obtained from Iron Mountain and cultured in pH <1.0, 42 °C solutions designed to enrich for chemolithotrophic species present at acid-generating sites. Planktonic and sessile microorganisms grew in enrichment cultures containing small amounts of yeast extract. The maximum density of attached cells was approximately 8×10^6 cells/cm^2. Attachment was specific for pyrite and occurred nonrandomly; rod-shaped bacteria tended to orient parallel to {100} and {110} pyrite. Attachment resulted in formation of euhedral dissolution pits. Cultures grown without yeast extract contained only planktonic cells and euhedral dissolution pits were not developed on the pyrite surface. All cultured organisms were identified as bacteria by fluorescence in situ hybridization and domain-specific probes. *Leptospirillum ferrooxidans* comprised 10–40% of planktonic organisms in both enrichments. *Thiobacillus ferrooxidans* was not identified in either enrichment. Oxidation rates were approximately equivalent in both enrichments (4×10^{-7} μM Fe/cell·day) over a 28 day period.

Pyrite cubes were exposed to natural solutions at Iron Mountain for two months. A subset of samples was exposed only to solutions that had passed through 0.22 μm Teflon filters. Denser colonization (by distinctive elongate bacteria not observed in laboratory cultures) occurred on pyrite in filter-covered vessels. Attachment specificity, orientation, and resulting degradation morphology were similar to that observed in laboratory cultures. Results show that interaction between attached cells and pyrite surface is highly specific and the impact on surface morphology evolution is different from that associated with planktonic microorganisms, despite the similarity in effect (per cell) on total dissolution rates.