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Microbial pyrite oxidation at various oxygen partial pressures

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In order to study the effect of oxygen partial pressure on pyrite oxidation in the presence of the sulfur and iron oxidizer *Acidithiobacillus ferrooxidans*, pyrite oxidation rates at various oxygen partial pressures (Po_2) were examined.

Six different batch experiments were performed at room temperature for 75 days under various Po_2 levels (0.21, 0.10, 0.05, 0.01, 0.00 atm), containing crushed pyrite (particle size 63-250 µm) and a modified 9K nutrient medium at pH 3. Five experiments were inoculated with *A. ferrooxidans*, and one acted as a sterile control at $Po_2 = 0.21$ atm. All solutions were frequently sampled and analyzed for sulfur, total iron, Fe(II), pH, redox potential and microbial activity.

In all experiments, pH decreased with time and sulfur and iron were released to the solution, indicating pyrite oxidation at all Po_2 levels. A gradual increase of total iron and sulfur concentrations with time and increased Po_2 levels was furthermore observed in the experiments. Pyrite oxidation rates (based upon total sulfur and iron release rates) were calculated in all experiments (Figure 1). Sulfur-based oxidation rates were generally more rapid relative to iron-based oxidation rates, since some of the iron precipitated on the pyrite surfaces. The microbial oxidation rate was most rapid at $Po_2 = 0.21$ atm and decreased with decreasing Po_2. A linear relationship was furthermore found between increasing Fe(III)-content and increasing sulfur-based pyrite oxidation rate.

It is thus concluded that oxidation rates due to bacterial activity increase with increasing Po_2 levels.

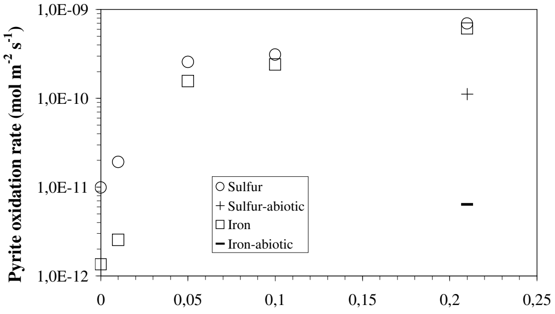

Figure 1. Pyrite oxidation rates (mol m^{-2} s^{-1}) in the different experiments.

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Geochemistry and biogeochemistry of Ga, Ge, and Ti during weathering

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Microorganisms and microbial metabolites can fractionate major and trace elements during mineral weathering due to the formation of metal organic complexes. Laboratory mineral dissolution experiments, and laser ablation ICP-MS analysis of naturally weathered samples collected from granodioritic soil and saprolite were conducted to determine the role of organic compounds on mineral weathering and element mobility.

Feldspar and biotite dissolution experiments were conducted in dilute solutions of organic acids (oxalate, citrate, and α-ketoglutarate) and an inorganic control to simulate the initial stages of mineral alteration. Solutions were analysed for major and trace element concentrations by ICP AES and ICP MS. The release of major ions (Si, Al, Ca) to solution was approximately 5 to 20 times higher in the organic acid solutions compared to the inorganic control at initial pH 4. Dissolution reactions were approximately stoichiometric in organic solutions, with the exception of Ca/Si in the oxalate experiments due to the formation of insoluble Ca-oxalate minerals.

Ti and Ga release to solutions in the organic experiments was approximately 10 to 50 times greater than in the inorganic control, and Ti/Si and Ga/Al release to solution was ~ two times greater than the controls. Ge was not detected in solution in the inorganic controls, though in the organic experiments, Ge concentrations were ~ 3 to 10 times higher than the detection limit. Results of laboratory experiments indicate that complexing organic compounds can preferentially mobilize trace elements from dissolving minerals.

Laser ablation analyses of mineral grains collected from the saprolite shows that Ge and Ga concentrations are somewhat variable depending on mineralogy and composition. For example, Ge and Ga concentrations are lower in quartz and higher in feldspar and biotite. Both Ge and Ga are significantly elevated in Al and Fe rich secondary mineral phases compared to adjacent mineral grains. Although the absolute Ga concentration is elevated in these the Ga/Al ratio is lower, indicating that Ga is preferentially mobilized compared to Al.