Field and laboratory measurements for modeling microbial and abiotic Fe(II) oxidation at mine sites

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Rates of Fe(II) oxidation to Fe(III) are mediated by microbial activity at lower pH (typically < 5), whereas abiotic oxidation dominates under near-neutral conditions [1]. Field sampling at two inactive mine sites in California, USA, and laboratory oxidation experiments using synthetic and natural Fe(II)-rich solutions provide data that we are using to develop a geochemical model of Fe(II) oxidation and the formation of secondary hydrous ferric oxides (HFO), such as goethite and ferrihydrite, and ferric oxyhydroxy-sulfates (FOHS), such as schwertmannite. These secondary Fe(III) minerals form pipe scale in acid-mine-drainage (AMD) treatment systems, causing costly cleanup challenges.

We are using PHREEQC with kinetics to develop a 1-dimensional transport model of a pipe-line carrying AMD at the Iron Mountain Mine. A series of tracer-injection tests (using rhodamine-WT or lithium chloride) over a range of flow conditions were conducted to measure travel time and dispersivity for model calibration. Oxidation of Fe(II) at Iron Mountain was microbially mediated, where pH was consistently between 2.5 and 3.0. The precipitate formed in the pipeline was dominantly FOHS with minor amounts of goethite. The microbial community, identified by both culture dependent and independent methods, was identified (including *Acidithiobacillus* and *Leptospirillum* species) and the Fe(II) oxidizing population was incorporated into the geochemical model through the microbial kinetic expressions.

At the Leviathan Mine, we sampled three acid mine waters flowing in and out of pipes over a pH range of 3.0 to 5.7. Laboratory oxidation experiments revealed that Fe(II) oxidation was microbially mediated at pH < 5 but proceeded abiotically at pH > 5.5. Pipe scale at Leviathan Mine was also primarily FOHS with minor HFO. The similarity of the pipe scale between the two sites suggests that the geochemical model developed in detail at Iron Mountain can be applied to other sites with pipe scale issues and may be useful for site management decisions.

[1] Singer and Stumm (1970) *Science* **167**, 1121-1123.