

Experiments of CO₂-brine-feldspar/sandstone/shale interactions: Implications for geological carbon sequestration

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A series of feldspar/sandstone/shale-brine-CO₂ hydrothermal experiments have been performed in the laboratory. Navajo Sandstone samples (target formation for CCS in the US west), shale chips from the basal Eau Claire Formation in south western Indiana (caprock for storage in the Midwest), and alkali feldspar samples were reacted with CO₂ and brine at 200 °C and 200 – 300 bars. The evolution of brine chemistry during the experiments was monitored and the solid reaction products were analyzed with XRD, SEM, and TEM.

The Navajo Sandstones after experiment show dissolution textures, the formation of carbonate minerals, and precipitation of allophane and illite/smectite cements. There is no evidence that suggests the removal of clay coating due to chemical reactions. For the CO₂-brine-shale system, only minor dissolution of K-feldspar and anhydrite was observed. However, precipitation of pore-filling and pore-bridging illite and/or smectite, carbonates may reduce the permeability and tend to locally enhancing the integrity of the repository.

The feldspar-CO₂-brine experiments allowed us to examine how the dissolution of feldspar and precipitation of secondary minerals are coupled. Experimental evidence shows that product mineral precipitation is a slow kinetic process and partial equilibria between aqueous solution and product minerals were not held. In contrast, the experimental evidences are consistent with our new hypothesis that slow clay precipitation kinetics partly explains the well known field – lab rate discrepancy [1].

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[1] Zhu, C. 2009. Geochemical Modeling of Reaction Paths & Geochemical Reaction Networks. In, Oelkers, E. H. & Schott, J. (eds) *Thermodynamics & kinetics of water-rock interaction*. vol. 70, pp.533-569, Mineralogical Society of America.

Taking the iron snow shuttle to the microbial iron cycle in acidic lake sediments

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Acidic coal mine lakes are characterized by low pH, high concentrations of Fe (II) and sulfate and high Fe (III) solubility. In Lake 77, Germany, microbial oxidation of dissolved Fe (II) forms iron-rich macroscopic aggregates (iron snow) that precipitate to anoxic sediments. This iron snow provides an important input of Fe (III)-oxides for microbial reduction. Currently, we have only a marginal understanding of the microorganisms involved in this iron cycle at pH 3 to 5. This study aimed to (i) explore the diversity of microbial communities in iron snow and sediments of an acidic coal mine lake and (ii) elucidate the mechanisms of iron reduction at acidic pH using isolates from lake sediments. Microorganisms in iron snow were found to co-existed with iron minerals, mainly schwertmannite, using confocal laser scanning microscopy. The dominant phylogenetic group in the iron snow was *α-Proteobacteria* (96% of 16S rDNA clones), and included two major genera *Acidocella* (63%) and *Acidiphilium* (22%), which are known Fe (III) reducers. Differences were observed in the composition of microbial communities in upper acidic (pH 2.8; zone I) and lower, slightly acidic (pH 5.3; zone IV) sediments. Zone I was dominated by *Actinobacteria* (37%), *α-proteobacteria* (16%) and *Acidobacteria* (12%), while zone IV was dominated by *Acidobacteria* (24%) and *δ-Proteobacteria* (19%). The abundance of *α-proteobacteria* was lower in zone I compared to the iron snow and only small portion were detected in zone IV. *Acidobacteria*, *γ-Proteobacteria* and *Firmicutes* were found in both zones suggesting that those taxa can cope with both acidic and slightly acidic conditions. A total of 37 acidophilic and acido-tolerant isolates were obtained using an overlay plate technique. A number of isolates were capable of either oxidizing or reducing iron, whereas, some strains showed both iron-oxidation and -reduction abilities. The ability to oxidize and reduce iron varied with different iron sources and availability of O₂. Our data indicates a link between microbial communities present in iron snow and lake sediment. However, further work is needed to understand the role of *α-Proteobacteria* in iron snow and the mechanisms of Fe (III)-reduction at low pH.