Pyrite dissolution rate in saline fluids and implications for fracking

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The production of shale gas, enabled by advances in horizontal drilling, has seen a significant bloom in the last decade. Natural gas is recognized as the cleanest type of fossil fuel, hence, it is favoured over use of coal for energy generation in strategies to mitigate carbon emissions. However, some concerns have been identified, mainly regarding induced microseismicity, air pollution, and groundwater contamination, due to underground injection of fracking fluids under high pressure, and potential leakage of methane or release of heavy metals.

Previous work has shown that geochemical interaction of fracking fluids with shale may trigger dissolution of e.g. calcite and pyrite, and release heavy metals from impurities in pyrite or through desorption from clays or organic matter. In this respect, it is important to constrain the rate of pyrite dissolution, which correlates with the rate of release of its impurities, under conditions representative of shale fracking activities in order to assess its potential environmental risks. Pyrite dissolution is thought to occur as an aqueous pyrite oxidation mechanism with the rate being mainly dependent on the dissolved oxygen content and acidity of the fluids. The injection of oxygenated fracking fluids into subsurface anoxic shale layers is thus expected to trigger changes of the geochemical fluid-rock equilibrium.

In this study, we investigate how the rate of pyrite dissolution changes with the salinity of the fluids. In the experiments, we used pyrite minerals from Spain. We separated the 63 to 125 µm size fraction, and treated those particles via several cleaning steps. Subsequently, we ran mixed flow reactor experiments with a flow rate of approximately 2 ml per minute, using 3 g pyrite in 300 ml fluid. Fluid salinities in the experiments were varied from 0 to 3.4 M NaCl, and a pH of 1 was maintained throughout the experiments. The results show that the pyrite dissolution rate overall decreases with increasing salinity in the experiments. However, fluid salinity correlates with oxidation reduction potential and other parameters. Hence, the pyrite dissolution rate may only be indirectly impacted by the salinity in the fluids. These results may help in the prediction of potential environmental impact by injection of oxygenated freshwater fluids in subsurface anoxic shale layers with saline formation fluids.