Chlorite Dissolution Rates in scCO₂-Saturated Saline Water at 100°C and 100 bar

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Mineralogical trapping is one of several trapping mechanisms of CO_2 for geological carbon sequestration, and presents the most secure form of CO_2 storage over millenia. Mineralization of CO_2 requires release of cations from dissolution of divalent cation-bearing silicate minerals, so the extent and timing of CO_2 mineralization depends on the mineralogy and dissolution kinetics of the sandstone reservoir rocks. There are currently few experiments that measure the coupled dissolution and precipitation rates of reactions of multi-mineral systems under the conditions of sequestration. We have experimentally measured the rate of chlorite dissolution in saline water saturated with supercritical CO_2 (pCO_2 = 100 bar) at 100°C using a mixed flow reactor. This experiment simulates the reactive front of supercritical CO_2 and aquifer water.

Chlorite is mechanically broken to pieces in the cm-range and then ground to millimetre size. Particles from 100 to 150 micron are sieved (surface area = 4.872 m^2 g^{-1}) and washed. 1 gram of chlorite particles is used for the experiment. The reactor is filled with saline water (0.01 mol/L NaCl), and brought to experimental run temperature. Supercritical CO_2 is pumped into the reactor to 100 bar and then equilibrated with saline water at this temperature and pressure. Saline water fills 260 ml of the 300 ml reactor and forms a 40 ml CO_2 cushion above the water surface to ensure that brine is always saturated with CO_2. The reactor containing chlorite is stirred as saline water is continually pumped through.

The measured release rate of Fe and Mg is 1-2 picomole/m^2/sec, which is not far from typical silicate dissolution rates under standard laboratory conditions. Nevertheless, this rate, especially when considered in the light of relatively high surface area for chlorite, is sufficient to allow substantial CO_2 mineralization in chlorite-bearing sands on a timescale of 1000 years.

Lattice Boltzmann modelling of Stellate Plagioclase, central layered series of Isle of Rum, Scotland

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Abstract

We propose a model for the formation of branching plagioclase textures visible at both macroscopic (~cm to m) and microscopic scale within melagabbro, Isle of Rum Scotland. The plagioclase crystals are typically linked as twins and form meshes of planar stellate structures (m-scale) with a large range in geometrical organization from patchy to radiating. Evidence of macroscopic crystal aggregation and alignment is attributed to interfacial free energy minimization at the microscopic scale during growth. Accordingly, a binary immiscible Lattice Boltzmann model was developed to simulate diffusion of simplified plagioclase in the melt phase. Isothermal phase transitions modelled via first order chemical reactions are subsequently coupled with stochastic dynamics at the crystal growth front to simulate energy minimization processes including twinning during crystallization in an igneous environment. A flexible coupling of the solid phase with respect to the melt phase sets the overall ratio between the rate of diffusion and chemical enrichment in the liquid state and the rate of crystallization. Results are in reasonable agreement with observations. Aspects of the model and current progress will be presented.