



Contribution ID: 139

Type: Oral 20 Minutes

Determining the effective surface area of minerals in consolidated sediments

Monday, 14 May 2018 11:18 (15 minutes)

The effective mineral surface area is often the least well constrained variable in the prediction of geochemical reaction rates and, therefore, poses a large uncertainty when modelling reactive-transport in porous rocks. The mineral surface area is often estimated using a combination of microscopic and spectroscopic techniques or using disaggregated sediment in dissolution experiments. Both approaches have been shown to overestimate the accessible or effective mineral surface area. In this study we have developed core-flood experiments to determine the effective surface areas of quartz, kaolinite and muscovite. Fluids with a pH of 2 and 12 are injected into a sandstone core plug at high flow rates to prohibit secondary mineral formation. The effective mineral surface area is calculated based on the general reactive-transport equation and uses the steady-state outflow concentrations of Si, Al and K, the fluid residence time and the known mineral dissolution rate constant at the given pH and temperature. This approach directly compares the dissolving mineral surface area in a consolidated sample to the normalised mineral surface area used to derive mineral specific dissolution rate constants. The derived effective mineral surface area therefore represents an intrinsic rock property. Variable injection rates and the associated differences in fluid residence time and cation concentrations in the outflow lead to similar surface area estimates as long as no secondary minerals are formed. The abundance and surface area of carbonate minerals can be estimated from the initial non-steady state core flooding phase using an injection fluid of pH 2 and the temporal changes in Ca, Mg and pH in the outflow by fitting the reactive-transport simulation curve to the experimental results.

References

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Session Classification: Parallel 1-D

Track Classification: GS 3: Experimental achievements