Dissolution kinetics of muscovite and K-feldspar at geothermal conditions

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Mineral reactivity can play an important role in fracture-controlled fluid networks where maintaining or increasing permeability is a goal, such as in enhanced geothermal systems. A set of kinetic experiments have been conducted using flow-through reactors at temperatures of 100-280 ˚C and a pH range of 2-9 for dissolution of muscovite and K-feldspar.

Muscovite reactivity showed little variation with pH above 150 ˚C, but is strongly dependent on temperature from 70 until 250 ˚C. Aluminum was released to solution nonstoichiometrically with respect to dissolved silica, resulting from secondary precipitation of an aluminum oxy-hydroxide identified as boehmite (γ-$AlO(OH)_{(s)}$) by X-ray diffraction in reaction products from experiments conducted at pH $\leq$ 6. The generalized TST rate expression described muscovite dissolution rates from this study along with lower temperature literature rates. Over a temperature range of 25-280 ˚C, muscovite dissolution rates increased by over 16,000 times at a given pH value. Seven rates at T $\geq$ 200 ˚C were identified as near muscovite equilibrium, which required the inclusion of a simplified linear reaction affinity term.

K-feldspar reactivity was found to be dependent on temperature with rates increasing as much as 14,000 times from 25 – 280 ˚C at a given pH. Resulting alkaline rates at 280 ˚C were strongly dependent on the reaction affinity term as fluid-mineral saturation was approached. Evaluation of the relative affinity term along with previously published data resulted in a nonlinear affinity term that best described the near-equilibrium model. The precipitation of an aluminum oxy-hydroxide was also observed by scanning electron microscopy and energy-dispersive spectroscopy at acidic conditions and 280 ˚C. These resultant rate models can be used in combination with reactive transport simulators to assess the role of geochemistry on flow through high-temperature shear zones, on the evolution of overall reservoir permeability and on a wide range of other relevant crustal processes.