Geophysical Research Abstracts
Vol. 18, EGU2016-2576, 2016
EGU General Assembly 2016

Combining water-rock interaction experiments with reaction path and reactive transport modelling to predict reservoir rock evolution in an enhanced geothermal system

Tim Kuesters (1,2), Thomas Mueller (2), and Joerg Renner (1)

(1) Institut fuer Geologie, Mineralogie und Geophysik, Ruhr-Universitaet Bochum, 44801 Bochum, Germany (tim.kuesters@rub.de), (2) Institute of Geophysics and Tectonics, School of Earth and Environmental Sciences, University of Leeds, Leeds, LS2 9JT, UK

Reliably predicting the evolution of mechanical and chemical properties of reservoir rocks is crucial for efficient exploitation of enhanced geothermal systems (EGS). For example, dissolution and precipitation of individual rock forming minerals often result in significant volume changes, affecting the hydraulic rock properties and chemical composition of fluid and solid phases. Reactive transport models are typically used to evaluate and predict the effect of the internal feedback of these processes. However, a quantitative evaluation of chemo-mechanical interaction in polycrystalline environments is elusive due to poorly constrained kinetic data of complex mineral reactions. In addition, experimentally derived reaction rates are generally faster than reaction rates determined from natural systems, likely a consequence of the experimental design: a) determining the rate of a single process only, e.g. the dissolution of a mineral, and b) using powdered sample materials and thus providing an unrealistically high reaction surface and at the same time eliminating the restrictions on element transport faced in-situ for fairly dense rocks. In reality, multiple reactions are coupled during the alteration of a polymineralic rocks in the presence of a fluid and the rate determining process of the overall reactions is often difficult to identify.

We present results of bulk rock–water interaction experiments quantifying alteration reactions between pure water and a granodiorite sample. The rock sample was chosen for its homogenous texture, small and uniform grain size ($\sim$0.5 mm in diameter), and absence of pre-existing alteration features. The primary minerals are plagioclase (plg – 58 vol.%), quartz (qtz – 21 vol.%), K-feldspar (Kfs – 17 vol.%), biotite (bio – 3 vol.%) and white mica (wm – 1 vol.%). Three sets of batch experiments were conducted at 200 °C to evaluate the effect of reactive surface area and different fluid path ways using (I) powders of the bulk rock with different grain sizes (<120 μm and 120 – 180 μm), (II) cubes of the intact rock ($\sim$ 1 cm^3) and (III) thermally cracked rock cubes. Run durations were up to 60 days and the bulk fluid reservoir was regularly sampled to monitor the compositional evolution (Na, K, Ca, Si, Al, Fe, and Mg) and pH. The temporal evolution of the fluid was compared to a numerical simulation which combines the iPhreeqC application library (thermodynamic calculations) with a self-coded FORTRAN program (dissolution / growth kinetic, mineral nucleation, crystal size distribution and reactive surface area). Experimental and modelling results both indicate a fast increase of Na, Ca, K and Si related to kinetically controlled dissolution of plg, Kfs and qtz. The concentrations of Al, Mg, and Fe reach a maximum in the first two days followed by a rapid decrease caused by clay mineral precipitation. Measured rates depend on the properties of the starting material controlling the effective element flux. The reaction path modelling based on new kinetic data constrained by our experiments provides a quantitative basis for a model of polycrystalline rocks that exhibits the potential for upscaling and thus an improved prediction of large scale reactive transport for EGS.