Geophysical Research Abstracts
Vol. 16, EGU2014-15121, 2014
EGU General Assembly 2014

How does the composition affect the mechanical behaviour of simulated clay-rich fault gouges?

Elisenda Bakker, Christopher J. Spiers, and Suzanne J.T. Hangx
High Pressure and Temperature Laboratory, Utrecht University, Utrecht, Netherlands (e.bakker1@uu.nl)

CO_2 capture and storage (CCS) in depleted oil and gas reservoirs is seen as one of the most promising large-scale CO_2-mitigation strategies. Prediction of the effect of fluid-rock interaction on the mechanical integrity and sealing capacity of a reservoir-seal system, on timescales of the order of 1,000 or 10,000 years, is important to ensure the safety and containment of a reservoir in relation to long-term CO_2 storage. However, most chemical reactions in rock/CO_2/brine systems are slow, which means that long-term effects of fluids on rock composition, microstructure, mechanical properties and transport properties cannot be easily reproduced under laboratory conditions. One way to overcome this problem is to use simulated fault gouges in experiments, investigating a range of possible mineralogical compositions resulting from CO_2-exposure.

Previous studies have shown that the mechanical and transport properties of clay-rich fault gouges are significantly influenced by the mineralogy, particularly by the presence and relative amount of secondary phases, such as quartz and/or carbonate. In CCS settings, where dissolution and/or precipitation of carbonates may play an important role, the carbonate:clay ratio is expected to influence fault frictional behaviour. This is supported by the different behaviour of phyllosilicates, which generally show stable slip behaviour (aseismic), compared to carbonates, which have shown to become prone to unstable slip (potentially seismic) with increasing temperature. However, little is known about the mechanical and transport properties of carbonate/clay mixtures.

We investigated the effect of the carbonate:clay ratio on fault friction, fault reactivation potential and slip stability, i.e. seismic vs. aseismic behaviour, as well as transmissivity evolution during and after fault reactivation. We used two types of starting material, derived from crushed Opalinus Claystone (Mont Terri, Switzerland): i) untreated samples consisting mainly of phyllosilicates (60%), quartz (~20%) and calcite (~15-25%) and ii) "leached" samples consisting of phyllosilicate (65%) and quartz (35%), where the removal of the calcite represents a worst-case scenario for rock/CO_2/brine (dissolution) reactions. We performed triaxial direct shear experiments at relevant in-situ temperatures (60-120°C) under saturated conditions (Pp = 25 MPa), using demineralized water as pore fluid, at an effective normal stress (σn) of 50 MPa and shear velocities of 0.22 to 10.9 μm/s.

Preliminary results show that the shear strength of the leached samples decreases by ~10-15% with respect to the natural, untreated clay samples. Typical steady-state friction coefficient values obtained for the natural samples are in the range 0.27-0.33, whereas for the leached samples they vary between 0.24 and 0.27. These values are significantly lower than typical friction coefficient values obtained for pure calcite (i.e. 0.62 to 0.71). Both natural and leached samples show velocity strengthening behaviour. The slip stability of the natural gouge appears to be slightly more temperature dependent, showing somewhat higher values of the stability (rate and state friction) parameter (a-b) for lower temperatures.