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The impact of geological storage of CO_2 on the mechanical behaviour of faults – Can we predict frictional strength and stability?

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CO_2 storage in depleted oil and gas reservoirs is seen as an important climate change mitigation strategy. In order to evaluate storage integrity of the reservoir-caprock system, potential leakage pathways, such as pre-existing or induced faults, need to be investigated. The mechanical and transport properties of intact and fractured rock may be affected by both short and long-term (> 100 years) fluid-rock interactions. In practice, chemical interactions that occur on timescales longer than a few months are too slow and difficult to reproduce in laboratory experiments.

Recently, research within the CCS community has steered towards investigating the effect of CO_2 on fault stability and particularly towards induced seismicity. In this context, we performed a variety of mechanical tests on rock types relevant for CCS sites, with the aim of investigating the effect of CO_2/brine/rock interactions on the mechanical and transport properties of faults. To this end, we used both CO_2-exposed and unaltered rocks obtained from sandstone reservoirs of natural CO_2 fields located at Green River (Utah, USA) and Werkendam (The Netherlands). Two main types of experiment were performed: 1) triaxial tests in which cylindrical samples were shear fractured, studying subsequent slip on the fault, and 2) direct shear tests performed on (simulated) fault gouge prepared by crushing intact rock.

Our results showed that the frictional stability of fault gouges is largely controlled by factors such as mineralogical composition, notably carbonate content, and temperature. We have placed our results in the context of the large body of data that already exists on fault gouge friction behaviour. The combined body of work encompasses materials ranging from clay-quartz mixtures, to anhydrite and carbonate rocks, all of which are relevant rock types for CCS. In this way, we delineate the knowledge gaps that still exist, and we show how the available data can be used to make preliminary predictions on fault friction behaviour and (micro)seismic fault reactivation potential in geological CO_2-storage systems.