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Along and across fault permeability of clay-rich fault gouges and implications for CO_2 storage.

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Faults are weak features within rock formations and therefore require attention when selecting suitable CO_2-storage reservoir – caprock systems. In response to changes in stress state due to CO_2-injection fault slip may occur and potentially result in the formation of leakage pathways to fluids stored in the reservoir (e.g. CO_2 or formation water). In the context of long-term CO_2 storage it is therefore important to investigate the mechanical strength and stability behaviour of faults. Furthermore, to assess the extent to which faults can serve as leakage pathways to fluids, it is also important to investigate the effect of changes in stress state (normal stress) on the transport properties of faults. The flow properties of a fault are determined by both the fault core and the surrounding damage zone. In our study, we focussed on the fault core, which consists of very fine-grained fault gouge.

Studies addressing the transport properties of faults have so far focussed predominantly on the permeability perpendicular to the fault plane ("across fault permeability"). These studies showed that faults are barriers to fluids, such as oil and gas, in closed reservoir systems retaining the fluids for over 1,000-10,000 years. However, little is known about the permeability of faults parallel to the fault plane ("along fault permeability"). Safe long-term CO_2-storage in systems containing pre-existing faults will only be effective if both the across and along fault permeability are low. Therefore, knowledge of the effect of shear displacement on both across and along fault permeability is needed. In particular, re-activation of a fault could cause dilatation of the fault plane, thereby increasing the permeability. We addressed these issues by performing permeability experiments, both across and along fault during shear deformation of simulated clay-rich fault gouges, serving as analogues for shaly caprocks. We used a direct shear configuration and performed slide-hold-slide experiments at applied normal stresses of 5-50 MPa at room temperature.

Preliminary results suggest that both the along and across fault permeability are sensitive to the applied normal stress, decreasing gradually with increasing normal stress. Permeability furthermore decreases with shear displacement, presumably due to progressive grain size reduction and compaction of the gouge layer.