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# Effects of phyllosilicates and diffusive mass transport on fault strength in the mid and upper crust

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An increasing body of field evidence indicates that mature crustal fault zones are characterised by low strength related to the presence of connected strands of foliated, phyllosilicate-rich fault rocks often showing intense fluid-rock interaction. In recent years, numerous experiments have been conducted at Utrecht to investigate the rheological behaviour of such materials. High strain rotary shear experiments performed on fault gouge analogues consisting of clays or micas plus halite (and brine), have shown that the presence of the phyllosilicates has a major effect on the frictional behaviour of the gouge under simulated upper crustal conditions – i.e. where both cataclasis and solution transfer operate in the halite (matrix) phase. While 100% halite and 100% phyllosilicate samples exhibit rate-independent frictional behaviour, the strength of mixtures containing 10-30% phyllosilicate is both normal stress and sliding velocity dependent. At low velocities ($< 1$ $\mu$m/s), the strength increases with increasing velocity and normal stress, and a strong phyllonitic foliation develops. At high velocities ($> 1$ $\mu$m/s), marked velocity-weakening occurs, along with the development of a structureless, cataclastic microstructure. Comparison with specifically developed microphysical models shows that the low velocity behaviour is the result of frictional sliding on the phyllosilicate foliae, with accommodation by pressure solution of the intervening halite clasts, whereas the velocity weakening (cataclastic) regime reflects two-phase granular flow involving competition between intergranular dilatation and compaction by pressure solution of the halite. Extension of our microphysical mod-

els to quartz-phyllosilicate systems predicts a major reduction of long term, steady state strength at mid-crustal depths, comparable to levels inferred for the San Andreas Fault, as well as major velocity weakening effects at higher slip rates. Interestingly, our experimental results and models imply that strength recovery, during periods of arrested slip, will be large in the rapid slip (velocity weakening) regime but only minor in the low velocity (velocity strengthening) regime. This offers a possible explanation for the recurrence of seismogenic slip at specific locations on natural faults. Work is in progress to test the applicability of our models to realistic fault rock systems relevant to the San Andreas and other faults, using our new hydrothermal rotary shear machine. Systems under consideration include quartz-muscovite, quartz-talc and serpentinite-talc gouges. Preliminary results indicate that about 10 volume percent phyllosilicate is needed for significant weakening.