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Effects of illite content on frictional properties of experimental carbonate faults

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A large number of earthquakes nucleate and/or propagate through thick sequences of carbonates that quite often are partially in contact with clay-rich formations. Faulting processes, within mechanically heterogeneous formations, result in fault rocks with different concentrations of calcite and clay. Since calcite (strong) and clay (weak) tend to produce an opposing effect on fault strength, we performed laboratory experiments to better understand how various amounts of clay influence the frictional properties of carbonate faults.
We used a biaxial rock deformation apparatus (BRAVA) to perform a series of friction experiments on dry and wet simulated calcite fault gouges, in which illite content ranges from 0 to 100% in weight. In double-direct shear configuration, we sheared a set of 5 mm-thick layers of calcite-illite mixtures at constant sliding velocity, 10 μm/s, and at normal stresses of 30, 50 and 100 MPa. In these experiments, we conducted velocity-stepping tests (0.1-300 μm/s) and slide-hold-slide tests (30-3000s) to assess frictional stability and measure frictional healing, respectively.
Our friction measurements indicate that the steady state friction coefficient decreases with the increasing illite content changing from μ = 0.7 for pure calcite to μ = 0.5 for pure illite samples. All the tested materials are characterized by a velocity strengthening behaviour, with a limited velocity weakening at low sliding velocities, observed in pure calcite and 30% illite mixtures. In general, the increase in clay content enhances the rate-strengthening behaviour and reduces the frictional healing of the experimental faults. Currently, we are analysing the wet experiments to test the possible role of water in frictional properties.
Our preliminary results suggest that illite presence modifies the frictional properties of carbonate gouge. In particular, an increasing amount of illite content tends to stabilize carbonate fault slip behaviour and therefore to favour stable sliding and fault creep.