Evolution of fault zones and its rheology

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Knowledge of the strength of faults in the continental upper crust is critical to our understanding of crustal stress states, coseismic faulting, and lithospheric deformation. In this paper, we investigate time- and displacement-dependent fault-zone weakening (softening) over geological time caused by the hydrothermal alteration of rock, the development of faulting-related structure and fabric, and changes in the relevant deformation mechanisms. In the shallow portion of the continental seismogenic zone (<5 km), hydrothermal alteration induced by comminution and fluid flow along fault zones progressively enriches weak phyllosilicates. The development of phyllosilicate-aligned fabric with increasing shear strain leads to an effective weakening with increasing cumulative fault displacement. In the deep portion of the seismogenic zone (>5 km), frictional–viscous flow occurs in combination with friction contributed by phyllosilicates and the dissolution–precipitation of clasts after the introduction of water, phyllosilicates and anastomosing fabrics all increasing with greater fault displacement. In addition, the water weakening of quartz and feldspar is an important softening process in the deeper portion of the seismogenic zone (>10 km). The smoothing of fault-zone topography by the shearing of irregularities and asperities, as well as the thickening of the fault zone, leads to a reduction over time in the bulk frictional resistance of a fault as displacement increases. These time- and displacement-dependent weakening processes of fault zones give rise to diverse strength and stress states of the crust depending on its maturity and may provide clues to reconciling the stress–heat flow paradox of crustal faults.

Keywords: Crustal strength profile, Brittle-plastic transition zone, Phyllosilicate, Frictional-viscous flow, Water weakening, The heat-flow paradox

