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Cohesive Strengthening of Fault Zones During the Interseismic Period: An Experimental Study

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There is widespread evidence indicating that faults regain a portion of their strength during the interseismic period. Here, we present experiments designed to understand and quantify the interseismic cohesive strengthening resulting from fluid-rock reactions in fault zones. The tri-axial experiments consist of fracturing cores of Fontainebleau sandstone under dry conditions, forming a localized shear fracture(stage 1). The specimens are then reacted hydrothermally under isostatic conditions, allowing fault gouge material to compact, consolidate and strengthen(stage 2). Following reaction, the specimens were then reloaded to failure under nominally dry conditions, so that the increase in cohesive strength of the fault could be measured(stage 3). Experiments show that cohesion increase is positively correlated to temperature and pore pressure during reaction. After 6 hours of reaction at highest temperatures(927°C) and pore pressures(200 MPa), cohesion increases by as much as 35 MPa. Microstructural examination of the specimens show that the gouge particles within the fault have compacted and cemented together, exhibiting textures typical of pressure solution. A theoretical treatment of the data has been conducted using these experiments in combinations with a time-dependent suite presented in Tenthorey et al. [2003]. We find that the rate-controlling process in our experiments has an activation energy(Q) of approximately 70 kJ/mol. We have used this information to develop a model for time-dependent cohesive strengthening in fault zones under realistic temperature conditions. We conclude that significant cohesive strengthening of fault zones should occur during the interseismic period of medium to large earthquakes.