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Effect of dehydration reactions on the stability of creeping faults

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The stability of creeping faults is studied under the effects of shear heating pore fluid pressurization, and dehydration reactions. The equations that govern the evolution of the velocity sliding block and of pore pressure and temperature inside the slip zone are deduced from the mass and energy balance of the multi-phases saturated medium and from the kinetics of the dehydration reaction. Such reactions induce two competing effects: a direct increase in pore pressure because they release fluid, and a limit in temperature increase because part of the frictional heat is absorbed in the endothermic reactions. We performed a linear perturbation analysis at the vicinity of the dehydration temperature to study the effect of the chemical reaction on the stability of stationary slip. Dehydration reactions increase the critical stiffness at which the system becomes unstable: they are thus a destabilizing factor. Depending on the sign of the perturbations, it is shown that dehydration reactions can either (1) trigger a catastrophic increase of pore pressure at quasi constant temperature leading to an acceleration of the fault motion, or (2) trigger an arrest of the fault. Numerical simulations demonstrate the crucial role of initial pore pressure and temperature in the slip zone prior to the onset of the chemical reaction on the subsequent evolution of the system. For highly pressurized fault zones, in which the creep motion of the fault is stable in absence of dehydration reactions, the onset of the reaction can trigger transient slip events induced by chemical pressurization. The magnitude of such events appears to be proportional to the reaction progress. We conclude that metamorphic dehydration reactions strongly modify the nucleation of unstable slip, and are a possible origin for slow slip events in subduction zones.