Heat, fluids and weakening: experimental clues on the microscale processes of high velocity sliding friction

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Fault rocks undergo abrupt dynamic weakening and lubrication during seismic slip, reputedly associated to thermally triggered physico-chemical processes. Recent experiments systematically explore rock friction under crustal earthquake conditions (fast slip rate $1<V<6$ m/s, intermediate normal stress $5<\sigma<50$ MPa, pore water pressure or dry, various lithologies). The detailed evolution during experiments is confronted to the predictions of various thermal weakening models (flash weakening, superplastic diffusion creep, frictional melt lubrication).
In the absence of melting and/or pressurization, the weakening transient is compatible with flash weakening of the contact asperities, in a revised version of the model proposed by Archard (1958) and Rice (2006). A simple model where the strength of the slip zone is directly controlled by Arrhenious-like thermal dependence also provides a reasonable fit. In all cases it is critical to include the effect of heat sinks (latent heat of phase transitions) in the evolution of temperature at the interface.
In silicatic rocks under coseismic conditions, the initial flash-weakening phase is followed by pervasive melting and subsequently shows a behavior compatible with the lubrication model of Nielsen et al. (2008, 2010).
The effects of water pore pressure on the mechanical evolution vary subtly depending on lithology and amount of sliding. These effects provide interesting clues as regards the strain mechanisms at the asperity scale.