Geophysical Research Abstracts, Vol. 8, 05369, 2006
SRef-ID: 1607-7962/gra/EGU06-A-05369

The effects of flash-weakening and damage on the evolution of fault strength and temperature

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The effects of fluid pressurization in altering the fault strength and limiting the temperature rise during earthquake slip are modeled for the case of a thin, but finite, shear zone, with state-dependent properties that are chosen to represent conditions along a mature fault at moderate seismogenic depth. We include the effects of flash-weakening at highly stressed asperity contacts by extending the model of Rice [1999; 2006] to treat the relative motion between gouge particles as equal to either 1) the slip rate or 2) the product of the particle diameter and the strain rate. At slips exceeding a few centimeters, the strength evolution is relatively insensitive to the difference between these two formulations, but the predicted temperature rise is considerably greater for the strain-rate dependent case. Our calculations demonstrate how increasing levels of damage can significantly limit the reduction in fault strength, resulting in more rapid heating and ultimately leading to the predicted onset of melting following relatively modest slips.