What controls the spectrum of slip behaviour of (laboratory) earthquakes?

Faults become transiently weak during the propagation of earthquakes. Any weakening occurring where the fault is actively slipping can release large elastic energy that promotes the propagation of the rupture tip (Fig. 1). In particular, fast, efficient lubrication of the thin sliding portion of seismic faults promotes slip acceleration, rupture propagation and radiation of potentially hazardous waves. On the other hand, larger-scale heterogeneities produced by coseismic off-fault damage contribute to energy dissipation. Such energy sinks can cause low radiation efficiency and promote slow rupture velocity.

Several mechanisms, triggered by shear heating, have been proposed to explain the coseismic weakening of faults. However, a unifying law describing the thermal weakening observed for different rock types is still lacking. Here we show that a general Arrhenius-type law, similar to those describing aseismic creep deformation and melt lubrication (common in silicate rocks), also describes lubrication of faults during earthquakes by viscous processes at sub-melting temperatures.

Further, we present experimental evidence that the interplay between localised coseismic weakening and fault heterogeneities, arising from coseismic distributed damage, can explain the spectrum of slip behaviour – from “slow” to “fast” – shown by laboratory earthquakes.

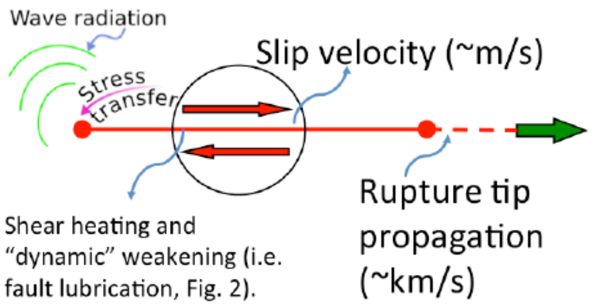

Fig. 1. *Schematic representation of the relationships between the actively slipping portion of a fault and rupture propagation at its tip. Coseismic temperature rise, due to shear heating in the slipping zone, can activate dynamic weakening mechanisms and cause fault lubrication. This eases rupture tip propagation (see text for details).*