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1 Lubrication of faults by seismic melts during earthquakes

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Several seismological observations suggest that the dynamic frictional resistance τ_f of faults during earthquakes be quite low. Hence various dynamic weakening mechanisms have been proposed, among which melt lubrication. Indeed, solidified friction-induced melts (pseudotachylytes) are observed on some exhumed faults. However, melts with high viscosity (e.g., silica-rich composition) might act as coseismic fault sealants, preventing rupture propagation. Experiments approaching in-situ conditions of faulting help discern whether the melt in fact plays a strengthening or a weakening role. Here we provide the first coherent evidence of low τ_f in the presence of granitic melt, from both exhumed faults and high-velocity rock friction experiments.

Assuming that all frictional work on the fault surface is converted to heat, the volume of pseudotachylyte observed in the field yields a direct estimate of τ_f. For this purpose, coseismic slip and pseudotachylyte volume ought to be well constrained, so that only exceptional fault exposures yield an accurate estimate. Pseudotachylyte-bearing, glacier-polished fault exposures in the Adamello Massif (Italian Southern Alps) indicate a τ_f of 18.1-48.1 MPa at 10 km in depth.

In addition, high-velocity (1.28 m/s) rotary-shear friction experiments were performed at normal stress between 5-20 MPa on rock samples from the same fault. Experimental data indicate, in the presence of melt, a low τ_f and a weak dependence of τ_f on normal stress (effective friction coefficient $\sim$0.05-0.2).

The texture of artificially-produced and natural pseudotachylytes is very similar. Experimental τ_f values extrapolated to a depth of 10 km lay on the same strength curve as the field estimates, well below the Byerlee frictional strength. We conclude that, at intermediate crustal depths, low fault strength and melt-lubrication can indeed occur during seismic faulting.