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The ubiquitous viscous nature of coseismic fault lubrication

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Faults become transiently weak during the propagation of earthquakes due to the onset of thermally-activated mechanisms triggered by the large amount of energy dissipated into heat during coseismic slip. Here we show that important non-silicate rock-forming minerals, commonly found in nature, show transient viscous behaviour in nanogranular aggregates deformed at seismic strain rates (e.g. > 0.1m/s) and sub-melting temperatures. We show that during the propagation of earthquakes, the strength of experimental faults is controlled by the local temperature according to Arrhenius-type laws. Mechanical results are corroborated by microstructural observations showing the development of textures compatible with viscous flow at sub-melting temperatures, which in rocks are classically believed to be exclusive of slow, sub-seismic deformation rates (« 0.1 m/s). Textures produced this way may represent an optimum configuration to minimize the energy dissipation along the fault, improving the efficiency of rupture propagation. Sub-solidus, Arrhenius-type flow in rocks is similar to the mechanism of frictional melting typical in silicate rocks and substantiate the ubiquitous, viscous nature of coseismic deformation. Therefore, our results may offer a unifying approach to the quantification of the dynamic fault strength and to the numerical modelling of earthquakes. Furthermore, the evidence of sub-solidus viscous processes at extremely high strain rates questions the classic divide between purely brittle and ductile deformation processes in Earth materials.