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Insights into rupture processes of a laboratory-earthquake in dry and lubricated faults

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Our understanding of the dynamics of earthquakes requires us to understand the mechanisms of transition from static to sliding friction. The weakening of a fault is mediated by the propagation of rapid interfacial ruptures (earthquakes) that detach the solid contacts forming the frictional interface. By measuring the real contact area and strain fields near rough frictional interfaces, we have shown that these ruptures correspond to true shear cracks [1]. In particular, dynamic ruptures may spontaneously arrest at various locations along the interface. We show that a fracture-mechanics-based criterion can predict the location of the rupture arrest [2]. These results shed light on the selection of an earthquake's magnitude and arrest.

Another interesting question is how interstitial fluids act to weaken a fault. By performing stick-slip experiments where the contacting surfaces are covered by a thin lubricating layer, we show that the established framework of fracture mechanics can also describe the measured strain fields when rupture of the interface takes place. A surprising result is that, although reducing the frictional strength of the interface (friction coefficient), lubricants actually significantly increase the fracture energy (amount of dissipated energy) during rupture. Thus surface lubrication, while strongly reducing the residual stresses in the wake of rupture propagation, actually toughens the contacting surfaces.

[1] Svetlizky, I. & Fineberg, J. Classical shear cracks drive the onset of dry frictional motion. Nature 509, 205-208 (2014).
[2] Bayart, E., Svetlizky, I. & Fineberg, J. Fracture mechanics determine the lengths of interface ruptures that mediate frictional motion. Nature Physics (2015).