The spectrum of slip behaviors emerging from the interactions between seismic and aseismic slip

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Abstract

Increasing observational evidence supports the view that natural faults are a patchwork of seismic and aseismic slipping areas. An ongoing debate about earthquake nucleation confronts two basic models: pre-slip and cascade. I will present recent observations of accelerating foreshock and foretremor sequences that have been successfully modeled as a failure process driven by aseismic slip, and will discuss them in contrast to the competing cascade model. Computational models of the interactions between slow and fast slip, in particular involving brittle asperities embedded in a ductile matrix, reveal a rich spectrum of slip behavior analogous to that observed in slow slip, tectonic tremors, earthquake swarms and foreshock phenomena. The density of asperities is an important property that can tune faults between two end-member models: seismic events driven by slow slip, or slow slip driven by multiple seismic failures. The latter is akin to the cascade model, but here the interactions between seismic asperities are mediated by transient creep propagation in the aseismic matrix that separates them. In between the two end-member models, there is a range of behaviors that cannot be classified with a simple pre-slip versus cascade dichotomy. Moreover, micro-mechanical models of fault gouge deformation, motivated by laboratory observations, feature transitions from velocity-strengthening (stable) to velocity-weakening (unstable) behavior that offer a framework to understand time-dependent effective friction properties of faults.

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