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Fault Constitutive Properties and Earthquake Interactions

Massimo Cocco, Andrea Bizzarri & Elisa Tinti
Istituto Nazionale di Geofisica e Vulcanologia (Rome, Department Seismology and Tectonophysics)

Constitutive laws govern fault friction during the nucleation and propagation of earthquake ruptures and are required to have a finite fracture energy absorbed at the crack tip. The relation between the adopted friction law and the total dynamic traction represents one of the fundamental equations to be solved to model spontaneous dynamic ruptures. Fault friction controls the dynamic process during a single rupture episode, the earthquake repetition during the seismic cycle and earthquake triggering mechanisms due to stress interactions. In the literature two main classes of constitutive formulations have been proposed: the slip–dependent and the rate– and state–dependent (R&S) friction laws. The former assumes that friction only depends on slip, while the latter considers that friction depends on slip velocity and state variables. The first class of constitutive models includes the "classical" slip–weakening (SW) law (Baremblatt, 1959; Ida, 1972; Palmer and Rice, 1973; Andrews, 1976a, b), although other modified slip–weakening behaviors have been proposed that include a slip–hardening phase and an exponential decrease of traction with displacement (see Ohnaka, 1996 and references therein). The second class of constitutive equations is based on the laboratory derived friction laws, which were originally proposed by Dieterich (Dieterich, 1979, 1986, 1992; Ruina 1983). These two constitutive formulations can both be applied to model a dynamic crack propagation (see Bizzarri et al., 2001 and references therein), but they provide a completely different description of the nucleation process (see Dieterich, 1992; Onhaka and Shen, 1999). Further modifications of these constitutive laws have been also proposed to model the rupture healing and to control the slip duration during dynamic rupture propagation (see Beeler and Tullis, 1996; Zheng and Rice, 1998 and references therein). The main difference between slip and rate & state constitutive formulations concerns the time dependence of friction: in fact only rate– and state–dependent friction laws consider an evolution equation for the state variable that yields a time dependency of friction and accounts for fault restrengthening. Therefore, R&S laws are suitable to model the faulting process and repeated slip episodes on the fault plane.