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Beyond Byerlee Friction, Weak Faults and Implications for Slip Behaviour

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Some faults are considered strong because their strength is consistent with the Coulomb criterion under Byerlee's friction, 0.6 <μ< 0.85. In marked contrast, numerous studies have documented significant fault weakening induced by fluid-assisted reaction softening that generally takes place during the long-term fault evolution. Reaction softening promotes the replacement of strong minerals with phyllosilicates. Phyllosilicate development within foliated and interconnected fault networks has been documented at different crustal depths, in different tectonic regimes and from a great variety of rock types, nominating fluid-assisted reaction softening as a general weakening mechanism within the seismogenic crust. This weakening originates at the grain-scale and is transmitted to the entire fault zone via the interconnectivity of the phyllosilicate-rich horizons resulting in a friction as low as $0.1 < \mu < 0.3$. Collectively, geological data and results from laboratory experiments provide a strong supporting evidence for structural and frictional heterogeneities within crustal faults. In these structures, creep along weak and rate-strengthening fault patches can promote earthquake nucleation within adjacent strong and locked, rate-weakening portions. Some new frontiers on this research topic regard: 1) when and how a seismic rupture nucleating within a strong patch might propagate within a weak velocity strengthening fault portion, and 2) if creep and slow slip can be accurately detected within the earthquake preparatory phase and therefore represent a reliable earthquake precursor.