
Physics of Earthquake Cycles: An energy perspective

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Abstract

Natural fault zones containing fractures/faults of various scales from millimeters to several kilometers, under tectonic loading show complex spatiotemporal stick-slip cycles which result in a broad spectrum of rupture velocity which corresponds to slow-slip earthquakes to major earthquakes. The competition between the frictional strength of faults against slip and the dissipation due to the damaged fault zone gives rise to such complex slip behavior. We developed a two-dimensional fault-zone seismic cycle model in which the main fault is surrounded by off-faults and sliding under the rate and state friction law, which can capture all the statistical scaling laws observed in natural faults.

Next, we formulate the energy budget for the seismic cycle and derive the energy relations in terms of observable energy quantities namely: Radiated energy, Potential energy change, and apparent fracture toughness of fault zone. We show that the observable part of energy quantities can be calculated just by deducing the accurate shear slip profiles on ruptures on faults in the model. Further by partitioning the energy quantities for the main fault and the off-fault contributions, and their interaction energy, we compare the underlying physical behavior of the damage zone around main faults during slow slip events and major earthquakes.

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