EGU21-1918
https://doi.org/10.5194/egusphere-egu21-1918
EGU General Assembly 2021

Spatial Distribution of Slip and Stress Changes in Contained Laboratory-Generated Earthquakes with Heterogeneous Initial Stress

Chun-Yu Ke[1], Gregory McLaskey[1], and David Kammer[2]
[1]School of Civil and Environmental Engineering, Cornell University, Ithaca, New York, United States of America (ck659@cornell.edu)
[2]Institute for Building Materials, ETH, Zurich, Switzerland

Earthquake ruptures arrest due to either encountering a barrier with high fracture energy or entering unfavorable stress conditions. Our large-scale laboratory earthquake experiments use heterogeneity in initial stress to confine the rupture within a 3-m long saw-cut granite fault. All earthquake processes, i.e., initiation, propagation, and arrest, were spontaneous and contained within the simulated fault. We proposed an analytical crack model to fit our experimental measurements and to better constrain the features in the spatial distribution of both slip and stress changes. Similar to natural earthquakes, laboratory measurements show coseismic slip that gradually tapers near the rupture tips. Measured stress changes show roughly constant stress drop in the center of the ruptured region, a maximum stress increase near the rupture tips, and a smooth transition in between, in a region we describe as the earthquake arrest zone. In our experiments, the earthquake arrest zone is more than one order of magnitude wider than the cohesive zone described by fracture mechanics. We propose that the transition in stress changes and the corresponding linear taper observed in the slip distribution are the result of rupture termination conditions primarily controlled by the initial stress distribution and are not related to the fault strength evolution. We also performed dynamic rupture simulations that confirm how arrest conditions can affect slip distribution and static stress changes, especially near the tip of an arrested rupture. If applicable to larger natural earthquakes, this distinction between the earthquake arrest zone resulted from heterogeneous initial stress and a cohesive zone that depends primarily on strength evolution has important implications for how seismic observations of earthquake fracture energy should be interpreted.