IMPACT OF STRESS HETEROGENEITY ON RUPTURE NUCLEATION AND SEISMIC CYCLE COMPLEXITY IN A LONG LABORATORY FAULT

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Various aspects of earthquake physics are still not completely understood given its intrinsically complex nature, notably the nucleation process and seismic cycle dynamics. Seismology faces challenges in accessing precise information about the physical processes taking place on the fault plane. Our study demonstrates how laboratory seismology illuminates fault dynamics. Using a large biaxial apparatus (2.5 m fault length), we replicate fault behavior with PMMA samples, imposing heterogeneous loading and specific boundary conditions. Strain gauges at 15 locations measure stress at 40 KHz.

The experiments provide insights into two crucial aspects of laboratory earthquakes: the location of rupture nucleation and the complexity of the seismic cycle. We discover that the initial stress distribution on the fault significantly influences both aspects. Ruptures consistently nucleate in regions where the stress ratio is highest. Remarkably, these values vary across experiments, challenging the prevalent notion that friction coefficients alone dictate instability onset. Additionally, we demonstrate how the heterogeneity of the initial prestress distribution along the fault governs the seismic cycle's complexity. In certain cases, the seismic cycle manifests as system-size events with regular complete ruptures. Conversely, other initial stress distributions generate more complex cycles, marked by multiple contained events preceding the main rupture. The seismic cycle's complexity can be delineated by the number of interseismic events, inter-event time, and rupture size.

This study highlights the complexities that emerge when heterogeneous, hence more realistic, stress conditions are applied, providing valuable insights into the physics of natural earthquakes.