LABORATORY EARTHQUAKES

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ABSTRACT

Earthquake dynamics and, in particular, the mechanics of dynamic shear rupture are two relatively underinvestigated sub-fields of seismology. Most efforts to date have focused on analytical studies (Rice 2001) and on the numerical modeling of dynamic rupture processes using finite element, finite difference, and boundary element methods (e.g., Ben-Zion and Andrews, 1997). As clearly elucidated by Rice (2001), the nature and stability of the predicted process depends very strongly on the choice of frictional laws employed in the modeling and, as a result, validation of the fidelity of such calculations becomes of primary importance.

The goal of the present study is to create model laboratory experiments mimicking the dynamic shear rupture process. We hope to use such experiments to observe new physical phenomena and to create benchmark comparisons with existing analysis and numerics. The experiments use high-speed photography, photoelasticity, and infrared thermography as diagnostics. The fault systems are simulated using two photoelastic plates (Homalite) held together by friction. The far field tectonic loading is simulated by precompression and the triggering of dynamic rupture (nucleation) is achieved by an exploding wire technique.

The fault forms an acute angle with the compression axis to provide the shear driving force necessary for continued rupturing.

Our goals are to investigate the dependence the characteristics of rupturing, such as rupture speed, rupture mode on experimental conditions such as far-field biaxial compression, tilt angle of the fault to the compression axis, as well as on the frictional properties of the fault interface.

Results on both homogeneous and bimaterial interfaces are reported. For bimaterial interfaces, various combination of dissimilar materials, including Homalite/polycarbonate pairs, are chosen to mimic wave speed mismatch conditions that are reported to exist across mature, crustal faults. In the present lecture we concentrate on the experimental observation of the phenomenon of, spontaneously unrelated, supershear rupture on the visualization of the mechanics of sub Rayleigh to supershear rupture transition in such frictionally held interfaces. The results suggest that under certain conditions supershear rupture propagation can be facilitated during large earthquakes (e.g. the 2001 central Kunlunshan earthquake in Tibet or the 2002 Denali earthquake in Alaska).