EARTHQUAKE RUPTURE MODELING USING FINITE ELEMENTS METHOD: FRACTURING VS. RATE AND STATE FRICTION

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Modern geodetic and seismic observations indicate that most earthquakes result from unstable shear on quasi-planar faults, usually represented as shear cracks. Better understanding of shear crack development, propagation, and arrest can help us learn more about earthquake behavior. In earthquake fracture mechanics, both the inelastic yielding at the rupture front and the evolution of friction on the remainder of the slipping surface should be considered. Thus, crack and friction models of an earthquake source should be intrinsically coupled and used jointly, but there is currently no theory that incorporates both effects simultaneously to describe earthquake rupture. To develop such a theory, we study different friction and fracturing models using Finite Element software PyLith and Abaqus. In this work we mostly consider planar ruptures. We use Abaqus eXtended Finite Element Method to model dynamic brittle cracking (i.e. mode I and mode II cracks) and fracture propagation in an elastic material, and PyLith to model plastic yielding at the crack tip regions and apply different friction laws along the fault (i.e. static friction, dynamic friction, slip-weakening friction, rate-and-state friction). We then compare the specifics of rupture propagation (i.e. time to instability, traction, slip, and slip rate distributions along the fault throughout the simulation) using the two approaches: brittle cracking and frictional sliding. Preliminary results show similarities in rupture propagation into the initially locked sections of the fault for the two methods, provided we predefine the crack path to be planar in the cracking approach. These results provide more insight into the correlation between friction and fracturing theories for the case of earthquake ruptures.

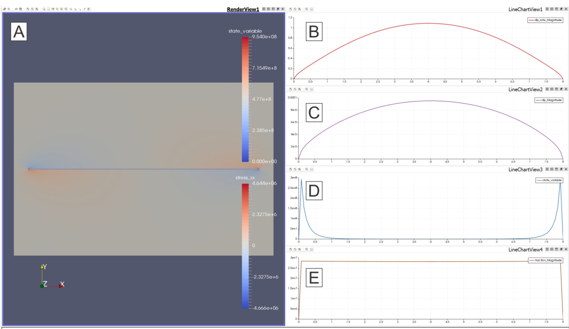

Figure 1. Rupture propagation along a planar fault with rate and state friction under shear loading conditions. A - horizontal stress distribution in the block, B - slip rate, C - slip magnitude, D - state variable and E - traction along the fault.