Dynamic Rupture Simulation on a Fault with Crack Opening : On High Pore Pressure and Generation of Isotropic Component of Seismic Moment

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Recently, some non-volcanic earthquakes with significant isotropic (ISO) components were observed. For example, Stierle et al. (2014) reported some aftershocks of the 1999 Izmit, Turkey, earthquake had more than 15 % ISO components.

In this study, we investigated how we can reproduce a rupture with such a large ISO component in a simulation of mixed Mode (I & II) dynamic rupture.

In our simulation, we used a space-domain 2-D Boundary Integral Equation Method (BIEM), which can handle mixed-mode rupture on a fault of complex geometry. We discretized the fault with linear elements, and used integration kernels showed in Tada & Madariaga (2001). For the time-marching scheme, we used a second-order accurate predictor-corrector method by Noda & Lapusta (2010) which enhances numerical accuracy and stability compared with that by Cochard and Madariaga (1994). For the friction law, we used a linear slip-weakening friction law.

First, in order to validate our code, we solved the benchmark problems TPV14&15 2-D which were defined by the SCEC/USGS Spontaneous Rupture Code Verification Project (Harris et al., 2009). Our results compared very well with those produced with other methods.

Second, we simulated dynamic ruptures on a fault with a step and evaluated the ratio of the ISO component. The fault was piecewise linear and consisted of three straight segments, L-fault C-fault and R-fault. L and R-faults are parallel, and C-fault connects them. The rupture was nucleated on C-fault by stress perturbation. We parameterized the ambient stress condition with three parameters, Φ(angle of the maximum stress axis from C-fault), Ψ(angle of the fault bends) and a S-value. With keeping the differential stress, the lower S-value corresponds to the higher pore pressure.

In the parameter study, lower S-value generally produced higher ISO components. However, if $\Psi$is small (~15°), no matter how low S-value we used, ISO components could not exceed 10 %. On the other hand with high Ψ(~75°), the failure criterion is often satisfied on the fault without the stress perturbation for rupture nucleation, and thus such initial conditions cannot be realized on the natural fault. ISO component became large for intermediate Ψ, a small S-value, and Φ< -30°. Our results indicate that not only high pore pressure, but also the fault geometry and the orientation of the stress field is important for generation of seismic events with a significant ISO component.

Keywords: Dynamic Rupture Simulation, Isotropic Component, Pore Pressure

