Effect of thermal pressurization on dynamic rupture propagation under depth-dependent stress

Yumi Urata[1]; Keiko Kuge[1]; Yuko Kase[2]

[1] Dept. of Geophysics, Kyoto Univ.; [2] Active Fault Research Center, AIST, GSJ

Fluid and pore pressure evolution can affect dynamic propagation of earthquake ruptures owing to thermal pressurization, because frictional heating caused by earthquake slip can increase pore pressure, then decrease effective normal stress on a fault surface (e.g., Mase and Smith, 1985). We investigate dynamic rupture propagation with thermal pressurization on a fault subjected to depth-dependent stress, on the basis of 3-D numerical simulations for spontaneous dynamic ruptures.

We put a vertical strike-slip rectangular fault in a semi-infinite, homogenous, and elastic medium. The length and width of the fault are 8 and 3 km, respectively. We assume a depth-dependent stress estimated by Yamashita et al. (2004). The numerical algorithm is based on the finite-difference method by Kase and Kuge (2001). A rupture is initiated by increasing shear stress in a small patch at the bottom of the fault, and then proceeds spontaneously, governed by a slip-weakening law with the Coulomb failure criteria. Coefficients of friction and Dc are homogeneous on the fault. On a fault with thermal pressurization, we allow effective normal stress to vary with pore pressure change due to frictional heating by the formulation of Bizzarri and Cocco (2006).

When thermal pressurization does not work, tractions drop in the same way everywhere and rupture velocity is subshear except near the free surface. Due to thermal pressurization, dynamic friction on the fault decreases and is heterogeneous not only vertically but horizontally, slip increases, and rupture velocity along the strike direction becomes supershear. As a result, plural peaks of final slip appear, as observed in the case of undrained dip-slip fault by Urata et al. (2008).

We found in this study that the early stage of rupture growth under the depth-dependent stress is affected by the location of an initial crack. When a rupture is initiated at the center of the fault without thermal pressurization, the rupture cannot propagate and terminates. Thermal pressurization can help such a powerless rupture to keep propagating.

We will investigate effects of thermal pressurization also on dynamic rupture propagation beyond fault discontinuities under a depth-dependent stress.