Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

SSS027-P21 会場:コンベンションホール 時間: 5月24日17:15-18:45

深さに依存した応力下における断層間の破壊の乗り移り: Thermal pressurizationの効果

Rupture propagation beyond fault discontinuities under depth-dependent stress: Effect of thermal pressurization

浦田 優美[1*], 久家 慶子[1], 加瀬 祐子[2]

Yumi Urata[1*], Keiko Kuge[1], Yuko Kase[2]

[1]京大院理地球惑星科学専攻, [2]産総研活断層・地震研究センター

[1]Dept. of Geophysics, Kyoto Univ., [2]AFERC, AIST, GSJ

We investigate rupture propagation beyond fault discontinuities under depth-dependent stress, on the basis of 3-D numerical simulations for spontaneous dynamic ruptures with thermal pressurization (TP).

Earthquake rupture often occurs over several faults. In previous numerical simulations of the earthquake rupture using two parallel strike-slip faults with uniform stress and coefficients of friction, a rupture sometimes fails to propagate to an unconnected fault, and the rupture, which succeeds to propagate, is usually triggered near the Earth's surface (e.g., Harris and Day, 1999). These natures of simulated rupture disagree with that of real earthquakes. To overcome the gaps between simulations and real earthquakes, we test simultaneous effects of depth-dependent stress and TP in this study. The two effects were examined separately (Kase, 2002; Urata et al., AGU, 2008), and the gaps still remained although either effect reduced the gaps.

We put a vertical strike-slip square fault in a semi-infinite, homogenous, and elastic medium. The length of the fault is 6 km. The fault reaches the free surface. We assume depth-dependent stress that increases linearly with depth, following Yamashita et al. (2004), except near the free surface. The numerical algorithm is based on the 3-D finite-difference method formulated by Kase and Kuge (2001). A rupture is initiated in a small patch at the depth of 3 km on the fault, and then proceeds spontaneously, governed by a slip-weakening law with the Coulomb failure criteria. The friction coefficients and Dc are uniform. On a fault with TP, we allow effective normal stress to vary with pore pressure change by the formulation of Bizzarri and Cocco (2006). Due to slip on the fault, stress in the medium varies with time and location. We investigate the stress difference defined by Harris and Day (1993) to discuss whether or not a rupture can be triggered in the medium.

If a secondary fault exists in a compressional area with a small stepover, a rupture on the fault can be triggered at a mid depth by S wave radiated at a side edge of the primary fault, whether or not TP works on the primary fault. TP enables a rupture to jump at a mid depth beyond a large stepover where the rupture can be triggered only at a shallow portion in the case without TP. In the case with TP, depths where the rupture can jump are slightly different between cases under uniform and depth-dependent stress.

In an extensional area, a rupture on a secondary fault can be triggered initially near the free surface in the case without TP. The rupture, however, may not grow because stress drop at a shallow portion is small and the yield stress increases with depth due to the depth-dependent stress. Later, another rupture can be also triggered at a shallow portion by static stress changes when a stepover is small. In the case with TP, regardless of a stepover width, a rupture trigger due to static stress changes can occur at a mid depth or a deep portion, because TP works more effectively with depth, increasing stress drop. This deep rupture jump under TP is also observed in the case with uniform stress. On the other hand, when a stepover is small in the case with TP, we predict another rupture jump at a shallow portion due to S wave before the rupture on the primary fault reaches the side fault edge.

Our numerical simulations suggested that under depth-dependent stress, TP works more effectively with depth and enables rupture to jump at deep portions even when a stepover is large. Thus, TP under depth-dependent stress reduces the gap between the previous numerical simulations and real earthquakes. Our results imply that TP can have a significant role on rupture processes on real earthquakes.

Keywords: thermal pressurization, rupture jump, depth-dependent stress, numerical simulation