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Dynamic fault branching with thermal pressurization

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We numerically investigate the effect of thermal pressurization (TP) on fault branch behavior during dynamic rupture propagation; a situation is likely to occur during large earthquakes at subduction interfaces.

We consider a 2-D mode II rupture that propagates along a planar main fault and encounters an intersection with a pre-existing branching fault. The fault system is in an infinite, homogenous, and elastic medium, and it is subjected to uniform external stresses. The friction coefficients and Dc are assumed to be uniform and the same on the two faults. The numerical algorism is based on the 2-D boundary integral equation method (BIEM) using the integration kernels proposed by Tada and Madariaga (2001, IJNME). A rupture is initiated in a small patch on the main fault, and then proceeds spontaneously, governed by a slip-weakening law with the Coulomb failure criteria. On a fault with TP, we allow effective normal stress to vary with pore pressure change owing to frictional heating using the formulation of Bizzarri and Cocco (2006, JGR).

We reveal that TP can alter the rupture propagation paths in the cases where a dip angle of the main fault is shallow. The rupture propagation paths depend on the branching angle when TP is not in effect on either of the faults, as described by Kame et al. (2003, JGR). On the other hand, the ruptures propagate along the main fault in the cases with TP on the main fault, and ruptures propagate along the branch when TP is in effect on both faults. These features are observed, regardless of the branching angle. Thus, the dynamic rupture processes are strongly controlled by TP, compared with the branching angle.

Finally, we consider the case when free surface exists above the branch fault system. It should be noted that full space and half space computations are the same until the reflected waves from free surface arrive at the branch fault system. Therefore, the above discussion is valid for half space case as far as we focus on the branching. However, once the reflected waves from the free surface arrive at the branch fault, they promote the rupture propagation along the branch fault. In this case, the rupture can propagate along both faults by the existence of the free surface in addition to TP on the main fault.

Keywords: fault branching, spontaneous ruptures, thermal pressurization