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Alteration of effective normal stress during dynamic rupture propagation due to heterogeneity of poroelastic properties near the slip plane

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Recent analysis of Rudnicki and Rice (JGR, 2006) has shown that a mismatch of poroeleastic properties causes a change of pore pressure on the fault (idealized as a plane) during slip propagation. The effect occurs because the pore pressure increase caused by compression on one side of the fault due to slip is not the same magnitude as the decrease caused by extension on the other if the properties differ across the fault. Consequently, the pore pressure at the interface changes and, in particular, increases if the compressive side is more permeable and decreases if the extensile is more permeable. A heterogeneous structure of near fault material and transport properties is consistent with recent field studies of mature slip zones. These indicate a wide (10's of meters) zone of damaged material that is sometimes different on the two sides of the fault (due to large accumulated displacements) but that the principal slip occurs in a very narrow (several mm's) zone of ultracataclastic and relatively impermeable material This alteration of pore pressure heterogeneous near-fault poroelastic properties accompanies the change in normal stress induced by slip at a bimaterial interface. Because both effects can be of either sign, depending on the direction of rupture propagation and the material mismatch, they may offset or reinforce each other. Consequently, the net effect depends not only on the bimaterial contrast in the less damaged material away from the slip plane but also on the near-fault contrast in poroelastic properties and permeability. The relative magnitude of these effects is assessed using the dynamic, steady-state, slip-weakening pulse model of Rice, Sammis and Parsons (BSSA, 2005). The effect of poroelastic mismatch is incorporated through an analy-

sis within the narrow boundary layer bordering the slip plane in which fluid diffusion can occur during the time scale of rupture propagation (less than a few 10's of millimeters). Assuming undrained conditions (outside the narrow boundary layer) in this model shows that the pore pressure change is proportional to the along fault slip gradient, the same form as the alteration of normal stress due to slip on a bimaterial interface. For a plausible range of near-fault poroelastic properties and a dissimilarity of elastic properties further from the fault consistent with seismic observations, the magnitudes of the effects are similar. The magnitude of the poroelastic effect is increased by increasing permeability contrast but the normal stress alteration due to the elastic mismatich increases rapidly as the rupture velocity approaches the Rayleigh wave velocity.