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Thermal Pressurization during Rupture Propagation with Measured Transport Properties

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During an earthquake, slip rate changes from a very low value in the nucleation phase up to the order of 1 m/s in the rupture propagation phase. Fault constitutive relation at high slip rate is important in the latter phase. High slip rate causes temperature rise, thermal pressurization of pore water [1-4] and frictional melting of rocks [5, 6] in extreme cases.

To evaluate the effect of thermal pressurization, transport properties (permeability, porosity, and storage capacity per unit volume of rock) of fault rocks just near the deformation localization zone are essentially important. Outcrop and thin section observations, laboratory measurements, and computer simulations reveal that this process effectively reduces frictional strength for a mature fault zone with clayey and impermeable fault material such as Hanaore fault, Southwest Japan. This effect is dependent on depth, slip rate, and width of deformation zone under constant slip rates. This process affects the mode of rupture propagation. In cases that rupture does not propagate due to low initial shear stress, thinning of deformation zone and concentration of heat generation allow rupture to propagate and at fastest, rupture velocity exceeds shear wave velocity (Fig.1). Width of deformation zone is possibly an important parameter which determines whether a nucleated rupture results in a large earthquake or not.

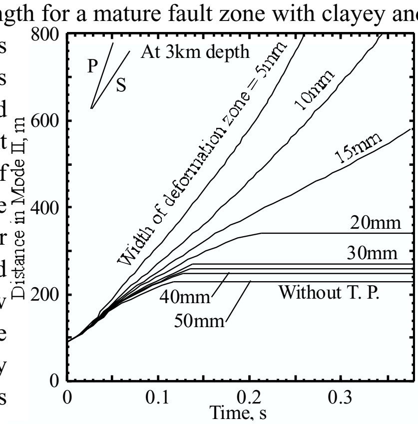

Fig.1 Rupture propagation with thermal pressurization at 3km depth, 100m asperity radius, and with various width of deformation zone. Static and dynamic frictional coefficients are set as 0.6 and 0.4. At the initial state, shear stress is equal to static and dynamic level inside and outside the asperity respectively.

References

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