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Implications of Fixed Rupture Velocity on Dynamic Rupture Simulation of Earthquake Faults

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ABSTRACT

Dynamic rupture of earthquakes faults can be simulated assuming either spontaneous rupture or fixed rupture velocity. Both methods need definition of the shear stress changes on the fault surface during rupture by specification of so-called fault constitutive laws (friction law). The simple physical idea of these models is that the dynamic rupture occurs when the shear stress on the fault reaches some critical value (yielding stress) then, the slipping occurs governed by the assumed friction law. The spontaneous rupture model simulates this problem very well; however, a fixed rupture velocity model could violate this idea for certain ranges of rupture velocity as shown in Figure 1. In this figure (for a fixed rupture velocity of 80% of the S wave velocity) we show that rupture initiates after a peak shear stress has passed some place of the fault. This numerical phenomenon is due to the peak shear stress associated with the S wave velocity. Since dynamic models are based on physical conditions of the friction and stress distribution across the fault zone, fixed rupture velocity violates this physics. This problem occurs for fixed rupture velocity between 0.70 to 0.95 times the S wave velocity. This corresponds to the interval of most of the real earthquakes occurred so far. From our simulations we arrive to the conclusion that constant sub-shear rupture velocity is physically impossible to happen. For the case shown in Figure 1, the rupture needed to happen either at the time before the peak stress or after some time later when the stress overcame this peak. Therefore, for a given fixed rupture velocity, there would be a minimum and a maximum rupture velocities that could correspond to the earthquake analyzed.

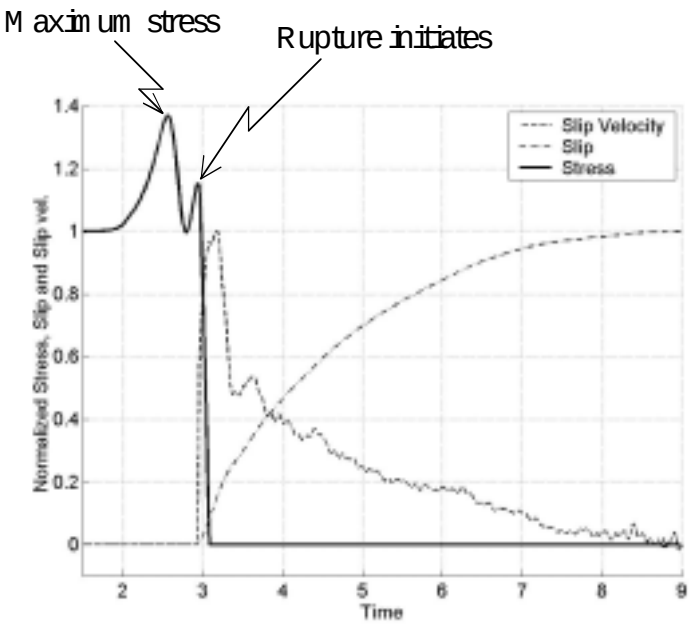

Figure 1. Shear stress, slip and slip velocity at some place of the fault during dynamic rupture propagation with fixed rupture velocity 80% of the S wave velocity.