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Effect of acceleration on frictional properties of faults

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Recent high-velocity friction experiments shows that frictional resistance of faults increases rapidly at the onset of sliding over distance of more than several centimeters, that is followed by prolonged slip-weakening. The initial frictional barrier may affect how earthquake ruptures propagate into the shallow crustal depth, but it received little attention up to now. Thus we have conducted constant acceleration experiments on simulated gouge using a rotary-shear friction apparatus. We especially focus on the effect of acceleration of fault on the initial frictional barrier.

In the experiments, we slid a simulated fault at a constant slip rate of 0.1 mm/s and then suddenly increase slip rate to 1.3 m/s with different acceleration of from 0.13 to 13 m/s^2. In all runs, friction coefficient is 0.6~0.7 at slip rate of 0.1 m/s and then increases by 2~10% over distance of several centimeters as a fault starts to accelerate. Amplitude of the initial frictional barrier and hardening distance seem to depend on acceleration. When a simulated fault overcomes the initial barrier, friction coefficient gradually decreases with slip toward the steady-state value of 0.1~0.2. In order to evaluate whether the initial barrier can affect rupture propagation, we estimate a ratio of the frictional work consumed on fault during the initial hardening stage to the frictional work during the slip weakening. The ratio is about ~0.01 at acceleration of 0.13 m/s^2, but tends to increase with acceleration to ~0.1 at 13 m/s^2. The result suggests that as the rupture speed increases, the effect of initial frictional barrier at the onset of rapid faulting could not be negligible and must be incorporated into the analysis of earthquake rupture propagation.

Keywords: fault, friction, earthquake, acceleration, slip hardening