



Slip-dependent weakening on shallow plate boundary fault in the Japan subduction zone: shallow coseismic slip facilitated by foreshock afterslip

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Understanding of role of slow earthquakes as they relate to the occurrence of both megathrust earthquakes and tsunami earthquakes is necessary to mitigate these disasters in the near future. Laboratory shearing experiments is one of important approach to evaluate these relationships. Here, we use powdered gouge samples from JFAST (IODP Expedition 343) Hole C0019E, core sample 17R-1, which is the plate boundary fault zone in the Japan Trench subduction zone. In this region, both large coseismic slip during the 2011 Tohoku-Oki earthquake as well as discrete slow slip events (SSE) have occurred. Experiments were conducted in a single-direct shear apparatus under normal stress of 16 MPa, with total shear displacements of up to 16 mm. We evaluate the slip-dependence of friction by extracting the velocity-dependent friction parameters a , b , and D_c , and also measure the rate of change in friction coefficient with shear displacement as the slip-dependence of friction.

We report that in friction experiments using the Tohoku fault zone samples, an increase in sliding velocity exceeding that of earthquake afterslip can induce a change from steady-state frictional strength or slip hardening friction to slip-weakening frictional behavior. Our results show that the slip weakening is observed when the slip velocity exceeds 3.7×10^{-6} m/s during our experiments, while steady-state frictional strength or slip hardening is observed below 1×10^{-6} m/s. In the Japan Trench region, two slow events prior to the mainshock were observed in the mainshock area with a coseismic slip exceeding 30 m. One event is an episodic SSE with a slip velocity of 0.1×10^{-6} m/s, and the other is afterslip after the largest Tohoku earthquake foreshock with a slip velocity exceeding 2×10^{-6} m/s. Our experiments show that slip-weakening friction should be expected at the afterslip rate, suggesting that the afterslip may have facilitated the large coseismic slip during the mainshock on the plate boundary fault of the Tohoku-Oki earthquake.