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# 龍門山断層ガウジの多彩なすべり履歴のもとでの高速摩擦挙動

# High-velocity frictional behavior of Longmenshan fault gouge during variable slip histories

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Disastrous Wenchuan earthquake (12 May 2009, Mw 7.9) was accompanied by surface ruptures of about 280 km in EW extension along existing Longmenshan fault system (e.g., Lin et al., 2009, Tectonophysics). We have conducted high-velocity friction experiments on fault gouge from this fault in order to understand the mechanisms of dynamic fault motion that caused this earthquake. Experiments were done with constant slip rates, accelerating and decelerating slip histories and Yoffe-function type slip histories to cover a variable slip histories expected for natural earthquakes. Fault gouge was collected from Hongkou outcrop of Yingxiu-Beichuan fault on the western part of the Longmenshan fault system (Lin et al., 2009). Experiments were done on gouge of about 1 mm in thickness between a pair of solid cylindrical specimens of Belfast gabbro of about 25 mm in diameter under dry or wet conditions, using the first high-velocity frictional testing machine at Kochi Core Center of JAMSTEC and a rotary-shear low-to-high-velocity friction apparatus (the Second HV machine at Hiroshima University).
Slip rates and normal stresses were varied, respectively, from 0.009 to 1.30 m/s and from 0.6 to 4.9 MPa for the constant slip rate experiments. Fault gouge exhibits dramatic slip weakening at high slip rates. A series of tests at slip rate of 0.3 m/s with normal stresses varied from 0.61 to 3.04 MPa shows that Coulomb friction law holds for both peak and steady-state friction with frictional coefficients of 0.65 and 0.12, respectively. The steady-state friction markedly decreases from around 0.75 to about 0.2 as slip rate increases from 0.01 to 1.3 m/s, even though the peak frictional coefficient remains at around 0.8 for the same range of slip rates.
Sone and Shimamoto (2009, Nature Geoscience) have shown that frictional behavior with a accelerating-decelerating slip history is notably different from that with a constant slip rate; i.e., a fault exhibits peak friction, nearly linear slip-weakening and strength recovery upon decelerating fault motion. The peak friction imposes resistance to rupture propagation, and the final strength recovery should foster pulse-like rupture propagation. They manually controlled the slip rate, but we controlled the slip history using a function generator and produced much better-controlled slip histories. Displacement to peak friction and amount of strength recovery with decelerating fault motion were smaller in our results than those of Sone and Shimamoto for Chelungpu fault. An empirical slip and velocity weakening law of Sone and Shimamoto can describe the gross frictional behavior reasonable well, using parameters determined from the constant velocity experiments.
We have conducted changing-velocity experiments as more representative slip history for natural earthquakes, using regularized Yoffe function (Fukuyama and Mizoguchi, 2009, Int. J. Fract.) and

sawtooth velocity function (set to 10% of the rise time and maximum slip rate is 1.3 m/s) are used. This slip history is characterized by abrupt acceleration of short duration and by gradual deceleration of long duration. An acceleration of short duration yields less slip weakening and gradual deceleration causes more strength recovery than the above two cases. The empirical law of Sone and Shimamoto, using parameters determined from constant slip-rate tests, describes the Yoffe-function behavior fairly well. Thus the equation will be useful in modeling earthquake rupture propagation.

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