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High-velocity frictional properties of clay-rich fault gouges from the Chelungpu fault zones, Taiwan

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The 1999 M7.6 Chi-Chi earthquake on the Chelungpu fault in Taiwan is especially well characterized. Therefore we have investigated the frictional behavior of the Chelungpu fault during seismic slip, using high-velocity friction tests conducted on clay-rich fault gouges from cores obtained from the Taiwan Chelungpu fault Drilling Project. Rotary friction experiments of the gouges, sheared in a ring configuration, were performed at normal stresses of 1-2 MPa, slip rates of 1-4 m/s, acceleration rates of 2-6 m/s2, and room-humidity conditions in the SHIVA apparatus (Slow to HIgh Velocity Apparatus) at INGV. The mechanical results obtained at low normal stress and velocity (1 MPa and 1m/s) display velocity-strengthening frictional behavior. Our experiments make use of a low-friction metal sleeve and are in contradiction with the published velocity-weakening results obtained using Teflon sleeves in a rotary-shear high-velocity frictional testing apparatus. On the other hand, the behavior of velocity-weakening is observed in the friction tests performed at higher normal stress, velocity and acceleration (2 MPa. 3-4 m/s, 6 m/s2). In addition, the fact that a strength recovery is observed in the final part of the slip suggests that healing occurs as velocity decreases. SEM microphotographs show that a very thin layer of reduced grain size was formed in the experimental products obtained at high normal stress, velocity and acceleration. This layer was not seen in the low pressure and low velocity experiments. The strength of a fault zone at high slip rates is not yet well understood, but the frictional behavior of clay-rich gouges appears to be strongly dependent on normal stress and velocity. Further analytical results such as microstructural and/or mineralogical evidences are required to determine the physicochemical processes in the slip zone and will be important for future investigations of dynamic strength of faults.