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A Transition from Gouge Generation to Frictional Melting in Pelitic Fault Zones: Insight into Seismogenic Fault Motion from High-Velocity Experiments

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Our understanding of earthquake-generation processes in phyllosilicate-rich rocks is limited, even though these rocks are common in the Earth's crust. We report here results from high-velocity (0.17 – 1.17 m/s) friction experiments on simulated faults in a siltstone from the Jurassic Bansong Formation of the Taebaeksan Basin in Korea, demonstrating that gouge-generating wear at low normal stress (7.4 MPa) and low slip rates (0.17 – 0.55 m/s) changes into frictional melting at high normal stresses (9.8 – 17.2 MPa) and high slip rate (1.17 m/s). The pelitic siltstone is composed mainly of subangular to subrounded quartz (10 – 150 μm), white mica (10 – 50 μm) and opaques (5 – 100 μm) with subordinate biotite (10 – 100 μm). The high normal-tress/slip-rate behavior associated with frictional melting is characterized by two phases of potentially unstable, slip weakening separated by strengthening, and this is very similar to high-velocity friction of gabbro [1]. Then with further slip, the friction coefficient increased to a peak value followed by a final weakening with steady-state friction coefficient of 0.35 – 0.5. The fault zone consists of a pseudotachylyte layer (0.3 – 0.4 mm thick) mantled by an opaque-rich layer (0.1 – 0.2 mm thick) along both margins. The pseudotachylyte layer comprises subrounded to rounded quartz clasts (5 – 80 μm) and glass matrix with little mica. Larger clasts of quartz tend to concentrate in the center of the pseudotachylyte layer, of which thermo-mechanical reason remains to be explained. The opaque-rich layers have less mica than the wall rock, suggesting that decomposition of mica may have occurred to generate more opaques. In contrast, the siltstone samples sheared under low normal stress (7.4 MPa) and low slip rates (0.17 – 0.55 m/s) show a stick-slip behavior without any significant weakening. The fault zone consists simply of fault gouges with no evidence of melt product in these samples. Our preliminary experimental results imply that normal stress and slip rate are important factors determining the strength of seismic faults in phyllosilicate-rich rocks.

Keywords: High-velocity friction experiment, seismogenic process, frictional melting, fault gouge, siltstone.

References

[1] T. Hirose and T. Shimamoto, *J. Geophys. Res.*, 110, B05202 (2005).