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Formation of weak faults during large shear deformation experiments of bimineral mixtures

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Measurements of heat flow, temperature anomaly, and stress orientations along the mature faults affirm that these faults are mechanically weak (e.g., Lachenbruch & Sass, 1980, Zoback, 2000, Kano et al., 2006). One of the explanations for these weak faults is that the presence of weak minerals (fault lubricants) such as phyllosilicates along the fault zones. Frictional experiments on bimineralic mixtures with phyllosilicates are conducted to examine its operation for weakening agent (e.g. Moore & Lockner, 2011). However, these previous studies are conducted with limited shear strain (mostly $<$10) in spite of significance of fabric development on weakening has been pointed out (Collettini et al., 2009). We thus have performed large strain, friction experiments for two kinds of fault lubricants of graphite and smectite with quartz, to understand how frictional behavior changes with fraction, shear strain, and associated textural maturation. Experiments were done with dry and both dry and water-saturated conditions for graphite and smectite mixtures, respectively. For the graphite-quartz mixtures, friction typically displays strain weakening at any slip rates we tested (150um/s-1.3 m/s). 10-30 vol% mixtures in particular decrease friction coefficient to almost half of the original associated with intense comminution and formation of graphite-connected slip surface within the gouge zone. Hence the relationship between strength versus graphite fraction evolves from gentle to abrupt sigmoidal curve which drops at a fraction of 10-30 vol%, with increasing shear strain. The friction of the smectite-quartz mixtures sheared at 30-150 um/s displays steady-state friction throughout the experiments while strain weakening can be observed for those sheared at faster than 22 mm/s (see Oohashi and Hirose, 2013, this meeting). Strength versus smectite fraction at 30-150 um/s shows sigmoidal curve which drops at a fraction of 30 vol% without visible correlation with shear strain. Textural observations suggest that slip localized within the smectite without visible comminution for the mixtures $>$30 vol %. These differences on slip localization between two fault lubricants may be ascribed to their physical properties to form foliation within the gouge.

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Keywords: Fault weakening, Graphite, Smectite, Fault gouge, Friction experiment