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Energy partition for grain crushing in quartz gouge and sintering effect during subseismic to seismic fault motion

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To determine how much of the frictional energy consume in grain crushing is important because this fraction will affect the energy used for frictional heating which in turn can affect the mechanical properties of a fault during seismic fault motion. In addition, it is geologically important to understand the formation and developing process of the mature fault zones.

Thus we have conducted friction experiments on quartz gouge as a simple case at subseismic to seismic slip rates. Quartz was selected because it is a very common mineral in fault zones and its surface energy is measured (about 1 J/m2, Brace and Walsh, 1962). Brunauer-Emmett-Teller (BET) surface area of quartz gouge was measured before and after shearing. Measurement of BET surface area provides more direct data on surface-area change than grain-size measurement does. Our recent results show that grain crushing absorbed only 0.02˜0.22 % of frictional work. Thus, grain comminution is unlikely to be an important energy sink at least for mature faults with well-developed slip zone.

Another new finding from our study is that the BET surface area of quartz gouge deformed at high slip rates begins to decrease after a certain displacement. Sawai et al. (2009) also have found that the surface area of Nojima fault gouge decreases, rather than increases, with shearing deformation at seismic slip rates. Our observations of quartz gouge revealed that fine grains formed cohesive aggregates and dendritic clusters. In particular, the dense granular aggregate strongly suggests that sintering of gouge partially occurred. The bulk temperature rise in quartz gouge in our experiments would be on the order of several hundred degrees Centigrade in view of recent experiments under similar conditions and temperature calculations (Mizoguchi et al., 2009; Kitajima et al., 2010; Han et al., 2011). This may not be enough for full sintering to occur, but flash heating probably contribute to partial sintering (see Rice, 2006; Han et al., 2007a, 2007b; Oohashi et al., 2011).

Keywords: High-velocity frictional experiment, Energy budget, Fracture energy, Sintering