Effect of grain fracture on stick-slip dynamics of granular fault gouge

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Fault gouge is produced by comminution, wear and other shearing processes that take place during geological tectonic movements. The frictional properties and stick-slip dynamics of granular fault show similar patterns as geophysical phenomena like earthquakes and landslides. In this work, we introduce a particle breakage model in a granular fault system to study the effect of grain fracture on the stick-slip dynamics. Our results show that particle breakage changes the macroscopic friction and the characteristics of slip events. By statistical analyses on a large number of slip events, we find that grain fracture changes the distribution of slip event size. During the evolution of crushable fault gouge, particle breakage does not lead to large slip events but triggers many small slips that partly dissipate the accumulated energy. On the other hand, the grain fracture is also influenced by the slip dynamics: it is shown that larger slip events will lead to a series of particle breakage due to localized high stresses during the rearrangement of granular gouge. Our findings in this study show that in faults with granular gouge particle breakage significantly changes the characteristics of frictional instabilities and affects the dynamics of fault system.