Geophysical Research Abstracts,
Vol. 10, EGU2008-A-08792, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-08792
EGU General Assembly 2008

How do Things break in Fault Gouge ? Abrasion vs. Grain splitting in Discrete Element Simulations.

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The micro-structure of fault gouge has important implications for the mechanical behaviour of faults. In order to understand how these structures evolve, it is important to investigate the processes involved. However, these processes are difficult to observe in nature or in laboratory experiments. We therefore use 3D discrete element (DEM) simulations where we can observe the details of the micro-mechanics of the gouge at any time. In this simulation approach the material is modelled as a collection of spherical particles interacting by elastic-brittle bonds or, if there is no bond between particles, by frictional interactions.

The simulation setup is modelled on laboratory experiments of gouge shear. The gouge is initially composed of spherical grains, each consisting of several thousand DEM particles bonded together. The grains are confined between two blocks of solid material. In order to investigate the influence of the shape of the boundary between the solid blocks and the developing gouge we have implemented both blocks with smooth edges and blocks with a defined regular roughness. A defined normal stress and a constant shear velocity are then applied to the rigid blocks and the deformation of the gouge is observed. At the model boundaries perpendicular to the shear direction periodic boundary conditions are implemented, so that arbitrarily large shear strains are possible.

The results match important aspects of laboratory data very well. With increasing strain, the grain size distribution is evolving towards a fractal distribution. This evolution of the grain size distribution is driven by two mechanisms of grain size reduction,

abrasion and grain splitting. The relative importance of the two mechanisms depends on the applied normal stress where abrasion dominates at low normal stress and grain splitting dominates at high normal stress.