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Fault Gouge, Grain Shape and Friction - new Results from 3D DEM Simulations

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The frictional properties of fault gouge are one of the most important parameters governing the mechanical behavior of faults. Using numerical modeling, significant progress has been made in recent years towards the understanding of the micro-mechanical processes which drive the evolution of fault gouge. However, many previous numerical models have predicted too low macroscopic frictional strength. To overcome this problem we have developed modified 3D discrete element (DEM) simulations of fault gouge to ensure that the smallest fragments produced during the comminution of the aggregate gouge grains are non-spherical.

In the discrete element method 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 aggregate grains, each consisting of several thousand DEM particles. Within those aggregate grains, clusters of particles are bonded together with unbreakable bonds, whereas the bonds between the clusters forming a grain can break. The grains are confined between two blocks of solid material. 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.

Results show that this new simulation setup which leads to non-spherical or "pseudo-angular" fragments instead of spherical ones during gouge evolution, can match the frictional strength of fault gouge measured in the laboratory quite closely. In addition, our results indicate that the macroscopic frictional strength of the simulated fault gouge using non-spherical fragments is not sensitive to the specific choice of micro-mechanical parameters such as the microscopic inter-grain friction coefficient.