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DEM Modelling of Comminution Processes in Fault Gouge

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The micro-structural texture of fault gouge, i.e. the shapes, sizes and the arrangement of the grains forming the gouge is a crucial aspect determining the mechanical behaviour of the fault. It is therefore important to understand the mechanisms governing the evolution of grains sizes and shapes in fault gouge. Numerical simulations can be a good tool to investigate the processes happening inside the fault gouge while it is sheared.
We are using a 3D Discrete Element Method (DEM) to model the micro-structural evolution of a fault gouge. In this model the initial aggregate gouge grains are represented by many small particles stuck together by brittle-elastic bonds. These bonds can break if a fracture criterion is exceeded allowing fracture of the gouge grains. The gouge material is confined between two blocks of solid material, subjected to a constant normal load and sheared. The geometry of the model is designed to approximate the setup used in laboratory friction experiments.
We observe two comminution mechanisms operating in the fault gouge, grain splitting and grain surface abrasion. The relative contributions of the two mechanisms to the evolution of the grain size distribution depends on normal stress, boundary shape and accumulated shear strain. At sufficiently high normal stresses, grain splitting contributes significantly to comminution, particularly in the early stages of the simulations. At low normal stresses and during the later stages of all simulations, grain abrasion is the dominant comminution mechanism. Rough boundaries promote relatively more grain splitting whereas smooth boundaries favour grain abrasion.
In simulations where we have strong grain splitting we observe a rapid evolution to a power law grain size distribution with an exponent that increases with strain. Thus, grain splitting combined with abrasion appears to be an efficient mechanism for reducing the mean grain size. When grain abrasion is the dominant comminution mechanism, we observe the generation excess fine grains and the evolution of a bimodal size distribution. Our Data obtained from the numerical models suggests a possible transition from a grain splitting dominated to an abrasion dominated regime during the life of a fault. Considering the resulting evolution in grain shape and size distribution this will likely have implications for the mechanical stability and therefore the earthquake potential of a fault.