Geophysical Research Abstracts
Vol. 21, EGU2019-10845, 2019
EGU General Assembly 2019

Granular flow and mineral anisotropy: exploring the influence of cleavage planes during brittle deformation using experiments and numerical models

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Fault gouges are amongst the main products of strain accommodation in the brittle upper crust. During shear, fracturing has a direct effect on grain size (and shape) evolution and ultimately grain-grain interactions. Such changes are believed to influence how stress is accomodated within the gouge and, on a broader scale, the mechanical and petrophysical properties of faults. Most microphysical models for the deformation of granular materials assume particles to have isotropic properties. However, natural fault zones are often composed of minerals (e.g., carbonates, phyllosilicates, feldspars and amphiboles) that have well-defined crystallographic anisotropies, such as cleavage planes, twin planes, and healed fractures. Recent observations of both natural and experimental strain localisation features have highlighted the potential for crystallgraphic anisotropy (such as cleavage planes) to play a key role in control fracturing processes. As a result, the occurrence of such anisotropies in natural gouges may strongly influence the rheology of a fault during deformation.

Numerical simulations using the Discrete Element Method (DEM) approach have proved, in recent years, to be a powerful tool in revealing grain scale processes associated with frictional sliding of granular fault gouges. Such an approach affords us unusual access inside a deforming material to precisely track the active grain processes and how they interact and evolve. In this contribution, we will summarise recent experimental work linking crystallographic anisotropy to preferential grain fracture, then present preliminary new results from DEM simulations designed to investigate the influence of weak cleavage planes on fracturing and the gouge mechanical response. In particular, we will explore (i) differences in strength between cleavage planes and bulk grains, (ii) the effect of increasing normal load, (iii) grain size, grain shape (SPO) and grain orientation (CPO) evolution with strain.

A better understanding of the role of cleavage planes, and in general mineral anisotropies, on fault mechanics will help to improve the development of more accurate microphysical models for gouge friction evolution during faulting and slip at the basal interface of landslides.