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Running dilatancy banding as a mechanism of jointing: Experimental and numerical models

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There are basically two approaches to the problem of quasi-brittle fracture/rupture of geomaterials. One is the fracture mechanics dealing with stability conditions of cracks characterized by a strong stress concentration at the tips causing crack propagation. The other approach is the formation of deformation localization bands as constitutive instabilities, whose onset in quasi-brittle rocks can be considered as corresponding to the inception of rupture. We investigate the conditions of applicability of these end-member approaches and show a continuous transition from one to another with an increase in the confining pressure P in the experimental extension tests on a synthetic physical rock analogue (granular, frictional, cohesive and dilatant) material GRAM1 . Discontinuities/fractures perpendicular to the least (axial) stress σ_3 were generated in GRAM1 samples. These fractures form dynamically and are of two types defined by the mean stress σor P. When σ is very small, the fractures form through mode I cracking with σ_3 equal to the material tensile strength. The fracture walls have smooth surfaces in this case. Increase in σ causes increase in σ_3 at fracturing, which becomes less negative and reaches small positive (compression) values, while the failure still occurs along a discontinuity perpendicular toσ_3. Thus, the discontinuities generated starting from a certain σ value cannot be mode I fractures. Increase in σ also results in changes in the relief of the surfaces of discontinuities after their *postmortem* opening (separation of the walls): the surfaces become rougher, with the topography features forming faint/delicate plumose patterns very similar to those on the geological joint walls. SEM observations of the unopened discontinuities show that they represent several grain sizes-thick bands of a material which underwent a heterogeneous decohesion and volume/porosity increase. This suggests a dilatancy within bands. After opening they become fractures with plumose fractography. As indicated, these fractures could not be formed through the mode I mechanism. It is suggested that the formation mechanism represents a running constitutive instability in the form of dilation banding. This instability is reproduced in the numerical models showing fracturing pattern very similar to that observed in the experiments. The morphological similarity between the experimentally generated plumose-surface fractures and natural joints surfaces is shown. On the other hand, MEB observations evidence a textural similarity between the experimental bands and natural unopened incipient joints found in fine grained rocks. It is suggested that propagating dilation bands could be an important mechanism for the generation of natural joints.