Geophysical Research Abstracts
Vol. 14, EGU2012-7426, 2012
EGU General Assembly 2012
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DEM modeling of fracture propagation in veined rock

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One fundamental aspect of crack seal veins is that an existing vein can act as a heterogeneity in the rock which controls the localization of successive fracturing at unchanged mean stress orientations.
Observations from crack-seal vein systems suggest that existing veins fundamentally influence the fracture behavior of a rock even in cases where the orientation of the stress field is highly incompatible with the orientation of the vein.
We used a series of 3D Discrete Element Simulations to systematically investigate the influence of existing veins with varying orientation and mechanical properties on an approaching fracture. The models consist of a tabular heterogeneity within a bonded particle volume fractured under uniaxial tension. The parameters varied in the study are the orientation of the heterogeneity relative to the direction of uniaxial extension and therefore relative to the orientation of the favorable fracture plane as well as the fracture strength ratio between the matrix material, the vein material and the interface between vein and matrix material. The elastic parameters (e.g. Young's modulus) are kept homogeneous throughout the model. Thereby it is ensured that the results are not altered by stress field perturbation induced by stiffness contrasts.
The model materials used were carefully tested and calibrated to ensure comparability with natural examples in terms of their fracture-mechanical properties. The simulations were repeated for several random particle packings to eliminate the effect of heterogeneities in the packing on the results.
The results show a strong influence of the tabular heterogeneity on the fracture propagation for all orientations and at cohesion ratios within the range of natural systems. Besides curving and deflection of the fracture path associated with changes in fracture mode, bifurcation of fractures as well as arrest of propagation and nucleation of new fractures can be observed.