Geophysical Research Abstracts
Vol. 14, EGU2012-2646, 2012
EGU General Assembly 2012
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Discrete Element Modelling of Boudinage in 3D

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Boudins are relatively common structures in layered rocks which have been shortened in the direction perpendicular to the layering. However, most information we have about the geometry of these structures, in particular at the outcrop scale, is in two dimensions only. In order to find out more about the process of boudinage in 3D and the resulting geometrical structures we have performed 3D Discrete Element Method (DEM) simulations of boudinage. The models consist of a brittle layer embedded between two ductile layers. To achieve a defined layer-parallel extension while the model is shortened in the direction perpendicular to the layers a constant normal stress is applied to the layer-parallel boundaries of the model and the 4 side boundaries perpendicular to the layering are moved outwards at a defined velocity. By varying the relative velocities of the 4 side walls the style of the layer-parallel extension can be changed from isotropic, i.e. both in-plane strain components have the same magnitude, to uni-axial when only one opposing pair of side walls is moved and the other is kept rigid.

The results show that the fracture patterns in the brittle layer are strongly dependent on the ratio of the two in-plane strain components. In case of uniaxial extension we observe the formation of a set of sub-parallel fractures whereas isotropic layer-parallel extension does result in a polygonal fracture pattern. For intermediate strain ratios we also obtain polygonal fracture patterns but with an anisotropic distribution of the fracture orientations. The degree of anisotropy of the fracture pattern varies systematically with the anisotropy of the layer-parallel strain.

We also observe that the degree of anisotropy of the fracture pattern in each of the models evolves with the amount of deformation. In most models, early macroscopic fractures are predominantly perpendicular to the main extension direction while with increasing deformation fractures with different orientations start to appear which eventually leads to a fracture pattern which is characteristic for the ratio of the layer-parallel extension components.