Discrete element modeling of boudinage in 2D and 3D: Insights on rock rheology, matrix flow, and evolution of 3D geometry

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We use discrete element model simulations to model the full boudinage process from initial fracturing of intact material to post-fracture flow of material into gaps between fragments and to investigate the role which the material properties of the weak and strong layers play in this process. The models are deformed in coaxial bulk flow. Results show natural- looking boudin morphologies and deformation patterns in the matrix. By varying the material properties of the competent layer between fully brittle and semi-ductile we obtain a wide range of deformation patterns ranging from pinch-and-swell structures to a variety of boudin types including drawn, shear band and straight sided torn boudins. In a number of models we observe rotation of the boudin blocks despite the applied deformation being purely coaxial. These rotations are generally related to asymmetric boudin shapes. Some features observed in natural boudins such as concave block faces or the formation of veins between fragments are not modeled because pore fluids are not yet included in our model.

A second series of models was run under nonplane strain conditions. As the models are shortened perpendicular to the layer orientation, they are extended at different rates in the two layer-parallel directions, changing the pattern of fractures between the boudin blocks. The fracture orientation distribution is closely connected to the ratio of the two layer-parallel extension rates. The anisotropy of the fracture orientation distribution increases systematically from no anisotropy at isotropic layer-parallel extension to a highly anisotropic distribution in case of uniaxial extension. We also observe an evolution of the anisotropy of fracture orientation distribution with increasing deformation in each individual model from a high-initial anisotropy towards a value characteristic for the ratio of the layer-parallel extension rates. The observations about the relation between the strain ratios and the fracture patterns do have the potential to serve as the basis for a new method to analyze strains in naturally boudinaged rocks.

References

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