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From Topology to Rheology: Impact of weak phase distribution effective rock rheology

Marcel Thielmann (1), Hauke Marquardt (2), and Gregor Golabek (1)

(1) Universität Bayreuth, Bayerisches Geoinstitut, Bayreuth, Germany (marcel.thielmann@uni-bayreuth.de), (2) University of Oxford, Department of Earth Science, Oxford, United Kingdom

Rocks in the Earth are not homogeneous, but consist of different mineralogical phases with different rheological properties. When deformed, these heterogeneous rocks therefore also exhibit heterogeneous deformation, which depends on the rheological contrast between the different phases and their distribution within the rock. The effective properties of such heterogeneous mixtures have received a significant amount of attention in the past [Treagus, 2002; Madi et al., 2005; Jessell et al., 2009; Dabrowski and Schmid, 2012; Kaercher et al., 2016], but it has not yet been possible to link random weak phase topologies to the effective rock rheology.
Here we use a numerical approach to gain insight into the relationship between phase distribution topology and the effective rheology/ deformation of two-phase rocks. To this end, we prescribe the distribution of weak phases is using random fields and deform the resulting structures in simple shear. The usage of random fields allows us to prescribe a certain topology of the weak phase and to investigate its effect on bulk properties. Adding a weak phase has several effects: First, the internal strain rate, stress and pressure fields become strongly heterogeneous, thus at times resulting in unexpected behavior and localization of deformation. Second, the bulk rock is weakened. The amount of weakening strongly depends on the topology of the weak phase as well as on its rheology. We performed a large number of simulations for different viscosity contrasts, volume fractions and weak phase topologies to obtain the desired amount of data needed for statistical analysis of bulk rock deformation properties. We then link the statistical properties of the weak phase distribution to the effective rheology using an analytical solution.

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