Deformation in two-phase rocks: a look through the statistical lens

Marcel Thielmann[1], Hauke Marquardt[2] and Gregor Golabek[1]

1) University of Bayreuth, Bavarian Geoinsitute, Bayreuth, Germany
2) University of Oxford, Department of Earth Science, Oxford, United Kingdom
marcel.thielmann@uni-bayreuth.de

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 the statistical properties of deformation-related fields such as stress and strain rate have not yet been studied in detail.
Here we use a numerical approach to gain insight into the relationship between phase distribution topology and deformation-related fields. 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 as well as stresses, strain rates and pressures. Adding a weak phase has several effects: First, the internal strain rate, stress and pressure fields become strongly heterogeneous, thus resulting in at times 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. Results show that stress and strain rate distributions are strongly dependent on all of those properties. We also find that the transition between the load bearing framework (LBF) and the interconnected weak layer (IWL) end members is relatively sharp and exhibits a behavior similar to a percolation threshold.

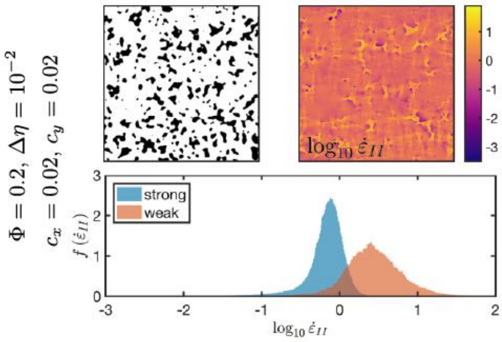

Figure 2: Deformation of a two-phase material in pure shear. Shown are phase distribution (top left), strain rate distribution (top right) and histograms of strain rate for both the strong and the weak phase (bottom). Strain rates are nondimensionalized with the background strain rate.

References

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