Geophysical Research Abstracts
Vol. 21, EGU2019-5112, 2019
EGU General Assembly 2019

Weakening Processes and Strain Localization in Viscously Deforming Rocks: Numerical Modeling based on Laboratory Torsion Experiments

Maximilian Döhmann, Sascha Brune, Livia Nardini, Erik Rybacki, and Georg Dresen
GFZ German Research Centre for Geosciences, Potsdam, Germany

Localization processes in the viscous lower crust lead to the formation of deformation zones over a broad range of scales. Weakening mechanisms on the grain scale cause strength reduction of rocks during localization. To gain insight into the processes involved, we conduct centimeter-scale numerical models with the finite element software SLIM3D. Our 2D models are benchmarked to high-temperature and high-pressure torsion experiments on Carrara marble samples containing a single weak Solnhofen limestone inclusion (Nardini et al., 2018). Bulk stress-strain evolution and final strain distribution are successfully reproduced by the numerical models. In order to mimic rheological weakening, a simple, strain dependent softening law is applied that alters the pre-exponential factor of the flow law. By varying softening parameter values within this modeling framework, the impact of rheological weakening on localization and shear zone formation is quantified.

We find that strain localization inside the host matrix is initiated by local stress concentrations at the inclusion tips. Rheological weakening is a precondition for shear zone formation within the matrix. At the tip of the propagating shear zone, weakening occurs within a process zone that evolves in four phases (P1) pre-weakening, (P2) onset and acceleration of weakening, (P3) deceleration of weakening and (P4) steady-state. The degree of softening controls the shear zone width. With the introduction of a second softening step at elevated local strain, a high strain layer develops inside the already localized shear zone, analogue to the formation of ultramylonite bands in mylonites.

Reference

Nardini, L., Rybacki, E., Döhmann, M. J., Morales, L. F., Brune, S., & Dresen, G. (2018). High-temperature shear zone formation in Carrara marble: The effect of loading conditions. Tectonophysics, 749, 120-139.