Geophysical Research Abstracts
Vol. 19, EGU2017-15462, 2017
EGU General Assembly 2017

Dimensional analysis and scaling for shear zones caused by thermal softening and comparison with 2D numerical models

Dániel Kiss, Thibault Duretz, Yuri Podladchikov, and Stefan M. Schmalholz
University of Lausanne, Institute of Earth Sciences, Géopolis, Lausanne, Switzerland (daniel.kiss@unil.ch)

Localization of strain plays a major role during geodynamic processes, such as mountain building, and in particular during the formation of shear zones on all geological scales. Strain localization in a homogenous material requires a softening mechanism and we consider here thermal softening. Thermal softening is a result of the conversion of mechanical work into heat (i.e. shear heating) and of the temperature dependence of rock viscosities. Previous studies have shown that thermal softening can cause strain localization and the formation of large-offset shear zones in ductile materials whose deformation behavior is described with creep flow laws (e.g. dislocation creep). Although shear zone formation by thermal softening in ductile rock has been already studied intensively, we present here new results for the dimensional analysis and scaling for such shear zones. We perform the dimensional scaling analysis for the equations that describe a 1D shear zone model in an infinite medium. We consider a 1D configuration where the bulk shear deformation is controlled by a constant, far-field shear velocity. The initial configuration exhibits small thermal perturbations. The dimensional analysis is performed in combination with 1D numerical simulations to determine dimensionless parameters that are useful to describe the large strain deformation and temperature evolution.

We present several results: (1) For a linear viscous material a constant maximum temperature inside the shear zone is reached after a transient stage, and this maximum temperature is independent of the initial thermal perturbation which can even be larger than the final temperature in the shear zone. (2) The width of the shear zone is not constant but is increasing with progressive deformation due to ongoing thermal diffusion. (3) The shear zone thickness with respect to the finite strain variation across the shear zone is always significantly smaller than the thickness with respect to the corresponding temperature variation. (4) The maximum temperature in the shear zone is controlled by only one dimensionless parameter. (5) The dimensionless thickening rate of the temperature variation can be predicted by only one dimensionless parameter. This dimensionless parameter can be used to estimate a priori whether shear heating is important or not, and whether significant shear zone formation takes place or not. We will also present shear zone formation by thermal softening in 2D thermo-mechanical numerical simulations for a pure shear configuration to compare the 2D results with the results of the dimensional scaling analysis applicable for the simple 1D shear zone model. The 2D numerical model is based on a staggered-grid finite difference method using a pseudo-transient solution strategy. Finally, potential applications of the presented dimensional analysis and scaling to natural ductile shear zones on several geological scales are discussed.