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Structural versus material softening

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Tectonic modeling accepts constitutive relationships of single building blocks in order to predict structural evolution and collective response of a large number of them. These constitutive or rheological relationships are constrained by rocks testing in laboratory at significantly shorter time scales and by indirect fitting of natural examples. Many orders of magnitude extrapolations and limited number of indirect constrains call for as simple rheological model as possible with minimum number of free parameters. Classical visco-elasto-plastic rheological relationships have a small number of well-defined free constants and lead to well-posed mathematical problems, i.e. good control on model predictions. Usual "matter stability" principle, assumed as an obvious and obligatory property of materials, requires positiveness of rheological constants, such as compressibility and viscosity. However, there are examples of unstable deformation paths and/or metastable structural states leading to, for example, spontaneous strain localization. Do we need to abandon stability constrains and allow for negative rheological constants for the single building blocks of tectonic models to be able to describe overall softening response of emerging structures? Negative constants ensure strain localization to happen but cause hard to resolve problems in laboratory testing and numerical simulation that both become highly sensitive on hopefully insignificant details of experimental setups. The easiest resolution is to have a microscopic model with sufficient number of positive constitutive constants allowing, under well-defined condition, for macroscopic softening and strain localization due to structural rather than material softening. Heating induced shear localization instability will be presented as a case study of structural softening.