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Shear localization due to thermo-mechanical feed-back and anisotropy

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Shear zones resulting from shear localization in deforming rock are important structures controlling the deformation of the lithosphere on nearly all scales. Field observations on pressure, temperature and strain in and around shear zones are important quantities to constrain the geodynamic evolution of mountain ranges or sedimentary basins. In order to link field observations to numerical models it is essential that the numerically modelled shear zones and the corresponding magnitudes of pressure, temperature and strain are independent on the numerical resolution. However, in many numerical models simulating shear localization so-called strain softening is applied for which a certain material parameter (often the friction angle or the cohesion) decreases with increasing strain. Such strain softening usually causes a mesh-dependency of the shear zone thickness, and consequently the shear zone thickness and the related magnitudes of pressure, temperature and strain are also mesh dependent. Such mesh dependency prohibits are correct link between numerically modelled and natural shear zones. In this contribution we present numerical simulations of shear localization for two scenarios without strain softening: (1) Compression of a viscous fluid with a weak circular inclusion where shear localization is caused by shear heating and the temperature dependent weakening of the viscosity. We show that the thickness of these shear zones is independent on the numerical resolution and applied numerical method (Finite Difference and Finite Element Method). We further show that the numerical algorithms are conservative, which means that the numerically calculated mechanical energy corresponds to the thermal energy. The control of the model parameters on the shear zone thickness is investigated. (2) Layer-parallel extension of a power-law viscous multilayer with alternating strong and weak layers where shear localization is caused by the linkage of individual necks within the strong layers across the multilayer. Thermo-mechanical coupling is not considered for this scenario. The shear localization into shear bands does not occur in a single extended layer but only in a multilayer suggesting that the anisotropy of the multilayer is the quantity controlling shear band formation. The impact of the numerical resolution on the shear band thickness is investigated. Applications of the two models to natural observations of shear localization are discussed.