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# The importance of shear heating for shear localization during tectonic nappe displacement

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Localization of deformation plays a major role during tectonic processes at all scale, from the formation of deformation bands within single grains up to crustal and lithospheric scale shear zones. The role of shear localization is particularly important for the formation and displacement of tectonic nappes during orogeny. It has been shown that a simple one-dimensional (1D) thermo-mechanical shear zone model, which considers a power-law flow law and temperature dependent viscosity, can to the first-order explain thrust-sheet and fold nappe formation. This 1D model could successfully reproduce the overall shear strain distribution across natural nappes and shear zones, but underestimated systematically the shear strain at the base of the nappe and shear zone. This underestimation indicates that certain processes have been ignored in the analysis. We present therefore a new 1D thermo-mechanical model which also considers shear heating and the related thermal softening of temperature-dependent viscosity to quantify the impact of shear heating on strain localization during nappe displacement.
We perform a dimensional analysis of the equations which describe the 1D shear zone model to determine the dimensionless parameters which control the deformation. Three deformation modes controlled by dimensionless parameters will be distinguished: (1) shear deformation for which shear heating is negligible, (2) shear deformation for which shear heating is moderate and displacement velocities stay in the range of plate velocities, (3) shear deformation for which shear heating is significant and velocities and temperatures increase continuously (thermal runaway). The 1D shear zone model is applied to the Helvetic nappe system in general and the Morcles, Doldenhorn and Wildhorn nappes in particular. For the geological and microstructural data available for the Helvetic nappe system we determine whether shear heating was important during nappe formation or not. The 1D results are compared with 2D numerical results and the potential impact of softening due to grain size reduction is discussed.