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Thermo-mechanical model for the finite strain gradient in kilometer-scale shear zones

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Many kilometer-scale crustal shear zones with thrust shear sense exhibit a similar nonlinear decrease of the finite shear strain (γ) with increasing distance (z) from the shear zone's base. To explain this strain gradient, we use a one-dimensional (1-D) thermo-mechanical shear zone model which considers a dislocation creep flow law with temperature dependent viscosity. The model predicts a linear finite strain gradient in $\ln(\gamma) - z$ space, which is quantified by the single dimensionless parameter β. β depends on the activation energy (Q), the temperature at the shear zone's base (T_0) and the temperature difference across it (ΔT), which are often well constrained parameters. We apply our model to several shear zones worldwide. Our model is based on physics and fits the strain data as well as previously published empirical functions. The estimates of β resulting from fitting the finite strain gradient agree with other independent estimates of β using realistic values for Q, T_0 and ΔT reported for the considered shear zones. This agreement of independent β estimates indicates that the model is physically feasible and that the dominant cause for the nonlinear strain gradient in kilometer-scale shear zones can be the temperature increase toward the shear zone's base and the related decrease in viscosity. he model, however, often underestimates the strain gradient in the lowermost part of natural shear zones. This underestimation indicates that additional processes such as grain-size reduction or viscous heating, not considered in the model, play an important role close to the base of the shear zone.