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Development of shear zones by shear heating instability: analytical and numerical models and comparison to natural example

S. Medvedev (1), S. Braeck (1), F.Fusseis (2) and Y. Y. Podladchikov (1)

(1) Physics of Geological Processes, University of Oslo, Norway, (2) Fachrichtung Geologie, Freie Universität Berlin, Germany (sergeim@fys.uio.no)

Shear heating instability presents a mechanism for localized deformation in a viscoelastic body. If the shear stress initially applied to the body is below a critical value, the resulting deformation is well distributed. However, if the initial stress exceeds a critical value, all the elastic energy stored in the body spontaneously dissipates as heat in a self-localizing shear zone. We present theoretical study of the shear heating instability and show that the process is controlled by two dimensionless complexes which can be estimated for natural cases. We also present a new estimate for maximum shear strength of viscoelastic materials. This study also attempts to understand if this mechanism of shear heating instability can explain the development of mylonitic shear zones. Using the analytical and numerical models we illustrate the main concepts of the shear heating instability applied to natural example. We model the behavior of a quartzite body described by laboratory derived rheological properties and then compare results with the strain pattern of the natural shear zone located in the Cala Prona (Cap de Creus, Spain). The resulting strain distribution in the model compares well to one in the natural example: total displacement of approximately 2 m is developed in a zone of shear approximately 1 m wide, with the most of deformation (90%) is accommodated by the narrow, less than 0.1 m wide, central part of the shear zone.