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Development of a mylonitic shear zone by shear heating instability: application of numerical model to natural examples of Cap de Creus, Spain

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The present study investigates the possible mechanism of formation of greenschist-facies shear zones exposed at the Cap de Creus, NE Spain. We use a physical model to reproduce the finite morphology as documented in the field. Strain localization in the model indicates an overcritical state of stress in the visco-elastic body of rocks. 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. This process is termed shear heating instability. We present analytical and numerical estimations of the critical value of shear stress, which depends on a number of rheological and geometrical parameters of the model. We applied the numerical model in order to find the conditions that control the strain history of one of the mylonitic shear zones in the Cala Prona, Cap de Creus. This shear zone is approximately 17 m long and 1 m wide, with variations of displacement from 0 - 3 m. Metamorphic mineral assemblages and microstructures indicate background temperatures of 450-500°C. The initial shear stress is assumed to be around 1 GPa. These conditions are used as a set-up for the deformation of a kilometer-scale quartzite body in the model. The model results in the development of a shear zone with a total width of approximately 1 m and a maximum displacement of around 2 m. The major amount of deformation, 80-90%, is accommodated by the narrow, less than 0.1 m wide, central part of the shear zone. This fits well to the natural data. The variations of the displacement along the natural shear zone can be reproduced by small variations of the initial conditions in the model. Our results indicate that shear heating instabilities can explain the evolution of greenschist-facies mylonitic shear zones.