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Inverted metamorphism and feedback between temperature and non-Newtonian viscosity in compressive shear zones: A 2D thermo-kinematic study.

Sylvia Duprat-Oualid and Philippe Yamato
CNRS - Géosciences Rennes, Université de Rennes 1, RENNES, France (sylvia.duprat.oualid@gmail.com)

The thermal evolution within major compressive shear zones is still difficult to characterise due to the fact that various parameters and complex processes are involved. Among them, the heat production obtained by converting mechanical energy, commonly called "shear heating", appears to be one of the most important. Indeed, it controls the potential inversion location of isotherms at crustal-scale. This intense thermal perturbation, preserved in time, is often regarded as responsible for the establishment of a plurikilometric sequence of inverted metamorphism.

Shear heating is proportionnal to the stress and strain intensities and, consequently, is strongly dependent on the strength of the shear zones. On one hand, this strength is controlled by the brittle rheology. On the other hand, it is controlled by the ductile rheology involving a non-Newtonian viscosity field depending on local lithology, strain rate and temperature. In the same time, this temperature is obviously controlled by the evolution of the local thermal budget and thus, by the cumulative shear heating and the dissipated thermal energy. Consequently, in order to understand the thermal evolution of a crustal compressive shear zone, we need to understand the respective influence of each one of these parameters involved in the local rheological behaviour.

In order to adress this problem, we realised a parametric study based on a 2D-thermo- kinematical model. The velocity field (including isostasy compensation) is imposed in the whole model in order to simulate a thrust at crustal-scale. By this way, we are able to control the thrust thickness and the strain rate profile across the sheared area. At each time step, we determine the brittle/ductile transition, we compute the potential heat production (shear heating) and we solve the heat diffusion equation on the grid. The temperatures are then advected by markers following the velocity field. This model is voluntary simplified in order to control each parameter which allows us to test their influence on the geothermal inversion

Our results show that the balance between heat production and heat diffusion is strongly influenced by the viscosity of the shear zone. A strain power law leads to the localisation of the thermal inversion around the strength peak. At the opposite, a Newtonian viscosity makes it to occur in the deepest crustal levels. The creep parameters specific to each lithology play a major role in the thermal development and on the inversion duration. Under realistic kinematic conditions, a significant thermal inversion is generated and continues over time for granitic rocks whereas a negligeable perturbation without inversion occurs when this initial rock is highly deformed and metasomatised.