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Thermo-kinematical modelling of intracontinental inverted metamorphism: a parametric study

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Inverted metamorphism corresponds to the stacking of high-temperature metamorphic units structurally on top of lower-temperature units and is commonly observed along main thrust in major orogens (e.g., Himalayas, Caledonian belt). Yet, in spite of numerous structural and petrological data, the origin of such a metamorphic inversion is still not really understood. Particularly, the relationship between the metamorphic events and the deformation is not well constrained even if many existing models propose that the metamorphic inversion result from a thermal inversion at crustal- scale. Hence, the conditions needed for such a geothermal perturbation are still not well defined. In addition, the preservation of the metamorphic inversion is also still debated.

Here, we investigate the key-parameters and processes controlling the inversion of the geothermal gradient at crustal-scale by using a 2D-thermo-kinematical model. The velocity field (including isostasy compensation) is imposed in the whole model in order to simulate a crustal-scale thrust. At each time step, we solve the heat diffusion equation on the grid including radiogenic heat production and shear heating. 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.

We realised a parametric study to quantify the impact of the initial conditions (thrust angle and convergence velocity) and of the thermal properties of the rocks on the thermal evolution around such a major compressive shear zone. Our results, in good agreement with previous studies (e.g., England and Molnar, 1993) suggest that the kinematic framework strongly impacts the thermal evolution around the thrust, but we also show that, in these cases, the thermal inversion is never preserved over time. Erosion rate and thermal conductivity of rocks are two parameters that control the location in space of the thermal perturbation and its intensity, respectively. We also show that thermal conductivity needs to be used with caution in numerical models due to its temperature dependence. Finally, shear heating appears to be the only processus allowing the preservation of the thermal inversion until the steady state. However, since shear heating is strongly dependent on the shear zone viscosity, we discuss its relationship with the evolution of the shear-zone composition.