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Major role of shear heating in intracontinental inverted metamorphism: Inference from a thermo-kinematic 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 thrusts in major orogens. Yet, in spite of many existing models, the origin and preservation of the metamorphic inversion in intracontinental collision belts is still debated.

In this study, we use a crustal-scale 2D thermo-kinematic model in order to investigate the key parameters controlling the inversion of the geothermal gradient at crustal scale. Our results confirm that the kinematic framework strongly impacts the thermal evolution around the thrust. Erosion velocity and thermal conductivity of rocks are two parameters that control the spatial location of the thermal perturbation and the intensity of inversion, respectively. However, even in extreme kinematic configurations, i.e. convergence velocities > 3cm/yr and relatively high thrust dip angles $\sim 30^\circ$, the thermal inversion is fleeting and thrust temperatures cannot reach the high temperature peak values characteristic of natural occurences (> 600°C) if shear heating is not taken into account.

Conversion of mechanical energy into heat represents a main contribution to the thermal budget along main crustal shear zones. It leads to high temperature conditions in the thrust zone and our results attest that it is the only process that allows the preservation through time of an intense thermal inversion. Our quantification shows that shear heating is much more efficient than other processes such as accretion and surface denudation and is compatible with the observations of inverted metamorphism in the Himalayan or Variscan belts, for example. This comparison with natural occurrences suggests that the formation and preservation of intracontinental thermal inversion require shear zone viscosity values of the order of 1e20-1e21 Pa.s for convergence velocities between 1 and 3 cm/yr.