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What we can learn from peak temperatures profiles in inverted metamorphic sequences

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Inverted metamorphic sequences correspond to the stacking of structural units through which the metamorphic peak temperatures progressively increase upwards. Such thermal profiles, already studied for years, are characteristic of lithospheric-scale thrust zones. Nevertheless, the processes allowing their formation still remain contentious. Several processes can, indeed, lead to peak temperatures inversion: heat advection, shear heating, in-depth accretion and/or erosion (allowing the exhumation of the overthrusting block). Furthermore, heat diffusion also has an important effect on temperatures distribution on both sides of the thrust. Each one of these processes distinctly impacts on the metamorphic thermal field in the vicinity of the thrust zone. However, their respective influences were never clearly analyzed and compared despite their crucial importance for the interpretation of the inverted peak temperatures signatures.

Here, we thus propose to address this shortcoming by using two-dimensional numerical models simulating intra-continental thrusts systems. To do so, we combine a parametric numerical study and the “analytical characterization” of the computed inverted peak temperatures recorded, in our models, along profiles perpendicular to the thrust zone. The parametric combinations, including kinematic setting (i.e. convergence, erosion and accretion), thermal properties, mechanical strength and heat sources, control the processes into play during the thrust activity whose relative importances can be quantified. When the resulting peak temperatures profiles present a noticeable inversion, they are converted into a function of approximation characterized by six parameters. These six outputs then constitute the keys to quantitatively decipher the inversions features, not only in terms of spatial extent and intensity over time, but also by characterizing the peak temperatures trends on either sides of the domain of inversion. This numerical and analytical coupled approach then allows to give the significance of peak temperatures profiles in relation with the different processes into play.

Our results allow to quantify the influence of each process (i.e. heat diffusion, heat advection, shear heating, erosion and accretion) on the different features of inverted peak temperatures signatures. They show that none of them can be considered alone. Finally, the function of approximation used in this study, allowing to efficiently fit a discrete dataset to a continuous signal, can also be applied to natural peak temperatures estimations following the same way. We thus propose to illustrate this on the example of the inverted metamorphic sequence associated to the Main Central Thrust zone in the Himalayas.