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On the meaning of peak temperatures profiles in inverted metamorphic sequences

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Inverted metamorphic sequences (IMS) exhibit an upwards continuous increase of peak temperatures and are common features of main thrust systems on Earth. They constitute evidence of the strong relationship existing between thermal field evolution and tectonic processes. Heat advection and shear heating are known to allow the formation of such metamorphic signatures while heat diffusion also plays an important role on temperatures distribution on both sides of the thrust. Furthermore, other advective processes such as erosion or accretion can also be responsible for local inversion of peak temperatures. However, despite of the crucial importance of all these processes for interpretating inverted peak temperatures signatures, their respective influences were never quantified and compared.

In order to address this issue, we here propose an innovative coupled approach: (i) We perform 2-D numerical models of various thrust systems by taking into account different kinematic settings (convergence, erosion, accretion), thermal properties, mechanical strength and heat sources. (ii) We quantify the relative contributions of each thermal process (i.e. diffusion, advection, shear heating) to the thermal budget evolution by using dimensionless numbers. Erosion and accretion are compared apart. (iii) We analytically examine peak temperatures recorded in our numerical experiments, along profiles perpendicular to the thrust zone. Each peak temperatures profile presenting an inversion is then characterised by a function of approximation involving six meaningful parameters: the location μFF and width σFF of the peak temperature inversion, the characteristic peak temperature Tcte and gradient GLB beneath the inversion zone, the inversion related contrasts of peak temperature ΔT and gradient ΔG.

This multi-approach allows in fine to quantitatively interpret any IMS in terms of involved processes. Its application to intra-continental thrust systems demonstrates that shear heating and erosion support significant inversions, but that the relative contributions of each process are also important. Especially, the competitions between shear heating and heat diffusion on one hand, and between erosion and accretion on other hand appear highly impactful. Particularly, the variability of rock's mechanical strength strongly influences the peak temperatures inversions features. Finally, our methodology is not restricted to the analysis of numerical data but constitutes also a way of broad interest to analyse peak temperature signatures around any worlwide shear zone.