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Ongoing compression triggered exhumation of the orogenic crust in the Variscan Maures-Tanneron Massif, France - Geological arguments and thermo-mechanical tests

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The Maures-Tanneron Massif (MTM), together with Corsica and Sardinia, hosted the South-Eastern Variscan belt and record a continuous evolution from continental collision to exhumation. We present a synthesis of the available geological and geochronogical data that explores the transition from convergence to perpendicular Permean extension in the MTM (at $\sim$ 325 Ma $\pm$ 25 My). The migmatitic Internal Zone that composes the Western MTM displays structural clues such as backthrusting and magmatic foliations, and metamorphic data indicating exhumation of deep seated partially molten rocks at an apparent heating rate of 1-2 °C/km/My from ca. 345 Ma to 320 Ma. This suggests vertical advective heat transport during continued N140° convergence (D2 phase). In contrast at the same time, the low grade External zone composing the Eastern part of the MTM recorded exhumation of more conductive patterns at an apparent rate of 0.3-0.6 °C/km/My. It is only from ca. 320 Ma that transcurrent motion dominates in the Internal zone and progressively leaves way to N-S streching (D3 phase), indicative of orogenic collapse and extension and in asociation with emplacement of larger volumes of magmatism in the crust.

Thermo-mechanical modeling complements this synthesis in order to highlight the conditions under which deep seated HP units could melt and massively start to exhume during maintained convergence (phase D2). Accounting for temperature dependent elasto-visco-plastic rheologies, our models explore the dynamics of an orogenic prism starting from a dis-equilibrated state just after slab break-off or delamination, at ca. 350 Ma. We simulate the development of gravitational instabilities in partially melting crust, a process that is already well known to depend on strain-rate, heat sources and strength layering. In order to reproduce the exhumation patterns of rocks from $\sim$50 km depth over the appropriate time-scale (>20 My) and spatial extent (>100 km), a best fit was obtained with a mean convergence rate of 0.5 cm/yr and no exceptional surface processes. Internal heating has a crucial effect and mostly resulted from the radiogenic decay of stacked felsic crustal units. However alternation with mafic units is also necessary in order to prevent lateral spreading of the orogeny. A low viscosity partially molten (eg. felsic) crust also permits mechanical decoupling of surface deformation from the deeper mantle domains, thus reducing the differences due to either a shallow asthenosphere or a competent mantle lithosphere under the orogeny. A shallow asthenosphere produces too warm and fast exhumation. The bulk viscosity of the partially molten orogenic crust controls the timing of exhumation, pointing to the need for further constraints to link the behaviour at different scales of partially molten crust. The MTM witnesses the typical competition between far-field plate convergence and internal body forces, and we plead for a subsequent progressive evolution of transpression to perpendicular extension (still to be tackled with 3D modeling).