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Lower crust exhumation and ongoing continental convergence in the Variscan Maures-Tanneron Massif, France, geological synthesis and numerical models

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The Maures-Tanneron Massif together with Corsica and Sardinia compose the present day southeastern part of the Variscan belt. Pressure-temperature-time patterns were compiled to adress how rocks once forming a thick orogenic crust were exhumed, from burial conditions of ca. 10 kb and ca. 800°C. A continuous evolution from subduction to collision, from ca. 420 Ma to 290 Ma has recently been proposed by Schneider et al., 2014, ending with orthogonal Permean rifting. Here we complement this study by exploring the thermo-mechanical conditions prevailing during the massive exhumation of this orogenic crust. Based on field observations and petrological analysis indicative of the acceleration of partial melting during ongoing convergence, our numerical models test a scenario in which pre-thickened units located at 40-60 km depth, would have molten due to internal heating and burrial, and were progressively exhumed by gravitationally-driven instabilities to the surface, within $\sim$15-25 Myrs. Assuming temperature dependent elasto-visco-plastic behavior, we have tested rheological layering including mafic or felsic units, far-field convergence and surface processes, as well as temperature-dependent melting conditions and density and viscosity evolution. In order to reproduce asymmetrical exhumation over the given time-scales and over an extent area of more than 50 km synchroneous with the development of compressional folds in the upper crust, a best fit was obtained for an applied far-field convergence of 0.5 cm/yr, equivalent to present day Alpine convergence rates, and a bulk crustal viscosity of at least 10^{20} Pa.s. Crustal heat source had to contribute significantly, whereas a too shallow mantle heat source triggers exceedingly warm and fast exhumation. We propose that the evolution from transpressional to tensile conditions perpendicular to the orogenic axis (north-south Permean rifting versus East-West vergence of the orogenic structures), occurred progressively as internal volume forces rose and exceeded far-field boundary forces, linked with the balancing of masses in all three directions. The original location of this portion of the Variscan belt remains unclear but it presents consistent transitional characteristics between the Massif Central and the Bohemian massif.