Late Cenozoic exhumation of the French Massif Central: constraints to long wavelength uplift from thermochronology analysis

Valerio Olivetti\textsuperscript{1,2}, Maria Laura Balestrieri\textsuperscript{3}, Vincent Godard\textsuperscript{1}, Olivier Bellier\textsuperscript{1}, Cécile Gautheron\textsuperscript{4}, Pierre Valla\textsuperscript{5,6}, Massimiliano Zattin\textsuperscript{2}, Claudio Faccenna\textsuperscript{7}, Rosella Pinna-Jamme\textsuperscript{4}, and Kevin Manchuel\textsuperscript{8}

\textsuperscript{1}Aix Marseille Univ, CNRS, IRD, INRAE, Coll France, CEREGE, Aix-en-Provence, France
\textsuperscript{2}University of Padova, geosciences, Italy (valerio.olivetti@unipd.it)
\textsuperscript{3}CNR, Istituto di Geoscienze e Georisorse, Firenze, Italy
\textsuperscript{4}GEOPS, Université Paris-Sud, CNRS, Université Paris-Saclay, 91405 Orsay, France
\textsuperscript{5}Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS,IRD, IFSTTAR, ISTerre, 38000 Grenoble, France.
\textsuperscript{6}Institute of Geological Sciences and Oeschger Center for Climate Research, University of Bern, Bern, Switzerland
\textsuperscript{7}Dipartimento di Scienze, Università di Roma Tre, Italy.
\textsuperscript{8}EDF-DIPNN-DI-TEGG, Aix en Provence, Cedex 02, France

The French Massif Central is a portion of the Variscan belt that exhibits a present-day high topography associated with a potential Cenozoic rejuvenation. Despite other Variscan massifs in Central Europe, such as the Bohemian, Rhenish and Vosges/Black Forest Massifs, show similar topography, the French Massif Central is higher, wider and with evidence of more intense late Cenozoic volcanism. Deep-seated processes controlled by mantle upwelling are generally invoked for the origin of Cenozoic uplift, although the timing and quantification of the relief formation remain unclear. Here we present

a thermochronological study based on new apatite (U-Th)/He and fission-track data that have been integrated with published data (Barbarand et al., 2001; Gautheron et al., 2009) to reconstruct the exhumation history of the eastern margin of the massif. Apatite (U-Th)/He and fission-track data show Cretaceous ages from the high elevation samples and Eocene ages from the lower samples. Although the thermochronological ages do not allow to clearly constrain the onset of Cenozoic exhumation, the regional distribution of the mean track length is essential for the interpretation of the eastern margin evolution: mean track length-elevation relationships show a complex and non-linear trend consisting in a general decrease of MTL from high elevation/old age toward intermediate elevations and then a slight increase for the lowermost and youngest samples. We integrated inverse and forward modelling approach to test different hypothesis of margin evolution. The best fit between observed and predicted data is obtained with a Cretaceous cooling followed by a phase of thermal stability around 40°C and a renewed (lower amplitude) cooling during late Cenozoic. These two cooling events represent two main tectonic phases, the first in the Cretaceous and a minor one in late Cenozoic.

The limited amount of erosion coupled with the occurrence of Cretaceous deposits on top of the
massif and in the Rhône river valley floor and no evidence for faulting suggest a long-wavelength flexure of the lithosphere, which has produced a margin topography characterized by a broad monocline with a very low gradient. This topography is consistent with a surface growth induced by mantle upwelling.