Geophysical Research Abstracts
Vol. 17, EGU2015-2050, 2015
EGU General Assembly 2015
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Unravelling the long-term cooling history of the northern Pyrenees from rifting-to-orogenic evolution

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Providing constraints on the temporal and spatial evolution of shortening in collision zones is key to reconstruct past plate motion. There are increasing evidences that the pre-orogenic architecture of the continental margins controls the development of continental accretion and therefore may be responsible for changes in the timing and rate of thrusting in collisional orogens. How this affect the thermal/exhumational record in the orogens is however little documented.

Here, we study the northern Pyrenees (Ariège, Central North-Pyrenean Zone) that is exposed on the retro-wedge side of the orogen. This region developed in the vicinity of a domain that recorded hyper-extension and mantle exhumation and therefore potentially recorded the transition from rifting to collision. Apatite fission-track data from the granitic massifs of the Arize and Trois-Seigneurs Massifs indicate that collision-related exhumation started in the Early Eocene and lasted until Miocene. However, there are only scarce constraints on the former thermal history as there is not enough data from higher temperature thermochronometers.

To gain a better resolution of the cooling/exhumation history from rift to mature collisional stage, we provide interpretations from new in-situ apatite and zircon fission-track and (U-Th-Sm)/He from the Arize and Trois Seigneurs massif.

During extension, the studied granite recorded spatially variable thermal histories depending on the original rift-related architecture of the massifs. We show that the southern side of the Arize and 3S massif recorded significant cooling at 130-115 Ma from temperatures of 300-350°C, in agreement with RSCM temperatures obtained from the surrounding folded Mesozoic units. The northern sides recorded heating with subsidence. The massifs were rapidly cooled and exhumed between 50 and 35 Ma. Onset of convergence is only recorded in the hot basins as contraction resulted in ductile deformation. In this study, we show that the rift-related architecture is well preserved in the northern part of the Ariège area. We propose this results from the inversion of a moderately thinnned part of the European domain. This contrasts with the highly deformed south Ariège région (Aulus basin) and with the Mauléon basin in western Pyrenees, interpeted as developed on an extremely thinned part of the European domain.

This study brings major constraints to a tectonic model in which shortening and exhumational patterns in orogens are largely controlled by the inherited pre-orogenic structure of the inverted domain.