Resolving timing of early convergence from low-temperature thermochronology applied to Alpine-type systems

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Low-temperature thermochronology has been successfully applied to constrain exhumation or rates of change in topographic relief, hence resolving key issues on the relative role of climate and geodynamics into mountain building. Nonetheless, this approach may lack resolution at the earliest stage of collision when inversion and exhumation of thinned continental margins are not coupled with significant erosion, possibly maintaining temperatures above the sensitivity limit of low-temperature thermochronometers and thus delaying the cooling record.

We here examine the case of the Pyrenean orogenic system which is a particulary suitable setting to address crustal thermal and dynamic behavior during early orogenesis. There is a growing literature arguing for tectonic processes as principal cooling mechanism during early convergence, but we still lack details on how thermochronologic ages vary as a function of margin architecture and rates of convergence during early inversion of distal rifted margins. We take advantage of recently published thermo-mechanical models of tectonically-inverted hyper-extended rifts (contribution of the Orogen project TOTAL R&D-BRGM-INSU) and perform detailed forward modelling to predict thermochronologic age patterns across a Pyrenees-like orogen.

The upper plate margin is predicted to preserve a clear rifting-related cooling signal in its proximal domains and early convergence cooling in its distal part. Postrift thermal relaxation is shown not to be sufficient for thermochronologic clocks in distal domains to start during early convergence. In contrast, thermal overprint due to later collision is expected within the lower plate margin. The good agreement between these modelling results and published thermochronologic data and pre-orogenic crustal architecture reconstructions for the Pyrenees shows that low-temperature thermochronology can provide an important piece of information for reconstructing orogenesis from rifting to collision. This work clarifies the contribution of tectonic processes during early convergence. We believe that in other natural Alpine-type systems, low-temperature thermochronology can potentially identify similar processes involved in orogenesis, especially during early inversion of the distal rifted margins.

Mots-Clés : Pyrenees, low-temperature thermochronology, thermal history modelling, inheritance, early orogenesis, tectonic inversion