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Evaluating balanced section restoration with thermochronological data in the Central Pyrenees

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Crustal-scale balanced section restoration is an elaborate procedure that requires understanding not just the present-day geology and the history of the area in question, but also the processes acting on the deep structures as well as those playing a role in the formation of topography. Integration of all available geological and geophysical data is essential to constrain a restoration that describes the present-day features in the most realistic and simplest possible way. Generally, these restorations are non-unique and their consistency with independent data – in particular thermochronological data that constrain spatial and temporal patterns of exhumation – is difficult to assess.

As part of the TOPO-Europe project PYRTEC, we developed a new method that can be used to quantitatively evaluate the consistency of balanced section restorations with thermochronological datasets. We have applied our method on the area-balanced, crustal-scale cross-section restoration of the ECORS deep-seismic profile in the Central-Pyrenees constructed by Muñoz (1992) and Beaumont et al. (2000). This restoration is well constrained and supported by a wide variety of geological and geophysical data. Moreover, an extensive thermochronological dataset, including apatite and zircon fission-track, (U-Th)/He, mica, and feldspar Ar/Ar ages has been collected independently in the area.

Using 2D-Move software, we have created a velocity field that describes the kinematics and internal deformation of different crustal blocks of the Central Pyrenees. The three central thrust sheets of the section – the Nogueres, the Orri and the Rialp – were our main focus, as these blocks make up the Axial Zone where basement is exposed and where the bulk of the thermochronological data was collected. We extend our model to the North Pyrenean Fault Zone to incorporate the available thermochronological data available from that area. Using this velocity field as an input for the thermo-kinematic model Pecube (Braun, 2003) we have derived predictions of the thermal history, exhumation rates and a range of thermochronometer ages for the modelled area. We have compared the predicted and observed thermochronological data to test the consistency of the section balancing with the observations and to evaluate the kinematic history inferred from the balanced crustal cross section through the Central Pyrenees.

We find that the observed thermochronological data are in good agreement with the kinematic history of the belt as inferred from section balancing. In order to explain the lowest-temperature (apatite fission-track and (U-Th)/He) data, two different scenarios for the topographic evolution are needed for the northern and the southern flank of the belt in the modeled area. Our results are in good agreement with previous studies arguing for late syn-orogenic sedimentary burial of the southern side of the Pyrenees between Late Oligocene to Mid Miocene times.