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Revisiting the crustal evolution of the Pyrenees and the Cantabrian Mountains: inferences from new concepts and data

Antonio Teixell (1), Pierre Labaume (2), and Yves Lagabrielle (3)

(1) Universitat Autonoma de Barcelona, Dept. de Geologia, Bellaterra, Spain (antonio.teixell@uab.es), (2) Géosciences Montpellier, Université Montpellier 2-CNRS, Montpellier, France, (3) Géosciences Rennes, Université Rennes 1-CNRS, Rennes, France

The evolution of the Pyrenean-Cantabrian orogenic system at the crustal scale is currently reformulated in the light of new concepts of continental hyperextension and mantle exhumation applied to the preorogenic stages. Major advances are being obtained in the frame of programs as TOPOIBERIA, TOPOEUROPE, GDR Marge, PYRAMID, PYROPE and BRGM-RGF. Crustal models developed in the 80's and 90's after the ECORS reflection profiles depicted a precursor Mesozoic rift basin floored by a strongly thinned, but entirely continental substratum, using Airy isostasy. In the past years, a restatement of the significance of the Pyrenean peridotites and the application of concepts from passive continental margins has led to scenarios of extreme crustal attenuation and mantle exhumation during mid-Cretaceous times. New paleothermometrical databases show a generalized high heat flow during the mid and late Cretaceous that accounts for thermal isostasy and explains the apparent disequilibrium between extreme crustal thinning and not so great synrift sedimentary thickness and paleobathymetry.

Models for the evolution of the Pyrenean orogeny must consider feedbacks between the Cretaceous hyperextension and the late Cretaceous to Cenozoic inversion. A key challenge is to identify the ancient continental margins of the European and Iberian plates and their suture. New sequential restorations of the compressional structure to selected steps allow a reassessment of the style of convergence through time. In preorogenic reconstructions, end-member models show a tilted-block structure vs. smoothly thinned (boudinaged) margins, overlain by a sedimentary lid detached in the Triassic evaporites.

As for the Pyrenees, different models agree that the early stages of convergence involved the subduction of the peridotite "ocean", which was followed by early collision of the thinned continental margins until the crust regained thickness. Late collision involved northward subduction of decoupled lower crust, currently imaged to depths that do not match the total amount of upper crustal shortening, but are in agreement with the hyperextension. How the orogenic shortening is transferred from the upper crust to lower crust is still the subject of contrasting views, although recent geophysical investigations support crustal wedging.

The eastern Cantabrian Mountains have a crustal structure not very different from the Pyrenees. Only one of two Cretaceous basins (Parentis and Basque-Cantabrian) was strongly inverted. In spite of facing the oceanic crust of the Bay of Biscay, the western Cantabrian Mountains are still underlain by N-directed continental subduction. Subduction of the Bay of Biscay oceanic crust under the margin remains elusive, only imaged (possibly) by subcrustal inclined reflections to a maximum depth of 40 km in a strike-parallel profile.

In spite of growing databases, major discrepancies remain between the amount of convergence derived from plate reconstructions and that admissible in the light of geological and geophysical observations. Differences in the presumed width of the exhumed mantle domain depicted in different models are of one order of magnitude. The subduction of several tens to hundreds of km of mantle peridotite proposed in some models are hard to reconcile with the lack of signature in the overlying sedimentary basin fill. Satisfactory solutions need to be investigated.