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Unravelling the link between deep structure, surface processes and topography in the Pyrenean-Cantabrian mountain belt: first steps and future work

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The Pyrenees and the Cantabrian Mountains are two E-W trending mountain chains located in the northern border of the Iberian Peninsula that grew during the Alpine orogenesis in Late Cretaceous-Tertiary times. The Pyrenees run along the isthmus separating the Iberian Peninsula from the rest of continental Europe, and were initiated by the inversion of a wide and elongated Mesozoic basin located between the Iberian and European plates. The Cantabrian Mountains, running in the same direction immediately to the west, constitute a coastal range uplifted as a consequence of shortening along the former Mesozoic passive continental margin of the Bay of Biscay. From the geological point of view, both ranges constitute a continuous mountain belt, in which the deformation progressed from east to west.

Geophysical studies in the Pyrenean-Cantabrian mountain belt have shown that this continuity also applies to the first-order features of the crustal structure. The lower part of the Iberian crust is underthrusted towards the north forming a continuous crustal root down to 55-60 km depth, over which a doubly-vergent orogenic wedge is developed. The style of crustal deformation, however, varies along the strike of the chain, with three distinctive major areas separated by lateral structures: 1) In the Pyrenees, the southern branch of the belt accommodates most of the deformation, including the so-called "Axial Zone", which constitutes a significant antiformal stack of south-directed pre-Mesozoic basement thrust sheets. The higher summits of the belt (with more than 200 peaks above 3000 m high) are located within or near the borders of this Axial Zone, approximately above the crustal root. 2) In the western part of the Cantabrian Mountains, most of the shortening is accommodated in the northern branch of the belt, along the southern margin of the Bay of Biscay, creating the shortening of the continental platform, the steepness of the continental slope, and the deformation of sediments at the foot of the slope with a typical accretionary prism-like geometry. In the southern branch, the deformation of the upper crust is concentrated in a south-directed crustal ramp that uplifts a stiff pre-Mesozoic basement block containing the higher summits of the Cantabrian Mountains (with more than 30 peaks above 2500 m). Deeper in the crust, a complex double delamination was inferred from several geophysical studies, being the deeper parts of the crustal root displaced towards the north of the higher summits and located beneath the shoreline. Therefore, an Airy-type of isostatic equilibrium cannot be assumed, and a combination of a Pratt model and flexural support must be considered for this zone. 3) In the eastern part of the Cantabrian Mountains, the shortening of both the northern and southern branches is more balanced, the relief is smoother and the altitudes are significantly lower. This area experienced a very intense extensional deformation in Mesozoic times, with several kilometres of sediments deposited over an extremely thinned continental crust that only crops out at present in small massifs in the transition to the western Pyrenees.

Deeper in the lithosphere, the uncertainties in the determination of the structure greatly increase, as studies

are scarce and their conclusions not always consistent. A joint modelling of gravity anomalies and geoidal undulations is being carried out at present and will hopefully add some constraints. Seismic tomography within the Topo-Iberia project will also provide useful information on the upper mantle composition and structure

Although there is at present a good understanding of the relationships between the origin of the main ranges and massifs within the belt and the presence and effect of individual geological structures in the upper crust, little is known about the relationship between the evolution of the lithospheric-scale structure and the evolution of the long-wavelength component of topography, both in time and along the strike of the belt. Also, the effect of surface processes and the potential feedback between them and the internal processes remain poorly understood.

To gain insight into these topics, a new project recently started within the Eurocores Topo-Europe programme, with the title "Spatial and temporal coupling between tectonics and surface processes during lithosphere inversion of the Pyrenean-Cantabrian mountain belt (PYRTEC)". This project will study interactions between surface processes, climate, and tectonic deformation during mountain building in the Pyrenean-Cantabrian belt. Although operating at vastly different time and length scales, a significant potential exists for feedback between large-scale tectonic deformation and redistribution of mass by the surface processes of erosion and sedimentation. This project will use a multidisciplinary approach involving field based studies, regional data compilation, geochronology, and quantitative modelling approaches that will couple tectonic and surface process models.