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Geophysical-petrological modelling of the lithosphere beneath the Cantabrian Mountains and North-Iberian margin: mantle wedge hydration triggered by eclogitization reactions?

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The Cantabrian Mountains constitute the western prolongation of the south-verging foreland fold-and-thrust belt of the Pyrenean Range along the northern border of the Iberian Peninsula. The north-verging structures of the North-Pyrenean Zone, on the other hand, extend to the west along the North-Iberian continental margin (southern Bay of Biscay), formerly created in Mesozoic times in relation to the opening of the central Atlantic. This submerged fold-and-thrust belt shortened the continental platform, steepened the continental slope, and affected the southern border of the Bay of Biscay abyssal plain, where it displays an accretionary prism-like geometry. The composition of the crust beneath this zone is controversial, although recent seismic studies suggest it is either thinned continental or transitional crust, ruling out a true oceanic nature. Previous studies based on several geophysical observations have suggested that the lower continental or transitional crust in this part of the margin is detached from the submerged fold-and-thrust belt and indented to the south into the Iberian crust. This indentation forced the lower half of the Iberian crust to underthrust to the north, in the same sense than in the Pyrenees, creating a crustal root that is well imaged by seismic methods down to at least 50-55 km depth. Geological reconstructions, however, suggest that remnants of this root may be present even $\sim$30 km deeper.

In order to gain insight into the deeper structure and nature of the mantle beneath the mountain chain and the shortened continental margin to the north, we performed a modelling of the thermal, compositional, density and seismic velocity structure of the upper mantle down to 400 km depth along a 470-km N-S transect using the finite-element code LitMod. From the pre-assigned chemical compositions for the different mantle bodies (in terms of their major element constituents) and the structure and density of the crustal bodies, the code calculates the pressure-temperature conditions at each node and determines the corresponding stable mineral assemblages, bulk density, and isotropic p-wave velocities. The final result is a model that simultaneously fits gravity anomalies, geoid undulations, surface heat flow and elevation (assuming local isostasy), and provides theoretical upper mantle velocities that can be compared with the results of available seismic experiments. This joint modelling of several observables in a self-consistent framework reduces the ambiguity of the final model and provides stronger constraints on the deep crustal/lithospheric structure.

We assume for the lithospheric mantle an average composition for "Tecton" continental lithospheric mantle (tectonothermal age of the overlying crust < 1Ga), while the sublithospheric mantle is modelled with a major-element composition representative of Primitive Upper Mantle. The results of the model, suggest that the lithosphere is 120-130 km thick in the northern border of the Iberian plate and around 100 km thick beneath the abyssal plain of the Bay of Biscay, with a small lithospheric root developed beneath the crustal root of the Cantabrian Mountains. This crustal root is assumed to be eclogitized, reducing its buoyancy and allowing a state of near isostatic equilibrium in spite of being present under the coastline. Beneath the continental margin and on top of the eclogitized crustal root, a reduction in the density and velocity of the uppermost mantle is necessary to properly fit the gravity, elevation and seismic observations (Vp=7.6-7.9 km/s against 8.0-8.2 km/s beneath the Iberian mainland Moho). We propose that a small body of partially serpentinized peridotites in this zone, originated by the addition of $\sim$1 wt % of water in the upper mantle either during the Mesozoic formation of the margin or due to the dehydration reactions during the eclogitization of the crustal root, can easily explain the observations.