Western Pyrenees: linking cretaceous rift architecture with present-day orogenic structure

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In plate tectonics, there is a general assumption that rifted margins represent most of the former material accreted into collisional orogenic prisms. In this regard, the former architecture, structures and composition of rifted margins, i.e. the pre-orogenic inheritances, play undoubtedly a major role during tectonic inversion. The discovery of hyper-extended domains of rifted margins, where low-angle detachment systems replace high-angle normal faults and mantle material is exhumed to the seafloor implies a revision of the margin's template used in orogenic models.

The Pyrenees can be considered as one of the best places to study the reactivation of hyper-extended rifts. Indeed, the Late Cretaceous and Tertiary shortening overprints a Latest Jurassic to Lower Cretaceous intracontinental rift linked with the opening of the North Atlantic. There, the so-called « Albian » hyper-extended rift basins developed where deep crustal and mantle rocks were tectonically exhumed to the seafloor.

In this presentation we discuss the example of the Mauléon-Arzacq rift section, which escaped from the most pervasive deformation because being preserved in the neutral point of the chain. Combining field study with subsurface data, we discuss the overall asymmetry of the rift system defined by the polarity of north dipping detachment systems. Along the European upper plate (hanging-wall of detachment systems), hyper-extension (HE) is recorded through the development of a rift sag basin (Arzacq Basin) under the control of depth-dependent crustal thinning. This contrasts with the Iberian lower plate from which HE is accommodated by tectonic exhumation of Iberian lithospheric rocks below the Mauléon lower plate Basin. Tectonic exhumation is controlled by two detachment systems that developed during two maturation stages of the rift system. The older detachment system separates the unextended Iberian continental crust to the south from the hyper-extended rift to the north along a crustal neck. The younger one exhumed further north an already thinned crust and mantle rocks along the basin floor front of the upper plate.

Nowadays, the progressive increase of the Pyrenean overprint can be observed from the west to the east along the rift axis making possible to explore reactivation modalities. In this area, the shortening is accommodated through two stages. 1) The tectonic inversion starts with the under-thrusting of the lower plate hyper-extended domain beneath Europe along the northern detachment system. Sediments are wedged, folded and thrust both north- and southward (thin-skin). 2) The northern structure locks and implies the southward migration of shortening. The southern crustal neck is therefore reactivated implying subsequent frontal nappe stacking (thick-skin) and coeval back-thrusting. This stage corresponds to excess shortening relative to rift-related space creation through “new” structures.

Using the Rifter® kinematic modeler, we show that this evolution can be computed through isostatically equilibrated lithospheric sections. Keeping in mind possible strike variations of hyper-extension polarities and location of rift axis, these results suggest that the Pyrenees exemplify how far hyper-extended rift structure may control the style and the timing of collisional orogeny.