The Pyrenees within the Iberian plate boundary: How much an orogenic lifecycle can be influenced by rift structural inheritances?

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The Orogen project is a 5-years geosciences research program resulting from an alliance between the CNRS, the French geological survey (BRGM) and Total R&D. Focusing on the Africa-Europe diffuse plate boundary across Iberia, « Orogen » aims at to better understand orogenic processes and its driving mechanisms. One advantage of the project's playground is that all of the orogenic maturity stages are today exposed from the incipient subduction of the Bay of Biscay to the post orogenic back-arc extension of the Gulf of Lion. One of the significant outcomes of the project is to reveal the fundamental control of the divergent setting on orogenesis through space and time. Through the reconstructed evolution of the Pyrenees, two main types of structural controls can be documented: 1) the crustal template and the spatial partitioning of rifts. Orogenesis starts by a pre-collision stage that consists in the subduction/underthrusting of an inherited divergent « consumable ». It corresponds to the domains located ahead of crustal necking zones (i.e. hyperextended rifts). An exception to the subduction fate of the « consumable » results from the 3D segmentation of rifts. At this stage, shortening needs to spatially link up different rift axes by shortcutting relay zone. It results in by back stepping the “subduction” from one branch of rift to the other. It leads to anomalously sample pieces of the « consumable » on the upper plate of the subduction (e.g. Mauléon hyperextended rift in the Western Pyrenees). Once convergence consumes its « consumable », mature collision occurs when crustal necking zones interact with the "subduction" fault plane. Indeed, underthrusting more buoyant thicker crust requires an increase of tectonic stress. At the plate boundary scale, it forces convergence to reorganize spatially and implies the inversion of neighboring less mature branches of rifts by far field stress transmission rather than rupturing unstretched continental domains. When reaching a critical level of stress, crustal indentation starts and thick-skin nappe-stacking propagates beyond necking zones into
thick crustal domains. Crustal thickening accelerates launching foreland basin dynamics while orogenic reliefs increase. The orogenic system tends to reach a new equilibrium between tectonic and body forces, accommodated strain, sustaining reliefs and their surface processes counterpart. Then, two end-member cases of post-orogenic dynamic can be defined. Starting right after early orogeny and forced by lateral mature collision, an orogenic system can enter in a "forced" back-arc dynamic (e.g. Gulf of Lion). To achieve this it requires a mature subduction (i.e. enough for a slab-pull) and a remaining "consumable" to subduct (oceanic domain/hyper-thinned crust). The other post-orogenic path following a collision, may be caused by the decrease of tectonic forces relative to body forces. This breaks the depth-surface equilibrium inherited from collision and lead to post-orogenic extension/collapse.