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Formation and reactivation of a segmented rift system: the example of the Pamplona transfer zone (western Pyrenees)

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Numerous studies point out the importance of transfer zones in shaping the architecture of rift systems. Yet, the role of transfer zones in hyperextended rift systems and their expression in passive margins is still unclear. Moreover, their fate during the subsequent convergence remains little explored.

Our study focuses on the Basque region (western Pyrenees) and more particularly on the Pamplona paleo-transfer zone that delimits the Mauléon-Arzacq basin to the east from the Basque-Cantabrian basin to the west. The aim of this study is twofold: 1) understanding the present-day structure of the inverted rift systems on both sides of the Pamplona transfer zone, and 2) defining the first order rift evolution and architecture during Cretaceous.

The influence of the Pamplona transfer zone on the formation and reactivation of the Mauléon-Arzacq and the Basque-Cantabrian basins is substantial as expressed by their large offset, the occurrence of exhumed deep crustal and mantle rocks flooring the two basins and the inversion style of the basins. North-south cross-sections allow to describe the architecture of the two reactivated rift systems. Based on the results of previous studies and new field work, we argue that the upper-lower plate architecture acquired during hyperextension controlled the reactivation of these basins. This is shown by the thrusting of the Nappe des Marbres and of the northern Mauléon basin, both representing former hyper-extended domains, onto the adjacent little extended northern border of the rift system (e.g. Central Depression/Grand Rieu High) during Pyrenean convergence. Simultaneous to the basin inversion, exhumed and hyperextended domains (mantle and/or crustal rocks) were underthrust along the former rift-related exhumation faults (detachment faults) toward the north, i.e. the upper plate. This first order structure is well expressed on tomographic and reflection seismic images. Moreover, we show that the exhumed middle to lower crustal granulites that are exposed north of the Labourd massif do not extend westwards and do not floor the St-Jean-de-Luz basin. This argues for a sharp north-south directed transfer fault in this area. Field work along the boundary between the two rift basins, i.e. along the Pamplona paleo-transfer zone, shows that this structure localized along a Permian basin capping the Labourd massif and that rift-related structures changed their orientation approaching the Pamplona transfer zone. This suggests a strong control of inheritance on the location of the transfer zone. Based on the new observations, a new regional kinematic model for the western Pyrenees is proposed.