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The deep structure of Alpine-type orogens: how important is rift-inheritance?

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Collisional belts are commonly thought to result from the closure of oceanic basins and subsequent inversion of former rifted margins. The formation and evolution of collisional belts should therefore be closely interlinked with the initial architecture of former rifted margins. Reflection and refraction seismic data from present-day magma-poor rifted margins show the omnipresence of hyperextended domains (severely thinned continental crust (<10 km) and/or exhumed serpentinized mantle with minor magmatic additions) between unequivocal continental and oceanic domains. Integrating these new observations and exploring their impact on mountain building processes may result in alternative interpretations of the lithospheric structure of collisional orogens.

We focus on the Pyrenees and Western to Central Alps, respectively resulting from the inversion of a Late Jurassic to Mid Cretaceous and an Early to Mid Jurassic rift system eventually floored by hyperextended crust, exhumed mantle or proto-oceanic crust. The rift-related pre-collisional architecture of the Pyrenees shows many similarities with that proposed for the Alps; although the width of the hyperextended and in particular of the proto-oceanic domains is little constrained. Contrasting with the Pyrenees, remnants of these domains are largely affected by orogeny-related deformation and show a HP-LT to HT-MP metamorphic overprint in the Alps. Nevertheless, in spite of the occurrence of these highly deformed and metamorphosed rocks constituting the internal parts of the Alps, the overall crustal and lithospheric structure looks surprisingly comparable. High resolution tomographic images across both orogens unravel the occurrence of a velocity anomaly dipping underneath the internal domains and progressively attenuated at depth that we interpret as former hyperextended domains subducted/underthrusted during collision. This interpretation contrasts with the classical assumption that the subducted material is made of lower crustal rocks only and may explain the emplacement of remnants of hyperextended domains in the internal parts of the orogen.

The comparison between the deep structure of the Pyrenean and Alpine belts enables us to evaluate some aspects of the relative role of rift-inherited hyperextension and collisional processes in building Alpine-type orogens. In particular, we aim to discuss: (1) the nature of orogenic roots (lower crust vs former hyperextended domains), (2) the nature of rheological weaknesses inherited from hyperextension controlling the location of decoupling levels during orogeny, and (3) the nature and importance of buttresses during collision. Our results suggest that the final stage of collision could have been similar between the Pyrenees and the Alps. More generally, this work may bring new insights to unravel the mountain building processes and the deep structure of Alpine-type orogens.