

Pyrenean hyper-extension : breaking, thinning, or stretching of the crust ? A view from the central north-Pyrenean zone

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The geology of the North Pyrenean Zone in the central Pyrenees allows for the observation in the field of the entire section of the Pyrenean rift, from the mantle to the crust and the Mesozoic cover (pre, syn and post rift). The good knowledge we have of the pre-Alpine history of the Pyrenees allows us to properly constrain the Alpine geological evolution of the pre-Triassic rocks which record both Variscan and Alpine orogenic cycles.

The mantle outcrop as kilometric to centimetric fragments of peridotite dispersed within a carbonate metamorphic breccia. The study of peridotite serpentinisation shows several events of low-temperature serpentinisation, in contact with seawater. In some localities, we can observe a mixture of fragments of variously serpentinized peridotites. This suggests a tectonic context where fragments of peridotites from different structural levels were sampled more or less synchronously.

The granulitic basement is characterized by a Variscan syndeformational HT event (300-280 Ma). So far we have not found any trace of a Cretaceous HT event (> 500°C). On the other hand, the basement is affected by a regional metasomatism that began during the Jurassic and became more spatially focused with time until it was restricted to the Pyrenean rift during the Aptien, Albian and Cenomanian. The talc-chlorite metasomatism (120-95 Ma) shows an evolution from a static toward a syn-deformation hydrothermal event, under a more or less normal geothermal gradient. Extensional deformation is recorded by the reworking of several inherited low-angle Variscan tectonic contacts, but also by dispersed high-angle extensional shear zones formed under greenschist conditions.

The metamorphic Mesozoic cover of the basement massifs, which constitute the so-called Internal Metamorphic Zone, is an allochthonous unit made of lenses of Mesozoic rocks enclosed into the breccia, which locally contains peridotite and basement clasts. The Mesozoic metamorphic carbonates show a first phase of syn-metamorphic (450-600°C, P < 2 kb) ductile deformation, and subsequent phases of folding and fracturing. The datation of neoformed minerals give a 108-85 Ma time span for the metamorphism. We interpret this breccia as an abandonment breccia which marks the emergence of the main detachment. The basal contact of the Mesozoic cover has a complex 3D geometry traced by Triassic evaporites. It corresponds to a major pre- and synorogenic polyphased tectonic contact.

All these data show a geometrically complex hyper-extended rift where the crust was not stretched under a high geothermal gradient but thinned by the tectonic extraction of relatively thin lenses and perhaps cut by high angle low-grade shear zones. The 3D geometry, as well as the strain records and the breccia lithologies strongly suggest a non-cylindricity for the exhumation process, probably within a transtensional system.