Geophysical Research Abstracts
Vol. 19, EGU2017-6229, 2017
EGU General Assembly 2017

Architecture of ductile-type, hyper-extended passive margins: Geological constraints from the inverted Cretaceous basin of the North-Pyrenean Zone ('Chaînons Béarnais', Western Pyrenees)

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Sub-continental lithospheric mantle rocks are exhumed at the foot of magma-poor distal passive margins as a response to extreme stretching of the continental crust during plate separation. Remnants of the Northern Iberian paleo-passive margin are now exposed in the North-Pyrenean Zone (NPZ) and represent field analogues to study the processes of continental crust thinning and subcontinental mantle exhumation. The NPZ results from the inversion of basins opened between the Iberia and Europa plates during Albo-Cenomanian times. In the western NPZ, the 'Chaînons Béarnais' ranges display a fold-and-thrust structure involving the Mesozoic sedimentary cover, decoupled from its continental basement and associated with peridotite bodies in tectonic contact with Palaeozoic basement lenses of small size. Continental extension developed under hot thermal conditions, as demonstrated by the syn-metamorphic Cretaceous ductile deformation affecting both the crustal basement and the allochthonous Mesozoic cover.

In this study, we present structural and geochemical data providing constraints to reconstruct the evolution of the northern Iberia paleo-margin. Field work confirms that the pre-rift Mesozoic cover is intimately associated to mantle rocks and to thin tectonic lenses of crustal basement. It also shows that the pre-rift cover was detached from its bedrock at the Keuper evaporites level and was welded to mantle rocks during their exhumation at the foot of the hyper-extended margin. The crust/mantle detachment fault is a major shear zone characterized by anastomosed shear bands defining a plurimetric phacoidal fabric at the top of the serpentinized mantle. The detachment is marked by a layer of metasomatic rocks, locally 20 meters thick, made of talc-chlorite-pyrite-rich rocks that developped under greenschist facies conditions. Raman Spectroscopy on Carbonaceous Materials (RSCM), performed on the Mesozoic cover reveal that the entire sedimentary pile underwent temperatures ranging between 200°C and 480°C.

We show that: (i) at the site of mantle rocks exhumation, the boudinaged pre-rift sediments have undergone drastic syn-metamorphic thinning with the genesis of a S0/S1 foliation and, (ii) the Paleozoic basement has been ductilely deformed, into thin tectonic lenses that remained welded to the exhumed mantle rocks. Therefore the overall crustal rheology appears dominated by shallow levels having a ductile behavior. This rheology is related to the presence of a thick pre- and syn-rift decoupled cover acting as an efficient thermal blanket. This new geological data set highlights important characteristics of ductile-type hyper-extended passive margin that cannot be obtained from the study of seismic lines. Finally, we stress that studying field analogues represents a major tool to better understand the mechanisms of extreme crustal thinning associated with mantle exhumation and their structural inheritance during tectonic inversion.