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Mineralogical insights for very high temperature conditions during Cretaceous mantle exhumation at the northern Iberian passive margin: the sapphirine-bearing supradetachment deposits of the North Pyrenean Zone in the Lherz area

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In order to decipher the mode of exhumation of the Pyrenean peridotites and the mechanisms of extreme thinning of the continental crust, consistent information from the direct geological environment of the mantle bodies has to be collected. Therefore, we focused our field investigations on the metasedimentary formations that occur in direct contact with the Lherz lherzolites in the inverted Aulus Basin of Albian-Cenomanian age, completed by a microscopic observation and microprobe analysis of more than 50 thin sections. This mineralogical approach provides robust constraints on the lithology of the units progressively exhumed during the successive stages of mantle unroofing. We show that various polymictic breccias, microbreccias and sandstones are exposed in the immediate vicinity of the mantle bodies and associated Upper Triassic meta-ophites. Among these detrital sediments, the sapphirine-bearing sandstones (Monchoux, 1970; 1972) are located on the northern edge of the Lherz lherzolite. At this site, we describe a progressive transition from the lherzolite body towards the surrounding massive limestones. This transition consists of breccias and sandstones, whose lithology varies according to the distance to the lherzolite. The mm-sized clasts are mainly composed of Al- and Mg-bearing minerals, such as sapphirine, phlogopite (altered to vermiculite), gedrite, kornerupine, metamorphic Al-spinel and enstatite, in a carbonate cement. Polymineralic clasts have been deposited along with the monomineralic debris, commonly defining a grain-size sorting. In addition, minor isolated clasts originating from the disaggregation of various rock types are observed in the sapphirine-bearing sandstones suite. These clasts include: lherzolite, micaschist, quartzite, alkaline gabbro, meta-ophite, metaevaporite and marble fragments. Sandstones composed of alternating beds of mineral debris deriving from these rock-types are also exposed close to the mantle body. All the sources of these detrital elements can be identified in the Aulus Basin, apart from the protolith of the sapphirine-bearing rocks which remains enigmatic. Microprobe analyses allowed an estimate of the average composition of this protolith. We found that the best candidate is a mix of evaporitic clays and dolomite, typical of the Keuper-Rhetian sediments, that evolved under the HT-LP conditions of the Pyrenean metamorphism. The presence of inclusions with evaporitic affinity (Cl-apatite and anhydrite) in the sapphirine and kornerupine crystals, revealed by electron microscopy and Raman analyses, strongly supports this hypothesis. In addition, earlier observations of anhydrite enclosed in metamorphic enstatite strengthen this interpretation (Foucard, 1997). Accordingly, we propose that the sapphirine-bearing rocks and associated sedimentary rocks originated from the transformation of sediments of Keuper-Rhetian age through cataclasis and metasomatism during the Cretaceous metamorphic event coeval with mantle exhumation. This complete transformation occurred along the extensional detachment fault which was progressively exposing the lherzolites to the seafloor. The cataclastic debris were abandoned on the unroofed detachment surface and rapidly reworked through sedimentary processes.