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Perspective

Nature and evolution of the lithospheric mantle under an internal Variscan zone

Ramon Capdevila

Géosciences Rennes, UMR 6118 CNRS–université Rennes-1, campus de Beaulieu, 35042 Rennes cedex, France

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Works on the secular evolution of the subcontinental lithospheric mantle (SCLM) have shown that there is a correlation between the composition of the latter and the age of the last major tectonothermal event in the overlying crust [8]. From then on, it becomes interesting to examine the role and the fate of the SCLM during the formation of a mountain belt like the Variscides.

Most of the available geochemical information on the European SCLM comes from the study of ultramafic xenoliths entrained in Neogene mafic alkaline volcanics [7]. The mantle sampled by these volcanics comprises spinel lherzolites, Cpx-poor lherzolites, and harzburgites. This suite results from the removal of basalt magma from the undepleted lherzolites between 0.6 and 2 Ga. Afterwards, the SCLM was enriched with silicate and carbonate magmas related to the Neogene asthenospheric mantle plume. It was also locally enriched with hydrous fluids released by Alpine subductions. Other information is supplied by the gabbros that accompany the Variscan granitoids. These gabbros are derived from a SCLM variably enriched with subduction-related hydrous fluids during the Palaeozoic [6,10,12]. Garnet peridotites associated with eclogites of the internal zones of the orogen bear also the signature of the subduction-related fluids [4]. In summary, all these results suggest that the SCLM of the Variscan domain was partly depleted before the Palaeozoic and enriched by hydrous fluids under the thickened zones in a subduction-related context.

An original approach that examines the evolution of the SCLM over a long period following the Variscan collision was recently published by Villaseca et al. [11]. These authors have studied basic rocks, some of which already analysed [3,5], intruding a thickened Variscan domain – the Spanish Central System (SCS) – distant from any influence of the Alpine subduction and the Neogene mantle plume. The authors have studied five basic to intermediate magmatic suites derived from different mantle sources. The first suite (Gb1) corresponds to small massifs that intruded between 345 and 310 Ma, before and/or during the emplacement of the large batholith of the peraluminous granite of the SCS, in a context of post-thickening continental convergence. The origin of these calc-alkaline gabbros is not easy to establish, due to the strong crustal contamination. However, their mantle source, apparently of the Bulk Silicate Earth-type, must be the result of an enrichment of a depleted mantle with subduction-related fluids. The two following suites (Gb2, Gb3) correspond to dykes of calc-alkaline and transalkaline character, respectively. Their emplacement is dated to about 290 Ma, contemporaneous with the gravitational collapse of the orogen, and they are also derived from a mantle enriched with crustal components during an episode of subduction. The Gb4 suite is composed of dykes of alkaline ultrabasic lamprophyres, intrusive at

E-mail address: ramon.capdevila@univ-rennes1.fr (R. Capdevila).

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about 280 Ma, at the end of the collapse. They are generated by the melting of a depleted source of OIB-type, enriched shortly before the extraction of the magmas by an alkaline component rich in incompatible elements. Gb5 gabbros are tholeiitic and belong to a dyke of the Central Atlantic Magmatic Province that intruded at about 200 Ma, when the Variscan activity has ceased a long time ago. They are derived from a mantle metasomatosed by a subduction-related component.

These results lead to several remarks.

(1) In the European Variscan belt, all the calc-alkaline gabbros that in the thickened domains accompany the granitoids during the stages of both post-thickening convergence and gravitational collapse seem to be derived from a mantle metasomatosed to various degrees by a subduction-related component. The Gb1 to Gb3 gabbros do not escape the rule, but the classical models of the Variscan belt predict no suture zones close to the SCS [9]. However, eclogites have been reported from the SCS [2] and Ballèvre et al. [1] proposed the existence of a cryptic suture between the Central Iberian Zone (not thickened) and the SCS (thickened). The results of Villaseca et al. [11], added to these indications, suggest that a suture neighbouring the SCS should be taken into consideration.

(2) The alkaline lamprophyres Gb4 demonstrate the existence of a metasomatism by the percolation of silicate magmas in the SCLM previous to that generated by the Neogene mantle plume. Their production is the consequence of the extension and of the lithospheric thinning. In fact, the latter is accompanied by an upwelling of the asthenosphere that undergoes incipient decompressional partial melting and supplies the metasomatising magmas. This upwelling also supplies the extra heat necessary to the extraction of the lamprophyric magmas.

(3) All in all, the results of Villaseca et al. [11] yield an image of a heterogeneous SCLM with three distinct components, whose spatial distribution has to be specified. They show also the evolution of the SCLM during the Variscan events with first an episode of enrichment by subduction-related hydrous fluids, predating the collision. Follow an episode of depletion of the metasomatosed mantle by extraction of calc-alkaline gabbros during the stages following the collision and finally a stage of enrichment by asthenospheric silicate magmas at the end of the lithospheric thinning. In the future, the studies of basic magmatism post-dating the Variscan collision, coupled with tomographic studies, should allow the mapping of ancient subduction zones and lithospheric terrane boundaries, yielding new constraints leading to a better understanding of the formation of the Variscan belt.

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