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Thickening vs. extension in the Variscan belt: P–T modelling in the Central Iberian autochthon

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ABSTRACT

The Variscan tectonothermal structure of the NW and Central Iberian Massif shows an important thickening during the Early Carboniferous, prior to its thermal weakening and gravitational collapse in the Middle Carboniferous, triggering the uplift of its orogenic roots. Pseudosections modelling of selected samples from Somosierra, in the Barrovian metamorphic area of Central Iberia, yield P–T conditions of at least 6 kbar and 500–540 °C for a micaschist of the garnet zone, 5.0–9.7 kbar and 580–620 °C for a psammitic schist of the staurolite zone, above 9.0 kbar and 680 °C for a kyanite micaschist of the sillimanite zone, and 4.0–9.0 kbar and 750–800 °C for a migmatitic paragneiss structurally beneath the Barrovian sequence. These data, together with previous metamorphic and structural data, imply the near-parallel emplacement of a >9 km-thick allochthonous nappe over the Central Iberian foreland during the Early Carboniferous. Emplacement was probably related to the lateral extension of a mid-European orogenic plateau in the form of a channel between opposite-verging collisional wedges. This orogen-parallel extension flow can be traced from the Bohemian Massif through the French Massif Central, South Domain of the Armorican Massif and NW of the Iberian Massif, to the Central Iberian area. The highly oblique emplacement of the thick allochthonous nappe explains the orogen-parallel stretching lineations, the development of Barrovian and subsequent low-pressure metamorphisms, and it could also explain the massive granitic magmatism located in the NW and central areas of the Central Iberian Zone.

1. Introduction

The Variscan Orogen in Europe formed a 1000 km wide belt (Fig. 1) with a rough fan-like symmetric double vergence shape (Bard et al., 1980; Matte, 1986; Franke, 1989) and central "hot" zones characterised by syn-collisional, orogen-parallel, to late orogenic extension (Mattauer et al., 1988; Ménard and Molnar, 1988; Faure, 1989, 1995; Echtler and Malavieille, 1990; Malavieille et al., 1990; Doblas, 1991; Faure and Pons, 1991; Vissers, 1992; Franke, 1993; Burg et al., 1994; Doblas et al., 1994; Escuder Viruete et al., 1994, 1998; Pitra et al., 1994; Willner et al., 1994, 1997; Zulauf, 1994; Díez Balda et al., 1995; Krohe, 1996, 1998; Martínez Catalán et al., 1996), and a large volume of anatectic granitoid intrusions (e.g. in the Iberian Massif: Casquet et al., 1988; Bea et al., 2003; Villaseca et al., 2012). Relatively late-orogenic dextral mega-shear zones with Z-shaped arcs, and oroclines related to continental indentations add complexity to the original structure. Along the 3500 km between the Bohemian and the Iberian massifs, the Variscan belt has been described either as a broad alternance of narrow highly thickened belts and low topographic areas (Franke, 2006, 2012) or as a Tibetan-style high topographic plateau (Zulauf et al., 2002; Dörr and Zulauf, 2010, 2012). Nevertheless, some characteristics of highly thickened Andean-type to collisional orogens may occur, especially those relative to growing of bivergent wedges and lateral "cold" escape or "hot" spreading of the most thickened areas located between them (Vanderhaeghe et al., 2003; Teyssier et al., 2008; Rey et al., 2010). In this context, the Central Iberian autochthon has been proposed as an example of foreland thickening connected to the Early Carboniferous lateral extension of the Variscan orogenic building (Rubio Pascual et al., 2013a), mainly formed by the overthrusting of the allochthonous Late Devonian subduction/accretion complex onto the continental margin of Gondwana. The existence and thickness estimates of this inferred large allochthonous sheet above the Central Iberian autochthon is highly sensitive to the accuracy of the thermobarometric constraints. Previous P–T–t paths determined in this region indicate a complex succession of processes during Variscan thickening and exhumation. Classical thermobarometric techniques applied to pelitic assemblages in the garnet, staurolite, sillimanite and sillimanite + Kfs zones show medium-pressure clockwise paths characteristic of mid-crustal levels in collisional orogens (Rubio Pascual et al., 2013a). Peak pressure conditions reached by the upper structural levels during the

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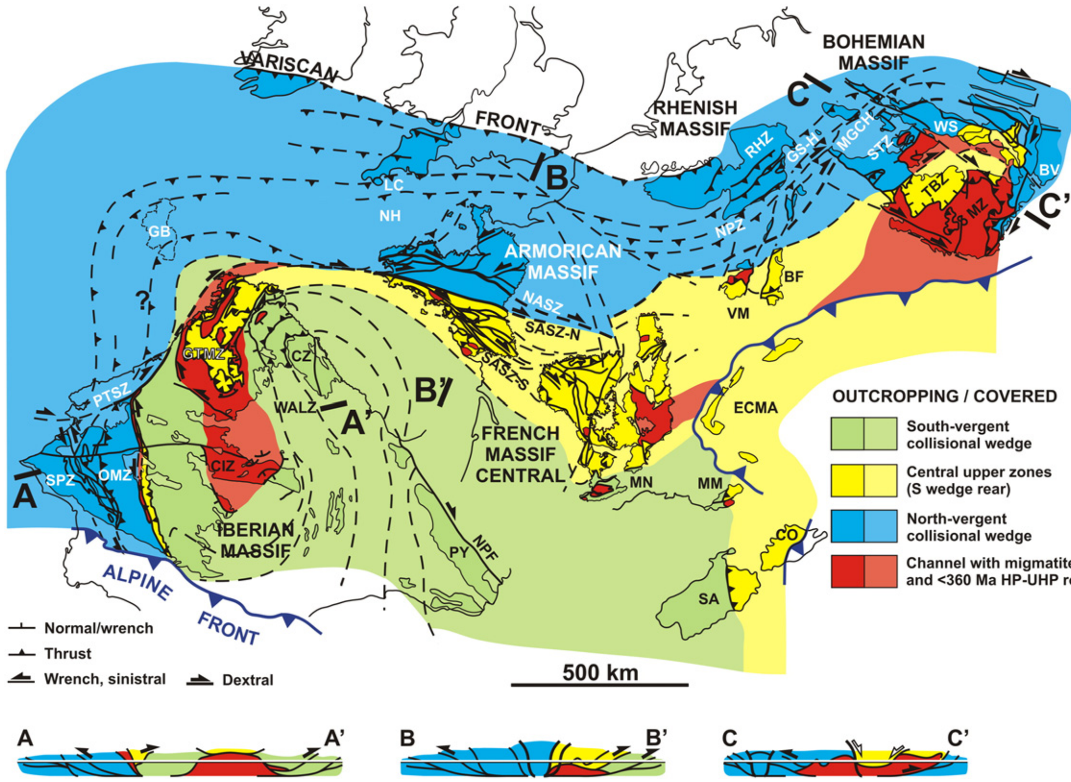

Fig. 1. Geodynamic sketch of the Variscan Orogen in Europe in four main elements: north and south opposite foreland wedges, plateau-like upper structurally central regions of the hinterland and outcropping areas of underlying high grade orogenic crust. BF, Black Forest; BV, Brunovistulian; CCSZ, Córdoba-Coimbra Shear Zone; CIZ, Central Iberian Zone; CO, Corsica; CZ, Cantabrian Zone; ECMA, External Crystalline Massifs of the Alps; GB, Galicia Banks (interpreted after sample descriptions in Capdevila and Mougenot, 1988); GS-H: Giessen-Hartz; GTMZ, Galicia–Trás-os-Montes Zone; LC, Lizard Complex; MGCH, Mid-German Crystalline High; MN, Montagne Noir; MM, Maures Massif; MZ, Moldanubian Zone; NASZ, North-Armorican Shear Zone; NH, Normannian High; NPF, North Pyrenean Fault; NPZ, Northern Phyllite Zone; OMZ, Ossa-Morena Zone; PTSZ, Porto-Tomar Shear Zone; PY, Pyrenees; RHZ, Rhenohercynian Zone; SA, Sardinia; SASZ, South-Armorican Shear Zone; SPZ, South Portuguese Zone; STZ, Saxo-Thuringian Zone; TBZ, Teplá-Barrandian Zone; VM, Vosgues Massif; WALZ, West Asturian-Leonese Zone; and WS, West Sudetes.

first crustal thickening event (P ~7 kbar, 21 km; T ~500 °C) could be 4–5 kbar higher than those deduced from the thickness of available lithostratigraphic series (~6 km). Given that shortening produced by the crustal thickening deformation does not exceed 50% (~9 km, Rubio Pascual et al., 2013a), the real thickening during metamorphism could be at least 12 km larger than expected for this section. The model suggested by Rubio Pascual et al. (2013a) explains that the large allochthonous sheet might be subsequently thermally weakened and gravitationally extended towards the NW, and thus was not preserved in the Central Iberian autochthon. However, this allochthonous sheet could be preserved towards the NW Iberian Massif, in the so called Galicia–Trás-os-Montes Zone (GTMZ, Arenas et al., 1986; Farias et al., 1987). This domain is formed by a succession of allochthonous units with Gondwanan affinity whose thickness exceeds 20 km and is widely represented across the European Variscan belt (e.g. Matte, 1986, 1991; Martínez Catalán, 1990).

Conventional thermobarometry may provide reasonable results, but requires important assumptions and has several limitations (e.g. Powell and Holland, 2008). To refine peak pressure constraints, as well as to progress in the optimisation of the proposed geodynamic models, this study aims to present the tectonometamorphic evolution of the unroofed Variscan roots in the Central Iberian autochthon using pseudosection approach in key lithologies from the Somosierra region. The Somosierra region is located in the eastern Iberian Central System (ICS) of the Central Iberian Zone (CIZ) and displays an almost complete section of upper and middle crustal rocks representing one of the most internal domains of the Variscan Orogen in the Iberian Massif. This region constitutes a classic region for the study of Barrovian metamorphism, and, as such has been the subject of numerous studies (e.g. Macaya et al., 1991; Escuder Viruete et al., 1998; Villaseca and Ubanell, 2005).

The second objective of this study is to explore the possible correlation between the Early Carboniferous thickening by orogen-parallel nappe tectonics in NW and Central Iberia (Martínez Catalán, 1990; Martínez Catalán et al., 2002; Díez Fernández et al., 2012a; Rubio Pascual et al., 2013a), the orogen-parallel thrusting and detachment in the French Massif Central and South-Armorican domain (e.g. Faure et al., 2005; Matte, 2007), and the regional uplift and vertical extrusion of deep crustal levels in the Bohemian Massif (Zulauf, 1997; Konopásek et al., 2001; Štípská et al., 2004; Schulmann et al., 2005, 2008; Franěk et al., 2006, 2011; Tajčmanová et al., 2006; Dörr and Zulauf, 2010). The geodynamic framework for our correlation purposes is a simplified model of the European Variscan chain (Fig. 1). The basic elements for this model are: a) S-vergent southern wedge, b) N-vergent northern wedge, c) the upper central regions from the plateau-like rear part of the S wedge, and d) the orogen-parallel extension channel developed in the most thickened and subsequently thermally weakened levels (equivalent to hot channels, e.g. Faccenda et al., 2008). The model considers that these geodynamic elements were situated in a subduction to collisional setting from the Late Devonian to the Early Carboniferous, irrespective of whether the Variscan bivergent geometry was produced by coeval bilateral subduction (e.g. Zulauf, 1997; Franke, 2000), intracontinental deformation (e.g. Schulmann and Gayer, 2000) or by means of a reversal change in the underplating polarity of indentation between Laurussia and Gondwana (Zeh and Gerdes, 2010; Kroner and Romer, 2013; Rubio Pascual et al., 2013b). The proposed model is similar to prowedge-retrowedge or PURC models (Willett et al., 1993; Zulauf, 1997; Beaumont et al., 1999; Dörr and Zulauf,