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Distinct sources for syntectonic Variscan granitoids: Insights from the Aguiar da Beira region, Central Portugal

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ABSTRACT

The Variscan syntectonic granitoid plutons from the Aguiar da Beira region (central Portugal) were emplaced into metasediments of Late Proterozoic–Early Cambrian age during the last Variscan ductile tectonic event (D_3), which is related to dextral and sinistral shearing.

The older intrusion, with a U–Pb ID–TIMS zircon age of 321.8 ± 2.0 Ma, consists of porphyritic biotite granodiorite–granite with transitional I–S type geochemical signature, relatively low $^{87}Sr/^{86}Sr_{322}$ ratios (0.7070–0.7074), εNd_{322} values of −3.9 to −4.6 and whole-rock and zircon $\delta^{18}O$ values of 10.6‰ and 8.0‰, respectively. By contrast, the younger intrusion is an S-type muscovite–biotite leucogranite, emplaced at 317.0 ± 1.1 Ma, showing more radiogenic $^{87}Sr/^{86}Sr_{317} = 0.7104–0.7146$, lower εNd_{317} values of −7.7 to −8.7 and higher $\delta^{18}O$-wr = 11.3‰ and $\delta^{18}O$-zr = 9.5‰. The combined isotopic and geochemical evidence supports a lower crustal origin for the biotite granodiorite–granite, involving the anatexis of lower crustal metaigneous protoliths, and possible hybridization with mantle-derived magmas. A shallower origin, at mid crustal levels, from pure crustal derivation, through moderate degrees of partial melting of Proterozoic–Cambrian metasediments is proposed instead for the muscovite–biotite leucogranite.

1. Introduction

The Iberian Variscan belt, also known as Iberian Massif, was formed in Carboniferous times after the complete subduction of the Palaeozoic Rheic Ocean, during amalgamation of Pangea by the complex and polycyclic collision of Laurussia with Gondwana. Continental collision began around 365 Ma (Dallmeyer et al., 1997), with crustal thickening (D_1) and associated prograde metamorphism of Barrovian type. Continued shortening is thought to have been followed by the exhumation of the thickened continental crust (D_2) (e.g. Arenas and Catalán, 2003; Escuder Viruete et al., 1994; Martínez Catalán et al., 2009; Valle Aguado et al., 2005), and final deformation (D_3) is considered to be related to crustal-scale strike-slip ductile shear zones that produced large-wavelength upright folds (Martínez Catalán et al., 2009). Migmatization and low-pressure/high-temperature (LP–HP) metamorphism started during D_2, continued throughout D_3 and culminated with the emplacement of abundant syntectonic granitoids. Immediately after D_3, large volumes of late- to post-tectonic granite magmas intruded the Variscan continental crust, strongly overprinting its previous tectono-metamorphic record.

To other authors the tectono-metamorphic evolution of the Iberian Variscan belt is better explained as the result of two compressive deformation phases (D_1 and D_2), during which the crust reached its maximum thickness, followed by a late, post-thickening, ductile tectonic event (D_3) marking the end of the continental collision in Iberia (Dias and Ribeiro, 1995; Noronha et al., 1981; Ribeiro et al., 1990). However, the P–T conditions attained during D_2, inferred from the mineral assemblages related to the S_2 fabrics, are considered as a strong evidence for the extensional character of this event (Valle Aguado et al., 2005) in opposition to the compressive regime interpretation. Nevertheless, irrespective of the model accepted, D_3 is considered in both interpretations to be a post-thickening strike-slip phase responsible for the final structural arrangement of the Iberian Massif.

Regional constraints show that Variscan granite plutonism in Iberia post-dates syn-collisional deformation ($D_1 + D_2$), being predominantly correlated with intracontinental shearing (D_3). The diversity of granite types observed in this segment of the Variscan belt represents the sum of a series of processes, ranging from partial melting of distinct source rock materials, mixing and/or mingling of crustal- and mantle-derived magmas, fractional crystallization, crustal contamination and more complex models involving concurrent assimilation and fractional

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crystallization (AFC) (e.g. Azevedo et al., 2005; Beetsma, 1995; Castro et al., 1999; Dias et al., 2002; Fernández-Suárez et al., 2011; Neiva and Gomes, 2001; Villaseca et al., 1999). In order to assess the factors controlling the evolution of each specific granitoid suite, it is crucial to understand the information stored in rock structures and to investigate the main vectors of chemical and isotopic change involved in their petrogenesis.

In this study petrographic, geochemical, Sr–Nd–O isotopic data and high-precision U–Pb ID–TIMS zircon and monazite ages are used to discuss the origin of two particular syntectonic intrusive suites from the central sector of the Central-Iberian Zone. The aim was to contribute to a better understanding of the origin, genesis and evolution of these magmas during the Variscan orogeny and constrain the nature of their potential sources, as well as the timing and duration of magmatic and deformation events in the studied area.

2. Geological background

Based on tectonostratigraphic criteria, the Iberian Variscan belt is divided into, from north to south, the Cantabrian, West Asturian-Leonese, Galicia-Trás-os-Montes, Central-Iberian, Ossa-Morena and South Portuguese zones (Fig. 1). In its internal domains, such as in the Central-Iberian Zone, where the study area is located, the stratigraphic record includes a Proterozoic Gondwanan basement of Cadomian (West African) affinity overlain by Early Palaeozoic, mostly siliciclastic sequences, deposited on the passive margin of northern Gondwana (e.g. Fernández-Suárez et al., 2002, 2011; Gutiérrez-Alonso et al., 2011; Martínez Catalán et al., 2007, 2009; Murphy et al., 2008; Robardet, 2002, 2003).

The Aguiar da Beira region is located within the axial zone of the Iberian Massif (Fig. 1), in central northern Portugal. The region is mainly composed of Variscan granitoids emplaced into Neoproterozoic–Early Palaeozoic sedimentary sequences, which were variably affected by regional metamorphism and deformation during the Variscan orogeny (Fig. 2). The oldest rocks exposed in this area belong to the so called "Schist–Greywacke Complex" (SGC), a thick turbidite-like formation of Neoproterozoic–Early Cambrian age consisting of metapelites and metagreywackes interlayered with relatively thin calc-silicate and metaconglomerate horizons (Oliveira et al., 1992; Rodríguez Alonso et al., 2004; Sousa, 1984). The SGC is unconformably overlain by an Ordovician clastic succession of stable marine platform sediments, spatially confined to the core of the NW–SE trending Porto–Sátão syncline that crosses the southwestern corner of the studied area (Fig. 1). A narrow deposit of Late Carboniferous molasse occurs in contact with the Ordovician rocks (Fig. 1).

The overall structure of the region can be ascribed to the combined effects of two main Variscan deformation events ($D_1 + D_3$). The first, D_1, affects all the pre-Carboniferous sequences and resulted in the generation of NW–SE striking subvertical folds with a penetrative axial plane schistosity (S_1), whilst D_3 is related to several crustal-scale transcurrent shear zones that have accommodated part of the shortening related to the final stages of the continental collision (Valle Aguado et al., 2005). One of these major shear zones, the NW–SE striking sinistral Douro–Beira shear zone, coincident with the Porto–Sátão syncline (Fig. 1), led to the development of a subvertical mylonitic S_3 fabric recorded in both the pre-Carboniferous and the Carboniferous metasedimentary units (Valle Aguado et al., 2005).

Regional metamorphism in this area corresponds to a low-grade metamorphic epizonal domain in which metamorphic recrystallization

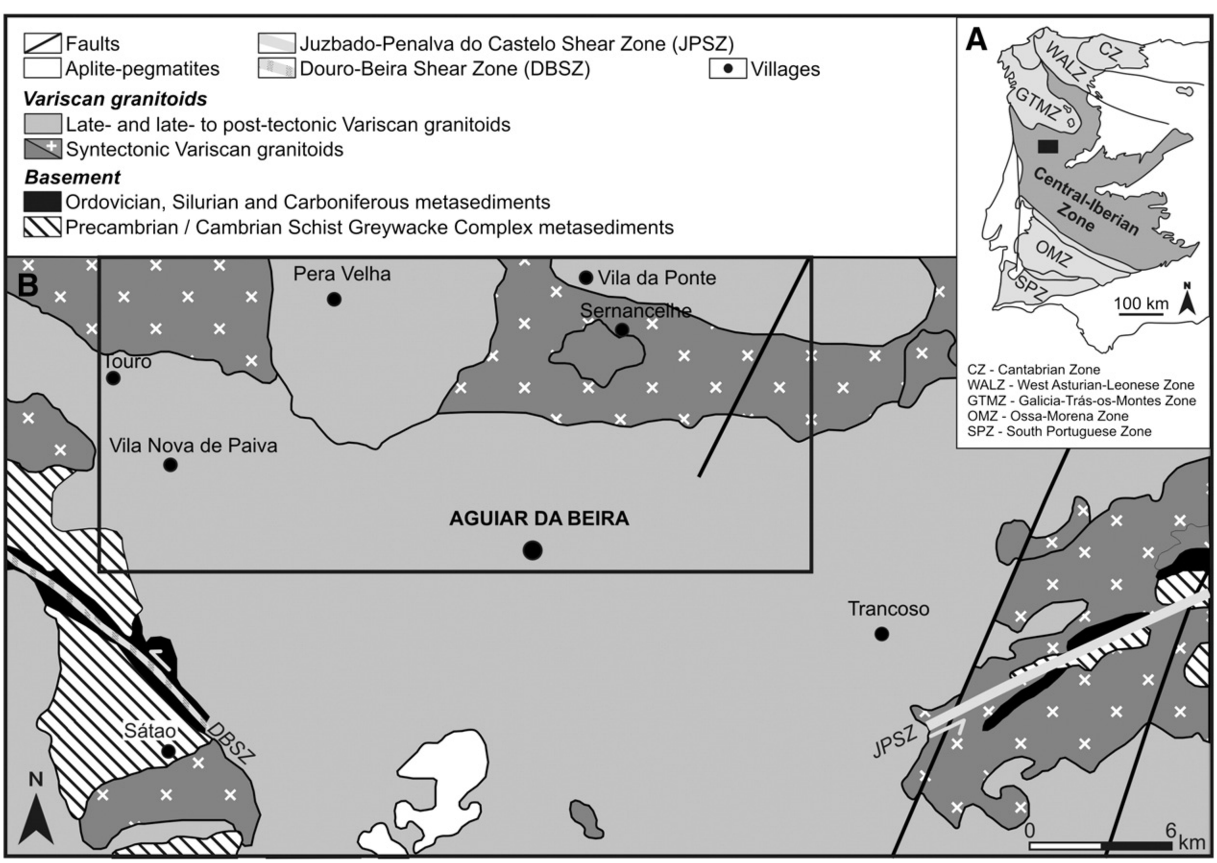

Fig. 1. A) Divisions of the Iberian Massif with location of the Aguiar da Beira region within the Central-Iberian Zone (redrawn from Sánchez-García et al., 2008); B) Geological map of part of the Beiras Batholith (adapted from Carta Geológica de Portugal à escala 1:1,000,000, LNEG, 2010) with identification of the Aguiar da Beira region.