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Variscan intracrustal recycling by melting of Carboniferous arc-like igneous protoliths (Évora Massif, Iberian Variscan belt)

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ABSTRACT

Bulk rock geochemistry and sensitive high-resolution ion microprobe zircon geochronology of igneous and metaigneous rocks of the Évora gneiss dome, located to the north of the reworked Rheic Ocean suture zone in the southwest Iberian Variscan belt, reveal a succession of magmatic and melting events lasting ~30 m.y. between ca. 341–314 Ma. The study of detailed field relationships of orthomigmatites (i.e., migmatites from igneous protoliths) and host granitic rocks proved to be crucial to reconstruct the complex sequence of tectono-thermal events of the Évora gneiss dome. The older igneous protoliths, with marked geochemical arc-like signatures, are represented by 338 ± 3 Ma tonalites and 336 ± 3 Ma diorites. These tonalites and diorites appear as mesosomes of igneous orthomigmatites containing new melts (leucosomes) of monzogranite composition and silica-poor trondhjemites formed in a melting episode at 329 ± 4/6 to 327 ± 3 Ma. The absence of peritectic phases (e.g., pyroxene), together with shearing associated with migmatization, imply the existence of water-rich fluids during melting of the older igneous rocks of the Évora gneiss dome. This melting event is coeval with the second magmatic event of the Évora gneiss dome represented by the neighboring Pavia pluton. A porphyritic monzogranite dated at 314 ± 4 Ma defines a later magmatic event. The porphyritic monzogranite encloses large blocks of the orthomigmatites and contains magmatic mafic enclaves (autoliths) dated at 337 ± 4 Ma that are ~23 m.y. older than the host rock. All studied rocks of the Évora gneiss dome show arc-like, calc-alkaline geochemical signatures. Our results support recycling of intermediate-mafic plutonic rocks, representing the root of an early magmatic arc that formed at the time of Gondwana-Laurussia convergence (after the closure of the Rheic Ocean) and coeval subduction of the Paleotethys. A geodynamic model involving ridge subduction is proposed to explain the Early Carboniferous intra-orogenic crustal extension, dome formation, exhumation of high-grade rocks, compositional variations of magmatism and formation of new granitic magmatism in which, arc-like signatures were inherited from the crustal source.

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INTRODUCTION

The role played by granite magmatism in orogenic processes has been among the most debated topics in geology over the last decades (Castro, 2014; Chappell and Stephens, 1988; Collins, 1996; Janoušek et al., 2020; Petford et al., 2000; Pitcher, 1987; Pitcher, 1997; Weinberg et al., 2018) and still remains under discussion (Castro et al., 2021; Janoušek et al., 2020). Moreover, granites (sensu lato) serve as age markers of tectonic and magmatic processes. However, understanding the tectonic implications of some granite types needs the determination of the magma source locations, thermal requirements, and melting mechanisms. Whether granites represent fractionated liquids from mantle-rooted magma or are the by-products of intracrustal recycling is a question at the core of most discussions on granite petrogenesis (Chappell and White, 2001; Chappell et al., 2004; Chappell et al., 2000; Zhou et al., 2020). In the particular case of I-type granites (Chappell and Stephens, 1988), which display unequivocal geochemical affinities with calc-alkaline rock series, deciphering the origin of magma may have important geodynamic implications regarding their spatial and temporal relationships. A genetic link with active subduction may be discarded in many cases in favor of crustal melting leading to recycling of older igneous protoliths in syn- to post-collisional orogenic settings. The two tectonic scenarios, subduction and large-scale intracontinental extension may produce very similar granites of the I-type family, being primary (fractionated from dioritic magmas) and secondary (crustal melts), respectively, which can be difficult to distinguish (Castro, 2020a). In this regard, the identification by field relationships of igneous precursors (i.e., protoliths) of migmatites—the source of secondary I-type granites—is crucial to address petrogenetic and tectonic interpretations. Moreover, water-fluxed melting (Aranovich et al., 2014; Weinberg and Hasalová, 2015) after igneous protoliths is a preferred hypothesis for secondary I-type magma generation (Castro, 2020a). Because granites formed by this mechanism of crustal recycling may inherit the geochemical features of the source, the knowledge of magma generation mechanisms and age determinations of sources and anatectic events, are requirements to address regional tectonic reconstructions.

In this study, we report field, geochemical, and geochronological data of Carboniferous igneous and metaigneous rocks of the southwest Iberian Variscan belt showing structural and microstructural relations of partial melting and melt

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