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Geochemistry and geothermometry of volcanic rocks from Serra Branca, Iberian Pyrite Belt, Portugal

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Abstract

Volcanic rocks from Serra Branca, Iberian Pyrite Belt, Portugal, consist of calc-alkaline felsic and intermediate rocks. The latter are massive andesites, whereas the former include four dacitic to rhyolitic lithologies, distinguishable on spiderdiagrams and binary plots of immobile elements. Zircon thermometry indicates that two felsic suites may have formed from different magmas produced at distinct temperatures, with only limited fractionation within each suite. Alternatively, all the felsic rocks can be related through fractionation of a single magma if the lower zircon saturation temperature obtained for one suite merely results from Zr dilution, mostly reflecting silicification.

The relatively high magma temperatures at Serra Branca ease the classification of felsic rocks based on their HFSE contents and also indicate volcanogenic massive sulfide deposit favorability. This contrasts with other areas of the Belt that register lower magma temperatures and are subsequently barren. However, magma temperatures may have not been high enough to cause complete melting of refractory phases in which HFSE reside during crustal fusion of an amphibolite protolith, implying difficult discrimination of tectonic environments for the felsic rocks. The intermediate rocks were possibly formed by mixing between basaltic magmas and crustal material, compatible with volcanism in an attenuated continental lithosphere setting.

Keywords: Iberian Pyrite Belt; Volcanogenic massive sulfide deposit; Zircon saturation temperatures; Porphyry; Volcanic

1. Introduction

The Iberian Pyrite Belt (IPB) consists of volcanic and sedimentary rocks of Devonian to Carboniferous age, locally containing syngenetic massive sulfide deposits. This Belt is located in the Southwest of the Iberian Peninsula, extending from near Seville in Spain to the Atlantic coast in Portugal (Fig. 1). The IPB is renowned as the largest (in tonnage) volcanogenic massive sulfide (VMS) province in the world and includes giant deposits such as Aljustrel and Neves-Corvo in Portugal and Rio Tinto and Tharsis in Spain (Fig. 1). These deposits are related to focused submarine hydrothermal systems. The IPB belongs to the Iberian segment of the Variscan fold belt and is part of the South Portuguese Zone (SPZ), which was accreted to the Ossa–Morena Zone (OMZ), presently located to the north, during the late Paleozoic Variscan orogeny (Ribeiro et al., 1979).

Although significant advances have been made regarding the structure, stratigraphy and metallogenesis of the IPB, the petrogenesis of its igneous rocks has not been fully established, in spite of the economic importance of VMS mineralization related to them. A detailed petrogenetic model, in addition to providing important constraints regarding the geotectonic setting of the IPB, may help to explain why broadly similar felsic rocks are in some instances associated to VMS mineralization and in other instances appear to be barren. This paper presents new geochemical data from one specific area of the Belt. Particular emphasis is put on the behavior of high-

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field-strength elements (HFSE), as they are often used in discriminating tectonic settings of felsic rocks, but their systematics can be affected by low-temperature crustal fusion and/or the presence of garnet at the source. These factors are also important because the conditions for magma formation and emplacement play an important role in the mineralization process. Finally, the petrogenesis and geotectonic setting for the intermediate rocks is established and evaluated.

2. Geological setting

Three lithostratigraphic groups are recognized in the IPB, from the oldest to the youngest: (1) the terrigenous Phyllite–Quartzite Group (PQ), whose base never crops out throughout the Belt but whose top is Famennian; (2) the Volcanic Siliceous Group (VS), hosting the VMS mineralization and including the igneous rocks studied in this paper, of late Famennian to middle Visean age; and (3) the turbiditic Flysch Group of late Visean to Serpukhovian age (Schermerhorn, 1971; Oliveira, 1990). As the result of the Variscan orogeny, the Belt has been affected by low-grade regional metamorphism, ranging from zeolite to greenschist facies (Munhá, 1990), and its structure is characterized by south- to southwest verging folds, corresponding to a thin-skinned foreland fold and thrust belt (Silva et al., 1990).

The Serra Branca area is part of the IPB's northernmost volcanic lineament, which also includes the Albernoa and São Domingos areas in Portugal. It consists of a WNW–ESE trending exposure of the VS, considered to be in an autochthonous position. The VS is conformably covered by the middle Visean Freixial Formation, which has an equivalent stratigraphic setting to that of the Flysch Group (Oliveira, 1992). The Serra Branca area corresponds to a Variscan anticlinal structure whose axis dips to the ESE (Fig. 2). The volcanic rocks at Serra Branca are predominantly felsic, with some intermediate rocks. The intermediate rocks are massive lava flows that occur in the core of the anticlinal structure, especially towards the west. Above the intermediate rocks, a variety of felsic rocks occur, constituting a volcanic dome complex. The volumetrically most important felsic rock is a coarse quartz–feldspar-phyric porphyry, which appears to have a thickness of almost 200 m. This porphyry is normally coherent, sometimes displaying flow banding, but is locally hyaloclastic, showing centimeter to decimeter clasts in a finely comminuted matrix. Near the Guadiana River, flows of this porphyry alternate with volcanogenic sandstones and

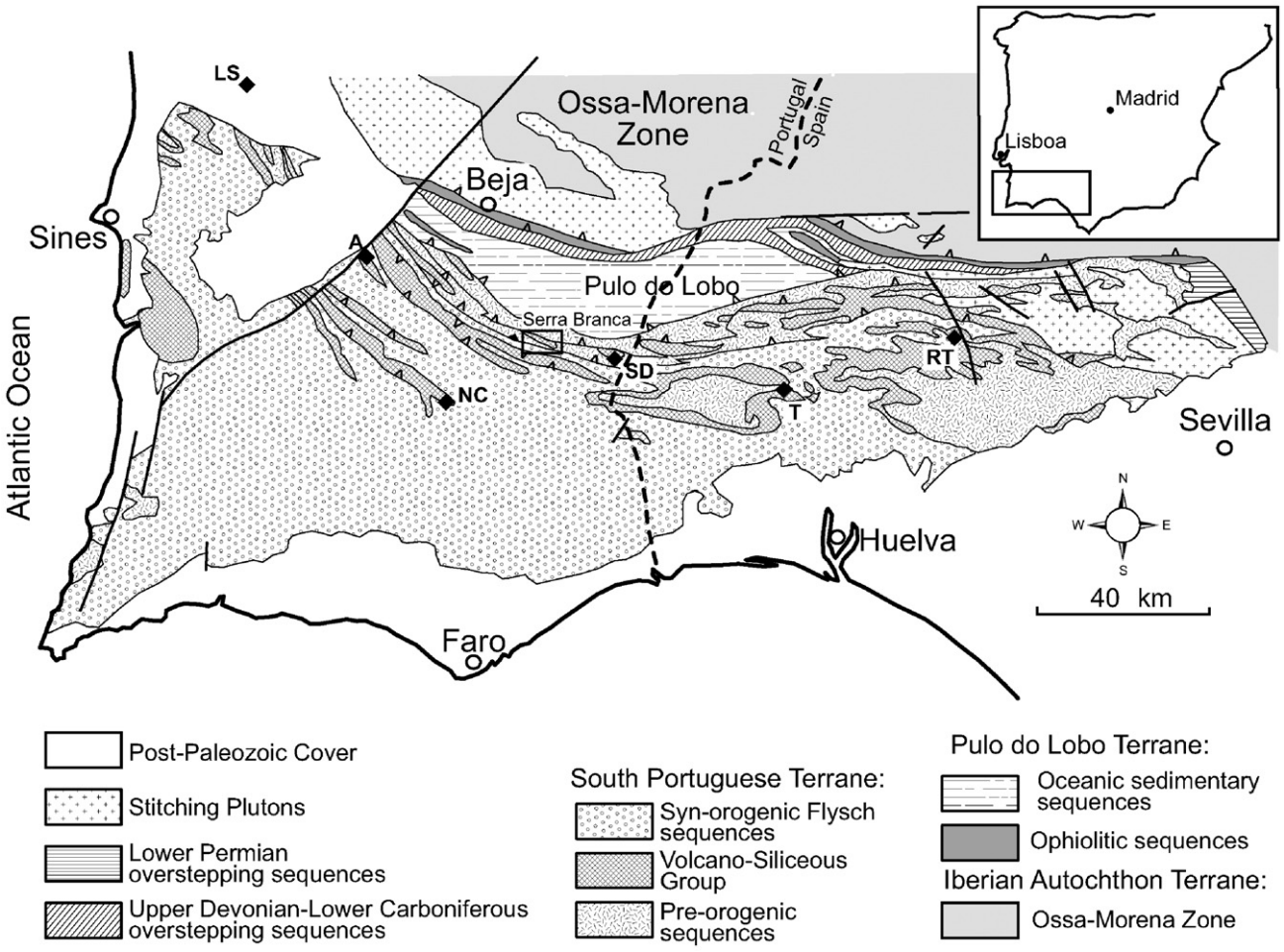

Fig. 1. Major structural units and tectono-stratigraphic domains in SW Iberia (modified after Quesada, 1991). VMS deposits: LS—Lagoa Salgada; A—Aljustrel; NC—Neves-Corvo; SD—São Domingos; T—Tharsis; RT—Rio Tinto. Study area indicated by rectangle.