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Petrogenetic links between lepidolite-subtype aplite-pegmatite, aplite veins and associated granites at Segura (central Portugal)

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ABSTRACT

In the Segura area, Variscan S-type granites, aplite veins and lepidolite-subtype granitic aplite-pegmatite veins intruded the Cambrian schist-metagraywacke complex. The granites are syn D3. Aplite veins also intruded the granites. Two-mica granite and muscovite granite have similar ages of 311.0 ± 0.5 Ma and 312.9 ± 2.0 Ma but are not genetically related, as indicated by their geochemical characteristics and $(^{87}Sr/^{86}Sr)_{311}$ values. They correspond to distinct pulses of magma derived by partial melting of heterogeneous metapelitic rocks. Major and trace elements suggest fractionation trends for: (a) muscovite granite and aplite veins; (b) two-mica granite and lepidolite-subtype aplite-pegmatite veins, but with a gap in most of these trends. Least square analysis for major elements, and modeling of trace elements, indicate that the aplite veins were derived from the muscovite granite magma by fractional crystallization of quartz, plagioclase, K-feldspar and ilmenite. This is supported by the similar $(^{87}Sr/^{86}Sr)_{311}$ and $\delta^{18}O$ values and the behavior of P_2O_5 in K-feldspar and albite. The decrease in $(^{87}Sr/^{86}Sr)_{311}$ and strong increase (1.6‰) in $\delta^{18}O$ from two-mica granite to lepidolite-subtype aplite-pegmatite veins, and the behaviors of Ca, Mn and F of hydroxylapatite indicate that these veins are not related to the two-mica granite.

The occurrence of amblygonite–montebrasite, lepidolite, cassiterite, columbite-(Fe), columbite-(Mn) and microlite suggests that lepidolite-subtype granitic aplite-pegmatite veins are highly differentiated. Montebrasite shows a heterogeneous Na distribution and secondary lacroixite was identified in some montebrasite areas enriched in Na. Unusual Mn > Fe cassiterite is zoned, with the alternating darker zones being strongly pleochroic, oscillatory zoned, and containing more Nb and Ta than the lighter zones. Inclusions of muscovite, apatite, tapiolite-(Fe), ixiolite and microlite are present both in lighter and darker zones of cassiterite. It shows exsolutions of columbite-(Fe), columbite-(Mn,Fe) and columbite-(Mn), particularly in darker zones.

1. Introduction

The mineralization processes related to granites, pegmatites and hydrothermal veins involve the enrichment of rare elements (e.g., Be, Ta, Li, Sn, Bi, W, Mo, Cu) and volatiles in late residual magma, or their enrichment in volatile phases in the final stages of magmatic crystallization (Beurlen et al., 2001). Almost all rare-element pegmatite types (low temperature and pressure) are associated with highly fractionated peraluminous granites (Černý, 1992) and are accepted as the products of magmatic differentiation from large granite bodies (e.g., Černý, 1992; Leal Gomes, 2006; Neiva et al., 2008, 2012; Neiva and Ramos, 2010). However, this mechanism is difficult to test for pegmatites (e.g., Neiva et al., 2008, 2012; Neiva and Ramos, 2010), due to the presence of B, F, P and Li fluxes, which are involved in the crystallization of tourmaline, topaz, montebrasite–amblygonite, lepidolite, and influence the crystallization of cassiterite, columbite-tantalite and microlite (e.g., Linnen and Cuney, 2005). These pegmatite minerals are important indicators, as the origin of the pegmatites must be responsible for the occurrence of all their minerals. Some examples of lepidolite-subtype pegmatites do not show this mineral association, as the volatile-rich fluids are stable at relatively low temperatures and commonly migrate to great distances from their plutonic sources (Černý et al., 2005). Therefore, parent granite and pegmatites can be spatially separated (e.g., Currie et al., 1998).

The aplite-pegmatite veins from Segura are REL-Li pegmatites and belong to the LCT family (sensu Černý and Ercit, 2005), which is characterized by the enrichment in Li, Cs and Ta. In central Portugal,

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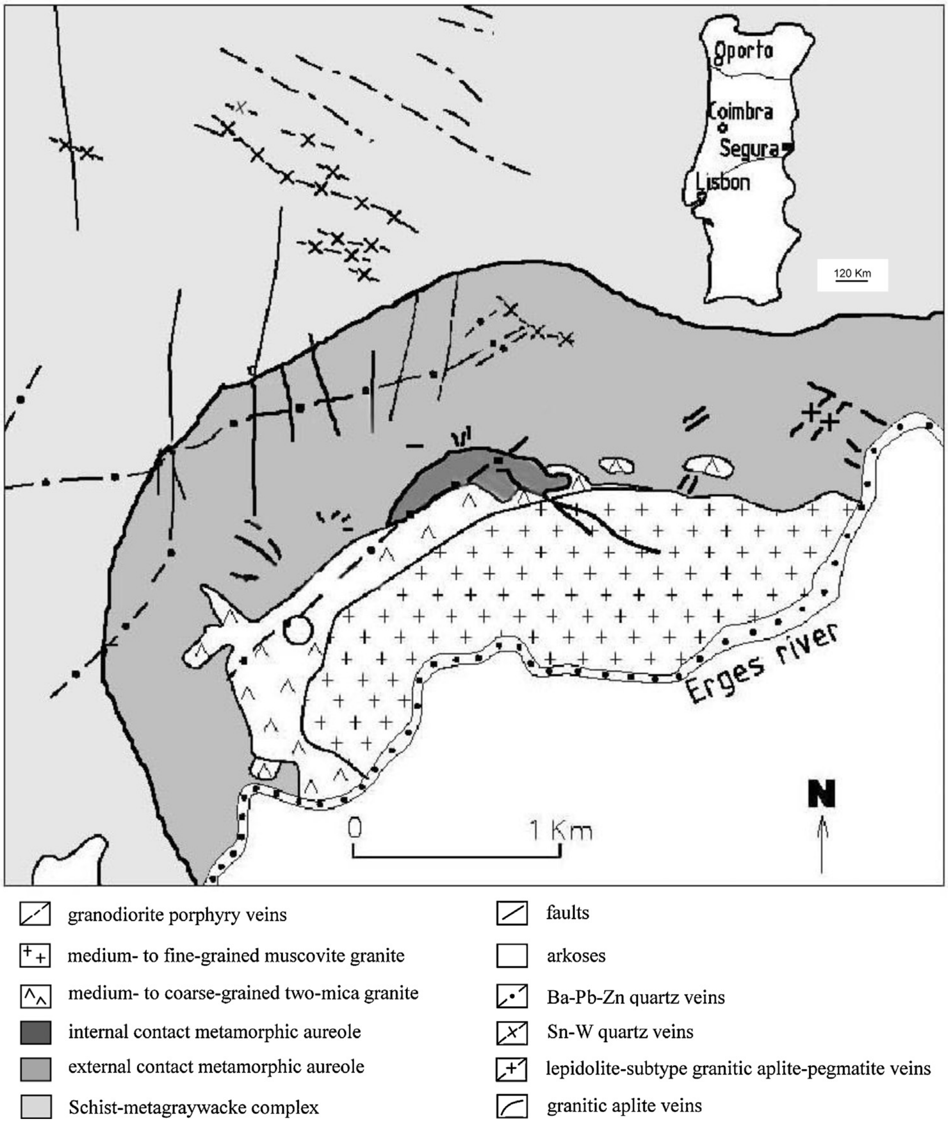

Fig. 1. Geological map of Segura, central Portugal.

there is an extensive field of LCT granitic aplite-pegmatite veins. They are mostly linked to S-type, peraluminous granitic rocks that were emplaced during the last deformation phase of the Variscan Orogeny (D3) and, therefore, are classified as syn- to post-D3 granites (e.g., Dias et al., 1998; Ramos et al., 2006; Cotelo Neiva, 2006). The mineralogy and geochemistry of lepidolite-subtype granitic aplite-pegmatite veins and associated granites and aplite veins from Segura are presented here and the data are used to discuss their origin and petrogenetic models.

2. Geological setting

The Segura area, located in central Portugal, close to the Portuguese–Spanish border (Fig. 1), is part of the Iberian Massif, which corresponds to the SW extension of the European Variscan Belt. It also belongs to the Central Iberian Pegmatitic Belt (Leal Gomes, 2006). The syn-D3 Variscan pluton of Segura intruded the schist-metagraywacke complex, which consists of alternating metapelites and metagraywackes with metaconglomerate and marble intercalations, initially deposited in Cambrian times. The contact metamorphic aureole is up to 500 m thick, with an outer zone of mica schist containing cordierite porphyroblasts and an inner zone with hornfels, containing cordierite and sillimanite, up to 20 m thick (Fig. 1).

The Segura pluton is exposed over an area of about 4 km^2 and is dominated by a medium- to coarse-grained two-mica granite, but a medium- to fine-grained muscovite-bearing granite also intruded the schist-metagraywacke complex (Fig. 1). The contact between these granites is sharp (Antunes et al., 2009). Subvertical, N45-60W trending veins of granodiorite porphyry intruded the schist-metagraywacke complex in the northern part of the area. Other crosscutting vein systems include NW-SE to NNW-SSE trending granitic aplite veins, subhorizontal NE-SW trending lepidolite-subtype, granitic aplite-pegmatite veins containing cassiterite and lepidolite (Fig. 2a), NW-SE to WNW-ESE trending quartz veins containing cassiterite and wolframite and ENE-WSW to NNE-SSW trending quartz veins containing barite, galena and sphalerite (Fig. 1). One of the latter veins also cuts the muscovite granite. These veins are up to 15 cm thick and 300 m long (Antunes et al., 2002).

The mineralized quartz veins fill late- to post-tectonic Variscan faults. Nowadays it is difficult to recognize the mineralized veins, because they generally occur in the old mines, which were in operation from 1949 to 1953.