GEOCHEMISTRY OF Li-BEARING APLITE-PEGMATITE VEINS FROM CABEÇO QUEIMADO AND ASSOCIATED GRANITIC ROCKS (SEGURA, CENTRAL PORTUGAL)

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ABSTRACT

At Segura area, two-mica granite, muscovite granite, granitic aplite veins and Li-bearing granitic aplite-pegmatite veins from Cabeço Queimado intruded the Cambrian schist-metagraywacke complex. Aplite veins also intruded both granites. Variation diagrams of major and trace elements of the granitic rocks show fractionation trends for: a) two-mica granite and Li-bearing aplite-pegmatite veins; b) muscovite granite and aplite veins. Least square analysis for major elements and modelling of trace elements indicate that: a) the Li-bearing aplite-pegmatite veins were derived from the two-mica granite by factional crystallization of quartz, plagioclase, potash feldspar and biotite; b) the aplite veins were derived from muscovite granite by fractional crystallization of quartz, plagioclase, potash feldspar and ilmenite, which is supported by the similar $\delta^{18}O$ values. The increase of $\delta^{18}O$ values from two-mica granite to aplite-pegmatite veins suggests that fractional crystallization was accompanied by assimilation of metasedimentary material (AFC process). The pegmatite veins are REL-Li pegmatites and belong to the LCT family. The occurrence of amblygonite-montebrasite, lepidolite, cassiterite, ferrocolumbite, manganocolumbite and microlite suggest that Li-bearing granitic aplite-pegmatite veins are highly differentiated.

Keywords: Li-bearing aplite-pegmatites, crystal fractionation, Sn-Nb-Ta oxide minerals.

INTRODUCTION

Lepidolite subtype granitic pegmatites are characterized by lepidolite as the main Li-bearing rock-forming mineral. They are enriched in Li, F, Rb, Cs, commonly also in B and P and with significant concentrations of Sn, Nb, Ta and Be-bearing minerals (Černý et al. 2005). Almost all rare-element pegmatite types are associated with highly fractionated peraluminous granites and accepted as products of magmatic differentiation from pluton granite bodies

(Černý 1992). At central Portugal, there is an extensive field of LCT-type pegmatite veins related to S-type peraluminous granites. Most Portuguese aplite-pegmatite veins are related to syn- to late- or post-D3 Variscan granitic rocks (Cotelo Neiva 2006). The mineralogy and geochemistry of Li-bearing aplite-pegmatite veins and associated granites and aplite veins from Segura are presented here and the data are used to test specific petrogenetic models.

GEOLOGICAL SETTING

Segura area is located in Central Portugal, close to the Portuguese-Spanish border. It belongs to the Iberian Massif, which corresponds to the SW extension of the European Variscan Belt, and to the Central Iberian Pegmatitic Belt. The syn-D3 Variscan pluton from Segura intruded the Cambrian schist-metagraywacke complex which consists of alternating metapelites and metagraywackes with metaconglomerate and marble intercalations. 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 granite also intruded the schist-metagraywacke complex. The contact between granites is sharp. Two-mica granite is probably the oldest granite. NW-SE to NNW-SSE granitic aplite veins intersect the schist-metagraywacke complex and granites. Subhorizontal NE-SW Li-bearing granitic aplite-pegmatite veins from Cabeço Queimado containing cassiterite and lepidolite also intruded the complex. The veins are up to 15 cm thick and 300 m long (Antunes et al. 2002).

PETROGRAPHY

The granitic rocks from Segura have a subhedral granular texture (Table I).

Table I. Constituent minerals of granitic rocks from Segura

Rock type	Constituent minerals
Two-mica granite	quartz, microcline, albite, biotite, chlorite, muscovite, sillimanite, tourmaline, zircon, apatite, monazite, rutile and ilmenite
Muscovite granite	quartz, microcline, orthoclase, albite, muscovite, apatite, zircon, monazite, rutile, ilmenite and secondary gormanite
Aplite veins	quartz, microcline, albite, muscovite, tourmaline, zircon, apatite and rutile
Li-bearing aplite-pegmatite	quartz, microcline, albite, muscovite, amblygonite-montebrasite, topaz, lepidolite, cassiterite, tapiolite, columbite, ixiolite, microlite, zircon, apatite, rutile and secondary lacroixite

WHOLE-ROCK GEOCHEMISTRY

All the rocks are peraluminous (A/CNK ratio = molecular $Al_2O_3/(CaO+Na_2O+K_2O)$: 1.12 – 1.43) and classified as Sn-bearing granites, with the highest values at Li-bearing granitic aplite-pegmatite (Sn: 295 – 334 ppm) (Fig. 1). The aplite-pegmatite veins from Cabeço Queimado are REL-Li pegmatites and can be included in the LCT family (Černý & Ercit 2005). These aplite-pegmatite veins have higher SiO_2, F, Nb, Sn, Li, Y, Rb, Ta, Ge contents and lower TiO_2, total FeO, MgO, K_2O, Cr and Sr contents than the other granitic rocks from Segura area (Fig. 1).

Variation diagrams for major and trace elements show that the two-mica granite and muscovite granite are not related (Fig. 1), which is supported by their REE patterns that are not subparallel. In the variation diagrams, two fractionation trends are defined for: a) two-mica granite and Li-bearing aplite-pegmatite veins; b) muscovite granite and granitic aplite veins (Fig. 1). Li-bearing aplite-pegmatite veins have a very low REE content (∑REE < 12 ppm).

GEOCHEMISTRY OF MINERALS

Plagioclase from granitic rocks of Segura is albite with similar composition, ranging from An_0 to An_5. Potassium-feldspar has a higher average P_2O_5 content than coexisting plagioclase. Feldspars from muscovite granite and aplite veins have higher P_2O_5 contents than feldspars from the other granitic rocks. The empirical distribution coefficient D[P]Kf/Pl between K-feldspar and plagioclase ranges between 1.02 and 2.15, showing that no significant fractionation of phosphorus took place between coexisting feldspars and equilibrium was only attained for the distribution of P between Kf-Pl pairs from two-mica granite.

Magmatic muscovites from two-mica granite and Li-bearing aplite-pegmatite veins define a fractionation trend (Fig. 2).

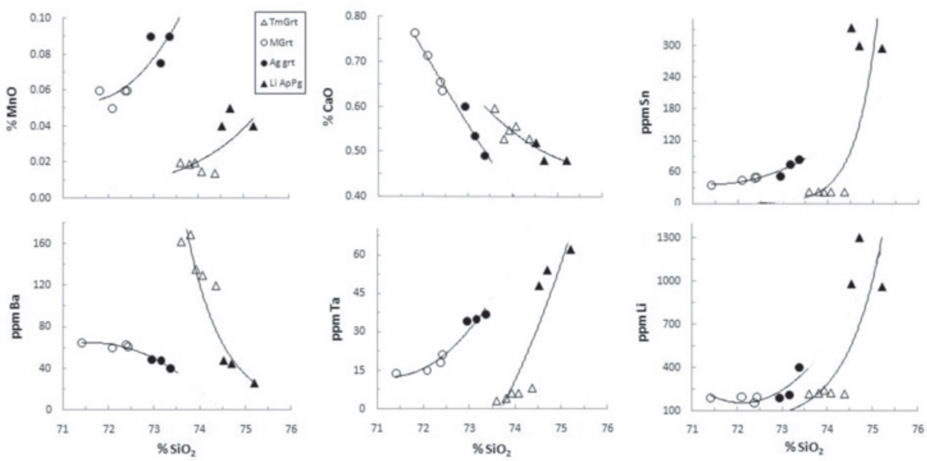

Figure 1. Variation diagrams of major and trace elements of Li-bearing aplite-pegmatite veins and granitic rocks from Segura.
Symbols: ∆ TmGrt – two-mica granite; ○ MGrt – muscovite granite; ● Ap grt – granitic aplite veins; ▲LiApPg – Li-bearing granitic aplite-pegmatite veins from Cabeço Queimado.

In the Li-bearing aplite-pegmatite veins from Cabeço Queimado, amblygonite-montebrasite shows some deficiency in Al, which is attributed to slight alteration (Neiva et al. 2000) and topaz has an homogeneous composition.

In these veins, cassiterite has unusual Nb > Ta and Mn > Fe. In zoned crystals of cassiterite, the darker zones are oscillatory zoned and have higher Nb and Ta contents than the lighter zones of the same crystal, which consist of nearly pure SnO_2. Ferrotapiolite, ixiolite and microlite occur as inclusions in cassiterite, whereas ferrocolumbite, manganoferrocolumbite and manganocolumbite are the exsolutions from cassiterite (Fig. 3). Inclusions and exsolutions were identified texturally and chemically. Tin, Ti, Sc and Mg are the most abundant minor elements in these inclusions and exsolution products. Ixiolite has Nb > Ta, Fe > Mn and W > Ti and corresponds to W-bearing ixiolite. There is a fractionation trend from ferrocolumbite to manganocolumbite.

PETROGENESIS

Variation diagrams of major and trace elements of granitic rocks from Segura area (Fig. 1) suggest two distinct trends of fractionation. The diagram for muscovite (Fig. 2) supports that two-mica granite and aplite-pegmatite veins are related. Least square analysis of major elements indicates: a) Li-bearing aplite-pegmatite veins from Cabeço Queimado are derived from the two-mica granite magma by fractional crystallization of quartz, albite, potash feldspar and biotite; b) aplite veins are derived from muscovite granite by fractional crystallization of quartz, albite, potash feldspar and ilmenite. Both fractional crystallization models are supported by modelling of trace elements, as calculated Sr and Ba contents decrease and Rb/Ba values increase versus a decrease in the weight fraction of remaining melt

during fractional crystallization from two-mica granite to Li-bearing aplite-pegmatite veins and from muscovite granite to granitic aplite veins. The increases of Sn and Li from two-mica

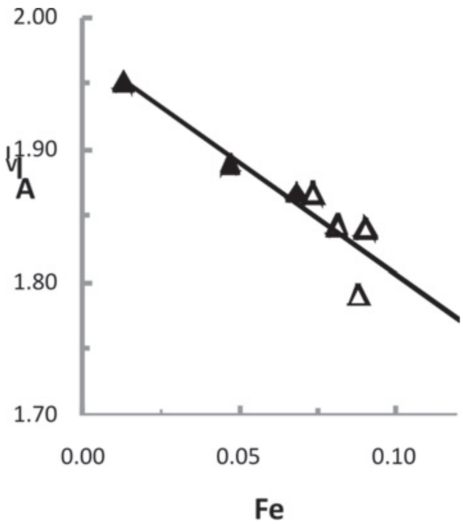

Figure 2. AlVI versus Fe diagram from muscovites of two-mica granite (∆ TmGrt) and Li-bearing aplite-pegmatite veins (▲LiApPg) from Segura.

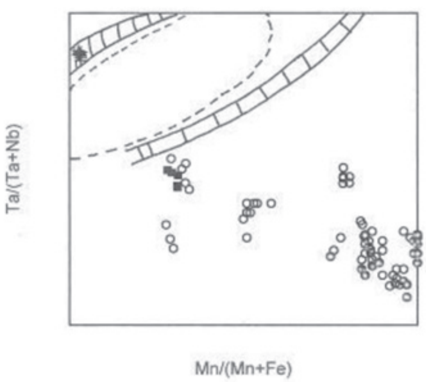

Figure 3. Plot of tapiolite, columbite and ixiolite from Li-bearing aplite- pegmatite veins of Segura on the columbite quadriteral of Černý (1992).

Symbols: ferrotapiolite (+); ixiolite (□); columbite (○).

granite to Li-bearing aplite pegmatite veins and from muscovite granite to aplite veins (Fig. 1) can be explained by the crystal fractionation processes. The $\delta^{18}O$ values are similar in muscovite granite (13.55 ‰) and granitic aplite veins (13.81 ‰) confirming this model. $\delta^{18}O$ values increase from two-mica granite (12.84 ‰) to aplite-pegmatite veins (14.38 ‰), suggesting an isotopic disequilibrium. $\delta^{18}O$ values of both granites indicate that they are derived by partial melting of metasedimentary materials.

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