PETROGENETIC LINKS OF GRANITIC APLITE-PEGMATITE SILLS FROM GONÇALO WITH GRANITES FROM GUARDA-BELMONTE AREA, CENTRAL PORTUGAL

A.M.R. Neiva[1], J.M.F. Ramos[2]

1 Department of Earth Sciences and Geosciences Center, University of Coimbra, 3000-272 Coimbra, Portugal, neiva@dct.uc.pt
2 INETI, 4466-956 S. Mamede de Infesta, Portugal, farinha.ramos@ineti.pt

ABSTRACT

Amblygonite-subtype and lepidolite-subtype (containing petalite) granitic aplite-pegmatite sills from Gonçalo intruded a Variscan granite from Guarda-Belmonte area. Variation diagrams of major and trace elements of four granites and aplite-pegmatite sills, their REE patterns and feldspar compositions indicate that the sills are not related to the host granite, but are related to a sequence defined by two biotite>muscovite granites, which is supported by $\delta^{18}O$ of whole-rocks and primary muscovite compositions. Least squares analysis of major elements and modelling of trace elements indicate that the youngest biotite>muscovite granite and amblygonite-subtype aplite-pegmatite sills are derived from a biotite>muscovite granite magma by fractional crystallization of quartz, potash feldspar, plagioclase, biotite and ilmenite. Tin and Li enrichments in both amblygonite-subtype and lepidolite-subtype aplite-pegmatite sills are due to fractional crystallization of the same granite magma. The two related granites do not represent crust anomalies in Sn and Li.

Keywords: granites, aplite-pegmatite sills, feldspars, micas, Sn- and Li-enrichments

INTRODUCTION

The petrogenesis of pegmatites had been debated (e.g. Simmons & Webber, 2008). The revised pegmatite classification is useful and widely applied (Černý & Ercit, 2005). The mineralogy, geochemistry and petrology of granites from Guarda-Belmonte area and aplite-pegmatite sills from Gonçalo are presented to test fractional crystallization for rare element aplite-pegmatite sills and their Sn and Li enrichments.

GEOLOGY

The Guarda-Belmonte area lies within the Central Iberian Zone of the Iberian Massif. Granites intruded the Cambrian schist-metagraywacke complex and were emplaced relatively to the third Variscan deformation phase (D3). Coarse- to very coarse-grained porphyritic biotite>muscovite granite (G1), fine- to medium-grained porphyritic biotite>muscovite granite (G2) and coarse-grained porphyritic biotite>muscovite granite (G3) are late-D3 and medium- to coarse-grained muscovite>biotite granite (G4) is post-D3. U-Th-Pb age by SHRIMP for G1 and U-Pb ages by ID-TIMS for the other granites indicate 301±3 Ma for G1, G2 and G3 and 293.9±0.5 Ma for G4. G1 passes gradually to G4. G2 intruded G1 showing sharp contacts and passes gradually to G3. G4 intruded G3 and the contacts are sharp. Granites G1, G3 and G4 are cut by many aplite-pegmatite sills and quartz veins and some mafic rock veins.

Aplite-pegmatite sills from Gonçalo intruded G1, are subhorizontal, trending NE-SW, 10-25° NE, N-S, 20° E and NNE-SSW, 20° E and up to 4 km long. The sills are from a few centimetres up to 15 m thick for amblygonite-subtype and up to 5 m thick for lepidolite-subtype. The latter contain 6-7 layers, up to 14 layers showing locally aplite at the footwall and hanging wall and have more complex structural zones and crop out at higher levels than the former, which consist of only one aplite-pegmatite layer. The aplite-pegmatite sills produced a metasomatic zone enriched in zinnwaldite, albite and tourmaline of 2-3 cm up to 20 m thick in host granite G1. The sills are cut by late aplite, pegmatite veins, quartz veins and mafic rock veins (Ramos, 1998).

PETROGRAPHY

The granites contain quartz, microperthitic microcline, plagioclase, biotite, chlorite, muscovite, zircon, apatite, monazite, ilmenite and rutile. All granites contain phenocrysts of microcline and G1 and G3 have albite-oligoclase phenocrysts and G2 has albite-andesine phenocrysts. The plagioclase of matrix is albite-oligoclase in most granites and albite in G4.

The aplite-pegmatite sills from Gonçalo contain quartz, microperthitic orthoclase and microcline, albite, muscovite, Li-bearing muscovite, tourmaline, topaz, beryl, zircon, apatite, amblygonite, monazite, cassiterite and columbite-tantalite. The lepidolite-subtype sills also contain lepidolite, petalite, microlite, torbernite, autunite and rare arsenopyrite, pyrite and chalcopyrite (Ramos, 1998).

WHOLE-ROCK GEOCHEMISTRY

Variation diagrams for major anda trace elements for granites show trends of fractionation for two series: a) G1 and G4; b) G2 and G3 (Fig. 1). The REE patterns are subparallel for granites within each series.

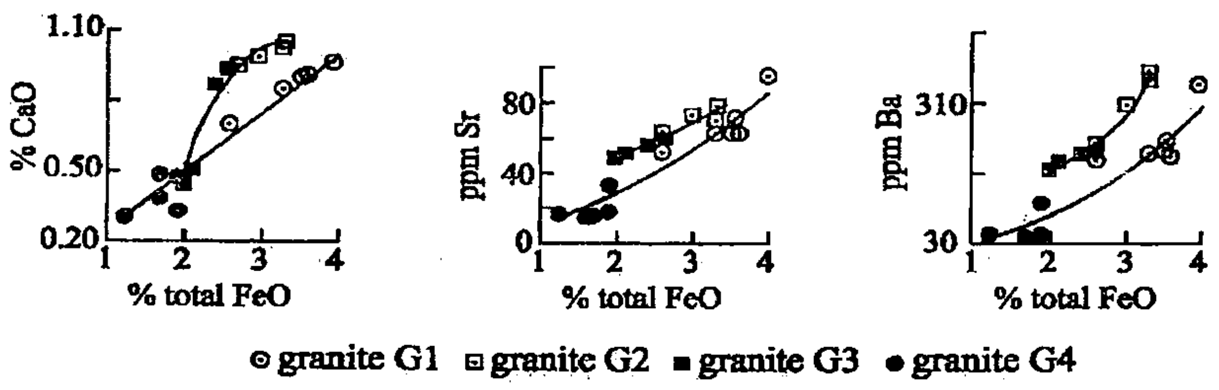

Figure 1 – Selected variation diagrams of granites from Guarda-Belmonte area, central Portugal, suggesting two distinct series.

The aplite-pegmatite sills have similar to higher MnO, P_2O_5, Nb contents and similar to lower total FeO, K_2O, CaO, Sr and Ba contents than G4 (Fig. 2). The similar contents in these granitic rocks and the fact that some sills have lower P_2O_5 content and higher Sr content than G4 indicate that the sills are not related to the series defined by granites G1 and G4, which is supported by the fact that the chondrite normalized REE patterns of sills are not subparallel to those of G1 and G4 and intersect the REE pattern for G4 in LREE and HREE.

The aplite-pegmatite sills have higher MnO, Nb, Ta, Sn, Li, Rb contents and Ta/Nb, Rb/Sr values and lower TiO_2, total FeO, MgO, CaO, Zr, Y, Sr and Ba contents than granites G2 and G3 (Fig. 3). The richest sills in Li also have higher Al_2O_3, Na_2O, and generally higher P_2O_5 contents and lower SiO_2 and K_2O contents than G2 and G3. Variation diagrams for major and trace elements show fractionation trends for granites G2 and G3 and sills (Fig. 3), suggesting that the sills are related to the series defined by granites G2 and G3. The highest F, Sn, Li, Rb and Ta/Nb values occur in the lepidolite-subtype sills. The chondrite normalized REE patterns for granites G2, G3 and sills are subparallel and all REE contents decrease from G2 to G3 to amblygonite-subtype and lepidolite-subtype sills. □^{18}O values increase slightly (0.44‰) from G2 to sills, but this increase is consistent with fractional crystallization.

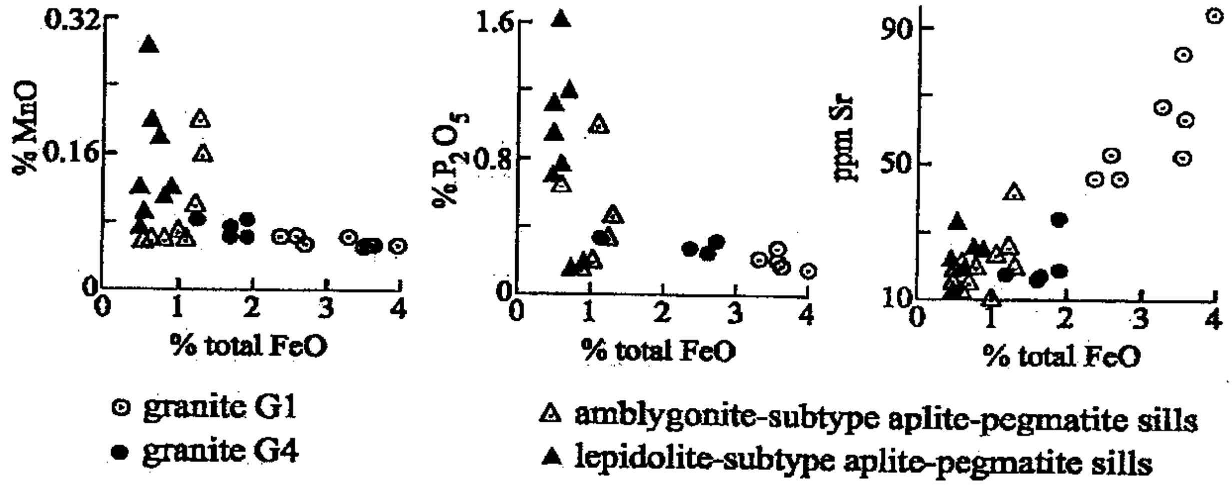

Figure 2 – Selected variation diagrams of some granites from Guarda-Belmonte area and granitic aplite-pegmatite sills from Gonçalo, central Portugal. The sills cannot be related to this series.

GEOCHEMISTRY OF MINERALS

Albite from aplite-pegmatite sills has a similar anorthite content to that of albite from G4, supporting that the sills are not related to the series defined by granites G1 and G4. The anorthite of plagioclase and Ba content of potash feldspar decrease and P_2O_5 content of both feldspars increases from G2 to G3 and to aplite-pegmatite sills supporting that the aplite-pegmatite sills are related to the series defined by granites G2 and G3. No significant fractionation of phosphorus took place between coexisting feldspars.

Primary muscovite from aplite-pegmatite sills has higher Al^{VI}, Mn, Li, F contents and lower Ti, Fe and Mg contents than primary muscovite from granites G2 and G3. Li-bearing muscovite from aplite-pegmatite sills has higher Mn, Li, F and paragonite contents and lower Al^{VI} content than primary muscovite from the granitic rocks.

In aplite-pegmatite sills, the later fine-grained lepidolite has higher Mn, Li, F and lower Sn, Rb contents than the earlier lepidolite; topaz has a pure composition and amblygonite shows some deficiency in Al, which is attributed to slight alteration. Petalite only occurs in lepidolite-subtype aplite-pegmatite sills and is a nearly pure phase (Ramos, 1998)..

Cassiterite from sills is zoned with alternate lighter and darker zones. The latter has higher (Nb+Ta+Fe+Mn) content than the former. Cassiterite with the high Nb and Ta contents has Mn>Fe and belongs to lepidolite-subtype aplite-pegmatite sills. Manganocolumbite occurs in all sills, but very rare ferrocolumbite only appears in amblygonite-subtype aplite-pegmatite sills; manganotantalite and reversely zoned crystals with an homogeneous microlite core and an heterogeneous uranmicrolite rim occur in lepidolite-subtype sills (Ramos, 1998).

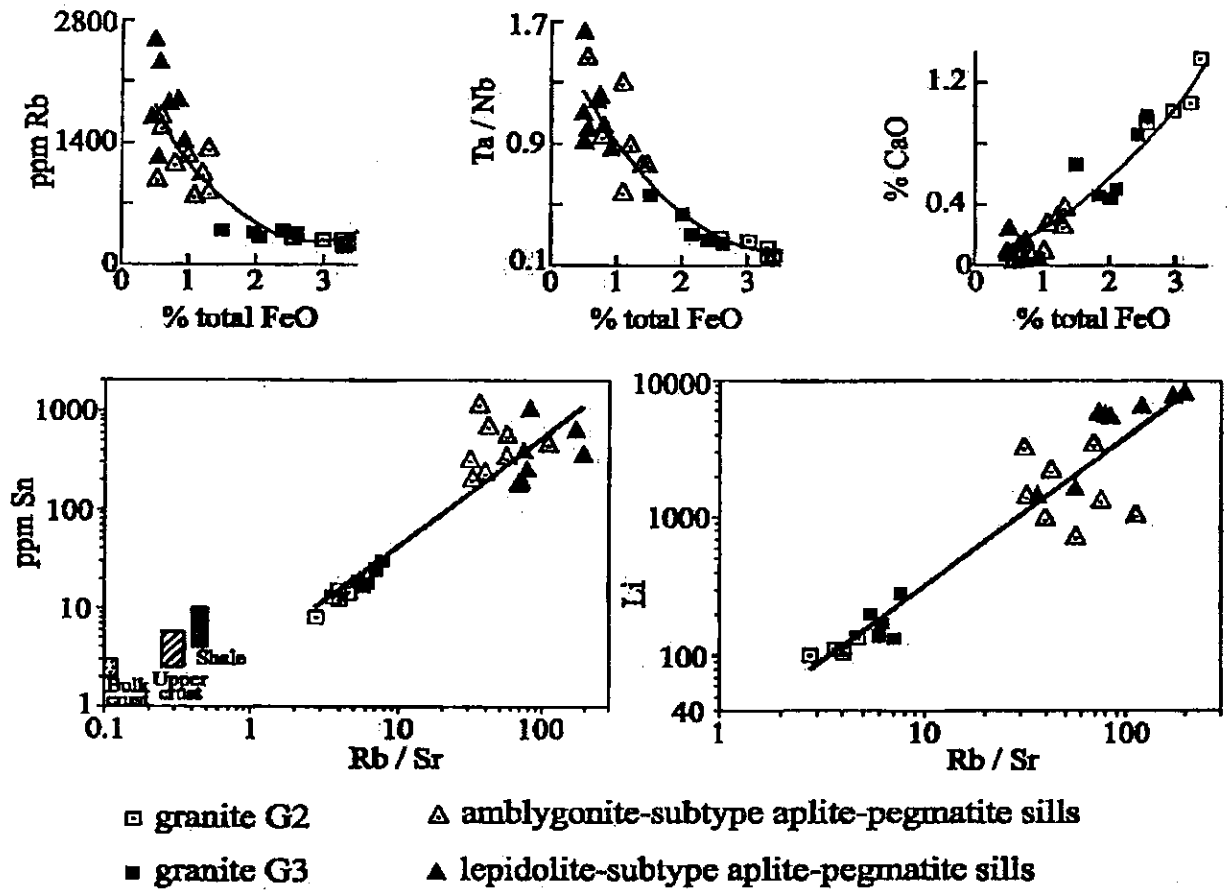

Figure 3 – Selected variation diagrams and log Rb/Sr-log Sn and log Rb/Sr-log Li correlations for two biotite>muscovite granites from Guarda-Belmonte area and granitic aplite-pegmatite sills from Gonçalo, central Portugal, indicating a crystal fractionation series.

PETROGENESIS

Fractionation trends in variation diagrams of major and trace elements for granites G2 and G3 and aplite-pegmatite sills (Fig. 3), subparallel whole-rock REE patterns, similar Q^{18}O values and compositions of feldspars and primary muscovite suggest that aplite-pegmatite sills are related to granites G2 and G3. Least squares analysis of major elements show that amblygonite-subtype aplite-pegmatite sills are derived from granite G2 magma by fractional crystallization of quartz, potash feldspar, plagioclase, biotite and ilmenite, which is supported by modelling of trace elements. There was also fractionation of: a) monazite responsible for depletion in LREE; b) zircon that caused decrease in HREE and Zr contents; c) apatite responsible for depletion in MREE and HREE from G2 to G3 to aplite-pegmatite sills. Fractional crystallization was responsible for Sn an Li enrichments in granite G3 and aplite-pegmatite sills (Fig. 3) reaching the highest concentrations in lepidolite-subtype sills.

REFERENCES

Černy, P. & Ercit, T.S. 2005. The classification of granitic pegmatites revisited. *Canadian Mineralogist*, 43: 2005-2026.

Simmons, Wm. B. & Webber, K.L. 2008. Pegmatite genesis: state of the art. *European Journal of Mineralogy*, 20: 421-438.

Ramos, J.M.F. 1998. Mineralizações de metais raros de Seixo Amarelo-Gonçalo (Guarda). *Unpublished Ph.D. thesis, University of Lisbon*, 685 pgs.