Geochemistry of granitic aplite-pegmatite sills and their minerals from Arcozelo da Serra (Gouveia, Portugal)

A.M.R. NEIVA[1], M.E.P. GOMES[2], J.M.F. RAMOS[3] & P.B. SILVA[3]

[1]Department of Earth Sciences, University of Coimbra, 3000-272 Coimbra, Portugal, neiva@dct.uc.pt
[2]Department of Geology, University of Trás-os-Montes e Alto Douro, 5000-911 Vila Real, Portugal, mgomes@utad.pt
[3]INETI 4466-956 S. Mamede de Infesta, Portugal, farinha.ramos@ineti.pt, paulo.bravo@ineti.pt

ABSTRACT

Granitic aplite-pegmatite sills intruded two Variscan granites from Arcozelo da Serra (Gouveia). Variations of major and trace elements for the three granites and aplite-pegmatite sills from this area and major elements of their feldspars and micas suggest that the two-mica granite is the parental granite for the sills. Least squares analysis of major elements and modelling of trace elements indicate that the aplite-pegmatite sills were derived from this granite magma by fractional crystallization of quartz, plagioclase, potash feldspar and biotite. The pegmatites belong to the muscovite-rare-element class.

Keywords: *granitic aplite-pegmatites, micas, feldspars, parental granite, crystal fractionation, columbite-tantalite.*

GEOLOGY

The Arcozelo da Serra (Gouveia) area is located in the Iberian Massif, which corresponds to the southwestern extension of the European Hercynides. Granitic rocks predominate in this area, intruded the Cambrian schist-metagraywacke complex and were emplaced relatively to the third Variscan deformation phase. SHRIMP monazite age for the coarse-grained porphyritic muscovite>biotite granodiorite to granite is 290.1±2.4 Ma by $^{206}Pb/^{238}U$ and 288.6±1.5 Ma by $^{208}Pb/^{232}Th$. This granite passes gradually to a medium- to coarse-grained slightly porphyritic muscovite>biotite granite. The fine- to medium-grained slightly porphyritic two-mica (biotite=muscovite) granite is 287.7±2.0 Ma by $^{206}Pb/^{238}U$ and 288.7±1.6 by $^{208}Pb/^{232}Th$ on monazite obtained by SHRIMP. It intruded the other two granites, showing sharp contacts. The three granites contain microgranular and metasedimentary enclaves.

Subhorizontal aplite-pegmatite sills trending NW-SE, are 50-700 m long and 20 cm – 2.5 m thick, intruded muscovite>biotite granodiorite to granite and locally produced minor metasomatism. N-S to WNW-SSE, <30º NE-trending aplite-pegmatite sills intruded the two-mica granite and did not cause any metasomatism. Commonly, they are 50-500 m long and 30 cm – 1.5 m thick. In general, pegmatite is more abundant than aplite and forms the sill's core and is surrounded by aplite. However, in other aplite-pegmatite sills, pegmatite occurs at the hanging wall and locally at the foot wall.

PETROGRAPHY

The granites contain quartz, microperthitic microcline, plagioclase, biotite, muscovite, zircon, apatite, monazite, ilmenite and rutile. The muscovite>biotite granite also has andalusite, sillimanite and tourmaline. The muscovite>biotite granodiorite to granite contains phenocrysts of microcline and oligoclase. The plagioclase of matrix is albite-oligoclase. The muscovite>biotite granite has rare phenocrysts of albite-oligoclase and rarer of microcline. The plagioclase of matrix is albite-oligoclase. The two-mica granite contains rare phenocrysts of microcline. The plagioclase of matrix is albite-oligoclase.

Aplite and pegmatite contain quartz, microperthitic orthoclase and microcline, albite, biotite, chlorite, muscovite, garnet (almandine-spessartine), tourmaline, beryl, zircon, monazite, apatite, ferrocolumbite, manganocolumbite, ferrotantalite and rare arsenopyrite. Very rare montebrasite and spodumene were only found in one sample containing quartz, orthoclase, microcline, albite, muscovite, tourmaline, zircon, apatite from an aplite-pegmatite sill, which is 500 m long and 1 m thick.

WHOLE-ROCK GEOCHEMISTRY

All the granitic rocks are peraluminous. The muscovite>biotite granodiorite to granite has the lowest A/CNK ratio = molecular $Al_2O_3/(CaO+Na_2O+K_2O)$ of 1.03-1.08, while the other granitic rocks present A/CNK values of 1.15-1.39. The aplite-pegmatite sills have similar chemical compositions, although they cut two distinct granites. The aplite-pegmatite sills have higher SiO_2, F, Sn, Rb contents and lower TiO_2, FeO, MgO, CaO, Zn, Zr, Y, Sr, Ba and Th contents than the granites they cut. They have lower REE contents than the three granites.

The muscovite>biotite granodiorite to granite and muscovite>biotite granite define fractionation trends for major and trace elements, a whole-rock Rb-Sr isochron and subparallel rare earth patterns. The muscovite>biotite granite is derived from the muscovite>biotite granodiorite to granite by fractional crystallization of quartz, plagioclase and biotite, as tested by modelling major and trace elements.

The aplite-pegmatite sills have similar to more SiO_2, Al_2O_3, Na_2O, Sn, Rb, similar to less CaO, K_2O, P_2O_5, F, Nb, Li and less TiO_2, FeO, MgO, Zn, Zr, Y, Sr, Ba and Th than muscovite>biotite granite. The similar contents in these granitic rocks suggest that this granite is not the parental granite for the aplite-pegmatite sills.

Variation diagrams of major and trace elements of two-mica granite and aplite-pegmatite sills show fractionation trends (Fig. 1). The aplite-pegmatite sills have similar $\delta^{18}O$ values to those of two-mica granite, but higher than those of the other two granites. The pegmatites studied belong to the muscovite-rare-element class (MSREL) of Cerný & Ercit (2005).

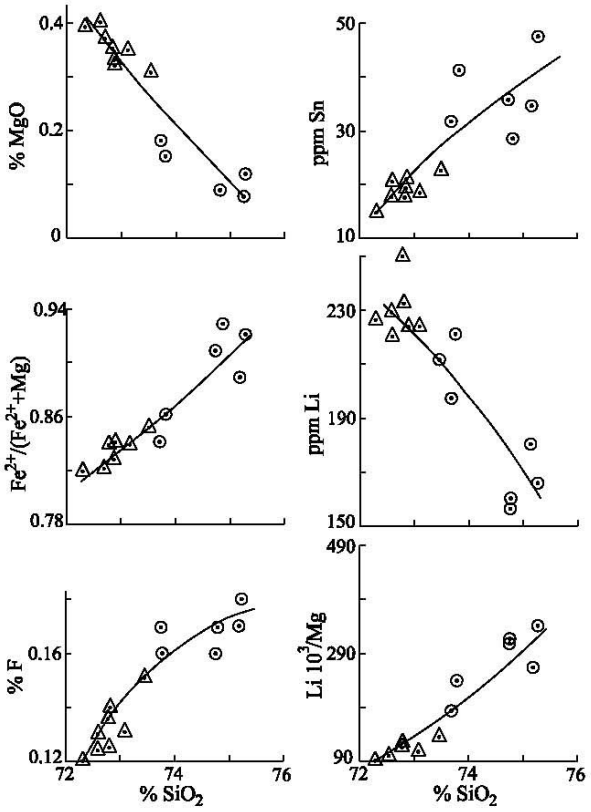

FIGURE 1. Variation diagrams of major, trace elements and ratios of granites and aplite-pegmatite sills from Arcozelo da Serra.
Symbols: △ - two-mica granite, ⊙ - aplite-pegmatite sills.

GEOCHEMISTRY OF MINERALS

Potash feldspar from aplite-pegmatite sills has similar to lower Ba content and higher P_2O_5 content than potash feldspars from the three granites. The albite from aplite-pegmatite sills contains less Ca and more P_2O_5 than the plagioclase from the two-mica granite.

The three granites contain Fe^{2+}-biotite, while aplite-pegmatite sills have siderophyllite (Foster, 1962), which has more Al^{VI}, Mn, F and less Ti and Mg than biotite from the granites. Total Fe^{2+} content of siderophyllite is similar to higher than that of biotite from two-mica granite, but similar to lower than that of biotite from muscovite>biotite granite. Li content of siderophyllite is similar to higher than that of biotite from muscovite>biotite granite and higher than that of biotite from the other granites.

Muscovite from aplite-pegmatite sills has more Mn, Na and less Ti and Mg than muscovites from the three granites and more, Fe, F and Li than muscovite from the two-mica granite.

PETROGENESIS

The variations of major and trace elements of granitic rocks from Arcozelo da Serra area and the compositions of their feldspars and micas suggest that the two-mica granite is the parental granite for aplite-pegmatite sills. The variations of major and trace elements for two-mica granite and aplite-pegmatite sills (Fig. 1) and major elements of micas and feldspars suggest a crystal fractionation model (e.g., Neiva, 1975), which is supported by similar $\delta^{18}O$ values for these granitic rocks. Least squares analysis of major elements indicate that the aplite-pegmatite sills are derived from the two-mica granite magma by fractional crystallization of quartz, plagioclase, potash feldspar and biotite (Fig. 2), which is supported by modelling of trace elements.

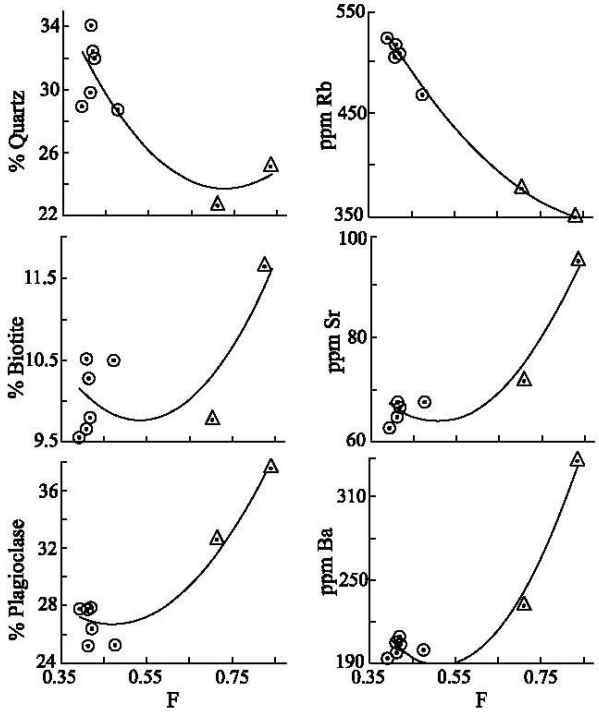

FIGURE 2. Plot of modal quartz, plagioclase and biotite of cumulate and of calculated trace element contents in two-mica granite and aplite-pegmatite sills from Arcozelo da Serra.
Symbols: △ - two-mica granite, ⊙ - aplite-pegmatite sills.

The decrease in LREE from two-mica granite to aplite-pegmatite sills is probably due to fractionation of monazite. The depletion in MREE and HREE is attributed to fractionation of apatite, but depletion in HREE is also due to fractionation of Zr. The increase in Sn content from two-mica granite to aplite-pegmatite sills (Fig. 1) is due to crystal fractionation and Sn must be mainly retained in muscovite from the sills.

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