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Geochemistry, geochronology and structural evolution of pre- to syn-kinematic granitoids in the Major Gercino shear zone, southern Brazil

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The Major Gercino Shear Zone (MGSZ) is one of the major NE-SW lineaments that affected all southern Brazilian and Uruguayan Precambrian terrains. In the State of Santa Catarina, southern Brazil, the MGSZ separates the supracrustal rocks of the Brusque Group, to the north, from the granitoids of the Granite-Migmatite Complex, to the south. The shear zone is characterized by a regional NE trend and a dextral oblique resultant in which ductile-brittle structures predominate. The importance of the pure shear component is emphasized by the orientation of the mylonitic belt in relation to the stress field[1].

In the Canelinha - Garcia area the MGSZ is composed of two mylonitic belts separated by granitoid rocks. Mylonites and protomylonites predominate in both belts. The mylonitic rocks present crystallographic orientations produced under greenschist metamorphic conditions at high strain rate. The transpressive character of MGSZ is indicated mainly by the high flattening component observed with an important coaxial deformation component[1].

The calc-alkalic granitoids in the area can be grouped into two associations with meta to peraluminous affinities. The Rolador Granitoid Association (RGA) is characterized by grayish porphyritic biotite-monzogranites, and the Fernandes Granitoid Association (FGA) by coarse-grained to porphyritic pinkish amphibole-syenogranites. The modal analysis of RGA and FGA are plotted on QAP diagram[2] (Fig.1).

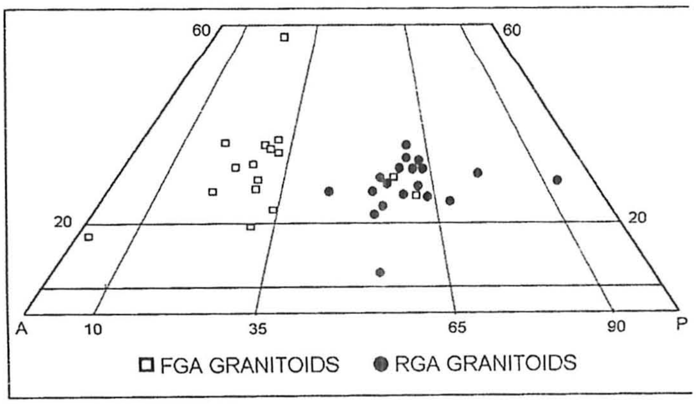

Fig. 1. Central granitoids of MGSZ plotted in the QAP diagram.

The FGA syenogranites present amphibole (hornblende group), and biotite is subordinate as major mafic phases. The common accessories minerals are zircon, allanite, titanite, apatite and garnet. The mineral assemblage has been reequilibrated under greenschist facies conditions, which promoted the partial change of amphibole into biotite and chlorite, and formation of albite, clinozoisite/zoisite, epidote and carbonate. They present monzonitic or high-potassium calc-alkalic association characteristics, having similarities with aluminous granitoids of alkalic provinces[3].

RGA monzogranites show K-feldspar and plagioclase megacrystals set in a medium-grained granodioritic to tonalitic matrix. The main minerals are quartz, K-feldspar and oligoclase, biotite and chlorite. The common accessories are apatite, titanite, allanite, zircon and muscovite. Tourmaline is uncommon.

The primary mineralogical association of RGA reequilibrated under greenschist facies, evidenced by the paragenesis: biotite (partially changed to chlorite), albite, clinozoisite/zoisite and epidote. These monzogranites are characterized by a normal or medium potassic calc-alkalic association, as defined by Lameyre & Bowden[3].

The multi-elemental diagrams (ORG normalization[4]), for RGA, FGA and their respective mylonites (Fig. 2) show rather smooth overall fractionation, with 80-100x enrichment for Rb and depletion of HFS elements (0.2-0.7x for Y). Ba, Nb, Hf and Zr have negative anomalies which are more accentuated in FGA. The main differences between RGA and FGA are found in the behavior of Hf, Zr and Sm, which are approximately ORG contents in FGA, and less than ORG in RGA. The patterns of RGA mylonites are very similar to those of the corresponding granites, except for slightly more pronounced negative Ba anomalies in the mylonites. The FGA mylonites have less K_2O, Rb, Ba, Th, Nb, Ce, Hf, Zr, and Sm and more Ta than their protoliths.

The granites keep some chemical similarities to syn-collisional granites as described by Pearce *et al*[4]; concentrations of elements to the left of Ce in Fig. 2, are higher than those in ORG.

The chondrite-normalized rare earth elements patterns, emphasizes the different geochemical signatures of the two associations. Both associations have the characteristic LREE/HREE fractionation of granitoid modes. However, FGA has larger negative Eu anomalies than RGA. The negative Eu anomalies suggest the involvement of crustal material in the generation of these granitoids and indicates feldspar participation in the partial fusion process or fractional crystallization, suggesting the retention of some plagioclase on magma source. FGA granitoids are also rather more enriched in REE than the RGA granitoids.

Passarelli[1] using multielement diagrams (ORG normalization[4]), and REE and Ba x Sr diagrams, suggested some correlations between RGA and FGA granites and those studied on MGSZ in the Porto Belo region, State of Santa Catarina, by Bitencourt & Nardi[5]. The RGA granites present geochemical similarities with the Estaleiro Complex granites of the early stages of transcurrent-related magmatism[5]. The main difference is in the Yb contents, which are lower in the RGA. On the other hand, the FGA granites present geochemical similarities to the Zimbros Intrusive Suite, also transcurrent-related magmatism[5]. The differences are mainly related to lower Yb and slightly higher Ba contents in the FGA.

These granitoids were only recognized between the two mylonitic belts and have stretched geometry, with their external parts affected by shear process. In the central parts, they are normally not much deformed. It is important to notice that although the RGA granites seems to be slightly older than the FGA, RGA xenoliths are not found in FGA.

The micaceous minerals formed during the shear development indicate K-Ar ages around 555 ± 15 Ma. The K-Ar ages of granitoids of both associations (around 570 Ma) are similar to the ones obtained on the mylonitic rocks, suggesting a period of intense termo-tectonic activity in the region, related to an important phase of MGSZ slip.

Basei et al.[6] suggested that an important stage of the juxtaposition of Costeiro granitic Belt to the northern terranes of MGSZ occurred during this period. This would represent part of the collision involving the whole of southeastern Brazil.

Studies made by several authors (e.g. McCaffrey[7], Hutton & Reavy[8]), suggest that transpressive shear zones may be locally transtensional. This process can produce in the material present in the shear zone, an horizontal shortening and a vertical

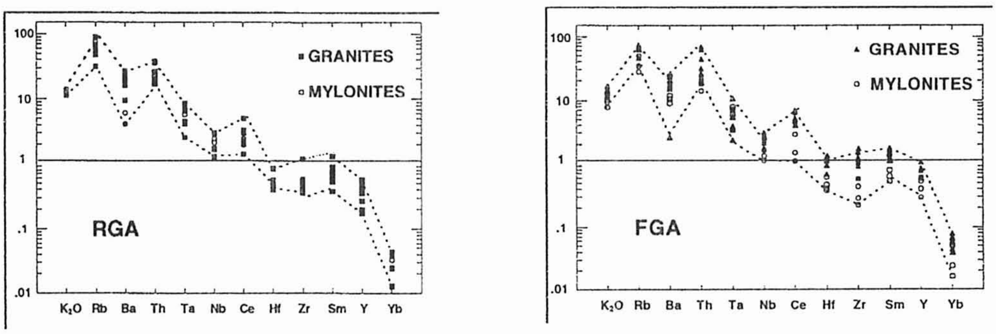

Fig. 2 - Multi-elemental diagrams of RGA, FGA and respective mylonites. Ocean ridge granites normalization values after Pearce *et al.* [4]

The U-Pb and Rb-Sr ages range from 670 to 590 Ma with the $^{87}Sr/^{86}Sr$ initial ratios, around 0.710, suggesting a crustal contribution in the generation of these rocks. K-Ar biotite cooling ages range from 580 to 560 Ma.

The geochronological data, the lack of tectonic control evidence on the granitic magmatic fabric formation and, in several places, the observation of the foliation path following the granite limits, suggest a pre-syn-kinematic emplacement of RGA and FGA granites in relation to shear zone deformation.

In some locations, the magma crystallization contemporanity to the shear zone development is suggested by the rotation of the magmatic foliation into the shear direction, and by a continuous passage from deformation in magmatic condition to deformation under solid conditions (presence of sub-magmatic flow). These characteristics may indicate that the late magmatic flow stage was influenced by the shear zone kinematics.

extension. This concept was used by Passarelli[1] to explain the steeply inclined X axes of strain ellipsoid found in the studied MGSZ mylonites, and the ascent, emplacement and even the genesis of the granitic magma of the FGA and RGA associations.

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