CALC-ALKALINE MAGMATISM IN A LOW PRESSURE HIGH TEMPERATURE NEOPROTEROZOIC TERRANE, SE BRAZIL: NEW U-Pb DATA

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Keywords: U-Pb age, cathodoluminescence, porphyritic granite, syn-collisional rocks, central Ribeira Belt.

INTRODUCTION

Calc-alkaline I-type granitoid rocks occupy a large area in the central segment of the Ribeira Belt, southeast Brazil. They are related to pre-, syn- to post-collisional magmatic events between ca. 790 Ma and 490 Ma (Heilbron & Machado, 2003). The megaporphyritic I-type Itacoatiara Granite, in southeast Rio de Janeiro State, has petrographic and geochemical signature similar to other several granitoids of the region, and its emplacement was probably controlled by an expressive NE-SW dextral shear zone. Preliminary geological features were described by Mendes et al. (2003) and geochronological data regarding this granite and its wall rocks are to be presented in this work.

GEOLOGICAL SETTING

The studied area is located in the Ribeira Belt, a Neoproterozoic unit (Brasiliano/Pan-African) that runs along the southeastern Brazilian coast. The central segment of the Ribeira Belt has been recently subdivided in five distinct tectonic terranes, in the sense of Howell (1989), from NW to SE, respectively: Occidental, Paraíba do Sul, Embú, Oriental and Cabo Frio Terranes (Trouw et al., 2000, Heilbron and Machado, 2003, Heilbron et al., 2004). The Oriental Terrane is divided in three tectonic domains: the Paraíba do Sul Klippe, the Rio Negro Complex, and the Costeiro Domain. The Rio Negro Complex was initially described as an association of granitic orthogneisses and heterogeneous migmatites (Barbosa & Grossi Sad, 1985). Recent works have pointed out its arc related nature (Tupinambá, 1999, Heilbron et al., 2000). Tupinambá (1999) associated such magmatism to a pre-collisional event with generation of Cordilleran-type, calc-alkalic granodioritic to tonalitic rocks of 634± 10 Ma. The granitic to granodioritic gneisses of the Serra dos Órgãos Batholith intruded the ortho-derived Rio Negro at 575 to 550 Ma. The Costeiro Domain is situated between the Rio Negro Complex and the Cabo Frio Terrane. It comprises ortho and para-derived rocks of high temperature low pressure (Ferrari et al., 1982). The Itacoatiara Granite is considered as part of this domain (Penha et al., 2001). It is located close to the tectonic boundary between the Oriental and the Cabo Frio Terranes. This last one is comprised of metasedimentary rocks and Paleoproterozoic basement orthogneisses, of high temperature and pressure. The metamorphic peak is slightly younger, 525 Ma, and it does not have large Brasiliano plutons (Schmitt et al., 2004).

THE ITACOATIARA GRANITE AND ASSOCIATED LITHOTYPES

The Itacoatiara Granite (Penha et al., 2001) crops out in an area of about 70 km^2. It is a NE-SW elongated pluton that occurs along the coastline as hills and mountain ranges. The geological contacts may be masked by alluvial and colluvial deposits. To the west the granitic body is in contact with the granitic to granodioritic porphyroblastic garnet-biotite gneiss, named Cassorotiba Gneiss. Towards the north it is interfingered and mingled with a quartzdiorite, and to the east, the contiguous lithotypes are the ortho-derived Maricá and Tingui gneisses, showing locally an intrusive contact with them (Rocha, 2002).

Along the contact between the Itacoatiara Granite and the Cassorotiba Gneiss there is a long and narrow (ca. 50m) vertical ductile shear zone. This structure has a N70E trend, parallel to the orientation of the granitic body that turns into a protomylonite to mylonite. In the shear zone both litotypes are strongly deformed and become very similar. There are stretching lineation of quartz and mafic enclaves, as well as garnet and feldspar porphyroclasts. Some kinematic indicators as stair-stepping asymmetric porphyroclasts (Passchier and Trouw, 1996) indicate a dextral shear sense. Inside the granitic body, there is evidence for local deformation which can vary from the generation of a conspicuous foliation to a development of small NE-SW flow ductile shear zone (Marre, 1986). Younger NW-SE sinistral shear zone showing S/C fabric was also observed.

The Itacoatiara Granite is monzogranitic in composition and its porphyritic texture is made up by euhedral to subhedral microcline megacrysts up to 5 cm long in a granodioritic groundmass containing plagioclase (An_{25}), quartz, microcline, biotite, opaque minerals (mainly ilmenite and magnetite), zircon and apatite. It is leucocratic, gray in color and bears an irregular igneous flow structure. When observed, the flow is marked by NE-SW aligned K-feldspars megacrysts. Linear flow clearly predominates over planar flow structures. A magmatic turbulent flow is somewhere observed as a result of confuse and intermingled phenocrysts positions.

The Cassorotiba Gneiss is an irregular NE-SW elongated unit that presents a tectonic contact with the Itacoatiara Granite. This gneiss locally shows a phlebitic to folded igmatitic structure and the field relationship with the ranite is not clear due to deformation.

Rounded to lenticular mafic microgranular enclaves as ell as sillimanite-garnet biotite gneiss xenoliths with variable shape, size and assimilation degree are widespread in the granite. The mafic enclaves are the most common and they locally present large K-feldspar crystals (up to 1cm) in a quartzdioritic to dioritic matrix. These crystals probably represent xenocrysts from the megaporphyritic granite. At the northeast limit of the Itacoatiara Granite, large amounts of the fine-grained quartzodiorite are found showing a commingling relationship with the granite in a schlieren-lyke structure.

The microgranular enclaves present a fine-grained, hypidiomorphic granular texture and plagioclase, hornblende, biotite, quartz, opaque minerals, apatite and zircon as mainly constituents. Biotite replacing hornblende and apatite bearing mafic aggregates are common textures.

GEOCHEMISTRY

Major and trace elements analysis of the Itacoatiara granite, Cassorotiba Gneiss and quartzdiorite were carried out at the Department of Geology, Rio de Janeiro Federal University, using a Philips PW2400 Rh tube X ray fluorescence spectrometer. REE samples were analyzed at Geolab/Geosol Laboratories.

The granite has notable higher K_20, Ba, Sr, Rb and Zr contents and different REE behavior when compared to the Cassorotiba Gneiss. High total REE concentrations associated with a strongly fractionated pattern is typical of well evolved rocks. I-type nature is depicted from ACNK ratios close to 1.0, as well as modal biotite, lack of muscovite and the presence of gneiss xenoliths. The quartzdiorite presents high Na_2O, Ba, Sr, REE and Zr quantities, besides considerable K_2O, TiO_2 and Fe_2O_3 concentrations. The anomalous incompatible elements values indicate possible contamination and/or magma mixing process during its evolution. The
porphyritic granite and the quartzdiorite show a calc-alkaline and metaluminous geochemical signature and similar REE pattern.

GEOCHRONOLOGICAL DATA

U-Pb data ages from non-abraded zircons, for the Itacoatiara Granite were obtained by isotope dilution/TIMS at the Laboratory of Geochronology of the University of Brasília. The analytical procedures were those presented by Laux et al. (2004). The Itacoatiara granite sample was collected in the least deformed domain, although it was quite difficult to avoid an outcrop with xenoliths. The zircon grains present internal structures of a wide range of morphology, observed in cathodoluminescense and SEM images performed at the Max Planck Institut fur Chemie (Mainz, Germany). The populations are: (1) metamorphic crystals (probably inherited from the wall rock or maybe some supracrustal melt; (2) grains with clear igneous zonation and an inherited core (magma source?); (3) igneous crystals with reabsorbed features. Four zircon crystals were selected for U-Pb single-grain analysis. An upper intercept of 572 +7-9 Ma was obtained for this granite (Figure 1). Though, some zircon fractions plot close to the concordia, giving a U/Pb age of 550 Ma. This age also coincides with the data obtained with the evaporation technique, in Max Planck Institut. The complex morphology of the crystals is reflected by the spread of the fractions in the Concordia. We interpreted the 570 Ma age as the crystallization age. The 550 Ma data could be related to the metamorphic peak coeval to deformation in this area.

Zircons from the host rock, Cassorotiba Gneiss, were also analyzed. Some zircons are concordant and give an age of 553 +- 2 Ma (Figure 2), coinciding also with the lower intercept of a regression with three crystals. Considering the high grade mineralogy of this gneiss, this age is interpreted as the metamorphic peak for the unit. Further 100 km to NE, monazites and metamorphic zircons of 550 Ma were dated in a paragneiss rock of the same terrane (Schmitt et al., 2004).

CONCLUSIONS

The Itacoatiara geochoronological data indicate a 20 m.y. interval that represents the intrusion and subsequent metamorphic event during the Neoproterozoic-Cambrian limit. The crystallisation age agrees with the 600 to 560 Ma collision I episode suggested by many authors for the central segment of the Ribeira Belt (Heilbron et al., 2004, Heilbron and Machado, 2003, Trouw et al., 2000). The metamorphic age (550 Ma), registered both in the granite and the Cassorotiba Gneiss, is similar to other metamorphic ages obtained in the Costeiro Domain (Schmitt et al., 2004; Heilbron & Machado, 2003).

The Itacoatiara granite is a typical example of I-type calc-alkaline metaluminous granitoid possibly emplaced in a stress field controlled by the development of a late NE-SW dextral subvertical shear zone. Taking into account geological and tectonic aspects, Mendes et al. (2003) considered a late- to post-tectonic emplacement, relative to the development of the referred shear zone. They suggested the granite was probably affected during its crystallization process. Considering as the obtained syn-collisional age of 572 to 550 Ma, as the shear zone delimitation, the small and local deformation evidences found overall the granite is noteworthy. The magmatic structures and textures are well preserved and obliteration of these aspects is only observed in the neighborhood of the shear zones. This characteristic may be related to an irregular response to the deformation found in porphyritic rocks, where the nucleus of the batholitic bodies can be isolated from the deformation observed in the border areas. If such process occurred, there is a hidden/not found deformed portion of the Itacoatiara Granite border

REFERENCES

Barbosa A. L. M. and Grossi Sad, J.H., 1985. Batólito granítico da serra dos Órgãos, Estado do Rio De Janeiro, Brasil. Contribuições à Geologia e à Petrologia, Núcleo de Minas Gerais – Sbgm: 49-61.

Ferrari, A., Brenner, T., Dalcomo, M. and Nunes, H., 1982. O

Pré-Cambriano das Folhas Itaboraí, Maricá, Saquarema e Baía da Guanabara. In: SBG, Cong. Bras. Geol., 32, Salvador, Anais, 1: 103-114.
Heilbron, M. and Machado, N., 2003. Timing of terrane accretion in the Neoproterozoic-Eopaleozoic Ribeira belt SE Brazil. Precambrian Research, 125 (1-2), 87-112.
Heilbron, M., Pedrosa-Soares, A.C., Campos Neto, M., Silva, L.C., Trouw, R.AJ. and Janasi, V.A., 2004. A Província Mantiqueira. In: Mantesso-Neto, V. et al. (Eds), Geologia do Continente Sul-americano: Evolução da obra de Fernando Flávio Marques de Almeida. Ed. Beca, São Paulo, 647p.
Heilbron, M., Mohriak, W., Valeriano, C.M., Milani, E., Almeida, J.C.H., Tupinambá, M., 2000. From collision to extension: the roots of the southeastern continental margin of Brazil. In: Mohriak, W.U. and Talvani, M. (Eds.), Geology and Geophysics of Continental Margins. American Geophisical Union, Geophisical Monograph, 1-31.
Howell D. G., 1989. Tectonics of suspect terranes: Mountain building and continental growth. In: Chapman and Hall (Eds). London, 232p.
Laux, J.H., Pimentel, M.M., Dantas, E.L., Armstrong, R., Armele, A. and Nilson, A.A., 2004. Mafic magmatism associated the Goiás magmatic arc in the Anicuns region, Goiás, central Brazil: Sm-Nd isotopes and new ID-TIMS and SHRIMP u-Pb data. J. South Am. Earth Sci., 16: 599-614.
Marre, J., 1986. The structural analysis of granitic rocks. Elsevier, Amsterdan. 123p.
Mendes, J.C., Penha, H.M. and Ludka, I.P., 2003. Geological features of the Itacoatiara Granite, southeast Rio de Janeiro State, Brazil. In: SBG, Simp. Nacional de Estudos Tectônicos, IX, Búzios, Boletim de Resumos: 222-224.
Passchier, C.W. and Trouw, R.A.J., 1996. Micro-tectonics. Springer-Verlag, Berlin. 289p.
Penha, H.M., Mendes, J.C., Ludka, I.P., Almeida, F.O., Guimarães, A.M. and Penha, L.L., 2001. Geologia do Granitóide Itacoatiara, RJ: resultados preliminares. In: SBG-RJ, Simpósio de Geologia do Sudeste, 7, Boletim de Resumos: 27.
Rocha, F.P. 2002. Mapeamento geológico da região de Marica, Estado do Rio de Janeiro. Dissertação de Mestrado, Depto. de Geologia, Igeo-UFRJ, 89p.
Schmitt, R. S., Trouw, R. A J, Van Schmus, W.R. and Pimentel, M. M., 2004. Late amalgamation in the central part of West Gondwana: new geochronological data and the characterization of a Cambrian orogeny in the Ribeira Belt - SE Brazil. Precambrian Research, 133 (1-2), 29-61.
Trouw, R., Heilbron, M., Ribeiro, A., Paciullo, F., Valeriano, C., Almeida, J., Tupinambá, M. and Andreis, R., 2000. The Central Segment of the Ribeira Belt. In: Cordani, U., Milani, E., Thomaz Filho, A. and Campos, D. (Eds.) Tectonic Evolution of South America. CPRM, Rio de Janeiro, 856 p.
Tupinambá, M., 1999. Evolução tectônica e magmática da Faixa Ribeira na região serrana do Estado do Rio de Janeiro. PhD Thesis, IG-USP, São Paulo, 222p.

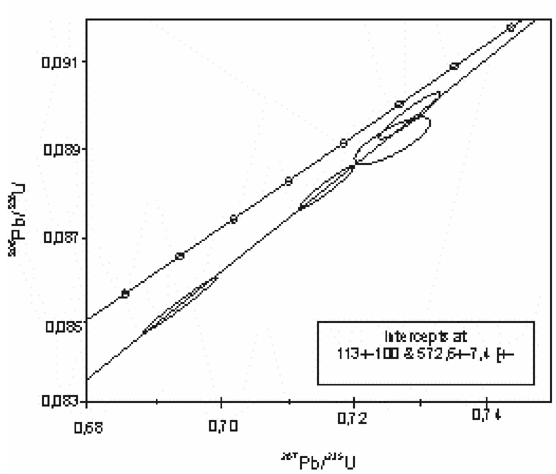

Figure 1- U-Pb Concordia diagram for zircon grains of the Itacoatiara Granite

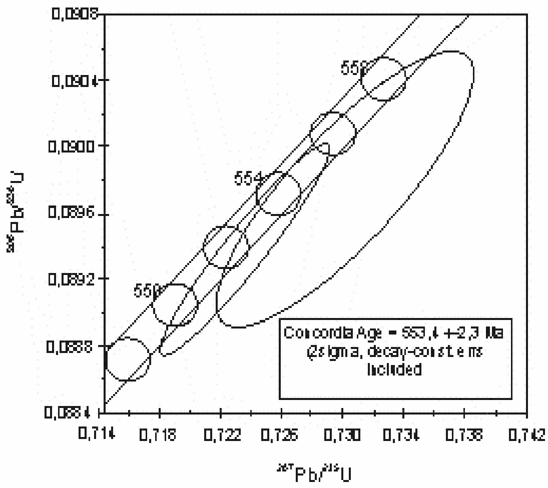

Figure 2- U-Pb Concordia diagram for zircon grains of the Cassorotiba Gneiss

RESUMO

O Granito porfirítico Itacoatiara aflora na porção sudeste do Estado do Rio de Janeiro, como um corpo alongado NE-SW, numa área de cerca de 70 km^2. Localiza-se no Domínio Costeiro do Terreno Oriental, no segmento central da Faixa Ribeira e possui uma características de magmatismo cálcio-alcalino tipo-I metaluminoso. Mostra contato tectônico, por meio de zona de cisalhamento, com o granada-biotita gnaisse porfiroblástico Cassorotiba e no seu limite norte está intercalado e misturado com rocha quartzodiorítica. O monzogranito porfirítico possui megacristais euhedrais a subedrais de microclina em matriz granodiorítica e suas estruturas e texturas ígneas estão obliteradas somente nas zonas de cisalhamento. Observam-se enclaves microgranulares máficos e xenólitos de paragnaisse. Diagrama concórdia obtido por dados isotópicos U-Pb em zircão mostra intercepto superior de 572 +7-9 Ma, provável idade de cristalização, enquanto que alguns zircões caem próximo da concórdia revelando idade Pb-Pb de 550 Ma. Análises por catodoluminescência e imagens de retroespalhamento indicam a presença de cristais metamórficos herdados, grãos com zoneamento magmático e núcleo herdado e cristais ígneos com feições de reabsorção. A idade de cristalização obtida está dentro do intervalo sin-colisional I de 600 a 560 Ma admitida para o segmento central da Faixa Ribeira. Alguns zircões do gnaisse encaixante Cassorotiba fornecem idades concordantes de 553 +-2 Ma. Esta idade próxima de 550 Ma obtida para o granito e para o gnaisse concorda com a idade metamórfica de zircões e monazitas de paragnaisse de unidade geológica vizinha.