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GEOCHEMICAL AND ISOTOPIC CHARACTERISTICS OF THE MORRO DO PÃO GRANITOID, SOUTHERN BRAZIL

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INTRODUCTION

The Ribeira belt (Almeida et al., 1973), on the coast of Brazil, extends for 1400 km from the south of Bahia, in the north, to Paraná state, in the south (Fig. 1). It constitutes a Neoproterozoic to Early Paleozoic orogenic belt developed along the southern and southeastern borders of the São Francisco craton during the Brasiliano-Pan-African collage (700 – 450 Ma). This is the result of the collision between three plates or microplates: São Francisco, Serra do Mar and another inferred block presently underlying the Paleozoic sequences of the Paraná basin (Brito Neves & Cordani, 1991; Campos Neto & Figueiredo, 1995; Heibron et al., 2000).

The studied region is located near São Paulo city, in the homonymous state. It consists of Brasiliano orthogneisses and granitoids intruding several metavolcanosedimentary sequences such as the Piracaia Complex, the São Roque and Serra do Itaberaba groups and the Embu Complex (Hasui et al., 1981; Campos Neto & Basei, 1983; Juliani et al., 1986). These granitoids have sizes varying from batolithic to relatively small (stocks) bodies, showing distinct deformation degrees and geochemical and isotopic signatures from different tectonic environments (Janasi & Ulbrich, 1991).

LOCAL GEOLOGY

In São Paulo state, the Ribeira belt is characterized by the presence of terrains of different lithostructural features, limited by high angle shear zones of predominantly northeastern direction (Fig. 1). From northwest to southeast, the Jundiaí, São Roque and Embú domains can be identified.

At the eastern São Paulo state, the Roque domain (Fig. 2) is constituted by rocks of the homonymous metavolcanosedimentary sequence and the underlying Serra do Itaberaba Group. The former displays greenschist metamorphism while the latter underwent amphibolite facies metamorphism (Juliani et al., 1986). Hackpacher et al. (2000) interpreted the lithological, metamorphic and deformational features of the São Roque Group as characterizing a retro-arc basin developed during the collisional phase of the Brasiliano Orogenesis (628-605 Ma). In the focused region, the basement rocks of metavolcano-sedimentary sequences are unknown. Several brasiliano granitoids are intrusive in these rocks

The Morro do Pão granitoid (MPG), target of the present work, is located near Igaratá city. It is a NW elongated body that crosscuts the metavolcano-sedimentary sequence of the São Roque Group. Campos Neto et al. (1983) characterized this body as a syntectonic one.

The more mafic facies is coarse-grained and characterized by the presence of naked eyes visible clots of hornblende crystals. In this facies, elongated crystals of hornblende and biotite defined a weak foliation. Hornblende crystals enclose plagioclase and quartz. Plagioclase occurs as anhedral grains. Fine grained quartz, biotite and plagioclase are minor components of this facies.

The felsic facies shows plagioclase and microcline as anhedral crystals and biotite as the only mafic mineral.

The main accessory minerals, common to both facies, include abundant titanite as euhedral and anhedral crystals, apatite, allanite, zircon, epidote and opaque phases. The Morro Azul granitoid (MAG) and the Machado granitoid (MG), near the MPG, show mafic enclaves similar to the MPG mafic facies.

RESULTS AND DISCUSSION

LITHOGEOCHEMISTRY

Eight samples from the MPG and two samples from the MAG and MG enclaves were analyzed for major and trace elements, including rare earth elements (REE). The analysis were made in the ACTLABS laboratories (Canada).

The composition of the MPG vary from monzonite to granite (Fig. 3). The silica values from the MPG vary between 50.5% and 65.4%, with a gap of about 56% - 63%. They are metaluminous (A/CNK from 0.65 to 0.95), sub-alkaline rocks of calc-alkaline character (Fig. 4). K_2O values range from 2.2%, in the more mafic terms, to 4.4%, in the more felsic ones, while CaO values decrease from 8.36% to 3.0%, Fe_2O_3 values from 9.5 to 5.0 %, and MgO values from 7.9 to 1.6 %. Two samples display relatively high concentrations of TiO_2 (about 2.2%) and P_2O_5 (about 1.0%).

Based on the major elements and the REE patterns (normalized by chondritic values of Boynton, 1984) three groups of rocks were defined: 1) La_N/Yb_N between 8.5 to 27.6; 2) La_N/Yb_N from 48.7 to 70; and 3) the two samples of high Ti and P, with La_N/Yb_N of 44.2 and 46.6.

Plotted in tectonic discriminant diagram (Fig. 5) the majority of the samples fall into the volcanic arc granites field with a trend to the intra-plate granites field.

The enclaves samples of MG and MAG are geochemically undistinguishable from those of the MPG (Figs. 2, 3, 4).

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AGE OF THE MORRO DO PÃO GRANITOID: RELATIVE GEOCHRONOLOGY

The crystallization age of the MPG is not available. However, the field observations described above allows us to make some inferences. The presence of mafic enclaves in the MAG and the MG of similar aspect and geochemical features as the MPG suggest that the last could be older than the other two granitoid bodies. The MAG have an age of 532 ± 20 Ma. Another closeby granitic body, the Imbiruçu Granite (IG) displays an age of 598 ± 21 Ma (Rb-Sr whole rock isochronic age, Ragatky et al., in press). The latter displays geochemical features of volcanic arc granites while the former shows transitional geochemical characteristics from volcanic arc to within-plate granites (Ragatky et al., in press*)*. Based on these observations, the age of the MPG could be of *ca.* 532 Ma or older. Considering that some facies of the MPG have chemical characteristics of volcanic arc granites, similar to that of the IG, it is possible that both granites are contemporaneous.

ISOTOPIC DATA

Three samples of the MPG and one sample of the mafic enclave from the MAG were analyzed for Sr and Nd isotopes. The analyses were performed at the Geochronological Research Center of São Paulo University (CPGeo – USP). The three samples of the MPG display depleted mantle model Sm-Nd age (T_{DM}) of 1.4 – 1.5 Ga. The values of ε_{Nd} for 598 Ma are -5.4, -7.5 and -8.1. The initial $^{87}Sr/^{86}Sr$ ratios vary from 0.70620 to 0.70836. The enclave of the MAG displays a T_{DM} age of 1.65, a $\varepsilon_{Nd(0.58)}$ value of -9 and a $^{87}Sr/^{86}Sr$ ratio of 0.70860 (Fig. 6).

The T_{DM} values of the MPG are considerably lower than those of most granitoids of this area, which display T_{DM} values between 2.1 and 1.8 Ga (Ragatky, 1998). The T_{DM} values of the MPG suggest that the parental magma was generated by a mixture with a greater proportion of juvenile neoproterozoic materials. Additionally, the T_{DM} values of the MPG are similar to that obtained for the IG (Ragatky et al, in press).

Indeed, the identified facies of the MPG present the same T_{DM} values which it suggests that the magmatic differentiation occurred from a homogeneous parental magma without the participation of crustal contamination processes.

CONCLUSIVE REMARKS

At the studied region no spatial zoning magmatism is observed. However, as pointed out by Barbarin (1997), in some areas the succession of different granitoid types is not spatially controlled, as in the Andes, but is temporal controlled. The present data suggest that the intrusion of the MPG preceds the emplacement of the MAG and the MG. The isotopic characteristics, together with its geochemical signature, are consistent with a greater participation of the mantle source on the generation of the magma rather than only the involvement of basement rock sources of about 1.4-1.5 Ga as described by Juliani et al. (1998).

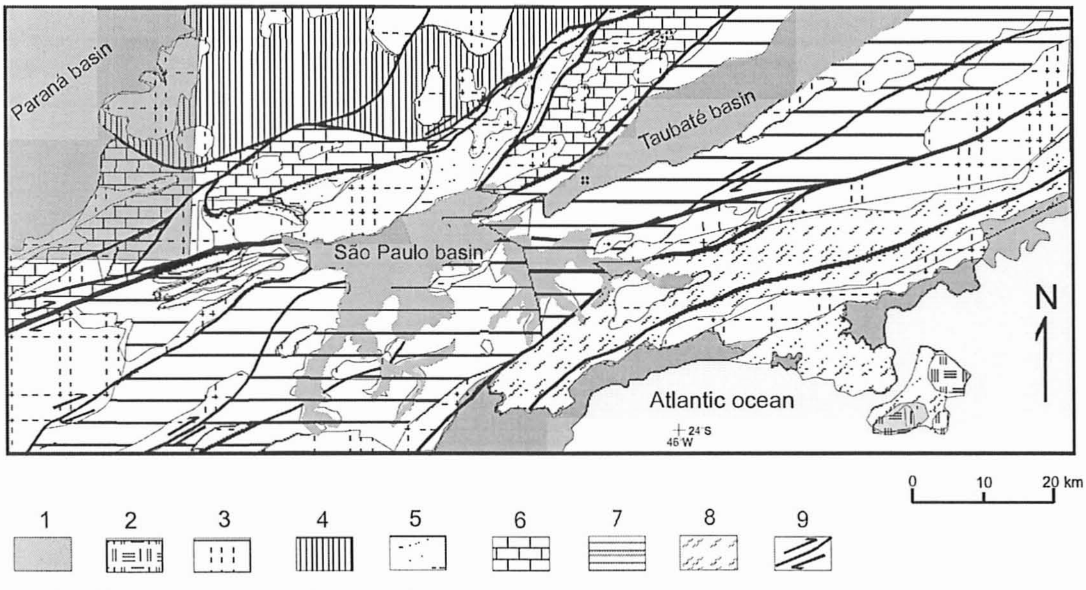

Figure 1. Simplified geological map of the east of São Paulo state (modified after Campos Neto, 2000) Symbols: 1- Phanerozoic cover; 2- Mesozoic alkaline intrusions; 3- Brasiliano granitoids; 4- Piracaia Complex; 5- Serra do Itaberaba Group; 6- São Roque Group; 7- Embú Complex; 8- Costeiro Complex; 9- Shear zones.

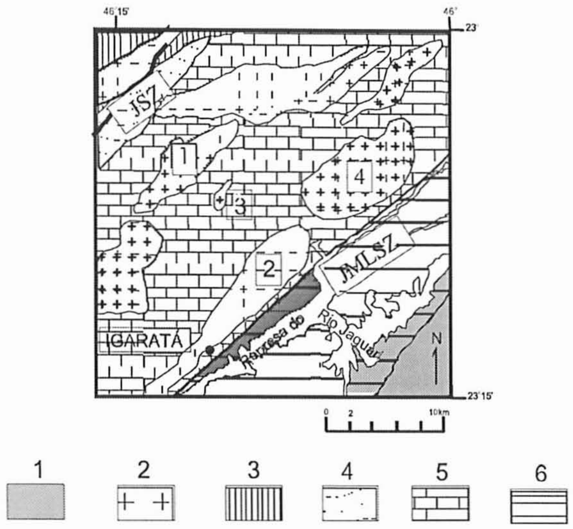

Figure 2: Simplified geologic map of Igaratá region, São Paulo state, with the location of the studied granites (Modified after Campos Neto and Basei, 1983). Symbos: 1- Phanerozoic cover; 2- Brasiliano granitoids; 3- Piracaia complex; 4- Serra do Itaberaba Group; 5- São Roque Group; 6- Embú Complex. JSZ - Jundiuvira shear zone; JMLSZ- Jaguarí-Monteiro Lobatoshear zone
Granitoids: 1- Morro do Pão; 2- Morro Azul; 3- Machado; 4- Imbiruçu.

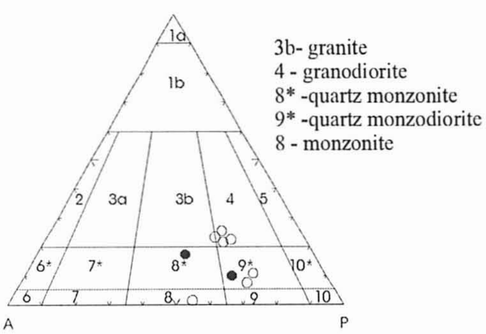

Figure 3. Plots of the samples from the Morro do Pão granitoid (open circles) and the Morro Azul and the Machado granitoids enclaves (filled circles) in the QAP normative diagram (Le Maitre, 1989).

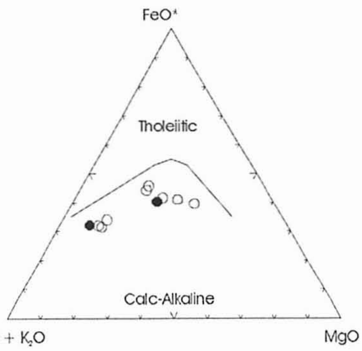

Figure 4. Plots of the Morro do Pão granitoid samples and the Morro Azul and the Machado granitoids enclaves samples in the AFM diagram (Irvine and Baragar, 1971). Symbols as in Figure 3.

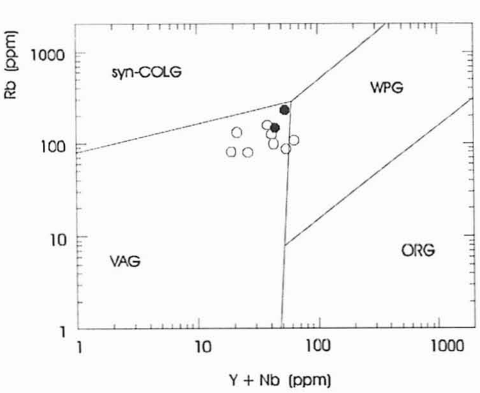

Figure 5. Tectonic discrimination diagram (Pearce *et al*, 1984) of the Morro do Pão granitoid samples and the Morro Azul and the Machado enclaves samples. Symbols as in Figure 3.

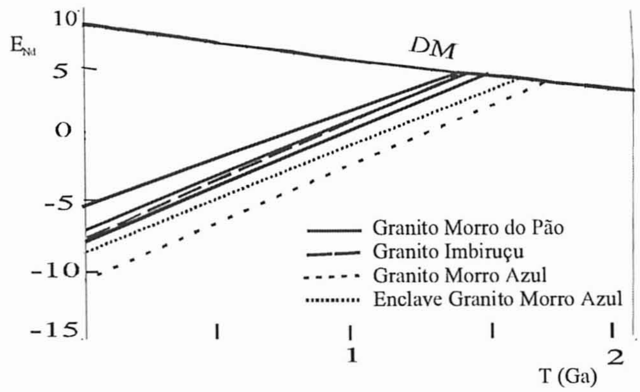

Figure 6: ε_{Nd} *versus* Time for the Morro do Pão granite. The Morro Azul granite, its enclave and the Imbiruçu granite samples were plotted for comparison.

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REFERENCES

Almeida, F.F.M.; Amaral, G.; Cordani, U.G.; Kawashita, K., 1973. Precambrian evolution of the South American cratonic margin south of Amazon River. In: The Ocean Basins and Margins. E.M. Nairn & F.G. Stheli (eds). New York, Plenun., v. 1, cap. 11, p. 411-446.

Barbarin, B., 1997. From the mineralogical compoŝtion of granitoids to their origins and tectonic settings. International Symposium on Granites and Associated mineralizations. Extended abstract. p 95-97.

Bergmann, M., 1988. Caracterização estratigráfica e estrutural da seqüência vulcano-sedimentar do Grupo São Roque na região de Pirapora do Bom Jesus, Estado de São Paulo. Dissertação de Mestrado. Universidade de São Paulo, São Paulo, SP, Brasil. 155 p.

Boynton, W.V., 1984. Cosmochemistry of the rare elements: meteorite studies. In: Developments in geochemistry, 2: Rare Earth Element Geochemistry. Henderson, P. (ed.). Netherlands, Elsevier, p. 63-114.

Brito Neves, B.B. & Cordani, U.G. 1991. Tectonic evolution of South America during the Late Proterozoic Precambrian Research 54: 23-40

Campos Neto, M.C., 2000. Orogenic system from southwestern Gondwana. An approach to Brasiliano-Pan African cycle and orogenic collage in southeastern Brazil. In: Tectonic Evolution of South America. Cordani, U.G.; Milani, E.J.; Thomaz Filho, A.; Campos D.A. (eds). Rio de Janeiro, RJ, Brazil. p. 335-365.

Campos Neto, M.C. & Basei, M.A.S., 1983. Evolução estrutural brasiliana do nordeste de São Paulo: dobramentos superpostos e esboço estratigráfico e tectônico. In: Simpósio Regional de Geologia, 4. São Paulo, 1983. Anais. São Paulo, SBG. p. 61-78.

Campos Neto, M.C., Basei, M.A.S., Artur, A.C., Machado, R., Dias Neto, C.M., Fragoso Cesar, R., Souza, A., 1983. Geologia das folhas Piracaia e Igaratá. In: Jornada sobre a carta geológica do Estado de São Paulo em 1:50.000. 1, São Paulo, 1983, Atas..São Paulo, Secretaria da Indústria, Comércio e Tecnologia, SP, Pró-Minério. IPT. p 61-78.

Campos Neto, M.C. & Figueiredo, M.C.H., 1995. The Rio Doce Orogeny., southeastern Brazil. Journal of South America Earth Science, 8, 143-162.

Haspacker, P.C., Dantas, E.L., Spoladore, A. Fetter, H., Faria de Oliveira, M., 2000. Evidence of Neoproterozoic basin development in the central Ribeira belt, southeastern Brazil: new geochronological and geochemical constraints from the São Roque – Açungui groups. Revista Brasileira de Geociências. 30(1): 110-114.

Hasui, Y., Dantas, A.S.L., Carneiro, C.D.R., Bistrichi, C., 1981. Mapa geológico do Estado de São Paulo. Escala 1:50.000. Almeida, F.F.M., Hasui, Y., Ponçano, W.L., Dantas, A.S.L., Carneiro, C.D.R., Melo, M.S., Bistrichi, C.A (eds). São Paulo. P. 12-45.

Irvine, T.N. & Baragar, W.R., 1971. A guide to the chemical classification of the common volcanic rocks. Canadian Journal of Earth Sciences, 8: 523-548.

Janasi, V.A. & Ulbrich, H.G.J., 1991. Late Proterozoic granitoid magmatism in the state of São Paulo, Brazil. Precambrian Research. 51: 351-374.

Juliani, C., Beljavskis, P., Schorscher, H.D. 1986. Petrogênese do vulcanismo e aspectos metogenéticos associados: Grupo Serra do Itaberaba na região de São Roque. 34 Congresso Brasileiro de Geologia, Goiânia. Anais. V. 2. p. 730-743.

Juliani, C., Martin, M.A.B., McReath, I., Perez-Aguilar, A., Clarimundo, S.J., Chiarini, A.P., Fernandes, F., 1998. A evolução dos grupos Serra do Itaberaba e São Roque a nordeste e noroeste da cidade de São Paulo (SP). 40 Congresso Brasileiro de Geologia, Belo Horizonte. Anais. p. 87.

Le Maitre, R.W. 1989. A classification of igneous rocks and glossary of terms. Blackwell, Oxford. 193 p.

Pearce, J.A, Harris, N.B.W., Tindle, A.G., 1984. Trace elements discrimination diagrams for the tectonic interpretation of granitic rocks. Journal of Petrology. 25:956-983.

Ragatky, D., 1998. Contribuição à geoquímica e geocronologia do Domínio São Roque e da Nappe Socorro-Guaxupé na região de Igaratá e Piracaia, Sp. Tese de doutoramento. Universidade de São Paulo, SP, Brasil. 130 p.

Ragatky, D., Duarte, B.P., Tassinari, C., Caracterização geoquímica e isotópica de granitóides do domínio São Roque, Faixa Ribeira, São Paulo. Revista da Universidade Federal Rural do Rio de Janeiro. Série Ciências Exatas e da Terra. In press.