Rb-Sr AND Sm-Nd ISOTOPE GEOCHEMISTRY OF GRANITOIDS FROM ESPERANÇA GRANITIC COMPLEX, PARAÍBA STATE, BORBOREMA PROVINCE, NORTHEAST BRAZIL

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INTRODUCTION

The Neoproterozoic evolution of Borborema Province, Northeast Brazil, was characterized by an intense granitic magmatism, associated with a network of continental-scale transcurrent ductile shear zone (Vauchez et al., 1995). Van Schmus et al. (1995, 1997) using U-Pb and Sm-Nd data, subdivided the Borborema Province in three tectonic domains: Northern, Central and Southern, which have shown contrasting isotopic characteristics The Central Tectonic Domain (CTD), region located betwen the continental shear zones Patos and Pernambuco, had affected by at least three thermotectonic events: Paleoproterozoic event (Transamazonian Orogeny, 2.2 to 1.8 G. a), Mesoproterozoic event (Cariris Velhos Orogeny, 1.0 to 0.9 G.a.) and Neoproterozoic event (Brasiliano Orogeny, 0.85 to 0.58 G. a), this last event was responsible for the intense magmatism which characterized Borborema Province.

Santos (1996, 1999) subdivided the Borborema Province in tectono-stratigraphic terrains, with distinctive stratigraphic, structural and petrologic features. The Central Tectonic Domain (CTD) was separated in five parts: West Gneissic Terrain (WGT), Piancó-Alto Brígida Terrain (PABT), Alto Pajeú Terrain (APT), Alto Moxotó Terrain (AMT), Rio Capibaribe Terrain (RCT). In the Alto Pajeú Terrain (APT), the magmatism was related at least to two orogenies (Cariris Velhos and Brasiliano events). The first event is characterized by low-angle structures, associated with low angle kinematics, wherever the last event is characterized for shearing structures, associated to an transcurrent kinematics.

Almeida et al. (1967) recognized four types of granitoids: Conceição type (granodiorites and tonalites, medium to fine grained), Itaporanga type (granodiorites with large phenocrystals of K-feldspar), Itapetim type (biotite fine grained granites, associated to Itaporanga type) and Catingueira type (peralkaline granites, syenites and quartz-syenites. Sial (1986) identified four granitoids types in the Piancó-Alto Brígida Terrain: calcalkalic (Conceição type), potassic-calcalkalic (Itaporanga type), peralkalic (Catingueira type) and trondhjemitic affinities (Serrita type).

Taking in consideration the crystallization age and geochemical characteristics, using U-Pb zircon and Sm-Nd data, Guimarães et al. (1999) divided the CTD granitoids into five groups: calc-alkaline granitoids (including the Conceição type and some Itaporanga type granitoids), which are examples the Tabira, Itapetim and Timbaúba Complexes; high-K metaluminous calc-alkaline granitoids (Itaporanga type granitoids), including the Fazenda Nova, Campina Grande and Esperança Complexes; syenites, quartz-syenites and syenogranites of shoshonitic affinities, including Bom Jardim, Toritama and Pajeú Complexes; monzogranites, syenogranites and syenites, including the Solidão, the east part of Teixeira, Queimadas, Triunfo and Serra Branca Complexes; and biotite syenogranites coarse to medium grained, equigranular to slightly porphiritic (Prata Complex, Pereiro, Serra do Velho Zuza, Serra da Engabelada and Serrote Santo Antônio plutons).

GEOLOGIC SETTING, GEOCHEMICAL AND MINERAL CHEMISTRY CHARACTERIZATION

The Esperança Complex comprises late tectonic Neoproterozoic intrusions, occupying an area of 580 km^2 intruded in ortogneisses of Mesoproterozoic ages of the Alto Pajeú Terrain (APT), Central Tectonic Domain (CTD) of Borborema Province. The emplacement of the Esperança Complex was controlled by transcurrent-extensional shear zones: Remígio-Pocinhos (Patos Lineament segment) in north and São Sebastião de Lagoa de Roça in the south.

Petrographic data suggest that the Esperança Complex comprises at least three intrusions, denominated north, south and west intrusions (Fig. 1).

The north intrusion comprises porphyritic to equigranulate fine grained biotite amphibole syeno and monzogranites; the south intrusion comprises coarse grained, porphyritic biotite amphibole syeno and monzogranites. The west intrusion comprises coarse-grained biotite amphibole monzogranites to quartz-monzonites. Biotite clots and syn-plutonic dykes of granodioritic to tonalitic composition occur in all intrusions. Dykes of pegmatites and late leucocratic alkali-feldspar granite are frequently recorded cutting the north intrusion.

Several textural features, mafic clots, sin-plutonic dykes of granodioritic to tonalitic composition, and rapakivi and anti-rapakivi texture, suggest coeval relationships between distinct granitic magmas, possibly implying processes of magma mixing and commingling.

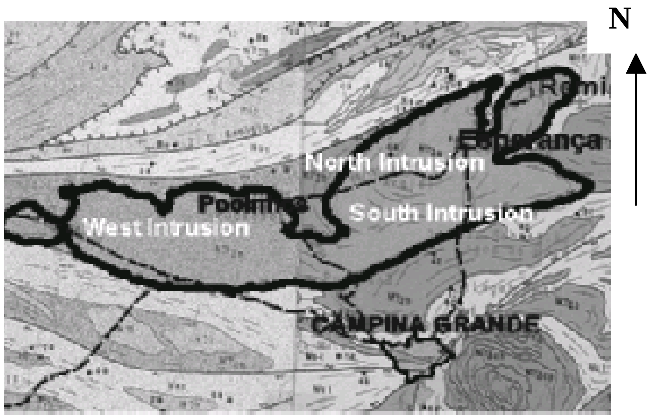

Figure 1. Geological sketching of Esperança Granitic Complex, PB. Modified from: Geological Map of Paraíba State, 2001, CPRM. Escale: 1/250.000.

The granitoids of the Esperança Complex are metaluminous to slightly peraluminous, and high-K calc-alkaline.

REE patterns normalized to chondrite values, display two distinct patterns: the pattern of the North Intrusion have $(Ce/Yb)_N$ ratios ranging from 16.6 to 24.4 and lack of the significant Eu anomalies. The granitoids of the south intrusion have REE pattern less fractionated, with $(Ce/Yb)_N$ ratios ranging from 8.4 to 16.6 and strong Eu negative anomalies, similar to those patterns recorded in A-type granites. Spiderdiagrams normalized to the primitive mantle are characterized by troughs at Nb, Sr and Ti.

Compositions of feldspars, biotites and amphiboles from the Esperança Complex granitoids also divided the complex in three distinct intrusions: the plagioclase of the north intrusion are slightly Ca-richer (oligoclase-andesine) compared to the plagioclase of the South and East intrusion (oligoclase composition). Biotites from the Esperança Complex divided their granitoids into three distinct groups: biotites from south intrusion show Fe# [100Fe/ (Fe+Mg)] values ranging from 64 to 66, FeO/MgO ratios ranging from 3.14 to 3.39 and Al^{IV} values ranging from 2.3 to 2.4; biotites from the north intrusion have Fe# ranging 36 to 53, FeO/MgO ratios ranging 1.6 to 2.0 and Al^{IV} values ranging 2.2 to 2.3. Biotites from the west intrusion are Fe-enriched, shown Fe# values ranging 68 to 73, FeO/MgO ratios ranging 3.8 to 4.7 and AlIV values ranging 2.46 to 2.53. In the discriminant diagrams to magmatic suites for biotite mineral chemistry (Abdel-Rahman, 1994), the biotites from granitoids of the north and south intrusions plotted within the calc-alkaline field, while the biotites from the west intrusion plotted within the peraluminous field.

Amphiboles from the all intrusions of Esperança Granitic Complex are calcic (Leake, 1997), with compositions ranging from Fe-edenite to Fe-pargasite. Fe# values of the amphiboles analyzed from the granitoids of the Esperança Complex define three distinct fields: 59 to 61 (north intrusion); 67 to 75 (south intrusion) and 70 to 72 (west intrusion), reflecting crystallization under different fO_2 conditions.

U-Pb ZIRCON GEOCHRONOLOGICAL DATA

U-Pb zircon data were obtained from three multicrystal magnetic fractions from the porphyritic granites from the south intrusion (ESP-01), at the Isotope Geochemistry Laboratory, University of Kansas. The analyzed zircon population comprises euhedral internally clear pink zircon grains without any inclusions. The zircon grains were abraded for 2h and then washed with HNO_3. The upper Concordia intercept defines an age of 581 ± 7 Ma (MSWD = 1.2) when forced to zero (Fig. 2).

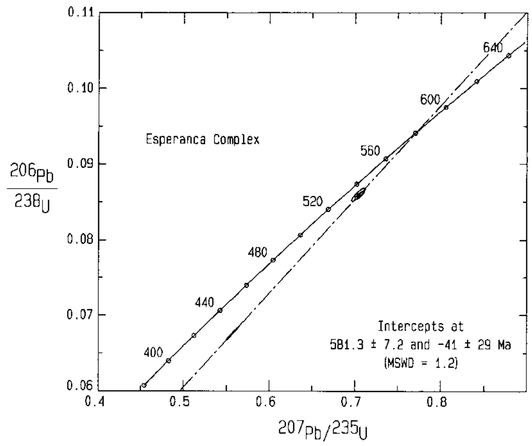

Figure 2. Concordia diagram for granitoids of Esperança Granitic Complex, PB.

Rb-Sr AND Sm-Nd ISOTOPIC DATA

Rb-Sr and Sm-Nd isotopic data of granitoids from the north and south intrusions of the Esperança Complex, were obtained at the Isotope Geochemistry Laboratory, University of Kansas. No isotopic data are available for the west intrusion. The results are showed in Tables 1 and 2.

The granitoids of the Esperança Complex show $\varepsilon_{Sr\,(580Ma)}$ ranging from 8.2 to 62.3 and exhibited initial rates Sr^{87}/Sr^{86} always less to 0.708, suggesting represent I-type granites (Chappell & White, 1974).

Sm-Nd data show distinct isotopic signatures, to the north and south intrusions granitoids. Both intrusions exhibited ε_{Nd} initials values strongly negative, suggesting crustal contribution in the source.

The granitoids of the north intrusion have $\varepsilon_{Nd(0)}$ values ranging –16.53 to –15.08, and T_{DM} model ages ranging from 1.82 to 2.1 Ga, suggesting a Paleoproterozoic source. The South Intrusion granitoids show $\varepsilon_{Nd\,(t)}$ values ranging from –7.19 to –6.02 and T_{DM} model ages ranging from 1.50 to 1.57 Ga, suggesting mixture of Paleoproterozoic crust with juvenile Mesoproterozoic (Cariris Velhos) or Neoproterozoic material (Brasiliano).

The Esperança Complex granitoids of the northintrusion, plotted in the ε_{Sr} initial vs ε_{Nd} initial diagram (Harmon et al., 1984), show isotopic composition similar to those recorded in the lower crust (Fig. 3). The sample analysed from the south intrusion plotted within the I-type granitoid field.

Table 1. Isotopic analysis obtained for Rb-Sr Method for the granitoids of Esperança Granitic Complex (PB State) (N) = North Intrusion; (S) = South Intrusion.

Samples	Rb (ppm)	Sr (ppm)	Rb^{87}/Sr^{86}	Sr^{87}/Sr^{86}hoje	Sr^{87}/Sr^{86}i (580Ma)	ε_{Sr} i (580Ma)
ESP-03A (N)	148.0	1194.0	0.35698	0.70896	0.705997	30.888
ESP-08A (N)	125.0	989.0	0.36400	0.70938	0.706359	36.031
ESP-08B (N)	230.0	1010.0	0.65584	0.70869	0.703247	8.184
ESP-12 (N)	85.0	838.0	0.29212	0.71063	0.708206	62.274
PX-01 (S)	164.2	283.4	1. 66865	0.72092	0.707070	46.134

Table 2. Isotopic analysis obtained for Sm-Nd Method for the granitoids of Esperança Granitic Complex (PB State). (N) = North Intrusion; (S) = South Intrusion.

Samples	Sm (ppm)	Nd (ppm)	Sm^{147}/Nd^{144}	Nd^{143}/Nd^{144} today	Nd^{143}/Nd^{144}i	$\varepsilon_{Nd(0)}$	$\varepsilon_{Nd(t)}$ (±580 Ma)	T_{DM} (Ma)
ESP-03A (N)	5.9632	45.5536	0.07914	0.511401	0.511100	-24.13	-15.45	1822.4
ESP-08A (N)	4.3378	31.3306	0.08371	0.511437	0.511119	-23.42	-15.08	1843.0
ESP-12 (N)	4.6832	27.2022	0.10409	0.511440	0.511045	-23.37	-16.53	2155.4
ESP-01 (S)	6.9140	39.0374	0.10708	0.511930	0.511523	-13.82	-7.19	1568.2
PX-01 (S)	8.1498	45.2183	0.10897	0.511997	0.511583	-12.50	-6.02	1503.5

CONCLUSIONS

Isotopic and geocronological data suggest that the Esperança Complex constitutes a post-collision multiple source intrusion, constituted by at least two distinct sources: 1) Paleoproterozoic lower crust (north intrusion) and 2) a mixture between Paleoproterozoic lower crust and juvenile Mesoproterozoic material (Cariris Velhos) or Neoproterozoic material (Brasiliano) (south intrusion).

Mineral chemistry of the essential minerals and whole-rock geochemistry allowed identifying three distinct intrusions: south, north and west intrusions.

In all of the three intrusions mixing processes between granite and granodiorite to quartz diorite magmas were recorded. The Fe# values of the mafic mineral phases point out that the west, north and south intrusions were crystallized under distinct degree of oxidation. The degree of oxidation in a magma is a function of dissolved water content, and the amount of water in granitic magma may depend on the tectonic setting. Because all three intrusions have approximately the same crystallization age, the differences in redox state recorded in the Esperança Complex granitoids may reflect distinct source rocks.

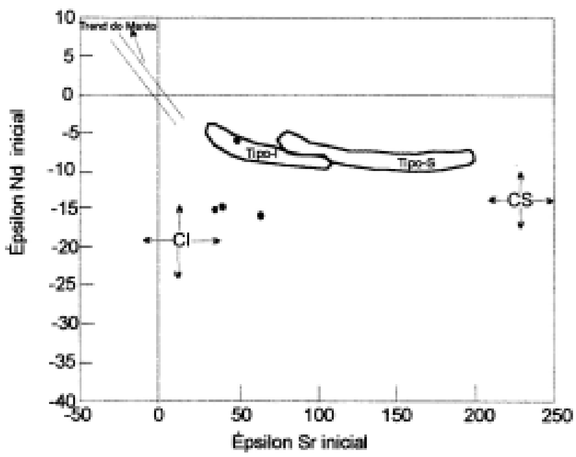

Figure 3. Discriminant diagram for I-type and S-type granites, using initial ε_{Sr} vs initial ε_{Nd} values, to Esperança Granitic Complex granitoids. CI = Lower Crust, CS: Upper Crust. (Harmon et al., 1984)

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