GEOCHRONOLOGY OF THE SÃO LUIS CRATON AND THE GURUPI BELT, BRAZIL

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INTRODUCTION

Since the early Rb-Sr and K-Ar geochronological studies of Hurley et al. (1967), Almeida et al. (1968) and Cordani et al. (1968) the regions of NE-Pará and NW-Maranhão states, in northern Brazil, has been divided in two geotectonic units: the São Luis Craton and the Gurupi Belt. The former has been considered a small Paleoproterozoic fragment of the West African Craton and the latter a surrounding Pan-African/Brasiliano belt. Recent systematic single zircon Pb-evaporation dating (Pb-Pb zircon) and Sm-Nd isotope investigation, mainly in the granitic rock, and some additional Rb-Sr geochronology, suggest a more complex geologic evolution where the Gurupi Belt may be a paleoproterozoic unit reworked in the Brasiliano (Klein & Moura, 2001; Palheta, 2001; Klein & Moura, in press). These geochronological data are reviewed in this paper and their implications for the lithostratigraphic framework and geologic evolution are discussed.

REGIONAL GEOLOGY

The main lithostratigraphic units recognized in the São Luís Craton and Gurupi Belt are shown in the figure 1. The Tentugal Shear Zone would mark the limit between the cratonic and mobile regions. In the São Luís Craton occur metavolcano-sedimentary rocks of the Aurizona Group, calc-alkaline granitic rocks with TTG affinity grouped in the Tromai Intrusive Suite, and S-type granites of the Tracuateua Intrusive Suite (Lowell, 1985; Pastana, 1995). The metavolcano-sedimentary rocks of the Gurupi Group compose the main lithostratigraphic unit of the Gurupi belt. Orthogneisses of TTG affinity and associated paragneisses and migmatites are grouped in the Maracaçumé Complex. Mylonitic leucogranite (with minor andaluzite) named Maria Suprema Granite is associated with this complex. The Itamoari Tonalite is a strongly deformed rock nearby the Tentugal Shear Zone. The Cantão Granite is a biotite monzogranite intrusive in the rocks of the Gurupi Group rocks. A number of two mica granites occur along the Gurupi belt. Some are of Paleoproterozoic age (Ourém, Jonasa and Japiim) and one is Neoproterozoic (Ney Peixoto Granite). A nepheline syenite is also associated with the Gurupi Belt (Boca Nova Syenitic Gneiss). Precambrian and/or Eopaleozoic molassic cover (Vizeu, Igarapé de Areia and Piriá formations) complete the rock units associated with the evolution of the São Luís Craton and Gurupi Belt.

GEOCHRONOLOGY AND ISOTOPE GEOLOGY

ANALYTICAL TECHNIQUES

Pb-Pb zircon analysis were performed in the Pará-Iso (CG-UFPA) using a Finnigan MAT 262 mass spectrometer, following procedure described in Costi et al. (2000). Sm-Nd analyses were also performed in the same instrument following the analytical procedure described in Palheta (2001). Model ages were calculated based on DePaolo (1988) and the Pb-Pb zircon ages were used to compute the values of $\varepsilon Nd_{(t)}$. Rb-Sr analyses were performed in the single collector VG-54E mass spectrometer of the Pará-Iso.

Pb-Pb ZIRCON AGES

In the domain of the São Luís Craton there are three units of distinct ages. The AzGp whose metapyroclastic rock gave zircon ages of 2240 ± 5 Ma; the TmISt whose magmatism took place between 2150 and 2165 Ma; and, finally, the S-Type granites of the TcISt emplaced around 2080-2090 Ma (Table 1).

Table 1. Pb-Pb zircon ages. Uncertainties are given in 2 σ. Abbreviations of the geologic units are in figure 1. Zr#: number of zircons used in the age calculation. 1- Klein & Moura (2001), 2- Klein & Moura (in press), 3- Palheta (2001).

Units	Rock type	Zr#	Age (Ma)	Ref.
AzGp	metapyroclatic	5	2240 ± 5	1
TmISt	trondhjemite	5	2165 ± 2	1
TmISt	monzogranite	5	2163 ± 3	1
TmISt	tonalite	4	2149 ± 5	1
TmISt	monzogranite	1	2152 ± 3	2
TmISt	syenogranite	4	2149 ± 4	2
TcISt	monzogranite	4	2080 ± 2	3
TcISt	foliat. monzogranite	6	2091± 5	3
ItTn	foliated tonalite	5	2148 ± 4	1
GuGp	felsic metavolcanic	4	2148 ± 1	1
GuGp	metadacite	5	2160 ± 3	1
MaCx	tonalitic gneiss	1	2135 ± 4	2
MaCx	leucogranite	1	2128 ± 16	2
CnGr	monzogranite	1	2163 ± 4	3
JoGr	foliat. granodiorito	2	2073 ± 4	3
JaGr	granodiorite	4	2084 ± 5	3
NPGr	monzogranite	7	549 ± 4	3

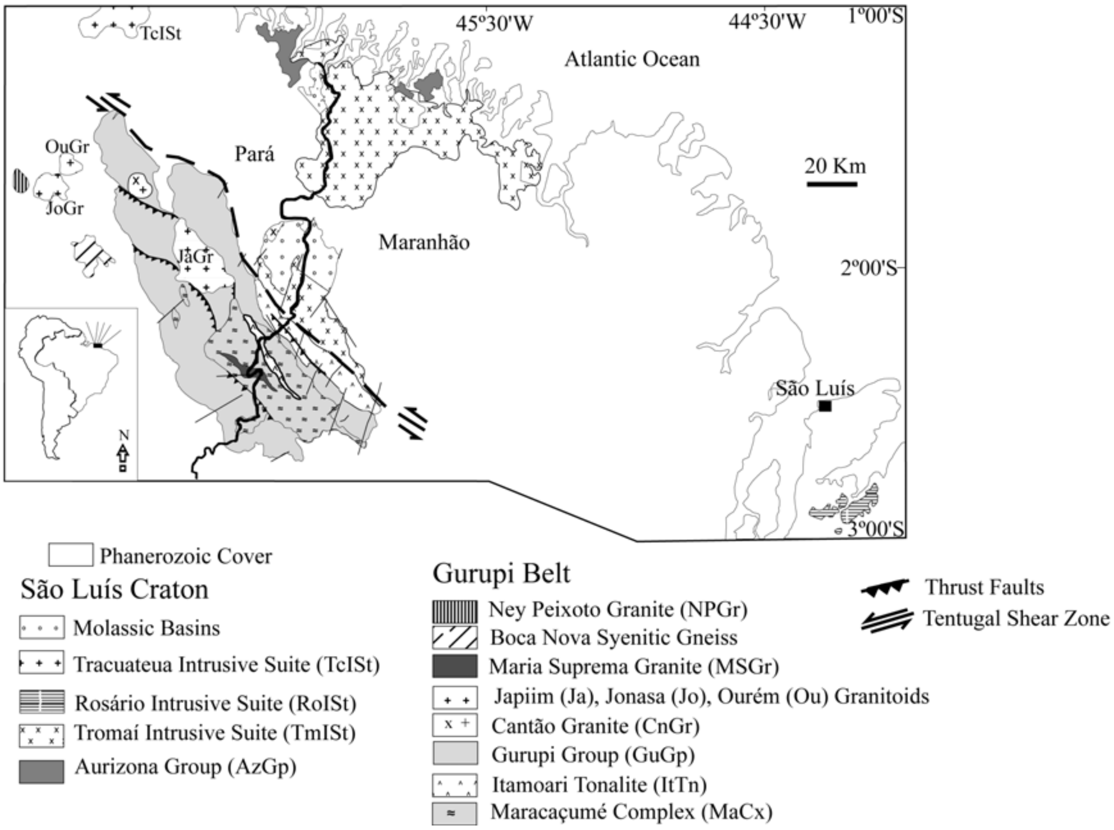

Figure 1. Simplified geologic map of the São Luís Craton and Gurupi Belt based on Hasui et al. (1984), Rodrigues et al. (1994) Pastana (1995) and Klein and Moura (2001).

In the domain of the Gurupi Belt three groups of ages have been recognized. The oldest one includes the ItTn, GuGp, CnGr and the MaCx.The deformed tonalite (ItTn). gave an age around 2150 Ma, and it may be coeval with the TTG rocks of the TmISt. The metavolcanic rocks of the GuGp yielded zircon ages of 2148 ± 1 Ma and 2160 ± 3 Ma, strongly suggesting that this volcanism and the TTG plutonic event may be contemporary. A small granitic pluton intrusive in the GuGp is also part of this older magmatic event (CnGr = 2163 ± 4 Ma). The gneissic rocks of the MaCx (2135 ± 4 Ma) and an associated leucogranitic mobilizate (2128 ± 16 Ma), whose zircons probable yielded minimum ages complete this first group of units. The ages of the two-mica granites JaGr (2084 ± 5 Ma) and JoGr (2073 ± 4 Ma) are similar to those of the S-type granites of the TcISt in the São Luís Craton. The zircon ages of the OuGr, although not well defined, are situated around 2.0 Ga suggesting that it may be part of this magmatic event. Finally, the NPGr with an age of 549 ± 4 Ma is the only Brasiliano age granitic pluton identified, so far, in this belt.

Inherited zircon crystals were found in the MaCx (2607 ± 11, 2509 ± 5 Ma and 2580 ± 4 Ma); JoGr (2325 ± 10 Ma, 2374 ± 6 Ma, 2387 ± 5, 2446 ± 7 Ma); JaGr (2351 ± 12 Ma) and OuGr (2459 ± 16 Ma). Detrital zircon grains of the Vizeu Formation gave ages between 2.0 and 2.1 Ga, while the zircon ages of the Igarapé de Areia Formation grouped in two populations. The older grains gave minimum ages around 2.0 Ga. The younger ones, the most abundant, provide ages mainly between 600 and 650 Ma permitting to constraint the maximum age for the deposition of the Igarapé de Areia Formation.

Sm-Nd ISOTOPE DATA

T_{DM} ages of the TcISt suggest a Paleoproterozoic crustal formation age for this region. However, the slightly positive or negative $\varepsilon Nd_{(t)}$ values of these granitic rocks may indicate some contribution of older crust. The Sm-Nd isotope data for the Paleoproterozoic granites in the Gurupi Belt also permit similar interpretation (Table 2). The contribution of older crust is confirmed by the presence of inherited zircon crystals in these granites, but its age is undefined. It may be an older Paleoproterozoic crust (≈ 2.4 Ga based on the inherited zircon ages) or even Archean.

The Neoproterozoic NPGr, have high negative $\varepsilon Nd_{(t)}$ values indicating a previous crustal history for its protolith (Table 1). The surrounding Paleoproterozoic crust is the natural candidate for source of this pluton, however, Sm-Nd fractionation, or some contribution of juvenile Neoproterozoic (?) sources, has to be argued to account for the younger T_{DM} ages (1.7-1.6 Ga).

Rb-Sr ISOTOPE DATA.

Rb-Sr whole rock isochron for the CnGr gave age of 2051 ± 165 Ma (MSWD = 0.69), with $^{87}Sr/^{86}Sr$ initial ratio of 0.70213 (191), confirming the Paleoproterozoic age of this rock. Rb-Sr internal isochron (rock + feldspar + muscovite) calculated for the JoGr yielded age of 523 ± 21 Ma (MSWD = 9.16) indicating the effect of Brasiliano age thermo-tectonic events in this rock unit. Similar approach was used for the MSGr (Fig. 1), a leucogranite formed by partial melt of the rocks of the MaCx during the formation of the Gurupi Belt (Pastana 1995). Rb-Sr age (rock + feldspar + muscovite) of 1710 ± 32 Ma (MSWD = 0.02) was obtained, suggesting that the Brasiliano event did not play an important role in the generation of this rock unit.

Table 2. Sm-Nd model ages $\varepsilon Nd_{(t)}$ for granitic rocks of the São Luís Craton and Gurupi Belt ater Palheta (2001).

Unit	Rock type	T_{DM} (Ga)	$\varepsilon Nd_{(t)}$
TcISt	Monzogranite	2.46	0.19
TcISt	Monzogranite	2.50	-1.33
TcISt	foliat. Monzogranite	2.32	0.97
TcISt	foliat. Monzogranite	2.31	1.15
JoGr	foliat. Granodiorite	2.40	-1.15
JoGr	foliat. Granodiorite	2.09	3.17
JaGr	Granodiorite	2.22	1.89
CnGr	Monzogranite	2.48	-0.93
CnGr	Monzogranite	2.21	2.68
NPGr	Monzogranite	1.78	-8.50
NPGr	Monzogranite	1.60	-7.83

DISCUSSIONS AND CONCLUSIONS

LITOSTRATIGRAPHIC IMPLICATIONS

The isotope data presented here contributes to understand the litostratigraphic framework of the São Luís Craton and Gurupi Belt and to constraint the ages of the studied geologic units. Although there are some inherited Neoarchean zircon crystals in the rocks of the MaCx, the Paleoproterozoic age of this complex is stressed by the zircon ages. Thus, the suggested Archean age for this unit is not confirmed. The granitic rocks of the TmISt (São Luís Craton) and of the ItTn, CnGr (Gurupi Belt), as well as the volcanic rocks of the GuGp seem to be coeval since their ages are in the same range (2150-2160 Ma). Thus, the relationship among these different magmatic events must be investigated. The ItTn, for instance, may represent a deformed portion of the TmISt. A widespread peraluminous granitic magmatism took place in this region around 2080 Ma generating a number of intrusive plutons, presently exposed in both cratonic and belt domains (TcISt, JaGr, JoGr and OuGr). As a result of the Brasiliano deformation, that reworked the rocks of the Gurupi belt, a small granitc pluton (NPGr) intruded the paleoproterozoic rocks. The detrital zircon ages of the Igarapé de Areia Formation, mainly between 600 and 650 Ma, constraint to the Neoproterozoic (Vendian) the maximum age for the deposition of the molassic cover occurring nearby the Gurupi Belt. The Vizeu Formation, which occurs near the AzGr (Fig. 1), may be contemporary cratonic cover, however, an older age cannot be ruled out since the detrital zircon ages of their rocks concentrated in the Paleoproterozoic.

GEOLOGIC EVOLUTION

The rock of the São Luís Craton and Gurupi Belt seem to share a common Paleoproterozoic evolution. By analogy with the Paleoproterozoic domains of the West African Craton this crustal segment is a result of amalgamation of oceanic plateau and island arc (and the associated back-arc basins) to the pre-existent Archean crust (Libéria, South Pará and Amapá for example). This evolution may have begun around 2.3 Ga, as suggested by some inherited zircon crystals. The older age of the metapyroclastic rocks of the AzGp (2.24 Ga) also suggests an older history, but the main period of rock formation is around 2.16 Ga. This Paleoproterozoic collage resulted in metamorphism and deformation of the metavolcano-sedimentary sequences (GuGp for example), in addition to the partial melt forming peraluminous granitic magmas, that intruded these sequences around 2.08 Ga. Subsequent stabilization was achieved until the assemblage of Gondwana has started. However, an incipient intracratonic fragmentation may have occured prior to this event to account for the presence of the nepheline syenite of Boca Nova (Fig.1) with a minimum Rb-Sr age of 720 Ma (Villas, 1982). The amalgamation of Gondwana resulted in the formation of a number of Pan-African/Brasiliano belts, sometimes involving both the accretion of new crust and reworked crustal segment. The exhumed portion of the Gurupi Belt is a Paleoproterozoic crust reworked during the Brasiliano by transcurrent shear zones (Tentugal Shear Zone) that accommodate mass displacement during Gondwana assemblage. The rock deformation and metamorphism associated with this shear zone reset, in some places, the Rb-Sr and K-Ar mineral system and led to localized partial melt forming granitic magmas (NPGr). Since the Gurupi Belt is covered by phanerozoic sediments to the south, it is not known if it is associated with younger rocks. However, the presence of detrital zircon grains of Brasiliano age in the molassic cratonic cover (Igarapé de Areia Formation) nearby the Gurupi Belt, requires the presence of younger (Brasiliano age) rocks in the neighborhood of the belt.

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