ISOTOPIC AND CHEMICAL EVIDENCE FOR THREE ACCRETIONARY MAGMATIC ARCS (1.79-1.42 GA) IN THE SW AMAZON CRATON, MATO GROSSO STATE, BRAZIL

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ABSTRACT Twenty-one U/Pb ages of granitoids in the SW Amazon craton define three crustal accretionary events during the Paleo- and Mesoproterozoic that represent significant portions of the Rio Negro-Juruena Province and the Rondonian/San Ignácio Province. Two events refer to the Rio Negro-Juruena Province: The Alto Jauru greenstone belt comprises acid volcanics and tonalite to granite gneisses with U/Pb ages from 1790 to 1750 Ma. Sm/Nd isotopic data ($e_{Nd(t)}$ from +2.6 to +2.2 and T_{DM} from 2.00 to 1.80 Ga) indicate a volcanic arc with juvenile signatures for these units. The second event (Cachoeirinha arc) comprises granites to tonalites with U/Pb ages from 1580 to 1530 Ma. Sm/Nd results ($e_{Nd(t)}$ from +3,7 to -1,3 and T_{DM} from 2.05 to 1.74 Ga) suggest a continental margin magmatic arc setting, with significant involvement of the Alto Jauru crust in the genesis of the respective magmas. The Santa Helena suite, which refers to Rondonian/San Ignácio Province, comprises granite to tonalite rocks, with calc-alkaline trends with U/Pb ages varying from 1460 to 1420 Ma and T_{DM} from 1.70 Ma to 1.50 Ma ($e_{Nd(t)}$ from +4.1 to +2.6). They were generated in a magmatic arc adjacent to the older (1790 to 1530 Ma) continental margin that partially participated in the Santa Helena magma genesis.

Keywords: Amazon craton, Mato Grosso state, magmatic arc, meproterozoic, geochronology.

INTRODUTION The southwestern part of the Amazonian Craton results from the evolution of orogenies between 2.0 and 1.0 Ga. Such a collage included successive magmatism, metamorphism and deformation, which regionally affected and reworked the precursor terranes (Cordani *et al.* 1979, Teixeira and Tassinari 1984, Teixeira *et al.* 1989, Tassinari and Macambira 1999). Four tectonic units are described: The Ventuari/Tapajós Province (2.0 to 1.80 Ga) (VTP); the Rio Negro/Juruena Province (1.75-1.55 Ga) (RJP), the Rondonian/San Ignácio Province (1.55-1.30 Ga) (RSIP), and the Sunsás/Aguapeí Province (1.30-1.00 Ga) (SAP).

In SW Mato Grosso State the Proterozoic basement consists of igneous and metamorphic associations correlated to the RNJP and to the RSIP. The country rocks include several domains of different rock types (gneisses, granulites and migmatites) and volcano-sedimentary assemblages.

This paper deals with Proterozoic evolution based on new geochronological U/Pb, Sm/Nd and chemical studies. We carried out these analyses on important granitic units ascribed to the RNJP and RSIP. The results suggest distinct accretionary events of this important sector of the Amazonian craton.

PROTEROZOIC UNITS OF SW AMAZON CRATON The RNJP is located in the west margin of the VTP and its exposures straddle along a NW-SE trend approximately 2000 km long and 600 km wide in the southwestern portion of the Amazonian Craton (Fig. 1). According to Tassinari *et al.* (1996) juvenile Paleo and Mesoproterozoic crust accreted to the western margin of the VTP, during at least two orogenic events (1.8-1.7 Ga and 1.65-1.55 Ga) is exposed in RNJP. The basement rocks of this region are composed almost entirely of granite-gneisses and granitoids, mainly of granodioritic and tonalitic compositions metamorphosed in the amphibolite facies, although granulites are also present. In Mato Grosso State they are represented by the Alto Jauru greenstone belt and Cachoeirinha suite.

Supracrustal sequences are scattered within the RNJP. They are represented by the Roosevelt metavolcano-sedimentary unit and Jamari terrane (1.74 Ga) in Rondonia State, which comprises dacites, rhyolites, andesites, tuffs, volcanic breccias, claystones, sandstones and banded iron formations, metamorphosed in greenschist facies.

The RSIP agglutinated during 1.45-1.25 Ga time interval which orogenesis reworked southwestern margin of the RNJP (Cordani *et al.* 1979). In Bolivia the Pensamiento Complex (Litherland *et al.* 1986) represents this tectonic unit. In Brazil this unit comprises the Santa Helena batholith (Saes *et al.* 1984) and Rio Alegre terrane (Geraldes 2000).

The youngest event in SW Amazonia comprises the SAP metasedimentary rocks represented by the Sunsas Group in Bolivia, Aguapei Group in Mato Grosso State and Nova Brasilandia terrane in Rondonia State. They were deformed during the 1.1-1.0 Ga Rodinia collage, represented by the Laurentia-Amazonia collision.

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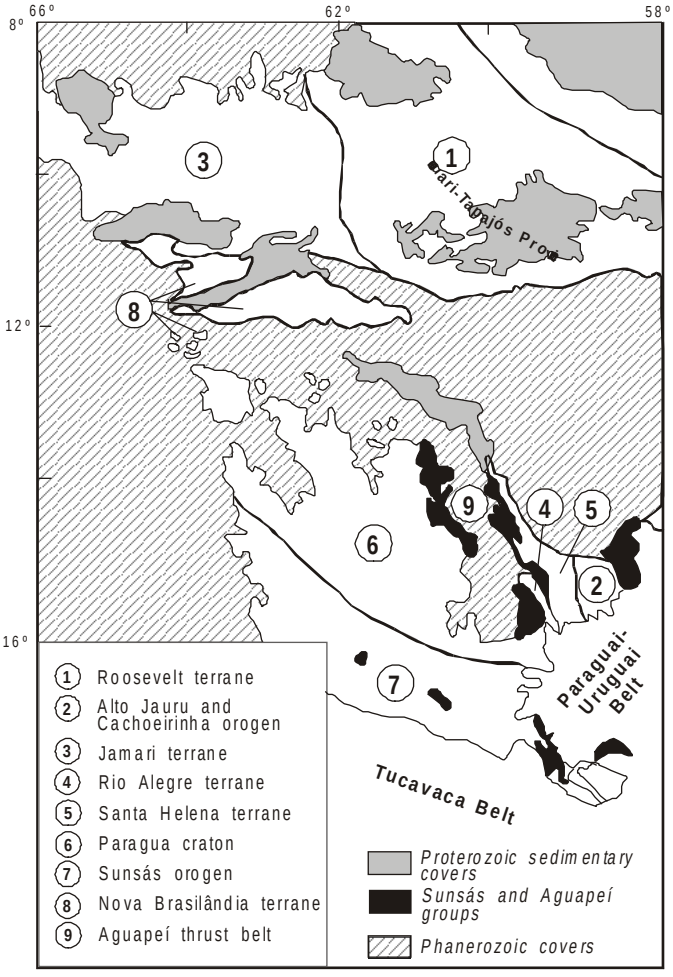

Figure 1 - Simplified tectonic framework of the SW Amazonian craton

ALTO JAURU GREENSTONE BELT Volcanic rocks of Jauru region were designated initially by Saes et. al., (1984) as Quatro Meninas Volcanic Complex and by Monteiro et. al., (1986) as Alto Jauru greenstone belt (AJGB). The AJGB comprises 3 distinct assemblages of metavolcanic and sedimentary rocks (from east to west): Cabaçal, Araputanga and Jauru, which are separated by granitic-gneiss terranes (Monteiro *et al.* 1986). The belts and basement rocks are intruded by Proterozoic dolerites and granitoids and are covered by Meso Proterozoic Aguapeí group rocks. U/Pb analyses in zircon of

volcaniclastic rocks (metatuff) results yielded 1767 ± 24 Ma (interpreted as crystallization age). The SHRIMP results obtained by Pinho (1996) on volcanic rocks of AJGB, where two zircon populations yielded two age groups: 1769 ± 29 Ma and 1724 ± 30 Ma, are concordant with the ages obtained here by U/Pb isotope dilution dating. In addition, the T_{DM} for the same metatuff is 1.87 Ma and $e_{Nd(t)}$ is 2.6 (Table 1).

Plutonic rocks of tonalitic to granitic composition were described in the Jauru region and considered as coeval with the Alto Jauru greenstone belt volcanic rocks. Pink Gneiss with Rb/Sr isochron age of 1734 ± 226 Ma and RI=0.7019 (Carneiro et. al. 1992) yielded U/Pb age of 1795±10 Ma, T_{DM} = 1.93 Ma and $e_{Nd(t)}$ = 2.2. Consistently, orthogneisses (Aliança gneiss according to Ruiz 1992) between Cabaçal and Araputanga volcanic belts yielded U/Pb age of 1747 ± 13 Ma, $T_{DM = 1.77}$ Ma and $\varepsilon_{Nd(t)}$ = 2.4.

Tonalites and granodiorites from AJGB show either tonalite-trondhjemite affinity (Pinho 1996) or calc-alkaline trend (Geraldes *et al.* 1999). Such chemical characteristics are consistent with an arc-related genesis for these intrusive rocks. Chemical data show that the felsic volcanic rocks are predominantly calc-alkaline whilst the ultrabasic-basic rocks are compatible with an ocean-floor origin. This conduct Pinho *et al.* (1997) to suggest the AJGB (western part) represents rocks formed in an ocean ridge setting, and the Cabaçal belt (eastern part) was formed in an arc-related setting.

Table 1 - U/Pb and Sm/Nd isotopic properties of samples from Paleoproterozoic rocks of Alto Jauru greenstone belt.

Lithology	U/Pb (Ma)	$\varepsilon_{Nd(0)}$	$\varepsilon_{Nd(t)}$	T_{DM}	*f*
Pink Gneiss	1795 ± 10	-18.1	2.2	1.93	-0.44
Aliança Gneiss	1746 ± 20	-18.1	2.4	1.77	-0.36
Tuff	1767 ± 24	-17.7	2.6	1.85	-0.48

CACHOEIRINHA OROGEN An important rock generation occurred between 1570-1530 Ma in SW Amazonian Craton border. The orogenic products are considered as part of the RNJP (Tassinari *et al.* 1996, Geraldes 2000). This event (Cachoeirinha orogen) formed a calc-alkaline suite chemically compatible with arc-related rocks, varying from tonalites to granites, which intrude older crust.

The basement rocks are represented by the AJGB (1.79-1.75 Ga). Granitoids of different compositions have been separated from the basement (Saes *et al.* 1984, Ruiz 1992) and time constrained by Rb/Sr ages varying from 1.70 to 1.40 Ga. Carneiro *et al.* (1992) described similar rocks in the region of São José do Quatro Marcos, suggesting at least two distinct rock associations, the first represented by gray gneisses (Rb/Sr ages about 1.96 Ga) and the second comprised by pink gneisses and granites with ages ranging from 1740 Ma to 1400 Ma (Rb/Sr whole-rock isochrons). U/Pb ages in zircons and the Sm/Nd composition obtained in the samples from this suite yielded results from 1587 ± 04 to 1522 ± 11, T_{DM} from 1.75 to 2.05 and e_{Nd} = from – 0.8 to +1.0), respectively (Table 2).

The Cachoeirinha suite displays major and trace elements trends resulting of a fractional crystallization process (Geraldes *et al.* 1999). Overall, the Cachoeirinha orogen rocks show calc-alkaline trend and Y, Nb and Rb contents indicate syn-collisional granitoids.

Table 2 - U/Pb and Sm/Nd results on Cachoeirinha Orogen rocks. U/Pb ages obtained in zircon by isotopic dissolution in monocrystal

Lithology	U/Pb (Ma)	$\varepsilon_{Nd(0)}$	$\varepsilon_{Nd(t)}$	T_{DM}	*f*
Quatro Marcos Tonalite	1536 ± 11	- 14.2	+ 0.5	1.77	-0.38
Cachoeirinha Tonalite	1549 ± 10	- 14.7	+ 1.0	1.83	-0.40
São Domingos Gneiss	1562 ± 36	- 20.2	+ 0.9	1.79	-0.53
Quatro Marcos Granite	1522 ± 12	- 19.6	+ 0.9	1.78	-0.54
Cachoeirinha Granite	1537 ± 06	- 22.2	+ 0.5	1.75	-0.60
Santa Cruz Granite	1587 ± 04	- 15.0	- 0.8	2.05	-0.36

SANTA HELENA OROGEN The Santa Helena orogen is bordered in the east by the Cachoeirinha and Alto Jauru greenstone belt. The western limit is the Rio Alegre terrane (Fig. 1).

The rocks of Santa Helena Suite (SHS) present compositional variations from tonalites to granites. Tonalites occur manly in the western portion (Lavrinha and Pau-a-Pique tonalites). Granodiorites are observed in north, central and west portion of the Santa Helena batholith while the granitic rocks have a homogeneous distribution.

U/Pb results for f this unit indicated ages ranging from 1488 ± 11 Ma to 1423 ± 15 Ma. The Sm/Nd model ages (T_{DM}) are from 1.70 Ga to 1.49 Ga and $\varepsilon_{Nd(t)}$ values vary from 4.1 to 2.6 (Table 3).

Table 3 - U/Pb and Sm/Nd results for Santa Helena Suite rocks.

Lithology	U/Pb (Ma)	$\varepsilon_{Nd(0)}$	$\varepsilon_{Nd(t)}$	T_{DM}	f
Triângulo Gneiss	1445 ± 04	-15.4	+ 2.9	1.56	-0.51
Alto Guaporé augen-gneiss	1424 ± 11	-12.8	+ 2.8	1.57	-0.44
Alto Guaporé gneiss	1424 ± 15	-8.6	+ 4.0	1.49	-0.35
Guaporé granodiorite	1435 ± 22	-11.8	+ 3.4	1.54	-0.42
Lavrinha tonalite	1464 ± 25	-13.1	+ 3.8	1.53	-0.45
Santa Helena granite	1433 ± 06	-8.9	+ 3.1	1.62	-0.32
Cardoso magnetite-granite	1423 ± 15	-11.7	+ 3.6	1.52	-0.33
Santa Elina granite	1436 ± 06	-10.2	+ 2.7	1.55	-0.38
Pau-a-Pique tonalite	1481 ± 47	-4.9	+ 4.1	1.50	-0.25
Maraboa granite	1449 ± 07	-7.1	+ 2.6	1.70	-0.26
Fazenda Ellus granite	1437 ± 12	-11.1	+ 3.7	1.52	-0.40
Garimpo Ellus granite	1444 ± 21	-10.8	+ 3.6	1.51	-0.39

Geochemistry studies on SHS rocks started by Menezes *et al.* (1993) with the characterization of the granitic rocks of this group, concluding that they are representative of an A-type granitic suite. According to Geraldes *et al.* (1999), this unit shows a variation from quartz monzogabbro and tonalites to granodiorites and granites *sensu latu*. Their results indicate a volcanic arc granites affinity for the primitive and intermediates rocks, while and the granites plot near the boundary between volcanic arc granites and within plate granites in discrimination diagrams. The REE patterns indicate higher degrees of fractionation between LREE and HREE in the primitive rocks than in the intermediate and fractionated ones. A positive Eu anomaly in the primitive rocks, a light negative Eu anomaly in the intermediate rocks, and a strong Eu negative anomaly in the granites, suggest that the units formed by fractional crystallization.

DISCUSSION AND TECTONIC IMPLICATIONS The Alto Jauru greenstone belt may be divided into two main sectors: the eastern sector comprised by coeval (1.79-1.74 Ga) volcanic and plutonic rocks which formed in a magmatic arc setting, and the western sector composed by ocean-floor type rocks (tholeiitic basalts, pillow lavas, chert and banded iron formation). These were probably originated in an ocean ridge system. The arc-related rocks and ocean-floor rocks were juxtaposed and resulted in a metamorphosed and deformed complex named as Alto Jauru greenstone belt by Monteiro *et al.* (1986). The ocean-floor association may be interpreted as suture zone record of an east-dipping subducting ocean crust.

The Cachoeirinha orogen took place in a time period ranging from 1.58 to 1.52 Ga, during a process of lithospheric convergence. It extended beyond the older continental margin represented by the Rio Negro-Juruena crust formed at 1.79-1.75 Ga ago. Most of the Cachoeirinha granitoids present T_{DM} ages ranging from 2.05 to 1.74 Ga, and $\varepsilon_{Nd(t)}$ values from – 0.8 to + 1.0, respectively. The Nd isotopic signature of part of these rocks is similar to that of the basement rocks, plotting within the isotopic evolution path of the country rocks. They probably represent material differentiated from the mantle at the same

time as the Alto Jauru greenstone belt older crust in addition of juvenile material. The exposure of intrusive juvenile and reworked plutonic rocks and, so far, the lack of corresponding volcanic rocks suggest that the Cachoeirinha orogen rocks represent the roots of a magmatic arc, formed on an older sialic crust whose volcanic building was eroded, exposing the internal structure.

The geochronological, isotopic and chemical data of the Santa Helena suite suggest the generation a large amount of granitoid rocks during a short period of time (1480 Ma to 1420 Ma), certainly correlated to an important regional event responsible for the Santa Helena suite formation. The variation of rock compositions from granite to tonalite of calcalkaline affinity is also suggestive of the arc-related formation.

The Sm/Nd ages (1.70-1.49) and $\varepsilon_{Nd(t)}$ values (4.1-2.6) for the rocks of the SHS suggest most of them represent juvenile crust. This magmatic arc developed along the western Mesoproterozoic margin of a continent which was comprised of volcanic and gneissic complexes to the east (Alto Jauru greenstone belt), suggesting that the associated subduction zone dipped east under the 1.8 to 1.7 Ga continental margin of the Amazonian craton.

Acknowledgements To FAPESP (grants 96-9022-0 and 96-12627-0) for financial support. MCG thanks to CAPES (grant BEX 002298-5). This paper is a contribuition to 426 IGCP Projet (Granite System and Proterozoic Lithosphere Process). To two anonymous referees of RBG for the critical analisis of the manuscript.

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Contribution IGC-130
Received March 1, 2000
Accepted for publication April 30, 2000