THREE DISTINCTIVE COLLISIONAL OROGENIES IN THE SOUTHWESTERN AMAZON CRATON: CONSTRAINTS FROM U-Pb GEOCHRONOLOGY

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INTRODUCTION

The characterization of major orogenies in the SW Amazon Craton is an issue of major importance for the evolution of the craton and Amazonia continent. The Southwestern Amazonian Craton contains the Rondônia-Juruena (1850-1540 Ma) and Sunsás (1450-980 Ma) provinces (Santos et al., 2000), which include both orogenic and post-orogenic rock associations. Two domains compose the Rondonia-Juruena Province: the Jamari Domain to the west and the Roosevelt-Juruena Domain to the east (Fig. 1). The Jamari Domain is formed by two main units: the orogenic Jamari Complex (1.76-1.75 Ga; Tassinari et al., 1996; Santos et al., 2000) and the post-orogenic Serra da Providência Intrusive Suite (1.58-1.53 Ga; Tassinari et al., 1996; Santos et al., 2000; Bettencourt et al., 2001; Payolla et al., 2002). The Serra da Providência Suite includes rapakivi-like granites and charnockitoids, which are not discriminated in the geological maps. The Jamari Complex has two main groups of rocks formed in two distinct environments: a tonalite-quartz diorite association possibly related to an island arc environment and an assemblage of high metamorphic grade metassedimentary rocks, such as kingzigite and paragneiss suggestive of a collisional orogenic environment. Both Serra da Providência and Jamari units are strongly affected by a much younger collisional event of the Sunsás Orogen producing mylonite gneisses and augen gneisses and making difficult the discrimination between the orogenic and post-orogenic rocks. This paper investigates the Jamari Complex to establish: a) the timing of the older collision, which formed the kinzigite-paragneiss association, and b) the timing of the younger collision affecting both Serra da Providência and Jamari units.

METHODS

We present the results of zircon geochronology of five rock samples and integrate the results with all available U-Pb isotopic data in the region (Table 1). The five rock samples selected for this investigation are three samples from Jamari Complex (JL78, GR59 and GR35); one sample from Serra da Providência (GR333), and one sample from the Sunsás belt (JS39). We used BSE images to select zircon for U-Pb analyses, picking grains showing evidence of possible metamorphic rims. Zircon analyses were carried out on the SHRIMP II at the Curtin University of Technology following standard procedures (Smith et al., 1998; Santos et al., 2000). Reference standard was CZ3 zircon (564 Ma; $^{206}Pb/^{238}U=0.0914$). We present here only $^{207}Pb/^{206}Pb$ ages. Sm-Nd isotopes were analyzed in the Laboratório de Geologia Isotópica, Universidade Federal do Rio Grande do Sul, Porto Alegre. Decay constants used are those recommended by Steiger & Jägger (1977).

RESULTS AND DISCUSSION

The Jamari Complex zircon crystals have the following magmatic ages (Table 1): 1752 ± 14 Ma (JL78), 1755 ± 9 Ma (GR59), and 1761 ± 3 Ma (GR35). The Sm-Nd model ages are slightly older: 1957, 1838, and 1947 Ma and indicate a short crustal residence (Table 2). The magmatic ages correlate to the age of 1752 ± 2 Ma determined by Tassinari et al. (1996) on zircon from tonalitic gneiss (A338a). Sample A338a, however, has a much older Sm-Nd T_{DM} model age (2200 Ma) than the results presently reported. Sample GR35 has one metamorphic rim formed at 1632 ± 6 Ma (grain d2; Th/U=0.01; Fig. 2) and sample GR59 has another population of magmatic zircon formed at 1677 ± 12 Ma (Fig. 3). These two ages are about 80 to 120 m.y. younger than the age of the Jamari Complex and are similar to several ages recently determined in the Jamari Domain: Ouro Preto Paragneiss (1675 ± 12 Ma; Santos et al., 2000), Machadinho Paragneiss (1677 ± 5 Ma; Payolla et al., 2002), Paraíso Farm granulitic gneiss (1655 ± 11 Ma; Bettencourt et al., 2001), and Presidente Médici garnet gneiss (1634 ± 8 Ma; Bettencourt et al., 2001). Sample JL78 (1752 ± 14 Ma, Fig. 4) was affected by high-grade metamorphism identified in zircon metamorphic rims (Th/U=0.09; Fig. 5) at 1335 ± 2 Ma (Fig. 4). This age is typical of the Candeias Orogeny of Sunsás Orogen (Santos et al., 2002) and is equivalent to the age of Ariquemes kinzigite (1331 ± 8; Tassinari et al., 1999).

Zircon crystals from Serra da Providência Granite (GR333) were formed at 1547 ± 13 Ma and recrystallized by metamorphism at 1349 ± 8 Ma (Th/U=0.009-0.015; Fig. 6), associated to the Candeias Orogeny. Santos et al. (2002) identified four main orogenies in the Sunsás Orogen based on detrital zircon geochronology. The Candeias Orogeny is the second orogeny of the Sunsás

Orogen and developed during the 1370-1320 Ma range according to the ages of populations of detrital zircon grains from the following sedimentary units: Pacaás-Novos (1368 Ma), Nova Brasilândia (1351 Ma), Palmeiral (1330 Ma), and Iata (1320 Ma). Another example of the Candeias metamorphism is the metamorphic age of 1326 Ma determined in monazite from 1526 Ma old WB44 augen gneiss (Payolla et al., 2002).

The Ariquemes Granite (1333 ± 8 Ma old; Santos et al., 2000) and other granites are correlated to the Alto Candeias Batholith (1330 ± 12 Ma; Bettencourt et al., 1999) in Central Rondônia State. Another sample (JS39) from that batholith was investigated to determine its U-Pb age. It has a single igneous zircon population formed at 1339 ± 7 Ma (Fig. 7). This age is within error of the previous age determined for the Ariquemes Granite (Santos et al., 2000), and correlates with the age of metamorphism affecting both Serra da Providência Suite (1349 Ma, sample GR333) and Jamari Complex (1336 Ma, sample JL78).

CONCLUSIONS

The Jamari Complex includes two main groups of rocks: a) an older tonalite-quartz diorite association generated in a juvenile environment at 1.76-1.75 Ga with minor contamination from continental crust (T_{DM} Nd model ages of 1.95-1.84 Ga); and b) a younger (1.67-1.63 Ga) association of high metamorphic grade metassedimentary rocks derived from crustal reworking (T_{DM} Nd model ages of 2.20 Ma and 2.13 Ga) representing a collisional event. The collisional rocks can be separated from the Jamari Complex and included in younger units such as Machadinho and Ouro Preto. The Machadinho-Ouro Preto collision is a regional orogeny affecting the Rondônia-Juruena Province because it is identified not only in the Jamari Domain (western zone), but also in its central and eastern zones. In the eastern Juruena region, metamorphic rims on Monte Verde Amphibolite zircon are 1653 ± 42 Ma old (Márcio Pimentel, 2003, personal communication), and in the Aripuanã River region (Colniza-Mureru area, Fig. 1), Pinho et al. (2003) identify a metamorphic granodiorite (P18) with an age of 1669 ± 13 Ma.

The Candeias Orogeny of the Sunsás Orogen was developed during 1370-1320 Ma and it is compose by two groups of rocks: a) collisional rocks, such as local kinzigite, such as RO8 (Tassinari et al., 1999) and mylonites and gneisses generated by high-grade metamorphism over previous rocks, mostly from Jamari Complex and Serra da Providência Suite; and b) monzo- to syenogranite batholiths probably generated in a continental arc environment; the Candeias Batholith and the Ariquemes Granite are the best examples.

We identify in southwestern Amazonian Craton three main collisional orogenies: The Ouro Preto orogeny (1670-1630 Ma) in the Rondônia-Juruena Province; and the Candeias (1370-1320 Ma) and Nova Brasilândia (1100 Ma; Rizzotto et al., 1999) orogenies related to the Sunsás Orogen (1450-1100 Ma; Santos et al., 2002).

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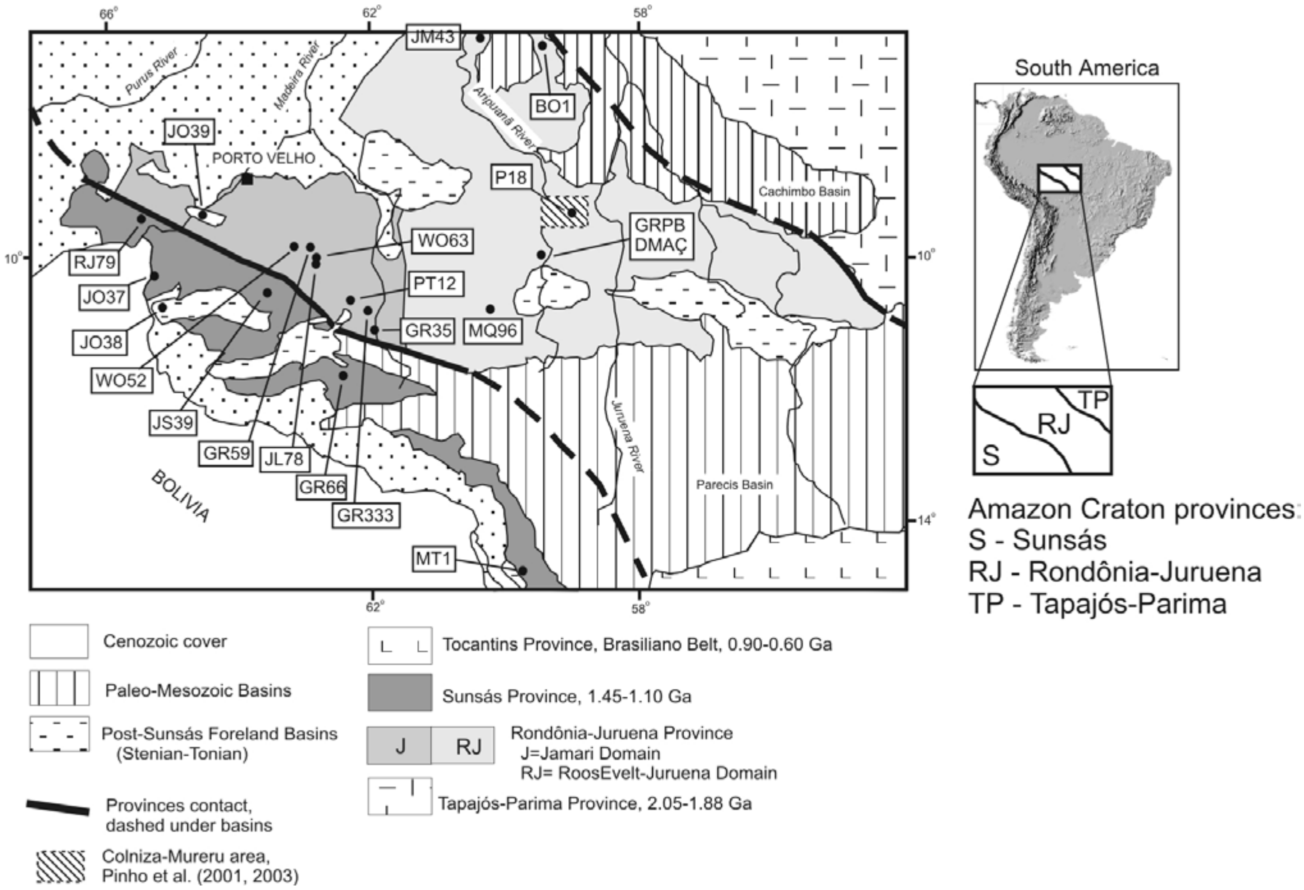

Figure 1. Geological map of southwestern Amazonian Craton showing provinces, domains, and location of samples with U-Pb data.

Table 1. List of rocks dated by U-Pb (this and previous work).

Sample	Rock	Unit	U-Pb age	n^1	n^2	σ	MSWD	zircon type	$T_{DM\ (t)}$	ε_{Nd}	Reference
WB44A	Augen gneiss	Jaru	1326 ± 2	4	1	2	-	metamorphic	1840	+0.50	Payolla et al. (2002)
RO8	Kinzigite	Candeias	1331 ± 8	4	4	2	n.a.	metamorphic			Tassinari et al. (1999)
JL78	Tonalite	Jamari	1336 ± 7	4	4	2	2.10	metamorphic	1947	+1.04	This work
JS39	Granite	Alto Candeias	1339 ± 7	7	6	2	1.70	magmatic			This work
GR333	Meta-granite	S. Providência	1349 ± 8	2	2	2	-	metamorphic	1990	-0.69	This work
P18	Meta-granodiorite	Colniza	1669 ± 13	4	3	1	5.00	metamorphic	2160	-0.30	Pinho et al. (2003)
GR59	Tonalite	Jamari	1677 ± 12	2	2	2	-	magmatic	1838	+2.33	This work
WB152	Paragneiss	Machadinho	1677 ± 5*	3	3	1	1.70	metamorphic	2129	-1.19	Payolla et al. (2002)
PT12	Paragneiss	Ouro Preto	1675 ± 12	4	3	2	0.41	metamorphic			Santos et al. (2000)
JWB10	Granulitic gneiss	Ouro Preto	1655 ± 11	4	4	2	33.00	metamorphic			Bettencourt et al. (2001)
PS171	Amphibolite	Monte Verde	1653 ± 42	4	4	2	n.a.	metamorphic	2001	+0.16	Márcio Pimentel (pers. comm.)
JWB3a	Garnet gneiss	Ouro Preto	1634 ± 8	4	4	2	14.00	metamorphic			Bettencourt et al. (2001)
GR35	Quartz diorite	Jamari	1632 ± 6	1	1	2	-	metamorphic	1957	+1.89	This work
JL78	Tonalite	Jamari	1752 ± 14	4	4	1	1.40	magmatic	1947	+1.04	This work
A338a	Tonalitic gneiss	Jamari	1752 ± 2*	4	4	2	0.02	magmatic	2200	-1.50	Tassinari et al. (1996)
GR66	Quartzite	N.Brasilândia	1753 ± 18	2	2	2	-	detrital	-	-	Santos et al. (2000)
GR59	Tonalite	Jamari	1755 ± 9	3	2	2	1.19	magmatic	1838	+2.33	This work
GR35	Quartz diorite	Jamari	1761 ± 3	9	8	1	0.32	magmatic	1957	+1.89	This work
WB152	Paragneiss	Machadinho	1762 ± 4	1	1	2	-	inherited	2129	-1.19	Payolla et al. (2002)

Table 2. Sm-Nd data of dated samples.

Sample	rock	Unit	Sm (ppm)	Nd (ppm)	$^{147}Sm/^{144}Nd$	$^{143}Nd/^{144}Nd$	T(Ma)	ε_{Nd}	T_{DM}
GR35	quartz-diorite	Jamari	2.0510	8.8010	0.13455	0.512016	1761	+1.89	1957
GR59	tonalite	Jamari	8.4093	45.3861	0.10736	0.511725	1755	+2.33	1838
GR333	meta-granite	Providência	7.4800	35.2100	0.128	0.511916	1547	-0.69	1990
JL78	tonalite	Jamari	8.5100	48.1500	0.10690	0.511669	1752	+1.04	1947

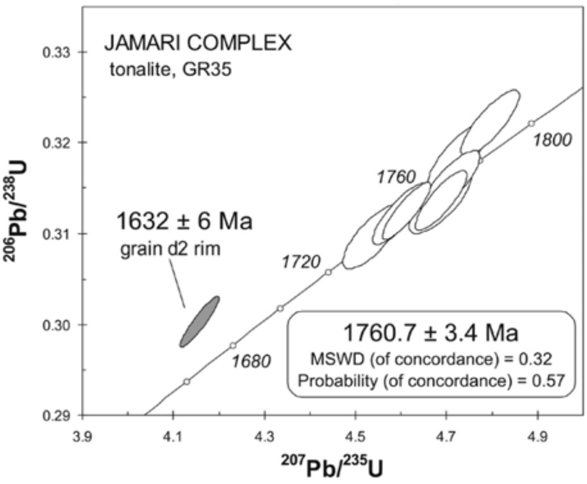

Figure 2. U-Pb concordia diagram for zircon from Jamari Complex quartz diorite (GR35).

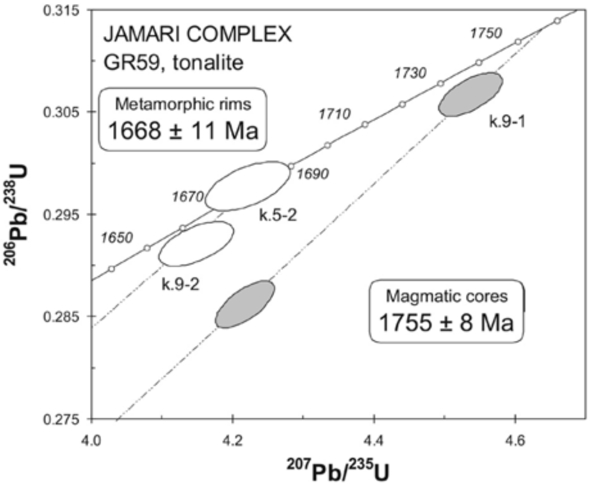

Figure 3. U-Pb concordia diagram for zircon from Jamari Complex tonalite (GR59).

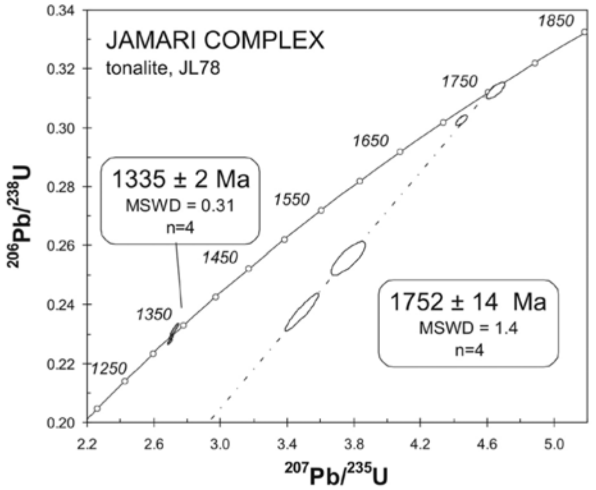

Figure 4. Concordia plot of two populations of zircon data: cores ages grouped at 1752 ± 14 Ma and rim ages at 1335 ± 2 Ma.

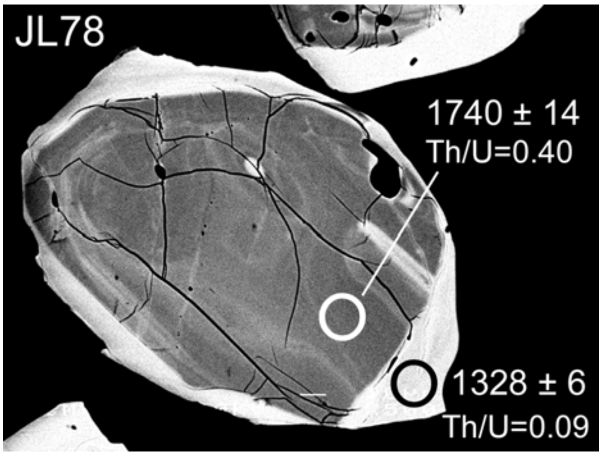

Figure 5. Back-scattered image of zircon h2 of JL78 tonalite, showing metamorphic rim (1328 Ma; Th/U=0.09) and igneous core (1740 Ma, Th/U=0.40).

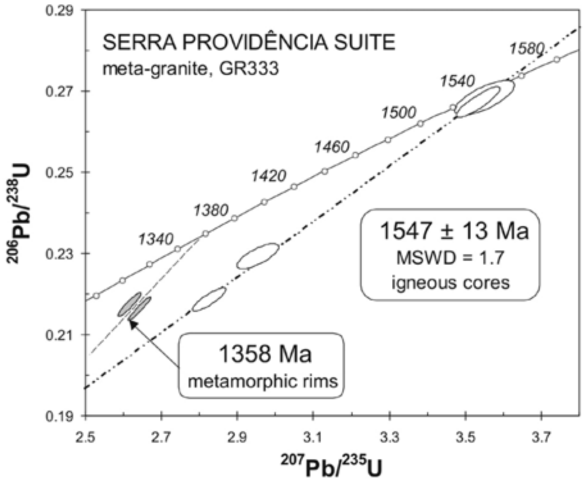

Figure 6. U-Pb concordia plot for zircon cores and rims from Serra Providência Suite meta-granite.

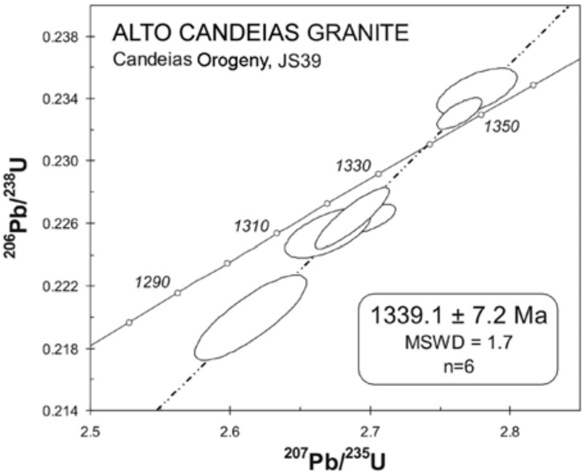

Figure 7. U-Pb concordia plot for igneous zircon from Alto Candeias Batholith (JS39).