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Neoproterozoic Anatexis of 2.9 Ga Old Granitoids in the Goiás-Crixás Archean Block, Central Brazil: Evidence From New SHRIMP U-Pb Data and Sm-Nd Isotopes

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Keywords: Archean, Goiás, SHRIMP U-Pb, Brasiliano, anatexis.

ABSTRACT

The first SHRIMP U-Pb ages for granitoid rocks from the southern part of the Goiás-Crixás Archean Block (Caiçara and Uvá complexes) are presented and discussed in combination with Sm-Nd isotopic data in order to elucidate the main aspects of the geological evolution of that part of the Brasília Belt in central Brazil. Zircon grains from a tonalitic gneiss (GOV-4) in the Uvá Complex show that the original tonalite crystallized at 2934 ± 5 Ma. One metamorphic zircon crystal is concordant and indicates an Archean age for the recrystallization episode (2793 ± 3 Ma) and one inherited grain with an age of 3092 ± 9 suggests, together with negative values of ε_{Nd}(T) (+0.4 and –4.6), that the magma was contaminated with older crust. One leucocratic granite (GOV-1) exposed north of the Goiás greenstone belt crystallized at 626 ± 7 Ma, as indicated by the igneous overgrowths surrounding older inherited cores. The latter indicate a crystallization age of 2893 ± 12 Ma. This rock is interpreted therefore as the product of Neoproterozoic anatexis of *ca.* 2.89 Ga-old rocks of the Caiçara Complex. This is reinforced by strongly negative ε_{Nd}(T = 626) values of – 28.0 and –29.0. Its crystallization age is identical to the U-Pb ages of the Itapuranga granite and Uruana quartz syenite, which are exposed to the north of the investigated area and interpreted as syn-tectonic intrusions in relation to the main Brasiliano tectonic event. This represents, therefore, the first evidence of Neoproterozoic magmatism within the Goiás Archean Block and raises the possibility that other leucogranite dykes and stocks identified regionally may also have been formed during the Brasiliano orogeny.

Palavras-chave: Arqueano, Goiás, U-Pb SHRIMP, Brasiliano, anatexia.

RESUMO

No presente estudo são reportadas as primeiras idades U-Pb SHRIMP para rochas granito-gnáissicas dos complexos Uvá e Caiçara, na parte sul dos terrenos arqueanos de Goiás. Combinados com análises isotópicas Sm-Nd, os dados U-Pb permitem aprofundar o conhecimento a respeito da evolução geológica daquela parte da Faixa Brasília. Cristais de zircão do gnaisse tonalítico de Uvá (GOV-4) indicam a idade de 2934 ± 5 Ma para a cristalização do protólito ígneo. Um grão de zircão metamórfico sugere idade de 2793 ± 3 Ma para o metamorfismo que afetou a rocha, enquanto que um grão herdado de zircão com idade de 3092 ± 9, aliado a valores de ε_{Nd}(T) variando entre +0,4 e –4,6, sugere contaminação com crosta continental mais antiga. Granito leucocrático exposto a norte do *greenstone belt* de Crixás no Complexo Caiçara apresenta idade de cristalização de 626 ± 7 Ma, dada por sobrecrescimentos ígneos cristalizados em torno de núcleo com idade de 2893 ± 12 Ma. O resultado, combinado com valores fortemente negativos de ε_{Nd}(T) (entre –28,0 e –29,0), indica que o granito é produto de refusão de rochas arqueanas com *ca.* 2,89 Ga de idade. A idade do granito é idêntica às idades U-Pb SHRIMP e convencional do álcali-granito Itapuranga e quartzo sienito de Uruana, expostos a norte da área estudada. Trata-se, portanto, do primeiro registro confiável de magmatismo Neoproterozóico no interior dos terrenos arqueanos de Goiás e pode sinalizar que vários dos pequenos corpos e diques de leucogranitos encontrados em meio aos terrenos TTG podem representar magmas gerados durante a orogênese brasiliana.

INTRODUCTION

The Goiás-Crixás Archean Block, in the central part of the Neoproterozoic Brasília Belt, central Brazil, is formed by typical komatiite-bearing Archean greenstone belts and associated TTG terranes, underlying an area of approximately 50,000 sq. km. It is oval-shaped, NE-SW oriented, and its limits with adjacent younger terranes are tectonic. To the north and west, the Archean rocks are in contact with Neoproterozoic rocks of the Goiás Magmatic Arc, and to the south and east, with Proterozoic metasedimentary and metavolcanic units of the Brasília Belt (Figure 1). The eastern limit of the Archean terrane is marked by an important regional gravimetric discontinuity, which separates it from the Proterozoic rocks of the northern part of the Anápolis-Itauçu Complex. The Archean block has been, therefore, interpreted as allocthonous in respect to the tectonic evolution of the Neoproterozoic mobile belt (Pimentel *et al.*, 2000).

Although tonalite and granodiorite gneiss rocks comprise approximately 80% of the Archean block, the geological evolution and stratigraphic relationships are better constrained for the supracrustal successions, due to detailed mapping and exploration projects carried out over the last two decades (*e. g.* Kuyumjian 1981; Danni et *al*., 1982; Jost & Oliveira, 1991; Lacerda & Lima Jr., 1996; Resende *et al*., 1998). Only recently, geological mapping and structural studies combined with U-Pb and Sm-Nd geochronology on granite-gneiss rocks of the northern part of the Goiás-Crixás Archaean Block have elucidated the main aspects of the geological evolution of the plutonic protoliths, as well as of their relationships with adjacent supracrustal belts (Queiroz *et al*., 1999, 2000, 2001; Queiroz, 2000; Queiroz & Jost, 2001; Jost *et al.*, 2001). In the northern part of the Goiás Archean Block, U-Pb data have revealed a very complex geological evolution, with main intrusive events between *ca.* 2.84 and 2.71 Ga and metamorphic episodes at *ca.* 2.71, 2.01 and 0.59 Ga (Queiroz, 2000). Imprint of the Brasiliano orogeny on the northern supracrustal rocks have also been demonstrated by Neoproterozoic Sm-Nd garnet ages (Fortes *et al.*, 2001) and K-Ar and Ar-Ar mineral ages in rocks of the Crixás greenstone belt (Fortes *et al.*, 1995, 1997).

On the other hand, granite-gneiss units in the southern part of the Archean terrane, adjacent to the Serra de Santa Rita greenstone belt, remain poorly known. Geochronologic data for the southern granitoids are limited to few regional whole-rock Rb-Sr and Sm-Nd isochron and model ages, as well as some K-Ar mineral ages (Tassinari *et al*., 1981; Tomazzoli, 1992; Pimentel *et al*., 1996). Rb-Sr isochron ages fall within the interval between *ca.* 2.84 and 1.90 Ga, while Nd model ages are mainly between 2.9 and 3.2 Ga.

In this study, new SHRIMP U-Pb ages, combined with Sm-Nd model ages, are presented for granitic and tonalitic rocks of the Caiçaras and Uvá complexes, in the southern part of the Goiás Archean Block. The preliminary data seem to indicate that the rocks exposed in the southern granite-gneiss terranes are distinctively older than those in the Crixás-Hidrolina area, in the north, and that anatexis of *ca.* 2.9 Ga old rocks occurred in response to the Brasiliano orogenic event.

THE GRANITE-GNEISS TERRANES - REGIONAL GEOLOGY AND PREVIOUS GEOCHRONOLOGY

Originally, Danni & Ribeiro (1978) grouped the granitoids of the northern portion of the Archean terranes into four independent blocks or complexes (Anta, Caiamar, Moquém, and Hidrolina) (Figure 1). To the south, the Anta Complex extends towards the Caiçara Complex, which, in turn, extends southwards until the northern limits of the Serra de Santa Rita and Faina greenstone belts. Gneisses and granite intrusions to the south of the supracrustal belt are grouped into the Uvá Complex, which extends to the south until the lower slope of the Serra Dourada range, formed by Proterozoic metasedimentary rock units.

The Anta, Caiamar, Moquém and Hidrolina complexes, in the north, are formed dominantly by tonalitic, granodioritic and granitic gneisses representing distinct pulses of intrusive activity. Geochronology studies carried out mainly during the 80's were based on Rb-Sr reference isochrons, which revealed ages varying from *ca.* 2.47 to 2.97 Ga (Table 1); one additional Pb-Pb whole-rock isochron age of *ca.* 2.48 ± 0.18 Ga was also reported by Tassinari & Montalvão (1980) for granodioritic gneisses of the Caiamar Complex.

The Caiamar Complex is the best known of the northern complexes and seems to contain the oldest gneissic rocks. Detailed mapping combined with SHRIMP U-Pb geochronology revealed that it comprises three main rock units: Crixás-Açu gneiss, Tocambira tonalite and Águas Claras gneiss, with SHRIMP U-Pb crystallization ages of 2817 ± 9 Ma, 2842 ± 6 Ma, 2844 ± 7 Ma, respectively (Queiroz *et al*., 1999, 2000). Inherited zircon grains with ages varying between *ca.* 3.08 and 2.93 Ga are found in the three granitoids, suggesting contamination with slightly older continental crust. One tonalite sample of the Anta Complex displays a similar age pattern, with igneous zircon grains indicating the age of 2820 ± 6 Ma, and inherited grains ranging from *ca.* 3.17 to 2.93 Ga. Granodiorites of the Hidrolina Block are younger than the Caiamar and Anta intrusives, with SHRIMP U-Pb zircon age of 2785 ± 5 Ma. The youngest granitoids in

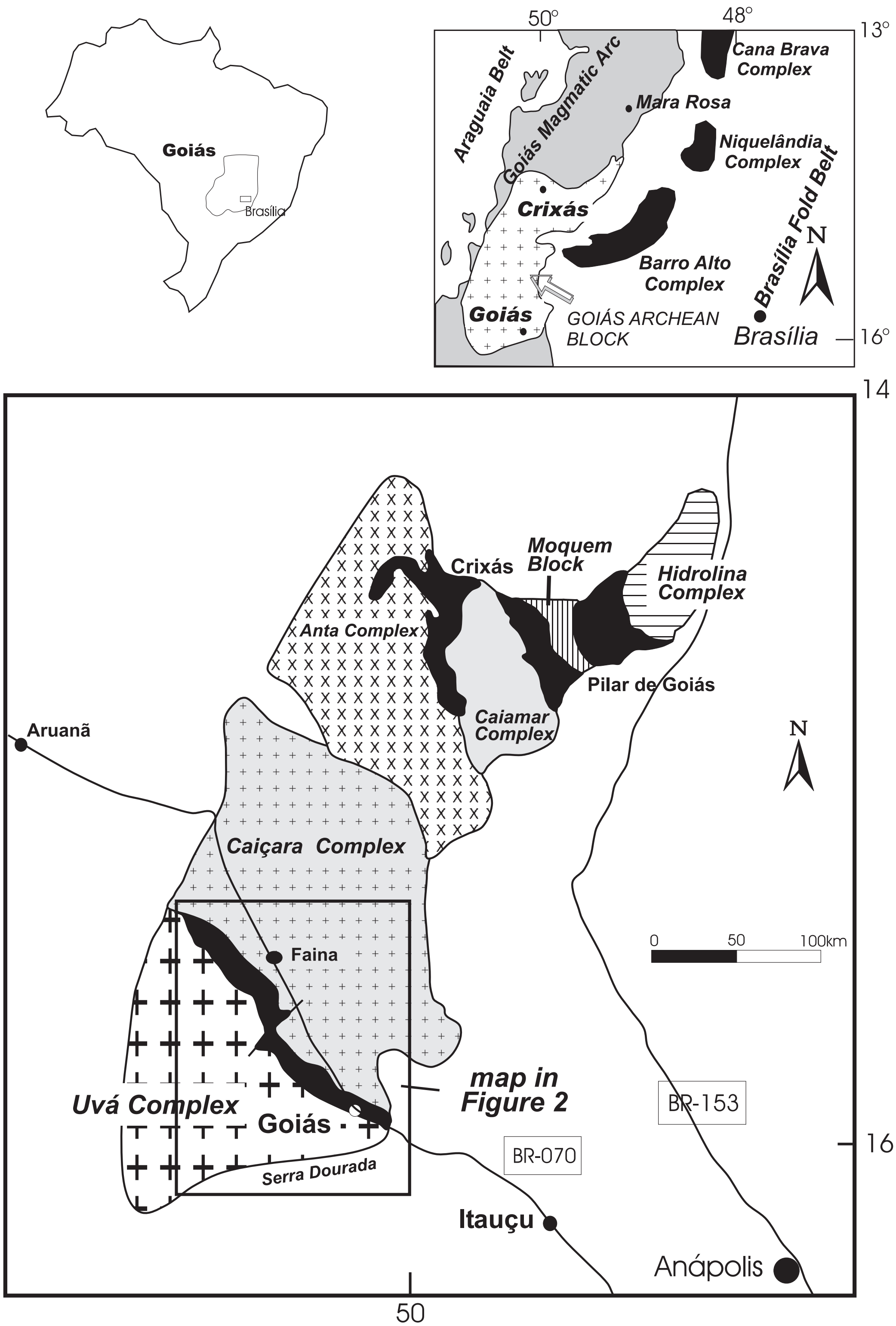

Figure 1. Geological sketch map and location of the Goiás-Crixás Archean Block.

the northern part of the Archean terrane are those exposed in the Moquém Block, where granodioritic and granitic gneisses have SHRIMP U-Pb ages of 2707 ± 4 Ma and 2711 ± 3 Ma, respectively (Queiroz *et al.*, 1999). Titanite grains from the Crixás-Açu gneiss indicate metamorphic events at 2711 ± 34 and 2011 ± 15 Ma. Metamorphic zircon grains from banded gneisses of the Moquém Block have indicated an additional metamorphic episode at 590 ± 10 Ma, suggesting, therefore, a very complex tectonic evolution for the northern part of the gneissic terranes (Queiroz *et al.*, 1999, 2000).

In the southern half of the Goiás Archean Block, the Caiçara and Uvá complexes (Jost *et al*., 1999) are not well known due to the lack of detailed mapping. The northern limit of the Caiçara Complex is difficult to establish, due to deep weathering, however, the contact with the Anta and Caiamar complexes is clearly defined by gammaspectrometric data (M. Blum personal comm.). Granodiorite, tonalite, and quartz-diorite are the main rock types, and are cut by a mafic dyke swarm and small mafic and ultramafic intrusions (Danni *et al*., 1981; Baeta Jr. *et al*., 1999). Small stocks and dykes of muscovite-bearing leucogranites intrusive into the tonalitic-granodioritic gneisses are also described in several localities within the Uvá and Caiçara complexes (Baeta Jr. *et al*., 1999).

The Uvá Complex is limited in the north by the Serra de Santa Rita and Faina greenstone belts, and by Proterozoic units in the west, south and east (Figure 2). The complex consists of tonalite gneiss and granite-granodiorite intrusions. Near the contact with the Serra de Santa Rita and Faina belts, the intrusions of both the Caiçara and Uvá complexes commonly contain xenoliths of mafic and ultramafic supracrustals (Resende *et al*., 1998). However, the contact between the intrusions and the supracrustals are northeasterly verging shallow angle thrust faults, indicating that the supracrustal sequence is allochtonous. The geological map in Figure 2 is based on field observation strongly supported by interpretation of satellite images and shows the main units recognized in the granite-gneiss terranes in the vicinities of the Serra de Santa Rita greenstone belt.

U-Pb data are still not available for rock units of the Uvá and Caiçara complexes. More recently, Pimentel *et al.* (1996) and Potrel *et al.* (1998) demonstrated, in regional Sm-Nd studies of the gneiss terranes to the south and north of the Serra de Santa Rita greenstone belt, that T_{DM} model ages are between *ca.* 3.2 and 3.0 Ga. These were interpreted as maximum ages for the protoliths of these gneissic and granitoid rocks. One Sm-Nd whole-rock isochron for the Uvá granite indicates the age of 2851 ± 180 Ma and $\varepsilon_{Nd}(T)$ of +0.3 (Pimentel *et al.*, 1996). Rb-Sr whole-rock isochrons are in the interval between *ca.* 2.84 and 1.90 Ga (see references in Table 1).

Table 1. Previous Rb-Sr data of granitoid rocks of the Goiás-Crixás Archean Block.

Rock Unit	Rb-Sr age (Ma)	Initial Sr ratio	MSWD	Refer.
Tocambira Tonalite	2965 ± 65 2924 ± 150	-	-	1,2,3
Granodiorites of the Hidrolina Complex	2653 ± 40	-	-	2
Granodiorites of the Anta Complex	2475 ± 20 2530 ± 98	0.7050	2.5	1, 3
Tonalitic gneiss of the Caiçara Complex	*ca.* 2,850 2651 ± 27	0.7050 0.7000	- 0.05	4
Tonalitic gneiss of the Caiçara Complex	*ca.* 1900	0.7040	-	6
Muscovite-biotite gneiss of the Caiçara Complex	2670 ± 142	0.719	22.6	6
Tonalitic gneisses of the Uvá Complex	2564 ± 140	0.7017	3.0	5
Muscovite gneiss of the Uvá Complex	2669 ± 122	0.7063	44.7	6

1 - Tassinari & Montalvão (1980); **2 -** Montalvão (1986); **3 -** Vargas (1992); **4 -**Tassinari *et al.* (1981); **5 -** Pimentel *et al.* (1996); **6 –** Tomazzoli (1992).

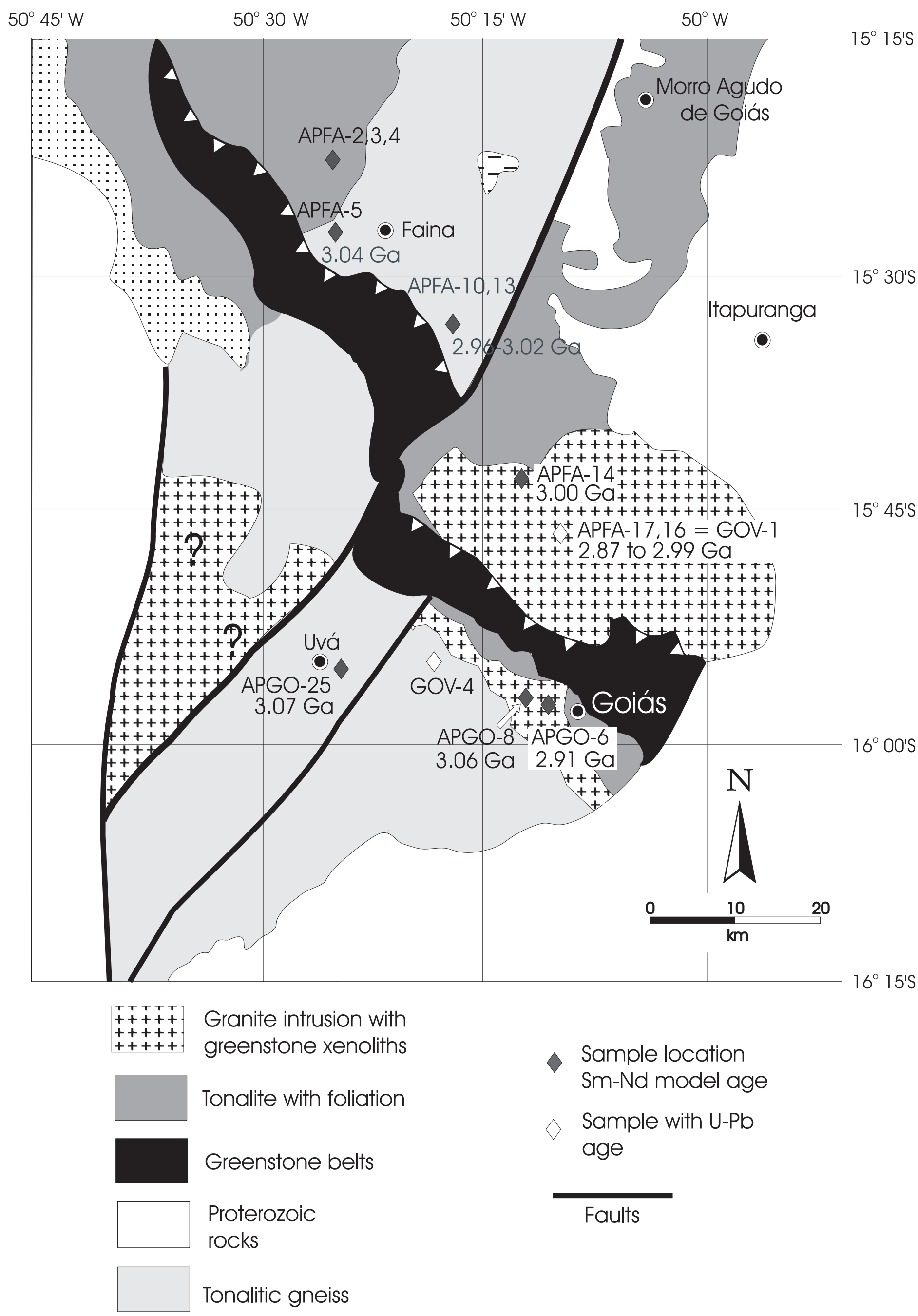

Figure 2. Geological sketch map based on satellite image interpretation, showing sample location.

ANALYTICAL PROCEDURES

Zircon separates were obtained by conventional gravimetric and magnetic methods at Universidade de Brasília. These concentrates were further hand picked under a binocular microscope and mounted in epoxy, together with reference zircon crystals FC1 and SL13. Cathodoluminescence images were done for all zircon grains and were used to investigate the internal structures of the sectioned grains and to target selected areas within the zircon crystals for spot analysis.

All U-Pb analyses were done using SHRIMP II at the Research School of Earth Sciences, Australian National University, Canberra. Each analysis consisted of six scans through the mass range. The data have been reduced in a manner similar to that described by Williams (1998), using SQUID Excel Macro of Ludwig (2001a). For the Pb/U calibration, the measured Pb/U ratios have been normalized relative to a value of 0.1859 for the $^{206}Pb^{*}/^{238}U$ ratio of the FC1 reference zircon, equivalent to an age of 1099 Ma (Paces and Miller, 1989). U and Th concentrations were determined relative to the SL13 standard.

Uncertainties given for individual analyses are at the 1σ level, and uncertainties in the calculated weighted mean or intercept ages are reported at the 95% confidence level. Concordia plots and regression calculations were carried out using Isoplot/Ex (Ludwig, 2001b).

Sm-Nd isotopic analyses followed the method described by Gioia and Pimentel (2000) and were carried out at the Geochronology Laboratory of Universidade de Brasília. Whole rock powders (*ca.* 50 mg) were mixed with ^{149}Sm-^{150}Nd spike solution and dissolved in Savillex capsules. Sm and Nd extraction of whole-rock samples followed conventional cation exchange techniques, using teflon columns containing LN-Spec resin (HDEHP – di-ethylhexil phosphoric acid supported on PTFE powder). Sm and Nd samples were loaded on Re evaporation filaments of double filament assemblies and the isotopic measurements were carried out on a multi-collector Finnigan MAT 262 mass spectrometer in static mode. Uncertainties for Sm/Nd and $^{143}Nd/^{144}Nd$ ratios are better than ± 0,4 % (1σ) and ± 0.005% (1σ) respectively, based on repeated analyses of international rock standards BHVO-1 and BCR-1. $^{143}Nd/^{144}Nd$ ratios were normalized to $^{146}Nd/^{144}Nd$ of 0.7219 and the decay constant (λ) used was 6.54×10^{-12}.

RESULTS AND DISCUSSION

Sm-Nd isotopic results for the main rock types exposed in the Caiçaras and Uvá complexes are in Table 2 and the T_{DM} model ages are displayed in the map of Figure 2. The twelve whole-rock samples analysed have $^{147}Sm/^{144}Nd$ ratios in the interval between 0.093 and 0.147 and T_{DM} values ranging between 2.99 and 3.99 Ga. The older model ages (> 3.4 Ga) correspond to those samples with higher $^{147}Sm/^{144}Nd$ ratios, suggesting that the age values might represent only the result of Sm-Nd fractionation during metamorphism or igneous crystallization. Samples with $^{147}Sm/^{144}Nd$ ratios < 0.12 have T_{DM} ages between 2.87 and 3.07 Ga, interpreted here as geologically meaningful. These are consistent with important addition of mantle-derived material to the continental crust at *ca.* 3.0 Ga in the southern part of the Goiás Archean Block. Older model ages of up to 3.5 Ga for samples with low Sm/Nd ratios reported by Pimentel *et al.* (1996) in the Uvá Complex might also suggest an older event of crust accretion.

Table 2. Sm-Nd isotopic results.

Sample	Sm (ppm)	Nd (ppm)	$^{147}Sm/^{144}Nd$	$^{143}Nd/^{144}Nd$ (2-sigma)	ε(0)	T_{DM} (Ma)	Sample Location Lat	Long
APFA 2	1.411	5.758	0.1481	0.510886 (26)	-34.2	-	555422	8298126
APFA 3	1.486	7.163	0.1254	0.511045 (24)	-31.1	-	557583	8296587
APFA4	0.926	4.133	0.1354	0.511082 (25)	-30.3	-	0.557583	8296587
APFA 5	5.648	36.82	0.0927	0.510632 (19)	-39.1	3042	0.562987	8293947
APFA 10	3.842	23.47	0.0989	0.510774 (19)	-36.4	3018	0.576346	8281204
APFA 13	3.78	23.86	0.0957	0.510753 (20)	-36.8	2961	0.576346	8281204
APFA 14	2.166	12.42	0.1054	0.510918 (23)	-33.6	2997	0.586884	8262368
APFA 17	2.179	13.83	0.0952	0.510719 (18)	-37.4	2993	0.590986	8256457
APFA 16	2.142	13.83	0.0936	0.510783 (32)	-36.2	2868	0.590986	8256457
APGO 6	2.553	12.88	0.1198	0.511254 (20)	-27.0	2911	0.589878	8237408
APGO 8	2.754	14.18	0.1174	0.511119 (20)	-29.6	3058	0.587835	8239133
APGO 25	0.373	1.534	0.1470	0.511713 (22)	-18.0	3067	0.562785	8242051

Zircon concentrates were separated from a tonalitic gneiss in the Uvá complex (sample GOV-4) and from a leucogranite in the Caiçara complex (sample GOV-1). Analytical results are in Tables 3 and 4, respectively. Zircon grains in sample GOV-4 are well formed, prismatic, pink crystals, and present oscillatory zoning in cathodoluminescence images, typical of igneous grains. Th/U ratios are mostly between 0.17 and 0.88. One spot analysis (2.2), however, of an unzoned crystal showed much lower U/Th (0.04), typical of metamorphic zircon grains. Analytical points for high-U/Th grains are mostly concordant and the resulting weighted average $^{207}Pb/^{206}Pb$ age is 2934 ± 5 Ma (95% conf.) interpreted as the best estimate for the crystallization age of the protolith (Figure 3a). Spot analysis 9.1 yielded the much older $^{207}Pb/^{206}Pb$ age of 3092 ± 9 Ma, and the grain is here interpreted as a xenocryst assimilated by the original tonalitic magma. Spot 2.2 resulted in the concordant analytical point with the $^{207}Pb/^{206}Pb$ age of 2793 ± 3 Ma, interpreted as indicative of an Archean metamorphic event. Sm-Nd isotopic results for these rocks indicate Sm-Nd model ages between *ca.* 3.27 and 3.51 Ga (Pimentel *et al*. 1996) and ε_{Nd}(T) varying between +0.4 and –4.6, also indicating, therefore, assimilation of older continental material.

Zircon grains from leucogranite GOV-1 form stubby prisms displaying clear older cores surrounded by younger zircon, as indicated by the cathodoluminescence images (Figure 4). The cores typically show oscillatory zoning, brighter luminescence, produced by lower concentrations of U and Th (Table 4), whereas the overgrowths are darker, much richer in both Th and U, and also display oscillatory zoning, typical of igneous crystals. The overgrowths represent, therefore, magmatic zircon growth and should indicate the crystallization age of the host rock.

The cores yielded concordant to sub-concordant analyses, and the regression indicated the upper intercept age of 2893 ± 12 Ma (Figure 3b), whereas the magmatic overgrowths yielded concordant analyses with the weighted average $^{238}U/^{206}Pb$ age of 626 ± 7 Ma (95% conf.) (Figure 3c). Spot 7.2 (Figure 3b) did not align with the regression and was not included in the age calculation. It represents a high U (1372 ppm) possibly Archean overgrowth, showing strong Neoproterozoic as well as younger (recent?) Pb-loss events. The age of 626 Ma for the igneous rims is interpreted as indicative of the crystallization of the leucogranite, and the age of the cores is considered to be the best estimate for the igneous crystallization of the magma source rock, being only marginally younger than the GOV-4 tonalite. Sm-Nd analyses of this leucogranite (APFA-16, APFA-17; Table 2) indicate T_{DM} values of 2.87 and 2.99 respectively, and strongly negative ε_{Nd}(T = 626) values of – 28.0 and –29.0, indicating

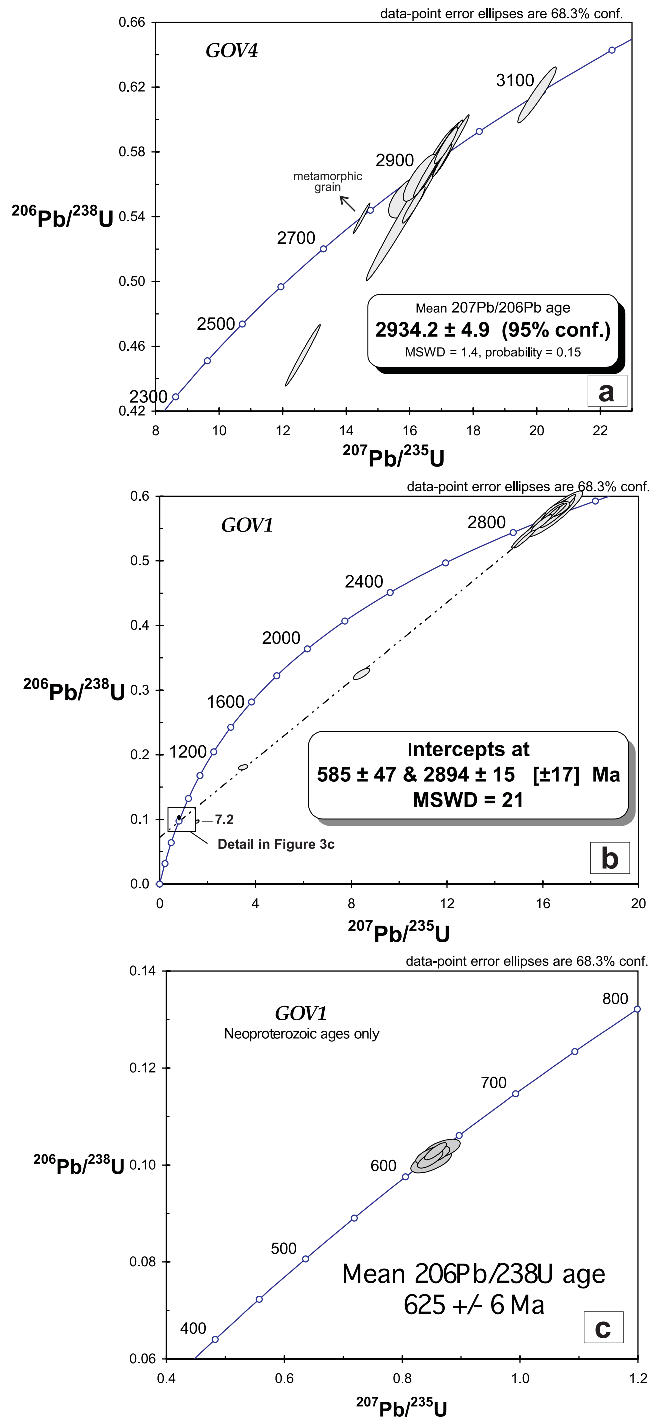

Figure 3. U-Pb concordia diagrams: **a.** GOV-4 – tonalitic gneiss of the Uvá Complex; **b.** Archean cores of GOV-1 leucogranite; **c.** igneous overgrowths of GOV-1 leucogranite.

Table 3. Summary of SHRIMP U-Th-Pb zircon results of sample GOV-4.

							Radiogenic Ratios						Ages (in Ma)						
Grain. spot	U (ppm)	Th (ppm)	Th/U	Pb* (ppm)	$^{204}Pb/^{206}Pb$	f_{206} %	$^{206}Pb/^{238}U$	±	$^{207}Pb/^{235}U$	±	$^{207}Pb/^{206}Pb$	±	$^{206}Pb/^{238}U$	±	$^{207}Pb/^{235}U$	±	$^{207}Pb/^{206}Pb$	±	Conc. %
1.1	321	269	0.84	222	0.000048	0.06	0.5564	0.0069	16.357	0.225	0.2132	0.0010	2852	29	2898	13	2930	8	97
1.2	26	6	0.24	16	0.000328	0.43	0.5522	0.0085	15.931	0.406	0.2093	0.0039	2834	35	2873	25	2900	30	98
2.2*	1030	45	0.04	578	0.000017	0.02	0.5393	0.0061	14.569	0.171	0.1959	0.0004	2781	26	2788	11	2793	3	100
3.1	89	22	0.24	57	0.000126	0.17	0.5798	0.0111	16.975	0.367	0.2123	0.0017	2948	45	2933	21	2924	13	101
4.1	278	79	0.28	170	0.000095	0.12	0.5493	0.0323	16.087	0.970	0.2124	0.0017	2822	136	2882	59	2924	13	97
5.1	335	171	0.51	229	0.000040	0.05	0.5878	0.0082	17.292	0.256	0.2134	0.0008	2980	33	2951	14	2931	6	102
6.1	196	152	0.78	139	0.000069	0.09	0.5798	0.0071	17.101	0.224	0.2139	0.0007	2948	29	2941	13	2936	5	100
7.1	184	32	0.17	109	0.000113	0.15	0.5473	0.0075	16.111	0.239	0.2135	0.0009	2814	31	2883	14	2932	7	96
8.1	62	19	0.31	39	0.000919	1.20	0.5641	0.0095	16.322	0.350	0.2099	0.0024	2883	39	2896	21	2905	18	99
9.1*	74	35	0.48	53	0.000099	0.13	0.6158	0.0114	20.022	0.403	0.2358	0.0014	3093	46	3092	20	3092	9	100
10.1*	154	72	0.47	81	0.000018	0.02	0.4542	0.0127	12.611	0.362	0.2014	0.0009	2414	56	2651	27	2837	7	85
11.1	110	46	0.42	72	0.000119	0.16	0.5685	0.0107	16.613	0.328	0.2119	0.0009	2902	44	2913	19	2920	7	99
12.1	199	72	0.36	130	0.000126	0.17	0.5759	0.0070	17.052	0.223	0.2147	0.0008	2932	29	2938	13	2942	6	100
13.1	130	41	0.32	85	0.000053	0.07	0.5845	0.0124	17.292	0.379	0.2146	0.0008	2967	51	2951	21	2940	6	101
14.1	307	263	0.86	220	0.000038	0.05	0.5751	0.0066	17.023	0.205	0.2147	0.0005	2929	27	2936	12	2941	4	100
14.2	215	189	0.88	158	0.000047	0.06	0.5845	0.0075	17.144	0.241	0.2127	0.0010	2967	30	2943	14	2926	7	101

Notes: 1. Uncertainties given at the one σ level; **2.** f_{206} % denotes the percentage of ^{206}Pb that is common Pb; **3.** Correction for common Pb made using the measured $^{204}Pb/^{206}Pb$ ratio; **4.** For % Conc., 100% denotes a concordant analysis; **5.** * not included in age calculation. Zircon grains form a homogeneous population of short, prismatic and pink coloured crystals.

Table 4. Summary of SHRIMP U-Th-Pb zircon results of sample GOV-1.

							Radiogenic Ratios						Ages (in Ma)						
Grain. spot	U (ppm)	Th (ppm)	Th/U	Pb* (ppm)	$^{204}Pb/^{206}Pb$	f_{206} %	$^{206}Pb/^{238}U$	±	$^{207}Pb/^{235}U$	±	$^{207}Pb/^{206}Pb$	±	$^{206}Pb/^{238}U$	±	$^{207}Pb/^{235}U$	±	$^{207}Pb/^{206}Pb$	±	Conc. %
1.1c	66	47	0.71	45	0.000337	0.45	0.5669	0.0114	16.442	0.372	0.2104	0.0018	2895	47	2903	22	2908	14	100
2.1c	83	49	0.59	53	0.000169	0.22	0.5367	0.0117	15.247	0.357	0.2060	0.0013	2770	49	2831	23	2875	10	96
3.1c	124	79	0.64	79	0.000073	0.10	0.5332	0.0095	15.260	0.289	0.2076	0.0009	2755	40	2832	18	2887	7	95
4.1c	64	32	0.50	23	0.000856	1.13	0.3240	0.0057	8.451	0.211	0.1892	0.0030	1809	28	2281	23	2735	26	66
5.1c	97	51	0.52	66	0.000108	0.14	0.5846	0.0110	16.844	0.344	0.2090	0.0013	2968	45	2926	20	2898	10	102
6.1c	90	56	0.62	59	0.000156	0.21	0.5576	0.0086	15.963	0.275	0.2076	0.0013	2857	35	2875	17	2887	10	99
7.1c	56	31	0.55	38	0.000087	0.12	0.5782	0.0078	16.610	0.347	0.2084	0.0030	2941	32	2913	20	2893	23	102
7.2r	1372	277	0.20	134	0.004830	6.37	0.0954	0.0013	1.580	0.050	0.1202	0.0033	587	7	963	20	1958	49	30
8.1r	270	205	0.76	31	0.000137	0.24	0.1019	0.0013	0.851	0.019	0.0606	0.0010	625	7	625	10	625	36	100
8.2c	32	8	0.26	20	0.000436	0.58	0.5753	0.0143	16.604	0.488	0.2093	0.0027	2930	59	2912	29	2900	21	101
9.1r	778	335	0.43	82	0.000109	0.19	0.1027	0.0012	0.855	0.012	0.0604	0.0005	630	7	628	7	619	17	102
9.2c	129	81	0.63	87	0.000094	0.12	0.5689	0.0093	16.300	0.280	0.2078	0.0007	2903	38	2895	17	2889	6	101
10.1r	673	119	0.18	124	0.001721	2.51	0.1799	0.0026	3.510	0.129	0.1416	0.0046	1066	14	1530	30	2246	57	48
11.1r	527	202	0.38	54	0.000119	0.21	0.1010	0.0012	0.846	0.014	0.0608	0.0007	620	7	623	8	631	24	98
11.2c	10	3	0.34	6	0.000554	0.73	0.5714	0.0233	16.499	0.768	0.2094	0.0038	2914	96	2906	46	2901	30	100
12.1r	241	182	0.75	27	0.000131	0.23	0.1006	0.0016	0.848	0.023	0.0612	0.0012	618	9	624	13	646	44	96
13.1c	122	74	0.61	83	0.000050	0.07	0.5742	0.0089	16.557	0.274	0.2092	0.0009	2925	37	2910	16	2899	7	101
14.1c	79	39	0.49	52	0.000139	0.18	0.5735	0.0091	16.420	0.297	0.2077	0.0015	2922	37	2902	17	2887	11	101
15.1r	336	319	0.95	41	0.000088	0.16	0.1031	0.0013	0.866	0.021	0.0609	0.0011	633	8	634	11	637	40	99

Notes: 1. Uncertainties given at the one σ level; **2.** f_{206} % denotes the percentage of ^{206}Pb that is common Pb; **3.** Correction for common Pb made using the measured $^{204}Pb/^{206}Pb$ ratio; **4.** For % Conc., 100% denotes a concordant analysis. Zircon crystals are short, prismatic and pink coloured, forming a homogeneous population (**c -** core; **r -** rim).

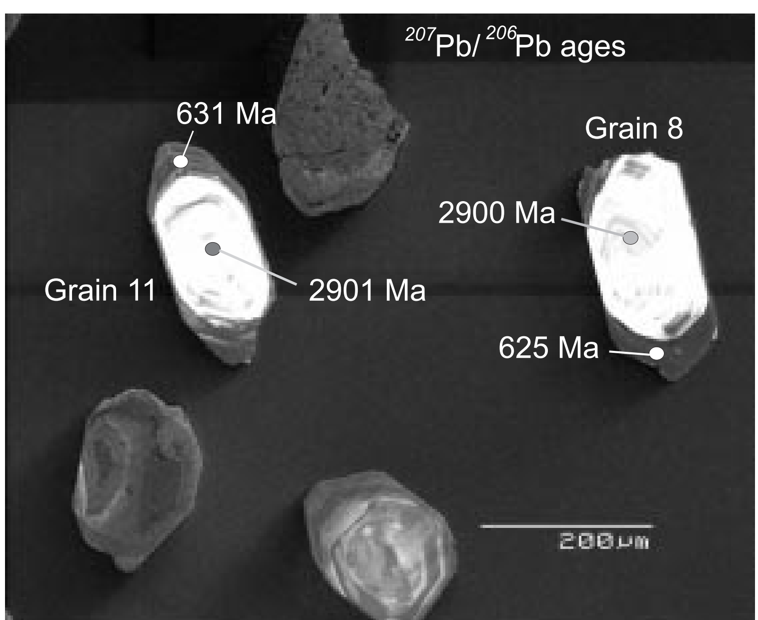

Figure 4. Cathodoluminescence image of zircon grains from sample GOV-1.

that most of the Nd in this rock is derived from the Archean source, and re-enforcing that the leucogranite original magma was formed by partial melting of a *ca.* 2.9 Ga old juvenile crustal rock.

The SHRIMP U-Pb analyses of zircon grains from rocks of the Caiçara and Uvá complexes yielded ages which are significantly different from those reported in previous Rb-Sr studies. A Rb-Sr isochron for rock samples of GOV-4 outcrop indicated the age of *ca.* 2.56 Ga (Pimentel *et al.*, 1996), which is significantly younger than the U-Pb age and might indicate re-setting of the Rb-Sr system. On the other hand, a whole-rock Rb-Sr "errorchron" showing considerable scatter of the analytical points, for rock samples from GOV-1 outcrop, indicated the age of *ca.* 2.67 Ga (Tomazzoli, 1992), suggesting that it might represent a mixing line.

CONCLUSIONS

Crystallization ages between 2.93 and 2.89 Ga of the Uvá tonalite gneiss and of the source rock of the leucogranite in the Caiçara Complex indicate that Archean igneous events which are older than those found in the northern part of the Goiás Archean Block are well represented in the southern complexes. Zircon inheritance in the Uvá tonalitic gneiss, associated with negative ε_{Nd} (T) values, reveal the presence of even older rocks in the Uvá complex. One analysed metamorphic zircon grain in that rock indicates an Archean metamorphic event at *ca.* 2.79 Ga, which might be equivalent to the *ca.* 2.71 Ga old metamorphic episode described by Queiroz (2000) in the Crixás-Açu gneiss, based on titanite analyses.

The igneous overgrowth on zircon grains of the leucogranite exposed just north of the Serra de Santa Rita greenstone belt suggests that the rock crystallized at *ca.* 626 Ma ago, during the final stages of the Brasiliano Cycle, due to re-melting of Archean crustal rocks. The overgrowths are fine (< 50 µm) and cores are well preserved and could be dated at 2893 ±12 Ma. The Neoproterozoic age of the leucogranite is similar to the SHRIMP and conventional U-Pb ages of 624 ± 10 Ma and 620 ± 5 Ma, respectively, for alkali granite and quartz syenite of the Itapirapuã granite suite, exposed just to the north, in the vicinities of Itapirapuã (Pimentel *et al.*, 2001, 2002).

This Brasiliano magmatic event, considered to be of syntectonic nature, is widespread in the central part of the Brasília Belt (Piuzana *et al.*, 2002, Pimentel *et al.*, 2002), and is here reported for the first time within the Goiás Archean Block.

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