


U-Pb SHRIMP dating of the Itabaiana Dome: a Mesoarchean basement inlier (2.83 Ga) in the Sergipano Orogenic System, Borborema Province

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Abstract

In the southern portion of the Borborema Province, in the Sergipano Orogenic System, three basement inliers have been described: the Domes of Itabaiana and Simão Dias, in Sergipe; and the Girau do Ponciano Dome, in Alagoas. The Itabaiana and Simão Dias Domes occur in the central part of the Vaza Barris Domain, being composed of gneisses and migmatites. The Itabaiana rocks are calc-alkaline with trondhjemitic affinities. The Girau do Ponciano Dome, outcropping in the Macururé Domain, consists mainly of tonalitic, dioritic, monzonitic, granodioritic and high-grade granitic orthogneisses. SHRIMP U-Pb zircon date of a melanosome sample from a trondhjemitic migmatitic gneiss in the central part of Itabaiana Dome provided an age of 2831 ± 6 Ma, indicating that the migmatitic gneisses of this dome are correlated to the Mesoarchean terranes of the São Francisco Craton (Serrinha Block). These rocks represent the oldest geological record in the Sergipe State.

KEYWORDS: geochronology; trondhjemite; Sergipano Orogenic System basement.

Introduction

The structure of orogenic systems involves complex tectonic assembly of different crustal blocks to result in collages of allochthonous terrane separates from the cratons in which they originated (Friend *et al.* 2008). Three structurally distinct terrane are identified in the Sergipe State:

- São Francisco Craton (SFC);
- Borborema;
- Coastal and Continental Margin.

The SFC comprises the Southern and Central area of Sergipe State, being represented by granulites and migmatitic grey gneisses, compositionally ranging from tonalite to granite, that are correlated to the Santa Luz and Rio Real complexes (Teixeira 2014). The granulitic rocks are formed by opdalite and charnockites, formerly grouped in the Atlantic Belt, and currently called Salvador-Esplanada-Boquim Mobile Belt (Oliveira 2014) or Salvador-Esplanada Complex (Teixeira 2014).

The Borborema Province in Sergipe is represented by the Sergipano Orogenic System (SOS), which is formed by a set of ESE-WNW trending belts with distinct geological

histories, placed between the São Francisco Craton in the South and the Pernambuco-Alagoas Superterrane Northwards (Santos *et al.* 1998, Oliveira *et al.* 2017, Brito Neves and Silva Filho 2019). The SOS is one of the most important Neoproterozoic orogens of Northeastern Brazil, being interpreted as the result of a collision between the Pernambuco-Alagoas Superterrane and the São Francisco paleoplate during the Brazilian/Pan-African Orogeny (Oliveira *et al.* 2010, 2017; Fig. 1). The SOS is essentially composed of Neoproterozoic rocks (D'el-Rey Silva 2005, Oliveira *et al.* 2017), and fragments of the anorogenic Tonian terrains (Oliveira *et al.* 2010, 2017). An expressive volume of acidic and subordinate intermediate to basic rocks intruded the metasedimentary rocks (Santos *et al.* 1998). Anchimetamorphic rocks make up the Estância and Vaza-Barris domains outcrops in the Southern area of the SOS, while in the Northern and Central regions at the Macururé, Marancó, Poço Redondo and Canindé domains (Fig. 1) the metamorphism reaches the amphibolite facies.

The presence of "structural windows" or "basement inliers" in the SOS was first proposed by Brito Neves *et al.* (1977) based on geological petrological arguments, and in the continuity of regional orientations.

In the Sergipe State, the Itabaiana and Simão Dias Domes are basement inliers made up of gneisses and migmatites which occur exposed in the central portion of the Vaza-Barris Domain (Fig. 1). Van Schmus *et al.* (1995) obtained Sm-Nd T_{DM} model ages of 2.75 Ga (Itabaiana Dome) and of 2.99 Ga (Simão Dias Dome). Zircon grains from a migmatite leucosome from the Itabaiana Dome were dated (U-Pb, LA-ICP-MS) at 2729 ± 12 Ma (MSWD = 1.4) by Santiago *et al.* (2017).

The Girau do Ponciano Dome, located in the Alagoas State, outcrops in the Northern sector of the Macururé

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Domain (Fig. 1) and is composed of tonalitic, dioritic, monzonitic, granodioritic and high-grade granitic orthogneisses, presumably of Archean age. Mendes and Brito (2016) obtained a T_{DM} Sm-Nd model age of 2.8 Ga for this dome.

The aim of this paper was to report a new age obtained from recent dating of the Itabaiana Dome basement inlier in the SOS. This age was obtained by using the U-Pb technique in single zircon, using Sensitive High Resolution Ion Microprobe

(SHRIMP) in a melanosome sample from a migmatitic gneiss from the central part of the dome.

Itabaiana Dome

The Itabaiana Dome stands out in the flat regional relief, with elevation up to 670 m. It shows a N50° elongated shape (Fig. 2), extending 45 km long by 30 km wide (Humphrey

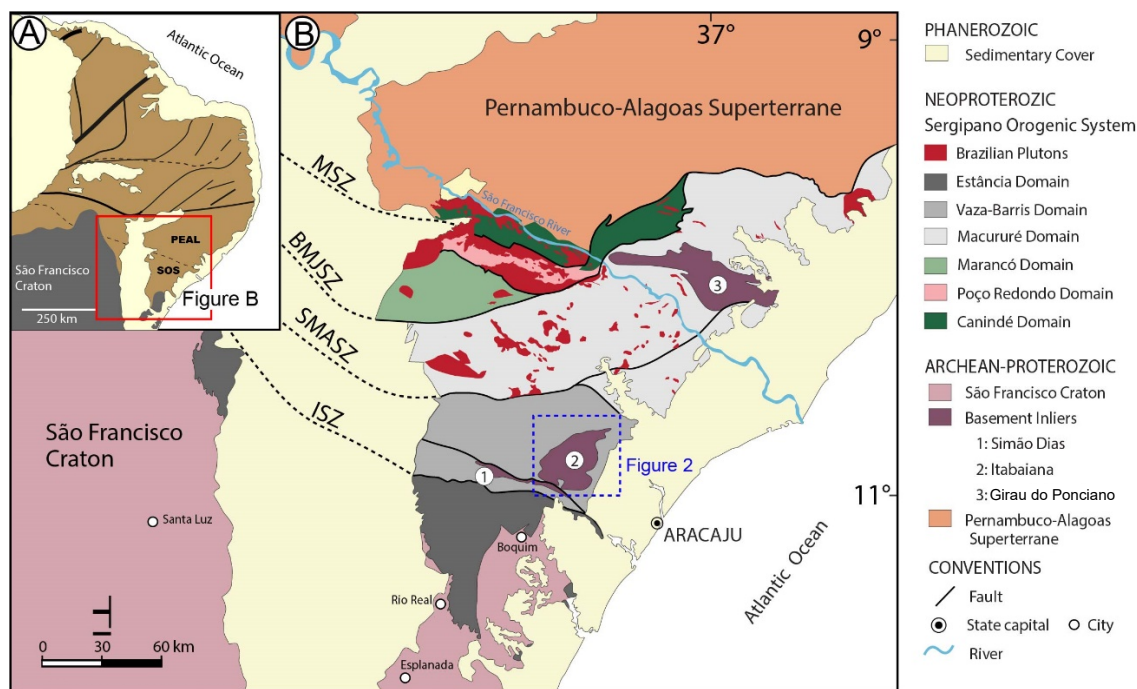


Figure 1. (A) Scheme of the Borborema Province, according to Van Schmus et al. (1995). (B) Geological scheme of the southern portion of Borborema Province, showing the geological domains of the Sergipano Orogenic System (adapted from Davison and Santos 1989). Macururé (MCZ), Belo Monte-Jeremoabo (BMJZC), São Miguel do Aleixo (SMACZ), Itaporanga (ICZ) shear zones, Pernambuco-Alagoas Superterrane (PEAL).

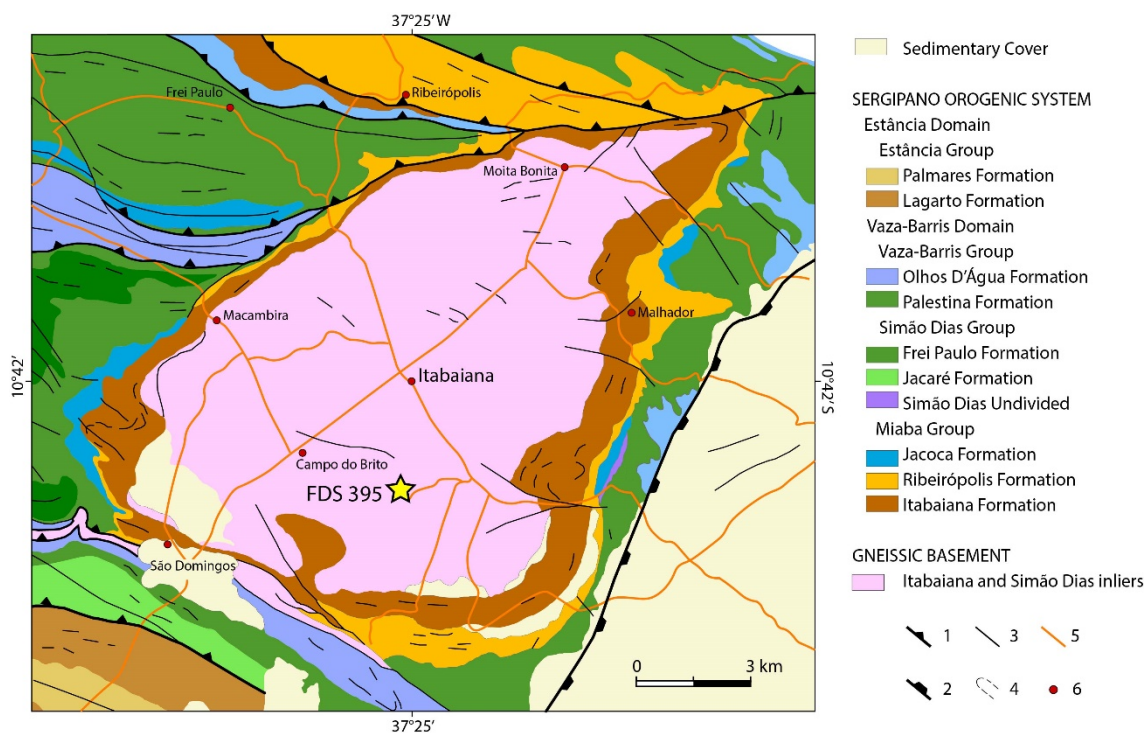


Figure 2. Geological map of the Itabaiana Dome region (Teixeira 2014). The yellow star indicates the location of the dated outcrop, sample FDS-395.

and Allard 1969). It is in fault contact with the quartzites of the Miaba Group, Vaza Barris Domain. Banded gneisses constitute the core of the dome, showing local partial melting features that originate migmatites. The gneisses have granodiorite, tonalite and granite compositions, with amphibolite lenses. These rocks are leucocratic to mesocratic, medium-to coarse grain size, granoblastic textures with feldspar phenocrysts/phenoblasts (< 3 cm). Biotite, ilmenite and magnetite are the mafic minerals. Hornblende, andesine and oligoclase are the main constituents of amphibolites that have coarse granulation and lepidoblastic texture.

Outcrops of the Itabaiana rocks occur in road cut slopes and in the rivers. The best expositions are located in local quarries, especially in the Anhanguera Quarry (Fig. 2).

These rocks have calc-alkaline and trondhjemitic affinities (Santiago *et al.* 2017) showing geochemical resemblance to the Paleoproterozoic and Archean Tonalite-trondhjemitic-granodiorite rocks (TTGs) of the SFC (*e.g.*, Cruz Filho *et al.* 2003, Oliveira *et al.* 2019).

Materials and Methods

A representative sample of the Itabaiana Dome was collected in the Anhanguera Quarry for geochronology purpose (FDS-395; UTM coordinates 671138E/88809332N). It corresponds to the melanosome of a migmatitic gneiss of trondhjemitic composition. The medium-grained grey melanosome is composed of oligoclase (64%), quartz (26%), microcline (3%), biotite (7%) and accessory minerals (zircon, ilmenite, magnetite, apatite). More homogeneous portions in this outcrop have a light grey color, probably reflecting a higher degree of melting.

About 5 kg of melanosome were crushed down to fragments close to 3 cm. The entire sample was ground to 60 mesh using a pan mill. A shaking table was used to concentrate heavy minerals. This concentrate was taken to a Frantz® isodynamic magnetic separator, applying 0.5, 1.0, 1.5 and 2.0 A. The non-magnetic fraction constituents were separated using bromoform (CHBr_3 ; $d = 2.89 \text{ g/cm}^3$) and diiodomethane (CH_2I_2 ; $d = 3.32 \text{ g/cm}^3$). At the end of the process, the zircon crystals were manually separated under a binocular microscope.

About 70 zircon crystals were selected for the analysis in the Geochronology Research Center, Institute of Geosciences, Universidade de São Paulo. Crystals were assembled in an epoxy resin circular mount, 2.5 cm in diameter. This mount was polished until the zircon grain cores were revealed. It was then coated with gold for scanning electron microscope imaging by the backscattered, secondary and cathodoluminescence electron detectors. The mount was repolished to remove the gold coating, leaving the material ready for U-Pb analysis on zircon crystals, in a SHRIMP IIe® equipment. Analytical procedures, as well as part of the reductions, were performed according to Sato *et al.* (2014). Grains of different habits and colors were analysed in a search for zircon different populations in the trondhjemitic melanosome.

Data reduction was performed using the SQUID 1.06 and ISOPLOT4 softwares (Ludwig 2002). Uranium, lead and thorium concentrations were referenced to the TEMORA 2 standard zircon (Black *et al.* 2003) and the equipment spot adjusted to a diameter of 30 μm . To determine the age, it was taken in consideration the low discordance ($\leq 5\%$), common lead content ($\leq 1.5\%$) and not more than 7% individual ratio errors.

Results and Discussion

Twelve brown, prismatic crystals (Fig. 3), ~ 0.3 mm in diameter, were analyzed (Tab. 1). They show oscillatory zoning and are inclusions free. A $2836 \pm 15 \text{ Ma}$ (MSWD = 2.0; Fig. 4A) discordant age was calculated. Four grains (2.1; 3.1; 6.1; 8.1) are concordant (Fig. 4B), resulting in an age of $2831 \pm 6 \text{ Ma}$ (MSWD = 0.86). The absolute ages obtained by these two calculations are equal (2.83 Ga), varying only the error intervals.

The Th/U ratios of the analyzed crystals range between 0.32 and 0.80. These crystals show textures indicative of magmatic origin (*e.g.*, Corfu *et al.* 2003). The hypothesis of magmatic crystals is corroborated by Th/U ratios greater than 0.1 like as to those described in the literature (Rubatto 2002).

The Mesoarchean age of Itabaiana Dome obtained in this work is the oldest already obtained for rocks in the Sergipe State. This record is almost 100 Ma older than the previous 2729 Ma age of the leucosome rock from this same dome Santiago *et al.* (2017). In this context, the age of 2.7 Ga obtained by these authors probably indicates the migmatization of the rocks, while the 2.83 Ga age obtained in this work represents the crystallization age of the protolith.

According to Mascarenhas (1979), the Archean to Paleoproterozoic structure of the SFC is marked by Archean nuclei surrounded by granulitic belts. The Archean nuclei, essentially constituted by gneisses and migmatites, are named Serrinha in the East (Mascarenhas 1979, Rios *et al.* 2009, Barbosa *et al.* 2012); Remanso/Lençóis/Gavião in the central portion of the craton (Mascarenhas 1979, Barbosa *et al.* 2012, Fernandes *et al.* 2019), and Guanambi to the West (Mascarenhas 1979, Rosa *et al.* 2000, Barbosa *et al.* 2012). Paleoproterozoic orogenic systems surround these Archean nuclei: these are the granulitic belts of Itabuna-Salvador-Curaçá (Mascarenhas 1979, Barbosa *et al.* 2012), which separates the Serrinha and Remanso nuclei, and Urandi-Paratinga in the West (Rosa *et al.* 2000), which separates the Remanso and Guanambi nuclei.

A summary of the available geochronological data for rocks from the Northeastern sector of the SFC is presented in Table 2. The youngest ages (2.4 to 2.6 Ga), present in the Esplanada-Boquim Granulitic Complex, are similar to those obtained in rocks of the Itabuna-Salvador-Curaçá Orogen. These ages record a granulitic metamorphic episode, described by several authors (Silva *et al.* 2002, Santiago *et al.* 2017). In the Uauá Complex, Oliveira *et al.* (2019) report an age of 3120 Ma from an igneous protoliths of the mafic granulite that reached the metamorphic equilibrium about 2820 Ma ago. The available ages for the rock units of the Northern part of the SFC, Uauá

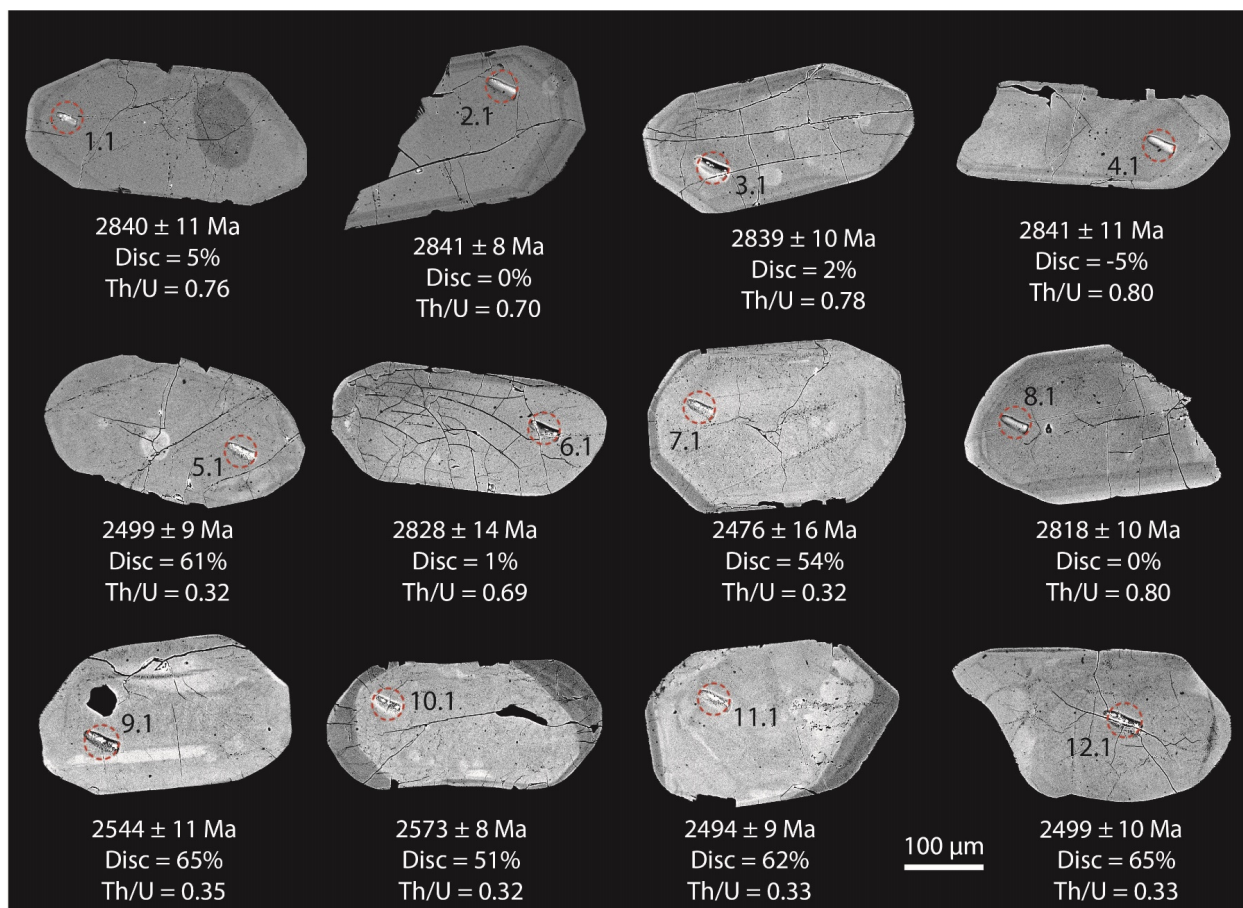


Figure 3. Backscattered electron images (BSE) of zircons of sample FDS-395 from Itabaiana Dome. The figure also shows the position of the analyzed spots listed in Table 1.

Table 1. Summary of U-Pb Sensitive high-resolution ion microprobe (SHRIMP) data in migmatitic trondhjemitic gneiss zircon crystals of the Itabaiana Dome.

Spot	f_{206}^a	$^{232}\text{Th}/^{238}\text{U}^b$	Isotopic ratios							Age (Ma)		
			$^{207}\text{Pb}/^{206}\text{Pb}^d$	1σ	$^{207}\text{Pb}/^{235}\text{U}$	1σ	$^{206}\text{Pb}/^{238}\text{U}$	1σ	Rho ^e	$^{206}\text{Pb}/^{238}\text{U}$	$^{207}\text{Pb}/^{206}\text{Pb}$	%Disc ^f
1.1	0.048	0.76	0.2017	0.6	14.4246	2.3	0.5188	2.2	0.960	2694 ± 49	2840 ± 11	5
2.1*	0.030	0.70	0.2018	0.5	15.3267	2.3	0.5509	2.2	0.976	2829 ± 51	2841 ± 8	0
3.1*	0.072	0.78	0.2015	0.6	15.0460	2.5	0.5415	2.4	0.966	2790 ± 54	2839 ± 10	2
4.1	0.079	0.80	0.2018	0.6	16.3501	2.4	0.5875	2.3	0.961	2979 ± 54	2841 ± 11	-5
5.1	0.117	0.32	0.1641	0.6	6.1419	2.4	0.2714	2.3	0.972	1548 ± 32	2499 ± 9	61
6.1*	0.399	0.69	0.2002	0.8	14.9344	2.4	0.5411	2.2	0.936	2788 ± 50	2828 ± 14	1
7.1	0.538	0.32	0.1619	1.0	6.3428	2.5	0.2841	2.3	0.922	1612 ± 33	2476 ± 16	54
8.1*	0.094	0.80	0.1990	0.6	15.0849	2.5	0.5498	2.4	0.967	2824 ± 55	2818 ± 10	0
9.1	0.113	0.35	0.1686	0.6	6.2617	2.2	0.2694	2.2	0.957	1538 ± 29	2544 ± 11	65
10.1	0.109	0.32	0.1716	0.5	7.1358	2.2	0.3016	2.2	0.975	1699 ± 32	2573 ± 8	51
11.1	0.044	0.33	0.1637	0.5	6.0753	2.3	0.2692	2.2	0.974	1537 ± 30	2494 ± 9	62
12.1	0.147	0.33	0.1642	0.6	5.9920	2.3	0.2647	2.2	0.966	1514 ± 30	2499 ± 10	65

^aPercentage of non-radiogenic ^{206}Pb ; ^bTh/U ratio and calculated Pb. Th and U concentration relative to reference zircon SL13; ^cratios normalized to the value equivalent to the reference age for TEMORA 2 zircon; ^derror correlation defined as the ratio of propagated errors of ratios $^{206}\text{Pb}/^{238}\text{U}$ and $^{207}\text{Pb}/^{235}\text{U}$; ^ecommon Pb corrected based on Stacey & Kramers (1975) lead composition model; ^fdegree of discordance; *Spots considered when calculating age.

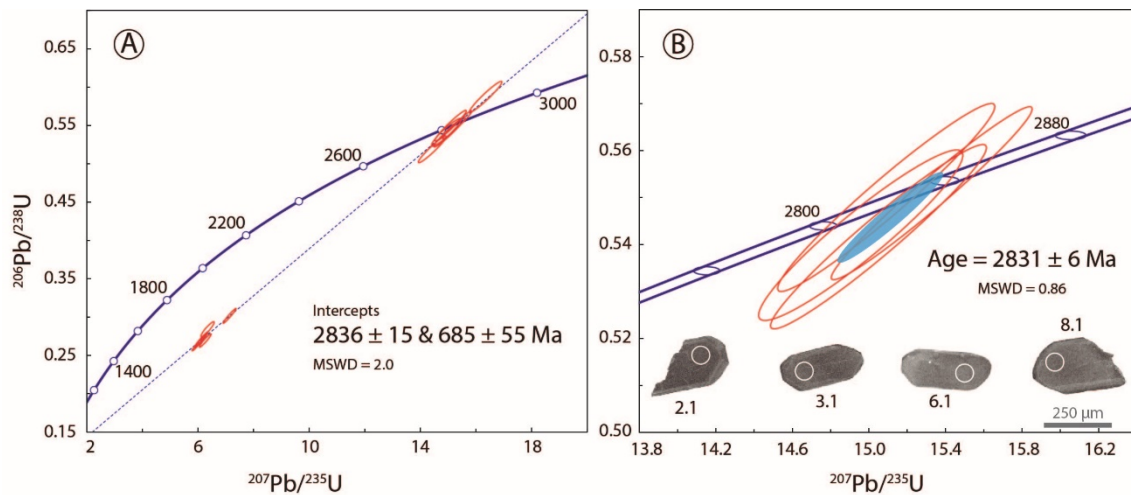


Figure 4. Concordia diagrams for the melanosome zircon crystals of migmatitic gneiss of trondhjemitic composition in the Itabaiana Dome. The ages and ellipses of error are presented in 2σ of uncertainty. (A) Discordia age. (B) Concordia Age. The blue ellipse corresponds to the age calculated from the concordant crystals.

Table 2. Compilation of geochronological data from Archean rocks of the northeastern part of the São Francisco Craton in the states of Sergipe and Bahia.

Geologic unit	Pluton or area	Age (Ma)/ T_{DM} (Ga)	Reference
Salvador-Esplanada Belt	Aporá Gneiss	2924 ± 25	Silva <i>et al.</i> (2002)
	Maracanã Gneiss	3025 ± 13	Rios <i>et al.</i> (2009)
Uauá Complex	Uauá Area/Mafic Granulite (I)	3127 ± 14	Oliveira <i>et al.</i> (2019)
	Uauá Area/Mafic Granulite (M)	2819 ± 14	Oliveira <i>et al.</i> (2019)
Santa Luz Complex	Valente Gneiss	3102 ± 5	Rios <i>et al.</i> (2009)
Paleoproterozoic Magmatism	Morro do Afonso Syenite (X)	2641 ± 4	Rios <i>et al.</i> (2009)
	Poço Grande Granite	2645 ± 70	Melo <i>et al.</i> (1995)
Esplanada Boquim Granulitic Complex	Pedrinhas Area	2473 ± 13/(2.6 Ga)	Oliveira (2014)
	Boquim Area	2582 ± 11/(2.9 Ga) 2683 ± 13	Oliveira (2014)

T_{DM} : Sm-Nd age of depleted mantle extraction; I: igneous zircon cores; M: metamorphic zircon rims; X: xenocrystals age.

and Santa Luz Complexes (Serrinha Block) are Mesoarchean (Tab. 2) and therefore comparable to those obtained for the Itabaiana Dome.

Conclusion

The U-Pb SHRIMP age of 2831 ± 6 Ma obtained from melanosome zircon grains of a trondhjemitic migmatitic gneiss of the Itabaiana Dome represents the oldest geological record in the Sergipe State. This age and the presence of a tonalitic-trondhjemitic-granitic magmatism make it possible to correlate this structural window with the Archean Serrinha Block in the SFC.

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