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Geochemistry, U–Pb geochronology, Sm–Nd and O isotopes of ca. 50 Ma long Ediacaran High-K Syn-Collisional Magmatism in the Pernambuco Alagoas Domain, Borborema Province, NE Brazil

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ABSTRACT

The Pernambuco Alagoas (PEAL) domain shows the major occurrence of granitic batholiths of the Borborema Province, NE Brazil, with Archean to Neoproterozoic range of Nd T_{DM} model ages, giving clues on the role of granites during the Brasiliano orogeny. SHRIMP U/Pb zircon geochronological data for seven granitic intrusions of the PEAL domain divide the studied granitoids into three groups: 1) early-to syn-collision granitoids with crystallization ages ca. 635 Ma (Serra do Catú pluton), 2) syn-collision granitoids with crystallization ages 610–618 Ma (Santana do Ipanema, Água Branca, Mata Grande and Correntes plutons) and 3) late-to post-collision granitoids with ages of ca. 590 Ma (Águas Belas, and Cachoeirinha plutons). The intrusions of group 1 and 2, except the Mata Grande and Correntes plutons, show Nd T_{DM} model ages ranging from 1.2 to 1.5 Ga, while the granitoids from group 3, and Mata Grande Pluton and Correntes plutons have Nd T_{DM} model ages ranging from 1.7 to 2.2 Ga. The studied granitoids with ages <600 Ma are high-K, calc-alkaline, shoshonitic and those with ages <600 Ma are transitional high-K calc-alkaline to alkaline. The volcanic arc signatures associated with the Paleoproterozoic Nd T_{DM} model ages are interpreted as inherited from the source rocks. The oldest ages and lower Nd T_{DM} model ages are recorded from granitoids intruded in the southwest part of the PEAL domain, suggesting that these intrusions are associated with slab-tearing during convergence between the PEAL and the Sergipano domains. Zircon oxygen isotopic data in some of the studied plutons, together with the available Nd isotopic data suggest that the Brasiliano orogeny strongly reworked older crust, of either Paleoproterozoic or Tonian ages. The studied granitoids are coeval with calc-alkaline granitoids of the Transversal Zone and Sergipano domains and rare high-K calc-alkaline granitoids from the Transversal Zone domain. Such large volumes of high-K granitoids with crystallization ages older than 600 Ma are not recorded in the Transversal Zone domains, suggesting that at least between 600 and 650 Ma, the granitic magmatism of these two areas were distinct. However, the studied granitoids (630–580 Ma) located in the north part of the PEAL domain, north of the Palmares shear zone are coeval with granitoids of similar geochemical compositions in the Transversal Zone domain. It suggests that the southeastern part of the Transversal Zone and the northern part of the PEAL domains belonged to the same crustal block during the Brasiliano/Pan-African orogeny.

1. Introduction

The Borborema Province in NE Brazil is part of the West Gondwana margin (Brito Neves et al., 2000; Van Schmus et al., 2011) (Fig. 1). It is located between the West Africa-São Luis craton to the north, the Parnaíba basin to the west, and the São Francisco-Congo craton to the south in various pre-drift

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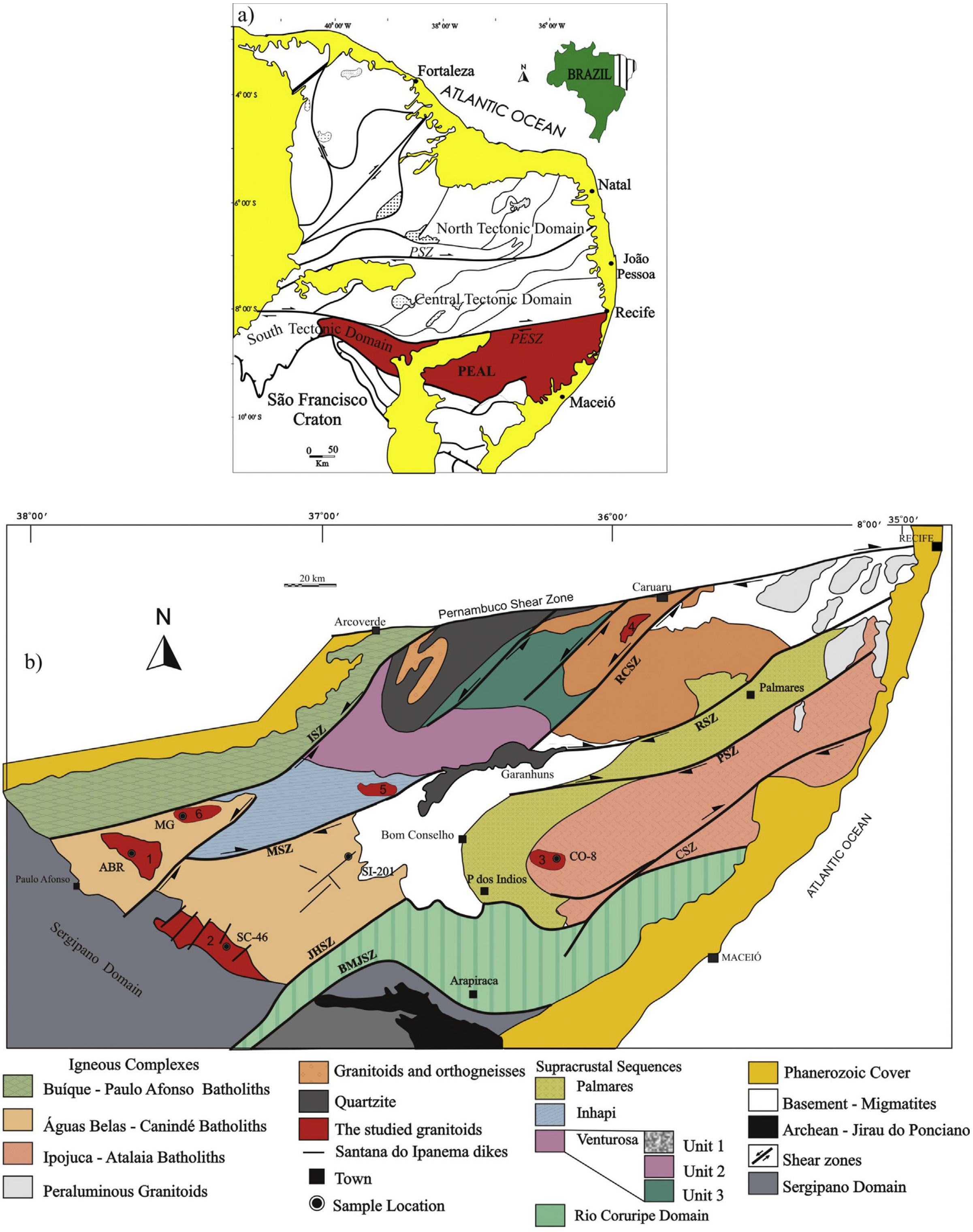

MODIFIED FROM: GOMES (2002), MARINHO (2004), MENDES (2013)

Fig. 1. a) Geological map of the Borborema Province with tectonic domains (Van Schmus et al., 2008). PEAL stands for Pernambuco-Alagoas Domain; b) Simplified geological map of eastern part of PEAL domain (Silva Filho, 2004; Silva Filho et al., 2007; Mendes et al., 2009; Silva Filho et al., 2014a), showing the location of the samples analyzed by SHRIMP Shear zones; PSZ Palmares shear zone, MSZ Maravilha shear zone, RSZ Ribeirão shear zone, LSZ Limitão shear zone, RCSZ Rio da Chata shear zone, BMJSZ Belo Monte Jeremoabo shear zone, ISZ Itaíba shear zone, RSZ Ribeirão shear zone, CSZ Cajueiro shear zone. Granitic suites: 1 – Água Branca, 2 – Serra do Catú, 3 – Correntes, 4 – Cachoeirinha, 5 – Águas Belas, 6 – Mata Grande, 7 – Santana do Ipanema.

reconstructions (De Witt et al., 1988; Van Schmus et al., 1995, 2008, 2011; Toteu et al., 2001; Brito Neves et al., 2002; Santos et al., 2009). This province has been interpreted as the northern part of a large Paleoproterozoic continent (Van Schmus et al., 2008, 2011).

Geologic correlations between NE Brazil and west – central Africa have long been recognized (Caby, 1989; Castaing et al., 1993; Trompette, 1994; Neves, 2003; Archanjo et al., 2013). According to the geotectonic model of Van Schmus et al. (2008, 2011), the Borborema Province was created from the break-up of the Columbia supercontinent (Rogers and Santosh, 2002) during the late Mesoproterozoic to early Neoproterozoic. Guimarães et al. (2012) have presented evidence for a Tonian extensional event, within the central part of the Borborema Province.

The Borborema Province consists of gneissic and migmatitic basement complexes, mostly formed during Paleoproterozoic orogenic events (2.0–2.2 Ga), along with minor Archean blocks, all of which are partially covered by Mesoproterozoic to Neoproterozoic metasedimentary and metavolcanic rocks (Van Schmus et al., 1995; Brito Neves et al., 2001; Kozuch, 2003; Dantas et al., 2004; Neves et al., 2008). Break-up and extensional basins occurred locally during the Statherian (1.8–1.6 Ga). Sá et al. (2002) and Accioly (2000) reported A-type metagranitoids and meta-anorthosites emplaced at 1.6 Ga and 1.7 Ga respectively, within the Transversal Zone domain of the Borborema Province.

In addition to the Paleoproterozoic orogenic cycle present in the basement, the Borborema Province was affected by the Cariris Velhos (~1.0 Ga) and Brasiliano (650–580 Ma) events. The Cariris Velhos event is represented by metasedimentary sequences and bimodal metavolcanic rocks intruded by 990 Ma to 940 Ma granitic plutons (now augen-gneisses) (Kozuch, 2003; Santos et al., 2010; Guimarães et al., 2012). The Brasiliano event affected the entire Borborema Province and was responsible for low-to high-grade metamorphism, a great abundance of granitic intrusions, and development of continental-scale transcurrent shear zones.

According to plate tectonic model proposed by Oliveira et al. (2010), the Sergipano belt, located on the southwestern margin of the Borborema Province, was formed by the collision of the Pernambuco-Alagoas Domain in the north with the São Francisco Craton in the south. Convergence of the Pernambuco-Alagoas Domain and the São Francisco Craton led to deformation on the passive margins (southern boundary of the Pernambuco-Alagoas Domain) and granite emplacement in the Sergipano belt (at 628–621 Ma and 590–570 Ma).

Extensive granitic magmatism (about 30% of the exposed bedrock), including intense Neoproterozoic remobilization as well as juvenile Neoproterozoic input, along with large scale transcurrent shearing, affected the entire province during the Brasiliano Orogeny (650–550 Ma). The transcurrent shear zones occur as contemporaneous conjugate sets of sinistral, NE–SW striking and dextral, E–W striking, mylonitic belts developed under middle-to upper-amphibolite facies conditions (Neves et al., 2006).

The granitic magmatism played several major roles in the Cryogenian/Ediacaran (Brasiliano/Pan-African) tectonic history of the Borborema Province.

The southern part of the Borborema Province (Pernambuco-Alagoas Domain) shows the major occurrence of granitic batholiths (Fig. 1a), with a wide range of Nd T_{DM} model ages from Archean to Neoproterozoic (Silva Filho et al., 2002), giving clues on the role of granites during the assembly of Western Gondwana and on the paleogeography of this area. High-K granite suites, including shoshonitic ones, were selected for geochronological studies. The studied granitoids can probe the mantle and the lower to middle crust, giving the opportunity to have a glimpse on the isotopic signature of the mantle and/or the lower crust of the Pernambuco-Alagoas (PEAL) domain, from the Paleoproterozoic to the Neoproterozoic.

This paper presents new U–Pb and oxygen SHRIMP on zircon data, Sm–Nd and geochemical data on whole-rocks from seven high-K granitic intrusions. We also compare these with granitoids from other domains (Sergipano and Transversal Zone domains) of the Borborema Province. The aim of this paper is to contribute to better understanding of the crustal growth of the PEAL domain of the Borborema Province during the Brasiliano/Pan-African orogeny.

2. Geological aspects of the Pernambuco Alagoas Domain

The PEAL domain is one among the six crustal domains proposed by Van Schmus et al. (2008) in the Borborema Province (Fig. 1a). It is limited to the north by the Transversal Zone domain, and to the south by the Sergipano domain; its eastern part is intruded by large granitic batholiths (Fig. 1a). Medeiros and Santos (1998) recognized two metamorphic sequences in the PEAL domain: I) The Cabrobó Complex is a dominantly supracrustal unit composed of biotite garnet–biotite–gneisses that are locally migmatized and intercalated with quartzite, schist, calc-silicate, amphibolite, orthogneiss and migmatite. II) The Belém do São Francisco complex is an infra-crustal segment composed of migmatites, tonalitic orthogneisses, and leucogranodiorites to leucomonzogranites. The occurrence of a flat-lying foliation and a swarm of small granitic intrusions controlled by transpressive deformation, suggest that thrusting has operated in the area (Silva Filho et al., 2002). Geological and geochronological data collected in the past few years show that the PEAL domain is composed of Paleoproterozoic basement complexes (Neves et al., 2005; Osako, 2005), three Proterozoic supracrustal sequences, and three Neoproterozoic granitic batholiths (Silva Filho et al., 2002, 2014a).

Silva Filho et al. (2002) grouped most of the granitic intrusions and suites from the eastern part of the PEAL domain in two granitic batholiths: Águas Belas-Canindé and Ipojuca-Atalaia. The studied granitoids belong to these batholiths as follows: Águas Belas-Canindé (Serra do Catú, Água Branca, Mata Grande and Santana do Ipanema plutons) and Ipojuca-Atalaia (Correntes pluton). The Cachoeirinha and Águas Belas plutons are external to these batholiths.

A larger Sm–Nd data set show T_{DM} model ages ranging from 0.9 to 2.8 Ga. The data show a bimodal distribution, indicating that most of the protolith ages are either Neoproterozoic or Paleoproterozoic. The low frequency of samples with T_{DM} within the 1.5–l.8 Ga interval indicates that Tonian igneous rocks, which commonly have T_{DM} model ages in this range (Van Schmus et al., 1995, 2011; Brito Neves et al., 2001), are scarce in the PEAL domain, and that such model ages are probably mixtures of older and younger sources.

2.1. Magmatism in the PEAL domain

Various authors have concluded that intra-continental rifts can be formed when a hot mantle upwelling helps to break-up a crust (Meso to Palaeoproterozoic crust in the present case), thinning the lithosphere and allowing the asthenosphere to bulge. Brasiliano tholeiitic gabbros from the Sergipano domain (Oliveira and Tarney, 1995) are evidence of an extensional event in the area during the early Neoproterozoic, prior to the Brasiliano collisional event, perhaps related to the break-up of Rodinia. According to Basei et al. (2010), the crustal evolution of the Borborema Province involved the development of proto-oceanic and oceanic basins of different nature, bordering the northern margin of the São Francisco craton, within the Ceará fold belt, the Riacho do Pontal and Sergipano domains. However, geological data are still not enough for a precise correlation between the Sergipano and the PEAL domains.

The convergence of the São Francisco Craton and the Borborema Province possibly started at about 650–700 Ma with emplacement of arc-type granites, and it continued until ca. 590–570 Ma with intrusion of leucogranites during the main shortening event (D_2)

(Bueno et al., 2009; Oliveira et al., 2010; Oliveira et al., 2015), in the Sergipano domain. Correlation between pre to syn-D_2 granites from the Sergipano Belt and coeval granites farther north in the PEAL domain match well, but not with those located within the Transversal Zone domain of the Borborema Province. Contrasting emplacement settings between them are more likely explained by a combination of continent–continent collision and extrusion tectonics (Bueno et al., 2009).

U–Pb zircon SHRIMP data obtained by Silva Filho et al. (2014a) indicates various late Neoproterozoic metamorphic events. The ages of the events are either U–Pb TIMS discordia ages or zircon ages obtained from orthogneisses and granites and on spots located within zircon overgrowths from metamorphic successions. These data, integrated with U–Pb LA-ICP-MS and SHRIMP zircon data of granites from the literature (Neves et al., 2008; Bueno et al., 2009; Silva Filho et al., 2013; Silva Filho et al., 2014a; Silva Filho et al., 2014b; Oliveira et al., 2015), suggest that the collision started at ca 650 Ma. It is classically considered that a granitic intrusion is capable of heating its country rocks, causing the formation of zircon overgrowth. It has long been considered (Le Fort, 1986; Harris et al., 1986; Vigneresse and Burg, 2003; Harrison et al., 2012) that a collisional event implies the action of metamorphism coupled with magma production, induced by increasing of heating within the crust during the crustal thickening. U–Pb zircon metamorphic overgrowth ages, recorded in supracrustal sequences and orthogneisses from the PEAL domain, are within the ranges 550 Ma to 580 Ma, 600 Ma to 620 Ma and 640 Ma to 650 Ma (Silva Filho et al., 2014a). These ages should correspond to different metamorphic events. Similar ages are recorded in granites from the PEAL and adjoining domains (Guimarães et al., 2004, 2011; Bueno et al., 2009; Van Schmus et al., 2011; Silva Filho et al., 2013), and interpreted as the crystallization ages. This coincidence leads us to infer they are part of the same process. The syn-collisional plutons are those that have emplaced syn-to late- D_2, and the pre-to early-D_2 plutons are referred to as pre-collisional plutons. The late-to post-collisional plutons are those that have emplaced during D_3 deformation, characterized by transcurrence. As they have emplaced at the final stage of the D_2 deformation, they show a very weak flat-lying foliation (Águas Belas pluton). The correspondent age ranges and related granitic plutons or other igneous rocks are summarized below:

Early to Syn-Collisional Magmatism (630 Ma to 650 Ma). Plutons related to this stage show solid-state deformation of the D_2 event. Granulitized pyroxenite (Osako, 2005) yielded a lower intercept U–Pb TIMS discordia age of 640 Ma and has been interpreted as a metamorphic age on a Paleoproterozoic orthogneiss protolith of tholeiitic composition. Detrital zircon overgrowths from the Rio Una sequence also record this event. The Maravilha orthogneiss yields a U–Pb zircon SHRIMP age of ca 650 Ma, and a strong character of arc-derived suite (Datolli and Silva Filho, unpublished data).

Syn-Collisional Magmatism (600 Ma to 625 Ma). Plutons from this stage absorbed part or all of the D_2 deformation and preserve magmatic structures, parallel to the D_2 structures in the country rocks. Various plutons with crystallization ages ranging from 625 to 600 Ma occur within the PEAL and Sergipano domains (Silva Filho et al., 2000, 2013, 2014b; Neves et al., 2008; Guimarães and Silva Filho, 1995; Silva Filho et al., 1997; Bueno et al., 2009; Oliveira et al., 2015).

Late-to Post-Collisional Magmatism (550 Ma to 600 Ma). Plutons related to this stage crosscut D_2 structures in the country rocks and do not present planar or linear structures related to D_2, or present very weak flat-lying foliation. Calc-alkaline granitic plutons from the PEAL, Sergipano, Transversal Zone domains, showing emplacement controlled by transcurrent shear zones, have crystallization ages within the 563–583Ma interval (Guimarães et al., 2004; Osako, 2005; Bueno et al., 2009; Mariano et al., 2009; Silva Filho et al., 2010, 2013, 2014b; Oliveira et al., 2015). Similar $^{40}Ar/^{39}Ar$ ages have been recorded in mylonites of the Sergipano domain (Oliveira et al., 2010) and interpreted as the ductile tectonic consolidation. $^{40}Ar/^{39}Ar$ age of 554 ± 8 Ma was recorded in mylonites related to the high-angle Pernambuco shear zone (Neves et al., 1996), being considered by various authors as the last stage of the Brasiliano orogeny.

Post-Collisional Magmatism (520 Ma to 550 Ma). Detrital zircon overgrowth yielding a U–Pb SHRIMP age of 525 Ma was recorded in the Inhapi sequence (Silva Filho et al., 2014a), where the sample was collected near to a transcurrent shear zone, and it records the age of the shearing and the associated magmatism. Basalts, rhyolites, and diabase fill a NE–SW high-temperature shear zone system that cuts the PEAL domain.

Sedimentation of the Rio Una sequence started before the onset of the Brasiliano collision (~650 Ma – Silva Filho et al., 2014a; Neves et al., 2015). Absence of zircon metamorphic overgrowths older than 650 in the PEAL and in the Transversal Zone domains (Neves et al., 2006) suggests that between 1000 Ma and 650 Ma no metamorphic events have been recorded so far within these domains.

3. Field relationships and petrography

3.1. Serra do Catú pluton

The Serra do Catú pluton is one of the two largest shoshonitic intrusions in the Borborema Province, occupying ca. 600 km^2 (Fig. 1b). It intrudes very coarse-grained porphyritic alkali feldspar granites with solid-state deformation and NW–SE striking foliation of the Águas Belas-Canindé Batholith. Three magmatic facies, showing sharp contacts among them, have been identified; quartz monzonite to monzonite, the oldest facies; inequigranular gray alkali feldspar syenites; porphyritic pink quartz syenite to quartz alkali feldspar syenite.

The quartz monzonite to monzonite facies are porphyritic, very coarse-grained biotite-hornblende quartz monzonite to monzonite. They have alkali feldspar phenocrysts up to 5 cm long, plagioclase up to 1 cm long and mafic enclaves and xenoliths of a wide range composition (diorites to quartz diorites, amphibolites, metatexites). They show magmatic/pre full crystallization foliation and alkali feldspar accumulations.

The two syenitic facies are medium-grained and porphyritic hornblende–clinopyroxene-biotite syenites with alkali feldspar phenocrysts up to 3 cm long. These rocks contain mafic enclaves, isolated or in swarms, with amphibolitic to lamprophyric compositions. The pink quartz syenite to quartz alkali feldspar syenites comprise a subcircular shape intrusion, emplaced between the two previous facies. They consist of clinopyroxene, biotite, amphibole-quartz syenite to quartz-alkali feldspar syenite, porphyritic to equigranular, with up to 5 cm long K-feldspar phenocrysts.

The quartz monzonites of the Serra do Catú pluton show flat-lying foliation, associated to the D_2 Brasiliano deformation stage identified within the PEAL domain supracrustal successions (Silva Filho et al., 2014a), suggesting that this facies is pre-to syn-collisional. Brito et al. (2009) showed that Serra do Catú flat-lying foliation was affected by the D_3 deformation stage, which is associated to the transcurrence stage of the Brasiliano orogeny. Later, the Serra do Catú underwent brittle deformation, with dacites filling NE–SW trending fractures.

3.2. *Água Branca, Mata Grande, Correntes and Santana do Ipanema suites*

The Água Branca Suite includes a main intrusion and four satellite plutons intruded into tonalitic metatexites, tonalitic orthogneisses and granites close to the boundary of the PEAL domain with the Sergipano domain, cropping out over ca. 100 km^2 (Fig. 1b). Four petrographic facies plus leucocratic dykes and mesocratic dykes (Sampaio, 2000). The main intrusion has its major axis parallel to the main foliation of the Sergipano domain (NW–SE direction), and it shows a discrete pre-full crystallization flat-lying foliation. The contacts with the country rocks are very sharp. The main intrusion of the Água Branca pluton is cut by a NE–SW/NW–SE brittle fracture system, which is associated with dyke swarms of felsic to intermediate composition. Dykes of leucogranitoids are also recorded as horizontal sheets. The Água Branca suite comprises porphyritic to equigranular biotite, amphibole ± pyroxene syenogranite, and quartz syenite. The porphyritic facies shows phenocrysts of plagioclase and K-feldspar. The accessories phases are sphene, opaque minerals, apatite, allanite and epidote. Rapakivi texture occurs locally. Allanite occurs as euhedral, zoned crystals, some surrounded by epidote.

The Mata Grande pluton constitutes a ca. 80 km^2 intrusion, located within the Buíque-Paulo Afonso batholith (Fig. 1b). The intrusion shows a NE–SW trend and is intruded into migmatized orthogneisses and granites, between two dextral shear zones, and shows a weak flat-lying foliation. It comprises isotropic, coarse to very coarse-grained, amphibole and pyroxene-bearing quartz syenites and syenogranites.

The Correntes pluton is part of the Ipojuca-Atalaia batholith, occupying an area of ~150 km^2 (Fig. 1b). It consists of medium-to coarse-grained, weakly porphyritic to equigranular amphibole ± clinopyroxene syenogranites and quartz syenites. Mafic enclaves are recorded rarely, showing elliptic shapes and sharp contacts with their host. The accessory phases are opaque minerals, titanite, zircon, epidote and apatite. The pluton main axis shows an E–W trend and shows a weak flat-lying foliation defined by tabular and platy minerals. It is emplaced in orthogneisses with Nd T_{DM} model ages of ca 1.0 Ga, close to the NE–SW sinistral splays of the Palmares shear zone. The Correntes pluton makes contact to the west with the metasedimentary rocks from the Cabrobó Complex. The contact to the east is marked by a NE–SW shear zone.

The studied granitoids from the Santa do Ipanema suite comprise mega dyke swarms intruded in porphyritic granites, according to three distinct directions of fractures and high-T shear zones: NE–SW (youngest), NW–SE and ENE. The fractures and high-T shear zone are associated to brittle – ductile deformation. Dykes of leucogranite with biotite clots intruded along a low-angle foliation were recorded locally. The field data suggest that the dyke swarms represent distinct magma pulses.

The NE–SW-oriented dykes show compositions ranging from amphibole syenites, quartz syenites to amphibole monzonites. Allanite, magmatic epidote, opaque minerals and apatite occur as accessory phases. The NW–SE trending dykes have composition varying from monzogranites to monzonites.

3.3. *Águas Belas and Cachoeirinha plutons*

The Águas Belas pluton constitutes an elongated intrusion with an 18 km long E–W trending major axis (Fig. 1b). It is intruded along the contact between the metasedimentary rocks from the Inhapi complex, cutting its foliation, and the Águas Belas-Canindé Batholith, being part of the Água Branca crustal sub-domain (Silva Filho et al., 2010). Along its northern contact an E–W trending mylonitic foliation has been identified.

The Águas Belas pluton was emplaced after the peak of the Brasiliano metamorphism, associated to a flat-lying foliation event (Silva Filho et al., 2010). The E–W trending lineation recorded within the Águas Belas pluton suggests that the intrusion took place at the beginning of the operation of a discrete ductile E–W shear zone. Silva Filho et al. (2010) presented petrographic details for the granitoids of the Águas Belas pluton.

The Limitão-Caetés ductile shear zone is a splay of the Pernambuco shear zone and it terminates at the eastern contact of the Águas Belas pluton. A two-mica granite, the Serrote dos Macacos pluton, is intruded within the Limitão-Caetés shear zone and yielded a U–Pb monazite age of 580 ± 3 Ma (Osako, 2005).

The Cachoeirinha pluton is intruded into the northern part of the PEAL domain, between the Pernambuco lineament to the north and the elongate, E–W trending Jupi orthogneisses to the south (Fig. 1b). The Cachoeirinha pluton shows a NE–SW 30 km long axis, making sharp contacts to the west and to the south with metasedimentary rocks from the Cabrobó Complex and to the east with orthogneisses. The Cachoeirinha pluton is cut by the two-mica Cabanas granite, with U–Pb zircon crystallization age of 573 ± 4 Ma. According to Neves et al. (2008) the Cabanas granite was deformed by strike-slip shearing under intermediate temperature conditions. The Cachoeirinha pluton shows two petrographic facies: porphyritic biotite, amphibole syenite and medium-grained biotite, amphibole quartz syenite. Magmatic foliation defined by the preferred orientation of K-feldspar phenocrysts, occurs in the biotite amphibole syenite, especially close to the margins, with steep dips dominantly to ESE (Neves et al., 2006). Solid-state deformation, overprinting the magmatic foliation, is restricted in most places to weak deformation at high temperatures. According to Neves et al. (2005), the intrusion of the Cachoeirinha pluton occurred during bulk NW–SE shortening, with local development of non-coaxial shear zones.

4. Zircon SHRIMP U–Pb data

The U–Th–Pb analyses were done using the SHRIMP II of the Research School of Earth Sciences, Australian National University Canberra, Australia, following the procedures described in Williams (1998 and references therein). The zircon standard SL13 (Claue-

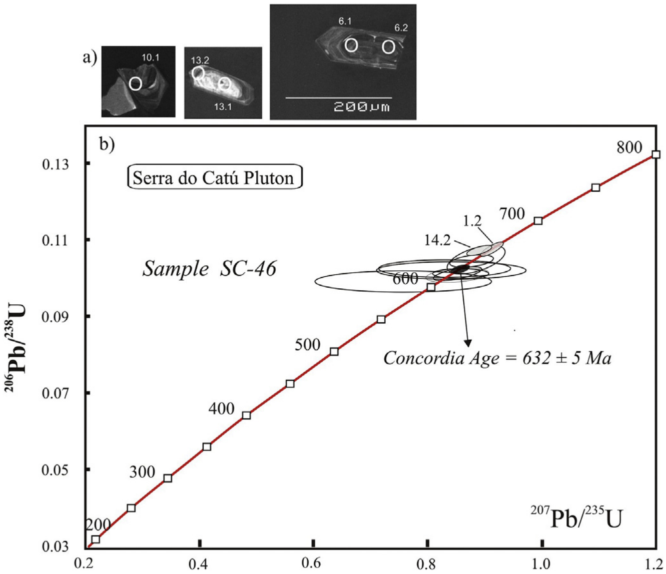

Fig. 2. a) CL image of analyzed spots; b) U–Pb Concordia diagram for Serra do Catú pluton. Ellipses are 1 sigma.

Table 1
Summary of SHRIMP U–Pb and oxygen zircon data for Serra do Catú Suite.

Grain. Spot	%^{206}Pb$_c$	ppm U	ppm Th	^{232}Th/^{238}U	±%	(1) ppm^{206}Pb*	(1)^{206}Pb/^{238}U age		(1)^{207}Pb/^{206}Pb age		% Disc.	(1)^{207}Pb*/^{206}Pb	±%	(1)^{207}P*/^{235}U	±%	(1)^{206}P*/^{238}U	±%	Err corr	δ^{18}O
1.1	7.62	118	100	0.88	1.59	10	610	±11	434	±293	13.1	0.76	13.1	0.76	13.3	0.099	1.9	0.1	7.48
1.2	0.00	285	158	0.57	2.49	26	661	±8	659	±19	0.9	0.92	0.9	0.92	1.6	0.108	1.3	0.8	7.10
2.1	1.03	324	386	1.23	0.19	28	627	±8	620	±59	2.7	0.85	2.7	0.85	3.0	0.102	1.3	0.4	
3.1	0.05	107	81	0.78	0.28	10	634	±7	615	±33	1.5	0.86	1.5	0.86	2.0	0.103	1.2	0.6	
4.1	21.76	438	196	0.46	1.29	57	904	±16	1478	±102	5.4	1.92	5.4	1.92	5.7	0.150	2.0	0.3	5.80
5.1	4.70	86	80	0.96	1.99	8	629	±10	561	±197	9.1	0.83	9.1	0.83	9.2	0.102	1.7	0.2	9.10
5.3	0.16	388	215	0.57	0.18	35	638	±7	579	±21	1.0	0.85	1.0	0.85	1.5	0.104	1.2	0.8	9.16
6.1	1.51	641	368	0.59	0.16	87	947	±12	961	±83	4.0	1.55	4.0	1.55	4.3	0.158	1.4	0.3	9.60
6.2	1.08	352	185	0.54	1.00	41	828	±9	952	±52	2.5	1.34	2.5	1.34	2.8	0.137	1.2	0.4	
7.1	0.00	319	204	0.66	0.41	28	617	±9	616	±17	0.8	0.84	0.8	0.84	1.7	0.100	1.5	0.9	8.92
7.2	4.11	478	128	0.28	0.20	42	621	±7	644	±87	4.0	0.85	4.0	0.85	4.2	0.101	1.2	0.3	
8.1	–	88	84	0.98	0.64	8	628	±7	638	±37	1.7	0.86	1.7	0.86	2.1	0.102	1.2	0.6	9.18
8.2	0.53	334	162	0.50	0.20	30	641	±8	611	±33	1.5	0.87	1.5	0.87	2.0	0.105	1.4	0.7	
10.1	5.46	357	88	0.25	1.43	55	1067	±17	1226	±261	13.3	2.02	13.3	2.02	13.4	0.180	1.8	0.1	8.93
11.1	3.90	1781	742	0.43	0.13	157	628	±8	591	±224	10.3	0.84	10.3	0.84	10.4	0.102	1.4	0.1	9.07
11.2	2.15	541	213	0.41	0.18	48	637	±8	653	±46	2.2	0.88	2.2	0.88	2.5	0.104	1.2	0.5	
12.1	0.04	149	160	1.11	0.67	13	640	±7	634	±29	1.3	0.88	1.3	0.88	1.8	0.104	1.1	0.6	9.06
13.1	0.00	82	89	1.12	0.29	7	619	±7	610	±36	1.7	0.84	1.7	0.84	2.0	0.101	1.2	0.6	8.90
13.2	1.67	318	272	0.88	1.20	29	640	±8	614	±60	2.8	0.87	2.8	0.87	3.1	0.104	1.3	0.4	
14.1	1.44	241	194	0.83	1.05	22	645	±13	661	±68	3.2	0.89	3.2	0.89	3.9	0.105	2.2	0.6	8.86
14.2	0.24	326	193	0.61	0.64	30	658	±7	619	±27	1.3	0.90	1.3	0.90	1.7	0.108	1.1	0.7	

Errors are 1-sigma; Pb$_c$ and Pb* indicate the common and radiogenic portions, respectively. Error in Standard calibration was 0.15% (not included in above errors but required when comparing data from different mounts). (1) Common Pb corrected using measured ^{204}Pb.

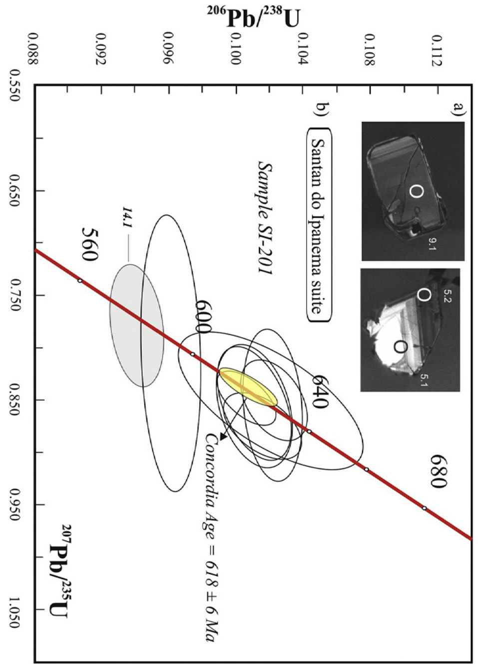

Fig. 3. (A) CL image of analyzed spots; (B) U–Pb Concordia diagram for Santana do Ipanema suite (SI-201). Ellipses are 1 sigma.

Long et al., 1995) was used to determine U concentration and the Pb/U ratios were normalized relative to a value equivalent to an age of 1099 for the FC1 reference zircon (Paces and Miller, 1993). Raw isotopic data were reduced using the Squid program (Ludwig, 2001), and age calculations and Concordia plots were done using both squid and Isoplot/Ex software (Ludwig, 2003).

4.1. *Serra do Catú suite*

The analyzed sample (SC-46) was collected from the syenitic facies (see location in Fig. 1b). It shows prismatic crystals, with length ranging from 180 µm to 80 µm, and aspect ratios ranging from 8:1 to 1:1. The CL images (Fig. 2a) show zircon grains with oscillatory zoning, in some case with complex pattern. Some grains show core with oscillatory zoning surrounded by rim with weak zoning, surrounded by overgrowth. Grains selected for analysis were free of cracks or inclusions. The analyzed zircon grains have high (0.28–1.23) Th/U ratios, suggesting an igneous origin. Fifteen analyzed spots defined a Concordia age of 632 ± 5 Ma (Fig. 2b), interpreted as the crystallization age of the suite. The analyzed overgrowths (spots #6.2, #5.3, #8.2 – Table 1) show oscillatory zoning, reflecting an igneous origin.

4.1.1. *Santana do Ipanema suite*

The analyzed sample (SI-201) is from a facies of intermediate composition, collected from an ENE-direction dyke close to where the suite cuts the Tanquinho pluton. The zircon grains have length ranging from 175 to 350 µm, and aspect ratio from 1.7 to 2.5 and, the majority of them have oscillatory zoning in the CL images (Fig. 3a). Grains selected for analysis were free of cracks and inclusions. The Th/U ratios are always higher than 0.10 (Table 2). A Concordia age of 618 ± 6 Ma was obtained on 12 analytical points (Fig. 3b), which is interpreted as the suite crystallization age.

4.1.2. *Água Branca, Mata Grande and Correntes plutons*

At least two distinct zircon populations were recorded in the Água Branca suite. The analyzed zircon population consists of pink and yellow euhedral, internally clear zircon grains free of inclusions. Images obtained by scanning electron microscope (SEM) and CL reveal zircon grains that are euhedral to sub-euhedral and well zoned (Fig. 4a); overgrowths are rare and, when they do occur, they are very narrow. They show length ranging from 125 to 200 µm, and aspect ratio ranging from 2 to 4. Grains free of cracks

Table 2
Summary of SHRIMP U–Pb and oxygen zircon data for Santana do Ipanema Suite.

Grain. spot	%^{206}Pb$_c$	ppm U	ppm Th	^{232}Th/^{238}U	±%	(1) ppm^{206}Pb*	(1)^{206}Pb/^{238}U age		(1)^{207}Pb/^{206}Pb age		% Disc	(1)^{207}Pb*/^{206}Pb*	±%	(1)^{207}Pb*/^{235}U	±%	(1)^{206}Pb*/^{238}U	±%	Err corr	δ^{18}O‰
1.1	0.01	724	534	0.76	1.6	63	617	±11	601	±16	−3	0.0599	0.8	0.830	2.0	0.1004	1.8	0.9	4.939
3.1	0.25	111	55	0.51	0.7	10	628	±8	615	±59	−2	0.0603	2.7	0.851	3.0	0.1023	1.3	0.4	5.818
4.1	5.79	160	127	0.82	1.9	15	677	±9	1119	±134	+42	0.0769	6.7	1.174	6.8	0.1107	1.4	0.2	5.791
4.2	47.79	1189	411	0.36	4.0	34	213	±12	776	±977	+74	0.0650	46.5	0.301	46.8	0.0336	5.7	0.1	6.345
5.1	1.21	576	96	0.17	0.5	50	624	±9	686	±46	+10	0.0624	2.1	0.874	2.6	0.1016	1.5	0.6	4.974
5.2	1.09	766	699	0.94	0.8	67	628	±7	629	±120	+0	0.0607	5.6	0.856	5.7	0.1023	1.2	0.2	6.660
6.1	3.61	741	466	0.65	2.6	61	592	±7	632	±236	+7	0.0608	11.0	0.806	11.0	0.0962	1.3	0.1	6.210
7.1	0.00	831	605	0.75	1.1	72	622	±10	602	±15	−3	0.0600	0.7	0.838	1.9	0.1013	1.7	0.9	5.946
7.2	70.65	993	1063	1.11	1.7	57	416	±18	552	±892	+25	0.0586	40.9	0.538	41.1	0.0666	4.4	0.1	6.822
8.1	0.96	976	859	0.91	0.5	84	619	±7	639	±36	+3	0.0610	1.7	0.847	2.0	0.1007	1.2	0.6	5.955
9.1	0.93	228	151	0.68	0.4	23	722	±15	722	±58	+0	0.0634	2.8	1.036	3.5	0.1185	2.2	0.6	−41.280
9.2	35.49	749	637	0.88	2.7	49	474	±16	385	±795	−24	0.0543	35.4	0.572	35.6	0.0763	3.5	0.1	6.446
10.1	25.91	660	263	0.41	12.7	54	588	±27	815	±1317	+29	0.0663	63.0	0.873	63.2	0.0955	4.9	0.1	6.249
10.2	4.71	267	175	0.68	0.7	19	525	±11	908	±122	+44	0.0693	5.9	0.811	6.3	0.0849	2.1	0.3	6.154
11.1	80.49	211	121	0.59	0.4	13	454	±33	1471	±1369	+72	0.0922	72.2	0.928	72.5	0.0730	7.4	0.1	4.757
12.1	0.57	94	45	0.50	0.7	8	621	±8	655	±87	+5	0.0615	4.1	0.858	4.3	0.1012	1.4	0.3	5.322
13.1	3.15	690	478	0.72	2.6	61	627	±21	619	±79	−1	0.0604	3.7	0.851	5.1	0.1021	3.6	0.7	5.827
14.1	6.15	605	87	0.15	3.0	49	580	±6	605	±108	+4	0.0601	5.0	0.779	5.1	0.0941	1.1	0.2	5.609
14.2	5.47	279	147	0.54	0.9	20	519	±15	665	±133	+23	0.0617	6.2	0.714	6.9	0.0839	3.0	0.4	6.569
15.1	0.30	773	689	0.92	2.9	67	621	±9	646	±83	+4	0.0612	3.9	0.854	4.1	0.1012	1.5	0.4	7.060

Errors are 1-sigma; Pb$_c$ and Pb* indicate the common and radiogenic portion, respectively. Error in Standard calibration was 0.33% (not included in above errors but required when comparing data from different mounts). (1) Common Pb corrected using measured ^{204}Pb.

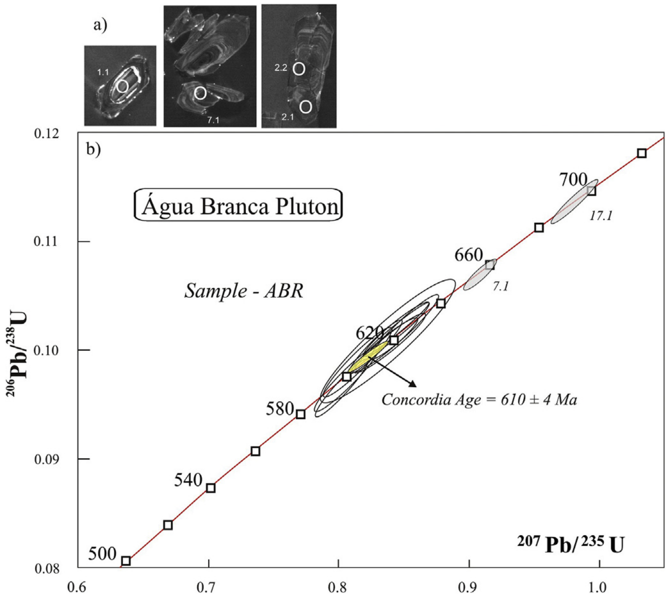

Fig. 4. a) CL image of analyzed spots; b) U–Pb Concordia diagram for Água Branca pluton. Ellipses are 1 sigma.

or inclusions were selected for analysis. The Th/U ratios are higher than 0.10, except for grain #7.1 (Table 3). The results point to a Concordia age of 610 ± 4 Ma, worked out on 21 analytical points (Fig. 4b), interpreted as the Água Branca pluton crystallization age.

The Mata Grande analyzed sample has prismatic and elongate zircon grains, 100–200 μm long; all of them show oscillatory zoning under the CL imaging (Fig. 5a), with very contrasting internal brightness pattern among several crystals. Many zircons show corroded oscillatory zoned older and inherited cores surrounded by external oscillatory zoned younger rims. Some zircon grains show only narrow overgrowths. U–Pb zircon SHRIMP data from fourteen zircon grains, totaling 18 spots, are shown in Table 4. The data defined a Concordia age of 612 ± 7 Ma (Fig. 5b), which is interpreted as the crystallization age of the Mata Grande Pluton. Th/U ratios are always higher than 0.20, suggesting that they all have igneous origin.

Zircon grains from the analyzed sample of the Correntes pluton (CO-8) are prismatic, very well formed with lengths ranging from 100 μm to 250 μm. They show a range of different textures, the most common being (1) zoned core and rim but very contrasting CL colors between them; (2) core and rim showing different and contrasting CL colors (Fig. 6a), where core shows embayed textures, suggesting that the core was corroded by the rim; (3) xenocrystal showing no zoning. Grains selected for analysis were free of cracks or inclusions. The Th/U ratios are always higher than 0.17, except grain #7.1, suggesting that they have igneous origin. The results points to a Concordia age of 602 ± 5 Ma, worked out with 19 points (Fig. 6b), interpreted as the crystallization age.

4.1.3. *Cachoeirinha and Águas Belas suites*

The sample from the Cachoeirinha pluton has a zircon grain population characterized by prismatic clear crystals. Silva Filho et al. (2013) reported a U–Pb TIMS zircon age of 587 ± 12 Ma. This age is identical to that (587 ± 8 Ma) defined by Neves et al. (2008) using LA-ICP-MS methods. There is no inherited zircon, and the age recorded in this work was interpreted as the crystallization age.

Silva Filho et al. (2010) reported U–Pb zircon SHRIMP crystallization age of 588 ± 4 Ma for the Águas Belas granitoids. The data are shown in Table 6.

5. Major and trace elements geochemistry

The studied granitoids show SiO_2 contents ranging from 60.8 to 76.1 wt%. SiO_2 values of <59 wt% were recorded in some mafic enclaves of Serra do Catú suite and in some granites from Santana do Ipanema suite (Table 7). The total alkali contents ($K_2O + Na_2O$) are high (>8.6 wt%) and K_2O/Na_2O ratios range from 0.6 to 2.1. They are metaluminous to slightly peraluminous according to the Shand index (Fig. 7a), high-K calc-alkaline to shoshonitic, in the K_2O versus SiO_2 diagram (Fig. 7b) with fields after Peccerillo and Taylor (1976), and alkali to alkalic-calcic (Fig. 7c) according to the modified alkali-lime index (MALI; Frost et al., 2001). In the Fe# [FeOt/(FeOt + MgO)] versus SiO_2 diagram (Fig. 7d) with fields after Frost et al. (2001), the studied granitoids range from magnesian (Serra do Catú, Água Branca, Mata Grande and one sample from the Santana do Ipanema suite), reflecting hydrous, oxidizing magmas (Frost and Lindsley, 1991), to ferroan (Correntes, Mata Grande and Santana do Ipanema suites), reflecting reduced magmas. In another words, (1) the older granitic suites, with ages 635–610 Ma, show compositions similar to those of *Cordilleran granites*, except the Santana do Ipanema suite which plots in the field for *A-type granites*, and (2) the younger ones, with ages 590–580 Ma show only compositions of *A-type granites*.

The metaluminous studied granitoids plot in the field for amphibolite-derived melt, or following the curve for low-pressure conditions (Patiño Douce, 1999), and in the field for greywackes-derived melt in the major elements correlations diagrams (Fig. 8a), suggesting that their photolith involved a mixture of melts generated by melting of greywackes + amphibolite (lower crust?), and the melt was extracted under low-pressure condition. However, most of the granitoids from the Cachoeirinha pluton plot in the curve of high-pressure. The peraluminous granitoids, which include most of the Santana do Ipanema suite, plot above the curve for low pressures (Fig. 8b) in the diagram after Patiño Douce (1999). This diagram suggests that the peraluminous studied granitoids were generated by melting of pelites + greywackes under low -pressure conditions.

Ba and Sr contents divided the studied granitoids in two groups (Table 7): 1) Ba contents > 2500 ppm and Sr > 1800 ppm (Mata Grande, Água Branca, Correntes, Serra do Catú suites and some plutons from the Santana do Ipanema suite), and 2) Ba contents < 2500 ppm and Sr contents < 900 ppm (Águas Belas, Cachoeirinha suites and some samples from the Santana do Ipanema suite). The Sr and Ba contents recorded in the granitoids from Água Branca, Mata Grande and Serra do Catú and some from the Santana do Ipanema suite are similar to those described in Hi Ba–Sr granites (Tarney and Jones, 1994; Fowler et al., 2008).

The granitoids from Água Branca, Mata Grande and Serra do Catú suites, and some granitoids from the Santana do Ipanema suite show the main characteristics of the shoshonitic association, i.e. high total alkalis ($K_2O + Na_2O > 5$), low TiO_2 (<1.3% wt), high contents of LILE (Ba, Sr, Rb) and low Nb (Morrison, 1980).

A selection of multi-element diagrams (spidergram), normalized to the chondrite values suggested by Thompson (1982) are presented in Fig. 9a–c. Silva Filho et al. (2013) show individual sample spidergrams for the Serra do Catú, Água Branca, Cachoeirinha and Águas Belas granitoids.

The spidergram patterns of the studied granitoids show many similar features. They share a comparably steep left–right slope indicating a general enrichment in the incompatible elements including Ba and Sr. All have negative Nb–Ta anomalies, of variable depth, which is the quintessential signature of subduction-related magmatism. In addition, most of them have variable Sr

Table 3
Summary of SHRIMP U–Pb zircon data for Água Branca Pluton.

Grain. spot	%^{206}Pb$_c$	ppm U	ppm Th	^{232}Th/^{238}U	±%	(1) ppm^{206}Pb*	(1)^{206}Pb/^{238}U age		(1)^{207}Pb/^{206}Pb age		% Discordant	(1)^{207}Pb*/^{206}Pb*	±%	(1)^{207}Pb*/^{235}U	±%	(1)^{206}Pb*/^{238}U	±%	Err corr
1.1	0.02	341	316	0.96	3.31	45	915	±9	972	±11	+6	0.0715	0.55	1.504	1.2	0.1525	1.1	0.89
2.1	–	451	330	0.76	0.41	39	614	±6	629	±13	+3	0.0607	0.61	0.836	1.2	0.0999	1.1	0.87
2.2	0.09	376	320	0.88	2.16	31	596	±11	626	±16	+5	0.0606	0.75	0.810	2.1	0.0969	2.0	0.93
3.1	0.06	473	463	1.01	0.49	41	618	±21	621	±42	+1	0.0605	1.94	0.839	4.1	0.1006	3.6	0.88
4.1	0.07	267	202	0.78	0.99	23	614	±9	632	±18	+3	0.0608	0.84	0.837	1.7	0.0998	1.5	0.87
5.1	–	379	318	0.87	0.21	32	598	±6	604	±14	+1	0.0600	0.65	0.804	1.3	0.0972	1.1	0.86
6.1	–	550	374	0.70	0.20	47	610	±6	622	±12	+2	0.0605	0.57	0.829	1.2	0.0993	1.1	0.88
7.1	–	509	51	0.10	2.52	47	654	±7	667	±12	+2	0.0618	0.56	0.910	1.2	0.1068	1.1	0.89
8.1	0.12	502	379	0.78	0.20	42	602	±9	607	±16	+1	0.0601	0.72	0.811	1.6	0.0979	1.5	0.90
9.1	0.06	490	370	0.78	0.21	42	617	±11	613	±14	−1	0.0603	0.67	0.834	2.0	0.1004	1.9	0.94
10.1	0.09	361	326	0.93	1.27	30	599	±8	615	±17	+3	0.0603	0.80	0.810	1.7	0.0974	1.5	0.88
11.1	0.01	477	358	0.77	0.20	40	606	±10	602	±20	−1	0.0600	0.92	0.815	1.9	0.0986	1.7	0.88
12.1	0.01	495	268	0.56	0.34	42	610	±9	629	±13	+3	0.0607	0.58	0.831	1.6	0.0992	1.5	0.93
13.1	0.02	538	370	0.71	0.21	46	606	±9	603	±13	−1	0.0600	0.58	0.815	1.7	0.0985	1.6	0.94
14.1	0.95	380	247	0.67	6.20	28	525	±8	791	±136	+35	0.0655	6.49	0.767	6.7	0.0849	1.5	0.22
15.1	0.05	262	113	0.45	1.14	23	619	±13	626	±18	+1	0.0606	0.83	0.842	2.3	0.1008	2.2	0.93
15.2	0.06	457	320	0.72	0.21	39	613	±9	604	±15	−2	0.0600	0.67	0.825	1.6	0.0997	1.5	0.91
16.1	0.10	326	267	0.85	0.71	27	594	±9	617	±18	+4	0.0604	0.84	0.804	1.8	0.0966	1.6	0.88
17.1	0.02	739	223	0.31	2.96	72	694	±8	694	±9	+0	0.0626	0.44	0.980	1.2	0.1136	1.2	0.93
17.2	0.03	571	258	0.47	0.43	49	619	±9	618	±12	−0	0.0604	0.57	0.839	1.6	0.1008	1.5	0.94
18.1	–	460	323	0.73	0.58	40	615	±7	596	±13	−3	0.0598	0.62	0.826	1.3	0.1002	1.2	0.89
19.1	–	500	310	0.64	0.46	42	608	±9	607	±13	−0	0.0601	0.62	0.819	1.6	0.0989	1.5	0.92

Errors are 1-sigma; Pb$_c$ and Pb* indicate the common and radiogenic portions, respectively.

Error in Standard calibration was 0.25% (not included in above errors but required when comparing data from different mounts).

(1) Common Pb corrected using measured ^{204}Pb.

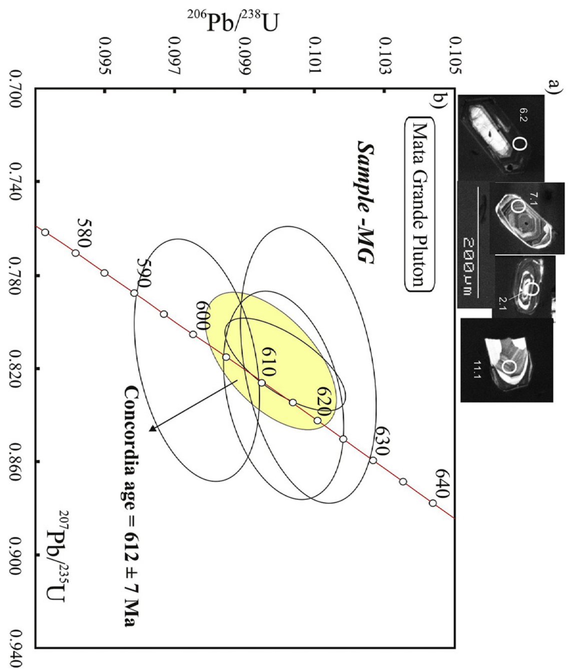

Fig. 5. a) CL image of analyzed spots; b) U–Pb Concordia diagram for Mata Grande pluton. Ellipses are 1 sigma.

abundances, which generate either peaks or troughs on the normalized patterns. The Serra do Catú, Água Branca Mata Grande and some samples from the Santana do Ipanema suites normalized patterns are similar to those described in high Ba–Sr granites (Tarney and Jones, 1994; Fowler et al., 2008). The other studied granitoids show patterns similar to those of transitional high-K calc-alkaline to alkaline magmatism.

The granitoids from the Santana do Ipanema suite (Fig. 9a) show at least two distinct patterns: 1) characterized by troughs at Ba, Th, Nb–Ta, P and Ti and peaks at Sr, and 2) characterized by peaks at Ba and Th, and variable troughs at Sr and troughs at P and Ti. The patterns of (2) are REE –rich compared to those of (1).

The Água Branca, Cachoeirinha, Mata Grande granitoids and some samples from the Santana do Ipanema suite show the smallest trough at Nb–Ta (Fig. 9a, c). Their spidergram patterns are similar to those recorded in post-collisional granitoids Thompson et al. (1984).

6. Oxygen isotope zircon data

The oxygen isotope analyses were conducted using the SHRIMP II and the SHRIMP SI from the ANU, in the same zircon spots analyzed previously for U–Pb, and results are reported in the SMOW scale (Tables 1, 2 and 6 and Fig. 10). Analyses were obtained for the Serra do Catú, Santana do Ipanema and Águas Belas suites.

Eleven valid $\delta^{18}O$ data for the Serra do Catú suite, from the cores of zircon grains are presented in Table 1. The analyses were performed on zircons with oscillatory zoning. The $\delta^{18}O$ values lie between 7.10 and 9.60‰. Zircon grain #6.1 ($^{206}Pb/^{238}Pb$ age of 947 ± 12 Ma), which is a xenocrystal, also shows high $\delta^{18}O$ value. The average $\delta^{18}O$ value is 8.67‰, not including the value of grain #6.1, is similar for those of rocks of SiO_2 contents 69 to 70wt%, and it is consistent and compatible with high $\delta^{18}O$ crust-derived magmas (Valley et al., 1994).

The valid $\delta^{18}O$ data for the Santana do Ipanema suite, from seven spots from the cores of zircon grains, are shown in Table 2. The $\delta^{18}O$ values lie between 4.93 (spot #1.1) and 6.82‰ (spot #8.1), with both showing similar $^{206}Pb/^{238}U$ ages. Grain #9.1 is a xenocrystal, with $^{206}Pb/^{238}U$ age of 722 ± 15 Ma and shows a $\delta^{18}O$

Table 4
Summary of SHRIMP U–Pb zircon data for sample MG.

Grain. spot	$\%^{206}Pb_c$	ppm U	ppm Th	$^{232}Th/^{238}U$	ppm$^{206}Pb^*$	(1)$^{206}Pb/^{238}U$ age		(1)$^{207}Pb/^{206}Pb$ age		% Discordant	(1)$^{207}Pb^*/^{206}Pb^*$	±%	(1)$^{207}Pb^*/^{235}U$	±%	(1)$^{206}Pb^*/^{238}U$	±%	Err corr
1.1	5.46	190	105	0.57	45.8	1514	±19	1838	±68	18	0.1124	3.8	4.1	4	0.2648	1.4	0.353
1.2	1.89	557	876	1.62	47.6	600.3	±7.1	627	±86	4	0.0607	4	0.816	4.2	0.0976	1.2	0.295
2.1	0.60	466	97	0.22	142	1947	±19	2064	±13	6	0.12749	0.74	6.198	1.3	0.3526	1.1	0.832
2.2	11.99	467	436	0.96	82.6	1074	±16	1878	±120	43	0.1149	6.7	2.87	6.9	0.1813	1.6	0.234
3.1	0.32	453	137	0.31	147	2064	±20	2142.2	±9.2	4	0.13332	0.53	6.937	1.2	0.3774	1.1	0.903
4.1	0.64	183	65	0.37	47.3	1689	±19	1959	±21	14	0.1202	1.2	4.965	1.7	0.2995	1.3	0.733
5.1	0.09	166	60	0.37	55.4	2110	±23	2150	±14	2	0.1339	0.78	7.15	1.5	0.3873	1.3	0.855
6.1	5.09	249	185	0.77	34.2	911	±12	1408	±100	35	0.0892	5.4	1.87	5.6	0.1519	1.4	0.243
6.2	3.05	1852	2658	1.48	164	615.1	±6.3	612	±72	−1	0.0602	3.3	0.832	3.5	0.1001	1.1	0.310
7.1	0.11	306	130	0.44	103	2134	±21	2160	±11	1	0.13465	0.62	7.285	1.3	0.3924	1.2	0.884
8.1	15.64	280	413	1.52	72.9	1469	±24	1911	±110	23	0.117	5.9	4.13	6.2	0.2559	1.8	0.296
8.2	23.26	408	715	1.81	28.3	388.2	±9.3	684	±400	43	0.062	19	0.533	19	0.0621	2.5	0.132
9.1	0.21	273	161	0.61	93.5	2158	±22	2137	±12	−1	0.13292	0.66	7.289	1.4	0.3977	1.2	0.876
10.1	0.07	72	20	0.29	21.2	1898	±26	1965	±21	3	0.1206	1.2	5.69	2	0.3424	1.6	0.800
11.1	0.22	217	91	0.43	71.2	2079	±31	2162	±13	4	0.13483	0.73	7.08	1.9	0.3807	1.7	0.921
12.1	0.09	94	23	0.25	31.8	2142	±33	2133	±19	0	0.1326	1.1	7.21	2.1	0.3941	1.8	0.857
13.1	0.06	521	444	0.88	44.8	615.4	±6.7	575	±24	−7	0.05922	1.1	0.818	1.6	0.1002	1.1	0.711
14.1	2.23	377	307	0.84	33.4	619.2	±7.5	562	±100	−10	0.0589	4.6	0.818	4.8	0.1008	1.3	0.263

Errors are 1-sigma; Pb_c and Pb^* indicate the common and radiogenic portions, respectively.
Error in Standard calibration was 0.21% (not included in above errors but required when comparing data from different mounts).
(1) Common Pb corrected using measured ^{204}Pb.

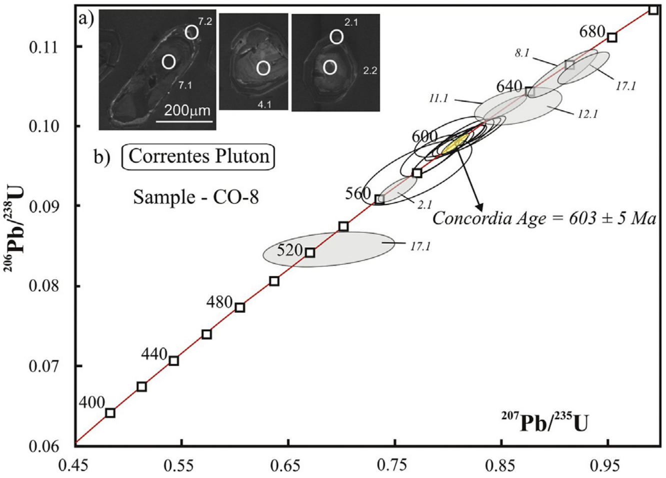

Fig. 6. a) CL image of analyzed spots; b) U–Pb Concordia diagram for Correntes pluton. Ellipses are 1 sigma.

value of 5.96‰. The average $\delta^{18}O$ value is 5.86‰.

The oxygen isotope analyses were conducted in 23 spots for the Águas Belas suite sample, and the results are reported in Table 6. The $\delta^{18}O$ values lie between 6.35‰ and 10.30‰. Grain 4 shows the lowest $\delta^{18}O$ values, 6.69‰ and 6.35‰, for core and rim respectively. Grain 11 shows values of $\delta^{18}O$ 8.19‰ and 10.01‰ for the rim and core respectively. The cores of zircon spots #11.2 and #22.1, show rounded shape and high values of $\delta^{18}O$. The $\delta^{18}O$ values for rims of Neoproterozoic age range from 6.69 to 10.30‰, with average value of 8.26 ± 0.71‰. This >2‰ variation is large and not compatible with cogenetic rocks crystallized in a closed system.

7. Nd isotope geochemistry

The Sm–Nd analytical work was carried out at the Isotope Geochemistry Laboratory (IGL), Kansas University. Representative results are shown in Table 8. The studied granitoids cluster into two different groups, according their Nd T_{DM} model ages (Fig. 11a,b):

Group 1 – T_{DM} 1.30 – 1.50 Ga. This group comprises the syn-collisional suites (Serra do Catú, Água Branca and the late dykes, NW–SE directions, of the Santana do Ipanema suite). They show a very narrow range of $\varepsilon Nd_{(0.60\ Ga)}$ values ranging from −4.1 to −5.2 (Table 8). This suggests that they all come from rocks with similar compositions.

Group 2 – T_{DM} 1.70 Ga 2.20 Ga. This group encloses: 1) syn-collisional suites (Mata Grande, Correntes and NW–SE oriented dykes of the Santana do Ipanema suite) and 2) late to post-collisional suites (Águas Belas and Cachoeirinha suites). They show $\varepsilon Nd_{(0.6\ Ga)}$ values ranging from −8.7 to −12.4.

8. Discussion

8.1. Relationship between age, regional deformation and tectonics

Field relationships associated with geochronological data suggest that the studied granitoids can be divided into two groups:

1) Granitoids with ages 635–610 Ma

Ages ca. 630 Ma were obtained by Oliveira et al. (2010), through ^{40}Ar–^{39}Ar dating of hornblendes of mylonites (623 ± 2 Ma to 637 ± 7 Ma), from the Belo Monte-Jeremoabo and Macururé shear zones, Sergipano domain. They interpreted this age as related to an uplift and slow cooling of the Sergipano domain. According to Bueno et al. (2009), plutons with ages of ~625 Ma from the Sergipano domain are pre-to syn-collisional and show character of suites related to magmatic arc. Guimarães et al. (2011) reported similar ages (~618 Ma) in granitoids associated with both extension and compression within the Transversal Zone domain of the Borborema Province. Data for the Serra do Catú suite suggest that it was emplaced during the early to syn-collisional stage of the Brasiliano orogeny.

The dyke swarms of the Santa do Ipanema suite cut the Tanquinho pluton, with sharp knife contacts, and the latter has U–Pb SHRIMP zircon age of ca 625 Ma (Cocentino, 2012). The dykes of the Santana do Ipanema suite were emplaced under the control of NE–SW/NW–SE fracture systems. Some dykes show foliation associated to ductile deformation, suggesting emplacement during the transition between the thrust stage (D_2 deformation stage) and the transcurrent stage (D_3 deformation stage) of the Maravilha shear zone (Fig. 1b). However, most of the dykes show geochemistry consistent with an extensional environment, suggesting either that they were emplaced in a extensional site of the collisional stage of the Brasiliano orogeny, or that they are associated to an uplift and slow cooling process, that is reported by Oliveira et al. (2010) in the Sergipano domain.

Flat-lying pre-full crystallization foliation, identified within the Água Branca pluton, suggests that it was intruded during the syn-collisional stage of the Brasiliano orogeny, and that at ca. 611 Ma the collisional process was still in operation. The age of the core of grain #1 (972 ± 11 Ma) suggests that the Água Branca granitic magma interacted with a Tonian crust. A Tonian orthogneiss is found 40 km to the east from this point, also suggesting that this is the age of a crust which is lying underneath the Águas Belas-Canindé batholith, and that its country rocks are, at least in part, of Tonian age.

Some zircon grains from Mata Grande pluton show ages ca. 2.15 Ga, 2.05 Ga and 1.96 Ga, similar to the Nd T_{DM} model age of the Mata Grande granitoids (Table 4). The occurrence of these Rhyacian to Orosirian zircon grains suggests the presence of a Paleoproterozoic crustal component in the protolith of the Mata Grande granitoids. These zircon grains should be crystals inherited from the source rock after a low-degree partial melting process. Their occurrence is evidence that the PEAL domain was involved in Rhyacian to Orosirian events, as has been demonstrated by Silva Filho et al. (2014a).

Granites and orthogneisses showing ages of ca. 610 Ma and flat-lying foliation have been recorded within the Sergipano (Guimarães and Silva Filho, 1995), PEAL (Neves et al., 2005; Silva Filho et al., 2014b) and Transversal Zone (Guimarães et al., 2004, 2011) domains. Within the Transversal Zone domain, granitoids of similar ages have been reported associated with either a compressional (flat-lying foliation formation event) or an extensional event (Guimarães et al., 2011). Intrusion and deformation of granitoids during the D_2 event was dated by Neves et al. (2008) at 606 ± 8 Ma in the north part of the PEAL domain (Fig. 1b). Oliveira et al. (2010) obtained Ar^{40}/Ar^{39} ages in muscovites of mylonitized amphibolites ranging from 615 ± 4 Ma to 611 ± 4 Ma in the Sergipano domain. They interpreted these ages as representing a second episode of shearing of the Belo Monte Jeremoabo Shear Zone, associated with the continuation of the uplift and slow cooling process of the Sergipano domain.

According to the geotectonic model for the evolution of the Sergipano domain proposed by Oliveira et al. (2010), convergence of the PEAL domain and the São Francisco Craton occurred between 630 Ma and 620 Ma and led to build up of a continental arc, slab-tearing and emplacement of those granites. According to Morrison (1980), shoshonites are generated during slab-tearing.

Table 5
Summary of SHRIMP U–Pb zircon data for Correntes Pluton.

Grain. spot	%^{206}Pb$_c$	ppm U	ppm Th	^{232}Th/^{238}U	±%	(1) ppm^{206}Pb*	(1)^{206}Pb/^{238}U age		(1)^{207}Pb/^{206}Pb age		% Discordant	(1)^{207}Pb*/^{206}Pb*	±%	(1)^{207}Pb*/^{235}U	±%	(1)^{206}Pb*/^{238}U	±%	Err corr
1.1	0.067	339	56	0.17	0.52	29	605	±11	638	±17	+5	0.0610	0.80	0.827	2.1	0.0984	1.9	0.92
2.1	0.654	416	268	0.67	1.71	33	568	±7	585	±26	+3	0.0595	1.19	0.756	1.7	0.0921	1.2	0.71
2.2	0.027	156	169	1.12	0.63	13	592	±9	589	±23	−1	0.0596	1.08	0.791	1.9	0.0963	1.6	0.82
3.1	2.774	934	891	0.99	0.42	75	576	±13	576	±63	−0	0.0592	2.90	0.763	3.7	0.0935	2.3	0.62
4.1	0.028	153	78	0.53	0.29	45	1901	±27	1964	±8	+4	0.1205	0.42	5.700	1.7	0.3430	1.6	0.97
5.1	0.707	473	183	0.40	0.22	57	841	±10	1611	±16	+51	0.0993	0.88	1.907	1.5	0.1393	1.2	0.81
6.1	0.349	745	331	0.46	1.02	61	585	±8	605	±17	+4	0.0600	0.77	0.786	1.6	0.0950	1.5	0.88
7.1	0.023	578	52	0.09	1.70	227	2432	±37	2595	±21	+8	0.1739	1.26	10.987	2.2	0.4583	1.8	0.82
7.2	0.016	433	229	0.55	0.79	164	2351	±38	2573	±19	+10	0.1715	1.14	10.410	2.2	0.4401	1.9	0.86
8.1	0.113	117	34	0.30	0.40	11	652	±12	675	±31	+4	0.0620	1.47	0.910	2.4	0.1064	1.9	0.79
9.1	0.101	89	64	0.74	0.59	8	609	±9	630	±36	+4	0.0607	1.67	0.829	2.2	0.0990	1.5	0.66
11.1	0.034	259	137	0.54	0.65	23	624	±8	627	±18	+0	0.0606	0.85	0.850	1.7	0.1017	1.4	0.86
12.1	0.420	738	147	0.21	8.04	65	626	±11	657	±68	+5	0.0615	3.15	0.865	3.6	0.1020	1.8	0.49
13.1	0.015	593	511	0.89	0.19	50	601	±9	584	±12	−3	0.0595	0.54	0.801	1.7	0.0976	1.6	0.95
14.1	0.119	111	74	0.68	0.55	9	599	±12	592	±34	−1	0.0597	1.55	0.802	2.6	0.0974	2.1	0.80
15.1	7.759	258	72	0.29	1.34	34	911	±21	1895	±108	+56	0.1160	6.00	2.427	6.5	0.1518	2.4	0.38
15.2	0.013	390	135	0.36	7.45	107	1791	±34	2059	±18	+15	0.1271	1.01	5.612	2.4	0.3202	2.2	0.91
15.3	2.043	604	395	0.67	0.20	50	591	±8	592	±37	+0	0.0597	1.71	0.789	2.3	0.0959	1.5	0.66
16.1	0.174	78	58	0.77	0.35	7	603	±9	579	±44	−4	0.0593	2.03	0.801	2.6	0.0980	1.6	0.61
17.1	11.453	583	440	0.78	0.43	42	524	±9	580	±133	+10	0.0593	6.12	0.692	6.4	0.0846	1.8	0.28
17.2	1.966	1034	609	0.61	1.66	95	654	±8	718	±32	+9	0.0633	1.53	0.932	2.0	0.1068	1.3	0.66
18.1	0.073	121	84	0.72	0.59	10	603	±8	601	±30	−0	0.0599	1.36	0.810	1.9	0.0980	1.3	0.70
19.1	0.071	591	444	0.78	0.19	50	609	±11	612	±12	+0	0.0602	0.57	0.823	2.0	0.0991	2.0	0.96
20.1	0.057	81	42	0.54	1.67	7	600	±10	597	±35	−0	0.0598	1.64	0.805	2.4	0.0975	1.8	0.74
22.1	0.177	200	243	0.87	1.04	12	595	±9	596	±29	+0	0.0598	1.34	0.797	2.0	0.0967	1.5	0.75

Errors are 1-sigma; Pb$_c$ and Pb* indicate the common and radiogenic portions, respectively.
Error in Standard calibration was 0.25% (not included in above errors but required when comparing data from different mounts).
(1) Common Pb corrected using measured ^{204}Pb.

Table 6

Summary of SHRIMP U–Pb and oxygen zircon data for Águas Belas Suite.

Grain. spot	%^{206}Pb$_c$	ppm U	ppm Th	^{232}Th/^{238}U	ppm^{206}Pb*	(1)^{206}Pb/^{238}U age		(1)^{207}Pb/^{206}Pb age		% Discordant	(1)^{207}Pb*/^{206}Pb*	±%	(1)^{207}Pb*/^{235}U	±%	(1)^{206}Pb*/^{238}U	±%	Err corr	δ^{18} O‰
1.1	0.10	608	118	0.20	49.6	583	±5.9	577	±18	−1	0.05926	0.83	0.774	1.3	0.0948	1.1	0.789	8.04
2.1	0.40	691	234	0.35	56.5	584	±5.9	575	±29	−2	0.05922	1.3	0.774	1.7	0.0948	1.1	0.618	8.72
3.1	–	496	128	0.27	41.3	596	±6.1	597	±16	0	0.05981	0.75	0.799	1.3	0.0969	1.1	0.820	10.30
4.1	0.24	431	138	0.33	37.0	613	±6.4	548	±27	−11	0.05848	1.2	0.804	1.7	0.0998	1.1	0.657	6.69
4.2	0.00	149	104	0.72	35.2	1565	±16	1594	±13	2	0.09838	0.7	3.727	1.4	0.2747	1.2	0.859	6.35
5.1	0.12	597	203	0.35	49.3	592	±7.5	595	±19	1	0.05977	0.89	0.792	1.6	0.0961	1.3	0.832	8.56
6.1	0.00	671	227	0.35	56.1	599	±6.1	572	±16	−5	0.05913	0.74	0.794	1.3	0.0974	1.1	0.820	8.35
7.1	12.16	1136	335	0.30	93.3	520	±6.8	671	±170	29	0.06190	8	0.717	8.1	0.0840	1.4	0.168	7.45
8.1	0.42	805	345	0.44	63.9	567	±5.7	593	±24	4	0.05970	1.1	0.758	1.5	0.0920	1.1	0.683	7.04
9.1	0.30	654	176	0.28	47.7	524	±14	584	±23	12	0.05947	1.1	0.694	2.9	0.0847	2.7	0.930	8.61
10.1	0.81	778	331	0.44	65.7	600	±6.2	608	±59	1	0.06010	2.7	0.809	2.9	0.0976	1.1	0.368	8.44
11.1	0.29	390	102	0.27	31.7	582	±10	585	±29	1	0.05950	1.3	0.775	2.3	0.0945	1.8	0.804	8.19
11.2	0.04	388	10	0.03	99.0	1675	±25	1895	±14	13	0.11600	0.76	4.747	1.8	0.2968	1.7	0.911	10.01
12.1	0.05	560	152	0.28	46.6	596	±6.1	592	±17	−1	0.05967	0.77	0.796	1.3	0.0968	1.1	0.811	8.67
13.1	2.06	816	243	0.31	59.0	511	±5.3	618	±63	21	0.0604	2.9	0.687	3.1	0.0825	1.1	0.347	8.41
14.1	0.20	694	298	0.44	57.3	591	±6	588	±19	0	0.05958	0.9	0.788	1.4	0.0960	1.1	0.765	8.55
16.1	0.22	679	199	0.30	55.3	583	±0.9	606	±21	4	0.06007	0.96	0.784	1.4	0.0946	1.1	0.741	8.74
16.2	0.38	528	210	0.41	42.8	580	±6	611	±29	5	0.0602	1.3	0.781	1.7	0.0941	1.1	0.634	8.67
17.1	0.49	761	267	0.36	61.4	576	±5.8	598	±25	4	0.05986	1.2	0.771	1.6	0.0935	1.1	0.671	8.26
18.1	0.04	692	365	0.55	57.8	598	±7.1	572	±16	−4	0.05914	0.74	0.793	1.4	0.0972	1.2	0.860	8.07
19.1	0.10	330	101	0.32	27.0	586	±6.3	604	±26	3	0.06001	1.2	0.788	1.6	0.0953	1.1	0.690	7.81
20.1	0.12	597	186	0.32	49.2	591	±6.7	589	±19	0	0.05958	0.9	0.788	1.5	0.0959	1.2	0.796	8.27
21.1	0.14	745	225	0.31	73.3	698	±7.1	1041	±29	49	0.07400	1.4	1.166	1.8	0.1143	1.1	0.598	6.89
22.1	0.15	241	6	0.03	73.6	1956	±19	2060	±23	5	0.12720	1.3	6.22	1.7	0.3545	1.1	0.649	11.01
23.1	3.54	905	280	0.32	73.3	561	±6.6	616	±99	10	0.06030	4.6	0.757	4.7	0.0910	1.2	0.258	7.57
23.2	6.53	250	115	0.47	30.1	794	±14	1315	±300	66	0.08500	15	1.54	16	0.1311	1.8	0.116	5.79

Errors are 1-sigma; Pb$_c$ and Pb* indicate the common and radiogenic portions, respectively.

Error in Standard calibration was 0.24% (not included in above errors but required when comparing data from different mounts).

(1) Common Pb corrected using measured ^{204}Pb.

Table 7
Representative whole rock data of the high − K granitoids from the PEAL Domain.

Sample	ABR2	ABR3	ABR4	ABR7	ABR13B[a]	ABR46A[a]	MG2a	MG2B	MG-4	MG-5	MG-6	CO-2	CO-5	CO-6	AB3	AB8	AB15	AB17	CH03	CH3B	CH-4	CH1A
SiO_2	67.02	65.60	68.94	67.60	59.47	63.24	72.05	65.17	61.51	62.47	63.17	70.36	69.42	68.20	71.15	69.14	73.12	72.39	63.79	58.88	63.29	62.46
TiO_2	0.20	0.43	0.16	0.52	0.70	0.77	0.24	0.49	0.55	0.49	0.40	0.37	0.27	0.32	0.33	0.25	0.11	0.13	0.54	0.47	0.57	0.57
Al_2O_3	15.13	12.69	16.02	14.02	14.05	13.92	13.56	14.49	14.70	14.08	15.50	14.03	14.53	14.48	14.24	14.39	14.20	14.23	17.89	13.95	17.21	17.90
Fe_2O_3	2.65	4.28	2.19	3.69	5.86	4.70	2.30	4.09	5.14	4.68	4.31	2.17	2.02	2.36	2.67	2.99	1.63	1.77	2.82	5.49	3.36	3.20
MnO	0.07	0.08	0.02	0.07	0.15	0.08	0.05	0.08	0.09	0.10	0.10	0.04	0.06	0.05	0.05	0.07	0.04	0.05	0.06	0.04	0.03	0.07
MgO	0.78	1.78	0.15	1.62	1.49	2.08	0.65	1.09	1.92	2.62	0.94	0.45	0.48	0.59	0.52	0.42	0.22	0.27	0.71	6.42	1.05	1.22
CaO	2.01	2.96	1.20	2.04	5.29	3.11	0.76	1.14	2.97	2.77	2.70	1.08	1.23	1.31	1.02	1.15	0.87	0.85	1.63	4.42	1.74	2.09
Na_2O	5.18	4.07	5.92	3.75	3.82	3.31	4.24	3.22	4.57	4.20	5.22	4.28	3.99	3.89	3.44	3.55	4.22	4.20	4.84	3.63	4.53	4.68
K_2O	5.31	5.88	3.58	5.28	6.47	6.20	5.06	8.08	5.94	6.23	5.92	5.70	5.71	6.15	5.49	6.92	5.23	5.25	6.67	4.43	6.42	7.16
P_2O_5	0.19	0.40	0.10	0.32	0.52	0.50	0.12	0.25	0.52	0.59	0.20	0.11	0.10	0.09	0.09	0.07	0.04	0.05	0.16	0.50	0.19	0.18
LOI	0.60	1.10	0.90	1.40	0.30	0.80	0.50	1.00	0.80	0.70	0.60	0.40	0.40	0.50	0.40	0.20	0.30	0.20	0.4	0.90	1.00	0.60
Total	99.14	99.27	99.18	100.31	98.12	98.71	99.53	99.10	98.71	98.93	99.06	98.99	98.21	97.94	99.40	95.15	99.98	99.47	94.49	99.26	99.43	100.13
Trace elements in ppm																						
Cr	15	28	9	70					26			20	15						14	335	16	54
Ni	21	42	10	48			20	52	41		27	21	32	37					<20	144	22	<20
Rb	115	176	77	228	96	164	0	0	199		0	170	134	0	245	203	231	224	241	125	190	164
Ba	4209	3790	3937	3457	6015	4141	1769	4861	5071	3928	4258	3386	3688	4639	800	2566	1335	1297	607	2426	1006	1510
Sr	1605	1178	1923	1297			789	512	1080		1255	519	857	805	169	710	460	458	328	926	432	646
Ta	1.60	2.10	1.00	1.70			1.06	0.80	1.50		0.00	0.30	0.80	0.00	0.50	0.30	0.8	0.30	1.10	0.30	0.70	0.30
Nb	16	33.6	16.0	27.0	19	15	17.0	12.0	24.0		10.0	4.8	12.8	0.0	8	4.8	9.4	10.5	26.00	11.00	27.00	11.0
Hf	5.60	8.00	5.20	6.50			3.63	7.28	9.00		6.72	4.00	3.90	3.84	4.90	3.60	3.10	3.30	12.20	1.60	10.80	7.00
Zr	162	323	129	226			136	273	271		252	322	144	144	177	159	87	92	482	50	410	495
Y	16	26	10	21			12	21	40		19	75	21	18	10	19	14	13	15	20	16	16
Th	10.5	9.1	5.2	18.4					22.0			10.8	3.9	0.0	38.4	11.1	12.3	19.0	8.6	2.2	6.1	1.9
La	44.8	98.7	32.2	159.0					75.6			122.0	23.6	28.5	81	31.0	16.4	15.7	46.20	45.10	49.30	54.2
Ce	66	161.0	46.0	313.0	133	102			131.0			197.0	69.0	77.4	165	59.0	29.3	29.9	82.30	90.00	93.50	120.0
Pr	0.0	0.0	0.0	0.0					0.0			0.0	0.0	8.2		0.0	3.22	3.08	8.31	10.14	9.23	0.0
Nd	35	63.0	22.0	137.0	83	63			75.0			81.0	26.0	12.2	66	23	12.1	12.3	31.30	41.50	34.50	57.0
Sm	6.4	11.2	3.1	22.4	16	11			14.9			15.9	5.4	0.4	21	4.1	2.3	2.3	5.10	7.60	5.90	9.9
Eu	1.8	2.7	1.1	5.1					4.1			4.3	1.6	1.5		1.1	0.5	0.5	1.28	1.69	1.09	2.9
Gd														4.6			2.28	2.03	3.28	4.88	3.41	
Tb														0.10			0.36	0.32	0.52	0.72	0.56	
Dy														1.30			2.36	2.06	2.61	3.55	2.72	
Ho														0.80			0.44	0.4	0.51	0.63	0.51	
Er														0.70			1.38	1.26	1.41	1.76	1.46	
Tm														0.70			0.24	0.22	0.23	0.23	0.21	
Yb	1.02	2.15	0.52	3.26					2.31		0.00	6.13	2.51	1.80	0.80	1.73	1.42	1.6	1.43	1.70	1.53	1.80
Lu			0.10	0.48								0.82		0.30			0.24	0.27	0.24	0.25	0.23	
T °C																			901		882	902

ABR − Agua Branca Pluton; MG − Mata Grande Pluton; AB − Águas Belas Pluton; CO = Correntes Pluton; SC = Serra do Catú Pluton; CH = Cachoeirinha Pluton; B = enclave. T °C calculated according to Zr − geothermometer $T = -273 + [12{,}900/(17.18 - \ln Zr)]$ − Watson, 1987).

[a] This work.

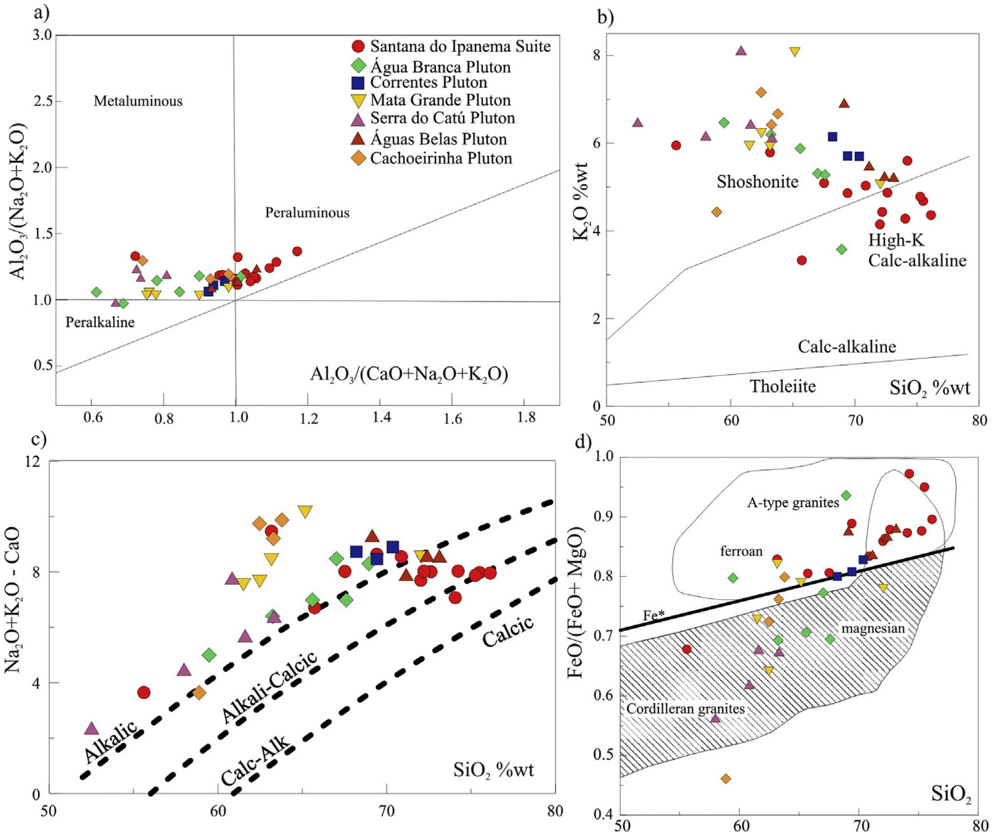

Fig. 7. a) Alumina saturation of the studied suites plotted in the Maniar and Piccolli (1989) diagram; b) K_2O versus SiO_2 diagram with fields after Peccerillo and Taylor (1976); c) Modified alkali-lime index (MALI), (Frost et al., 2001) versus SiO_2 diagram; d) Fe number (Fe#) versus SiO_2 with fields after Frost et al. (2001).

The geotectonic model of Oliveira et al. (2010) explains the intrusions showing Mesoproterozoic Nd T_{DM} model ages (Água Branca and Serra do Catú plutons) intruded within the contact zone between the Sergipano and PEAL domains or close to it (Fig. 1b). The magma generation could be explained by a plume, during 750–680 Ma, as has been demonstrated in the previous section.

2) Granitoids with ages of ca. 590 Ma

According to Neves et al. (2005) the intrusion of the Cachoeirinha pluton occurred during bulk NW–SE shortening, with zones of non-coaxial shear developing locally. The age recorded in this work is interpreted as the age of the granitoids crystallization which occurred during a shortening event. This shortening event could be related to the collision of PEAL domain and adjoining terranes. Bueno et al. (2009) identified within the Sergipano domain plutons with crystallization ages of 580 Ma, intruded during a flat-lying foliation event. The intrusion of the Águas Belas pluton has been interpreted as marking the transition between compression and extension, during the final stage of the Brasiliano Orogeny (Silva Filho et al., 2010).

Ages of ca. 590 Ma with Nd T_{DM} model ages ca. 1.70–2.20 Ga were obtained for various calc-alkaline granitic plutons (Osako, 2005; Neves et al., 2005, 2008; Silva Filho et al., 2007, 2010, 2013, 2014b; Mariano et al., 2009) located in the northern part of the PEAL domain, Garanhuns sub-domain. Their emplacements were controlled by ductile transcurrent shear zones active during the D_3 stage of the Brasiliano collision. Within the Transversal Zone domain this age has been reported in many high-K calc-alkaline to shoshonitic, pre-to syn-transcurrent granitoids (Guimarães and Silva Filho, 2000; Guimarães et al., 2004; 2011; Neves et al., 2004, 2005, 1996; Archanjo et al., 2008). All these authors concluded that most of these plutons were emplaced during a transcurrent event. Bueno et al. (2009) characterized syn-collisional plutons with this age from the Sergipano domain. This geological setting was responsible for generating granites with some A-type signature in the northern part of the PEAL, and in the Transversal Zone domains (Guimarães et al., 2004; Guimarães et al., 2005).

The simultaneous emplacement of syn-collision high-K calc-alkaline granites in the Sergipano domain (granites of 590–570 Ma) and syn-transcurrent granites (590–580 Ma) in the Transversal Zone domain can be explained by continent–continent collision. In this case, the Sergipano domain syn-collision granites formed in the collision zone and the Transversal domain syn-transcurrence granites formed in the passive indentor (Bueno et al., 2009). The data presented in this paper allow us to say that the northern part of the PEAL domain behaved as a passive indentor, during the Criogenian/Ediacaran collision, i.e., a mechanical behavior similar to the Transversal domain, suggesting they have same crustal structure.

Another reason for arguing that the northern PEAL domain, Garanhuns sub-domain of Silva Filho et al. (2014a), shows crustal continuity with the Transversal Zone domain is that the PEAL domain has granites with age ca 610 Ma, as in the Transversal Zone, and there is a gap on the granitic calc-alkaline magmatism, between 610 and 590 Ma. This gap is not recorded in the Sergipano domain.

The ca. 1.7 Ga Nd T_{DM} model age recorded in the granitoids of the Cachoeirinha pluton is unique among the studied granitoids (Table 4). U–Pb LA-ICP-MS zircon data presented by Neves et al.

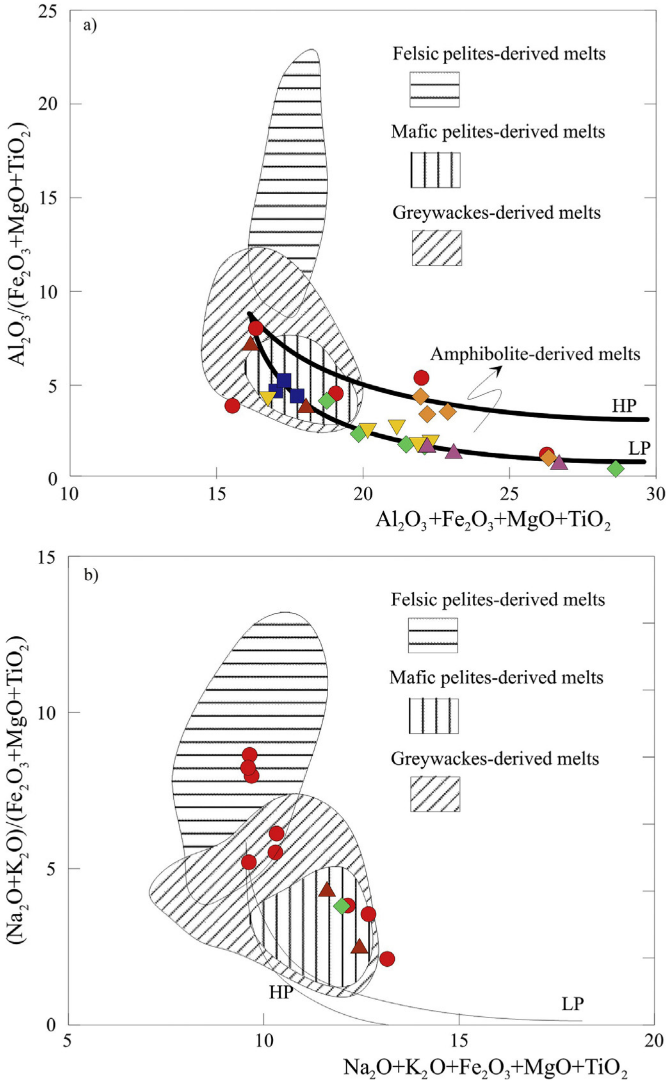

Fig. 8. a) Studied samples plotted in the diagram with fields after Patiño Douce (1999) for metaluminous rocks; b) Studied samples plotted in the diagram with fields after Patiño Douce (1999) for peraluminous rocks.

(2008) suggest that this suite does not have inherited zircons. Intrusions with Mesoproterozoic crystallization ages do not occur so far within the PEAL domain. However, the Rio Una metasedimentary sequence has a large number of detrital zircon grains with ages within the 1.62–1.74 Ga interval (Neves et al., 2008; Silva Filho et al., 2014a). Ages within the 1.5–1.7 Ga interval have been recorded in anorogenic orthogneisses and meta-anorthosites in the so-called Rio Capibaribe Terrane in the Transversal Zone domain (Fig. 1a). The Sm–Nd T_{DM} model age of ca 1.7 Ga can be interpreted as either (a) a mixing age resulted from mixture between Paleoproterozoic and Neoproterozoic (Tonian or Criogenian/Ediacaran) crustal material or (b) melting of a crustal component inherited from an extensional Mesoproterozoic event. However, the second hypothesis is not supported by the available data. Therefore, the Sm–Nd T_{DM} model ages recorded in the Correntes, Viçosa and Águas Belas plutons suggest a mixed source of Paleoproterozoic and Neoproterozoic components from the isotopic crustal sub-domain in which they are located.

Examples from the Borborema Province (Guimarães and Silva Filho, 1995; Oliveira and Tarney, 1995; Brito, 2005) and from classical areas (Turner et al., 1996), suggest that high-K calc-alkaline rocks can be generated during syn-to post-collisional setting. During collision the doubled thickness of a granitic continental crust would result in the thickened crust warming to a temperature high enough to produce its partial melting after a few tens of millions years. This could be an explanation why during the Brasiliano orogeny only very few granitoids older than 625 Ma have been found within the PEAL and elsewhere within the Borborema Province.

8.2. *Inferences on sources*

8.2.1. *U–Th–Pb and oxygen data*

It is important to point out the analysis of the core of zircon #10, spot #10.1 (Table 1) from the Sera do Catú suite, yielding $^{207}Pb/^{206}Pb$ age of 1.226 ± 251 Ma, and that of core of zircon #6, spot #6.1 (Table 1) yielding $^{206}Pb/^{238}U$ age of 961 Ma. Although the age of grain #10 shows large error, both grains, #10 and #6, show a rounded and zoned core, surrounded by an overgrowth, suggesting that both are inherited zircon grains from the Águas Belas-Canindé batholith Tonian basement.

The U–Pb data of Santana do Ipanema suite show only a zircon grain with $^{206}Pb/^{238}U$ age of 722 ± 15 Ma. Lack of zircon with Tonian or older age, and at the same time the mantle $^{18}O/^{16}O$ values of this suite (Table 2) suggest that at least, part of the Santana do Ipanema suite magmas were separated directly from the mantle, and contaminated with heterogeneous crust (Fig. 10).

Two zircon xenocrystal grains (#4.1 and #7.1), yielding $^{207}Pb/^{206}Pb$ ages ca 1964 Ma and 2595 Ma (Table 5) were recorded in the Correntes granitoids, suggesting that the Correntes pluton had participation of Archean and Paleoproterozoic components in their source.

The Águas Belas suite has inherited zircon cores that yield slightly discordant $^{207}Pb/^{206}Pb$ ages (Table 6). The zircon cores yield ages of 1594 ± 13 Ma, 1895 ± 14 Ma, and 2060 ± 23 Ma. The core of crystal 4 yielded an age of 1594 ± 13 Ma while the rim shows an age of 613 ± 6 Ma.

The inheritance of Paleoproterozoic zircon grains in the Mata Grande and Correntes granitoids, associated to their metaluminous signature, suggest that their source was probably a Paleoproterozoic lower crust. However, the metaluminous to slightly peraluminous character of the Águas Belas granitoids, associated to the recorded inherited zircon, suggests many components in their source, Paleoproterozoic lithospheric mantle; Paleoproterozoic crustal rocks; Neoproterozoic supracrustal sequences, and Mesoproterozoic igneous rocks, as suggested by Silva Filho et al. (2010).

Average $\delta^{18}O$ (zircon) value for Águas Belas suite is lower (8.23 ± 0.46‰) when the highest (10.30‰) and the lowest (6.69‰) values are not considered. In this case, considering whole rock silica contents, calculated average whole rock $\delta^{18}O$ values, following Valley et al. (1994), vary from 10.06 ± 0.46‰ to 10.30 ± 0.46‰ for SiO_2 contents of 69.14% and 73.12%, respectively, the silica range observed for the Águas Belas rocks. These average values are consistent and compatible with high $\delta^{18}O$ crustal derived magmas crystallized in a closed system. The highest $\delta^{18}O$ (zircon) values (10.01 and 11.01‰) from the Paleoproterozoic cores are 2–3‰ higher than the $\delta^{18}O$ (zircon) values observed for zircons of this age studied by Valley et al. (2005), who reported that during the Proterozoic the range of $\delta^{18}O$ (zircon) gradually increases in a secular change that documents maturation of the crust. The high $\delta^{18}O$ values of Proterozoic zircon cores of this study are compatible with high $\delta^{18}O$ values of (meta) sedimentary rocks. The $\delta^{18}O$ (zircon) values of Mesoproterozoic cores are lower (6.35‰ and 6.89‰) and can be interpreted as resulting from the exchange of protoliths with surface waters at low temperature followed by melting or contamination, as suggested by Valley et al. (2005) for Archean

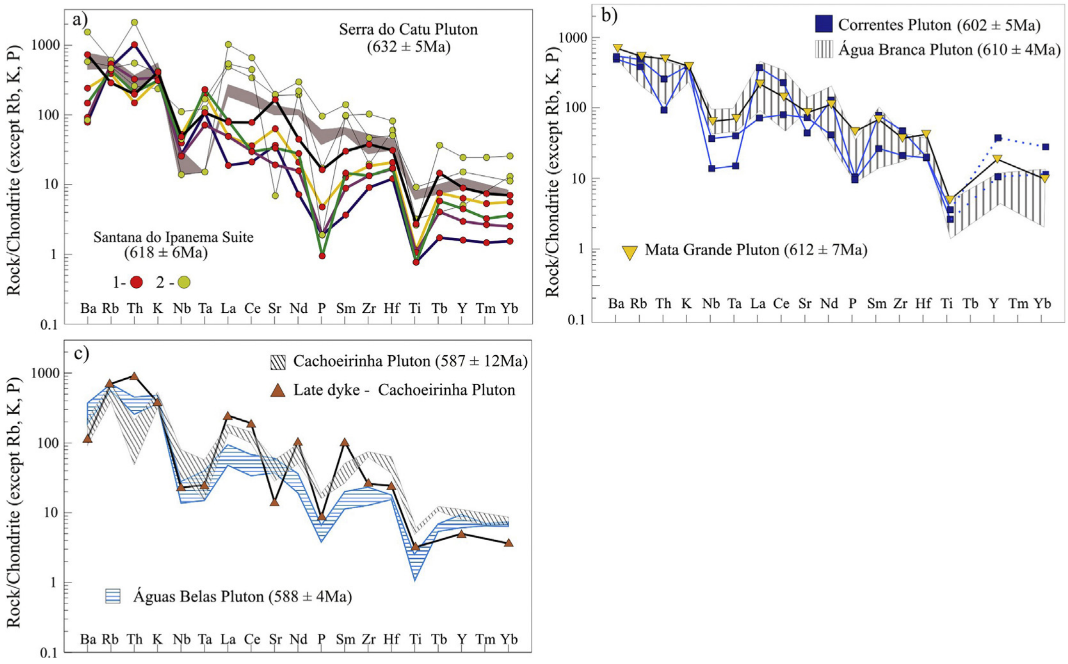

Fig. 9. Chondrite – normalized (Thompson, 1982) spidergrams of the studied granitoids; a) Serra do Catú and Santana do Ipanema suites, 1-monzogranites to monzonites and 2-syenites, quartz-syenites to monzonites; b) Correntes, Água Branca and Mata Grande suites; c) Águas Belas and Cachoeirinha suites.

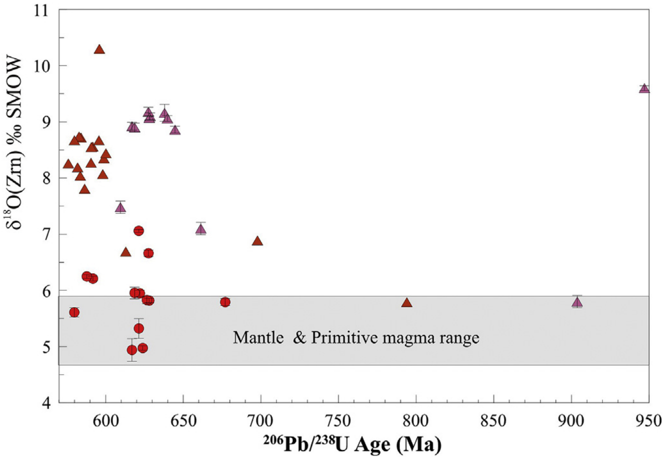

Fig. 10. Diagram of $\delta^{18}O$ (Zrn) ‰ SMOW vs. $^{206}Pb/^{238}U$ Age (Ma). Field after Valley et al. (2005). Symbols as in Fig. 7.

zircons that show $\delta^{18}O$ values in the range 6.5–7.5‰.

8.2.2. U–Th–Pb and Sm–Nd isotopic data

The granites of the *Group 1 (Nd T_{DM} 1.30 – 1.50 Ga)* show Sm–Nd signatures similar to those recorded in the Inhapi and Rio Una metasedimentary sequence (Fig. 11a). However, magmas derived from purely metasedimentary or biotite-bearing metaigneous sources are strongly peraluminous, SiO_2-rich (>72 wt%) and depleted in Ca, Mg and Fe (Patiño Douce and Johnston, 1991; Patiño Douce and Beard, 1996; Gardien et al., 1995). As the granitoids of Group 1 comprise metaluminous suites, their source may have involved a depleted mantle component mixed with melts originated from either deep-seated sediments and/or melts from the Tonian orthogneisses. In the $^{143}Nd/^{144}Nd$ vs. SiO_2 diagram with fields after Foden et al. (2015) the granitoids of group 1 plot into the fields for S-type and I-type granites (Fig. 12), and in the fields of rocks with pelite and metagraywacke protoliths (Fig. 8a,b) after Patiño Douce (1999). They also follow the open system – AFC trend and the open system – crustal melting trend. These three lines of evidence show that the studied suites from the group 1 have a sedimentary component in their protoliths.

The granitoids of Group 2 (Nd T_{DM} 1.70–2.20 Ga) have Nd T_{DM} model ages similar to those recorded in the Rio Una metasediments (ca 2.0 Ga – Table 8), and only one sample from the Águas Belas suite showing Sm–Nd T_{DM} model age similar to the Belém do São Francisco orthogneisses (Fig. 11b). Hf detrital zircon data from the Rio Una metasediments show Hf T_{DM} of 1.80 Ga (Silva Filho – in preparation). In the $^{143}Nd/^{144}Nd$ vs. SiO_2 diagram with fields after Foden et al. (2015) (Fig. 12) the granitoids from group 2 plot in the field for S-type granites, reinforcing the participation of the Rio Una metasedimentary sequence in the source of these granitoids.

8.3. Correlations with adjoining domains

U–Pb SHRIMP zircon data of Água Branca and Serra do Catú suites suggest the presence of Tonian age crust as their source rock component, as both suites have zircon xenocrysts with $^{207}Pb/^{206}Pb$ ages ca. 970 Ma. Tonian orthogneisses with similar age have been dated within the Águas Belas-Canindé batholith (Silva Filho et al., 2014a), which should be the country rocks to these suites and they also show Nd T_{DM} age of ca 1.4 Ga. They constitute the largest high–K granitoid intrusions within the Borborema Province that show Mesoproterozoic Sm–Nd T_{DM} model ages. Within the Transversal Zone domain to the north, high-K to shoshonitic granitoids from large intrusions, such as the Triunfo batholith (Ferreira et al., 2011) and the Bom Jardim complex (Guimarães et al., 2004), show Paleoproterozoic Sm–Nd T_{DM} model ages.

Zircon grains with age ca. 750 Ma were recorded in the Santana do Ipanema suite, in the Ipojuca-Atalaia batholith, and as detrital zircon in the Rio Una sequence. Recently, Arthaud et al. (2015) identified a ca. 750 Ma bimodal volcanism within the Ceará Central domain, and a population of detrital zircon with this age in the Ceará Group. Neves et al. (2006) in the metasedimentary Surubim

Table 8
Whole rock Sm–Nd isotopic data for rocks of the PE-AL complex.

Sample	S. latitude	N latitude	Rock type and plutons	Nd (ppm)	Sm (ppm)	147Sm/144Nd	143Nd/144Nd	±2δ	e(Nd) Today	e(Nd) 0,6Ga	TDM (Ga)	Ref.
SI-43	9° 19.36′	37° 07.64′	Santana do Ipanema dike	24.26	4.02	0.10030	0.51205	9	−11.5	−4.1	1.33	1
SI-32			Santana do Ipanema dike	534.92	76.81	0.08682	0.511932		−13.78	−5.36	1.34	0
SC-71			Serra do Catú pluton		6.0	0.11055	0.512105		−10.4	−3.8	1.4	0
ABR-46A			Água Branca pluton	62.914	11.48	0.11036	0.512064		−11.2	−4.6	1.44	0
92–20	9° 16.60′	37° 56.80′	Água Branca pluton	100.94	17.80	0.10660	0.51202	13	−12.1	−5.2	1.46	2
SC-95-A	9° 29.22′	37° 45.26′	Serra do Catú pluton	76.04	13.93	0.11072	0.51204	9	−11.6	−5.0	1.48	1
ABR-4			Água Branca pluton	20.28	2.87	0.08559	0.511787		−16.61	−8.11	1.49	0
SC-46A			Serra do Catú pluton		11.0	0.11095	0.512037		−11.71	−5.15	1.5	0
SI-9			Santana do Ipanema dike	23.06	4.30	0.11265	0.511900		−14.4	−7.97	1.72	0
CHA-1-A	8° 30.12′	36° 14.84′	Cachoeirinha pluton -Granite	56.52	8.53	0.09126	0.51165	9	−19.3	−11.2	1.74	1
CO-2	9° 12.28′	36° 28.71′	Correntes pluton	76.76	15.01	0.11825	0.51191	9	−14.2	−8.2	1.81	1
ABR-2			Água Branca pluton	36.74	7.15	0.11769	0.511893		−14.54	−8.5	1.82	0
SI-11			Santana do Ipanema dike	65.45	14.32	0.13231	0.512065		−11.18	−6.25	1.83	0
SI-8			Santana do Ipanema dike	17.68	3.6	0.12305	0.511946		−13.5	−7.86	1.84	0
ABR-13B			Água Branca pluton	83.29	16.52	0.11992	0.511871		−14.95	−9.08	1.9	0
SI-10			Santana do Ipanema dike	19.9	4.34	0.13183	0.511968		−13.08	−8.11	2.00	0
MG-4	9° 08.30′	37° 44.19′	Mata Grande pluton	76.09	15.79	0.12542	0.51188	9	−14.7	−9.3	2.04	1
AB-8	9° 03.49′	37° 02.61′	Águas Belas pluton	21.26	4.12	0.11710	0.51169	9	−18.5	−12.4	2.14	1
Rio Una Pelites												
95–266	8° 43.42′	36° 46.41′	Garnet biotite gneiss	54.67	9.54	0.10549	0.51121	9	−27.8	−20.9	2.60	1
VENT-202	8° 51.56′	36° 55.53′	Garnet biotite gneiss	8.67	1.88	0.13139	0.51203	20	−11.8	−6.8	1.86	1
95–263	8° 27.41′	36° 46.41′	Biotite hornblende gneiss	72.51	11.16	0.09308	0.51149	9	−22.3	−14.4	1.96	1
VENT-8	8° 47.06′	36° 36.81′	Garnet–biotite-gneiss	37.89	1.50	0.02388	0.511283	51	−26.4	−13.2	1.41	1
VENT-204	8° 35.04′	36° 42.53′	Garnet-gneiss	15.63	3.14	0.12157	0.511978	20	−12.9	−7.1	1.75	1
GUS-208	8° 35.48′	36° 26.29′	Garnet–biotite-gneiss	29.95	5.88	0.11867	0.512088	20	−10.7	−4.8	1.52	1
Inhapi Pelites												
2004–26	9° 05.57′	37° 09.53′	Garnet–biotite- gneiss	19.68	3.92	0.12028	0.512115	16	−10.2	−4.4	1.50	1
2004–24C	9° 13.00′	37° 35.16′	Garnet–biotite-gneiss	32.53	7.44	0.13832	0.512282	9	−6.9	−2.5	1.53	1
Tonian Orthogneisses												
ABR-101	9° 16.28′	37° 44.97′	Migmatized orthogneiss	67.07	10.51	0.09479	0.512133	12	−9.8	−2.0	1.16	1
SI-100	9° 17.75′	37° 16.57′	Migmatized orthogneiss	27.94	6.34	0.13725	0.512371	6	−5.21	−0.65	1.33	1
2004–24B	9° 13.00′	37° 35.16′	Migmatized orthogneiss	14.46	2.91	0.12164	0.512168	11	−9.2	−3.4	1.44	1
Belém do SãoFrancisco Complex												
VENT-6	8° 56.72′	36° 53.51′	Migmatized orthogneiss	72.59	11.86	0.09876	0.511379	19	−24.56	−17.08	2.20	1
2004–027	8° 58.66′	36° 49.50′	Migmatized orthogneiss	95.40	17.15	0.10869	0.511497	8	−22.3	−15.5	2.24	1
2004–28A	8° 48.53′	36° 27.42′	Orthogneiss	4.25	0.78	0.11122	0.511554	10	−21.1	−14.6	2.21	1
VI-4	8° 26.28′	35° 04.95′	Viçosa pluton	33.11	5.50	0.10047	0.51162	9	−19.9	−12.6	1.92	1
VENT-203	8° 49.75′	36° 55.11′	Migmatized orthogneiss	19.65	3.20	0.09854	0.511252	20	−27.1	−19.6	2.37	1
2004–25	9° 10.65′	37° 27.94′	Orthogneiss	70.41	12.35	0.10604	0.511471	8	−22.8	−15.8	2.22	1
92–15	9° 23.00′	36° 40.90′	Migmatized orthogneiss	65.43	9.42	0.08707	0.51140	10	−24.1	−15.7	1.98	2
95–271	8° 52.95′	36° 17.06′	Migmatized orthogneiss	32.22	5.70	0.10704	0.51129	14	−26.4	−19.5	2.52	1
VI-12	8° 26.93′	35° 20.97′	Meta-tonalite	21.40	4.75	0.13429	0.511663	102	−19.0	−14.3	2.65	1
JGO-3	8° 42.34′	35° 36.35′	Migmatized orthogneiss	50.26	6.94	0.08351	0.510736	38	−37.11	−28.47	2.70	1

0 – This Work; 1 – Silva Filho et al. (2002, 2013, 2014); 2 – Van Schmus et al. (1995).

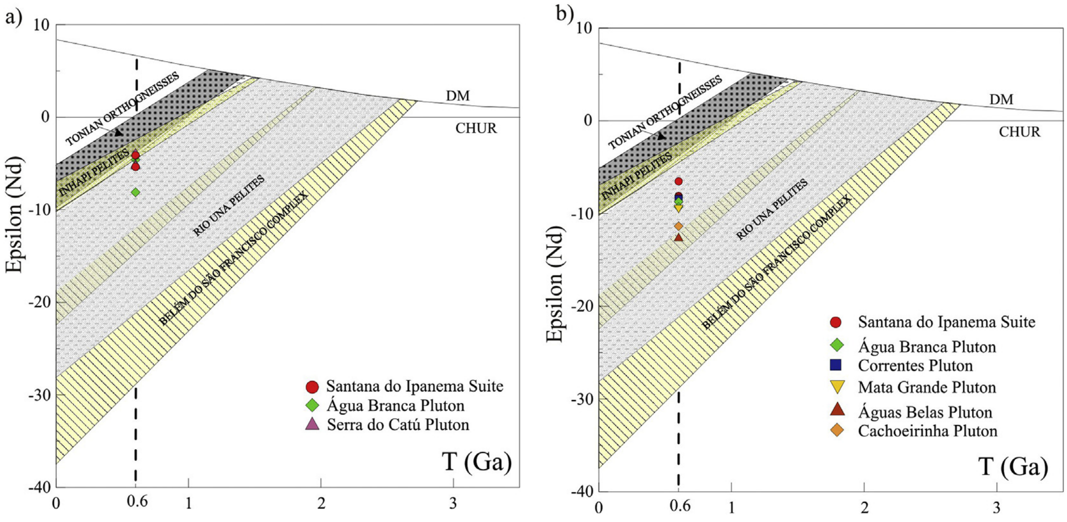

Fig. 11. (A) ƐNd vs. time diagram with studied samples of Nd T_{DM} 1.3–1.5 Ga, and fields of PEAL Tonian orthogneisses, Inhapi sequence pelites, Rio Una sequence pelites and Belém do São Francisco orthogneisses; (B) ƐNd vs. Time diagram with studied samples of Nd T_{DM} 1.7–2.2 Ga, and fields of PEAL Tonian orthogneisses, Inhapi sequence pelites, Rio Una sequence pelites and Belém do São Francisco orthogneisses.

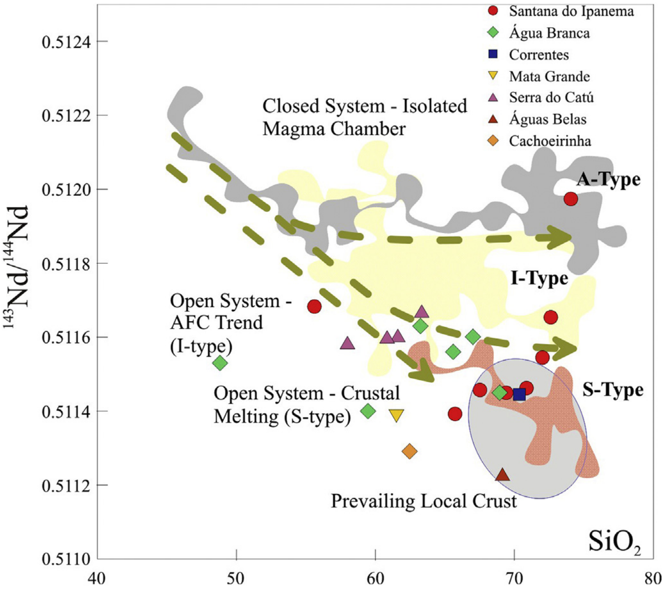

Fig. 12. $^{143}Nd/^{144}Nd$ vs. SiO_2 diagram with studied samples and fields after Foden et al. (2015).

Complex, eastern portion of the Transversal Zone domain, recorded similar ages. Arthaud et al. (2015) suggest that it is the age of the Rodinia break-up and the age of a plume – related regional magmatism. The Canindé sub-domain is a continental rift, which evolved from ca 715 Ma to ca. 640 Ma, including generation of tholeiitic magmatism, and rapakivi granites, just prior to the onset of the Brasiliano orogeny (Oliveira et al., 2010).

The heat generated by a plume could provide the necessary temperature for a massive partial melting of the lower crust + lithospheric mantle, before the onset of the Brasiliano orogeny. The magmas stored would be channeled through shear zones, during the Cryogenian to Ediacaran collision. Thus, there are two lines of evidence suggesting that a plume was the source of heat to generate a massive partial melting of the lower crust + lithospheric mantle, before the onset of the Brasiliano orogeny in the southern PEAL domain.

The Nd isotopic signature of Group 2 granites (Nd T_{DM} 1.7–2.2 Ga) suggests an old and heterogeneous source (Fig. 11b). They are all intruded into rocks from the Garanhuns and Arapiraca geophysical domains of Oliveira (2008), that correspond roughly to the Garanhuns crustal domain of Silva Filho et al. (2002), dominated by Paleoproterozoic rocks. SHRIMP U–Pb zircon data of these plutons show inherited zircons ranging in age from 1.4 to 2.8 Ga. Rhyacian and Orosirian age rocks have been identified within the PEAL (Silva Filho et al., 2014a), as well as detrital zircon with same age from the Rio Una sequence.

The Correntes pluton intrudes Neoproterozoic orthogneisses (Silva Filho et al., 2014a), along the NE–SW Palmares shear zone, whose transcurrent stage is correlated with the D_3 deformation phase in the Sergipano domain. Archean rocks occur 100 km to the south in the Jirau do Ponciano dome, while Paleoproterozoic ages have also been recorded ca. 100 km to the south of the Correntes pluton. Oliveira et al. (2010) dated post-tectonic muscovites from mylonites in shear zones of the Sergipano domain using the $^{40}Ar/^{39}Ar$ method, obtaining ages ranging from 581 ± 2 to 591 ± 3 Ma. The D_3 final deformation phase marks the end of the Neoproterozoic orogeny in the Sergipano domain and adjoining areas (Oliveira et al., 2010).

According to Oliveira et al. (2015), granitoids from the Sergipano domain with crystallization ages similar to those recorded in the Cachoeirinha and Águas Belas pluton are related to syn-D_2/syn-collision. They are emplaced into the Macururé sub-domain which is consider to be a Neoproterozoic analogous of the ductile channel flow model proposed for the High Himalaya (Oliveira et al., 2015). The Macururé metasedimentary sub-domain is located between two shear zones. During the collision between the PEAL domain and the São Francisco Craton the Macururé sub-domain was compressed, and partial melting of metasedimentary rocks may have taken place to form *in situ* granitic magmas, which migrated and were collected in the hinge of F_2 folds (Oliveira et al., 2015). These authors concluded that the Macururé subdomain operated as a ductile channel flow bound by two shear zones, between which the metasedimentary pile was exhumed and eroded, exposing side by side contrasting lithotectonic units.

9. Conclusions

The studied granitoids vary from high-K calc-alkaline to shoshonitic compositions. They are divided into 2 groups: 1) high Ba–Sr granitoids showing volcanic arc geochemical signature (Água Branca, Mata Grande and Serra do Catú) and (2) transitional high-K, calc alkaline to alkaline granitoids (Cachoeirinha, Correntes, Santana do Ipanema and Águas Belas).

The Sm–Nd and oxygen isotopic data associated with the inherited Paleoproterozoic zircon grains recorded within the Mata Grande, Águas Belas and Correntes granitoids suggest that their magmas were originated by partial melting of either Paleoproterozoic metassomatised lithospheric sub-continental mantle or mafic lower crust + metasediments. On the other hand, the magmas of the Serra do Catú, Água Branca and Santana do Ipanema suites appear to have involved a mixture between magmas generated by partial melting of Paleoproterozoic and Tonian and/or Cryogenian to Ediacaran juvenile component crustal sources. The zircon oxygen data from Santana do Ipanema suite suggest a Cryogenian to Ediacaran juvenile component. The lack of inherited zircon grains in the Cachoeirinha granitoids and their Sm–Nd signature suggest that their magmas were generated by high temperature partial melting of a Paleoproterozoic mafic crust.

The emplacement of the studied granitoids occurred at 635 Ma (Serra do Catú), 618 Ma (Santana do Ipanema suite), 610 Ma (Água Branca, Mata Grande and Correntes), and ca. 590 Ma (Cachoeirinha and Águas Belas). According to the available data, the intrusion of these granitoids ranges from early-to post-collisional/syn-transcurrence stage. The oldest age was recorded in high-K granitoids (Serra do Catú) intruded in the southwest part of the PEAL domain, close to its contact with the Sergipano domain. The intrusion of the studied granitoids appears to be associated to slab-tearing during the convergence between the PEAL domain and in the Sergipano domain, as the geotectonic model proposed by Oliveira et al. (2010).

The petrologic correlation and tectonic significance of the granitic magmatism in the Borborema Province is still an open theme. However, the data presented in this paper suggest that the southeastern part of the Transversal Zone and the northern part of the PEAL domains belonged to the same crustal block during the Brasiliano/Pan-African orogeny.

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