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PALEOPROTEROZOIC CRUSTAL GROWTH IN THE TROMBETAS REGION, SOUTHERN GUYANA SHIELD, SOUTH AMERICA

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ABSTRACT

The granitic rocks of the Erepecuru-Trombetas Domain (Central Amazon Province, southern Guyana Shield) are part of two extensive volcano-plutonic associations that marked the central portion of the Amazonian Craton during the Orosirian. The oldest episode (2.0-1.97 Ga) encompasses the Igarapé Paboca volcanic Formation and Caxipacoré Suite and the youngest episode (1.90-1.86 Ga) comprises the Água Branca and Mapuera plutonic suites and the pyroclastic/effusive rocks of the Iricoumé Group. Petrographic studies allow the definition of five lithological types: quartz monzonite, monzonites, monzogranites (Caxipacoré and Água Branca suites), syenogranites and alkali-feldspar granites (Mapuera Suite), with variable content of hornblende and biotite. The geochemical characteristics of the Caxipacoré granitoids suggest that they formed in an orogenic tectonic setting, related to a subduction environment, while the coexistence of the Água Branca and Mapuera granitoids is suggestive of a changing period, from a convergent context of subduction to an extensional intracontinental environment. LA-ICP-MS U-Pb zircon dating of granitoids furnished ages of 1991±5.9 and 2005±7.2 Ma for the Caxipacoré suite, 1886.5±4.8 Ma for the Água Branca suite and 1870±14 Ma for the Mapuera suite. Nd-T$_{DM}$ (1.95-2.30 Ga) and Sr-T$_{UR}$ (1.84-2.02 Ga) model ages and positive to slightly negative εNd (+2,29 to -0.58) for all granitoids indicate that parental magmas derived from melting of dominantly Rhyacian crustal sources with minor mantle contribution. In addition, the Nd signature and U-Pb zircon ages for the plutonic rocks do not favor the existence of an Archean basement in this part of the Central Amazon Province. This assumption together with the similarity of the geological units in both Erepecuru-Trombetas and adjacent Uatumã-Anauá domains led to consider these two domains as part of a same geotectonic province and to reevaluate their limits.

Key-words: U-Pb and Sm-Nd geochronology; Amazonian Craton; Central Amazon Province; Orosirian Magmatism; Rhyacian crustal growth.

1 INTRODUCTION

The central region of the Guyana Shield hosts a large amount of granitic rocks (*lato sensu*) formed during several Paleoproterozoic volcano-plutonic events, bracketed between 2.0 and 1.86 Ga. The Guyana Shield represents the northern component of the Amazonian Craton (Almeida *et al.* 1981), which is formed of different tectonic-geochronological provinces (Tassinari and Macambira 2004; Santos *et al.* 2000, 2006; Cordani *et al.* 2009; Figure 1) and domains (Reis *et al.* 2003, 2006; Vasquez and Rosa-Costa 2008; Figure 2). According to these authors, the northwestern of Pará State has been included in the northern part of the Archean Central Amazon Province, defined as Erepecuru-Trombetas Domain, to the north of the Amazonian Basin (Figure 2). The study area is located in the southwestern of the Erepecuru-Trombetas Domain (Figure 2), close to the poorly defined limit between Central Amazon and Tapajós-Parima/Ventuari-Tapajós provinces.

For many years, rainforest vegetation and scarce roads in the Erepecuru-Trombetas Domain have hampered field studies. First works were performed from 1970s only in reconnaissance ~~geological~~ scale (Geomineração 1972; Lima *et al.* 1974; Montalvão *et al.* 1975; Oliveira *et al.* 1975; Araújo *et al* 1976; Chaves 1977; CPRM 1978; Veiga Jr. *et al.* 1979; Jorge João *et al.*1984; Lemos *et al.* 1988; Lemos and Gaspar 2002). However, in 2011, the Geological Survey of Brazil (CPRM) has initiated a new 1:250.000 geological mapping project in the region (Castro *et al.* 2014) supported by petrographic, geochronological, geochemical and airborne geophysical studies (Barreto *et al.* 2013, 2014; Leal *et al.* 2013, 2015; Castro *et al.* 2014; Rosa-Costa and Andrade 2016, *in press*).

Figure 1

Figure 1. Geochronological provinces of the Amazonian Craton according to the models of (A) Tassinari and Macambira (2004) and (B) Santos et al. (2006) with age ranges updated by Cordani et al. (2009) and the location of the study area in the northern part of the Central Amazon Province.

Despite the recent improvement of geological knowledge, ages and geodynamic condition of formation for the plutonic rocks that outcrop in the Erepecuru-Trombetas Domain are not fully understood. Most of these plutonic rocks have been associated to the Uatumã magmatism (1.86-1.88 Ga), and included in the Orosirian Água Branca and Mapuera suites, based ~~mainly~~ on their chemical and petrographic similarities to ~~other~~ plutonic units from adjacent Orosirian Uatumã-Anauá Domain (Tapajós-Parima/Ventuari-Tapajós Province) and scarce geochronological and geochemical data (e.g. Oliveira *et al.* 1975; Jorge João *et al.* 1984). In addition, Barreto *et al.* (2013), Castro *et al.* (2014) and Leal *et al.* (2015) recently identified the existence of an older Orosirian magmati~~sm~~ event (≈1.98 Ga) encompassing granitic plutons and volcanic/pyroclastic rocks along the Trombetas and Caxipacoré rivers in the southern part of the domain and which was not charted yet.

Figure 2

Figure 2. Geochronological provinces and tectono-stratigraphic domains of the Amazonian Craton proposed by Reis et al. (2006). The colored squares represent the sites of occurrence of Orosirian volcano-plutonic associations in the central portion of the Amazonian Craton. Notes: AM – Amazonas State, PA – Pará State, MT – Mato Grosso State. ETD: Erepecuru-Trombetas domain, IXD: Iriri-Xingu domain, SD: Surumu Domain, UAD: Utuamã-Anauá domain, TJD: Tapajós domain.

The geodynamic context proposed for the Orosirian volcano-plutonic associations of the Erepecuru-Trombetas Domain is another important issue. During decades, the nature and age of the magmatic sources and the existence or not of an Archean crustal basement in ~~the Erepecuru-Trombetas~~ Domain were not clarified. According to ~~the~~ Tassinari and Macambira (1999, 2004) ~~model~~, Archean rocks in the Central Amazon Province outcrop only in the Carajás region. In the ~~other~~ northern (Iricoumé Block/Erepecuru-Trombetas Domain) and southern (Xingu Block/Iriri-Xingu Domain) portions of the Province, an Archean basement, inferred by Archean Nd T_{DM} model ages and negative ε_{Nd} values, have been covered by the extensive Paleoproterozoic granitic and volcanic units (2.0-1.88 Ga). In their proposal, Santos *et al.* (2000, 2006), individuate the Archean Carajás Province from the Central Amazon Province. ~~The latter Province, in both northern and southern portions~~, is dominantly composed of 2.0-1.88 Ga rocks, although the range of Nd model ages and negative ε_{Nd} values also suggest older Archean sources for these rocks. Actually, these proposals are better constrained in southern part of Central Amazon Province where most of the isotopic data have been obtained. The first Sm-Nd radiometric data for the volcanic rocks in the northern part of the Central Amazon Province were provided by Barreto *et al.* (2014), revealing Paleoproterozoic Nd-T_{DM} ages (1.98 to 2.39 Ga, see below), not Archean. In addition, Barreto *et al.* (2014) also suggested that the

Western Erepecuru-Trombetas Domain might represent an extension westward of the Tapajós-Parima/Ventuari-Tapajós Province due to the geochemical, petrographic, geochronological and Nd signature similarity with the rocks from this province, rather than the northwestern part of the Central Amazon Province. Further Paleoproterozoic Nd-T_{DM} ages from the same region reinforced this assumption (Castro *et al.* 2014). Although there have been important contributions, the relationships and limits between the Tapajós-Parima/Ventuari-Tapajós and Central Amazon provinces remain poorly constrained.

The study area constitutes a key region, for the understanding of the processes involved in the formation of the expressive Paleoproterozoic magmatic associations in the Ereprecuru-Trombetas, as well as for the geotectonic reconstruction of the central part of the Amazonian Craton, as this region may be considered perhaps the least known of the Amazonian craton. Therefore, the aims of this work are (1) to provide new petrographic and whole-rock geochemical data in order to characterize both Orosirian magmatic events (≈1.98 Ga and 1.88 Ga) in the Erepecuru-Trombetas Domain and thus define their geodynamic environments; (2) to discuss the existence or not of an Archean basement in the northern segment of the Central Amazon Province based on Nd and Sr isotopic evidences coupled ~~eventually~~ with ~~inherited zircons~~; and (3) to reexamine the limits between the Central Amazon and Tapajós-Parima provinces with implications for the current partitioning models of the Amazonian Craton (e.g. Tassinari and Macambira 2004; Santos *et al.* 2006).

2 GEOLOGICAL SETTING

According to the ~~lithostratigraphic setting~~ proposed by Rosa-Costa and Andrade (2016, *in press*), the Erepecuru-Trombetas Domain is constituted by Archean (?) and/or Paleoproterozoic basement units (undifferentiated complex and volcano-sedimentary sequences) and two Paleoproterozoic magmatic associations~~, dated at around~~ 1.99 ~~and~~ 1.89 Ga. The younge~~st~~ is composed by volcanic rocks of Iricoumé Group (1.89-1.87 Ga) and plutonic rocks of Mapuera (1.88-1.86 Ga) and Água Branca (1.91-1.87 Ga) suites. The oldest, ~~recently defined as Igarapé Paboca Formation (1.99-1.95 Ga) for the volcanic rocks and Caxipacoré Suite (1.98-1.97 Ga) for the plutonic rocks.~~ Sedimentary ~~units of Paleoproterozoic (Urupi Formation) and Paleozoic (Trombetas Group and Maecuru Formation) are also described, as well as undifferentiated mafic rocks, diabases and nepheline syenites.~~ In the study area ~~(southwestern portion)~~, ~~the~~ Archean (?) and/or Paleoproterozoic basement units and ~~the~~ Paleozoic rocks are not found (Figure 3).

The Caxipacoré Suite and Igarapé Paboca Formation were formally defined by Castro *et al.* (2014) ~~to describe~~ the ~~oldest Orosirian magmatism~~ identified by Barreto *et al.* (2013) and Leal *et al.* (2013, 2015)~~, which are considered coeval~~. The Caxipacoré Suite is composed of isotropic and medium- to coarse-grained alkali~~-~~feldspar granites, syenogranites, monzogranites and granodiorites with ~~varied contents of~~ amphibole and biotite. These rocks display a high-K calc-alkaline to shoshonitic affinity.

The Igarapé Paboca Formation comprises intermediate to acid volcanic and pyroclastic rocks with geochemical signature similar to high-K calc-alkaline rocks. The rock types vary from andesites, dacites to subordinate trachyandesites, trachytes, ignimbrites, tuffs and breccias.

The Água Branca suite (Oliveira *et al.* 1996) is composed dominantly by hornblende-biotite granodiorites, with subordinate monzogranites, quartz monzonites, quartz monzodiorites, quartz diorites, diorites and tonalites (CPRM 2000; Reis *et al.* 2006; Almeida and Macambira 2007; Vasquez and Rosa-Costa 2008; Valério *et al.* 2009, 2012). They are generally isotropic, greyish, medium- to coarse grained and equigranular to porphyritic granitoids, displaying a metaluminous to peraluminous

I-type calc-alkaline geochemical affinity (Araújo Neto and Moreira 1976; CPRM 2000; Almeida 2006; Reis *et al.* 2006; Valério *et al.* 2009, 2012).

The Mapuera Suite (Melo *et al.* 1978) is characterized by isotropic, equigranular to porphyritic monzogranites, syenogranites and alkali feldspar granites, with variations of rapakivi and granophyric textures (Jorge João *et al.* 1984; Ferron *et al.* 2006; Reis *et al.* 2006; Vasquez and Rosa-Costa 2008; Lombello 2011). These rocks are weakly aluminous to moderately peraluminous and eventually peralkaline with high-K and have geochemical characteristics similar to A-type granites (CPRM 2000; Ferron *et al.* 2006; Almeida 2006, Lombello 2011).

Figure 3

Figure 3. Geological map of the study area (southern of Erepecuru-Trombetas Domain) with ~~the location~~ ~~of the rock samples targeted for petrography, Sm-Nd and Sr analysis, U-Pb geochronology and whole-rock geochemistry. Source: Rosa-Costa and Andrade (2016, in press), modified.~~

The Iricoumé Group (Veiga Jr. *et al.* 1979), which represents an extrusive phase contemporaneous of Agua Branca and Mapuera magmatisms, is constituted of effusive, hypabyssal and pyroclastic rocks with compositional predominance of rhyolites, dacites and subordinate andesites, latites and trachytes (Oliveira *et al.* 1975; Jorge João *et al.* 1984; CPRM 2000; Reis *et al.* 2006; Vasquez and Rosa-Costa 2008; Valério *et al.* 2009; Ferron *et al.* 2006, 2010; Pierosan *et al.* 2011; Barreto *et al.* 2013; Marques *et al.* 2014; Castro *et al.* 2014).

Several mafic bodies were identified by Vasquez and Rosa-Costa (2008) through available field data and remote-sensing products. These bodies are intrusive in rocks of the Iricoumé Group and Mapuera Suite, displaying elongated shapes with no preferred orientation, tabular to rounded crests and low drainage density. Due to the lack of geochronological data, Vasquez and Rosa-Costa (2008) interpreted this unit as an intra-plate mafic magmatism related to either Orosirian (≈1.88 Ga) or Statherian (≈1.78 Ga) extensional event. The Suretama Diabase (≈1.78 Ga) is composed of three mafic bodies found in the lower stream of the Mapuera River (Geomineração 1972; Montalvão *et al.* 1975; Jorge João *et al.* 1985). The predominant lithological type is a melanocratic, isotropic, coarse-grained, equigranular to porphyritic olivine diabase. According to Jorge João *et al.* (1985), this unit has geochemical signature similar to continental basalts, related to anorogenic within-plate environment.

The Urupi Formation constitutes elongated ridges with NW-SE direction, having as main lithological types quartz sandstones, arkosian sandstones, arkoses and lithic sandstones with fragments of siltstones, cherts, acid volcanic and volcanoclastic rocks (silicified tuffs and ignimbrites), conglomerates and mudstones (Veiga Jr. *et al.* 1979; Jorge João *et al.* 1984; Cunha *et al.* 2006). A minimum age of 1.78 Ga was established for this unit by U-Pb zircon SHRIMP dating of mafic dikes westward in the Pitinga region (Santos *et al.* 2002), which are intrusive in the Urupi Formation, while the maximum age is constrained at 1.89 Ga by the underlying Iricoumé Group.

3 PREVIOUS GEOCHRONOLOGICAL DATA FOR OROSIRIAN ~~GRANITOIDS~~ IN THE CENTRAL AMAZON AND TAPAJÓS-PARIMA PROVINCES

The Água Branca and Mapuera suites occur in large areas of central portion of the Amazonian Craton, with several granitic bodies spread up in the northern segments of the Central Amazon and Tapajós-Parima provinces, which are defined as Erepecuru-Trombetas and Uatumã-Anaua domains, respectively.

In the Erepecuru-Trombetas Domain, the set of geochronological data is still limited. For the Água Branca Suite, there is only a whole-rock Rb-Sr isochron of 1910±23 Ma (Jorge João *et al.* 1985) while for the Mapuera Suite, an age of 1773±53 Ma by whole-rock Rb-Sr method was obtained by Oliveira *et al.* (1975). Recently, Castro *et al.* (2014) obtained two zircon ages of 1889±2 Ma and 1861±20 Ma by Pb-Pb method for the Mapuera granitoids. On the other hand, a larger number of U-Pb and Pb-Pb zircon ages is available in the Uatumã-Anauá Domain. The crystallization age of the Água Branca suite was established between 1.91 and 1.88 Ga by zircon Pb-Pb and U-Pb SHRIMP dating while the Mapuera Suite yielded ages of 1.88-1.86 Ga (references in Table 1). Correlated Iricoumé volcanic furnished ages of 1.89-1.87 Ga (Costi *et al.* 2000; Macambira *et al.* 2002; Santos *et al.* 2004, Ferron *et al.* 2006; Valério *et al.* 2009, Barreto *et al.* 2013; Marques *et al.* 2014; Castro *et al.* 2014).

The Caxipacoré Suite ~~was defined according to ages~~ about 1.98 Ga obtained in Erepecuru-Trombetas Domain. Outcropping granitoids along the Caxipacoré River furnished ages of 1982±9 Ma and 1977±4 Ma by zircon Pb-Pb method (Leal *et al.* 2015). Similar U-Pb zircon ages of 1985±5 Ma and 1985±4.4 Ma were found in granitoids located in areas near the Erepecuru River and its inflowing rivers (Castro *et al.* 2014). Correlated volcanic rocks are represented by Igarapé Paboca Formation, which crystallization ages are defined between 1.99 and 1.95 Ga (Barreto *et al.* 2013; Castro *et al.* 2014). In the Uatumã-Anauá Domain, the 2.0-1.96 Ga granitoids are represented by Martins Pereira and Serra Dourada suites (Faria *et al.* 2002; Almeida *et al.* 2007). In the northern of Roraima State, in the Surumu Domain, rocks with approximately 1.98 Ga are related to the Orocaima episode (Reis *et al.* 2000) and are represented by Pedra Pintada Suite (Almeida *et al.* 1997; Santos 1999, 2003; Fraga *et al.* 2010) and Surumu Group (Schobbenhaus *et al.* 1994; Santos 1999)

A compilation of geochronological data for the studied units in the northern part of the Amazon craton is presented in Table 1.

Table 1

Table 1. Available geochronological data for the 1.90-1.86 Ga ~~granitoids~~ (Água Branca and Mapuera suites) and 2.0-1.95 Ga granitoids (Caxipacoré, Serra Dourada, Martins Pereira and Pedra Pintada suites) in the northern para of the Central Amazon (Erepecuru-Trombetas Domain) and Tapajós-Parima/Ventuari-Tapajós (Uatumã-Anauá Domain) provinces.

In the Central Brazil/Guaporé Shield, south of the Amazon Basin, coeval magmatic events to those of the Erepecuru-Trombetas and Uatumã-Anauá domains are also known. In the Tapajós Domain, the Tropas and Parauari plutonic suites with ages about 1.90-1.87 Ga (Santos *et al.* 1997, 2000, 2001, 2004; Brito *et al.* 1999; Klein and Vasquez 2000; Lamarão *et al.* 2002) are correlated with Água Branca Suite. Jardim do Ouro, Younger São Jorge and Maloquinha granitoids and Moraes Almeida volcanic rocks, which ages range from 1.88 to 1.86 Ga (Klein and Vasquez 2000; Santos *et al.* 2000; Lamarão *et al.* 2002) have geochemical and geochronological similarities with Mapuera granitoids and Iricoumé volcanics. Felsic volcanic and plutonic rocks of the Iriri-Xingu Domain and northern of the Mato Grosso State also furnished ages of 1.88-1.86 Ga, especially the granitoids of the Velho Guilherme (Teixeira *et al.* 2002) and Rio Dourado suites (Barros *et al.* 2009; 2011) and Iriri Group and Sobreiro and Santa Rosa volcanic formations (Teixeira *et al.* 2002; Fernandes *et al.* 2011).

The oldest magmatic event (≈1.98 Ga) is recognized in the Tapajós Domain. Granitoids of the Creporizão Suite (including Old São Jorge Granite) and volcanic of the Vila Riozinho Formation furnished ages between 1.99 and 1.95 Ga (Tassinari 1996; Klein and Vasquez 2000; Santos *et al.* 2000, 2001, 2004; Lamarão *et al.* 2002).

4 ANALYTICAL PROCEDURES

4.1 GEOCHEMISTRY

Whole-rock chemical analyses of 17 samples of the Caxipacoré (3), Água Branca (4) and Mapuera (10) suites were performed at the ACME Analytical Laboratories Ltd in Vancouver, British Columbia, Canada. The analytical package includes the analysis of major oxides and trace elements, including rare earth elements (REE), by inductively coupled plasma atomic emission spectrometry (ICP-AES) and inductively coupled plasma atomic mass spectrometry (ICP-MS), respectively. The analytical accuracy was ensured by the analysis of the standard STD SO-18, chemical blanks and two sample duplicates (CS-97 and CS-113). The detailed analytical procedures performed by ACME labs are available on http://acmelab.com. The geochemical results were processed by GeoChemical Data Toolkit 3.0 software (available at http://www.gcdkit.org/download) and plotted in classificatory and geotectonic diagrams.

4.2 U-Pb GEOCHRONOLOGY

U-Pb *in situ* analyses of zircons from 2 samples of the Caxipacoré Suite, 1 from Água Branca and 1 from Mapuera suites were carried out at the Geochronology Laboratory of University of Brasília (UnB) and Isotope Geology Laboratory of Federal University of Pará (Pará-Iso). The analytical procedures followed the methods described in Bühn *et al.* (2009) and Chemale Jr. *et al.* (2012). The zircon crystals were concentrated using conventional techniques at the Pará-Iso Laboratory, which include mineral sieving (250-180 μm and 180-125 μm), magnetic separation with Isodynamic Frantz and gravimetric separation by heavy liquid method. The zircon grains were selected and mounted in epoxy circular mounts with 2.5 cm-diameters. Posteriorly, they were polished to obtain a smooth surface. Cathodoluminescence images were obtained using a scanning electron microscope (SEM) of Geological Survey of Brazil (CPRM-Belém) and Microanalyses Laboratory of Federal University of Pará.

At the UnB laboratory, the zircon grains were dated with a New Wave UP213 Nd: YAG laser (λ = 213 nm) coupled to a Thermo Finnigan Neptune Multi-collector ICP-MS at frequency rate of 10 Hz, energy of approximately 100 mJ/cm^2 and spot size varying from 15 to 30 μm. At the Pará-Iso Laboratory the zircon grains were dated with a LSX-213 G2 Nd: YAG CETAC laser (λ = 213 nm) coupled to a Thermo Finnigan Neptune Multi-collector ICP-MS at frequency rate of 10 Hz, energy of 45-50 mJ/cm^2 and spot size of 25μm. The instrumental mass discriminations were corrected by the analyses of zircon reference material GJ-1 (Jackson *et al.* 2004) and 91500 (Wiedenbeck *et al.* 1995), which ages are 608.5±1.5 Ma and 1065.4±0.3 Ma, respectively. Age calculations and U-Pb plots in ~~the~~ Concordia diagram were performed using homemade software ~~and~~ the ISOPLOT/EX 3.0 software from Ludwig (2003).

4.3 Sm-Nd AND Sr ISOTOPIC ANALYSES

Sm-Nd and isotopic analyses were performed at the Isotope Geology Laboratory of Federal University of Pará (Pará-Iso), following the analytical procedures of Gioia and Pimentel (2000) and Oliveira *et al.* (2008), ~~and~~ described in details ~~by~~ Barreto *et al.* (2014). Approximately 100 mg of whole-rock powders were mixed with 100 mg of a ^{149}Sm-^{150}Nd spike solution and dissolved in Savillex capsules using a mixture of concentrated HNO_3, HF e HCl acids. The element extraction and purification was performed by two steps ion-exchange chromatography in Teflon columns, using Biorad DOWEX AG 50x8 resin for Sr and REE extraction, followed by Ln Eichrom resin for Sm and Nd separation.

The Sm and Nd isotopic analyses were performed in a Thermo Finnigan Neptune Multi-collector ICP-MS, with approximately 10 measurement blocks for Nd and 4 for Sm. For the correction of mass discrimination, the $^{143}Nd/^{144}Nd$ ratio was normalized to $^{146}Nd/^{144}Nd = 0.7219$ using the exponential law (Russell *et al.* 1978). ~~Furthermore,~~ the accuracy and reproducibility of results were controlled according to the BCR-1 and La Jolla reference material (Oliveira *et al.* 2008). The decay constant used was 6.54 x 10^{-12} year^{-1} (Lugmair and Marti 1978) and the Nd model ages were calculated according to the model of depleted mantle evolution (T_{DM}) from DePaolo (1981). The Sr aliquots were loaded on tungsten-filaments and the isotopic ratios were measured on a Finnigan MAT 262 thermal ionization mass spectrometer (TIMS) using dynamic multicollection. The isotopic ratios were corrected from mass discrimination using $^{84}Sr/^{88}Sr = 0.1194$. The decay constant used was 1.42 x 10^{-11} year^{-1}(Davis *et al.* 1977; Steiger and Jäger 1977) and the Sr model ages were calculated according to the model of Uniform Reservoir mantle evolution (T_{UR}) from DePaolo and Wasserburg (1977). The T_{UR} calculation was performed using the Rb and Sr concentrations provided by ACME analyses. During the ~~period of~~ Sr, Nd and Sm ~~procedures~~, total chemical blanks were lower than 0.1% of the elements concentration and then considered negligible.

5 RESULTS

5.1 PETROGRAPHY

Petrographic analyses of 31 thin sections from Caxipacoré, Água Branca and Mapuera ranitoids using an optical microscope and the modal content are presented in Table 2. A set of approximately 1500 points was ~~performed~~ for each thin section. The facies classification was defined according to Streckeisen (1976) and Le Maitre *et al.* (2002) and the modal results were plotted in Q-AP and Q-(A+P)-M' diagrams (Figure 4).

Table 2

Table 2. Average modal composition of the Caxipacoré, Água Branca and Mapuera ~~granitoids~~.

Figure 4

Figure 4. QAP and Q-(A+P)-M' diagrams (Streckeisen 1976) with the modal composition of Caxipacoré, Água Branca and Mapuera suites and displaying the composition trends of ~~granitoids~~ series from Lameyre and Bowden (1982): (1) tholeiitic, (2) TTG, (3) calc-alkaline granodioritic, (4) calc-alkaline monzonitic or shoshonitic and (5) Alkaline to peralkaline.

5.1.1 Caxipacoré Suite

The Caxipacoré granitoids were classified as biotite-hornblende monzogranite (BHMz) and biotite leuco-monzogranite (BLMz). All granite varieties are isotropic, leucocratic, with mafic mineral content (M') between 4.4% and 15.9 8%, medium- to coarse grained, inequigranular and color varying from grayish to ~~slightly~~ pinkish (Figure 5A). They normally exhibit hipidiomorphic granular textures with crystals varying from 0.4 to 7.3 mm. The crystals of plagioclase are subhedral, moderately zoned, with calcic cores and sodic borders, highlighted by alteration to sericite±epidote, especially in the cores (descalcification).

The mega-crystals of alkali feldspar (5 to 7 mm) are intensely perthitic (Figure 5D), anhedral to subhedral and the minor crystals (0.5 to 1.3 mm) are moderately altered to clay minerals, which give them a turbid aspect. The main ferromagnesian phases are hornblende and biotite, which are generally altered to chlorite and fine grains of titanite. In the BLMz facies, the hornblende is absent or only a relic phase (<0.1%) and biotite content does not exceed 4%. The most common accessory minerals are zircon, titanite and opaque minerals, with rare apatite, and epidote, which occur generally as inclusions in crystals of biotite and hornblende.

5.1.2 Água Branca Suite

The Água Branca Suite is composed of grayish, medium- to coarse-grained, holo- to leucocratic (M'= 2.2-17.2%) granitoids (Figure 5B) ~~and~~ classified as biotite-hornblende quartz monzonite (BHQzM), biotite-hornblende monzonite (BHM), hornblende monzogranite (HMz) and biotite leuco-monzogranite (BLMz). All granite facies display hipidiomorphic granular textures with subhedral crystals of plagioclase (1 to 8 mm), showing normal oscillatory zoning marked by alteration in An-rich zones. In the BLMz facies, the plagioclase is strongly saussuritized (Figure 5E) and fractured (Figure 5F), sometimes it remains only pseudomorphic crystals, and locally, they are contorted (Figure 5G), showing strain twinned and kink bands (Figure 6A). The microcline exhibits aeuhedral to subhedral crystals (1.4 to 9.5 mm), with string-type perthites and locally it is intensely fractured and crossed by epidote±quartz veins, mainly in the HMz and BLMz facies. The quartz is found as: 1) interstitial, anhedral, medium- to fine-grained crystals~~, measuring~~ 0.4-1.3 mm; and 2) subhedral, coarse-grained crystals with strong ondulatory extinction~~, measuring 1.8 to 4.6 mm~~. Biotite and hornblende represent the main mafic phases, and both are subhedral to anhedral, moderately altered to chlorite. They generally occur as mafic clots, associated with titanite and opaque minerals. Sometimes, the hornblende crystals show relic cores of clinopyroxene (corona texture; Figure 6B).

Figure 5

Figure 5. Macroscopic aspect of a monzogranite (A), quartz monzonite (B) and alkali feldspar granite (C) from Caxipacoré, Água Branca and Mapuera suites, respectively; (D) perthitic mega-crystal of K-feldspar with inclusion of biotite (AB-85); (E) crystals of plagioclase strongly saussuritized and (F) intensely fractured (CS-120); (G) Crystal of plagioclase contorted (CS-120). Mineral abbreviations ~~according to Whitney and Evans (2010)~~: Bt – Biotite, Kfs – K-feldspar, and Pl – Plagioclase.

5.1.3 Mapuera Suite

The Mapuera Suite comprises reddish, medium- to coarse-grained, isotropic and leucocratic rocks, with ~~mineral mafic content~~ (M') between 2.8 and 12.1% (Figure 5C). Five different facies were identified: Biotite alkali feldspar leuco-granite (BALg), biotite alkali feldspar granite (BAg), biotite leuco-syenogranite (BLSy), biotite syenogranite (BSy) and hornblende-biotite syenogranite (HBSy). Most of the facies displays hipidiomorphic granular textures, with variations of porphyritic and rapakivi textures (Figure 6C e D). Alkali feldspar megacrystals (1-8 mm) are common, with ovoid and tabular shapes and locally with coarse ~~mantles of plagioclase (rapakivi texture~~; Figure 6D). They are generally perthitic and sometimes exhibit the late-magmatic granophyric quartz-K-feldspar intergrowths, mainly in the BLSy facies (Figure 6E). The crystals of quartz occur as: 1) ovoid megacrystals, measuring 1 to 3.5 mm, with abundant embayment and recrystallized borders, slightly fractured (Figure 6F); 2) subhedral porphyritic crystals, intensely fractured, with strong ondulatory extinction; 3) subhedral recrystallized crystals, forming a medium to fine matrix, mainly in porphyritic facies (BAg and HBSy); 4) fine-grained crystals which intergrowth the K-feldspar crystals. Biotite is the dominant ferromagnesian mineral, ~~whereas the hornblende occurs only in the HBSy facies~~. They are intensely altered to chlorite and opaque minerals, sometimes, remaining only relic crystals. The hornblende crystals measure 0.5 to 1 mm and they are generally subhedral, intensely fractured with inclusions of zircon, epidote and opaque minerals. The zircon, apatite, epidote and opaque minerals occur generally as inclusion in the ~~bigger~~ crystals of biotite and hornblende. The post-magmatic minerals are represented by chlorite, sericite, clay minerals and epidote.

Figure 6

Figure 6. Microscopic aspect of Água Branca and Mapuera ~~granitoids~~. (A) Plagioclase crystals showing strain twinned and kink bands (CS-121); (B) clots of mafic minerals with relic cores of clinopyroxene surrounded by amphibole (CS-109); (C) glomeroporphyritic textures (AB-98, AB-90); (D) crystal of K-feldspar surrounded by coarse mantles of plagioclase, characterizing a rapakivi texture (AT-176); (E) late-magmatic granophyric quartz-K-feldspar intergrowths (AB-134); (F) ovoid crystal of quartz with embayments, inclusions and recrystallized rims and matrix (AT-99). Mineral abbreviations ~~according to Whitney and Evans (2010)~~: Amp – Amphibole, Bt – Biotite, Cpx – Clinopyroxene, Ep –Epidote, Kfs – K-feldspar, Pl – Plagioclase and Qz – Quartz.

5.2 GEOCHEMISTRY

The whole-rock geochemical data of the Caxipacoré, Água Branca and Mapuera granitoids are presented in Table 3. In most diagrams, the geochemical fields of other Orosirian granitoids from Central Amazon and Tapajós-Parima/Ventuari-Tapajós provinces, which are correlated to studied granitoids, are displayed (Figure 2).

The Caxipacoré Suite granitoids display a small range of SiO_2 (66.73-71.95 wt.%), MgO (0.48-0.78 wt.%) and CaO (1.67-2.56 wt.%) contents, low ~~content of~~ TiO_2 (0.27-0.44 wt.%) and moderate ~~content of~~ Al_2O_3 (14.12-16.12 wt.%), K_2O (4.23-4.51 wt.%) and Na_2O (3.75-4.15 wt.%). The K_2O/Na_2O ratio varies between 1.02 and 1.20 and $FeO_t/(FeO_t+MgO)$ ranges from 0.78 to 0.80. The Água Branca granitoids exhibit similar chemical composition, with a larger range of silica content (59.43-70.81 wt.%), and slightly higher TiO_2 (0.35-0.76 wt%), Al_2O_3 (14.40-17.93 wt.%), and Na_2O (3.56-4.63 wt.%) contents than previous rocks and lower K_2O (4.05-4.60 wt.%) values. Thus, the K_2O/Na_2O ~~ratio~~ ranges between 0.87 and 1.28 and the $FeO_t/(FeO_t+MgO)$ ~~ratio varies~~ from 0.67 to 0.81. The Mapuera Suite displays a small range of SiO_2 ~~values~~ (71.29-78.03 wt.%) with the lowest contents of TiO_2 (0.11-0.33 wt.%), Al_2O_3 (11.14-14.32 wt.%) and Na_2O (3.20-3.99 wt.%) and the highest K_2O (4.49-5.33 wt.%) contents. These rocks have a K_2O/Na_2O values ranging from 1.25 to 1.63 and $FeO_t/(FeO_t+MgO)$ from 0.87 to 0.95.

Table 3

Table 3. Whole-rock major and trace elements for the Caxipacoré, Água Branca and Mapuera granitoids.

In the R1-R2 diagram (De La Roche *et al.* 1980; Figure 7A), all samples of the three suites display a subalkaline trend. The rocks from the Caxipacoré Suite plot in the field of monzogranite while the Água Branca granitoids range from monzogranite, monzonite and quartz monzonite. The Mapuera granitoids are concentrated in syenogranite and alkali granite fields.

Figure 7

Figure 7. (A) R1-R2 diagram (De La Roche et al. 1980); (B) AFM diagram (Irvine and Baragar 1971); (C) K_2O versus SiO_2 (Peccerillo and Taylor 1976) diagram. Compositional fields of the Caxipacoré (Castro et al. 2014), Pedra Pintada (Fraga et al. 2010), Martins Pereira (Almeida 2006), Serra Dourada (Almeida 2006), Creporizão (Vasquez et al. 2002; Lamarão et al. 2002), Água Branca (Faria et al. 2000; Almeida 2006; Valério et al. 2009); Parauari (Vasquez et al. 2002); Mapuera (CPRM 2000; Ferron et al. 2006; Valério et al. 2009; Lombello 2011); Maloquinha (Lamarão et al.

2002; Vasquez et al. 2002) and Velho Guilherme (Teixeira et al. 2005) are also plotted for comparison.Symbology of samples ~~as in petrographic facies in~~ Figure. 4.

~~According to~~ the AFM (Irvine and Baragar 1971; Figure 7B) and K_2O *versus* SiO_2 (Peccerillo and Taylor 1976; Figure 7C) diagrams, all samples show affinity with a high-K calc-alkaline series. In the A/NKversusA/CNK diagram (Maniar and Piccoli 1989; Figure8A), the Caxipacoré granitoids have dominantly peraluminous character, whereas the Água Branca ~~granitoids have~~ metaluminous ~~character~~ and the Mapuera granitoids plot close to metaluminous-peraluminous boundary. In the FeO_t/ (FeO_t + MgO) *versus* SiO_2 (Frost *et al.* 2001; Figure 8B), Caxipacoré and Água Branca ~~granitoids~~ plot within the magnesian field (cordilleran granites), while all samples of Mapuera Suite plot within ferroan field, corresponding to ~~the~~ A-type granites ~~field~~.

Figure 8

Figure 8. (A) Aluminum saturation index (~~Maniar and Piccoli 1989~~); (B) FeOt/(FeOt+MgO) versus SiO_2 *(Frost et al. 2001). Symbology of samples and field as in Figure 7.*

In the multi-elementary spider-diagram with chondrite-normalized elements (Thompson 1982), the Caxipacoré Suite demonstrates a pattern with high Rb, Th, K, La and Nd contents and strong negative anomalies of Ba, Nb, Sr, P and Ti (Figure 9A). The Água Branca Suite displays weak negative anomalies of Th, Sr and P ~~in the samples of monzonite~~ (CS-113) and quartz monzonite (CS-97 and CS-109), while the monzogranite sample (CS-121) exhibits slightly stronger negative anomalies ~~of these elements~~ (Figure 9B). Moreover, all samples show strong negative ~~anomalies of Nb~~ and Ti and slightly positive anomalies ~~of~~ Rb, K, La, Nd, Sm, Zr and Tb. The Mapuera Suite has high ~~content of~~ Rb, Th, La, Ce, Nd, Sm and Tb and strong negative anomalies ~~of~~ Ba, Nb, Sr, P and Ti (Figure 9C).

Figure 9

Figure 9. Multi-elementary spider-diagram with chondrite-normalized trace elements (Thompson 1982) for the (A) Caxipacoré (B), Água Branca and (C) Mapuera suites. Symbology of samples as in Figure 7.

~~In the~~ rare earth element (REE) diagrams normalized to chondrite (Boynton 1984), all studied ~~granitoids~~ display a steeper pattern with light REE-enrichment (LREE) in relation to heavy REE (HREE). The Caxipacoré granitoids have a relatively low REE content (~~183.03-339.81~~ ppm), with moderate fractionation of HREE $[(La/Yb)_N = 9.78\text{-}14.82]$. Furthermore, the HREE exhibit a slightly concave-upwards pattern, which is indicative of hornblende fractionation during the magmatic evolution (Figure 10A). All varieties display negative Eu anomaly $[(Eu/Eu^*)_N = 0.45\text{-}0.65]$ and generally decreasing from the biotite-hornblende monzogranites ~~(AB-65 and AB-73 A) to the leucogranite (AB-85)~~. The Água Branca ~~granitoids~~ have the lowest REE content (~~156.64-246.61~~ ppm) and significant HREE fractionation (Figure 10B) with $(La/Yb)_N$ ratio ranging from 12.78 to 16.85. The Eu anomaly is very weak $[(Eu/Eu^*)_N = 0.77\text{-}0.87]$. The highest ~~content of REE~~ is found in the Mapuera Suite (198.88-934.82 ppm), with a strong variation of $(La/Yb)_N$ ratio, ranging from a minimum of 4.39 to a maximum of 23.76. The negative Eu anomaly is ~~very accentuated~~ in the alkali feldspar granites (AT-89, AT-90, AT-99, AT-153 and AT-172), with the $(Eu/Eu^*)_N$ values from 0.07 to 0.13, and moderate Eu anomaly in the syenogranites (AB-98 A, AT-16 A, AT-92, AT-173 and AT-177), with $(Eu/Eu^*)_N$ values between 0.18 and 0.42 (Figure 10C).

Figure 10

Figure 10. Rare earth element (REE) diagrams normalized to chondrite (Boynton 1984) for the (A) Caxipacoré (B), Água Branca and (C) Mapuera suites. REE data from (D) Pedra Pintada, Martins Pereira, Serra Dourada and Creporizão suites, (E) Água Branca and Parauari suites, (F) Mapuera, Maloquinha and Velho Guilherme suites are also plotted for comparison. References and symbology of samples and fields as in Figure 7.

According to the tectonic discrimination and ~~granitic rock~~ typology diagrams, two different geochemical groups were identified. In the Rb *versus* Y+Nb and Rb *versus* Ta+Yb diagrams (Pearce 1996; Figure 11A, B), the Caxipacoré granitoids plot in the fields of post-collisional and volcanic arc granite (VAG), as well as~~,~~ the rocks of Água Branca Suite. The Mapuera granitoids are mostly positioned in the within-plate granite (WPG) field, except ~~two samples of syenogranite~~ that plot in the VAG field.

In the (K_2O+Na_2O)/CaO *versus* Zr+Nb+Ce+Y diagram (~~Nardi and Bitencourt 2009 modified from Whalen *et al.* 1987~~; Figure 11C), the Caxipacoré and Água Branca ~~granitoids~~ plot within non A-type granite field and close to the A-type/non A-type boundary, while most of Mapuera granitoids plot within the A-type granite field and are classified as A_2-type, according ~~to Eby (1992) diagrams~~ (Figure 11D).

Figure 11

Figure 11. (A) Rb versus Y+Nb and (B) Rb versus Ta+Yb diagrams (Pearce 1996). COLG – collisional granitoids, WPG – within-plate granitoids, VAG – volcanic arc granitoids, ORG – ocean ridge granitoids; (C) (K_2O+Na_2O)/CaO versus Zr+Nb+Ce+Y diagram (~~Nardi & Bitencourt 2009 modified from Whalen et al. 1987~~); (D) Nb-Y-3Ga and Nb-Y-Ce ternary diagrams for the Mapuera granitoids (Eby 1992). References and symbology of samples and field as in Figure 7.

In the CaO/($FeO_t+MgO+TiO_2$) *versus* $CaO+Al_2O_3$ and CaO/($FeO_t+MgO+TiO_2$) *versus* Al_2O_3 diagrams from Dall'Agnol and Oliveira (2007; Figure 12A, B), both Caxipacoré and Água Branca ~~granitoids~~ plot in calc-alkaline field, while Mapuera granitoids are concentrated in the A-type granite field. According to the $(Nb/Zr)_N$ *versus* Zr diagram (Thiéblemont and Tegyey 1994; Figure 12C), the Caxipacoré and Água Branca ~~granitoids~~ are related to a subduction environment and the Mapuera granitoids have ~~dominant~~ affinity with post-collisional calc-alkaline to alkaline A_2-type rocks.

In the log [CaO/(Na_2O+K_2O)] *versus* SiO_2 diagram of Brown *et al.* (1984; Figure 12D), all samples of the Caxipacoré and Água Branca suites exhibit a trend similar to a normal continental arc, whereas the Mapuera granitoids are spread out in the alkaline field, which indicates a ~~mature arc~~ series.

Figure 12

Figure 12. (A) CaO/($FeOt+MgO+TiO_2$) versus $CaO+Al_2O_3$ and (B) CaO/($FeOt+MgO+TiO_2$) versus Al_2O_3 diagrams (Dall'Agnol and Oliveira 2007); (C) $(Nb/Zr)_N$ versus Zr diagram (Thiéblemont & Tegyey 1994), values normalized according to Hoffman (1988); (D) log [CaO/(Na_2O+K_2O)] versus SiO_2 diagram (Brown et al. 1984), alkaline field from Nardi (1991). ~~SNB – Sierra Nevada Batholith, PCB – Peru Coastal Batholith, NGCA – New Guinea Continental Arc~~. References and symbology of samples and field as in Figure 7.

5.3 U-Pb GEOCHRONOLOGY

Zircon U-Pb analytical data and calculated ages are displayed in Table 4. Four samples were analyzed by LA-MC-ICP-MS, a biotite leuco-monzogranite (AB-85) and biotite-hornblende monzogranite (AB-73A) from Caxipacoré Suite, a biotite-hornblende monzonite (CS-113) from Água Branca Suite and a biotite alkali-feldspar granite (AT-89) from Mapuera Suite. Cathodoluminescence images of representative ~~analyzed zircons~~ and the respective spots are shown in Figure 13.

Table 4

Table 4. Summary of LA-ICP-MS dating of the zircon grains from Caxipacoré and Água Branca suites.

Figure 13

Figure 13. Cathodoluminescence images of representative ~~analyzed zircon~~ grains from the ~~granitoids of the~~ Caxipacoré and Água Branca suites. Circles mark spots analyzed by LA-ICP~~ mass spectrometer~~ (15-30 μm-size).

~~The analyzed zircons of~~ AB-85 and AB-73A ~~samples~~ are euhedral to subhedral, with long-prismatic shapes and lengths between 230 and 350 μm. They generally display a concentric oscillatory ~~zonation~~, typical of magmatic zircons, although some of them are strongly fractured, with micro-inclusions and highlighted cores. ~~The zircons of~~ CS-113 ~~sample~~ are smaller, with size ranging from 180 to 280 μm, display pale brownish short-prismatic and bipyramidal shapes with weak zonation, micro-fractures and micro-inclusions. Most of zircons from Mapuera suite display elongated prismatic shapes~~ with sizes of~~ 250-300 μm and concentric oscillatory ~~zonation~~. They generally exhibit a metamictic aspect with patchy texture, corroded rims and large number of fractures and inclusions, which are indicative of strong ~~alteration~~.

For the Caxipacoré Suite, 27 ~~zircons~~ from sample AB-85 were analyzed. Two analyses are discordant. The remaining 25 analyzed zircon crystals allowed the calculation of a Discordia line (Figure 14A), indicating an upper intercept age of 1977 ± 7.6 Ma (MSWD = 1.7), and 6 points plot on Concordia line, showing a concordant age of 1991 ± 5.9 Ma with a MSWD (of concordance) of 0.058. For the sample AB-73A, the Discordia line was drawn using 15 zircon crystals (Figure 14B), which defines an upper intercept of 2005 ± 8.8 Ma (MSWD = 1.2) and 7 concordant crystals ~~furnished~~ a similar age of 2005 ± 7.2 Ma with MSWD (of concordance) of 0.004. Other 3 concordant zircons ~~furnished~~ older ages (2.25, 2.27 and 2.32 Ga) and were not included in the age calculation. For the sample of the Água Branca suite (CS-113), 26 zircon crystals were analyzed, allowing the calculation of a Discordia line (Figure 14C) with an upper intercept of 1886 ± 7.4 Ma (MSWD = 0.55). The Concordia age was established at 1887 ± 4.8 Ma (MSWD of concordance = 0.28). These ages are interpreted as crystallization age of studied granitoids. For the Mapuera Suite, only a small set of 5 zircons furnished data for the age calculation. These zircons yield a Concordia age of 1870 ± 14 Ma with a MSWD of concordance of 2.7. Due to the ~~unreliable data~~, these ages should be interpreted as minimum crystallization age of these granitoids.

Figure 14

Figure 14. Concordia diagrams for the analyzed zircon grains by LA-ICP-MS from (A), (B) Caxipacoré, (C) Água Branca and (D) Mapuera suites. Grayish ellipses are not included in the age calculation.

5.4 Sm-Nd AND Sr ISOTOPIC RESULTS

Ten representative samples were selected for the Sm-Nd and Rb-Sr whole-rock determination and T_{DM} and T_{UR} model age calculation~~, of which three are from~~ Caxipacoré ~~Suite~~ (AB-73 A, AB-85 and AB-98 A), three from Água Branca ~~Suite~~ (CS-97, CS-113 and CS-121) and four from Mapuera Suite (AT-16 A, AT-99, AT-153 and AT-177). The Sm-Nd and Rb-Sr isotopic results are listed in Table 5, which includes the ε_{Nd} values calculated from respective crystallization ages of 1999 Ma and 2005 Ma for the Caxipacoré ~~Suite~~, 1886 Ma for the Água Branca ~~Suite~~ and 1870 for the Mapuera ~~granitoids~~.

Sm and Nd contents of the different granitoids range from approximately 4.5-22.5 ppm and 26-132 ppm, respectively and tend to be higher ~~in~~ the Mapuera granitoids due to its more alkaline character. All samples display homogeneous $^{147}Sm/^{144}Nd$ ratios, ranging from 0.0819 to 0.1049, which are within the acceptable range (0.080-0.120) for the T_{DM} age calculation. Furthermore, the $f_{Sm/Nd}$ values, which range from -0.46 to -0.58, demonstrate that there was not a considerable Sm/Nd fractionation during formation of studied ~~granitoids~~ (DePaolo, 1988).

Therefore, all rocks provided uniform T_{DM} ages and ε_{Nd} values, ranging from 1.95 to 2.30 Ga and -1.96 to +2.92, respectively. In the ε_{Nd} *versus* T(Ga) diagram (Figure 15), ~~where the Nd isotopic evolution of Paleoproterozoic and Archean crusts of southeastern Guyana Shield is exhibited,~~ all samples are concentrated in the field of Paleoproterozoic crust with dominantly Rhyacian T_{DM} ages. ~~In addition, fields of the coeval volcanic rocks of the Iricoumé Group and Igarapé Paboca Formation (Barreto *et al.* 2014) in the Erepecuru-Trombetas Domain and correlated volcano plutonic rocks from Uatumã-Anauá and Tapajós domains are plotted for comparison (Almeida 2006; Lamarão *et al.* 2005).~~

The Rb and Sr contents range from 86.7 to 290.2 ppm and 52.9 to 754 ppm, respectively. The $^{87}Rb/^{86}Sr$ ratios show values of 0.33-78.19. The T_{UR} model ages ~~furnished~~ dominantly consistent values, varying from 1.84 to 2.02 Ga, except for one sample of the Mapuera Suite, which show ~~a younger age of~~ 1.41 Ga.

Table 5

Table 5. Whole-rock Sm-Nd and Rb-Sr isotopic data from Caxipacoré, Água Branca and Mapuera ~~granitoids~~.

6 DISCUSSION

6.1 AGES AND GEOCHEMICAL CONSTRAINTS

The ~~granitoid~~ rocks of the Erepecuru-Trombetas Domain have been included in three Orosirian plutonic suites: Caxipacoré, Água Branca and Mapuera. They are dominantly composed of monzonites, monzogranites, syenogranites and alkali-feldspar granites with ~~varied content of~~ amphibole and biotite. Available U-Pb and Pb-Pb geochronological data ~~in~~ the Tapajós-Parima Province indicated ages of 1.90-1.89 Ga and 1.89-1.86 Ga, respectively, for the Água Branca and Mapuera suites, and ≈ 2.0-1.95 Ga for the correlated magmatic rocks of the Caxipacoré Suite (see Table 1). In the study area, however, the occurrence of these units ~~was~~ not ~~clarified~~ due to the lack of geochronological and geochemical studies and they were individualized solely based on a compilation of scarce petrographic and available field data (e.g. Jorge João *et al.* 1984) combined with geophysical interpretation (Vasquez and Rosa-Costa 2008; Rosa-Costa and Andrade 2016, *in press*) and correlation with adjacent areas. Thus, these new U-Pb zircon ~~data for the granitic rocks in the study area and the whole-rock geochemistry~~ allowed the identification of different Orosirian magmatic events and ~~the characterization of~~ their geodynamic environments.

The geochemical results point out the existence of two rock groups with different signatures. The first group ~~is constituted of granitoid rocks of~~ the Caxipacoré and Água Branca suites, which display a magnesian, metaluminous, shoshonitic to high-K calc-alkaline signature (Figures 7A, B, C and 8A, B). These LILE-enrichment (K, Rb, Ba and Sr) in relation to HFS elements and strong negative Nb anomalies (Figure 9A, B) are typical characteristics of magma generated by subduction-related process in modern magmatic arcs (Brown 1982; Brown *et al.* 1984; Barbarin 1999) or post-collisional calc-alkaline rocks derived from lithospheric mantle sources modified by subduction (Pearce *et al.* 1984; Bitencourt and Nardi 1993; Kelemen *et al.* 1993; Hawkesworth *et al.*1997; Waichel *et al.* 2000; Elburg *et al.* 2002). In addition, the REE pattern with moderate HREE fractionation and slightly negative Eu anomalies (Figure 10A, B) are characteristics of calc-alkaline associations (Brown *et al.* 1984). The positioning of the Caxipacoré and Água Branca granitoids in tectonic discrimination diagrams (Figure 11 and 12) suggests an origin in orogenic zones related to subduction environment for both. However, U-Pb geochronological analyses furnished ages with a gap of approximately 100 m.y. between these suites. The oldest ages of 1991 ± 5.9 and 2005 ± 7.2 Ma were obtained in a biotite leuco-monzogranite and biotite-hornblende monzogranite ~~for~~ the Caxipacoré Suite, respectively, and 1886.5±4.8 Ma in a hornblende-biotite monzonite for the Água Branca Suite (Table 4; Figure 14). Then, we identified two distinct event of magmatic arc formation or a protracted subduction episode ~~of around~~ 100 m.y.

The second geochemical signature ~~identified~~ is represented by the ~~syeno-~~ and alkali feldspar granites of the Mapuera Suite. These rocks have a dominantly peraluminous, high-K alkaline trends and affinity with ferroan granitoids. The restricted and high SiO_2 interval (71.29-78.03 wt.%; Table 3), $FeO_t/(FeO_t+MgO)$ ratio higher than 0.85 (0.87 to 0.95; Table 3) and low $CaO/(Na_2O+K_2O)$ are compatible with metaluminous to weakly peraluminous granites from sub-alkaline to alkaline associations. The Mapuera granitoids also display the alkali contents (Na_2O+K_2O) higher than 8% and (Zr+Ce+Y+Nb) sum ~~greater~~ than 340 ppm (Table 3), comparable to typical values of A-type granites (Nardi and Bitencourt 2009; Whalen *et al.* 1987) or to those of granites that belong to the sodic-silica-saturated alkaline series (Le Maitre *et al.* 2002). In addition, the HSFE-enrichment (e.g. Zr, Hf, Th) and the high REE content with pronounced negative Eu anomalies (Figure 12C) reinforce the alkaline character of these rocks. In the tectonic classification diagrams, a post-collisional within-plate environment is proposed for the Mapuera granitoids. In the Eby (1992) diagram, they were classified as A_2-type granitoids (Figure 11D), defined as granites originated by melting of crustal rocks emplaced in a variety of tectonic settings, including post-collisional and anorogenic environments. Accordingly, the plots in the Thieblémont and Téygey (1994) diagram also point out an A_2-type affinity, reflecting a relatively Nb/Zr ratio-enrichment and/or high concentrations of Zr, commonly found in post-collisional calc-alkaline and alkaline rocks (Figure 12C).

Despite of showing geochemical characteristics of I-type granitoids, the crystallization ages of the Água Branca Suite are almost contemporaneous to those of the A-type Mapuera granitoids, ~~according to the U-Pb zircon age of~~ 1870 ± 14 Ma ~~furnished by a biotite alkali-feldspar granite of this suite.~~ This close association between calc-alkaline and A-type magmatism is suggestive of a post-orogenic extensional environment ~~than~~ of a magmatic arc at that time (≈ 1.88 Ga). In such case, an origin by subduction processes may be committed. I-type granitoids not related to active subduction tectonic setting is reported in the Lachlan Fold Belt/southeastern Australia (Chappell and White 1974, 1992; Collins *et al.* 1982; White and Chappell 1983; Blevin and Chappell 1995; King *et al.* 1997; Chappell *et al.* 2000), northern Australia (Wyborn and Page 1988) and western United States (Smith *et al.* 1990; Coleman and Walker 1992; Hooper *et al.* 1995; Hawskesworth *et al.* 1995). These alternative models imply for an intracontinental orogenesis by process of magmatic underplating, crustal distension, lithospheric delamination, convective removal of the lithosphere, slab break off or asthenospheric influx (Bird 1979; Housemann *et al.* 1981; Kröner 1983; Etheridge *et al.* 1987; Liégeois and Black 1987; Davies and Blankenburg 1995).

6.2 CONSIDERATIONS ON SOURCES

The sources of the volcano-plutonic associations of the Erepecuru-Trombetas are still not ~~clarified~~ and ~~their interpretations~~ are open to debate. For decades, a model based on Paleoproterozoic mantle-derived magmas contaminated by the assimilation of Archean crust or mixing with magmas derived from an Archean source was assumed for the entire Central Amazon Province, including the Erepecuru-Trombetas Domain (e.g. Sato and Tassinari 1997; Tassinari and Macambira 1999, 2004; Santos *et al.* 2000).

Nd-T_{DM} ages between 1.95 and 2.30 Ga, Sr-T_{UR} model ages from 1.84 to 2.02 Ga (Table 5) and ε_{Nd} ranging from positive (+2.92) to slightly negative (-1.01) values (Figure 17) obtained for the Caxipacoré, Água Branca and Mapuera granitoids indicate that the magmas were originated essentially from older Paleoproterozoic crustal sources, with dominantly Rhyacian T_{DM} ages, and some primitive mantle source contribution. No reworked Archean crust seems to be involved in the source. The ~~inexistence~~ of inherited Archean cores or xenocrystals ~~in the dated~~ zircon populations also reinforces this assumption.

For the older rocks (2.0-1.97 Ga Caxipacoré granitoids), the magma derivation may be related to accretionary process in an Andean-type arc magmatic with magmas modified by crustal interaction. In this case, the high-K calc alkaline associations ~~are~~ derived from remelting of an older sialic crust. A derivation of the magmas from the remelting of crustal sources is consistent with geochemical and ~~Nd data~~ and ~~with a~~ few inherited zircon crystals~~, which presented dominantly Rhyacian ages, between 2.25 and 2.32 Ga~~. This Rhyacian crust could be related to the Maroni-Itacaiúnas ~~Province~~ (2.26-2.05 Ga)/Transamazonas ~~Province~~ (2.26-2.01 Ga), a widespread domain over the eastern part of the Guyana Shield and strongly ~~marked~~ by Transamazonian Orogeny (e.g. Tassinari and Macambira 2004; Rosa-Costa *et al.* 2006; Santos *et al.* 2006). An alternative ~~proposal~~ implies in a juvenile ~~derivation~~ with incipient crustal contribution, but the data presented herein are not fully conclusive for this nature. Juvenile (oceanic) magmatic arc context or, more probably, a continental margin context developed on a young (Rhyacian) continental crust would account for the geochemical signature of the older Orosirian volcanic-plutonic episode.

The younger units (≈1.89-1.87 Ga Água Branca and Mapuera suites) also demonstrated dominantly ancient crustal sources mixed with a juvenile component. ~~However, geochemical data and U-Pb ages point out that the process of magma genesis may be related to an intracontinental environment~~. In this case, the Água Branca and Mapuera granitoids would be product of an extensively reworked sialic crust, older than 1.9 Ga, during the ≈1.88 Ga extensional event.

A similar isotopic Nd signature had already been found by Barreto *et al.* (2014) for the coeval ≈1.88 Ga Iricoumé and ≈1.99 Ga Igarapé Paboca volcanic rocks eastward, in the Erepecuru-Trombetas Domain. Their results have demonstrated that these rocks were also originated by both mantle sources and an older Paleoproterozoic sialic crust (ε_{Nd} = -3.04 to +2.35), with dominantly Rhyacian ages (1.98 Ga to 2.39 Ga).

In other areas of the central portion of the Amazonian Craton, Nd isotopic studies led to interpretations regarding the magma sources similar to those made by Barreto *et al.* (2014) for the volcanic rocks and presented herein for the plutonic rocks of the Erepecuru-Trombetas Domain (Figure 15).

In the southern Uatumã-Anauá Domain, the $\approx$1.88 Ga Água Branca and Mapuera ~~granitoids~~ and the coeval Iricoumé volcanic rocks have ~~demonstrated~~ dominantly Rhyacian Nd-T_{DM} model ages (2.29-2.13 Ga) and slightly negative ε_{Nd} values (-0.02 to -1.61) to locally positive ε_{Nd} values (+0.46). Subordinated Siderian Nd-T_{DM} model ages (2.34-2.47 Ga) associated to negative ε_{Nd} values (-2.05 to -5.43) are also found (Costi *et al.* 2000; Almeida 2006; Marques *et al.* 2007, 2014; Valério 2011). For the oldest rocks (2.03-1.96 Ga), the Nd pattern is slightly contrasted. The Martins Pereira and Serra Dourada granitoids exhibit dominantly Siderian Nd-T_{DM} model ages (2.47-2.33 Ga) with negative ε_{Nd} values varying from -0.92 to -4.74 (Almeida 2006). Despite of ~~showing~~ variable Nd-T_{DM} model ages and ε_{Nd} ~~ranging from strongly negative to positive values,~~ Almeida (2006) states that the origin of the Uatumã-Anauá granitoids ~~is better~~ explained by the melting/recycling of an older Paleoproterozoic sialic crust (Rhyacian to Siderian).

These Nd isotopic signatures are in agreement with those obtained for the volcano-plutonic associations of the Tapajós Domain (Figure 15). In summary, the rocks related to both magmatic events - 2.0-1.97 Ga (Creporizão/Old São Jorge granites and Vila Riozinho Formation) and 1.90-1.87 Ga (Jardim do Ouro, Younger São Jorge and Maloquinha granitoids, and Moraes Almeida volcanic rocks), have shown similar ~~behavior in~~ Nd pattern. The ε_{Nd} is negative (-5.21 to -0.72) and dominantly Rhyacian to Siderian Nd-T_{DM} model ages (2.22-2.49 Ga). Lamarão *et al.* (2005) proposed a magmatic origin from Paleoproterozoic sources during a continental-scale extensional for these rocks. However, for the 2.0-1.97 Ga magmatism, Lamarão *et al.* (2005) also proposed alternatively a derivation by remelting of an older Paleoproterozoic juvenile arc with contribution from Archean sialic sources, excluding the existence of a subduction zone in the region, as has been discussed by Vasquez *et al.* (2002). In the Santos *et al.* (2004) conception, the volcano and plutonic rocks of the Tapajós Domain have Archean components in their sources.

Figure 15

Figure 15. ε_{Nd} versus time (T_{Ga}) diagram, showing the isotopic composition of the Caxipacoré, Água Branca and Mapuera suites. Fields of Archean and Paleoproterozoic crusts of the Guiana shield are from Avelar et al. *(2003) and Rosa-Costa* et al. *(2006) while the elliptical fields are from Barreto* et al. *(2014), Almeida (2006) and Lamarão et al. (2005).*

In the Iriri-Xingu Domain, the Nd patterns are quite different. The volcano-plutonic associations have dominantly Archean Nd-T_{DM} model ages (3.25-2.49 Ga) and strongly negative εNd values, ranging from -12.2 to -4.56 (Sato and Tassinari 1997; Teixeira *et al.* 2002; Vasquez 2006; Fernandes *et al.* 2011). In general sense, a dominant Archean crustal source with minor mantle contribution is admitted for the Velho Guilherme and Rio Dourado granitoids and for Iriri, Santa Rosa and Sobreiro volcanic rocks. The inherited Archean signature could be explained by the geographical proximity with Carajás Province (3.0-2.5 Ga).

6.3 GEODYNAMIC ENVIRONMENT

Two different important times of intense magmatic activities are registered in the Erepecuru-Trombetas Domain. Geochemical and geochronological data support the hypothesis of an orogenic context for the Caxipacoré granitoids at 2.0-1.97 Ga. Barreto *et al.* (2014) also suggested a similar setting for the coeval calc-alkaline volcanic rocks of the Igarapé Paboca Formation, which geochemical characteristics point to a subduction-related environment. For the younger magmatic episode (1.90-1.87 Ga), the coexistence of the I-type Água Branca and A-type Mapuera ~~granitoids~~ and

Iricoumé volcanics is suggestive of a transitional environment, ranging from an orogenic to a post-orogenic context.

Similar geodynamic framework is also documented in Orosirian volcano-plutonic associations elsewhere ~~of the central part of~~ the Amazonian Craton. In the Uatumã-Anauá Domain, the collisional orogenic stage is represented by ≈1.98-1.96 Ga I-type Martins Pereira and S-type Serra Dourada suites, f~~ollowed~~ by a post-orogenic setting related to an extensional tectonic, which favored the emplacement of ≈1.90-1.88 Ga Água Branca and Mapuera ~~granitoids~~ by underplating mafic magma process (Almeida *et al.*2007; Valério *et al.*2009). In the Tapajós Domain, Lamarão *et al.* (2002) ~~also~~ recognized that rocks of Vila Riozinho region were formed ~~by an older~~ subduction-related magmatism at 2.01-1.97 Ga (Old São Jorge Granite and coeval Vila Riozinho Formation volcanic rocks) followed by 1.90-1.87 Ga intracontinental taphrogenic event, originating the magmas of Jardim do Ouro, Younger São Jorge and Maloquinha granitoids and Moraes Almeida volcanic rocks. ~~In the Iriri-Xingu Domain, the 2.0-1.96 magmatic event is not documented, but the correlated 1.90-1.86 Ga volcano-plutonic associations include the plutonic rocks of the Velho Guilherme and Rio Dourado suites and volcanic rocks of the Iriri Group and Santa Rosa and Sobreiro formations, with ages between 1.88 and 1.86 Ga (Teixeira *et al.* 2002; Pinho *et al.* 2006; Barros *et al.* 2009, 2011; Fernandes *et al.* 2011).~~ The Velho Guilherme and Rio Dourado suites and the Iriri Group and Santa Rosa formation show geochemical characteristics similar to A-type granites and their geodynamic evolution ~~could be explained~~ by an extensional intracontinental setting (Bahia *et al.* 2001, Lamarão *et al.* 2002; Teixeira *et al.* 2005; Barros *et al.* 2011; Fernandes *et al.* 2011). Differently, the coeval Sobreiro Formation may be formed under subduction-related setting (Fernandes *et al.* 2011).

In a global geodynamic context, the period between 2.2 and 1.8 Ga is marked by development of Paleoproterozoic Wilson cycles around the world, with a period of 2.2-2.0 Ga global-rifting followed by dominant 2.0-1.8 Ga global crustal amalgamation and buildup of several collisional belts (e.g. Hoffman 1988; Condie 2002; Zhao *et al.* 2002), welding Archean crustal fragments together and forming a number of supercratons/supercontinents (e.g. Zhao *et al.* 2002). Thus, the 2.0-1.97 Ga Igarapé Paboca and Caxipacoré units in the western Erepecuru-Trombetas may represent the fingerprint of a global-scale accretionary time related to the major phase of Atlantica continent formation (Santos *et al.* 2004). On the other hand, the intracontinental magmatism at approximately 1.90-1.86 Ga may be relative either to a post-orogenic setting or to the beginning of a continental-scale taphrogenic event (Neves *et al.* 1995) that affected the Amazonian Craton throughout the Mesoproterozoic. In the first case, the A-type Mapuera granitoids would represent the latest post-orogenic manifestation of an older subduction event (2.0-1.99 Ga), analogous to some Proterozoic post-orogenic associations, which the most alkaline magmatism may occurs 100 Ma later (Liégeois and Black 1987; Bonin 1987; Bonin *et al.*1998). In addition, it is accepted that alkaline magmatism can be generated in both post-orogenic and anorogenic settings (Whalen *et al.* 1987; Sylvester 1989; Bonin 1990; Pitcher 1997; Liégois *et al.* 1998). However, the close spatial and temporal association between I-type Água Branca and A-type Mapuera granitoids may actually represent the record of a transition time from arc-related calc alkaline magmatism to extensional intraplate magmatism in a stable continental block. A geodynamic change from orogenic calc alkaline magmatism to alkaline post-orogenic is observed in several Proterozoic and Phanerozoic post-collisional/post-orogenic terranes (e.g. Sylvester 1989; Bonin *et al.* 1998; Black and Liégois 1993; Liégois *et al.* 1998; Bitencourt and Nardi 2000; Bonin 2004). Otherwise, evidences of collisional phases have not been documented yet in the study area. In addition, it is not fully clarified if the 1.90-1.86 Ga granitoids were formed by (1) post-collisional processes, (2) ≈1.88 Ga taphrogenic event or

(3) convergence of both process/events; thus, the designation of post-orogenic is preferred for these granitoids.

In summary, the geodynamic evolution of western Erepecuru-Trombetas may be explained by at least two main stages: (1) an older subduction-related magmatism at 2.0-1.95 Ga, which produced the Caxipacoré Suite granitoids and coeval volcanic rocks of the IgarapéPaboca Formation; a second stage (2), which could be associated either to a (2a) late period of subduction-related magmatism (1.90-1.88 Ga), which would have originated the Água Branca granitoids and posteriorly the Mapuera-Iricoumé rocks in a post-orogenic intracontinental environment at 1.88-1.87 Ga, or alternatively a (2b) major period of intracontinental magmatism (1.90-1.87 Ga), posteriorly to the 2.0-1.95 Ga subduction event, originating both Água Branca and Iricoumé-Mapuera rocks, suggesting a transition for more stable tectonic crustal conditions (Figure 16).

The geochemical and Nd-T_{DM} characteristics also corroborate the existence of a continental magmatic arc at 2.0-1.95 Ga, showing similarities with other regions of the Amazonian Craton (e.g. Tapajós-Parima Province). A transitional period between arc-related magmatism and intracontinental is marked by the coexistence of calc-alkaline Água Branca and alkaline granitoids at 1.90-1.87 Ga. In such case, the model (2b) seems to be more consistent for the genesis of Água Branca and Mapuera granitoids. The origin of melts can be associated to the continental crust of the Maroni-Itacaiúnas Province (2.26-2.05 Ga)/Transamazonas Province (2.26-2.01 Ga) and an enriched lithospheric mantle previously modified by subducted slab. The heat could have been result of tectonically driven asthenospheric upwelling (?), slab break-off (?), underplated mafic magmas (?) or mantle plume (?).

These magmatic events had an important role in the crustal growth of the Amazonian Craton during Orosirian times. They cover extended areas and are widespread in several tectonic provinces. Such characteristics allied to a short age interval (≤ 40 Ma) and geochemical similarities have led some authors to include the 1.90-1.87 Ga volcano-plutonic rocks from the Erepecuru-Trombetas Domain into a Silicic Large Igneous Province (SLIP; Klein *et al.* 2012; Barreto *et al.* 2013, 2014). A SLIP had already been described previously in the central part of the Amazonian craton (Schobbenhaus and Neves 2003; Neves 2011; Fernandes *et al.* 2011; Juliani *et al.* 2011; Klein *et al.* 2012).

Figure 16

Figure 16. Schematic tectonic model for the Western Erepecuru-Trombetas Domain. (1) Subduction environment at 2.0-1.97 Ga that produced the magmas of Caxipacoré Suite and Igarapé Paboca Formation by dehydratation of subducted oceanic crust and subsequent hydratation of overlying mantle wedge and lower crust. Two models are proposed for the 1.90-1.86 Ga magmatic stage: (2a) a late period of subduction setting, related to a more mature magmatic arc (1.90-1.88 Ga), originating the Água Branca granitoids, followed by post-orogenic intracontinental magmatism at 1.88-1.86 Ga, producing the Iricoumé-Mapuera rocks or alternatively (2b) a major extensional event in an intracontinental environment, generating the Água Branca, Mapuera and Iricoumé rocks. The heat could have been produced by asthenospheric upwelling ~~(?)~~, slab-break-off ~~(?)~~,underplated mafic magmas or ~~(?)~~ mantle plumes ~~(?)~~.

6.4 IMPLICATION FOR THE BOUNDARIES AND AGE OF THE CENTRAL AMAZON PROVINCE

Several tectonic models have been proposed in order to understand the geodynamic evolution of the Amazonian Craton (e.g. Amaral 1974; Almeida *et al.* 1981; Cordani *et al.* 1979;

Teixeira *et al.* 1989; Sato and Tassinari 1997; Costa and Hasui 1997; Tassinari *et al.* 2000; Santos 2003). Posteriorly, the raise of available geochronological and isotope geochemical data favored spatial and temporal modifications and even proposition of new provinces. Thus, the proposal of Cordani *et al.* (1979) was constantly modified, resulting in the two widely discussed models nowadays: Tassinari and Macambira (1999, 2004) and Santos *et al.* (2000, 2006) models. In general terms, these proposals focus on the partitioning of the Amazonian Craton in several tectonic-geochronological provinces based on geochronological data, structural patterns and geodynamic evolution (Figure 1). Despite of some conceptual similarities, the models have differences in the boundaries and extension area of provinces, especially the Central Amazon Province, which are not equivalent. For Tassinari and Macambira (1999, 2004) the Archean Carajás region is still part of the Central Amazon Province, whereas Santos *et al.* (2006) exclude it from the province. There are also significant differences in the limits of the Ventuari-Tapajós/Tapajós-Parima Province.

Although there are divergent points, both models consider the existence of an Archean basement in the Central Amazon Province, even though that no Archean rocks have been still identified. According to Tassinari and Macambira (1999, 2004), the Central Amazon Province is constituted of a “hidden” basement (>2.5 Ga) and a widespread volcano-plutonic association which origin is associated to melting of an Archean crust at depth. Otherwise, Santos *et al.* (2000, 2006) do not recognized an older basement exposed in the Central Amazon Province, but point out a dominantly Archean sources for the magmas of the younger granites and volcanic rocks (≈1.88-1.86 Ga). These proposals were based on Archean isotopic and geochronological data (Nd-T_{DM}, U-Pb and Pb-Pb zircon ages) obtained exclusively in the southern part of the province (e.g. Sato and Tassinari 1997; Teixeira *et al.* 2002; Vasquez 2006), while the northern portion, in the Guyana shield, was defined mainly by correlations.

For the rocks exposed in the northern part of the Central Amazon Province, the first Nd isotopic studies were obtained recently by Barreto *et al.* (2014) and Castro *et al.* (2014) in the Orosirian volcanic/pyroclastic rocks of the Iricoumé Group (≈1.89 Ga) and Igarapé Paboca Formation (≈1.99 Ga). These authors have found Nd-T_{DM} model ages not older than 2.34 Ga, attempting thus, for the inexistence of volcanic rocks with Archean signature in the northern part of the Central Amazon Province. For the coeval Água Branca, Mapuera (≈1.88 Ga) and Caxipacoré (≈1.98 Ga) granitoids, Nd-T_{DM} and Sr-T_{UR} model ages not older than 2.30 Ga (Table 5), coupled with the lack of inherited Archean zircons also argue for a Paleoproterozoic basement in the northern part of the Central Amazon Province, rather than an Archean, as previously proposed by Barreto *et al.* (2014). These results are also in agreement with Nd signatures of the rocks of the Uatumã-Anauá domain, which Nd-T_{DM} model ages range from 2.47 to 2.01 Ga and ε_{Nd} values between +1.93 and -5.43 (Costi *et al.* 2000; Almeida 2006; Marques *et al.* 2007; 2014; Valério 2011).

Overall, the petrographic, geochemical, U-Pb ages and Nd isotope studies have ~~pointed out a strong similarity~~ to the Orosirian volcano-plutonic associations of the Tapajós-Parima Province, especially the Uatumã-Anauá Domain. ~~These recent results have raised important questions about the positioning of the Central Amazon Province in the Guyana Shield. Barreto *et al.* (2014) had already emphasized that the western portion of the Erepecuru-Trombetas Domain may represent actually an extension of the Tapajós-Parima Province instead of the Central Amazon Province, although their hypothesis was based only on a few data from volcanic rocks.~~ Accordingly, we also propose herein, based on data from granitoid rocks, that the limit of the Tapajós-Parima Province should be extended eastward until, at least, the western Erepecuru-Trombetas domain. Such assumption is also in good agreement with the proposal of Santos *et al.* (2006), which tend to extend the Tapajós-Parima

Province eastward. Although these proposals bring important geodynamic implications, further detailed field investigations allied to a larger set of geochronological ~~isotopic data are needed for the reconstitution of a more realistic model~~ for this poorly known portion of the Amazonian Craton.

7 CONCLUDING REMARKS

U-Pb zircon data on granitoids reinforce that two Paleoproterozoic episodes of intense magmatic activity have marked the Erepecuru-Trombetas Domain in the southwestern Guyana shield. At 2.0-1.95 Ga, the Caxipacoré Suite granitoids and the Igarapé Paboca volcanic Formation were formed. During the second episode, approximately at 1.90-1.87 Ga, the Água Branca and Mapuera granitoids and the Iricoumé Group were formed. The geochemical signatures indicate that Caxipacoré and Água Branca granitoids display high-K to shoshonitic calc-alkaline series with signature of volcanic arc granites (VAG), while Mapuera granitoids show peraluminous A_2-type affinity with characteristics of within-plate granites (WPG). The geodynamic evolution is associated to anorogenic context related to a subduction process (Caxipacoré Suite), followed by a transitional period, from a convergent to intracontinental magmatism related to an extensional tectonics (calc-alkaline Água Branca and alkaline Mapuera granitoids). These interval ages, geochemical characteristics and geodynamic interpretations are largely coincident to the Orosirian magmatic associations encountered in both Uatumã-Anauá and Tapajós domains.

Nd-T_{DM} (1.95-2.30 Ga) and Sr-T_{UR} (1.84-2.02 Ga) model ages and positive to slightly negative εNd (+2,29 to -0.58) for most rocks of the Caxipacoré, Água Branca and Mapuera suites indicate that parental magmas derived from melting of dominantly Rhyacian crustal sources with minor juvenile contribution. In addition, the Nd signature and U-Pb zircon ages for the plutonic rocks obtained in this study coupled with Nd and Pb-Pb zircon data of Barreto *et al.* (2013, 2014) do not favor the existence of an Archean basement in this part of the Central Amazon Province. This assumption together with the similarity of the geological units in both Erepecuru-Trombetas and Uatumã-Anauá domains led to consider that such domains are part of a same geotectonic province.

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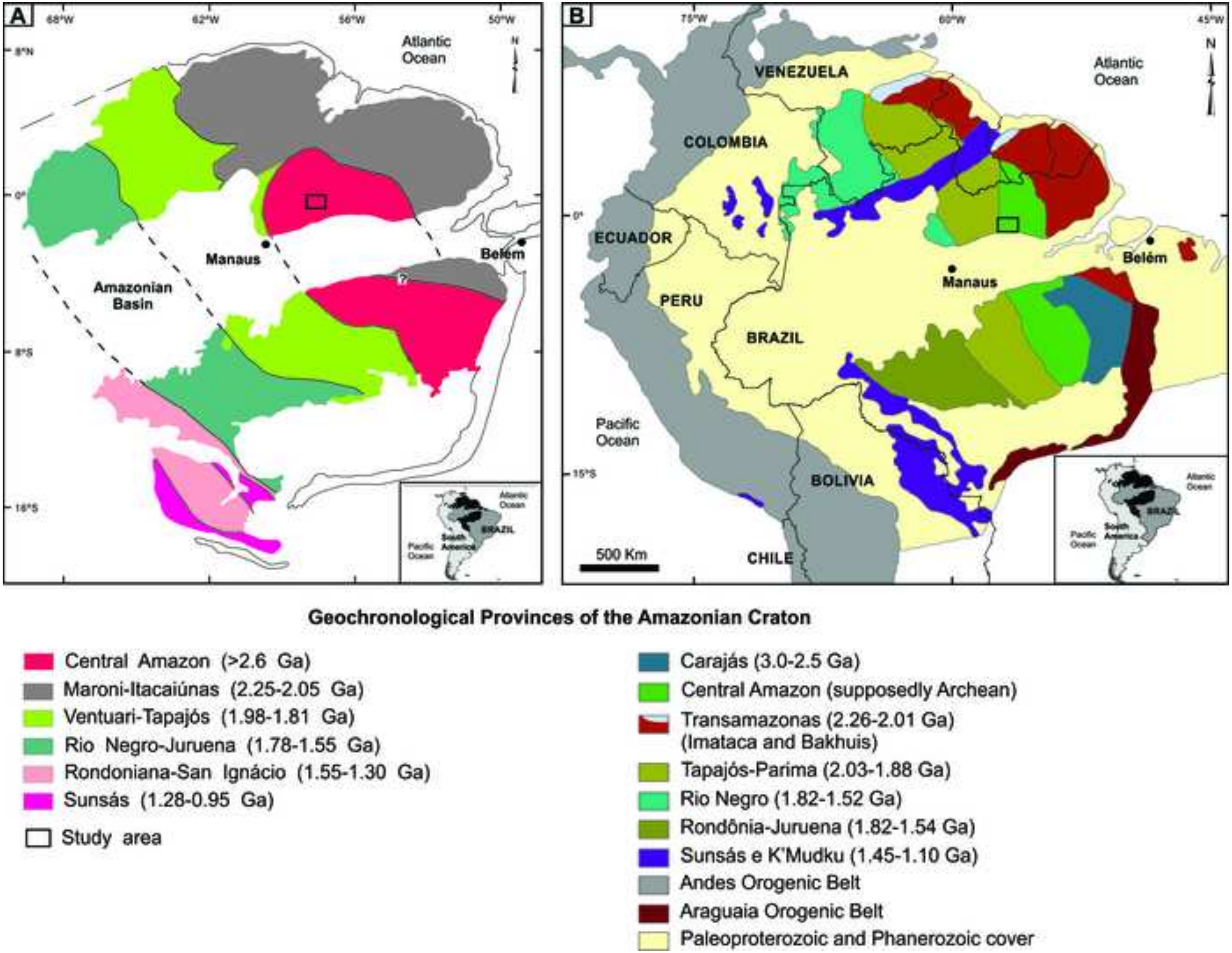
Figure 1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Manaus
Belém
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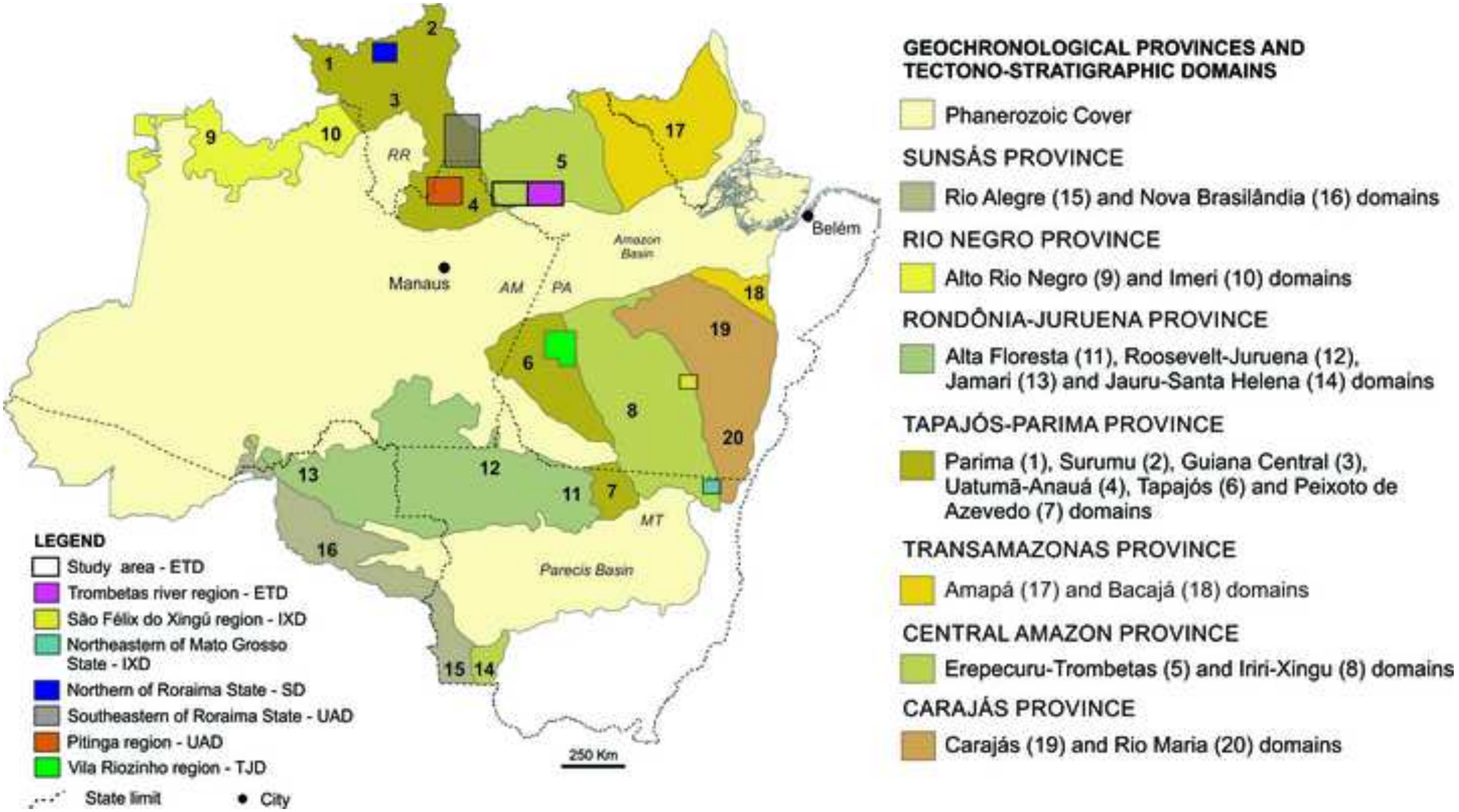
Atlantic Ocean
Pacific Ocean
South America
BRAZIL
B
75°W
60°W
45°W
0°
15°S
VENEZUELA
COLOMBIA
ECUADOR
PERU
BRAZIL
BOLIVIA
CHILE
Manaus
Belém
Pacific Ocean
Atlantic Ocean
N
500 Km
Geochronological Provinces of the Amazonian Craton
🟥 Central Amazon (>2.6 Ga)
⬛ Maroni-Itacaiúnas (2.25-2.05 Ga)
🟩 Ventuari-Tapajós (1.98-1.81 Ga)
🟩 Rio Negro-Juruena (1.78-1.55 Ga)
🟪 Rondoniana-San Ignácio (1.55-1.30 Ga)
🟪 Sunsás (1.28-0.95 Ga)
☐ Study area
🟦 Carajás (3.0-2.5 Ga)
🟩 Central Amazon (supposedly Archean)
🟥 Transamazonas (2.26-2.01 Ga) (Imataca and Bakhuis)
🟩 Tapajós-Parima (2.03-1.88 Ga)
🟩 Rio Negro (1.82-1.52 Ga)
🟩 Rondônia-Juruena (1.82-1.54 Ga)
🟦 Sunsás e K'Mudku (1.45-1.10 Ga)
⬛ Andes Orogenic Belt
🟥 Araguaia Orogenic Belt
🟨 Paleoproterozoic and Phanerozoic cover

Figure 2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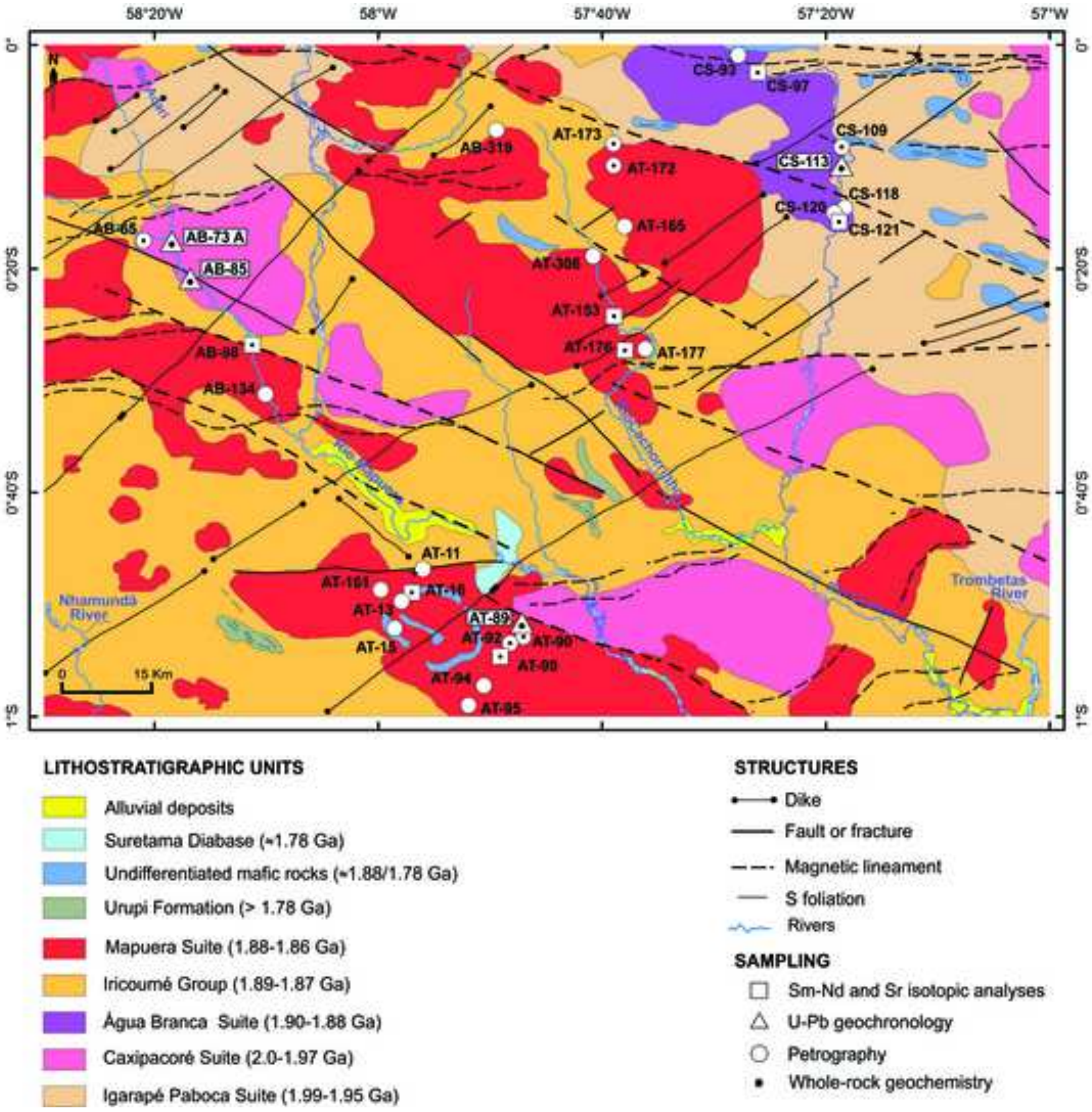
MT
Manaus
Belém
Amazon Basin
Parecis Basin
250 Km
LEGEND
Study area - ETD
Trombetas river region - ETD
São Félix do Xingú region - IXD
Northeastern of Mato Grosso State - IXD
Northern of Roraima State - SD
Southeastern of Roraima State - UAD
Pitinga region - UAD
Vila Riozinho region - TJD
State limit
City
GEOCHRONOLOGICAL PROVINCES AND TECTONO-STRATIGRAPHIC DOMAINS
Phanerozoic Cover
SUNSÁS PROVINCE
Rio Alegre (15) and Nova Brasilândia (16) domains
RIO NEGRO PROVINCE
Alto Rio Negro (9) and Imeri (10) domains
RONDÔNIA-JURUENA PROVINCE
Alta Floresta (11), Roosevelt-Juruena (12), Jamari (13) and Jauru-Santa Helena (14) domains
TAPAJÓS-PARIMA PROVINCE
Parima (1), Surumu (2), Guiana Central (3), Uatumã-Anauá (4), Tapajós (6) and Peixoto de Azevedo (7) domains
TRANSAMAZONAS PROVINCE
Amapá (17) and Bacajá (18) domains
CENTRAL AMAZON PROVINCE
Erepecuru-Trombetas (5) and Iriri-Xingu (8) domains
CARAJÁS PROVINCE
Carajás (19) and Rio Maria (20) domains

Figure 3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CS-120
CS-121
AB-319
AT-173
AT-172
AT-165
AT-308
AT-153
AT-176
AT-177
AB-65
AB-73 A
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AB-134
AT-11
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AT-15
AT-89
AT-92
AT-90
AT-99
AT-94
AT-95
Nhamundá River
Trombetas River
0
15 Km
LITHOSTRATIGRAPHIC UNITS
Alluvial deposits
Suretama Diabase (≈1.78 Ga)
Undifferentiated mafic rocks (≈1.88/1.78 Ga)
Urupi Formation (> 1.78 Ga)
Mapuera Suite (1.88-1.86 Ga)
Iricoumé Group (1.89-1.87 Ga)
Água Branca Suite (1.90-1.88 Ga)
Caxipacoré Suite (2.0-1.97 Ga)
Igarapé Paboca Suite (1.99-1.95 Ga)
STRUCTURES
Dike
Fault or fracture
Magnetic lineament
S foliation
Rivers
SAMPLING
Sm-Nd and Sr isotopic analyses
U-Pb geochronology
Petrography
Whole-rock geochemistry

Figure 4

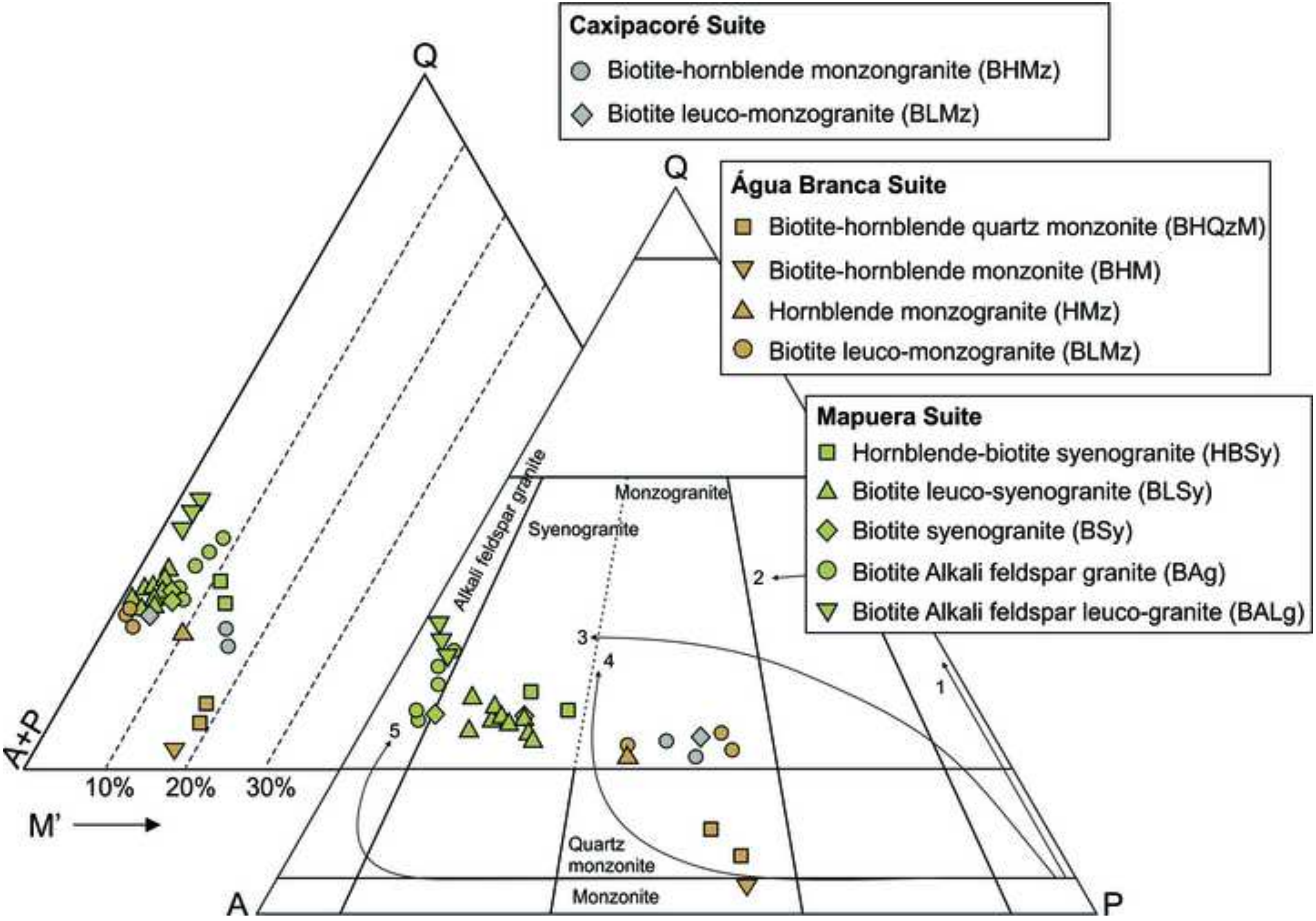
Caxipacoré Suite
Biotite-hornblende monzongranite (BHMz)
Biotite leuco-monzogranite (BLMz)
Água Branca Suite
Biotite-hornblende quartz monzonite (BHQzM)
Biotite-hornblende monzonite (BHM)
Hornblende monzogranite (HMz)
Biotite leuco-monzogranite (BLMz)
Mapuera Suite
Hornblende-biotite syenogranite (HBSy)
Biotite leuco-syenogranite (BLSy)
Biotite syenogranite (BSy)
Biotite Alkali feldspar granite (BAg)
Biotite Alkali feldspar leuco-granite (BALg)
Q
Q
A+P
10%
20%
30%
M'
Alkali feldspar granite
Syenogranite
Monzogranite
Quartz monzonite
Monzonite
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Figure 5

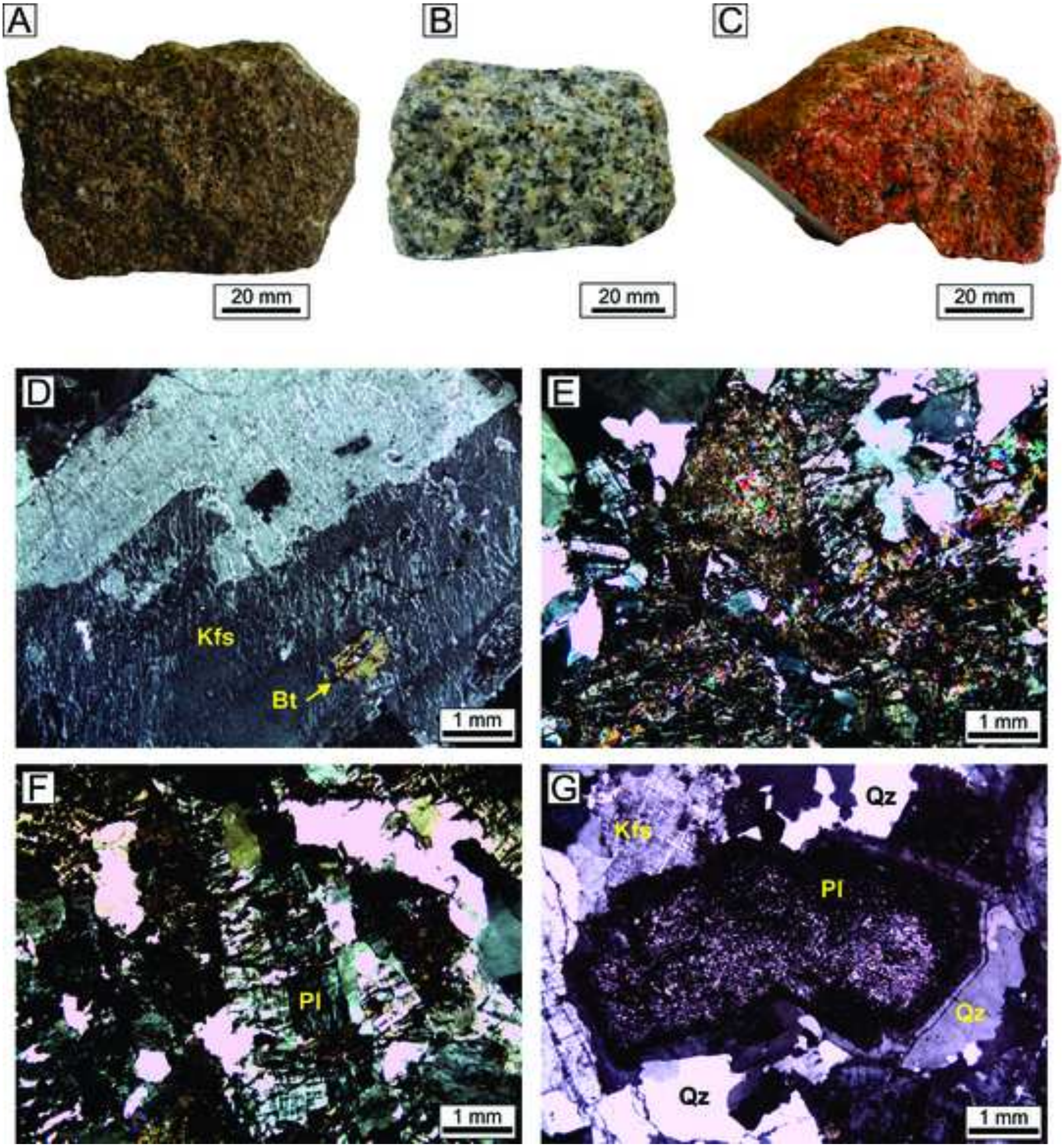

Figure 6

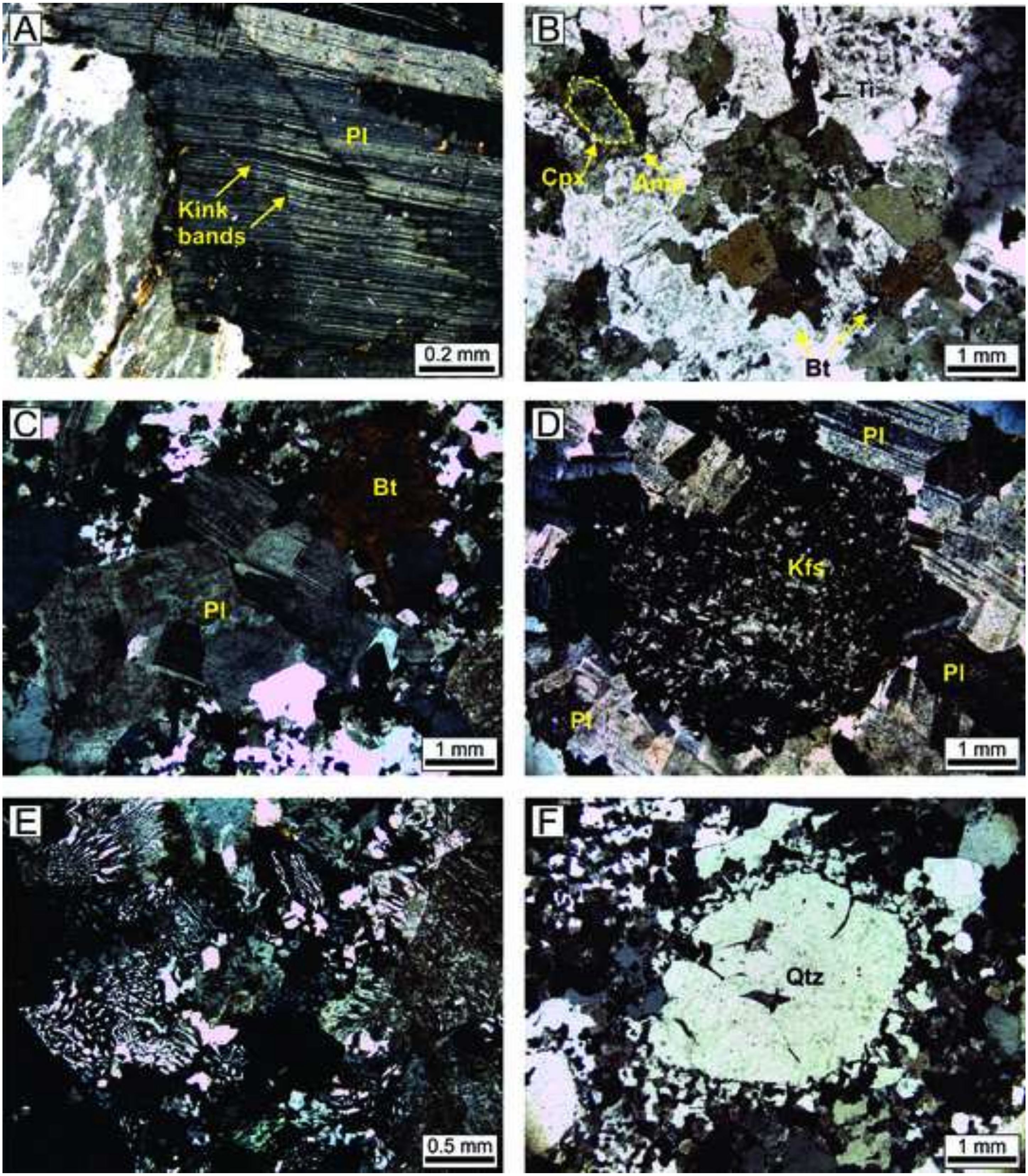
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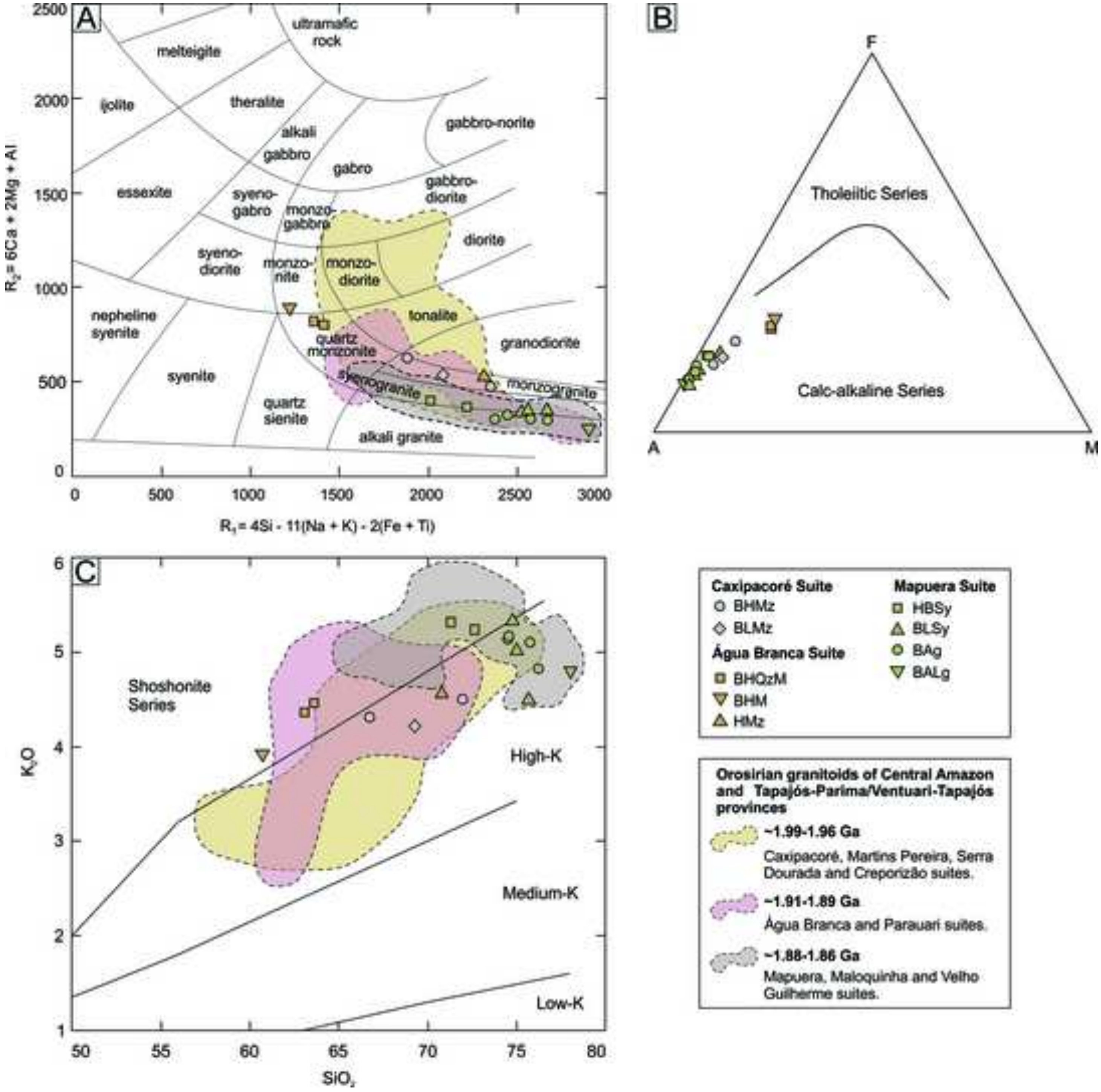
Figure 7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syeno-gabro
monzo-gabbro
gabbro-diorite
diorite
syeno-diorite
monzo-nite
monzo-diorite
tonalite
nepheline syenite
quartz monzonite
granodiorite
syenite
syenogranite
monzogranite
quartz sienite
alkali granite
R_2 = 6Ca + 2Mg + Al
R_1 = 4Si - 11(Na + K) - 2(Fe + Ti)
0
500
1000
1500
2000
2500
3000
B
F
Tholeiitic Series
Calc-alkaline Series
A
M
C
Shoshonite Series
High-K
Medium-K
Low-K
K_2O
SiO_2
1
2
3
4
5
6
50
55
60
65
70
75
80
Caxipacoré Suite
○ BHMz
◇ BLMz
Água Branca Suite
□ BHQzM
▽ BHM
△ HMz
Mapuera Suite
□ HBSy
△ BLSy
○ BAg
▽ BALg
Orosirian granitoids of Central Amazon and Tapajós-Parima/Ventuari-Tapajós provinces
~1.99-1.96 Ga
Caxipacoré, Martins Pereira, Serra Dourada and Creporizão suites.
~1.91-1.89 Ga
Água Branca and Parauari suites.
~1.88-1.86 Ga
Mapuera, Maloquinha and Velho Guilherme suites.

Figure 8

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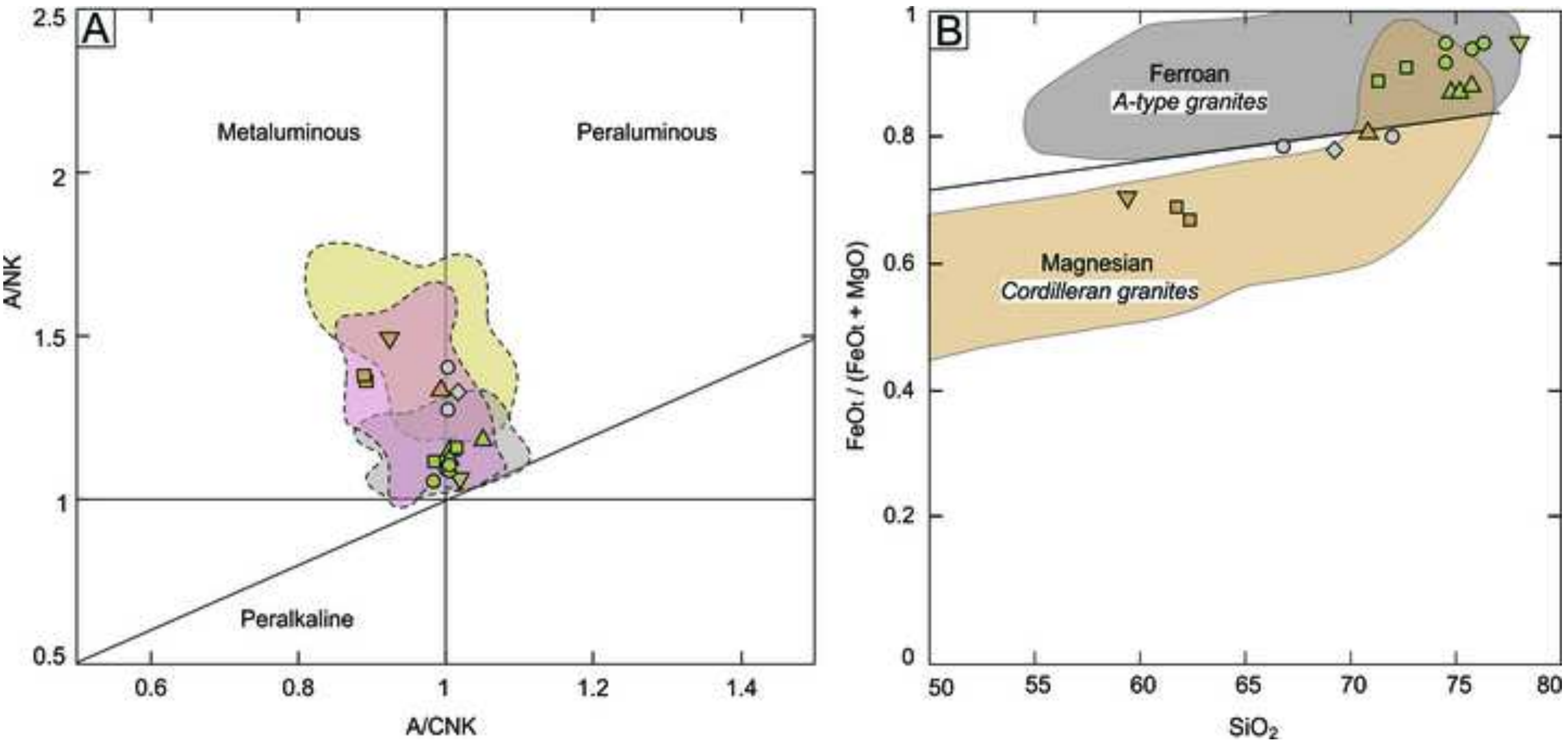

Figure 9

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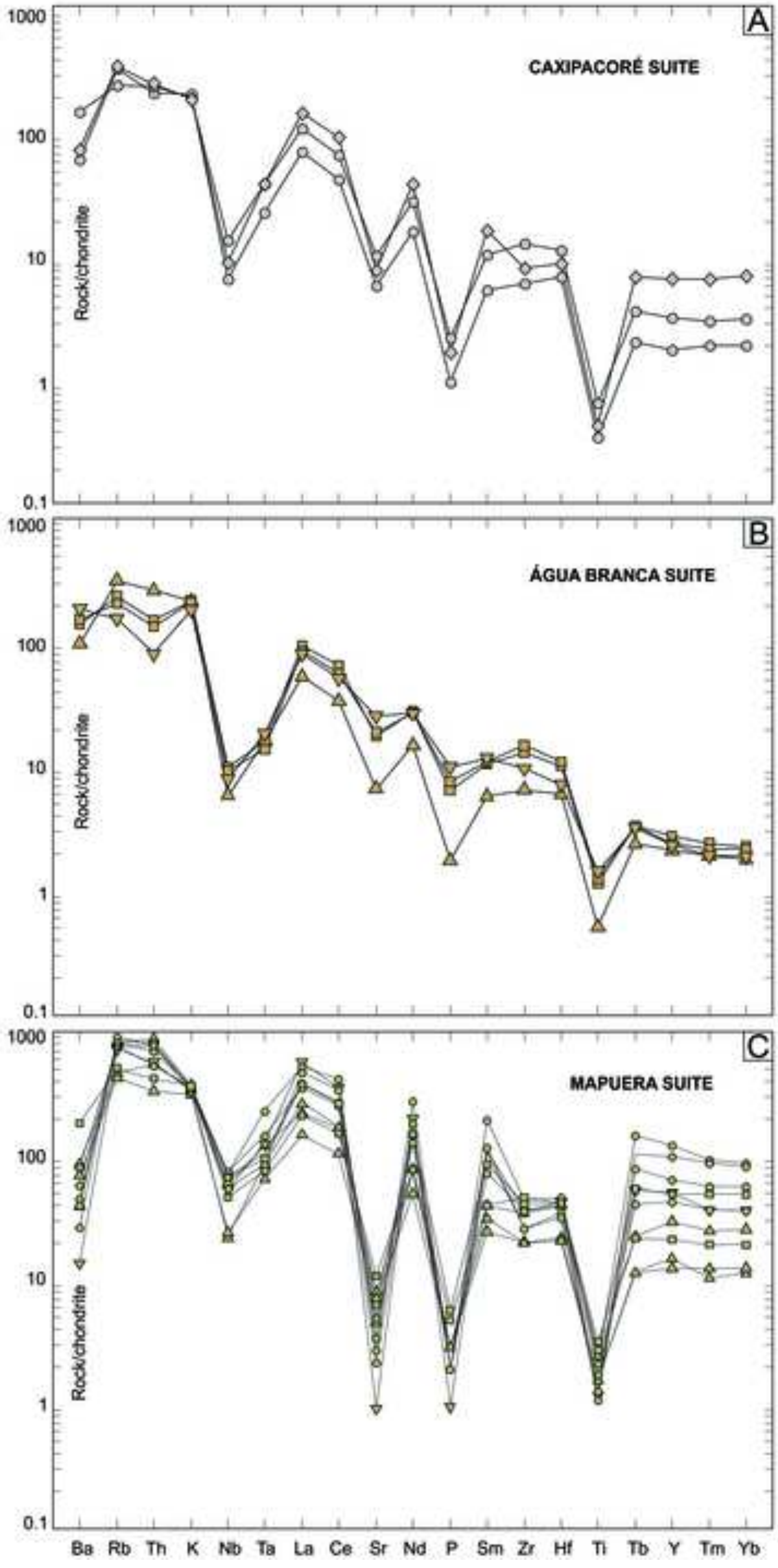

Figure 10

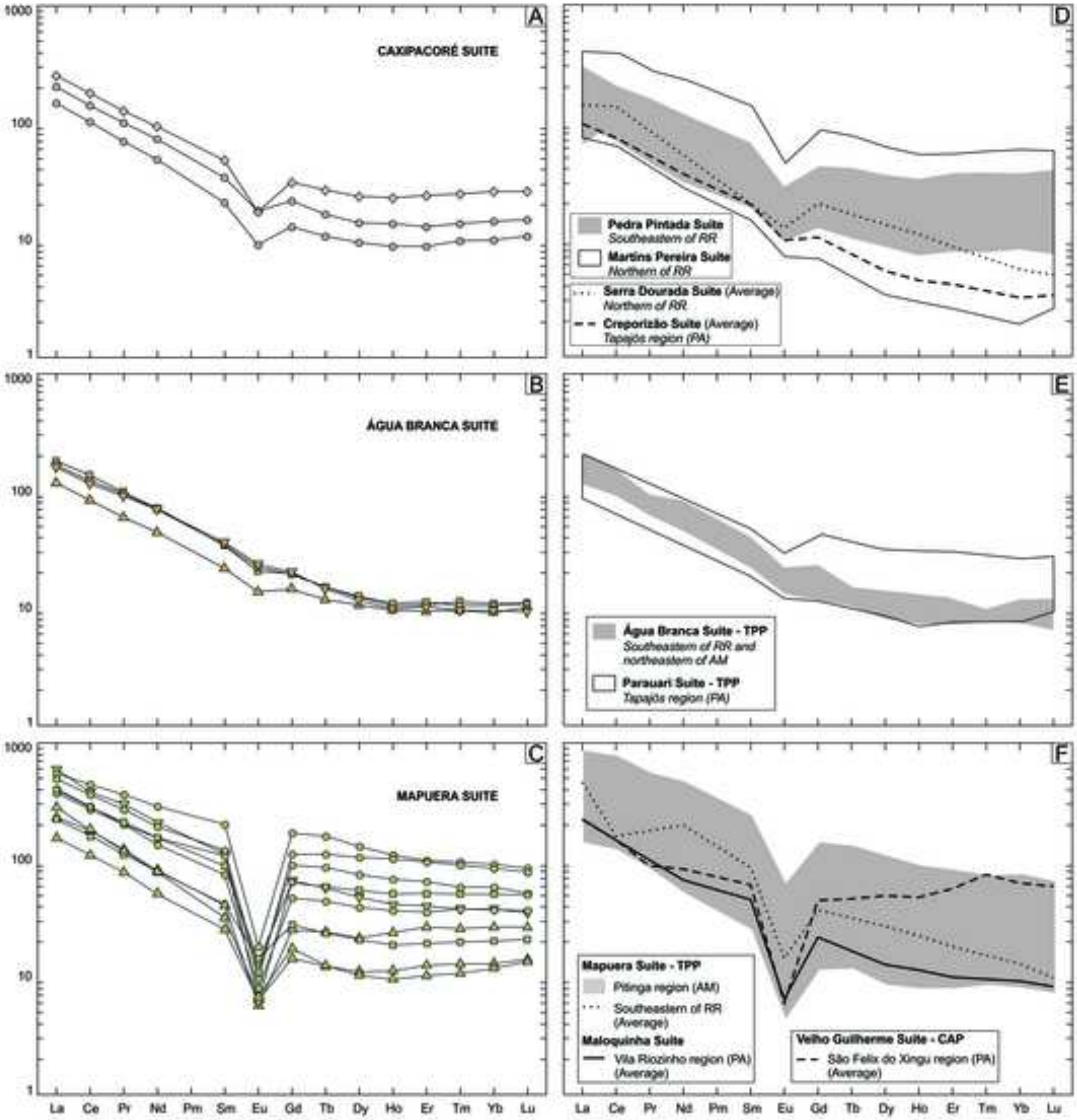
A
CAXIPACORÉ SUITE
B
ÁGUA BRANCA SUITE
C
MAPUERA SUITE
D
Pedra Pintada Suite
Southeastern of RR
Martins Pereira Suite
Northern of RR
Serra Dourada Suite (Average)
Northern of RR
Creporizão Suite (Average)
Tapajós region (PA)
E
Água Branca Suite - TPP
Southeastern of RR and northeastern of AM
Parauari Suite - TPP
Tapajós region (PA)
F
Mapuera Suite - TPP
Pitinga region (AM)
Southeastern of RR (Average)
Maloquinha Suite
Vila Riozinho region (PA) (Average)
Velho Guilherme Suite - CAP
São Felix do Xingu region (PA) (Average)
1000
100
10
1
La
Ce
Pr
Nd
Pm
Sm
Eu
Gd
Tb
Dy
Ho
Er
Tm
Yb
Lu

Figure 11

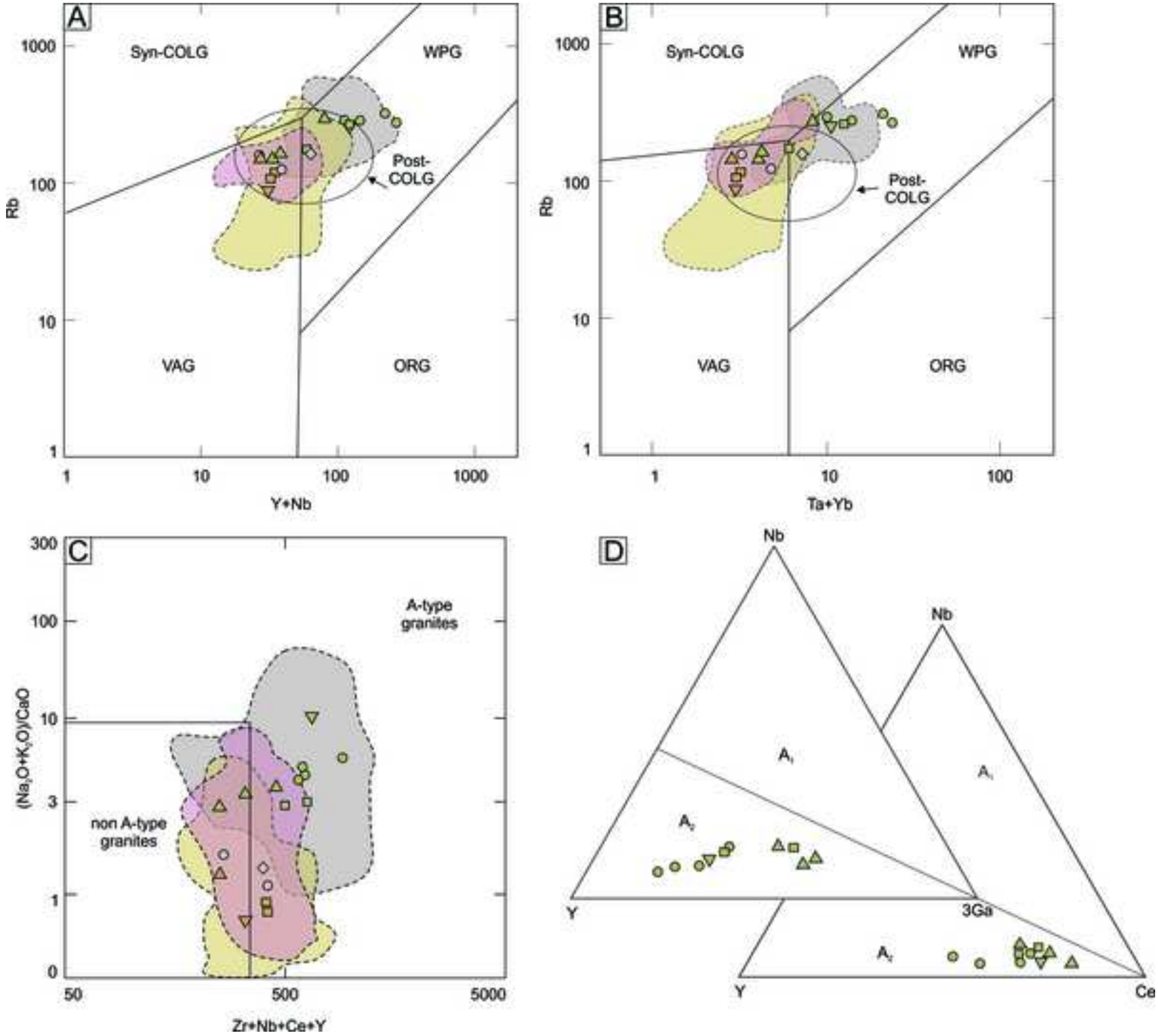
A
1000
100
10
1
Rb
Syn-COLG
WPG
Post-
COLG
VAG
ORG
1
10
100
1000
Y+Nb
B
1000
100
10
1
Rb
Syn-COLG
WPG
Post-
COLG
VAG
ORG
1
10
100
Ta+Yb
C
300
100
10
3
1
0
(Na$_2$O+K$_2$O)/CaO
A-type
granites
non A-type
granites
50
500
5000
Zr+Nb+Ce+Y
D
Nb
Nb
A$_1$
A$_1$
A$_2$
A$_2$
Y
3Ga
Y
Ce

Figure 12

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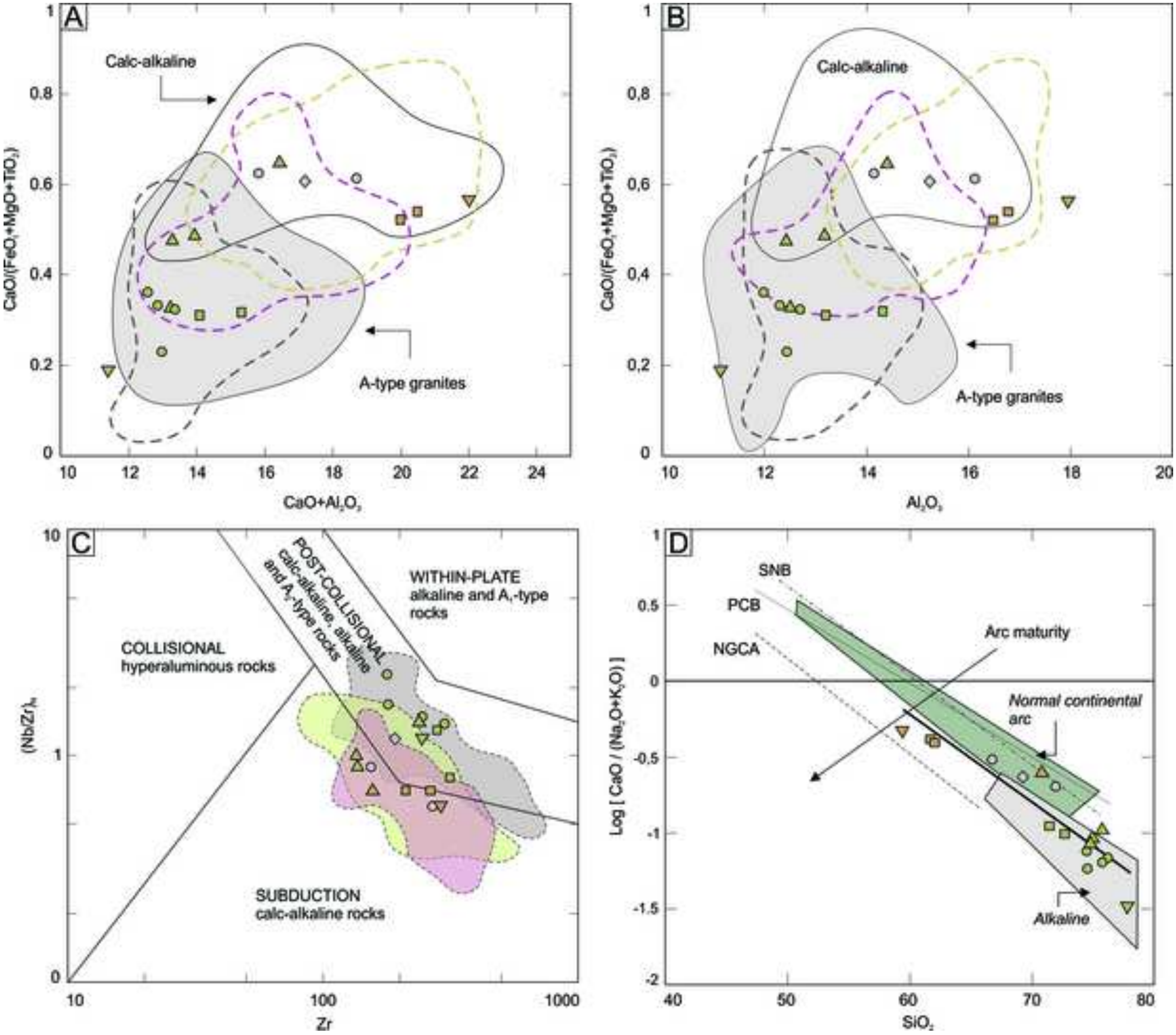

Figure 13

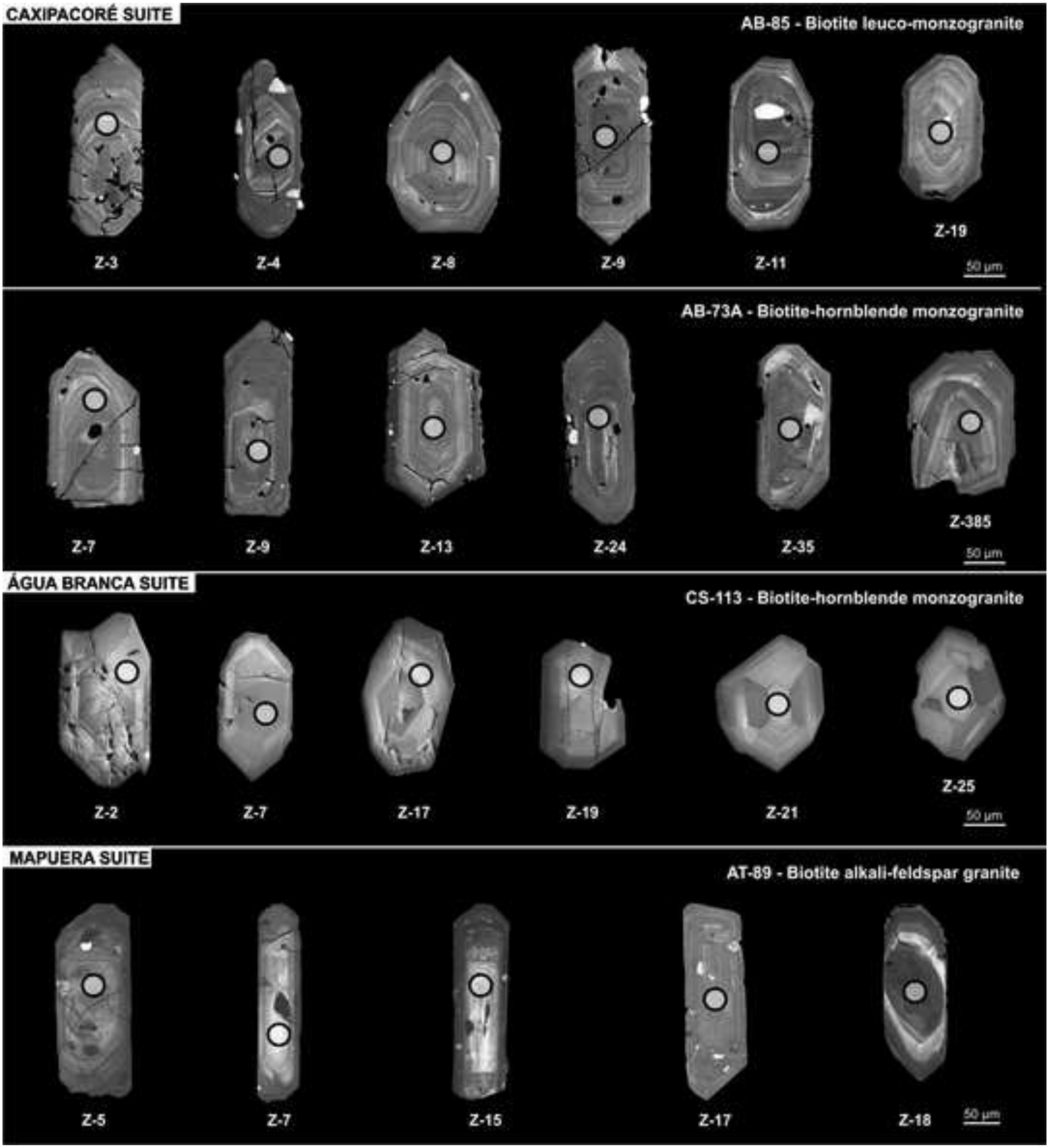
CAXIPACORÉ SUITE
AB-85 - Biotite leuco-monzogranite
Z-3
Z-4
Z-8
Z-9
Z-11
Z-19
50 µm
AB-73A - Biotite-hornblende monzogranite
Z-7
Z-9
Z-13
Z-24
Z-35
Z-385
50 µm
ÁGUA BRANCA SUITE
CS-113 - Biotite-hornblende monzogranite
Z-2
Z-7
Z-17
Z-19
Z-21
Z-25
50 µm
MAPUERA SUITE
AT-89 - Biotite alkali-feldspar granite
Z-5
Z-7
Z-15
Z-17
Z-18
50 µm

Figure 14

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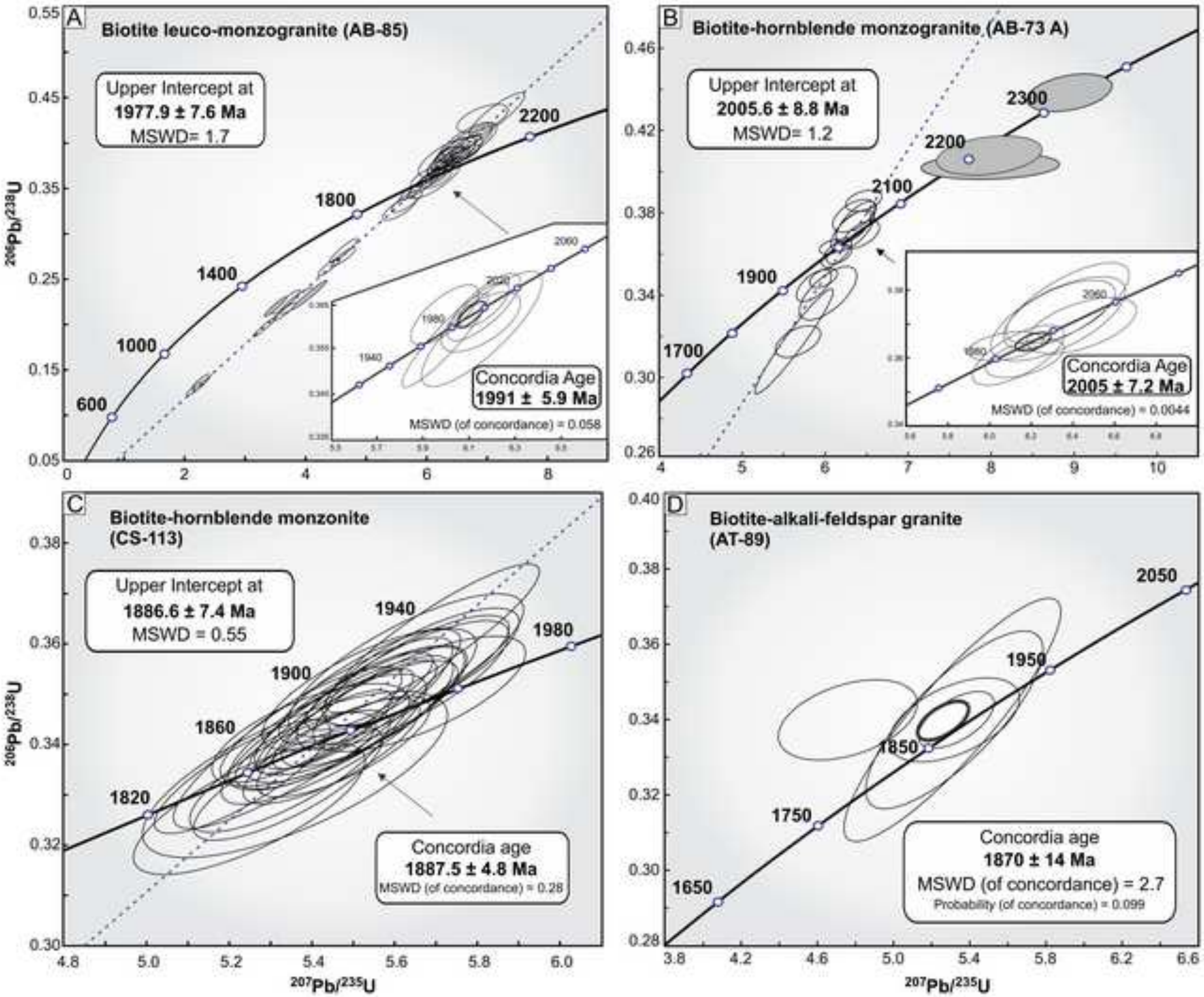


Figure 15

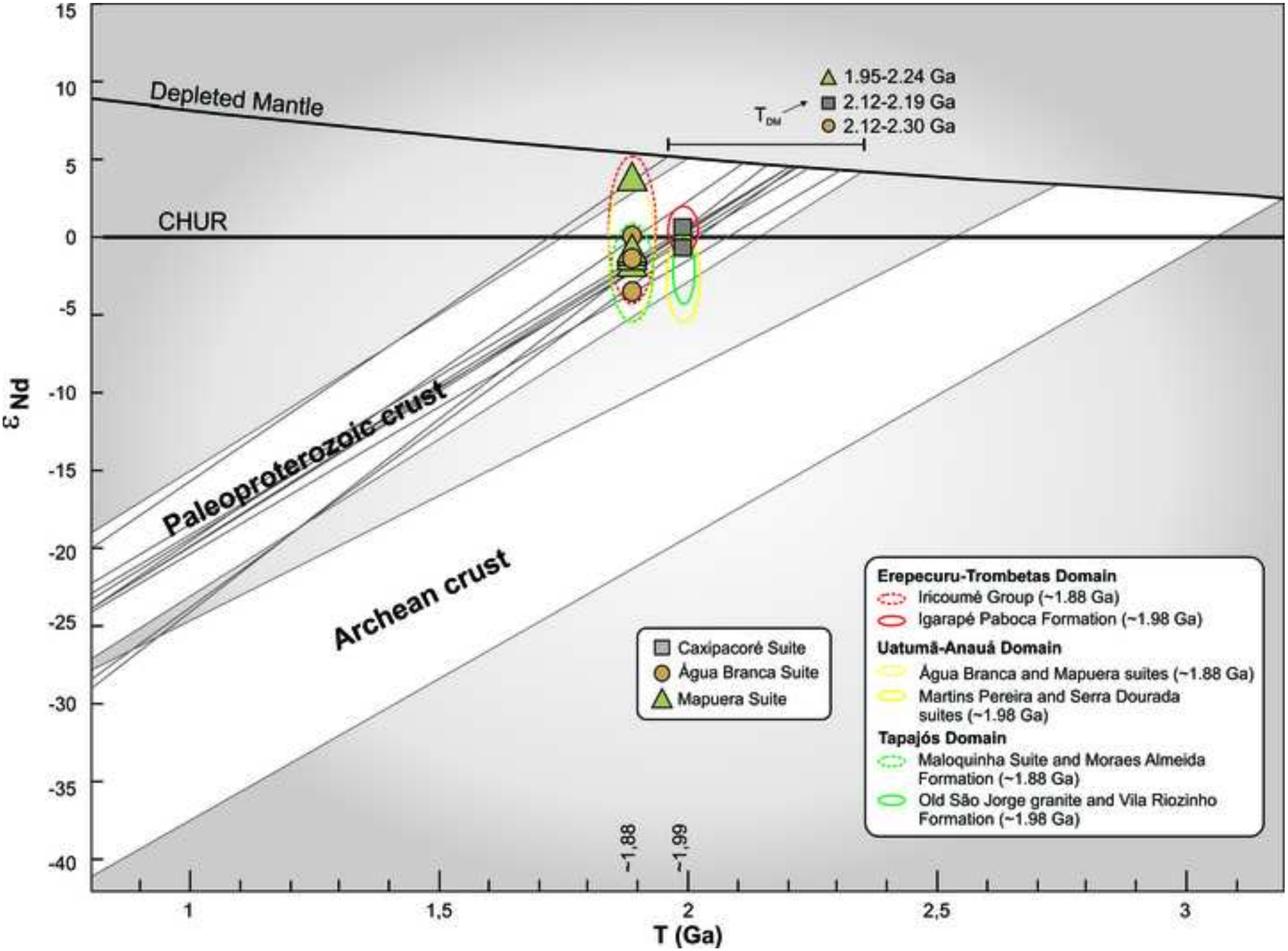
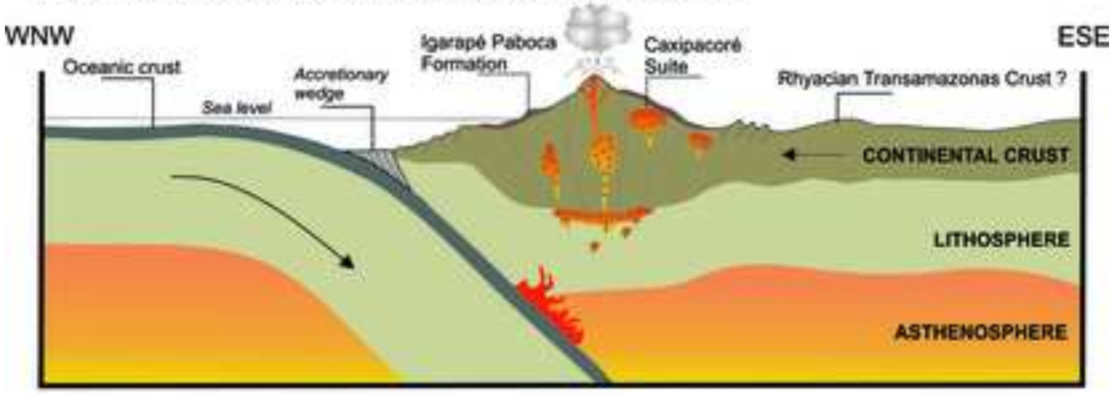

ε Nd
T (Ga)
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
1
1,5
2
2,5
3
~1,88
~1,99
Depleted Mantle
CHUR
Paleoproterozoic crust
Archean crust
T_DM
1.95-2.24 Ga
2.12-2.19 Ga
2.12-2.30 Ga
Caxipacoré Suite
Água Branca Suite
Mapuera Suite
Erepecuru-Trombetas Domain
Iricoumé Group (~1.88 Ga)
Igarapé Paboca Formation (~1.98 Ga)
Uatumã-Anauá Domain
Água Branca and Mapuera suites (~1.88 Ga)
Martins Pereira and Serra Dourada suites (~1.98 Ga)
Tapajós Domain
Maloquinha Suite and Moraes Almeida Formation (~1.88 Ga)
Old São Jorge granite and Vila Riozinho Formation (~1.98 Ga)

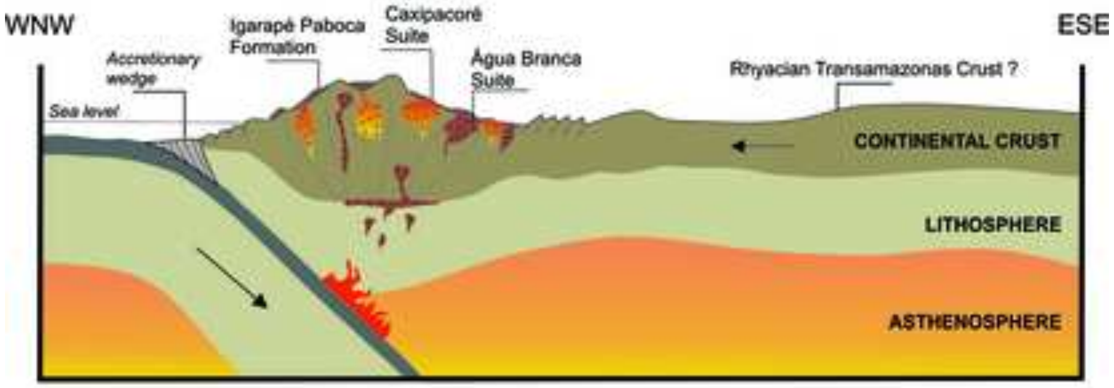
Figure 16

1 **Older Orosirian magmatic arc episode (≈2.0-1.95 Ga)**

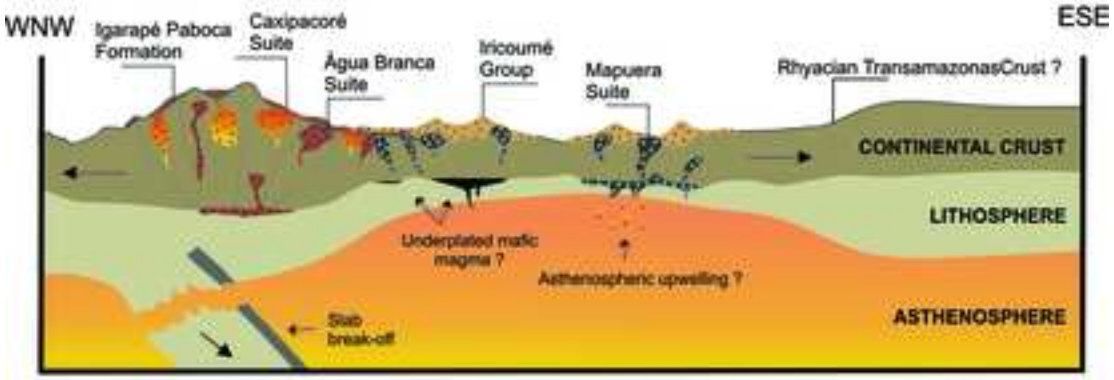


2 **Younger Orosirian magmatic episode (≈1.90-1.87 Ga)**

2a *First Stage: ≈1.90-1.88 Ga Later arc magmatic stage*



2a *Second Stage: ≈1.88-1.87 Ga Post-orogenic intracontinental stage*



2b *≈1.90-1.87 Ga Major intracontinental stage*

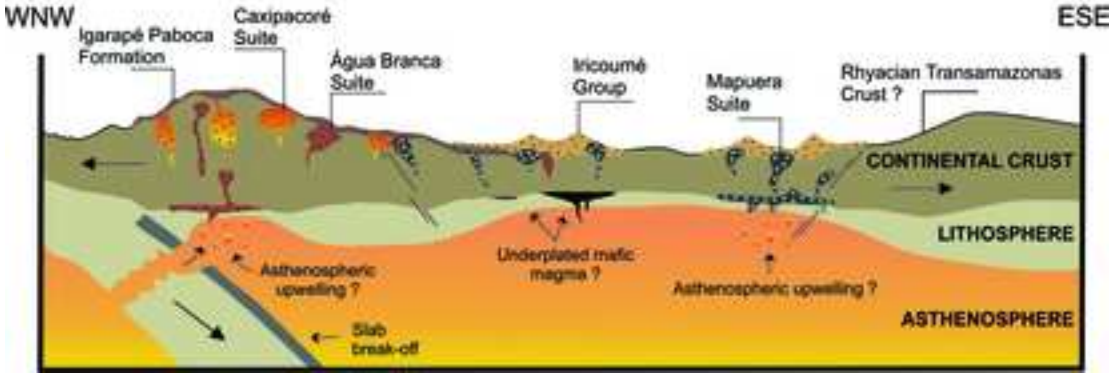


Table 1

Unit	Location	Rock type	Age (Ma)	Method	Ref.
Erepecuru-Trombetas Domain (Central Amazon Province)					
Água Branca Suite	NW of Pará	-	1910 ± 23	Rb-Sr - wr	1
Mapuera Suite	NW of Pará	-	1773 ± 53	Rb-Sr - wr	2
	Erepecuru-River (PA)	Granite	1889 ± 2	U-Pb – LA zr	3
	…	…	1861± 20	Pb-Pb – zr	3
Caxipacoré Suite	Caxipacoré River (PA)	Syenogranite	1977 ± 4	Pb-Pb - zr	4
	…	Monzogranite	1982 ± 9	Pb-Pb - zr	4
	Erepecuru-River (PA)	Granite	1985 ± 5	U-Pb – LA zr	3
	…	…	1985 ± 4.4	U-Pb – LA zr	3
Uatumã-Anauá Domain (Tapajós-Parima Province)					
Água Branca Suite	Içana River (AM)	Monzogranite	1889 ± 3	Pb-Pb - zr	5
	Presidente Figueiredo (AM)	Biotite monzogranite	1890 ± 2	Pb-Pb - zr	6
		Biotite monzogranite	1895 ± 3	Pb-Pb - zr	6
		monzogranite	1898 ± 3	Pb-Pb - zr	6
	Southeastern of Roraima	Granodiorite?	1891 ± 7	U-Pb – S zr	7
		Quartz monzodiorite	1891 ± 6	U-Pb – S zr	8
		Enderbite	1890 ± 2	Pb-Pb - zr	8
		granodiorite	1901 ± 5	Pb-Pb - zr	8
		quartz monzodiorite	1895 ± 3	Pb-Pb - zr	8
		quartz monzodiorite	1891 ± 2	Pb-Pb - zr	8
Mapuera Suite	Jaburu River (RR)	Monzogranite	1871 ± 5	Pb-Pb - zr	8
		Charnockite	1873 ± 6	U-Pb – S zr	9
	Pitinga (AM)	Granite	1861 ± 20	U-Pb – S zr	10
	Pitinga (AM)	...	1864 ± 13	U-Pb – S zr	10
Mapuera Suite		...	1865 ± 15	U-Pb – S zr	10
		...	1872 ± 24	U-Pb – S zr	11
		...	1864	U-Pb – S zr	12
		...	1877	U-Pb – S zr	12
		Biotite granite	1882 ± 4	Pb-Pb - zr	13
		Alkali feldspar granite	1885 ± 4	Pb-Pb - zr	13
		Biotite syenogranite	1875 ± 4	Pb-Pb - zr	13
		Granophyric syenog.	1882 ± 2	Pb-Pb - zr	13
		Syenogranite	1882 ± 3	Pb-Pb - zr	13
		Biotite monzogranite	1885 ± 3	Pb-Pb - zr	13
		Biotite monzogranite	1888 ± 3	Pb-Pb - zr	13
		Biotite syenogranite	1875 ± 4	Pb-Pb - zr	14
		Granite	1879 ± 2	U-Pb – S zr	15
		...	1880 ± 3	U-Pb – S zr	15
		...	1865 ± 15	U-Pb – S zr	7
	Alalaú River (AM)	...	1869 ± 10	U-Pb – S zr	7
		...	1876 ± 4	U-Pb – S zr	7
		...	1871 ± 5	U-Pb – S zr	7
	Aborani Sierra (AM)	Hastingsite granite	1871 ± 5	U-Pb – S zr	15
	Presidente Figueiredo (AM)	Syenogranite	1889 ± 2	Pb-Pb - zr	6

		Syeno/monzogranite	1866 ± 4	U-Pb – LA zr	16
Serra Dourada Suite	Southeastern of Roraima	Monzogranite	1962 ± 6 1948 ± 11	U-Pb – ID zr Pb-Pb - zr	17
Martins Pereira Suite	Southeastern of Roraima	Biotite monzogranite	1975 ± 6	Pb-Pb - zr	17
		Biotite granodiorite	1973 ± 2	Pb-Pb - zr	17
		Biotite meta-monzo-Granite	1971 ± 2	Pb-Pb - zr	17
		Granodiorite	1972 ± 7	U-Pb – S zr	18
Pedra Pintada Suite	Orocaima Sierra	Granodiorite	1956 ± 5	U-Pb – S zr	7
	(Northern of RR)	Granodiorite	1958 ± 11	U-Pb – S zr	19
	Central northern of RR	Monzogranite	2009 ± 2	Pb-Pb zr	20
		Quartz-diorite	1985 ± 1	Pb-Pb zr	20
		Granodiorite	1991 ± 18	U-Pb – LA zr	20
		Monzogranite	2005 ± 45 1960 ± 21	Pb-Pb zr	21

Abbreviations: AM – Amazonas State; PA – Pará State; RR – Roraima State; wr – whole-rock; zr – zircon; Pb-Pb – lead evaporation thermos-ionization mass spectrometry; LA – ICP mass spectrometry with Laser Ablation; S – SHRIMP ion microprobe; ID – Isotope Dilution and thermo-ionization mass spectrometry. **References:** 1 **-** Jorge João *et al.*(1985); 2 - Oliveira *et al.* (1975); 3 – Castro *et al.* (2014); 4 – Leal *et al.* (2015); 5 – Reis *et al.* (2006); 6 – Valério *et al.* (2009); 7 – Santos (2003); 8 – Almeida (2006); 9 - Santos *et al.* (2001); 10 – Lenharo (1998); 11 – Santos *in* Reis *et al.* (2003); 12 – Santos *in* Reis *et al.* (2006); 13 – Ferron *et al.* (2006); 14 – Ferron *et al.* (2010); 15 – Santos *et al.* (2002), 16 – Lombello (2011), 17 – Almeida *et al.* (2007), 18 – Faria *et al.* (2002), 19 – Santos (1999); 20 – Fraga *et al.* (2010); 21 - Almeida *et al.* (1997).

Table 2

Unit	**Caxipacoré**		**Água Branca**				**Mapuera**				
Facies	BHMz (2)	BLMz (1)	BLMz (3)	HMz (1)	BHQzM (2)	BHM (1)	BALg (3)	BAg (5)	BLSy (9)	BSy (2)	HBSy (2)
Primary minerals (%)											
Quartz	19.1	22.4	22.5	19.6	8.0	3.1	36.1	29.1	25.6	25.2	25.7
K-feldspar	31.9	33.1	36	40.3	32.1	32.9	57.6	59.0	55.5	56.6	44.5
Plagioclase	33.3	40.1	39.3	30.4	41.6	46.8	3.5	4.9	15.7	12.5	17.9
Hornblende	7.7	Tr	-	-	8.5	8.1	-	-	-	-	6.1
Biotite	6.2	3.4	1.6	6.8	6.6	6.3	2.2	6.2	2.3	5.2	4.8
Titanite	0.2	-	-	0.6	0.4	0.2	0.1	-	0.1	-	0.1
Opaque	1.1	0.4	0.5	1.5	2	2.1	0.3	0.5	0.5	0.5	0.6
Others^{Z+A}	0.5	0.6	0.2	0.4	0.4	0.5	0.2	0.3	0.2	0.3	0,4
Secondary minerals											
Chlorite	0.2	Tr	Tr	0.4	0.6	Tr	Tr	Tr	Tr	Tr	0.2
Epidote	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Sericite	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Clay-minerals	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Felsic	84.2	95.6	97.8	90.3	81.7	82.8	97.2	93.0	96.8	94.2	88.1
Mafic	15.9	4.4	2.2	9.7	18.5	17.2	2.8	7	3.2	5.9	12.1
100% Calculation											
Quartz	22.6	23.4	23.0	21.7	9.8	3.7	37.1	31.3	26.5	26.7	29.2
K-feldspar	37.9	34.6	36.8	44.6	39.3	39.7	59.2	63.4	57.3	60.1	50.5
Plagioclase	39.5	41.9	40.2	33.7	50.9	56.5	3.6	5.3	16.2	13.2	20.3

Abbreviations: Tr – trace (<1 vol.%); ( ) number of averaged samples; B – biotite, H – hornblende, L – leuco, Mz – monzogranite, QzM – quartz monzonite, M – monzonite, Sy – syenogranite, Ag – Alkali feldspar granite, ALg – Alkali feldspar leuco-granite. Z – zircon, A – apatite.

Table 3

Unit	CAXIPACORÉ SUITE			ÁGUA BRANCA SUITE				MAPUERA SUITE									
Facies	**BHMz**		**BLMz**	**HMz**	**BHQzM**		**BHM**	**BALg**	**Bag**				**BLSy**			**HBSy**	
Sample	**AB-65**	**AB-73A**	**AB-85**	**CS-121**	**CS-97**	**CS-109**	**CS-113**	**AT-153**	**AT-89**	**AT-90**	**AT-99**	**AT-172**	**AB-98A**	**AT-173**	**AT-177**	**AT-16A**	**AT-92**
SiO_2 (%)	66.73	71.95	69.25	70.81	62.3	61.79	59.43	78.03	76.2	75.73	74.49	74.53	75.02	75.68	74.77	71.29	72.63
TiO_2	0.44	0.27	0.32	0.35	0.64	0.69	0.76	0.12	0.11	0.13	0.18	0.22	0.16	0.16	0.25	0.33	0.28
Al_2O_3	16.12	14.12	15.21	14.4	16.47	16.78	17.93	11.14	11.98	12.28	12.69	12.43	13.17	12.42	12.51	14.32	13.2
Fe_2O_3	3.28	2.14	2.51	2.51	4.56	4.7	5.05	1.33	1.54	1.59	1.89	2.15	1.37	1.62	1.9	2.76	2.61
MnO	0.07	0.04	0.07	0.04	0.09	0.08	0.1	0.02	0.03	0.04	0.04	0.06	0.03	0.04	0.05	0.08	0.08
MgO	0.78	0.48	0.64	0.54	2,00	1.93	1.93	0.06	0.07	0.09	0.15	0.1	0.19	0.19	0.25	0.31	0.24
CaO	2.56	1.67	1.96	2.04	3.52	3.7	4.08	0.26	0.57	0.55	0.66	0.52	0.77	0.86	0.72	0.99	0.89
Na_2O	4.12	3.75	4.15	3.56	4.31	4.43	4.63	3.2	3.48	3.47	3.57	3.72	3.46	3.6	3.26	3.99	3.73
K_2O	4.32	4.51	4.23	4.56	4.6	4.5	4.05	4.8	4.83	5.11	5.14	5.18	5.02	4.49	5.33	5.32	5.24
P_2O_5	0.11	0.06	0.09	0.09	0.24	0.27	0.33	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.05	0.06
LOI	1.3	0.8	1.3	0.9	0.9	0.7	1.3	0.9	1.0	0.8	1,0	0.8	0.6	0.8	0.8	0.3	0.9
K_2O/Na_2O	1.05	1.20	1.02	1.28	1.07	1.02	0.87	1.5	1.39	1.47	1.44	1.39	1.45	1.25	1.63	1.33	1.40
$FeO_t/(FeO_t+MgO)$	0.79	0.80	0.78	0.81	0.67	0.69	0.70	0.95	0.95	0.94	0.92	0.95	0.87	0.88	0.87	0.89	0.91
Mo (ppm)	1.6	0.5	0.8	0.6	1,0	0.8	0.4	1.2	1.3	2,0	1.3	2.3	1.6	1,0	2.7	1.8	2.6
Cu	7.6	2.3	4.3	6.8	42,0	39.6	42.4	3.9	4.4	4.7	2.3	1.9	5.2	4.1	7.5	6.2	3.6
Zn	55	39	52	45	53	40	49	36	56	67	63	95	33	35	69	63	114
Ni	2.1	2.9	3.2	3.1	14,0	11.4	12.9	1.7	1.9	2.2	2.2	1.3	4.8	2.8	5.1	3.8	3.8
Sc	8	4	6	5	10	10	10	2	1	2	3	4	2	2	3	7	4
Ba	1683	860	990	1203	1589	1690	1968	93	182	275	396	314	619	476	269	1258	552
Be	2	<1	3	1	1	1	<1	4	9	4	3	5	<1	2	7	1	5
Co	6.6	4.5	3.6	5.8	13.7	10.7	11.3	1.6	3.3	2.6	3,0	6.5	6.5	3.1	5.8	4.6	4.5
Cs	1.3	3.1	2.3	1.7	2.1	1.6	1.2	1.8	3.3	2.9	3.5	7.7	2.9	2.8	6.9	2.4	4.4
Ga	17.9	16	17.4	16.6	21.8	21	19.3	15.8	19.3	17.8	16.6	18.7	13.7	13.2	20.5	17.5	18.2
Hf	7.1	4.9	5.9	4.3	6.4	6.8	4.9	8.5	6.9	6.4	8,0	9.2	4.4	4.1	7.9	8.3	8.3
Nb	10.5	8.3	14.3	7.4	10.9	10.4	9.3	18.7	26.1	18.9	23.6	25.5	7.8	8.4	20.8	16.1	23.3
Rb	124,0	156.3	160.2	146.9	118.4	106.7	86.7	252.8	317.6	284.8	287.1	269.3	164.7	147.7	290.2	176.4	265.1
Sr	384.4	254.7	316.1	273.6	571.8	600.6	754.4	10.8	25.4	39.9	58.4	32.1	94.8	82.9	52.9	126.4	73.8
Ta	1.8	1.2	1.8	0.9	0.9	0.8	1,0	2.5	2.9	1.7	2.1	4.6	1.7	1.3	2.4	1.5	1.9

Unit	**CAXIPACORÉ SUITE**			**ÁGUA BRANCA SUITE**				**MAPUERA SUITE**									
Facies	**BHMz**		**BLMz**	**HMz**	**BHQzM**		**BHM**	**BALg**	**Bag**				**BLSy**			**HBSy**	
Sample	**AB-65**	**AB-73A**	**AB-85**	**CS-121**	**CS-97**	**CS-109**	**CS-113**	**AT-153**	**AT-89**	**AT-90**	**AT-99**	**AT-172**	**AB-98A**	**AT-173**	**AT-177**	**AT-16A**	**AT-92**
Th	14.6	13.3	15.1	15.4	10.2	9.3	6.4	23.6	32.0	29.2	34.6	22.2	22.6	13.9	36.5	17.6	32.1
U	3.8	3.1	5.4	4.1	2.3	2.4	1.6	7.3	9.9	8.3	9.3	9.8	5.3	3.1	9.7	4.1	7.9
V	36	20	22	28	98	99	109	<8	13	25	<8	<8	8	<8	14	8	10
W	27.3	12.6	4.7	14.1	13.5	8,0	4.4	9.4	23.2	12.9	15.3	52.9	36.9	16.6	33.1	26.5	24.7
Zr	267.3	152.6	189.7	156.2	263.1	289.7	210.5	244.1	177.7	178.4	244.2	296.4	136.5	134.9	237.5	313.2	280.0
Y	27.8	17.7	47.8	19.7	24.2	21.7	21.2	100.6	196.0	127.6	85.2	242.4	29.9	24.8	58.9	42.0	97.8
La	63.5	45.7	79.1	36.4	56.3	51.9	50.0	186.3	116.5	153.7	125.6	171.7	88.1	48.3	72.1	69.2	122.9
Ce	115.0	82.6	147.3	67.9	111.3	100.0	93.9	307.8	217.3	294.5	231.3	356.1	147.4	89.5	144.7	131.5	229.5
Pr	12.24	8.55	15.55	7.28	12.04	11.65	11.08	36.88	24.63	33.12	24.5	44.51	14.64	9.57	15.07	13.73	25.63
Nd	44.2	29.2	56.3	26.8	42.9	42.0	41.9	126.3	93.8	115.4	81.7	173.1	47.6	31.0	49.2	48.4	93.2
Sm	6.72	4.12	9.44	4.26	6.68	6.82	7.18	21.99	21.33	23.67	14.63	39.59	6.29	4.97	8.02	8.18	17.33
Eu	1.31	0.67	1.29	1.01	1.52	1.65	1.75	0.46	0.71	0.82	0.59	1.35	0.5	0.47	0.42	1.06	1.00
Gd	5.58	3.37	8.12	3.77	5.14	5.06	5.27	17.24	28.96	23.35	12.35	44.35	4.59	3.76	6.59	7.27	16.83
Tb	0.79	0.51	1.27	0.56	0.72	0.72	0.7	2.75	5.33	4.12	2.11	7.63	0.6	0.59	1.16	1.12	2.8
Dy	4.55	3.06	7.64	3.43	4.01	4.09	3.78	15.63	33.87	24.14	12.73	42.48	3.35	3.62	6.97	6.73	17.78
Ho	0.99	0.64	1.65	0.69	0.75	0.79	0.71	3.00	7.32	4.91	2.65	7.93	0.69	0.82	1.73	1.35	3.71
Er	2.74	1.86	5.05	1.98	2.23	2.39	2.16	8.52	20.37	13.71	7.51	21.05	2.17	2.66	5.64	4.07	10.88
Tm	0.45	0.32	0.81	0.31	0.37	0.34	0.31	1.24	2.94	1.92	1.24	3.12	0.35	0.42	0.84	0.65	1.66
Yb	3.01	2.08	5.45	1.92	2.29	2.2	2.00	7.99	17.89	12.38	7.88	19.16	2.5	2.74	5.58	4.26	10.7
Lu	0.48	0.35	0.84	0.33	0.36	0.35	0.3	1.15	2.53	1.69	1.19	2.75	0.44	0.46	0.86	0.68	1.63
ΣREE	261.56	183.03	339.81	156.64	246.61	229.96	221.04	737.25	593.48	707.43	525.98	934.82	319.22	198.88	318.88	298.2	555.55
$(La/Sm)_N$	5.94	6.98	5.27	5.37	5.30	4.79	4.32	5.33	3.44	4.08	5.40	2.73	8.81	6.11	5.65	5.32	4.46
$(Gd/Yb)_N$	1.50	1.31	1.20	1.58	1.81	1.86	2.13	1.74	1.31	1.52	1.26	1.87	1.48	1.11	0.95	1.38	1.27
$(La/Yb)_N$	14.23	14.82	9.78	12.78	16.57	15.90	16.85	15.72	4.39	8.37	10.75	6.04	23.76	11.8	8.71	10.95	7.74
$(Eu/Eu^*)_N$	0.65	0.55	0.45	0.77	0.79	0.86	0.87	0.07	0.09	0.11	0.13	0.10	0.28	0.33	0.18	0.42	0.18
$(Nb/Zr)_N$	0.62	0.85	1.18	0.74	0.65	0.56	0.69	1.20	2.31	1.66	1.52	1.35	0.90	0.98	1.38	0.81	1.31

Abbreviations: B – biotite, H – hornblende, L – leuco, Mz – monzogranite, QzM – quartz monzonite, M – monzonite, Sy – syenogranite, Ag – Alkali feldspar granite, ALg – Alkali feldspar leuco-granite. $FeO_t = Fe_2O_3 * 0.8995$.

Table 4

Spot Number	f_{206}[a]	Th/U[b]	Isotope ratios[c]							Ages (Ma)						
			^{207}Pb/^{235}U	1 σ [%]	^{206}Pb/^{238}U	1 σ [%]	Rho[d]	^{207}Pb/^{206}Pb[e]	1 σ [%]	^{206}Pb/^{238}U	1 σ abs	^{207}Pb/^{235}U	1 σ abs	^{207}Pb/^{206}Pb	1 σ abs	% Conc[f]
CAXIPACORÉ SUITE - SAMPLE AB-85																
AB-85-01 (I)	**0.01082**	**0.30**	**4.08**	**2.87**	**0.23**	**2.80**	**0.97**	**0.13**	**0.64**	**1349.6**	**34.1**	**1649.7**	**23.4**	**2005.8**	**11.8**	**148.6**
AB-85-01 (II)	0.3332	0.31	6.35	1.16	0.39	0.93	0.79	0.12	0.70	2112.9	16.7	2024.9	10.1	1885.1	12.6	89.2
AB-85-03	0.0077	0.36	6.23	1.10	0.37	0.87	0.77	0.12	0.67	2033.0	15.2	2008.3	9.6	1932.1	12.3	95.0
AB-85-04	0.0257	0.34	5.69	1.83	0.34	1.48	0.80	0.12	1.08	1865.9	24.0	1929.7	15.8	1948.1	19.9	104.4
AB-85-05	0.0058	0.37	6.24	1.41	0.38	1.20	0.84	0.12	0.74	2055.6	21.1	2009.8	12.3	1912.0	13.6	93.0
AB-85-06 (I)	0.0073	0.45	6.48	1.14	0.39	0.86	0.73	0.12	0.75	2117.0	15.5	2043.3	10.0	1918.7	13.8	90.6
AB-85-06 (II)	0.0185	0.35	6.35	1.26	0.38	1.01	0.78	0.12	0.76	2054.3	17.7	2025.1	11.1	1944.6	14.0	94.7
AB-85-07	0.0113	0.38	5.57	2.05	0.33	1.58	0.77	0.12	1.30	1828.6	25.2	1911.2	17.6	1951.3	23.8	106.7
AB-85-08	**0.0111**	**0.29**	**3.51**	**2.15**	**0.22**	**2.05**	**0.95**	**0.12**	**0.65**	**1280.6**	**23.8**	**1530.2**	**17.0**	**1843.2**	**12.2**	**143.9**
AB-85-09	0.0278	0.48	6.40	1.99	0.38	1.51	0.75	0.12	1.30	2099.1	27.1	2032.1	17.5	1913.7	23.9	91.2
AB-85-11	0.0077	0.76	5.75	1.23	0.35	1.01	0.81	0.12	0.69	1914.9	16.8	1938.8	10.6	1913.3	12.7	99.9
AB-85-12 (I)	0.0310	0.60	6.89	1.18	0.41	0.91	0.75	0.12	0.75	2214.8	17.0	2097.6	10.4	1933.4	13.8	87.3
AB-85-12 (II)	0.0063	0.40	6.33	1.05	0.38	0.85	0.79	0.12	0.61	2076.4	15.1	2022.8	9.2	1917.5	11.3	92.3
AB-85-13 (I)	0.0131	0.38	6.28	1.67	0.38	1.32	0.78	0.12	1.01	2069.9	23.4	2015.5	14.6	1909.0	18.7	92.2
AB-85-13 (II)	0.0136	0.36	5.99	1.62	0.36	1.19	0.72	0.12	1.10	1992.9	20.4	1975.0	14.1	1905.2	20.4	95.6
AB-85-14	0.0078	0.34	6.64	1.27	0.40	0.99	0.77	0.12	0.79	2159.1	18.2	2065.0	11.2	1921.2	14.6	89.0
AB-85-16	0.0213	0.46	6.54	2.52	0.39	1.81	0.71	0.12	1.75	2127.1	32.8	2051.9	22.2	1926.2	32.2	90.6
AB-85-17 (I)	0.0221	0.38	6.66	2.81	0.40	2.21	0.79	0.12	1.73	2174.4	40.8	2067.8	24.8	1912.0	31.9	87.9
AB-85-17 (II)	0.0132	0.35	6.72	2.81	0.40	2.26	0.80	0.12	1.67	2170.4	41.6	2075.4	24.8	1931.5	30.7	89.0
AB-85-19	0.0254	0.43	6.16	2.81	0.36	2.31	0.82	0.12	1.59	1978.2	39.4	1998.1	24.5	1968.1	29.3	99.5
AB-85-20	0.0360	0.38	6.35	3.05	0.38	2.30	0.75	0.12	1.99	2099.0	41.3	2025.7	26.7	1900.6	36.9	90.6
AB-85-21	0.0239	0.52	6.15	1.85	0.36	1.19	0.63	0.12	1.41	1985.4	20.4	1997.5	16.1	1959.3	25.9	98.7
AB-85-22	0.0089	0.50	6.00	2.06	0.36	1.90	0.92	0.12	0.80	1966.4	32.1	1975.3	17.9	1933.7	14.7	98.3
AB-85-24 (I)	0.0175	0.54	6.16	1.69	0.36	1.33	0.78	0.12	1.05	2000.6	22.9	1999.4	14.8	1947.2	19.3	97.3
AB-85-24 (II)	0.0010	0.77	6.74	1.08	0.40	0.89	0.81	0.12	0.61	2177.5	16.5	2078.3	9.5	1930.4	11.2	88.7
AB-85-25 (I)	0.6639	0.71	6.67	1.40	0.39	1.00	0.72	0.12	0.97	2117.9	18.1	2068.0	12.3	1967.9	17.2	92.9
AB-85-25 (II)	0.3185	0.38	6.50	1.06	0.39	0.86	0.79	0.12	0.63	2115.0	15.5	2045.4	9.3	1924.9	11.2	91.0
AB-85-27	0.0119	0.48	6.16	1.18	0.36	0.88	0.72	0.12	0.80	2002.8	15.1	1999.3	10.3	1944.8	14.7	97.1

(continued)

Spot Number	f_{206}[a]	Th/U[b]	Isotope ratios[c]							Ages (Ma)						
			^{207}Pb/^{235}U	1 σ [%]	^{206}Pb/^{238}U	1 σ [%]	Rho[d]	^{207}Pb/^{206}Pb[e]	1 σ [%]	^{206}Pb/^{238}U	1 σ abs	^{207}Pb/^{235}U	1 σ abs	^{207}Pb/^{206}Pb	1 σ abs	% Conc[f]
AB-85-28 (I)	0.3455	0.65	4.64	2.07	0.28	1.93	0.93	0.12	0.77	1599.5	27.2	1757.3	17.2	1899.4	13.8	118.7
AB-85-28 (II)	0.0062	0.30	6.54	1.27	0.38	0.99	0.76	0.12	0.81	2094.7	17.6	2051.8	11.2	1958.2	14.8	93.5
CAXIPACORÉ SUITE - SAMPLE AB-73 A																
AB-73A-1	0.0000	0.70	5.67	3.92	0.32	1.98	0.50	0.13	3.39	1777.7	35.1	1927.2	75.6	2091.9	70.8	117.7
AB-73A-3	0.0002	1.26	5.98	2.29	0.35	1.10	0.48	0.12	2.01	1927.2	21.1	1972.8	45.2	2021.0	40.7	104.9
AB-73A-5	**0.0000**	**0.72**	**7.99**	**8.52**	**0.40**	**1.29**	**0.15**	**0.14**	**8.42**	**2182.5**	**28.0**	**2230.1**	**190.1**	**2274.1**	**191.6**	**104.2**
AB-73A-7	0.0000	0.75	5.86	2.95	0.34	1.81	0.61	0.12	2.33	1909.6	34.7	1955.8	57.8	2005.1	46.7	105.0
AB-73A-8	0.0000	0.71	6.34	2.73	0.37	1.66	0.61	0.12	2.17	2046.1	34.0	2024.0	55.3	2001.6	43.5	97.8
AB-73A-9	0.0002	0.79	6.33	3.38	0.37	2.21	0.65	0.12	2.56	2036.9	45.0	2022.4	68.4	2007.6	51.4	98.6
AB-73A-10	0.0000	0.74	6.44	2.70	0.37	1.48	0.55	0.13	2.26	2027.5	30.0	2038.0	55.1	2048.6	46.3	101.0
AB-73A-13	0.0003	0.68	6.35	3.27	0.38	1.71	0.52	0.12	2.78	2070.2	35.5	2024.7	66.2	1978.7	55.1	95.6
AB-73A-20	0.0000	0.58	6.03	4.68	0.34	3.10	0.66	0.13	3.50	1891.8	58.7	1980.7	92.6	2074.9	72.6	109.7
AB-73A-21	0.0000	0.88	5.63	6.86	0.32	6.57	0.96	0.13	1.98	1778.3	116.8	1920.0	131.6	2076.7	41.1	116.8
AB-73A-23	0.0009	0.70	6.46	2.73	0.39	1.09	0.40	0.12	2.50	2104.1	23.0	2041.0	55.8	1977.9	49.5	94.0
AB-73A-24	0.0006	0.61	6.37	3.13	0.38	2.23	0.71	0.12	2.19	2055.0	45.8	2027.9	63.4	2000.6	43.9	97.4
AB-73A-26	0.0000	0.71	5.87	3.74	0.32	1.36	0.36	0.13	3.49	1795.1	24.5	1956.8	73.2	2132.5	74.3	118.8
AB-73A-28	**0.0004**	**0.33**	**8.91**	**4.71**	**0.44**	**1.77**	**0.37**	**0.15**	**4.37**	**2337.7**	**41.3**	**2329.2**	**109.8**	**2321.8**	**101.5**	**99.3**
AB-73A-31	0.0007	0.74	6.14	2.37	0.36	1.62	0.68	0.12	1.73	1986.2	32.2	1995.7	47.4	2005.4	34.7	101.0
AB-73A-33	**0.0000**	**1.24**	**7.97**	**6.50**	**0.41**	**1.90**	**0.29**	**0.14**	**6.22**	**2204.2**	**42.0**	**2227.7**	**144.9**	**2249.3**	**139.9**	**102.0**
AB-73A-35	0.0004	0.60	6.17	2.02	0.36	1.04	0.52	0.12	1.73	1981.9	20.6	2000.1	40.4	2018.8	35.0	101.9
AB-73A-37	0.0010	0.50	6.08	1.97	0.36	0.77	0.39	0.12	1.81	1998.9	15.4	1986.8	39.1	1974.3	35.7	98.8
ÁGUA BRANCA SUITE – SAMPLE CS-113																
CS-113-2	0.0152	0.56	5.69	1.85	0.36	1.67	0.90	0.11	0.80	1987.5	28.6	1930.3	16.0	1817.9	15.0	91.5
CS-113-3 (I)	0.0196	0.55	5.40	1.66	0.34	1.36	0.81	0.11	0.96	1905.8	22.5	1884.7	14.3	1809.8	17.9	95.0
CS-113-3 (II)	0.0113	0.65	5.23	1.66	0.33	1.38	0.83	0.11	0.92	1856.2	22.3	1857.8	14.2	1808.0	17.2	97.4
CS-113-4 (I)	0.0106	0.76	5.46	1.42	0.34	1.23	0.86	0.11	0.71	1909.0	20.4	1893.9	12.2	1825.7	13.3	95.6
CS-113-4 (II)	0.0098	0.53	5.51	1.47	0.35	1.27	0.86	0.12	0.74	1915.6	21.1	1901.4	12.7	1834.4	13.8	95.8
CS-113-5 (I)	0.0269	0.73	5.25	2.18	0.33	1.63	0.74	0.12	1.46	1825.1	25.9	1860.7	18.6	1849.2	27.1	101.3
CS-113-5 (II)	0.0167	0.58	5.45	1.60	0.34	1.27	0.78	0.12	0.98	1880.6	20.7	1892.5	13.8	1854.2	18.3	98.6

(Continued)

Spot Number	$ƒ_{206}$[a]	Th/U[b]	Isotope ratios[c]							Ages (Ma)						
			^{207}Pb/^{235}U	1 σ [%]	^{206}Pb/^{238}U	1 σ [%]	Rho[d]	^{207}Pb/^{206}Pb[e]	1 σ [%]	^{206}Pb/^{238}U	1 σ abs	^{207}Pb/^{235}U	1 σ abs	^{207}Pb/^{206}Pb	1 σ abs	% Conc[f]
CS-113-6 (I)	0.0188	0.54	5.66	1.72	0.36	1.34	0.77	0.12	1.07	1960.9	22.6	1926.0	14.8	1837.1	20.0	93.7
CS-113-6(II)	0.0088	0.52	5.44	1.15	0.34	0.94	0.80	0.12	0.67	1901.0	15.4	1891.4	9.9	1829.3	12.5	96.2
CS-113-7	0.0152	0.58	5.66	1.60	0.35	1.27	0.78	0.12	0.98	1957.0	21.4	1924.7	13.8	1838.4	18.3	93.9
CS-113-9	0.0194	0.76	5.40	1.81	0.34	1.22	0.66	0.11	1.34	1895.9	20.0	1884.6	15.5	1820.4	25.0	96.0
CS-113-10	0.0168	0.56	5.54	1.91	0.35	1.42	0.73	0.11	1.28	1939.2	23.7	1906.8	16.4	1820.1	24.0	93.9
CS-113-11 (I)	0.0132	0.61	5.39	1.30	0.34	0.92	0.69	0.12	0.91	1881.1	15.0	1882.6	11.1	1832.6	17.0	97.4
CS-113-11 (II)	0.0074	0.49	5.54	1.13	0.35	0.90	0.77	0.11	0.69	1937.7	15.1	1906.8	9.8	1821.7	12.9	94.0
CS-113-15 (I)	0.0112	0.59	5.40	2.56	0.34	2.26	0.88	0.11	1.19	1897.8	37.2	1885.5	21.9	1820.5	22.1	95.9
CS-113-15 (II)	0.0170	0.53	5.66	1.85	0.35	1.34	0.71	0.12	1.28	1935.1	22.3	1925.5	16.0	1863.9	23.9	96.3
CS-113-16 (I)	0.0203	0.67	5.52	1.90	0.35	1.52	0.79	0.12	1.15	1919.5	25.2	1903.6	16.4	1834.8	21.5	95.6
CS-113-16 (II)	0.0227	0.49	5.44	1.80	0.34	1.38	0.76	0.12	1.15	1898.7	22.7	1891.0	15.4	1830.9	21.5	96.4
CS-113-17	0.0184	0.59	5.62	1.87	0.35	1.48	0.79	0.12	1.13	1943.4	24.9	1919.3	16.1	1841.9	21.1	94.8
CS-113-18	0.0184	0.39	5.34	1.75	0.33	1.38	0.78	0.12	1.07	1849.4	22.2	1875.8	15.0	1853.8	19.9	100.2
CS-113-19	0.0150	0.73	5.48	1.56	0.34	1.21	0.76	0.12	1.00	1884.9	19.7	1897.1	13.4	1859.2	18.5	98.6
CS-113-21	0.0282	0.40	5.36	2.81	0.33	2.02	0.71	0.12	1.96	1858.1	32.6	1878.5	24.1	1849.7	36.5	99.6
CS-113-23 (I)	0.0138	0.72	5.46	2.10	0.34	1.75	0.83	0.12	1.16	1900.7	28.8	1894.8	18.0	1836.7	21.6	96.6
CS-113-23 (II)	0.0172	0.51	5.35	1.85	0.33	1.48	0.79	0.12	1.12	1861.3	23.9	1876.5	15.9	1841.9	20.8	99.0
CS-113-24	0.0166	0.51	5.51	1.95	0.35	1.59	0.81	0.12	1.12	1915.2	26.4	1901.9	16.7	1836.0	20.9	95.9
CS-113-25	0.0255	0.53	5.63	2.06	0.36	1.63	0.78	0.11	1.27	1962.3	27.5	1920.6	17.8	1824.3	23.7	93.0
CS-113-26 (I)	0.0136	0.77	5.54	1.57	0.35	1.25	0.78	0.12	0.96	1916.3	20.6	1906.9	13.5	1845.2	17.9	96.3
CS-113-26 (II)	0.0160	0.51	5.54	1.62	0.35	1.32	0.81	0.11	0.94	1942.0	22.2	1907.0	14.0	1817.4	17.6	93.6
MAPUERA SUITE – SAMPLE AT-89																
AT-89-05	0.0000	1.01	4.76	5.06	0.34	2.07	0.41	0.1	4.62	1873.5	38.8	1778.3	90	1668.4	77	89.1
AT-89-07	0.0000	0.35	5.33	2.47	0.34	1.46	0.59	0.11	1.99	1875.6	27.3	1873.1	46.2	1870.3	37.3	99.7
AT-89-15	0.0000	0.42	5.32	5.78	0.34	4.58	0.79	0.11	3.52	1874	85.9	1872.8	108.3	1871.5	66	99.9
AT-89-17	0.0000	0.9	5.32	4.24	0.34	2.17	0.51	0.11	3.64	1873.3	40.7	1872	79.3	1870.4	68	99.8
AT-89-18	0.0000	0.33	5.31	7.08	0.34	6.27	0.89	0.11	3.29	1869.5	117.2	1870	132.4	1870.6	61.6	100.1

[a] Fraction of the non-radiogenic ^{206}Pb in the analyzed zircon spot, where $ƒ_{206}$=[^{206}Pb/^{204}Pb]c/[^{206}Pb/^{204}Pb]s (c=common; s=sample); [b] Th/U ratios and amount of Pb, Th and U (in ppm) are calculated relative to 91500 reference zircon; [c] Corrected for background and within-run Pb/U fractionation and normalized to reference zircon GJ-1 (ID-TIMS values/measured value); ^{207Pb}/^{235}U calculated using (^{207}Pb/^{206}Pb)/(^{238}U/^{206}Pb * 1/137.88); [d] Rho is the error correlation defined as the quotient of the propagated errors of the ^{206}Pb/^{238}U and the ^{207}/^{235}U ratio; [e] Corrected for mass-bias by normalizing to GJ-1 reference zircon and common Pb using the model Pb composition of Stacey and Kramers (1975); [f] Degree of concordance = (100*^{206}Pb/^{238}U age /^{207}Pb/^{206}U age);(I) Core (II) rim; Bold values were not included in age calculation.

Table 5

Sample	Sm (ppm)	Nd (ppm)	$^{147}Sm/^{144}Nd$	2σ	$^{143}Nd/^{144}Nd$	2σ	$f_{(Sm/Nd)}$	Age (Ga) U-Pb zircon	$\varepsilon_{Nd(\tau)}$	$T_{(DM)}$ (Ga)	Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	2σ	T_{UR} (Ga)
Caxipacoré Suite																
AB-73A	4.25	28.0	0.0918	0.00016	0.511270	0.000005	-0.533	2.00[a]	+0.26	2.22	156.3	254.7	1.78	0.75251	0.00003	1.96
AB-85	10.26	60.2	0.1031	0.00025	0.511458	0.000006	-0.476	1.99[a]	+0.66	2.19	160.2	316.1	1.47	0.74358	0.00002	1.95
Água Branca Suite																
CS-121	4.45	26.2	0.1026	0.00015	0.511374	0.000008	-0.478	1.88[a]	-1.96	2.30	146.9	273.6	1.56	0.74755	0.00002	2.02
CS-97	6.79	43.0	0.0955	0.00018	0.511404	0.000004	-0.514	1.88[a]	+0.34	2.12	118.4	571.8	0.60	0.71957	0.00001	2.02
CS-113	6.72	41.3	0.0984	0.00022	0.511391	0.000010	-0.500	1.88[a]	-0.60	2.19	86.7	754.4	0.33	0.71182	0.00001	2.02
Mapuera Suite																
AT-153	22.42	131.9	0.1028	0.00029	0.511625	0.000003	-0.478	1.87[a]	+2.92	1.95	252.8	10.8	78.19	2.28874	0.00004	1.41
AT-99	13.69	78.9	0.1049	0.00024	0.511451	0.000003	-0.467	1.87[a]	-1.01	2.24	287.1	58.4	14.77	1.09827	0.00002	1.86
AT-16A	8.51	50.9	0.1011	0.00016	0.511408	0.000004	-0.486	1.87[a]	-0.94	2.22	176.4	126.4	4.08	0.81030	0.00002	1.84
AT-177	7.77	46.2	0.1015	0.00054	0.511431	0.000004	-0.484	1.87[a]	-0.58	2.20	290.2	52.9	16.59	1.16917	0.00002	1.96
AB-98A	6.4	46.9	0.0819	0.00012	0.511178	0.000004	-0.583	1.87[a]	-0.79	2.16	164.7	94.8	5.10	0.84944	0.00004	2.01

[a] Ages obtained in this work.