

Alto Moxotó Terrane, a fragment of Columbia supercontinent in the Transversal Zone interior: Borborema Province, Northeast Brazil

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Abstract

In the central part or central subprovince of the Borborema Province, in the so-called Transversal Zone, an assemblage of Paleoproterozoic (predominantly Rhyacian) rocks occurs together with sparsely distributed Neoproterozoic nuclei. These rocks constitute the main basement of the Tonian (Cariris Velhos Cycle) and Ediacaran (Brasiliano Cycle) mobile belts. They are older tectonostratigraphic terranes and *par excellence* ramifying elements (as "inliers") of the Neoproterozoic orogenic constructions. This tectonostratigraphic terrane known as Alto Moxotó composes a litho-structural context typical of accretionary orogens, with the presence of granitic, granodioritic, and trondhjemitic orthogneisses (\approx arc-type associations) that stretch out for some hundreds of kilometers (Floresta Suite) and are partially covered by medium-grade pelitic-psammitic sequences (Sertânia Supergroup). This basement outline (Floresta Suite + Sertânia Supergroup) depicts an irregular sigmoidal shape, from the interior of Pernambuco (meridian 39°W) to the Paraíba coastal area (meridian 34°45'W), along about 450 km, varying from 40 to 80 km in width, resulting in a total area of *ca.* 28,000 km². This Rhyacian petrotectonic scenario is conditioned and delimited by extensive (shear + thrust) faults that configure a tectonostratigraphic terrane. Moreover, there are pieces of continuity evidence of this tectonostratigraphic terrane not only in the basement of the adjacent Neoproterozoic mobile belts to the North and South of the TAM in Brazil, but also in Northern Cameroon, in Africa. Within this broader predominantly Rhyacian belt, some small Neoproterozoic gneissic and migmatitic nuclei were identified. The Rhyacian lithologies reveal evidence (T_{DM} ages) of sources from a Neoproterozoic paleosubstrate. During the Statherian, the whole Rhyacian context was affected by a series of small-scale magmatic manifestations of varied petrologic composition: syenitic, granitic, granodioritic, and gabbro-anorthositic. In this paper, a synthesis of the bibliographic data is presented, including a series of unpublished (geologic and geochronologic) data that together validate our conviction that we are dealing with an extensive (re-worked) fragment (TAM) derived from the basement of a Paleoproterozoic supercontinent (Columbia).

KEYWORDS: Transversal Zone; Borborema Province; Rhyacian accretion; Cariris Velhos Fold System; Brasiliano.

INTRODUCTION

The tectonostratigraphic Alto Moxotó Terrane (TAM, acronym in Portuguese), as originally named by Santos (1995, 1996), has been the subject of many investigations that were carried out after seminal studies. TAM has been recognized as an extensive area (> 28,000 km²) of irregular sigmoidal shape, varying from 40 to 80 km in width, and with a basement context strikingly Paleoproterozoic (Rhyacian system) in age, with local Archean nuclei. This terrane lies diagonally to the Central-eastern portion of the Transversal Zone of Borborema Province, resulting in a general NE to E-NE trend. From Floresta in Pernambuco (PE) to the Paraíba (PB) coastal area, TAM presents an outcropping longitudinal extent of circa 450 km. If we consider the probable continuity in the African

territory (Western Cameroonian domain — Bouyo *et al.* 2019), TAM will exceed 1,000 km in length. On the South American side, this pre-Mesoproterozoic terrane ostensibly separates branches (as inliers) of younger Neoproterozoic fold systems (of Cariris Velhos/Eotonian and of Brasiliano/Ediacaran-Cambrian cycles).

Two ample lithostratigraphic contexts predominate in the lithostructural framework of TAM (Fig. 1). The first is mainly

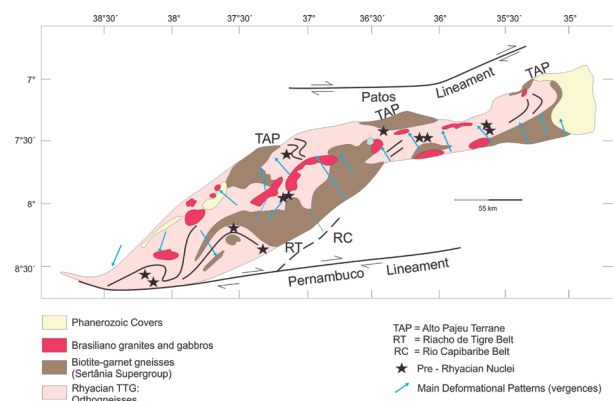


Figure 1. Schematic geologic map of Alto Moxotó Terrane, highlighting its main lithostructural elements at small scale.

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constituted by medium- to high-grade metamorphic rocks, essentially orthogneisses — TTG, that is, granitic, granodioritic, and trondhjemitic (arc-type sources) —, metagabbros and other orthoderived rocks, referred herein as Floresta Suite. The positioning of the entire and varied orthogneiss context under the epigraph of a single lithostratigraphic designation (even if informal) is problematic. In this case, the informal Floresta Complex designation has been persistently circulating since Santos (1995). In our opinion, this ample collection of high-grade rocks should be dealt with as “suite”, and this is also in accordance with the modern recommendation of the Stratigraphic Nomenclature Code (Murphy and Salvador 1999, Easton *et al.* 2005). However, we are aware that regardless of the nomenclature, as, for example, the adopted “Floresta Suite” here, it will not be consensual, but rather debatable. This originally accretionary context is well marked by magmatic, mafic-ultramafic manifestations of tholeiitic (the Paleoproterozoic Malhada Vermelha Suite) and granitic (Camalau, Salvador, Sucuru, etc.) nature. The latter occurred in the Rhyacian-Orosirian transition. These manifestations are present in practically all the available 1/100,000 maps (Figs. 1 and 2).

The second group of rocks predominating in the TAM is constituted by abundant supracrustal, medium-grade metapelitic-metapsammitic sequences — micaschists; aluminous (biotite, sillimanite, garnet) paragneisses; meta-greywackes; with quartzites, calc-silicates, limestones, etc., as bands and lenses. This context overlies the Floresta Suite, encompassed under Sertânia Group/Complex umbrella. It is a typical “QPC” sequence (*sensu* Condie 1982, association of quartzites + pelites + conglomerates), which usually presents banded meta-laminites. Only locally can we distinguish volcanic contributions. It is possible that it used to be a shallow backarc basin developed (on continental lithosphere?) under tectonic quiescence (with some rare felsic and mafic magmatism). Initially mapped as “Sertânia Sequence” (Santos 1971), this unit is characterized by its extensive geographic area (despite intense erosion), but it is larger than the “Floresta” itself, and by the almost constant preservation of its lithostructural characteristics. We will adopt the designation “Sertânia Supergroup” for this metavolcanic-sedimentary tract, which is the closest to the Nomenclature Code premises and recommendations.

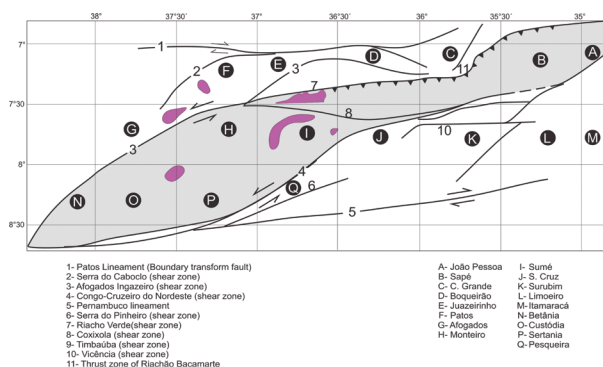


Figure 2. Scheme of 1/100,000 sheets from the Brazilian Geological Survey (CPRM) used in this research, as well as the main shear zones belonging to Alto Moxotó Terrane (TAM) and its limits.

Crosscutting the two main geological contexts, a sparse anorogenic magmatism occurred from Statherian to Calymmian (“A”-type magmatism): monzogranitic meta-granitoids informally named as Carnoió, Coloete, and Serra da Barra; and metamorphosed basic rocks and gabbro-anorthosites (Limoeiro, Piranhas), among others. The latter are Fe-Ti-V mineralized (see Lages *et al.* 2019, Accioly 2000).

Some (Neoproterozoic?) cover sequences/occurrences of relatively small sizes and still problematic (stratigraphic and tectonic) positioning, which include low-grade metavolcanosedimentary rocks, biotite muscovite gneisses, metatuffs (“Irajá”) and medium- to low-grade schists (“Surubim-Caroalina”), have been mapped mostly overlying the Floresta Suite. These can be either remnants of previous covers of the orogenic belts lateral to TAM and/or tracts of these belts tectonically placed by nappism/thrusting (still unsure), or mere remnants of regional erosional processes. However, we cannot discard that these occurrences (or some of them) are yet mere expositions of the Sertânia Supergroup itself, with no clear connections.

It is noteworthy that the above-mentioned Statherian-Calymmian lithostructural units are only sporadically represented, with no major geographical-geological expression. Furthermore, their presence is part and in time similar to those recorded in the cratons of Northern continents.

The geographical-geological delimitation of this reworked terrane of the pre-Brasiliano basement (TAM) to its present shape and position is clearly marked by sinistral shearing fault zones (to the West, Afogados do Ingazeira; to the South and Southeast, the Pernambuco Lineament; and Congo-Cruzeiro do Nordeste Shear Zone, and by a long and sinuous line of thrust faulting — Riachão do Bacamarte-Sumé), which are conspicuous in their Northern portion. This fact puts the basement context on top of the Alto Pajeú Terrane (TAP, acronym in Portuguese), as shown in Figure 2. Therefore, this tectonostratigraphic terrane (*sensu* Howell 1995) is notably exposed as a domain of basement rocks between the 39°00’W and 34°45’W meridians, in the Central-northeastern part of the Transversal Zone and that occurs diagonally to this zone for ca. 450 km, from the vicinities of Floresta/PE to the Paraíba coastal area. This wide pre-Mesoproterozoic segment presents a sparse tectonic and magmatic reworking history from the end of the Paleoproterozoic to the first half of the Mesoproterozoic (between 1,800 and 1,500 Ma). The latter is responding for anorogenic causes and processes. Later in the Neoproterozoic, during the Tonian (Cariris Velhos Cycle) and from the Neocryogenian-Ediacaran to the Cambrian cycles (Brasiliano Cycle), this framework was intensely reworked with important and pervasive participation in tectonic (and magmatic) events, including their present (acquired) positioning between distinct mobile belts (as basement “highs” or “terrane”). Indications of discrete preservation of the pre-Brasiliano original fabrics and conditions remain, despite the strong crustal reworking affecting TAM.

It is opportune to add that expressive fractions of the Paleoproterozoic lithostructural context similar (and contiguous) to TAM have been identified, although markedly reworked and incorporated to the basement of the Neoproterozoic mobile

belts adjacent to TAM. This is true both for the rocks of the Cariris Velhos Cycle basement (TAP, to the North; and for the Riacho do Tigre Terrane/Belt, to the South and Southeast) and for the belts of the “Brasiliano Cycle”. These additional observations lead us to conclude that the original extent of this Paleoproterozoic lithostructural context (TAM) was much larger and stretched out (in pre-Neoproterozoic times) much farther than the present magnitude (ca. 28,000 km²). In addition, there are some indications of a previous continuity of this same terrane in the basement of the Northern portion of Cameroon, in Africa (Van Schmus *et al.* 2008, De Witt *et al.* 2008, Buoyo *et al.* 2019).

Besides these characteristics of a striking accretionary and metamorphic tectogenesis in the Rhyacian (Late Siderian to the Early Orosirian), the possibility of a superimposed magmatism and metamorphism occurring in the Orosirian will be discussed. A reasonable geologic and geochronologic data set signaling this regional-scale tectonic event already exists, but many questions persist regarding both the Floresta Suite and Sertânia Supergroup. Presence of the (metamorphosed) accretionary edifice is a new fact in the regional geological knowledge. Despite the insufficiency of data to solve this issue, those available point out to the presence of a tectonic event of the Orosirian, overprinting those of the Rhyacian.

In summary, TAM is an extensive, pre-Mesoproterozoic tectonostratigraphic terrane (*sensu* Howell 1995), which today is fragmented as a result of orogenic constructions of the Neoproterozoic (Cariris Velhos and Brasiliano orogenic cycles) and, in part, (laterally), is affected by them, but still preserving an extensive area of its identity and a very rich pre-Neoproterozoic history. On these terms, we can already attest that the lithostructural components usually found in the basement of the suggested Paleoproterozoic supercontinents (Columbia, NENA, Hudsonia, etc.) are well represented in the TAM. We will return to this subject and we will discuss all data we do have, based on recent bibliography (*e.g.*, Lahtinen *et al.* 2008, Meert and Santosh 2017).

An intense bibliographic survey has been carried out (and is available in our data collection) encompassing different geologic areas, with the addition of valuable data to our own records. The geologic sections presented in Figures 3 to 6 were drawn in order to aid the reader and to synthesize the regional geological scenario.

From the seminal study of Santos (1995), who named and classified TAM as a tectonostratigraphic terrane (*sensu*

Howell 1995), an extraordinary quantity of papers has dealt with this tectonic unit.

BRIEF HISTORY/MAIN REFERENCES

Since the last quarter of the 20th century, many authors have signaled the presence of a pre-Brasiliano basement in the Transversal Zone, which is recorded in a variety of small-scale maps (DNPM-CPRM consortium, SUDENE, RADAMBRASIL Project, etc.), with little reliable geochronologic determinations and specific concern towards the tectonic significance of these old lithostructural units. Santos (1995, 1996) and Santos *et al.* (1997) were pioneers in the identification of the (pre-Neoproterozoic) tectonostratigraphic terranes in the composition of the Transversal Zone (in particular, the case of TAM) and Borborema Province as a whole.

In this century, the geological mapping at medium scales has been improved throughout the Transversal Zone (The Basic Geological Survey Project — PLGB from CPRM and akin, as in Fig. 2), *pari passu* with a variety of academic studies (masters and doctor’s degrees by UFPE, UFC, UFRN, USP), which developed an extensive and valuable bibliographic collection. In particular, we highlight (preliminary syntheses of good quality) the 1/500,000 geological maps of the states of Pernambuco (Gomes *et al.* 2001) and Paraíba (Santos *et al.* 2002) as fundamental references, greatly based on basic geological cartography.

The papers published by Santos *et al.* (2010), Van Schmus *et al.* (2011) and Santos *et al.* (2014) provide concepts regarding terranes (including the TAM), and they are the best recent syntheses worthy of mention. Particularly, in the synthesis of 2014, Santos *et al.* (2014) present the terranes of the Borborema Province, as a whole, with all new available geological, petrographic, geochronologic, metallogenetic, and geophysical data (see Oliveira 2008), specially highlighting the TAM and TAP terranes.

BORBOREMA PROVINCE AND TRANSVERSAL ZONE

The central part (subprovince) of Borborema Province is limited by two subparallel transcontinental lineaments, Patos (Garoua) to the North (Boundary Transform of Patos), and Pernambuco (\approx Adamawa) to the South (Figs. 1 and 2), which are subject of many previous studies. We highlight the last

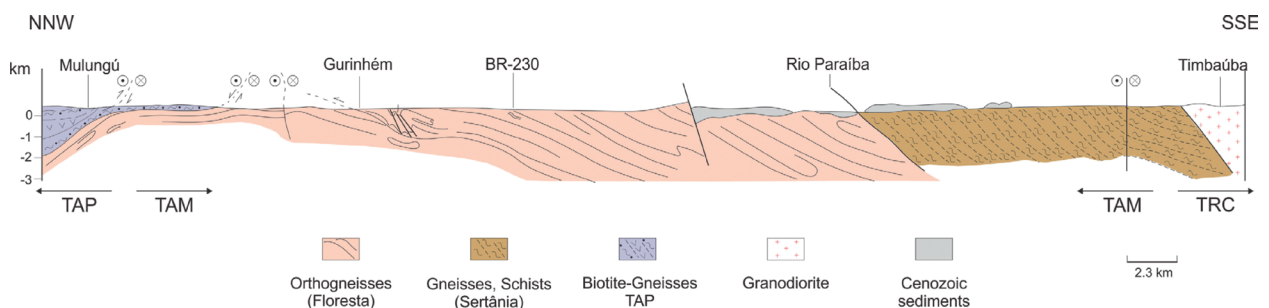


Figure 3. Schematic geological section transversal to the Eastern sector of Alto Moxotó Terrane — TAM (Eastern Paraíba).

syntheses by Oliveira (2008), Santos *et al.* (2010, 2014), Van Schmus *et al.* (2011), and Brito Neves *et al.* (2016). Inside this zone that constitutes the Borborema central subprovince, several tectonostratigraphic terranes (besides TAM), polygonal segments of the basement (basement *inliers*) of the Archean and Paleoproterozoic orogenic constructions are found: Alto Moxotó, Coremas Dam, São José do Caiana, Icaçara, and São Pedro. These basement inliers ramify orogenic belts of the Tonian/Cariris Velhos Cycle (Alto Pajeú Belt/Terrane = TAP, and Riacho do Tigre = RT) and Cryogenian/Ediacaran/Brasiliano (Piancó Alto Brígida belt/Terrane — SPAB, to the Northwest, and Rio Capibaribe Belt/Terrane — TRC (to the Southeast).

These pre-Mesoproterozoic basement inliers present a series of lithostructural and geochronologic similarities, which suggest that they were integrating parts of a previous single tectonic-stratigraphic context that underwent fission and dispersion (Howell 1995), thus forming more or less dispersed segments that were distinctly reworked (during the Brasiliano period). These basement segments were intensely reworked by tectonism (important internal shear zones) and magmatism of the Neoproterozoic events and cycles. TAM, in particular, is the segment located diagonally to the Central-eastern portion of the Transversal Zone and separates important and distinct orogenic belts (North-Northwest and South-Southeast of Cariris Velhos/Tonian and Brasiliano cycles).

Up to now, only in the fraction of TAM basement (Archean + Paleoproterozoic) has possible to identify evidence of anorogenic magmatism of the end of the Paleoproterozoic (from the Statherian to the Calymmian). This is a fact to better characterization of the TAM and for its distinction from the other terranes of the Transversal Zone (see Lages *et al.* 2019, among others). The other terranes in the Transversal Zone are TAM partners in the branching of the Neoproterozoic lithostructural belts. These present some similarities with the tectonic and geochronologic development of TAM (their histories are essentially Rhyacian), but with a significant group of differences. In particular, there is a terrane located Westwards of the Transversal Zone along Pernambuco-Piauí border — São Pedro Terrane (TSP) — that is very distinct from the others (including TAM), due to its geochronologic and lithostructural characteristics. In the TSP basement, there are significant records of the Paleo-, Meso- and Neoproterozoic cycles.

ALTO MOXOTÓ TECTONOSTRATIGRAPHIC TERRANE

An intense bibliographic review was carried out, encompassing different geologic areas, using compilation and addition of valuable data on our main objective. The geologic sections presented here try to aid the reader to follow the text and synthesize the regional geologic scenario.

For expository reasons (but not only), the lithostructural and geochronologic analysis of TAM is addressed in three parts: the South-western portion (West of meridian 37°15'W, in Pernambuco); the Central portion (\pm between meridians 37°15'W and 36°00'W), and the Eastern portion (from meridian 36°00'W to the coastal area, portion previously named “Caldas Brandão Massif”), the last two located in Paraíba State. In all the three domains, the presence of (sparsely distributed) Neoproterozoic tracts has been attested conspicuously in the central domain. Nevertheless, we believe that it is only because of a larger (and circumstantial) concentration of age determinations in this region. The cartographic discrimination of these older domains has not been possible (with the expected accuracy), so that they are not represented on 1/100,000 maps. Despite these nuclei being identified by geochronological determinations, the majority of them have been found on the basis of previous suppositions (working hypothesis) arisen during field work (petrographic composition, migmatites with paleosome derived from basic rocks, complex structural style, varied and polyphase participation of neosomatic terms, etc.). Indications of a behavior different from the dominant lithostructural context of orthogneisses — meta TTG —, which is the basement of TAM, have been our guides (together with the initial application of the Sm-Nd method) as the research developed. We are convinced that more Archean contexts will be identified and mapped as geological survey and sampling are intensified in the area.

The geologic sections presented help provide a better idea of the lithostratigraphic composition and structural framework of the Eastern (Fig. 3) and Central (Figs. 4 and 5) sectors — in which the structural vergence to the North is more conspicuous. In the South-Western sector (farthest from the intersection of the Ediacaran arc plates, Fig. 6, entirely in Pernambuco), the vergence somewhat trends Southwards and Southeastwards. These schematic geologic sections show the persistence of the Rhyacian units — varied orthogneisses — Floresta Suite; the

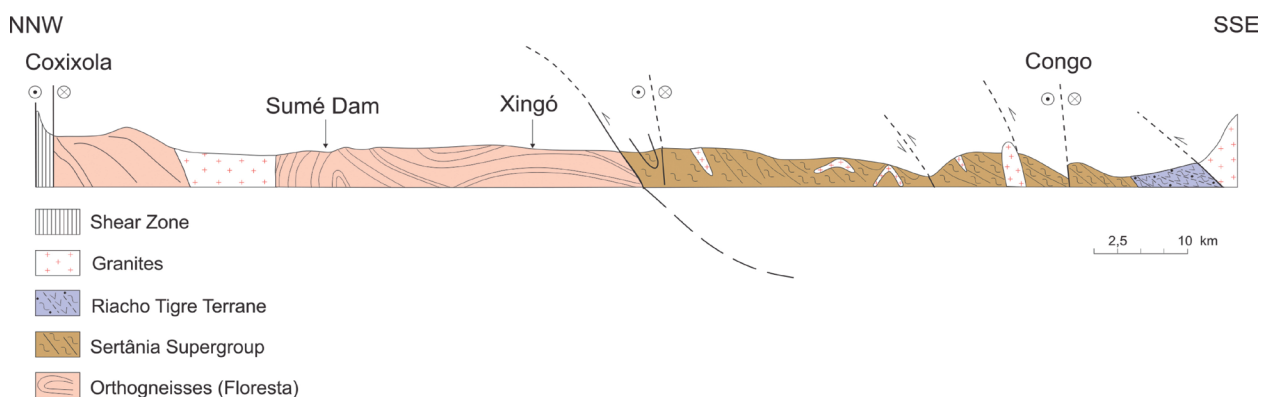


Figure 4. Schematic geologic section transversal to the Central sector of Alto Moxotó Terrane — TAM (Southern Paraíba).

peraluminous supracrustal rocks — Sertânia Supergroup —, and the respective movements (structural vergence) developed during the end of the Neoproterozoic.

For discussion and better understanding of this terrane, it is necessary to anticipate its evolutionary history, trying to connect its different lithostructural components with the geochronological scenario designed according to our bibliographic review and the obtained data to be presented:

- Local presence of some pre-Rhyacian nuclei (all of them Neoproterozoic in age), possible records of old terranes and continental basement tracts (pre-2,300 Ma) of difficult cartographic discrimination (even at larger scales) from the components of their ample and predominant Rhyacian accretionary history. Some of these pre-Rhyacian rock units will be discussed, and we believe (from our observations and field inferences) that the number (around a dozen, up to now) of these nuclei (see Fig. 1) will increase after the progress of the investigations, and there is motive (based on Sm-Nd data, as it will be discussed) to think about the existence of a previous Archean crust occurring in the whole terrane. More than 55% of the T_{DM} data obtained for the Paleoproterozoic rocks are Archean;
- The Rhyacian accretionary system, from the post-Siderian (ca. 2300 Ma) to the Early-Orosirian (ca. 2050 Ma), circumscribed and reworked previous tectonic-stratigraphic

elements and rock units (microplates, microcontinents, Archean terranes?). This system points to the formation of an extraordinary and more or less continuous system of plutonic rocks typical of (TTG-type) magmatic arcs. These were transformed into a varied tract of orthogneisses, which were crosscutting the Rhyacian (and later in the Orosirian) by felsic, mafic, and ultramafic intrusions. This accretionary context is predominant in the framework of the TAM basement. Isotopic data (a universe of ca. 150 Sm-Nd determinations) are enough to support such supposition, which must be pursued and confirmed in the future. The identification in 1/100,000 geological maps and outcrops of tonalitic, granodioritic, trondhjemitic, quartz-dioritic, and granitic orthogneisses is expressive. The majority of geochemical data confirm that the data are compatible with the classification of an ample (“VAG”-type) accretionary process, with a few exceptions. Meanwhile, rock samples that yielded Archean ages come predominantly from complex migmatitic rocks with mafic (amphibole- and biotite-bearing) paleosomes and several insertion phases of leucocratic bands;

- Sparse, but important, granitic (stocks, tabular, and very irregular bodies) and mafic (to ultramafic) activity at the end of the accretionary development is a relatively common phenomenon (even if sparsely distributed). These late

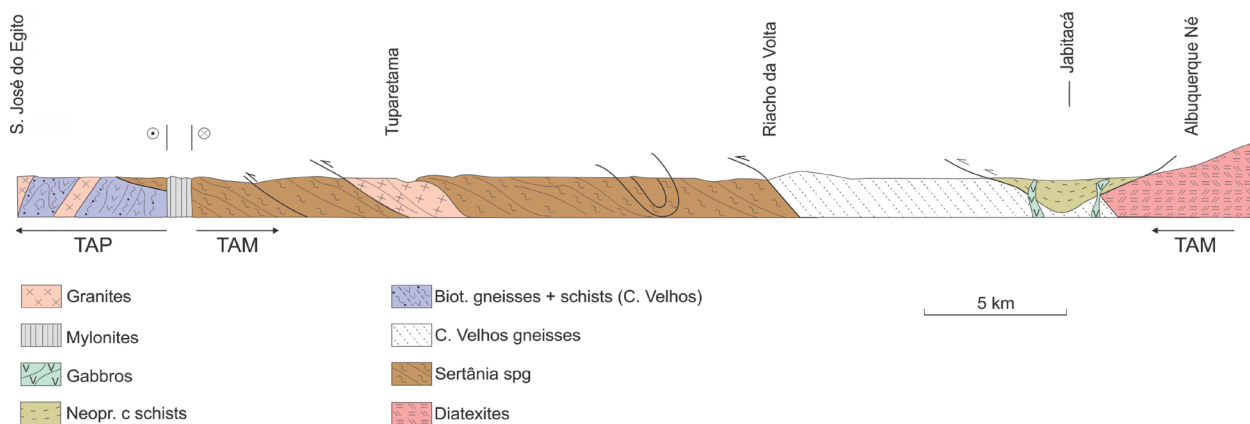


Figure 5. Schematic geologic section of the Westernmost part of the central sector of Alto Moxotó Terrane — AMT (Northern Pernambuco).

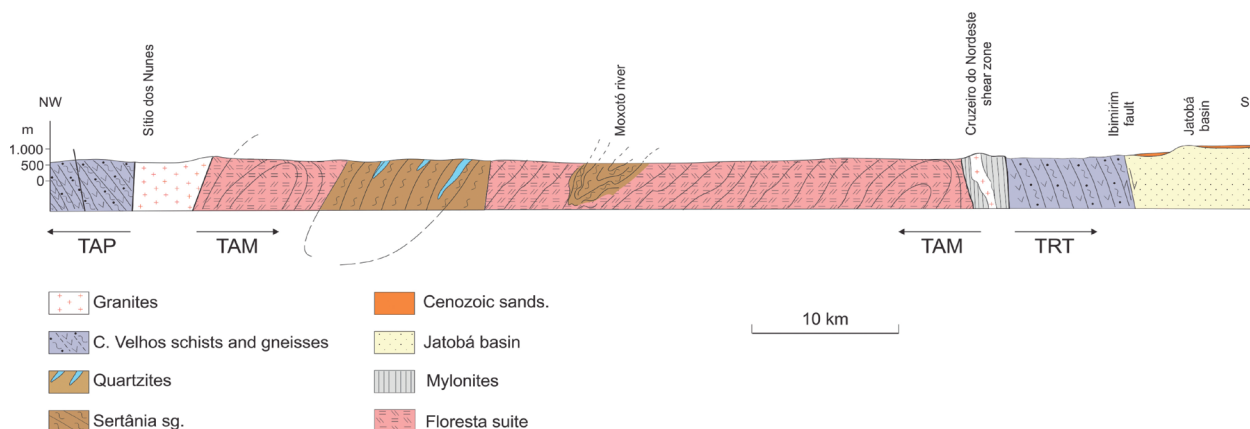


Figure 6. Schematic geologic section of the South-western sector of Alto Moxotó Terrane — AMT (Central-southern of Pernambuco).

magmatic events indicate (late- to post-Rhyacian) extensional processes observed in the South-Southwestern to the Northeastern parts of the terrane;

- In fact, there are some sporadic geologic and geochronologic indications of deformational tectonic events during the Orosirian. This was observed in the geochronologic studies of the Floresta Suite and Sertânia Supergroup (more strongly in the latter), as it will be seen in the Concordia diagrams. These observations are also valid for the basement of Neoproterozoic mobile belts that flank TAM. However, these observations are not considered complete (or enough) and they need further support and ratification. There are some good indicators (metamorphism, granitic activity, U-Pb geochronologic data) of the Rhyacian data overprinting. But the critical mass of the available data is still insufficient to conclude the matter. The mark of the Orosirian deformational events, relatively common in the province, still requires a better objective fitting in the TAM tectonic history;
- This accretionary context (and its subsequent stages of Paleo- and Mesoproterozoic development), in terms of composition and age, shows some similarities in the other (above-mentioned) terranes of the Transversal Zone, and probable continuity in the African territory (North of Cameroon). Analogously, but not reworked by the Brasiliano, they can be pointed out in other Brazilian structural provinces, in the Eastern Mobile Belt of Bahia, in Eastern Amazonia, in Western Europe (Fennoscandia), and also in some provinces of the North-American (Trans-Hudsonian, Wopmay) and African (Eburnean) continents;
- During the Statherian and in part in the Calymmian, intercepting the previous (already metamorphosed) accretionary system, there is a series of anorogenic rock types: granitic, granodioritic, quartz-syenitic, basic, ultrabasic, and gabbro-anorthositic intrusive rocks. The contacts with the host rocks and other petrologic characteristics (within-plate plutonic rocks in geochemical diagrams) make the anorogenic nature very clear. There are several academic works on the theme (*e.g.*, Sá *et al.* 2002, Accioly *et al.* 2011, Lages *et al.* 2019). It is worth mentioning, however, that not all these occurrences could be properly catalogued and studied, and several others are being gradually discovered and demanding more investigation. This is another point of resemblance with those Paleoproterozoic domains mentioned above (for comparison), in this and in other continents;
- During the Early Tonian, the Paleoproterozoic basement system was sectioned to the North (Alto Pajeú Belt/Terrane — TAP) and to the South (Riacho do Tigre Belt — RT) by long faults that, in part, preceded the paleogeographic and tectonic basin formation and the development of these Eo-Neoproterozoic belts. Inside these Tonian belts and on the TAP margins, important lithological records of reworked Paleoproterozoic rocks were found. In addition, South of TAM and of the limit of Riacho do Tigre Terrane, which is an important fault (with transcurrent movement — “Congo-Cruzeiro do Nordeste”), Paleoproterozoic gneissic rocks reappeared (“Pão de Açúcar Complex”, Santos and Accioly 2010), which were similar to those of TAM. In other words, there was a previous geographic-geologic extent of TAM, much larger than that considered at present;
- During the Neocryogenian and the Ediacaran, the whole TAM and its marginal portions (already reworked by the Cariris Velhos Cycle) were once again intensely reworked both by tectonism and magmatism, in accordance with orogenic processes of the Rodinia fission evolution and further fusion of the West Gondwana in the Brasiliano Cycle. In fact, the main structural lineaments currently present and entirely observed inside and within TAM limits are Neoproterozoic in age. In all TAM tectonic elements, field observations of pre-Brasiliano structures are possible, but in a veiled form, which is difficult to be identified due to the intensity (superposition) of the Brasiliano processes;
- It is possible, and has already been proposed and schematized, that TAM (already added to TAP, TAM + TAP as a whole) has played the role of a more or less linear, upper plate in an (Brasiliano) accretionary process, located almost longitudinally to the South of Patos Lineament (Brito Neves *et al.* 2016), and later collided with the Northern plate — Rio Grande do Norte terrane — which had acted as the lower plate. Records of the development of this arc are seen from the North of João Pessoa (Jacaraú) to the Piauí border, with an estimated longitudinal length of 700 km. The TAM (still added to TAP), in the condition of upper plate, has constituted an ample retroarc foreland domain during plate interaction (between 630 and 580 Ma — Brito Neves *et al.* 2016). The deformation scenario shown in Figure 1 reflects this Ediacaran post-magmatism collisional moment;
- Whereas all the Northern portion of that upper plate (TAM + TAP) was characterized by an almost continuous zone of granitic arc magmatism (“VAG”, Ediacaran), its central part was relatively spared from this granitic magmatism. The occurrences of Brasiliano stocks and granitic batholiths are relatively sparse along the TAM central portion. Such behavior (low intensity of granite genesis) is unusual in the province. However, this contrasts with the intense degree of pervasive deformation caused by tectonic movements (collisional) trending North (probably in more than one phase) in the Central and Central-Eastern domains of TAM, culminating with the long and sinuous thrust lines, from the Atlantic coast to the vicinities of São José do Egito/PE (meridian 37°15'W);
- Along the Phanerozoic, during the development of Gondwanan (pre-Pangea) and post-Gondwanan sedimentary covers (Pangea fission), the Neoproterozoic structures imposed to the Transversal Zone as a whole and TAM (and other terranes, particularly São Pedro Terrane) were extremely important. These basement structures hosted and played an important role in many tectonic inheritance events affecting the sedimentary basins (structural highs *versus* depocenters).

Pre-Rhyacian nuclei/tracts

The initial aim of this research project was to identify and discriminate the pre-Rhyacian nuclei present in TAM. In fact, these have been identified in all three domains of TAM. There is predominant presence of complex metatexites with mafic paleosomes (ortho- and paraderived) bearing amphibole and biotite (sometimes garnet) crosscut by leucocratic, granitic, and granodioritic rocks. These metatexites frequently present stromatic structures, in general revealing strong shearing conditions. The sampled outcrops are in fact different from those of Rhyacian orthogneissic contexts, but not to an extent to be discriminated as possible contact lines. The cartographic discrimination of these older domains has not been possible yet. Only with the enlargement of the mapping scales, these units would be cartographically discriminated.

Despite the identification of these nuclei, it was possible with the support of geochronologic determinations to identify all of them (or the majority of them) on the basis of suppositions arisen by field geology experience (petrographic composition, migmatites with paleosome of basic rocks, etc.). Indications of this order of very different behavior (of the “sea” of orthogneisses — meta-TTG — characteristic of the Floresta Suite) acted as our guides, together with the initial application of the Sm-Nd method. In a little more than a dozen times, we were successful in identifying these nuclei.

The cartographic discrimination of these nuclei from the Rhyacian orthogneisses (predominating in the TAM) will only be possible with large-scale geological mapping with significant geologic (petrographic, structural, and geochronologic) support. The designation of Archean rock types had always been done, but it was speculative. Our concern was to find these old nuclei (petrographic and structural evidences), which are distinct from the predominant sea of orthogneisses (the Rhyacian meta — TTG).

Adding our data to more recent surveys focusing on the TAM domains, a total of more than 100 geochronologic determinations by the Sm/Nd method was obtained. More than 55% of the analyzed samples yielded Archean T_{DM} ages and strongly negative E_{Nd} values (≥ -20), as shown in the figures and tables herein. In other words, it is clear that despite the prevalence of Paleoproterozoic ages (that reflect the predominance of the Rhyacian accretionary belt), we have to assume the previous presence of many Archean sources (see the varied figures of the Nd evolution) and some nuclei of this age, confirmed by U-Pb determinations. With the U-Pb method, some Archean nuclei were attested (predominantly Neoproterozoic in age) and will be presented (distinctly marked in Fig. 1).

The first conclusions of the presence of Archean (pre-Rhyacian) nuclei/rock units inserted in the TAM Paleoproterozoic accretionary domain have been discussed above. In fact, older terranes occupying the internal part of accretionary mobile belts of all eras have been reported worldwide. A second and more daring observation (lacking additional data) can be added in face of the Sm-Nd results, that is, the possibility of the existence of a kind of Archean crust — see the great number of Archean T_{DM} data, with strongly negative E_{Nd} values obtained for the orthogneisses of accretionary origin.

The Floresta Suite

There is a great variety of meta-TTG gneissic types in the three TAM geographic-geologic domains, such as granodioritic and tonalitic, granitic, among others. There are cases of orthogneisses with calc-silicate and limestone levels, trondhjemites, metagabbros with discrete indications of migmatization that have had great coverage by petrographic and geochemical studies. From Santos (1995) to Santos *et al.* (2017), in all cartographic surveys at the 1/100,000 scale of the Basic Geological Survey Project — PLGB/CPRM (Fig. 2), petrographic and geochemical studies have been carried out, which unanimously indicated continental magmatic arc evolutionary settings.

The initial designation “Floresta Complex” has been extended from the TAM South-Westernmost corner (in Floresta/PE) to Paraíba coast on the 1/100,000 geological maps, which is understandable, but certainly not ideal. Such classification is not even the one suggested by lithostratigraphic nomenclature codes and code summaries. The name “Floresta Supergroup” does not seem to be ideal either, but it is the one that is closer to the suggestions (Chapter 5, item C, sub-item 7) of the IUGS Stratigraphic Nomenclature Code (Murphy and Salvador 1999). More recently, according to the Commission on Lithostratigraphic Nomenclature, a better possibility for the term “supergroup” would be the use of lithodemic units (large intrusive units, changing composition from a place to another, not following the superposition rules), which is what we have chosen and adopted from now on. So, our choice is done: Floresta Suite.

We reiterate the description above of a very rich and varied context. Some granitic and alkaline granitic rocks occur locally. The metamorphic facies is always from medium to high (amphibolitic facies), and there are some local indications of previous metamorphism at granulite facies (mainly detectable in some mafic-ultramafic lithotypes).

In the 1/100,000 sheets of the Eastern areas, such as Campina Grande and Sapé, we must highlight the (exceptional, up to now exclusive) presence of banded orthogneisses predominantly granodioritic in composition, presenting interesting intercalations of calc-silicate rocks and even marble, together with some ultramafic rocks of tholeiitic nature (Santos R.V. *et al.* 2013, Santos E.J. *et al.* 2013). Indications of a previous higher metamorphic peak (symplectitic textures, optical textures, etc.) are found in these rocks, superimposed by a second phase of metamorphism. Moreover, these rocks yielded geochronologic (SHRIMP and TIMS) determinations of the pre-Rhyacian (ca. 2308 ± 23 Ma) zircon nuclei, but with Orosirian “rims” (ca. 2012 ± 17 and 1953 ± 20 Ma). This is indeed one of the few opportunities in which Orosirian events were recorded clearly superimposing the regionally dominant scenario of Rhyacian ages. Another interesting and unusual observation is the presence of anorthositic leucogneisses in the spillway of Epitácio Pessoa Dam, in Boqueirão/PB, which is emplaced in a regional context of granodioritic and granitic orthogneisses (informally named “Cabaceiras” and/or “Floresta” Complex). This rock (PAPE BOQ) is presenting a U-Pb age of 2136 ± 15 Ma.

In the vicinity of Floresta/PE (place name, main occurrence, South-Westernmost corner of TAM and in several other domains, such as Custódia, Sertânia, Sumé, and Itabaiana sheets) and localities (in the three domains previously proposed), more or less tabular in shape intrusive bodies of metabasites, quartz-diorites, diorites and gabbroids of Rhyacian age are known (some local indications of older lithotypes), which were informally treated as “Malhada Vermelha Suite”.

Malhada Vermelha Suite

The maintenance of the general geologic and geochemical characteristics of Floresta Suite (orthogneisses derived from I-type granitoids originated in amagmatic-arc setting) for such an extensive area with good outcrops is very interesting. At large scales, some characteristics and additional lithologic associations are present, even if dispersedly, and are important for understanding the original context of these orthogneisses.

We focus on metamafic and metaultramafic rocks of tholeiitic affinity, metagabbros, metadiorites, meta-quartz-diorites, meta-anorthosites, hornblendites, amphibole schists and others that sparsely occurred in the three TAM domains, and they are usually named “Malhada Vermelha Suite” (*sensu* Santos 1995, in the South-Western area of TAM). As already mentioned, despite of being sparsely distributed, these rocks were found in three geographic portions proposed for the TAM. These rocks are considered intercalations regarding the orthogneisses that Santos (1995) had originally named “Floresta Complex”. In this South-Western area, the author described metamafic and metaultramafic rocks of the tholeiitic suite emplaced (along fault zones) in orthogneiss bodies as very narrow, kilometer-long lenses.

Later, still in the Western domain, Melo and Beurlen (2004) described a series of large (meter- to hectometer-sized) enclaves of mafic nature within the orthogneissic domain, containing gabbros, gabbronorites, gabbrodiorites, anorthosites and amphibolites, including Fe-Ti ore occurrences. These rocks were interpreted as originating from volcanic-arc tholeiitic magmas. Ages of ca. 2440 Ma and ca. 2010 Ma were attributed to the host orthogneisses by Melo *et al.* (2002).

In the central portion of TAM (close to Sumé/PB) similar rocks were mapped and described by Santos (2012) under the name “Malhada Vermelha” complex, which are mainly composed of metagabbros and amphibolites. This author ascribed to these rocks a retroeclogitic paragenesis based on preliminary mineralogical and geochemical studies.

In the Eastern portion, in the vicinities of Itatuba/PB (where some pre-Rhyacian nuclei were identified), Santos E.J. (2013) and Santos R.V. (2013) described an interesting occurrence of (meta) mafic-ultramafic and anorthositic rocks of tholeiitic affinity associated with meta-limestones (proven to be of sedimentary origin), which were embedded in the orthogneisses via shear zones. These rocks were interpreted as derived from a juvenile crust originated in an arc setting. There are indications in the orthoderived rocks (symplectitic structures) that these rocks underwent high-pressure metamorphism.

Sertânia Supergroup

When observing the mosaic of the 1/100,000 maps that cover the TAM domains (Figs. 1 and 2), the large territorial extent of what we call Sertânia Supergroup (following the recommendations of the Nomenclature Code) is verified from parallel 38°W to the basement of the coastal sedimentary basins, covering the rocks of Floresta Suite and even surpassing it in area. The striking characteristic of this lithostratigraphic unit is the repetitiveness of its (meta) psammitic-pelitic composition, with some calc-silicate rocks and associated quartzites and marbles. We identified in this context all the characteristics of a “QPC-type Sequence” of Assemblage I (Condie 1982), which is well represented and originated from a relatively stable tectonic setting.

The regional metamorphism reached the amphibolite facies, with descriptions of the predominant peraluminous gneisses and schists that cover a great part of the Floresta Suite. In all geologic sheets, the Sertânia Supergroup has a notorious repetition of these lithotypes. Garnet-biotite-muscovite-sillimanite gneisses and schists by far predominate with frequent migmatitic transformations, most commonly and locally with pronounced stromatic features. Some local intercalations of amphibolite and metagabbro have been described. More restrictedly, there are occurrences of bimodal volcanism (meta-rhyolites, metabasalts). We identified the presence of granitic sills (today orthogneisses) in some outcrops as along the railway to Henrique Dias (Pernambuco). In all the geologic sections, the position of post-Floresta Suite is clearly marked by unconformity. This could be locally masked, because of the actions of the Brasiliano tectonism.

There are some local occurrences of low-grade schists (metapsammitic-metapelitic), as in the Custódia, Sertânia and Sapé sheets. These low-grade metamorphic rock units were separated (in 1/100,000 mapping) as younger Neoproterozoic lithostratigraphic units and usually named “Surubim Carolina Unit”. There are no geochronologic determinations that can discriminate these alleged Neoproterozoic units. It is possible this lithostratigraphic observation may be in part true, but in most of these “Neoproterozoic” portions/tracts, we have only obtained Paleoproterozoic ages (as it will be shown in the concordia diagrams). This possibility exists, and this theme has not been solved and still awaits additional data.

There are some possibilities that have not been discarded yet: fractions of previous Neoproterozoic cover in TAM, as remnants preserved from erosion of covers coming from the Brasiliano mobile belts, lateral to TAM; nappism and/or thrusting; transpression; slivers connected with the shear zones etc. Nevertheless, the hypothesis of being fractions of the Paleoproterozoic supergroup in a peculiar tectono-metamorphic condition cannot be ruled out. In the Monteiro sheet, part of these low-grade fractions was crosscut by Orosirian granites. However, we need more data.

In all the mapped sheets, the (Orosirian and Statherian) igneous rocks that clearly crosscut the Floresta Suite are also crosscutting the Sertânia Supergroup. For the time being, the Rhyacian age for this supergroup seems to be proven (Santos *et al.* 2004, Neves *et al.* 2014). This supergroup is sparsely

crosscut by several granitic intrusions (small stocks, branched dikes, tabular bodies) of Paleoproterozoic age and later by Mesoproterozoic magmatism (Lages *et al.* 2019).

It seems that the metasedimentary context of the Sertânia Supergroup can be formalized, with only a few, small and local pending questions, as discussed. Throughout TAM, from meridians 35°W to 38°30'W, this unit crops out with the same lithostructural characteristics and, in great part, the same metamorphic facies. These peraluminous schists and gneisses predominate with frequent migmatitic transformations. Locally, we identified amphibolite, metagabbro and quartzite intercalations and more restrictedly the occurrence of bimodal volcanism (meta-rhyolites, metabasalts, as in Rio da Barra/PE). We also identified the presence of some granitic sills (now orthogneisses), like in Henrique Dias, as mentioned.

From the structural point of view, this unit always covers the Floresta Suite, as shown in the geologic sections (Figs. 3 to 6). In some specific cases (*e.g.*, the Central-Western portion — Mulungu-Feliciano antiform, Sertânia-Custódia sheets — Santos 1971, and in the Eastern portion — Cajá antiform, Campina Grande-Sapé sheets), these metasediments occur on the flanks of “Floresta Complex” structural highs, which were constructed by the Brasiliano deformation.

It is possible that fractions of Neoproterozoic belts that covered TAM could have been preserved from erosion and/or be ectonically placed (inverse faults, thrusting, transpression) over TAM, as discussed above. All these cases and suppositions demand future investigation.

South of Sumé sheet, part of what had been spared as this unit (“Surubim-Caroalina”) turned out to be part of the Tonian belt named Riacho do Tigre. There are other occurrences to be investigated in the South of Custódia/PE, Southeast of Congo/PB, among others. Quite often, even dealing with Sm-Nd (the majority presenting T_{DM} Archean ages) as well as with U-Pb determinations, a doubt remains: are we dealing with a single lithostratigraphic unit?

From the arguments of Murphy & Salvador (1999) (Lithostratigraphic Nomenclature Code, NACSN-IUGS), the designation “complex” for this lithostratigraphic unit is inadequate. It should be replaced by “supergroup” as the closest to the field reality and a less problematic term.

Orosirian events

There is no robust geologic-geochronologic documentation for the Orosirian events along TAM (and its lateral portions of the basement reworked by the Neoproterozoic orogenies), but they cannot be forgotten. There are some indications in this sense that need to be remembered and that are compulsory aims of future research projects, because of their importance. In other words, the data compiled and obtained indicate that these magmatic and metamorphic processes of the Orosirian are present and overlain to the Rhyacian accretionary complexes. However, this relation has not been fully clear yet, it is desirable. Sporadically there are geochronologic (zircon U-Pb) results between 1,950 and 2,050 Ma (both for rocks of the Floresta and Sertânia Suites, being more frequent in the

latter), as it will be more explicit in the discussion regarding geochronologic data (see Fig. 7 onwards) containing U/Pb concordias for Floresta and Sertânia. For the significance of these data, meanwhile (under the scale of reconnaissance), we can only speculate about the real meaning of the obtained results (later post-Rhyacian intrusions?, superimposed regional metamorphism?). But there are not data enough to support a satisfactory preliminary working hypothesis. The possibility exists (a collisional tectonic process involving TAM?), but the issue is open to questions and to reach a conclusion. It is necessary to invest in a lot of new researches, especially in zircon dating.

It is opportune to add that regarding the basement of other terranes in Borborema, Orosirian ages are also present in basement rocks, which call our attention to something more valid regionally, extrapolating the conditions and area of the TAM. One question remains: would it be masked by the supremacy of the Rhyacian accretionary and metamorphic events? It is assumed the hypothesis of regional metamorphism involving the entire province.

In the Eastern domain, in the Sapé sheet, Guimarães *et al.* (2011) detected a batholith composed of biotite augen gneisses, with dioritic enclaves that yielded an age of 2057 ± 20 Ma. In this domain, in a relatively contiguous area, Santos E.J. *et al.* (2013), while studying a tonalitic orthogneiss (of the Floresta Suite) obtained a U-Pb age of 2308 ± 23 Ma for zircon crystals that show a notorious overgrowth (rims) indicating ages of 2086 ± 15 Ma and 1953 ± 25 Ma, attesting here the superimposed Paleoproterozoic metamorphism.

In the Central domain, Santos (2012), while describing a monzogranitic gneissic suite (Pedra D'Água Suite) in the South of Sumé-Paraíba (see Fig. 4), a U-Pb age of the order of 2057 ± 15 Ma was detected. In the same area, while dating a gneiss of trondhjemitic nature, intrusive in a mafic-ultramafic suite (considered part of Malhada Vermelha suite), this author obtained a U-Pb age of 2006 ± 22 Ma. Still in the same area (between Sumé and Monteiro), trying to determine the ages of the Floresta Suite, the same author obtained two very distinct alignments (discordias): the first indicated an age of 2373 ± 74 Ma (pre-Rhyacian!), which is an unusual value for the majority of the geochronologic data for this suite. The second alignment, also of very good analytical quality, yielded an age of 2040 ± 63 Ma (\pm the boundary between Rhyacian and Orosirian).

As mentioned, in the Western domain, Melo *et al.* (2002), by studying tonalitic orthogneisses in the vicinity of Custódia/PE (Barro Vermelho village), which is considered part of Floresta Suite, obtained a concordia age of 2440 ± 18 Ma (pre-Rhyacian!?) and also identified and distinguished a series of granitic orthogneisses dated at 2010 ± 30 Ma in the same area. These rocks of different ages yielded T_{DM} values between 2.3 and 3.0 Ga.

In the lateral domains of TAM, where its (reworked) rocks constitute the basement of the Neoproterozoic mobile belts, the identification of Paleoproterozoic lithotypes has also been common. There is a certain difficulty in interpreting the ages (the superposition of Neoproterozoic events is intense).

In the same part of the Rio Capibaribe terrane – TRC basement (similar to TAM in composition), Sá *et al.* (2002), when studying the quartz-monzodioritic gneissic basement of the porphyritic granitic batholith (today augen gneiss) of Serra de Taquaritinga (originally Calymmian in age), obtained a good U-Pb age of 1974 ± 32 Ma. Furthermore, these authors identified and dated Neoproterozoic granitic intrusions cross-cutting this Orosirian basement.

Thus, along the TAM and vicinities, the presence of geologic events between 2,150 and 1,950 Ma has been clearly unquestionable, in part succeeding the predominant Rhyacian data and preceding the striking events of the Statherian.

From the combined data exposed and analogy with other basement areas of the Neoproterozoic continental Brazilian structural provinces (and even of great part of the Borborema Province itself), we can suggest the working hypothesis that

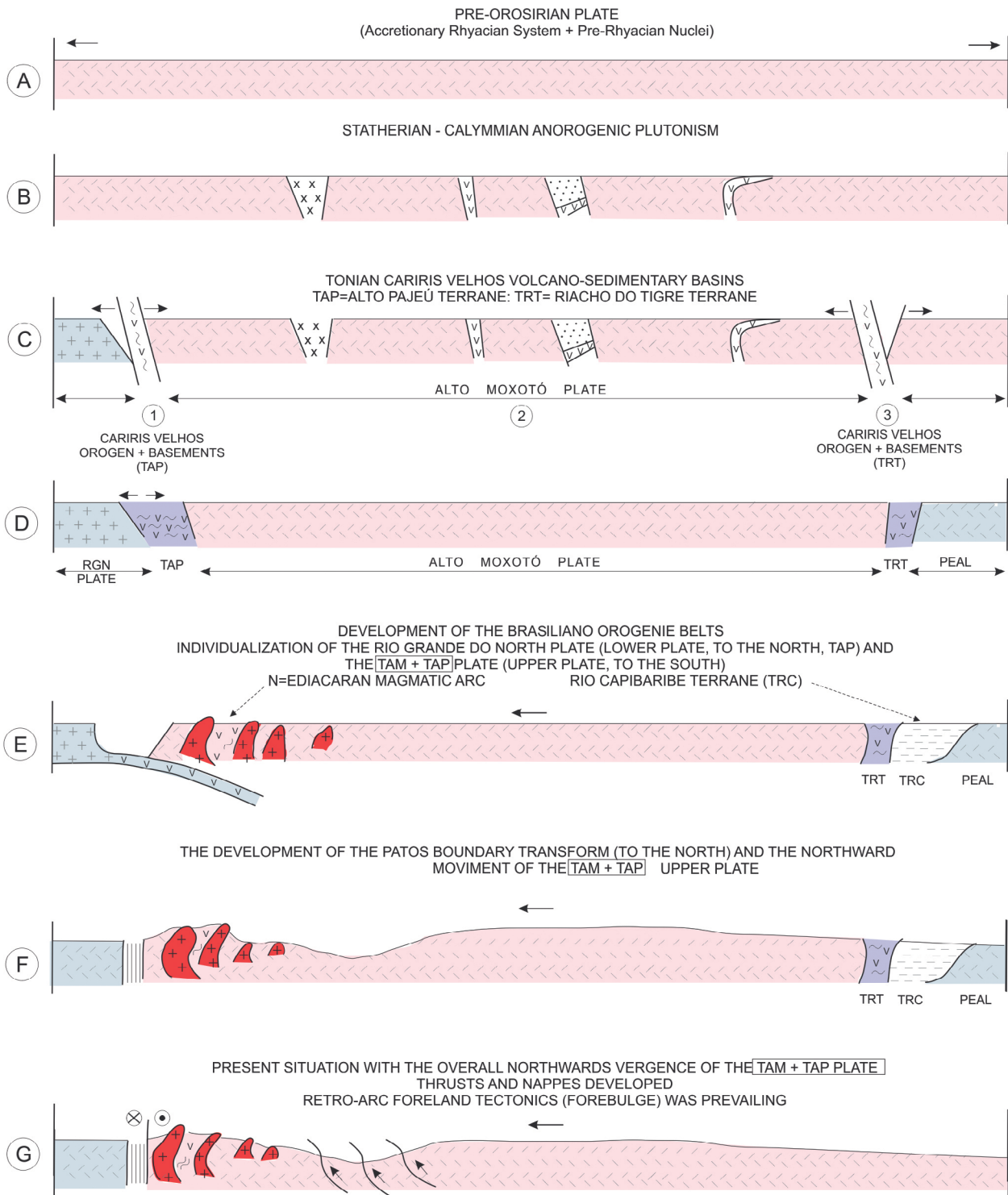


Figure 7. Hypotetic scheme of the global evolution of the central part of Borborema Province (Transversal Zone and surroundings) from the Paleoproterozoic (pre-Orosirian plate — A) to the Upper Ediacaran.

an important Orosirian tectonic-magmatic event was superimposed on the Rhyacian accretionary processes. We are aware that there are many problems to be solved yet.

STATHERIAN-CALYMMIAN MAGMATISM

Along the TAM, in several dispersed areas, varied meta-plutonites and gabbro-anorthositic associations in the 1,800-1,500 Ma time-interval have been recorded. They are in general small bodies (with only just one exception), but of great importance for the geotectonic understanding of this terrane and for comparison with analogues in Brazil and in the world. These bodies clearly show intrusive relationships with the rocks of the TAM basement (“Floresta”, “Sertânia” and akin), several shapes (small stocks, tabular forms, swarms), and superimposed metamorphism of the Brasiliano Cycle (some of them even crosscut by Ediacaran igneous rocks). These events/occurrences are mostly relevant because they mark an ample time interval (post-Orosirian) of relative tectonic stability (“geocratic”/anorogenic period), which is typical of several of the present continents (and is an important milestone of the supercontinents proposed for the Paleoproterozoic).

There are three main groups of occurrences properly cartographed with reliable petrographic and geochronologic studies: syenites and quartzsyenites (“Carnoió suite”, ca. 1638 Ma); granodiorites and syenogranites (“Coloete suite”, 1652 Ma), quartzsyenites and syenogranites and alkali-feldspar granites (“Serra da Barra suite”, ca. 1645 Ma), which occur in the Central-Eastern portion of Paraíba State. A recent synthesis on these bodies and discussion of the geotectonic positioning and geochronology is available in the literature (Lages *et al.* 2019).

The geochemical data obtained for these rocks point to A-type granitoids, and the geochronologic data (ca. 1650 ± 15 Ma) and structural relations point out to intraplate granitic magmatism. These rocks are not the only ones, because there are several other similar bodies still devoid of specific studies that are natural candidates for this classification and geotectonic setting.

Other interesting occurrences are the small tabular bodies of meta-anorthosites, metagabbros, metadiorites (with associated Fe and Ti mineralizations) inserted in the TAM Central-Western portion: “Piranhas Suite” on West of Algodões-Pernambuco (Accioly *et al.* 2011). These are clearly intrusive bodies in the “Floresta Suite” and that were later metamorphosed (Brasiliano structures present as the case of the granites discussed). Direct geochronologic data are not yet available for these bodies.

Outside the outcropping area of TAM, in the basement of Rio Capibaribe Terrane/Belt (Santa Cruz do Capibaribe sheet and neighboring areas) there is a batholith (today augen gneisses) of circa 450 km² of subalkaline and calc-alkaline granites of syeno-to monzogranitic composition, intrusive in the Orosirian gneissic basement, and that is crosscut by Ediacaran granites. This body forms a huge ridge (“Serra de Taquaritinga”), as it is situated in front of a nappe developed in the Brasiliano (northward movement), dipping southwards at

low angles. It was studied and interpreted by Sá *et al.* (2002) as an old A-type granitoid reworked in the Brasiliano. This rock unit yielded a U-Pb discordia age of 1521 ± 6 Ma.

A gabbro-anorthositic complex (stocks, lodes) occurs a little towards to the South of Taquaritinga (vicinities of Passira/PE, ca. parallel 8°00’S), constituted by meta-anorthosites and amphibole gneisses associated with Fe-Ti ore occurrences. This context yielded Late-Statherian ages of -1.7 to 1.6 Ga (according to Accioly 2000).

These occurrences established an important parameter, the confirmation of a (±) stable area — anorogenic, cratonic — from the Late-Statherian to the Calymmian, which succeeded the orogenic stages of the Paleoproterozoic. In this period, the TAM was affected by the intrusion of several granitic and gabbro-anorthositic rocks, that is, a very similar scenario to other areas behaving as continents in these periods in Brazil (*e.g.*, São Francisco and Amazonian cratons) and in the Northern Hemisphere (*e.g.*, in the Trans-Hudsonian domain in North America, and in the Fennoscandian domain, in Greenland, etc.). Besides highlighting the presence of this ample interval of relative stability, we must reiterate that many of these bodies were *a posteriori* intensely reworked during the Neoproterozoic orogenies (post-1,000 Ma).

STRUCTURAL FEATURES

It is not easy nor simple transcribing and encompassing the TAM structural history according to simplistic schemes of folding phases as it is usually done in the Brazilian literature. Initially, considering the extensive outcropping area, we divided it in three geographic-geologic domains (descriptive reasons). Discriminating the events for these three sectors (at the scale we are exposing) linearly — together and separately — is a risky procedure, as we have to admit that there are still many uncertainties. Any advance in this field should be carried out with caution and tolerance.

The pre-Rhyacian (Neoproterozoic) nuclei, in general, present their own distinct structural traits (more than a phase, different from an occurrence to another) related to their long history preceding the Rhyacian accretionary processes. In the migmatitic protoliths (complex metatexites and diatexites), we noticed the presence of many distinct long-lasting structural traits (folding, shearing, foliations, etc.) that cannot be compared and correlated from an outcrop to another. These events will be broadly dealt with as D_{p-1} , which is a simplism from that we cannot escape in face of the present knowledge degree. In the studies regarding the main foliation (in several of the geologic sections presented herein), it is usual to find remnants of folds of these pre-Brasiliano phases.

The rocks of the accretionary and subsequent processes can be treated with less simplism, but with some differences and discretion, from a domain to another (TAM South-Western, Central and Eastern domains). The main deformation (D_p) and foliation (S_p) in this terrane are extremely penetrative in a great part of the area, indicating northward, low-angle movements (especially in the Central and Eastern domains). We can even admit more than one thrusting stage, which reached Riachão do

Bacamarte-São João do Cariri fault zone to the North, thrusting metamorphic and igneous rocks (even) of the Neoproterozoic cycles and also penetrating them, thus configuring a typical scenario of retroarc foreland, as represented in the geologic sections (Figs. 3 to 5), which correspond to the Eastern and Central domains of TAM (this is very clear in Paraíba). In the Western portion of TAM (Pernambuco state), the main foliation (S_p) is folded (D_{p+1}) with different vergences, turning gradually to South and Southwest.

There is a very interesting fact: the main foliation (S_p) penetrates Brasiliano granitic bodies either intensely (e.g., Serra Redonda, Campina Grande) or moderately (Bravo, Sítio dos Nunes, etc.), and the ages of these bodies are relatively well determined (Ediacaran, ca. 580 Ma). Moreover, this foliation penetrates the Tonian supracrustal rocks. Thus, these foliations are associated with the orogenic events of the Upper Neoproterozoic (certainly transposing other foliations of previous deformational cycles). Even if this foliation has previous histories, important movements took place in the Ediacaran (post-580 Ma). The trait of Northward and Northwestward thrusting is very common, as observed in the whole TAM, Central and Eastern sectors, as represented in geologic sections. Within these north-verging structures, there is evidence of Tonian rocks involved (Cariris Velhos Cycle), both in the more Northern sector of TAM and in part to the South (Northern area of Albuquerque Né/PE).

This predominant foliation phase presents convincing structural elements of subsequent events. In the Central and Eastern domains, an ample and open fold is outlined with conspicuous antiformal nature. The BR-230 highway, from Riachão do Bacamarte to João Pessoa, is coincidentally following the axis of an antiform (D_{p+1}), which generally strikes E-W.

In the TAM South-Western domain (entirely within the State of Pernambuco), this folding is a little tighter, forming a series of anticlinal and synclinal folds (D_{n+1} — Sertânia, Algodões, Bandarra, Floresta) and generating a new foliation (S_{p+1}), with the axial plane trending N-NW (Fig. 6), which is a different pattern from that of the Central and Eastern domains. This folding locally develops an interesting axial plane schistosity (S_{p+1}). The characteristics and differences between the South-Western and Central and Eastern domains are striking. We assumed as a working hypothesis the retroarc foreland behavior (represented in Fig. 7, below) for the Central and Eastern domains, and therefore we conclude that the pattern observed in the South-Western domain is associated with accretionary processes situated to the South (not identified in the field), or alternatively it is a consequence of transpressional tectonics (associated with the Congo Lineament, which has been considered an important lithospheric suture, even with striking geophysical data according to Oliveira 2008). Another possibility is the fact that this South-Western sector is too far away (hundreds of kilometers) from the Ediacaran magmatic arc and was not significantly affected by the foreland tectonics.

Besides these stages of main foliation folding (very open in the Central and Eastern portions, and relatively closed in the

South-Western portion), in both cases there is evidence of later shearing associated with the transcurrent faulting/lineaments that delimit TAM, such as Afogados da Ingazeira (West and Northwest) and Congo (South and Southeast) shear zones and their bifurcations (see Fig. 2); São João do Cariri Shear Zone, which delimits TAM to the North and stretches out to the South of Campina Grande (where it juxtaposes with the thrust belt northwards); Taperoá Shear Zone, in which North-Eastward will meet and become parallel to Patos Lineament. This striking set of shear zones that delimit and transect TAM and intercept foliations S_p and S_{p+1} certainly had a polycyclic character. We are relating it to a third deformational phase (D_{n+2}), having in mind that there is a late phase of deformation crosscutting and displacing previous foliations. It is necessary to reiterate that all these mentioned shear zones have been active more than once. Some of them somehow have reached the coastline, where they presented an importance in the development of the Cretaceous basin.

GEOCHRONOLOGIC SURVEYS

The predominance of geochronologic determinations (U-Pb method) in the Rhyacian for the TAM basement is a fact that has been broadly supported by the literature, even before the presentation of data regarding the obtained results (see Van Schmus *et al.* 2011, Santos *et al.* 2010, among others). Our research was favored and even privileged by a new and considerable collection of 1/100,000 geological maps (Fig. 2) of *Companhia de Pesquisa de Recursos Minerais* (CPRM) and and some new contributions from academic theses (USP, UnB, UFRN, UFPE).

Besides this support, the search for older data relied on Sm-Nd determinations. In fact, including our own data, more than 150 determinations cover rocks of the TAM. While executing the major geologic sections transversal to TAM (Figs. 3 to 6), the field observations corroborated our assumptions regarding older lithostructural traits that mainly occurred in migmatitic rocks of complex history, usually recording more than one migmatization event. In general, these nuclei are composed of (ortho- and paraderived) rocks with biotite- and amphibole-bearing mafic paleosome. The intermingled leucocratic contexts (“neosomes”) are usually complex and result from more than one generation phase.

Methodology

The study was supported by thorough field geology work carried out in the last five years, utilizing geologic maps prepared by CPRM at 1:100,000 scale (Fig. 2) and some other available maps at the 1:250,000 scale. In the beginning, samples were collected for Sm/Nd analyses, and the obtained results ($T_{DM} + E_{Nd}$) have been used to select samples for U/Pb (zircon) analyses. These isotope analyses were performed at the laboratories of Universidade de São Paulo (Sm/Nd and partially U/Pb) and at Universidade de Brasília (only U/Pb). Details on the analytical approach used for Sm/N analyses in São Paulo can be found in Sato (1998), and for LA-MC-ICP-MS used in Brasília in Buhn *et al.* (2009).

Obtained Sm-Nd determinations for the pre-Rhyacian rock units

Circa 150 Sm-Nd determinations available for TAM (previous works + our survey) have been discussed in many published studies of local or regional scale (e.g. Van Schmus *et al.* 1995, 2011, Santos 2017, among others).

Regarding the Floresta Suite (s.l.), more than 55% of these data indicate Archean T_{DM} ages, with strongly negative E_{Nd} values (mostly between -20 and -40), and this fact is an excellent guide for the search of older nuclei.

More than 80% of the Sm/Nd data of Sertânia Supergroup point to Archean T_{DM} ages, with negative E_{Nd} values. We will discuss Sm-Nd values obtained for the pre-Rhyacian nuclei that have not been properly addressed yet. Regarding the Sertânia Supergroup, a great number of data is also available (for example, in Santos 2012, 2017, among others).

In Figure 8, we present a selection of Sm-Nd data obtained for the main Archean nuclei identified in our research (Fig. 1). We have observed a group of parallel (to subparallel) straight lines intercepting the depleted mantle curve (DePaolo *et al.* 1991) between 2.5 and 3.1 Ga, yielding E_{Nd} values between -21 and -46.

U-Pb obtained determinations for the pre-Rhyacian rock units

With the preliminary support of Sm-Nd data, we were able to identify a dozen pre-Rhyacian ages in the three TAM sectors. Neoproterozoic ages predominate in these older rocks.

For the Eastern sector of TAM there is an enormous series of Sm-Nd data and two pre-Rhyacian ages (Brito Neves *et al.* 2001, Santos *et al.* 2013), all of them from the Central-Southeastern area of Paraíba (Ingá-Itatuba-Itabaiana surroundings). In the first case, a few points of a migmatized orthogneissic complex were dated by the TIMS method ($T = 2,393 \pm 110$ Ma). In the second case, there was a “Salvador” banded hornblende biotite augen-orthogneiss, exhibiting mafic-felsic mingling patterns and originating from a rock geochemically characteristic of a magmatic arc. A metasedimentary rock unit with limestones (brecciated lenses) was dated by the TIMS method. The zircon

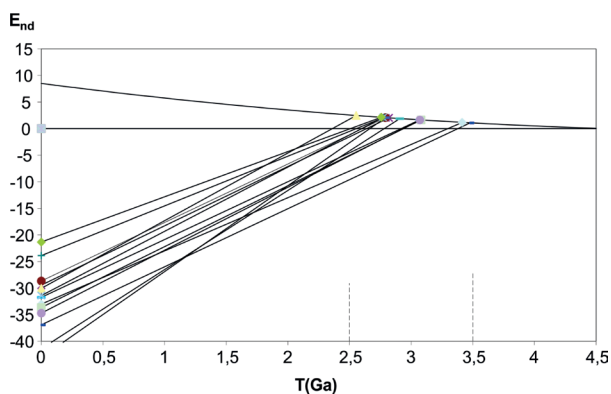


Figure 8. Nd evolutionary diagram for the main pre-Rhyacian nuclei identified for Alto Moxotó Terrane (TAM). A set of parallel straight lines, mostly intercepting the depleted mantle curve between 2.5 and 3.5 Ga has been observed. The E_{Nd} values obtained in this study varied from -21 to -3.5. The highest values, on the right of the diagram, correspond to the so-called “Riacho das Lages Complex” (Santos *et al.* 2017), Airi region (PE). See concordia diagrams (next figures).

nuclei (igneous origins) yielded an age of 2308 ± 23 Ma (cores) and metamorphic overgrowth (rims) ages of $T = 2012 \pm 17$ Ma and $T = 1953 \pm 19$ Ma (these Orosirian metamorphic ages do not frequently appear, as already commented). The T_{DM} ages obtained for these rocks are of the order of 2000 to 2500 Ma.

In the past, several authors alluded to the presence of Archean rocks in the central sector of TAM, still devoid of any geochronological data. Currently, in this Central-Southern sector of Paraíba (between the meridians $35^{\circ}00'W$ and $37^{\circ}00'W$), we found the greatest number of Archean nuclei, whose samples will be further presented and discussed (Fig. 9, sample PAPE 36, as a good example). In the South-Western part of TAM (in Pernambuco), despite previous mapping indicating Archean rocks, around four or five occurrences have been identified yet (Figs. 10 to 17).

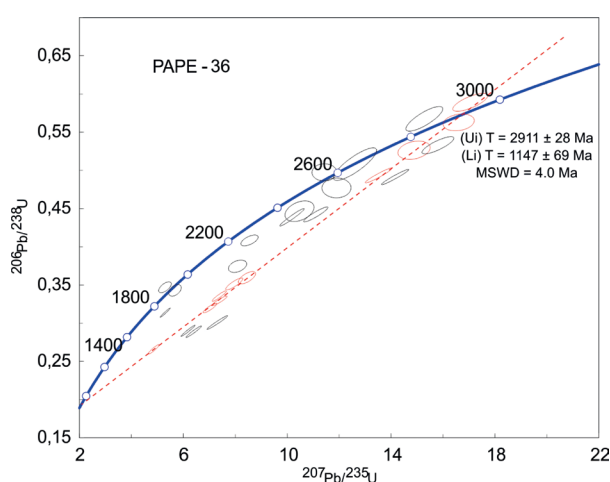


Figure 9. PAPE 36 — Concordia diagram for Fazenda Oiti migmatitic complex, North Itatuba-PB. Upper intercept indicates an age of 2911 ± 69 Ma (error ca. 2.3%) and $MSWD = 4.0$. The value of the lower intercept (1147 ± 28 Ma) has no tectonic significance (in our opinion). This Mesoarchean age of the easternmost sector of Alto Moxotó Terrane (TAM) is special, no similar ages have been found in this or in any other sector. It must be further checked.

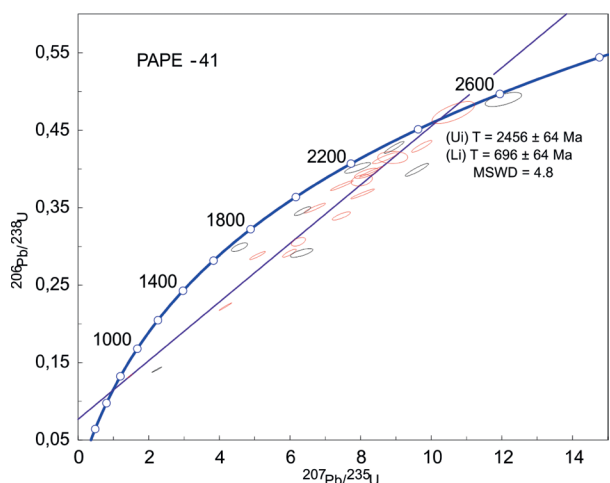


Figure 10. PAPE 41 — Concordia diagram for the zircons of extremely banded and sheared gneisses (“stromatic structure”) from Parari, East of São João do Cariri (Paraíba). Upper intercept indicates an age of 2456 ± 64 Ma, chosen according to the best set of points (error ca. 2.6%). The error of the lower intercept is large and must be related to radiogenic Pb losses (Brasiliano overprinting).

Sm/Nd determinations for the Floresta Suite rock units

As mentioned, more than 55% of the lithologies sampled in this suite (by different authors) yielded Neoproterozoic T_{DM} ages, in a general scenario for all TAM sectors. We observed a very interesting result in the Nd evolutionary diagram for the Floresta Suite rocks, with main sampling in the Eastern and Central sectors of TAM, as described in Fig. 18.

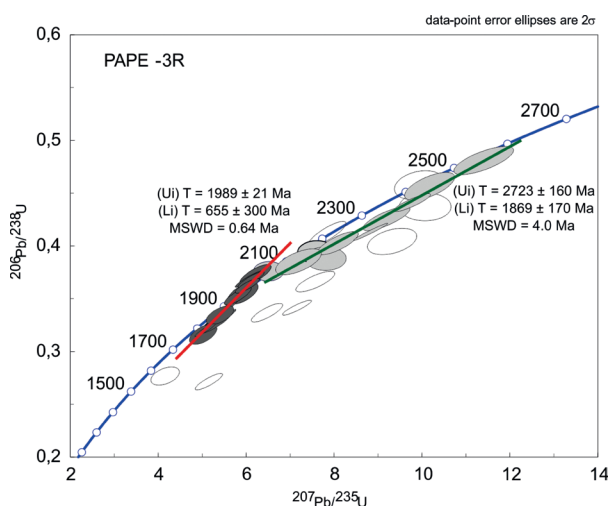


Figure 11. PAPE 3R — Concordia diagram for the zircons of an extremely banded and sheared gneiss (such as PAPE 41, above), 17 km South of Boa Vista (Paraíba). Two cords are identified: the first of 2723 ± 160 Ma (error ca. 6%) is attributed to the formation of melanosome protoliths, with MSWD = 4.0. Another cord is well marked with an age of 1989 ± 21 Ma (error ca. 1%). We attribute this cord to a possible superposition of an Orosirian regional metamorphism, as already commented in the text.

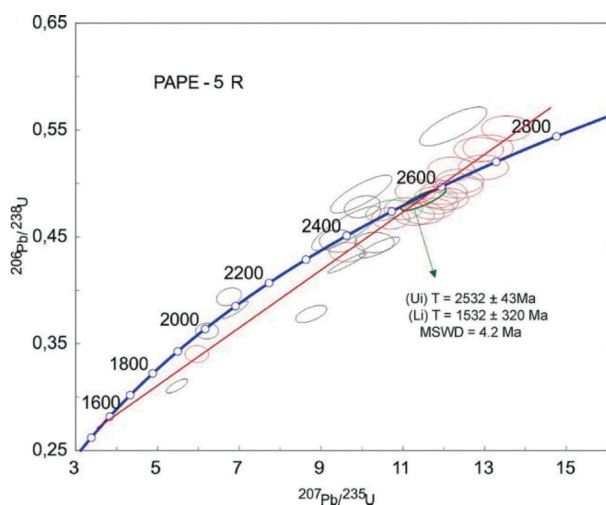


Figure 12. PAPE 5R — Concordia diagram for the migmatitic complex (in part paleosome samples, probably of metasedimentary origin) of Sítio Aconchego (Boqueirão municipality, Paraíba). Two cords could be drawn, the former with an age of 2532 ± 31 Ma (error ca. 1.2%) with MSWD = 2.3, which we attribute to the protolith portion. The latter indicates an age of the order of 1530 Ma (with a large error) that could be related to a probable late metamorphic event (Orosirian? Brasiliano?).

U/Pb determinations for the Floresta Suite rock units

Several previous works presented U/Pb geochronologic determinations for the Floresta Suite, with an indication of a mainly Rhyacian ages for this unit. Sometimes a superposition of Orosirian values in the concordia diagrams was observed.

Firstly, we will point out from our surveys an unusual lithologic context, which is the sheared gneiss of anorthositic

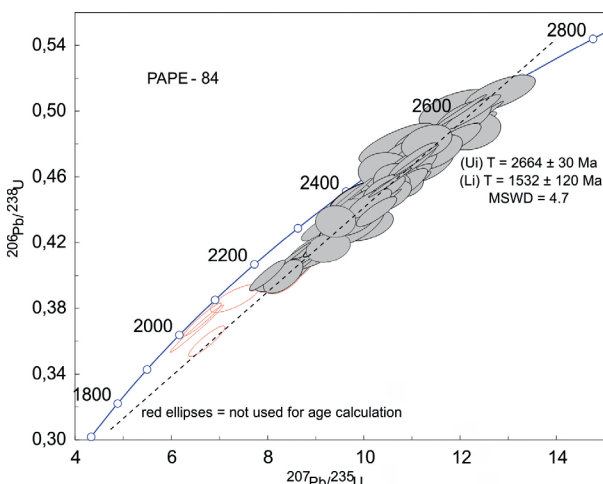


Figure 13. PAPE 84 — Concordia diagram drawn with varied samples from Pedreira Carlos (Boqueirão municipality-Paraíba), which is a very complex migmatitic context both in phases and structures, with different types of protoliths (hornblende biotite gneisses, meta-quartzdiorites, metadiorites, etc.). The obtained alignment is of good quality, in which the upper intercept indicates an age of ca. 2674 ± 30 Ma (error ca. 1.1%), MSWD = 4.7. There is indication (not complete) of a lower intercept for an age of ca. 1532 Ma (with a large error). Like in Figure 11 this could be indicating superposition of late Paleoproterozoic or Neoproterozoic metamorphism.

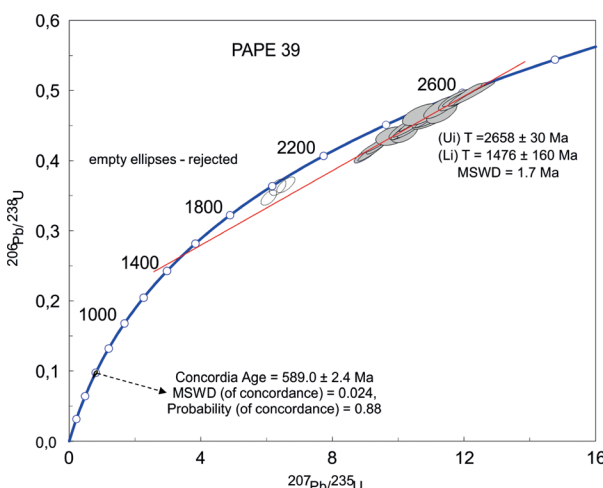


Figure 14. PAPE 39 — Concordia diagram for the finely banded (stromatic structure) migmatitic complex (hornblende-and biotite-bearing paleosome), cropping out at a roadcut 17 km East of Monteiro-Paraíba. The main cord indicates (upper intercept) an age of 2658 ± 30 Ma (error ca. 1.2%, MSWD = 1.7), of excellent quality. The lower intercept does not seem to have geological significance (related to Brasiliano events?). Some Brasiliano data are observed in the lower part of the diagram. It is worth noting that even using the Rb-Sr method, this age was preserved in the outcrop.

composition of Boqueirão Dam spillway in Paraíba (Fig. 19). Secondly, we will show data from Rhyacian units completely rejuvenated in the migmatization and shear events of the Brasiliano Cycle (somehow preserving the original age, Figs. 20 to 22).

A similar behavior (reworking) to that of Figs. 20 and 21 was later found to the North of the geologic section of Figure 5, in Fazenda Melancias, East of Vila de Grossos (Figs. 22 and 23), where a diatexitic rock crops out very close to the N-trending thrusts. Similarities were found in the field between two sampled units (reason for such sampling).

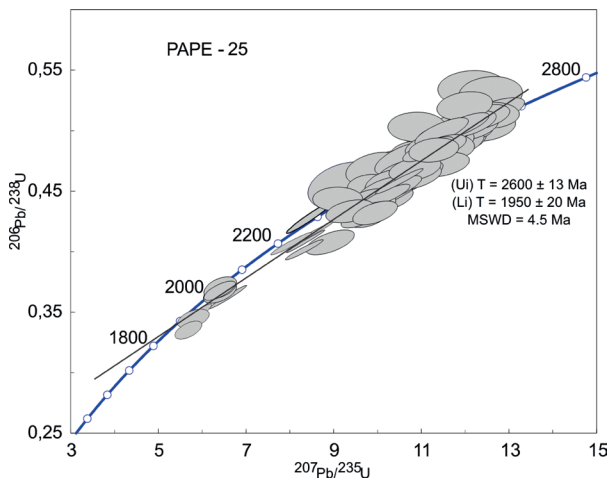


Figure 15. PAPE 25 — Concordia diagram for the quartz-dioritic orthogneiss that constitutes the paleosome of a complex migmatite from a cut of the Transposition Channel close to Custódia (Pernambuco). The upper intercept indicates an age of 2600 ± 13 Ma (error ca. 0.5%). A lower intercept (ca. 1950 Ma) could be drawn (it does not seem adequate to indicate an age), probably suggesting superposition of Orosirian events.

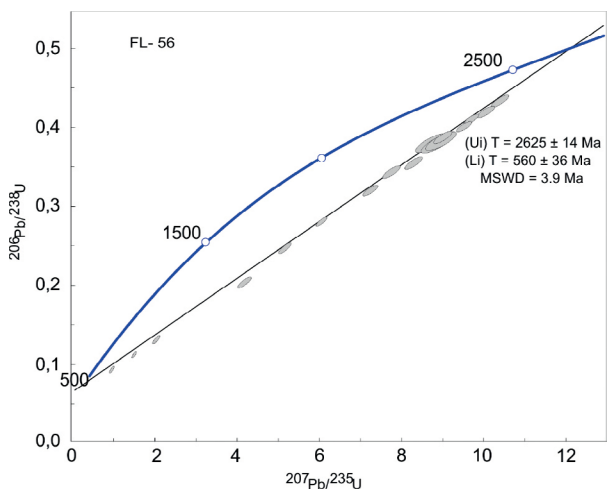


Figure 16. FL-56 — Concordia diagram for the coarse-grained metatonalite of the proximities of Airi (South-Western portion of TAM), informally attributed to “Riacho das Lages Complex” (Santos 2017). The upper intercept indicates an age of 2625 ± 14 Ma (error ca. 0.5%, MSWD = 3.9), and the lower intercept shows an age of 560 ± 36 Ma, which probably corresponds to the overprinting of the Brasiliano Cycle.

Sm/Nd determinations for Sertânia Supergroup rock units

Regarding the Sertânia Supergroup, we were surprised with a great amount of Archean T_{DM} ages, comprising more than 75% of the data published in the last decade. The samples we collected along the three sectors of TAM yielded T_{DM} ages mainly between 2.0 and 3.1 Ga, with age distribution more or less equitable between the two eras (Paleoproterozoic and Neoproterozoic), as in Fig. 24.

U/Pb determinations for Sertânia Supergroup rock units

Sertânia Supergroup still presents problems when determining its Paleoproterozoic age, which was initially defined by

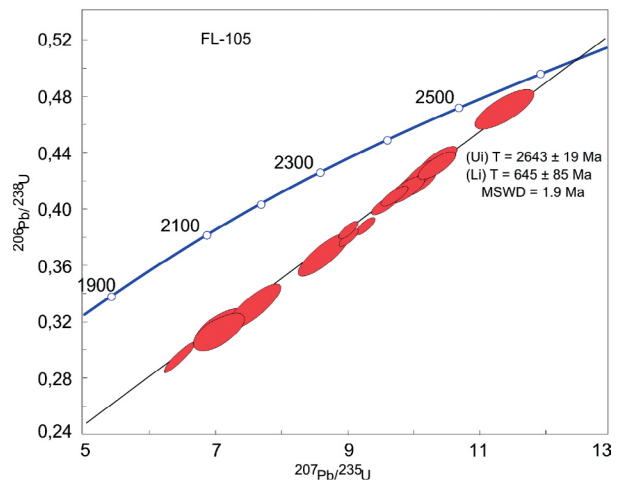


Figure 17. FL-105 — Concordia diagram for the banded meta-granodiorite of the proximities of Airi (SW Pernambuco), attributed to “Riacho das Lages Complex” (Santos 2017). The upper intercept indicates an age of 2643 ± 18 Ma (error ca. 0.7%), and the lower intercept an age of 645 ± 85 Ma, attributed to Brasiliano events. The obtained MSWD was 1.9, reiterating the good quality of the diagram.

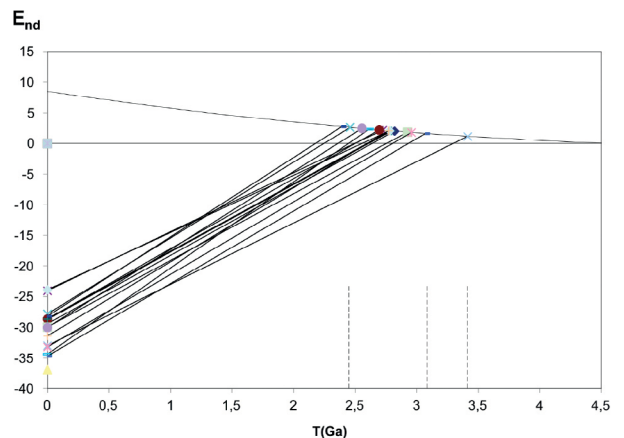


Figure 18. Nd evolutionary diagram for the Floresta Suite rocks (Eastern and Central sectors of Alto Moxotó Terrane (TAM). The resulting scenario is a harmonic group of almost parallel straight lines intersecting the depleted mantle curve between 2.45 and 3.1 Ga (100% of the lines), which very much resemble the results obtained with the pre-Rhyacian nuclei (Fig. 7). The differences are the better harmonic arrangement of the evolutionary line. E_{Nd} values are between -25 and -35, showing a relatively long crustal residence time. Just one line intercepts the mantle curve at ca. 3.4 Ga.

Santos *et al.* (2004) with data obtained from felsic metavolcanics in the South of the central sector of TAM (South of Queimadas-Paraíba). However, there have been contestations along the years motivated by probable younger (up to the Neoproterozoic) metasediments found in lithostratigraphic units that were being mapped as Sertânia. The geologic control is not good. Therefore, we made a point to look for outcrops with igneous rocks intercalated with metasediments in order to support the presented determinations. Thus, two Rhyacian and two Orosirian results are consigned for such rocks. However, we understand that there are difficulties in reaching a definitive solution to the problem, as already discussed.

ALTO MOXOTÓ TERRANE AND COLUMBIA

We have demonstrated the presence of pre-Rhyacian, Rhyacian and Orosirian tectonostratigraphic units and important records of Sthaterian-Calyminian anorogenic plutonism. In addition, we showed the data we obtained in the last five years. These data are somehow very similar (and comparable) with those we know of the South American (Brasiliano) cratons and those of the Northern continents.

The expectations, hypotheses and theories regarding the agglutination of continental masses (physical assemblies and/or important connections) are themes of large debate and have

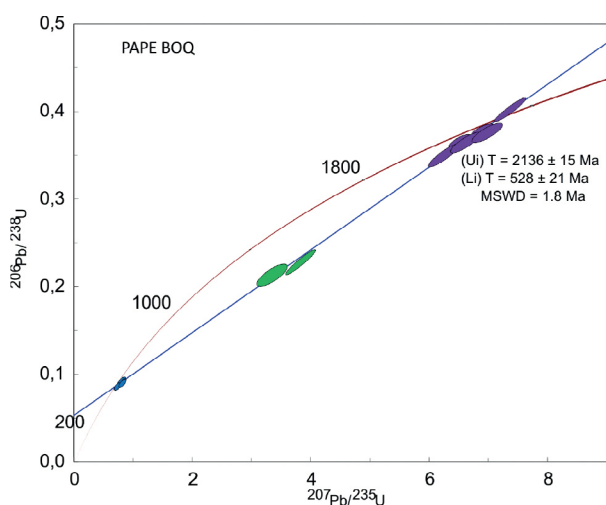


Figure 19. PAPE BOQ — Concordia diagram drawn for the (intensely) sheared anorthositic orthogneiss from the spillway of Boqueirão Dam (Epitácio Pessoa, SE of Paraíba). The upper intercept indicates an age of 2136 ± 15 Ma (attributed to intrusion or to the first metamorphism), and the lower intercept an age of 528 ± 21 Ma (attributed to the Brasiliano tectonism). The MSWD of 1.6 attests the quality of results.

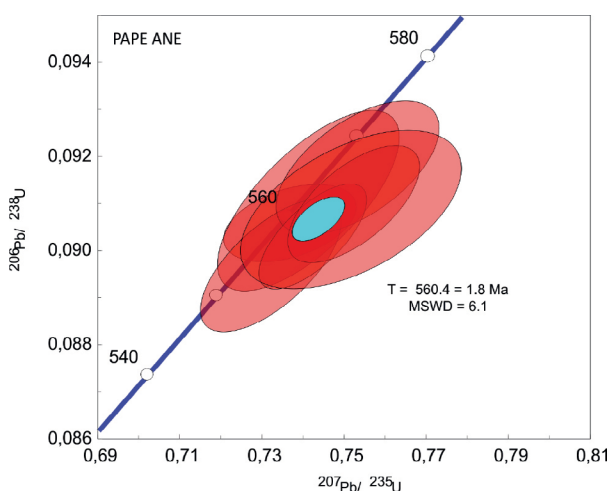


Figure 21. PAPE ANE 2 — Concordia diagram drawn for Albuquerque Né diatexite (see Fig. 19), with emphasis on many points clustered around the lower intercept. This group points to an age of 560 ± 1.8 Ma (error ca. 0.35%) and MSWD = 6.1. This shows a substantial rejuvenation affecting this Paleoproterozoic diatexite (see Fig. 19) during the Brasiliano Cycle (Ediacaran) events.

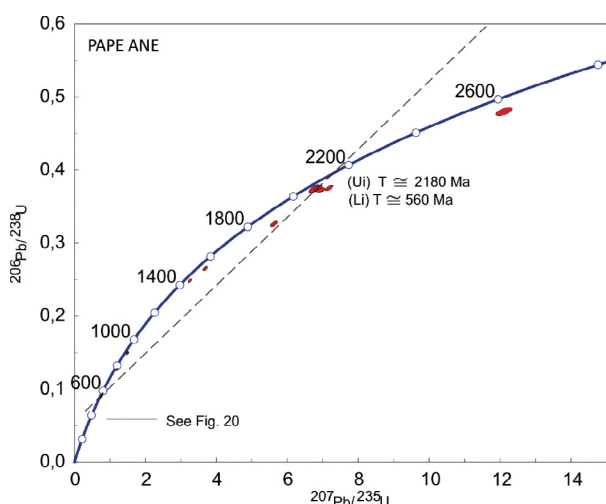


Figure 20. PAPE ANE1 — Concordia diagram for the laminated thin diatexite that occurs in Albuquerque Né (Pernambuco) at South of the geologic section in Figure 5. In the distribution of sub-concordant points (continuous loss of Pb isotopes since 2200 Ma), it is possible to estimate a cord with upper intercept around 2180 Ma and a lower intercept around 550 Ma (Brasiliano events), according to the best exposed points as it possible to see in the next Figure 20.

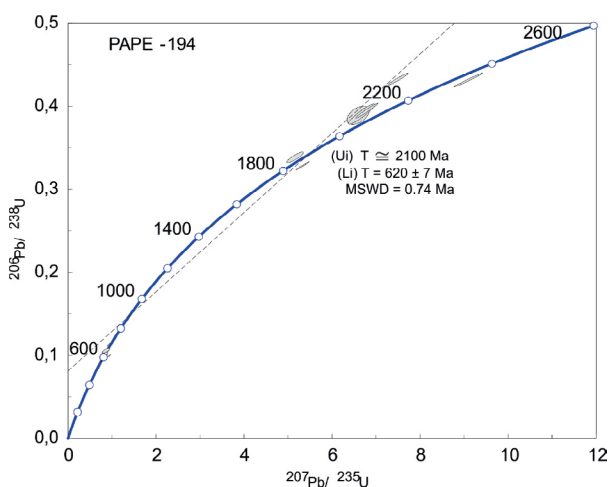


Figure 22. PAPE 194a — Concordia diagram for the sheared fine diatexite of Fazenda Melancias (East of Village of Grossos, Fig. 5, South of São José do Egito). The distribution of points is sub-concordant from 2100 Ma, with ample concentration around 600 Ma. For this diagram, it was possible to draw a cord from the upper intercept at ca. 2100 Ma (considering the lower intercept at ca. 620 Ma). The data concentrated close to the lower intercept will be seen and discussed in Figure 23.

been the recurrent mark of discussions since the last decade of the last century (Figures 25 to 30). These insights (and propositions) have started with different suggestions involving the end of the Neoproterozoic. Several scientific meetings and work groups have been formed (since the 1990s) in order to reach a global consensus (which has not always been possible).

Regarding the worldwide agglutination of continental masses at the end of the Paleoproterozoic, many schemes and designations have arisen (“Atlantica”, “NENA”, “Hudsonia”, “NUNA”, “Columbia” etc.). We can affirm that in the first decade of this century, there was a huge progress in the studies of this super-agglutination of continental lithosphere with many outstanding proposals (Rogers and Santosh 2004, Zhao *et al.* 2002, Lahtinen *et al.* 2008, and the recent revision of

Meert and Santosh 2017, etc.). The formation of this huge continental mass at the end of the Orosirian orogenies called considerable attention, even if the agglutination schemes varied substantially (as expected) and many names were assigned to it (as anticipated above). The designation “Columbia” (Rogers and Santosh 2004, Zhao *et al.* 2002) has been the most published, but the theme and the schemes of evolution continue to progress (Meert and Santosh 2017, Lahtinen *et al.* 2008).

This alleged (pre-Statherian) continent was conceived by means of the development of a branched global chain of Paleoproterozoic (mostly collisional) orogenies. This supercontinent had a long history (ca. 600 Ma) with distinct geological records and some striking characteristics, today disposed and exposed in the world main continents (inside varied orogenic

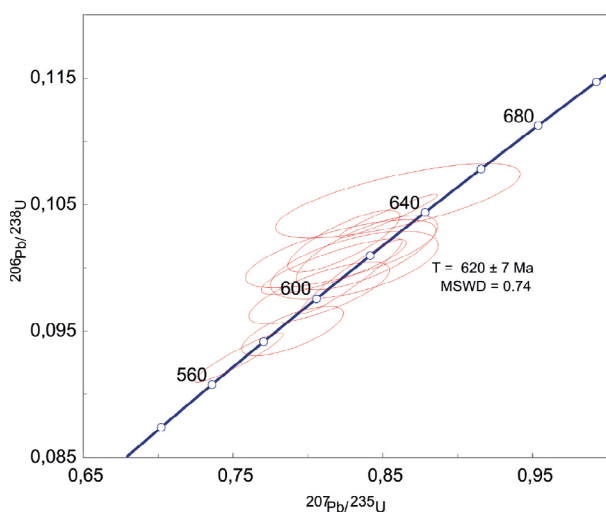


Figure 23. PAPE 194b — Concordia diagram drawn for the diatextite of Fazenda Melancias, considering the great concentration of points marking the lower intercept (see Fig. 22). With these data it is possible to draw a cord indicating an age of 620 ± 7 Ma (error ca. 1.2%) and $MSWD = 0.71$. This age (lower Ediacaran) points to pervasive reworking along the Brasiliano Cycle, which has affected this diatextite, originally Paleoproterozoic in age.

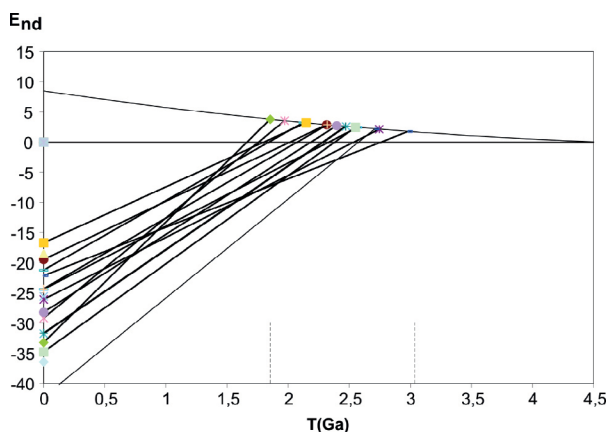


Figure 24. Nd evolutionary diagram for the Sertânia Supergroup. The group of straight lines is very irregular (varied sources — metasedimentary and metaigneous rocks), in which three more or less distinct groups could be discriminated. These straight lines are intercepting the depleted mantle curve between 1.8 and 3.1 Ga and signaling E_{Nd} values from -17 to -45, attesting a long crustal residence.

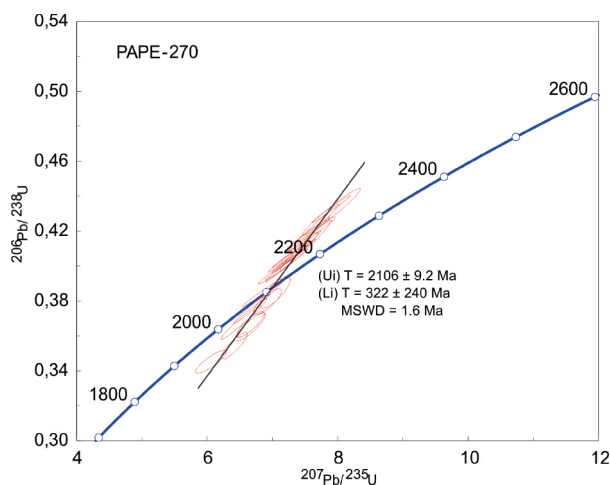


Figure 25. PAPE 270 — Concordia diagram for the banded meta-gabbro intercalated in Sertânia sequence, with clearly preserved magmatic banding ($S_0 // S_p$). The outcrop is located South of Salgado do São Felix-Paraíba. The well-marked age in the upper intercept is 2106 ± 10 Ga (error ca. 0.4%), $MSWD = 1.6$. The lower intercept does not seem to have geologic significance (ca. 322 ± 240 Ma), besides the very high error.

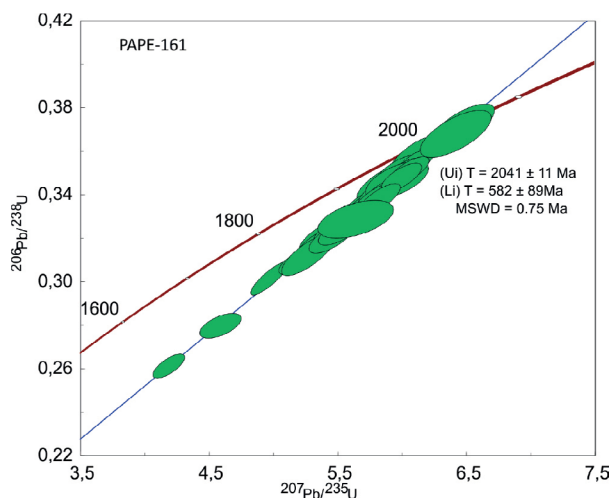


Figure 26. PAPE 161 — Concordia diagram for bimodal felsic metavolcanic rocks intercalated with Sertânia metasediments, Rio da Barra/Pernambuco. The upper intercept indicates an age of 2041 ± 11 Ma, with lower intercept without apparent geologic meaning (see very high error).

fabrics from the the pre-Ectasian). Some characteristics and lithostructural contexts of this long history expose very typical records and have been discriminated in the basement of several continents. Particularly in this portion of the Borborema Province, the Transversal Zone (not only) and along the development of TAM, we came across many chapters of this history. It would be interesting to mention and try to interpret (recapitulate) the following characteristics:

- South America and Western Africa are always conspicuously agglutinated in all reconstitutions of Columbia;
- There is previous history of important Archean nuclei in fission processes (2.4 to 3.3 Ga, Lahtinen *et al.* 2008) and

subsequent fusion processes, followed by important accretionary phenomena (rhyacian times) and a subsequent collisional history;

- A complex network of accretionary orogenies in the foreground (Rhyacian period), and later strikingly collisional more extensive and impressive (Orosirian period), of evident and ample recollection in the whole world (Trans-Hudson, Fennoscandia, Eburnean, “Trans-Amazonian”, Barramundi, etc.). These late Proterozoic tectonic events were responsible for this super-agglutination or fusion (of worldwide repercussion);
- The lengthy Statherian to Ectasian history has been considered as intraplate or intracratonic activity *par excellence*

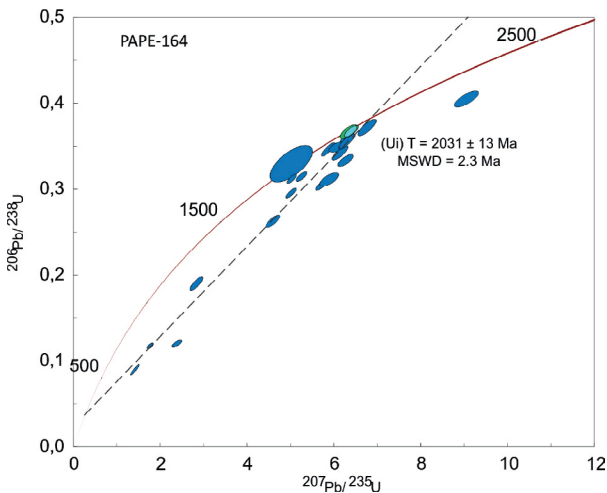


Figure 27. PAPE 164 — Concordia diagram drawn for the orthogneissic sill intercalated with mesozonal biotite gneisses, collected in the flanks of Henrique Dias railway (North of Arcoverde-Pernambuco). The age given by the upper intercept is 2031 ± 13 Ma (error ca. 0.64%, MSWD = 2.3). The lower intercept with no apparent geologic meaning radiogenic losses, very high error.

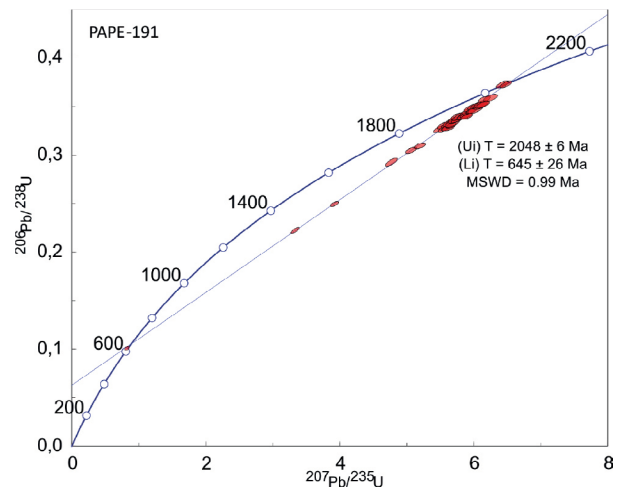


Figure 29. PAPE 191 — Concordia diagram for the biotite schists located 12 km South of Tuparetama-Pernambuco (see Fig. 5). The upper intercept once again points out an age to the Upper Rhyacian–Orosirian limit, 2048 ± 6 Ma (error ca. 0.3%, MSWD = 0.99). The lower intercept points out an age of 645 ± 26 Ma, attributed to the Brasiliano Cycle events (the North-trending nappism of this the area is striking).

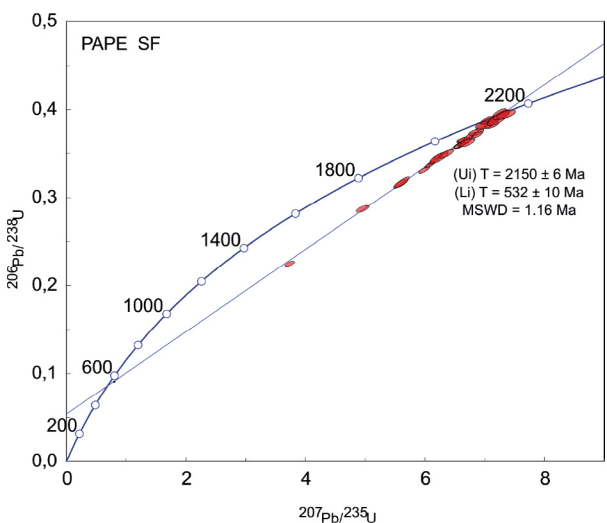


Figure 28. PAPE SF — Concordia diagram drawn for the coarse-grained (meta-clastic) schist of Serra do Fogo, 18 km South of Monteiro-Paraíba, on the flank of an ample synform of Sertânia Supergroup, probably part of the basal fractions of this unit. The upper intercept indicates a Rhyacian age of 2150 ± 6 Ma, and the lower intercept an age of ca. 532 ± 10 Ma (attributed to Brasiliano events).

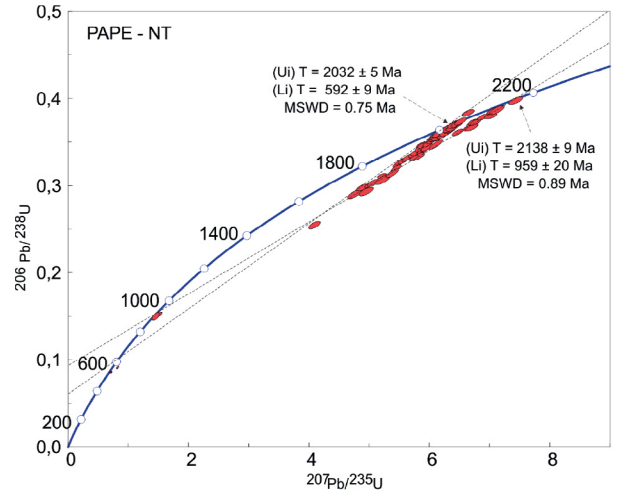


Figure 30. PAPE NT — Concordia diagram for the biotite schist located North of Tuparetama (see Fig. 5). Two cords were drawn, the older with an age/upper intercept at 2138 ± 9 Ma (presumably Rhyacian original age) and the lower intercept at 592 ± 9 Ma (Brasiliano Cycle). The other cord points to an age of 2032 ± 5 Ma that is probably related to an Orosirian regional event, with lower intercept pointing at 959 Ma, which (in our opinion) is devoid of geologic significance (it could somehow be a mark of Cariris Velhos Cycle).

(geocratic systems), according to the presence of moderately folded sedimentary covers and magmatism (varied granites, gabbros, gabbro-anorthosites, etc.);

- A diachronic fission history started from the Stenian to the Tonian, which came to be built by a worldwide network of collisional orogenies (Grenville, Sveconorwegian, Aguapeí, Cariris Velhos, Ghats, Albany/Fraser, Namaqua-Natal, etc.). They were certainly not absolutely chrono-correlated processes or exactly coeval, but they were a geologic-structural milestone present in all continents during the fusion of the Rodinia supercontinent (completed ca. 900 Ma);
- The history of Rodinia, its later fission (= Gondwana, Laurentia, Baltica, Artica) and the development of a network of Neoproterozoic mobile belts are well known, with special records in the meridional continents (Africa and South America).

In the TAM, we have well-preserved records of this Columbia agglutination history, such as: its Archean nuclei branching Paleoproterozoic belts (Rhyacian accretionary); Orosirian collisional orogenies; and records of its long-lasting evolution during the post-Orosirian, with well-marked igneous interferences (from the Statherian to the Calymmian). In the Tonian, there was the installation of fission (volcaniclastic rocks) and fusion processes that certainly contributed to the diachronic agglutination of Rodinia. TAM, as some other tectonostratigraphic terranes of the Transversal Zone and Borborema Province worked, as a whole, as “structural highs” (basement inliers), notably branching the layout of the Neoproterozoic orogenies.

ARTICLE INFORMATION

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B.B.B.N. took part in all field trips and sampling for geochronological dating in this study and wrote the manuscript. W.R.V.S. participated in some of the field trips and played a fundamental role in the discussion of isotope data, and their tectonic interpretation and reviewed the manuscript text. L.C.M.S. took part in some of the field trips and provided us some unpublished data from his recent doctoral thesis and reviewed the manuscript text.

Competing interests: The authors declare no competing interests.

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The Archean, Paleoproterozoic and Mesoproterozoic evolutionary histories in the Borborema Province in general, consonant to the TAM expositions (+ Nigeria + Cameroon) in South America and Africa, are notorious and noteworthy, without undoing the final chapters of the Precambrian, where this identity is still assured. Figure 7 tries to show the steps of this evolution, according to what has been exposed in this last item and in the previous ones.

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