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# Depositional ages of Paleozoic and Mesozoic pre-rift supersequences of the Recôncavo Basin in northeastern Brazil: A Rb–Sr radiometric study of sedimentary rocks

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ABSTRACT

The relative dating of sedimentary rocks can be carried out either from fossils or by stratigraphic correlation. In the absence of fossil content with unequivocal age significance, or in cases in which correlations are neither possible nor conclusive, the task of estimating the depositional age of a sedimentary rock is inviable. Rb–Sr whole-rock isochron method, combined with granulometric and X-ray diffraction studies, has been successfully used to date the deposition of fine-grained sedimentary rocks. In the present study, samples of argillites and siltstones of the Paleozoic and pre-rift sections of the Recôncavo Basin, in the northeastern coast of Brazil, have been investigated. Samples from the Afligidos (Cazumba Member), Aliança (Capianga Member) and Itaparica formations, yielded ages of 290 ± 21 Ma (Permian), 224 ± 32 Ma, and 226 ± 6 Ma (Neotriassic), respectively, which were interpreted as their original depositional ages. The age results for the units of the pre-rift section (Aliança and Itaparica formations) present significant implications to the paleogeographic model previously established for the Recôncavo Basin and other correlated basins, since these sedimentary units were traditionally considered to be Neojurassic.



## 1. Introduction

Relative dating of sedimentary rocks can be achieved either from their fossil content or by stratigraphic correlation. In the cases in which fossil content with unequivocal age significance is absent, or when stratigraphic correlations are neither possible nor conclusive, the task of estimating the depositional age of a sedimentary rock becomes inviable. Radiometric dating techniques usually applied to igneous and metamorphic rocks have been used to date either the depositional or the diagenetic age of fine-grained sedimentary rocks (Cordani et al., 1978; Thomaz Filho and Lima, 1979; Silva et al., 2006a).

Rb–Sr radiometric dating of sedimentary rocks has achieved geologically significant results, when some constraints are observed, such as: stratigraphic control of the samples, low silt/clay ratio, and mineralogy of the fine fraction of samples rich in expansive clay minerals (smectite, interstratified illite-smectite and degraded illite) (Whitney and Hurley, 1964; Byscae and Dasch, 1971; Cordani et al., 1978; Morton, 1985; Mizusaki, 1992). Although there are still some questions regarding the use of this technique for sedimentary rocks, many significant results have been described in the literature (Clauer, 1979; Mizusaki et al., 1998, 2002; Silva et al., 2006b).

The Brazilian continental margin is an example of a passive continental margin, in which the tectono-sedimentary phases of pre-rift, rift, and drift are well known. A classical pre-rift example is the basal section of the Recôncavo Basin, which does not include the necessary elements to support the precise biostratigraphic dating of the sedimentary units due to the endogenous nature of the non-marine ostracod micropaleontological content, associated with sparsely varied and low palynomorph content (Arai et al., 1989).

A Paleozoic sequence is also described in this basin (Silva et al., 2007), with units deposited under arid paleoclimate in an intracratonic basin context before the pre-rift stage. The ages assigned to

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the Paleozoic are also subject of discussion due to their poor fossil records (Milani et al., 2007).

Given the importance and significance of determining absolute ages of the Paleozoic and pre-rift sedimentary sections, which serve as a link to sections with international references, it seems to be interesting to follow this line of research.

In this regard, we analyzed samples of fine-grained siliciclastic rocks from the Paleozoic and pre-rift sections of the Recôncavo Basin, a geologically well known region, but with large gaps of knowledge with regard to the depositional ages.

## 2. Basal section of the Recôncavo Basin

The Recôncavo Basin is located in northeastern Brazil and it is exposed over an area of 11,500 km$^2$ (Fig. 1). It is limited to the north and northwest by the Aporá High, to the south by the Barra fault system, to the west by the Maragogipe Fault, and to the east by the Salvador fault system.

The structural configuration of the basin is related to extensional stresses resulting from the breakup of Gondwana during the Early Cretaceous, bringing about the opening of the Atlantic Ocean and the development of the Brazilian continental margin.

The tectono-sedimentary development of the Brazilian continental margin from the Gondwana Mesozoic breakup (called Wealdenian Reactivation, Almeida, 1967), has been described by different authors (e.g. Asmus and Porto, 1980; Chang et al., 1990).

According to Silva et al. (2007), the sedimentary package of the Recôncavo Basin is formed by four supersequences: Paleozoic, pre-rift, rift, and post-rift. In the present study the sedimentary units of the Paleozoic and pre-rift supersequences, representing the basal portion of the basin, are investigated (Fig. 2).

In the Paleozoic supersequence, the studied unit is represented by the Cazumba member of the Afligidos Formation. It was deposited in an intracratonic basin under arid paleoclimate. The facies associations that characterize the Paleozoic units represent a regressive trend, with transition from shallow, marginal marine sedimentation to isolated evaporite basins, continental *sabkha* environments and, lacustrine systems (Aguiar and Mato, 1990). In the Cazumba Member, red lacustrine pelites and mudstones prevail, with anhydrite nodules at the base of the section. The age of the Cazumba Member is subject of discussion due to its poor fossil record. According to Caixeta et al. (1994), the deposition of the Afligidos Formation is limited to the Permian.

The pre-rift supersequence comprises deposits related to the initial stage of the crustal flexure. The sedimentary package accumulated in a broad and shallow basin of flexural origin; the origin of this depression is tectonically associated with the large-scale extensional process that led to the rift phase and continental rifting. At the time of the pre-rift sedimentation, normal faults were still rare and dislocations were inexpressive. The pre-rift supersequence corresponds to the Afro-Brazilian Depression of Cesero et al. (1972, *apud* Cesero and Ponte, 1997) and includes continental sediments, corresponding to fluvial deposits locally

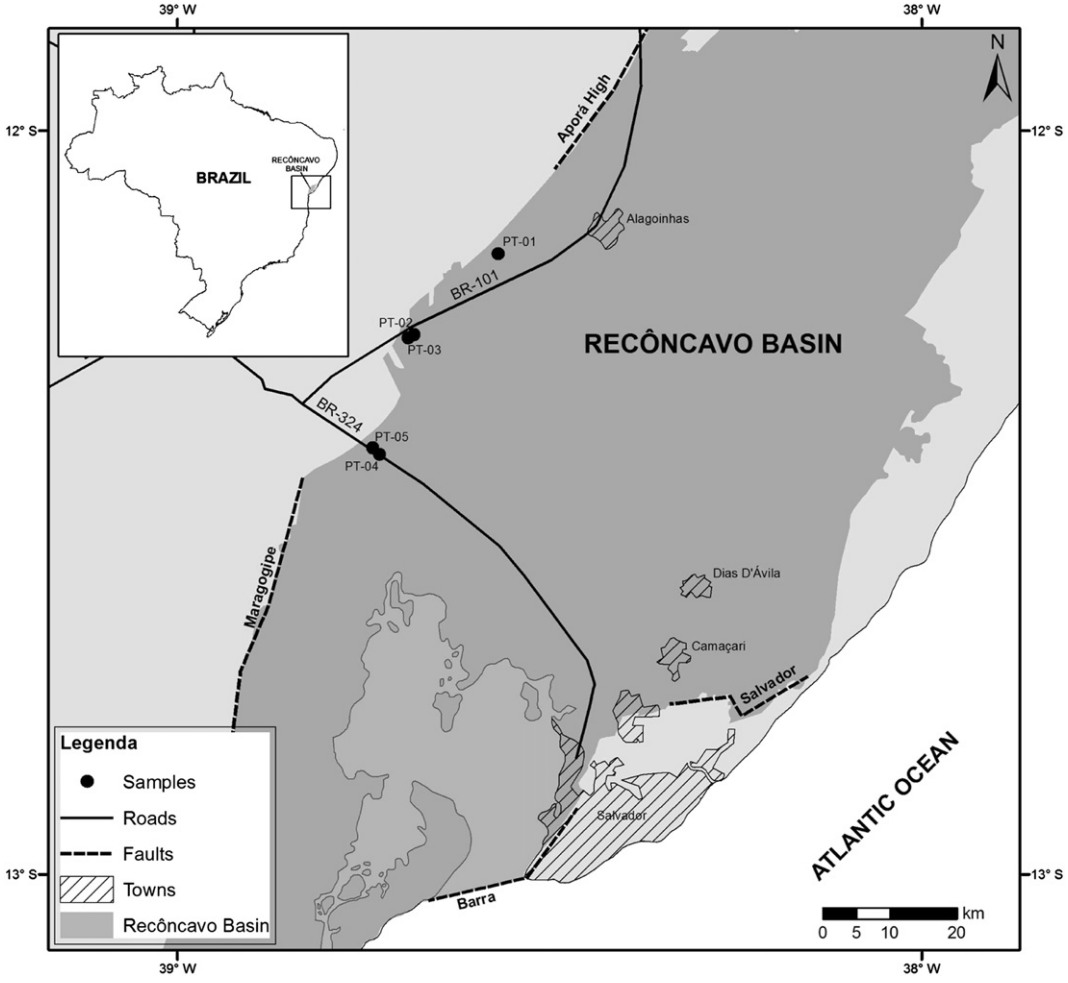


**Fig. 1.** Map of the Recôncavo Basin and location of the sampling sites.

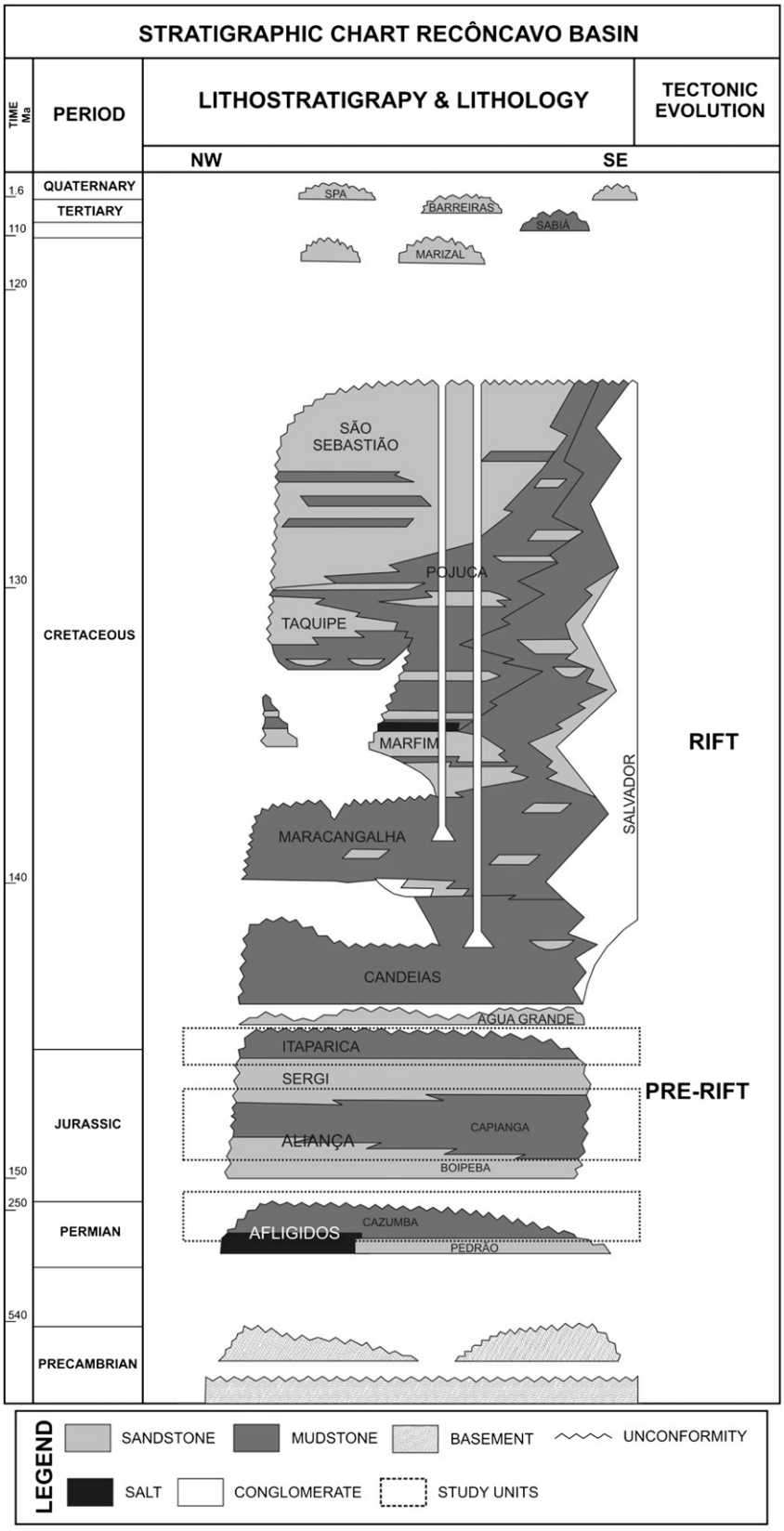


**Fig. 2.** Stratigraphic chart of the Recôncavo Basin (modif. from Pierini et al., 2010).

reworked by wind, as well as very shallow lacustrine deposits, all with red bed features.

According to the lithostratigraphy, the pre-rift section of the Recôncavo Basin corresponds to the Brotas Group and partially to the Santo Amaro Group. The Brotas Group includes the Aliança (Boipeba and Capianga members) and Sergi formations, whereas the Santo Amaro Group includes the Itaparica and Água Grande formations (Fig. 2).

According to Silva et al. (2007), the pre-rift sedimentation comprises three big fluvial–aeolian cycles, represented, from the base to the top, by the Boipeba Member and the Sergi and Água Grande formations. Regional lacustrine transgressions separate these cycles and are expressed by a predominantly pelitic sedimentation, which characterizes the Capianga Member (Aliança Formation), and the Itaparica Formation.

The Aliança Formation is stratigraphically correlated to the Bananeiras Formation of the Sergipe-Alagoas Basin, and, therefore considered to be of Neojurassic age due to its non-marine ostracod content, which, in this case, corresponds to the RT-001 biozone, Dom João Stage of the Recôncavo Series (Viana et al., 1971). According to Silva et al. (2007), the Itaparica and Água Grande formations are of Early Cretaceous (Early Berriasian) age, as indicated by micropaleontological data.

The correlation of the biostratigraphic zoning of the Recôncavo Series with international reference schemes has been widely discussed, and several questions remain unanswered (Regali and Viana, 1989; Arai et al., 1989). Particularly in the case of the pre-rift, Arai et al. (1989) postulate that "… *there is no dating data which allow us to assign a Neojurassic age to the Dom João Stage*…". The same authors remind that equivalent units in the Gabon Basin were dated as Middle Jurassic by palynology (Wenger, 1973, *apud* Arai et al., 1989). The endogenous nature of non-marine ostracods, upon which the biostratigraphic scheme of the Recôncavo Series is based, does not allow significant progress other than that already achieved with correlation with reference sections.

## 3. The Rb–Sr radiometric technique applied to sedimentary rocks

The Rb–Sr radiometric technique is based on the radioactive decay of $^{87}Rb$–$^{87}Sr$. This radioactive decay has a constant $\lambda$ of $1.42 \times 10^{-11}$ year$^{-1}$, which corresponds to a half-life of 48.8 Ga.

This method has been traditionally used for determining the absolute ages of igneous rocks, as they were formed under conditions of high temperature. In the case of magma crystallization, radiogenic $^{87}Sr$ is homogenized as long as the rock temperature remains above 350 °C. As a result, the phenomenon of Sr isotope homogenization takes place, which is interrupted by cooling of the rock. Therefore, the Rb–Sr age represents the timing of closure of the isotopic system following the crystallization event.

In the sedimentary environment, characterized by low temperatures and by materials derived from various sources, the behavior of the Rb–Sr isotope system is more complex. Rb is easily adsorbed by clay minerals, whilst Sr tends to be released from the crystalline structure of minerals into the interstitial fluids. This characteristic favors the process of Sr isotope homogenization during sediment deposition, a condition required for Rb–Sr radiometric dating (Compston and Pidgeon, 1962; Faure, 1986; Mizusaki, 1992).

If the assumption of Sr isotope homogenization during sediment deposition is valid, successful Rb–Sr of siliciclastic sedimentary rocks depends on the selection of samples with high contents of expansive clays (see Mizusaki, 1992; Mizusaki et al. 1998; Cordani et al., 2004) such as smectite and interstratified illite-smectite sampled according to the recommendations of Thomaz Filho and Lima (1979).

## 4. Methodology

### 4.1. Sampling

The samples used in the present study were collected from the Paleozoic and pre-rift sections of the Recôncavo Basin, which are stratigraphically positioned at the base of the Afligidos (Cazumba Member), Aliança (Capianga Member) and Itaparica formations (Fig. 2).

This section also includes the Sergi Formation and the Boipeba and Pedrão members of the Aliança and Afligidos formations, respectively. However, since these units are formed of very fine-grained siltstones and sandstones, and in view of the chosen criteria, they were not deemed suitable for Rb dating (Mizusaki, 1992; Cordani et al., 2004).

Forty-three (43) samples were collected from outcrops along the BR-101 and BR-324 highways, near the city of Salvador (Bahia, Brazil). The precise location of the sampling sites is shown in Fig. 1 and Table 1. At each point, 500–700 g of rocks were sampled in their natural state. The traditional sampling technique (Thomaz Filho and Lima, 1979) was used, whereby a minimum of four samples was collected from each outcrop, at a distance of approximately 1 m horizontally and 10–50 cm vertically.

### 4.2. Analytical procedures

The samples were described macroscopically, with homogeneous portions of each sample being selected for analysis by X-ray diffraction (XRD), X-ray fluorescence (XRF) and mass spectrometry techniques.

For the X-ray diffraction analysis, we used the Siemens D5000 diffractometer of the Laboratory of X-ray Diffractometry of the Geosciences Institute of the Federal University of Grande do Sul (UFRGS), with KαCu radiation set at 40 kV and 30 mA of filament current and a 2–28° ($2\theta$) range.

Sample preparation for XRD followed procedures described by Alves (1987), with samples being powdered with a pestle and an agate mortar. Approximately 5 g of the resulting powder were dispersed in 50 mL of distilled water and taken to the ultrasound

**Table 1**
Location of the sampling sites in UTM coordinates and their stratigraphic positioning.

| Sample collection | Sample | Location | | Sedimentary unit |
|---|---|---|---|---|
| | | UTM N | UTM E | |
| Point 01 | IT-01–10 | 546870 | 8655130 | Itaparica Formation |
| Point 02 | CP-01–12 | 534571 | 8431110 | Aliança Formation – Capianga Member |
| Point 03 | CP-20–31 | 533706 | 8642640 | Aliança Formation – Capianga Member |
| Point 04 | CP-40–50 | 529503 | 8625302 | Aliança Formation – Capianga Member |
| Point 05 | CZ-01–11 | 528556 | 8626290 | Afligidos Formation – Cazumba Member |

**Table 2**
Isotope ratios of the fine fraction separated from the samples of the Recôncavo Basin. Error values of the isotope ratios are expressed as absolute SD.

| Sedimentary unit | Sample | Rb (ppm) | Sr (ppm) | $^{87}Rb/^{86}Sr$ | Error | $^{87}Sr/^{86}Sr$ | Error |
|---|---|---|---|---|---|---|---|
| Itaparica Formation (IT) | 01 | 54.44 | 239.85 | 0.6614 | 0.0066 | 0.71746 | 0.00005 |
| | 03 | 61.25 | 326.15 | 0.5534 | 0.0086 | 0.71736 | 0.00002 |
| | 06 | 94.02 | 70.06 | 3.9159 | 0.0386 | 0.72831 | 0.00001 |
| | 08 | 89.37 | 14.46 | 18.1422 | 0.3938 | 0.76715 | 0.00002 |
| | 10 | 79.81 | 313.41 | 0.7420 | 0.0099 | 0.71771 | 0.00005 |
| Aliança Formation Capianga Member (CP) | 21 | 101.39 | 16.62 | 17.9126 | 0.1725 | 0.77707 | 0.00001 |
| | 23 | 93.67 | 10.69 | 25.8180 | 0.3847 | 0.79995 | 0.00001 |
| | 25 | 104.72 | 14.28 | 21.5586 | 0.2224 | 0.78826 | 0.00002 |
| | 26 | 106.60 | 13.13 | 23.8824 | 0.3283 | 0.79281 | 0.00002 |
| | 40 | 91.78 | 30.47 | 8.8091 | 0.0779 | 0.74648 | 0.00001 |
| | 42 | 98.85 | 56.98 | 5.0662 | 0.0443 | 0.73452 | 0.00000 |
| | 43 | 93.66 | 22.31 | 12.2991 | 0.1111 | 0.75746 | 0.00001 |
| | 47 | 84.03 | 32.98 | 7.4495 | 0.1149 | 0.74237 | 0.00000 |
| Afligidos Formation Cazumba Member (CZ) | 06 | 153.22 | 62.76 | 7.133 | 0.063 | 0.74122 | 0.00002 |
| | 07 | 124.86 | 51.60 | 7.071 | 0.056 | 0.74094 | 0.00003 |
| | 08 | 128.57 | 57.17 | 6.570 | 0.055 | 0.73879 | 0.00002 |
| | 09 | 145.53 | 68.30 | 6.223 | 0.052 | 0.73756 | 0.00002 |
| | 10 | 150.16 | 63.94 | 6.862 | 0.058 | 0.74036 | 0.00001 |
| | 11 | 138.77 | 60.45 | 6.707 | 0.055 | 0.73960 | 0.00001 |

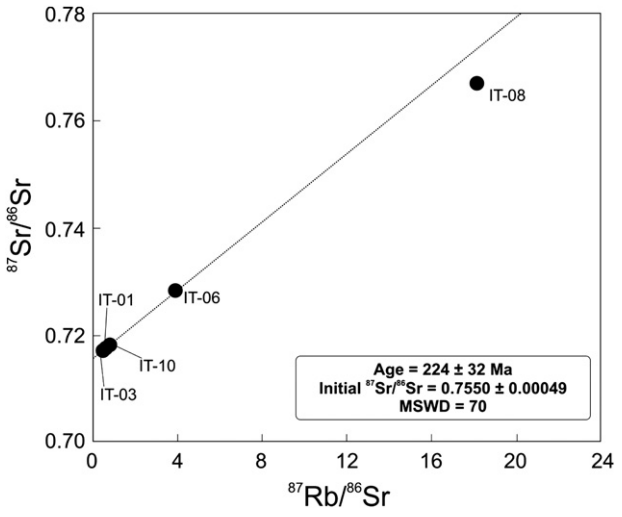


**Fig. 3.** Isochron diagram for the Itaparica Formation, according to Ludwig's model (2003).

device in the presence of a sodium pyrophosphate solution used as deflocculating agent. The <2 μm fraction (FF < 2 μm) was separated from the solution with a centrifuge. This fraction was placed on two slides, in which clay minerals were directed by using the smear technique (Gibbs, 1965).

One of the slides was dried under ambient conditions (standard slide) and analyzed by XRD. The second slide was also dried and soaked with ethylene glycol ($CH_2OHOH_2OH$) in order to form the glycolated sample. After analyzing this slide in the diffractometer, it was calcined for 2 h in an oven at 500 °C in order to obtain the calcined slide. From the combined analysis of the standard, glycolated and calcined diffractograms, the clay minerals in the samples were identified.

Determination of Rb and Sr contents were performed in the Laboratory of X-ray Fluorescence of the Geosciences Institute of the Federal University of Rio Grande do Sul (UFRGS) using a Rigaku Model RIX 2000 device set at 40 kV, 20 mA. The samples were prepared in the form of compressed tablets obtained from 10 g of rock powder.

For Rb and Sr isotope analyses we chose to use only the <2 μm-fraction (clay fraction separated according to procedures

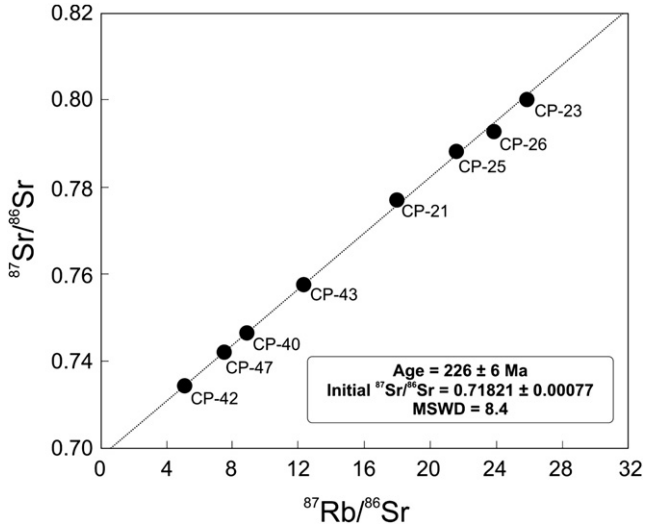


**Fig. 4.** Isochron diagram for the Capianga Member, Aliança Formation, according to Ludwig's model (2003).

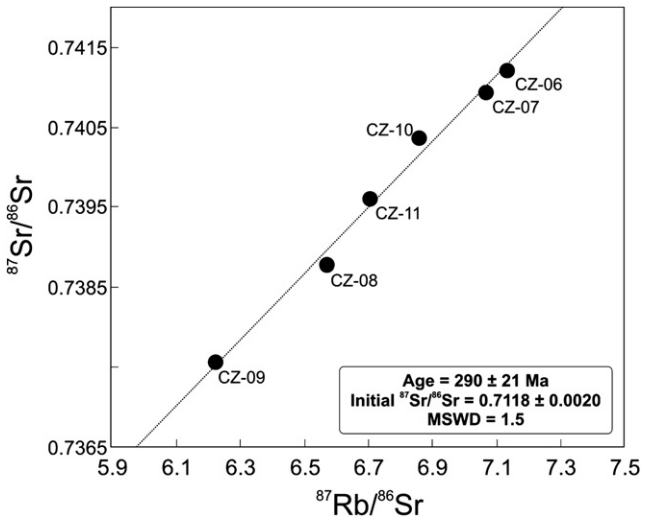


**Fig. 5.** Isochron diagram for the Cazumba Member, Afligidos Formation, according to Ludwig's model (2003).

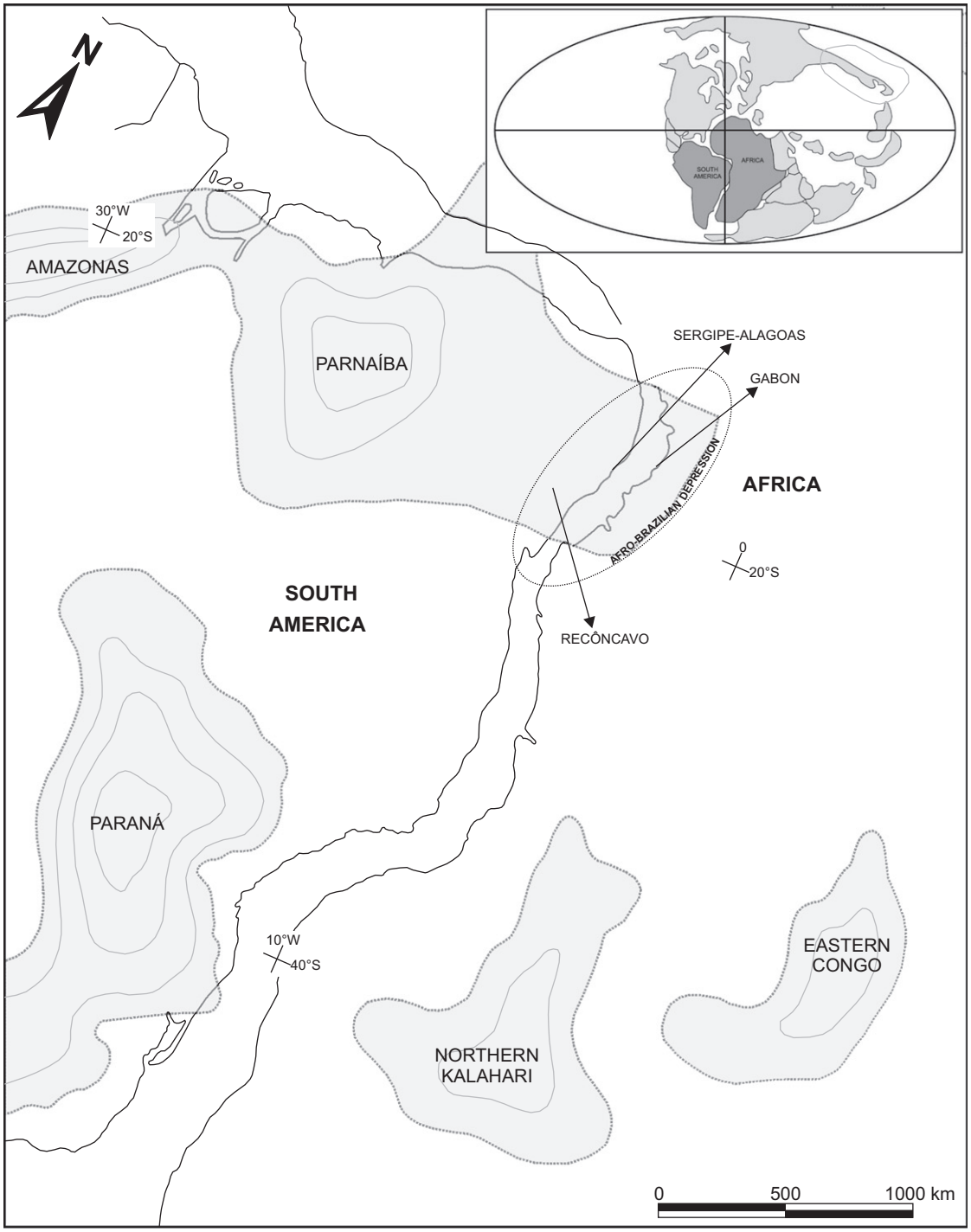


**Fig. 6.** Paleogeological map of the Paleozoic (modif. from Cesero and Ponte, 1997).

described previously) of the samples from the Aliança (Capianga Member) and Itaparica formations, since the coarse grain fraction contained a high level of detrital micaceous rock fragments.

Rb–Sr isotopic analyses were carried out at the Laboratory of Isotope Geology of the Geosciences Institute of the Federal University of Rio Grande do Sul (UFRGS).

The samples were initially dried in an oven at 70 °C, avoiding damage to the structure of clay minerals. Then, the following procedures took place:

- Sample dissolution was carried out in HF–$HNO_3$ in Savillex® vials and separation and purification of Rb and Sr were carried out using conventional ion exchange techniques
- Analysis of isotope ratios and Rb and Sr concentrations were done by isotope dilution in a Micromass VG 354 Multi-collector spectrometer in static mode; External precision based on repeated measurements of internal standard was 20 ppm ($2\sigma$). All analyses were adjusted according to NBS-987 standard with a mean of 0.71028 ± 0.00006. Sr and Rb blanks were better than 150 pg and 750 pg, respectively.

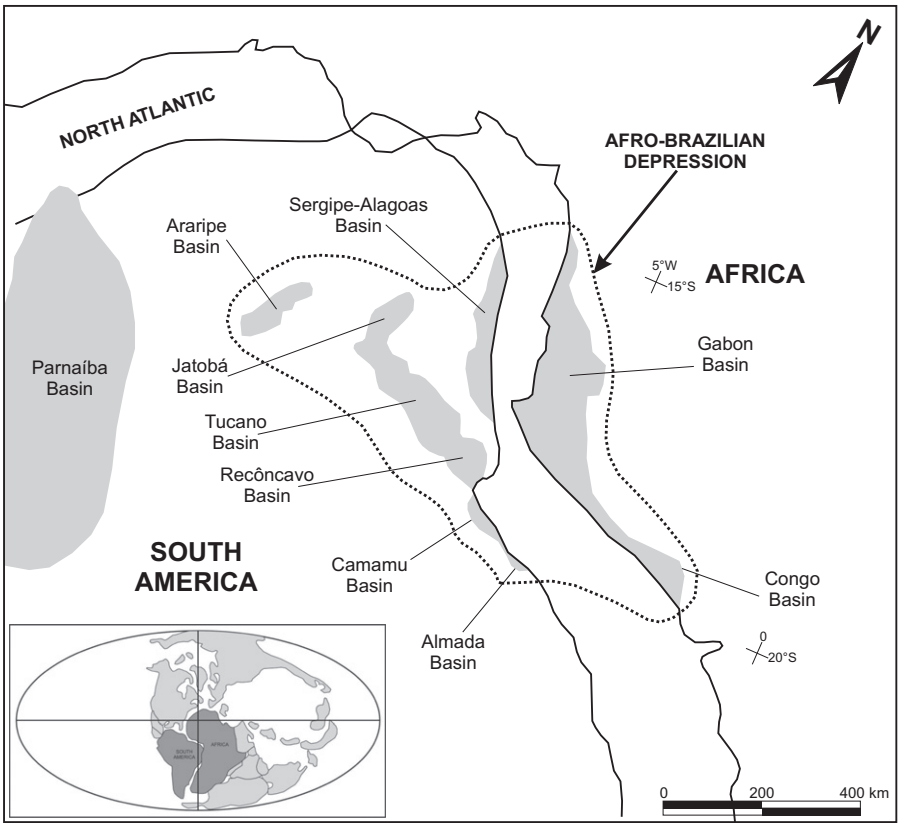


**Fig. 7.** Map of the Afro-Brazilian Depression.

- Isochron plots and age calculations were carried out with the Isoplot software (Ludwig, 2003).

## 5. Results

### 5.1. Itaparica Formation

The analyzed samples of the Itaparica Formation are reddish argillites, with significant presence of micaceous fragments. Analyzes by X-ray diffraction of the fine fraction (FF $<$ 2 μm) indicated the prevalence of kaolinite, smectite, illite with traces of quartz, and interstratified illite-smectite. Rb–Sr analytical results for the $<$2 μg fraction are shown in Table 2.

Rubidium concentration for the Itaparica Formation ranged from 54.4 to 94.0 ppm while Sr ranged from 14.5 to 326.2 ppm. The $^{87}Sr/^{86}Sr$ ratios ranged from 0.71736 to 0.76715 and the $^{87}Rb/^{86}Sr$ ratio from 0.553 to 18.14 (Table 2). The analytical data resulted in an isochron indicating the age of 224 ± 32 Ma for the basal portion of the Itaparica Formation (Fig. 3).

### 5.2. Aliança Formation – Capianga Member

Samples of the Capianga Member are reddish siltstones, with significant micaceous fragments identified as muscovite. Analyzes by X-ray diffraction in the fine fraction (FF $<$ 2 μm) indicated the prevalence of illite and smectite, with traces of interstratified illite-smectite. Rb–Sr results for the $<$2 μg fraction are shown in Table 2.

Rb concentrations ranged from 84.0 to 106.6 ppm while those of Sr ranged from 10.7 to 57.0 ppm. The $^{87}Sr/^{86}Sr$ ratios ranged from 0.73452 to 0.79995 and the $^{87}Rb/^{86}Sr$ ratio ranged from 5.066 to 23.88. The isotope data for samples of the Capianga Member, Aliança Formation, resulted in an isochron age of 226 ± 6 Ma (Fig. 4).

| GEOCHRONOLOGY | | | | PARNAÍBA BASIN | RECÔNCAVO BASIN | SERGIPE-ALAGOAS BASIN |
|---|---|---|---|---|---|---|
| 200 Ma | MESOZOIC | TRIASSIC | NEO | MOSQUITO FORM. | ALIANÇA FORM. | BANANEIRAS FORM. |
| | | | MESO | SAMAMBAIA FORM. | | |
| | | | EO | MOTUCA FORM. | | |
| 280 Ma | PALEOZOIC | PERMIAN | | PEDRA DE FOGO FORM. | AFLIGIDOS FORM. | ARACARÉ FORM. |

**Fig. 8.** Stratigraphic correlation among the Parnaíba, Recôncavo and Sergipe-Alagoas basins during the Paleozoic.

### 5.3. Afligidos Formation – Cazumba Member

The samples of the Cazumba Member are reddish argillites. X-ray diffraction data for the fine fraction (FF $< 2$ μm) indicated the prevalence of illite, smectite and kaolinite. Rb–Sr data are in Table 2.

The Rb concentrations ranged from 124.9 to 153.2 ppm, while those of Sr ranged from 51.6 to 68.3 ppm. Values of the $^{87}Sr/^{86}Sr$ ratios ranged from 0.73756 to 0.74122 and of the $^{87}Rb/^{86}Sr$ ratio ranged from 6.223 to 7.133. The Rb–Sr data for the Capianga Member, Aliança Formation, resulted in an isochron indicating the age of 290 ± 21 Ma (Fig. 5).

## 6. Discussion

The final stages of the Brazilian/Pan-African Cycle (early Paleozoic) and cratonization of the South-American platform marks the beginning of a period where the tectonic stresses delineated the sites of future Paleozoic syneclises in Gondwana. The large Brazilian Paleozoic basins or syneclises (e.g. the Solimões, Amazonas, Parnaíba and Paraná basins) show extensive, predominantly continental sedimentation. Paleozoic sedimentary basins are also recognized in the African portion of Gondwana (Fig. 6). The area underlain by the Paleozoic basins, particularly with regard to the behavior of Parnaíba Basin in northeastern Brazil, has been subject of discussion, as different areal extension and forms during the geological time are proposed for this basin (Zalán et al., 1990).

Small areas of sedimentary remnants are recognized especially in the Paraiba Basin. They are considered to be remnants of earlier depositional cycles of different ages. Milani et al. (2007) report the local exposure of Paleozoic units under the Meso–Cenozoic sediments of the marginal basins and in their aborted branches. The Paleozoic section can be easily observed in the Recôncavo, Tucano, Jatobá and Sergipe-Alagoas basins. The Recôncavo, Tucano and Jatobá basins are examples of aborted intracontinental rift, formed together with the Sergipe-Alagoas Basin by crustal stretching responsible for the breakup of the Gondwana supercontinent and development of the Brazilian marginal basins. The basins are in the so-called Afro-Brazilian Depression which is a broad NW–SE America from Africa and in the formation of the South Atlantic Ocean and in the South-American continental margin (Cesero et al., 1972, *apud* Cesero and Ponte, 1997) (Fig. 7). The western branch of the rift was aborted in the end of lower Cretaceous, allowing the preservation of this trench at a stage prior to the total breakup of the crust and, therefore, not allowing the deposition of marine sediments (Santos et al., 1990).

The infill included a so-called pre-rift package including shallow continental alluvial, aeolian and lacustrine sediments (Fig. 2). These comprise the so-called Aliança, Sergi and Itaparica formations.

Paleozoic sediments have also been described in the area of the "future" Afro-Brazilian Depression, associated with an extended stage of subsidence, which might have contributed to the development of an intracratonic-type basin. In the case of the Recôncavo Basin, this is represented by the Pedrão and Cazumba members of the Afligidos Formation.

The Paleozoic sequence in this region has been widely discussed, but its recognition and extension is impaired due to the lack of dating. One of the main controversies rely on the time elapsed between the end of the Paleozoic sedimentation and the onset of the Afro-Brazilian Depression.

With respect to the Recôncavo Basin, palynological data have assigned a Permian age to the Pedrão Member (Afligidos Formation), which correlates with the Ingá Member of the Santa Brígida Formation (Northern Tucano) and the Aracaré (Sergipe-Alagoas Basin) and Pedra de Fogo (Parnaíba Basin) formations (Fig. 8).

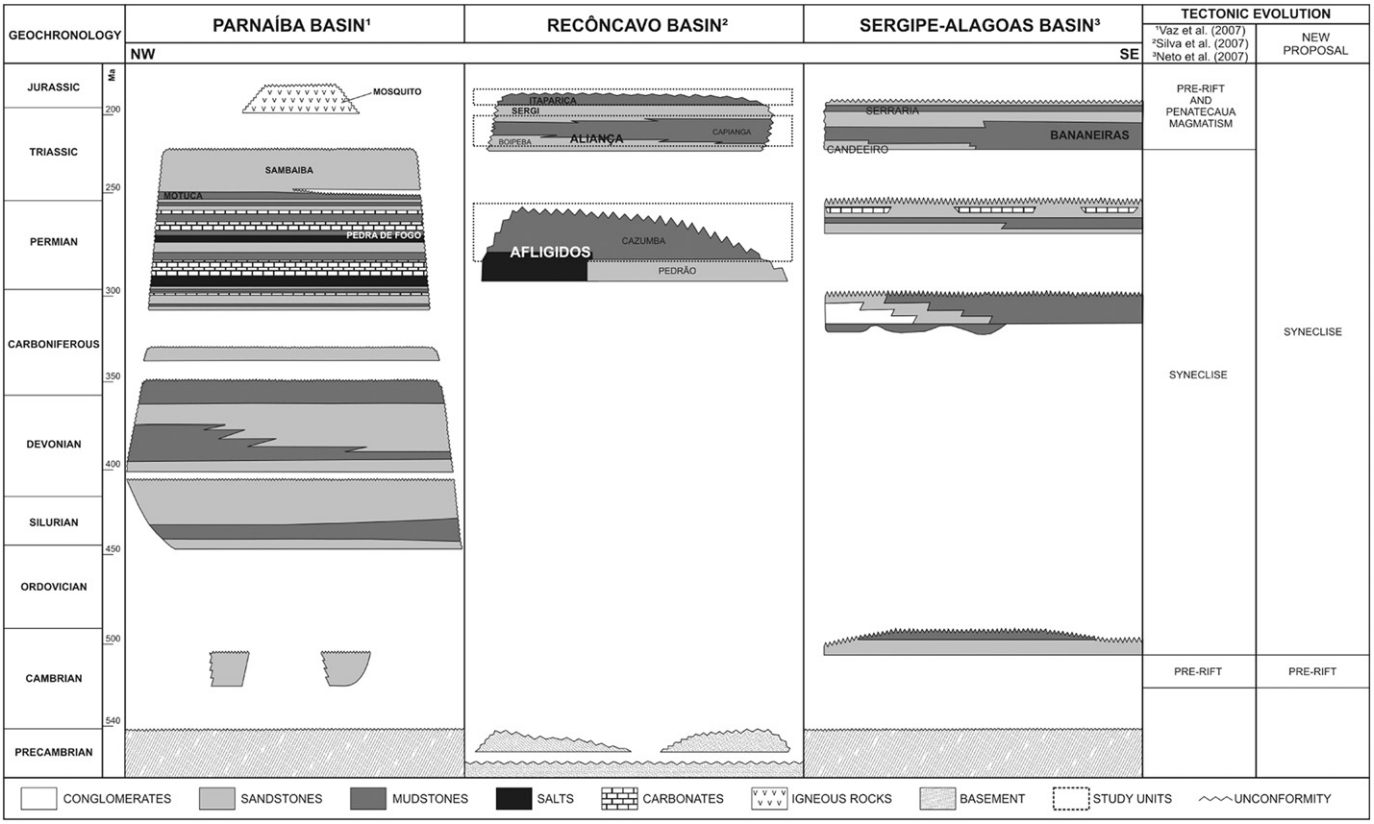


**Fig. 9.** Stratigraphic correlation among the Parnaíba, Recôncavo and Sergipe-Alagoas basins.

The age of the Cazumba Member is not well constrained due to its poor fossil record. Based on palynological analyses, Aguiar and Mato (1990) admitted the extension of this unit into the Triassic. For these authors, nature of the contact with the Boipeba Member (Aliança Formation) is unclear in most parts of the Recôncavo Basin, but in the southwestern area of the basin, based on field observation they considered the contact as transitional. Caixeta et al. (1994) suggest that the deposition of the Afligidos Formation took place in the Permian. The Rb–Sr absolute age of 290 ± 21 Ma for the Cazumba Member of the Afligidos Formation confirms the Permian age for this interval.

Concerning the pre-rift phase, sedimentation in Paleozoic conditions was continental and associated with a slightly depressed region. In that time interval, the conditions were lacustrine, and the few fossils found were of endemic ostracods, which do not allow a correlation with other regions. Considering the continental sedimentation and the inconclusive fossil record, it is not possible to correlate with intervals in other areas. Therefore, it was decided to use a regional time division characterized by stages, with the big question being which time intervals to assign to these stages.

The name Dom João Local Stage was adopted where it is represented by the Aliança and Sergi formations (pre-rift sequence) in the Recôncavo Basin. With regard to the age, Viana et al. (1971) assumed that the ostracods found in the Aliança Formation are indicative of a Jurassic age. However, according to Arai et al. (1989), there is no dating element to attest a Neojurassic age for the Dom João Stage.

In the present study, Rb–Sr isochronic ages of 224 ± 32 Ma (Neotriassic) and 226 ± 6 Ma (Neotriassic) for samples of the Itaparica and Aliança (Capianga Member) formations were obtained and considered to be representative of the depositional age of these units. The ages can be associated with the depositional age of the units as Sr homogenization in the fine fraction of the samples during the deposition process of these units was suggest inferred. This assumption was validated by the presence of expansive clay

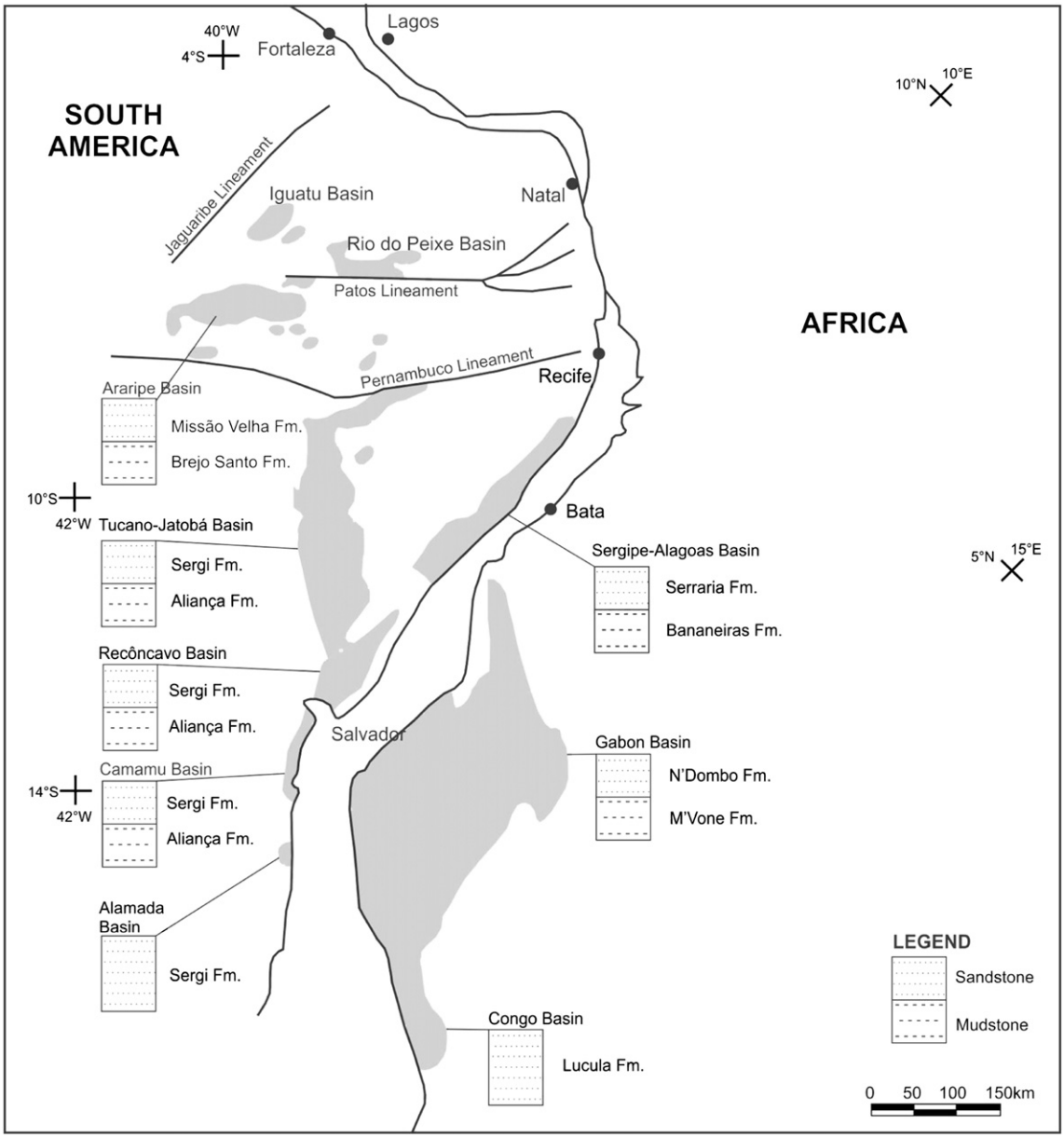


**Fig. 10.** Regional distribution of sedimentary records of the pre-rift sequence in northeastern Brazil and surrounding regions of the African shore (modif. from Da Rosa, 1996).

minerals in the fine fraction, the sampling following criteria of Thomaz Filho and Lima (1979), the alignment of the points in the isochron and absence of contaminations and diagenetic alterations in the original mineralogy. In addition, the reported uncertainty is compatible with the application of the Rb–Sr technique to sedimentary rocks, as discussed by Mizusaki (1992). In the case of the Itaparica Formation, despite the error of the isochron age being greater than that of the remaining units, the age is significant when compared to the age measured for the Capianga Member.

The absolute ages of 224 ± 32 Ma and 226 ± 6 Ma (Neotriassic) have important implications regarding the paleographic schemes established previously. The pre-rift section of the Recôncavo Basin was traditionally considered to be of Neojurassic age (Silva et al., 2007). It should be pointed out that a similar age also based on Rb–Sr methodology had already been obtained for the Bananeiras Formation (Silva et al., 2006b) in the Sergipe-Alagoas Basin (Fig. 6). As shown in Figs. 8 and 9, it is assumed that the Bananeiras Formation correlates with the Aliança Formation.

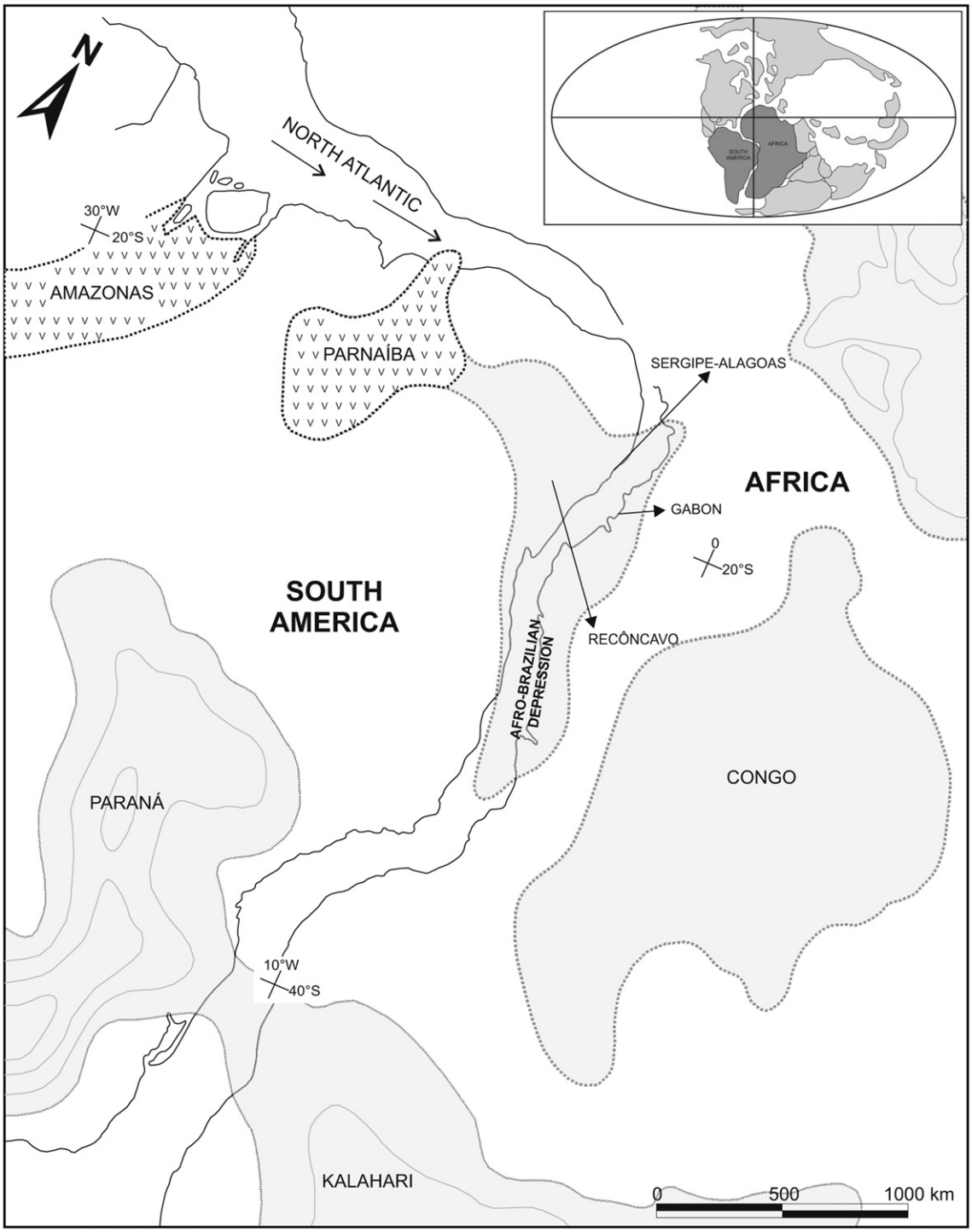


**Fig. 11.** Paleogeological map of the Triassic (modif. from Cesero and Ponte, 1997).

The geochronological results obtained for the Itaparica Formation, the Capianga Member (Aliança Formation), and the Bananeiras Formation (Sergipe Basin) indicate that sedimentation in the Afro-Brazilian Depression (Cesero et al., 1972, *apud* Cesero and Ponte, 1997) began during the Neotriassic, possibly continuing until the Jurassic. This finding extends to other sedimentary units of the Brazilian and African Basins, since continental sediments of the Sergi and Aliança formations (Recôncavo, Tucano and Camamu, and Almada basins), Serraria and Bananeiras formations (Sergipe-Alagoas Basin), Brejo Santo and Missão Velha formations (Araripe Basin) and their correlate M'Vone and N'Dombo (Gabon Basin) formations (Cesero and Ponte, 1972, *apud* Cesero and Ponte, 1997) (Fig. 10) were deposited in this broad basin.

The pre-rift sedimentation in the Afro-Brazilian Depression occurred in an intracratonic basin, as a combined system of alluvial fans and interior lakes that developed under stable tectonic conditions, with no influence from the Gondwana breakup processes (Da Rosa, 1996). The evolutionary model of the Recôncavo and southern Tucano rifts proposed by Milani (1987) presents no evidence of crustal arching previous to the rift phase of these basins. The pre-rift sedimentation geometry is characterized by a slow and gradual subsidence process of that region, typical of passive rifting.

One could also assume correlation with the Parnaíba Paleozoic basin. In this context, one might think of an integrated scheme for the northeastern region of Brazil concerning Fig. 11. With regard to the Parnaíba Basin – whose remnants are seen in areas where the northeastern interior basins developed (e.g. Araripe and Jatobá basins) – it is known that during the Silurian it spread far beyond its present eastern boundary (Ghignone, 1972; Caputo and Crowell, 1985).

Milani and Thomaz-Filho (2000) showed that the North Atlantic rifting (at about 200 Ma) broke the connection between the Parnaíba syneclise and other basins presently found in northwestern Africa.

Permian sedimentation in the Parnaiba Basin is represented by the Pedra de Fogo Formation (Dino et al., 2002). Taking the age of Pedra de Fogo Formation into account, the Motuca Formation (Fig. 8) would have extended until the end of the Eotriassic. The Sambaíba Formation, overlying the Motuca Formation and underlying the Mosquito basalts (approximately 200 Ma, Mizusaki et al., 2002) is considered to be Medium-Upper Triassic by Lima and Leite (1978). This deposition coincided with major environmental and tectonic changes in the region of the Parnaíba Basin associated with the early opening of the North Atlantic (Vaz and Rezende, 2007). Extensional events, remobilization of ancient faults, and magmatism characterized this period in the geological evolution of the area (Almeida, 2004). Therefore, during the Neotriassic, there was substantial magmatism (both flows and sills) which, in the case of the Parnaíba Basin, is represented by the Mosquito Formation.

The Rb–Sr ages of the Bananeiras and Itaparica formations and the Capianga Member of the Aliança Formation were associated to this interval, represented by magmatism in the Parnaíba Basin, indicating that there was continental sedimentation in the area of the future rift. This may indicate that basic magmatism would be reported during the Neotriassic in those portions most affected by the beginning of the North Atlantic rifting, with depocenters of the Parnaíba Basin migrating to distant areas.

## 7. Conclusions

The geochronological results for the Aliança and Itaparica formations of the Recôncavo Basin reinforce the potential occurrence of a Triassic section in the region, comprising the Afro-Brazilian Depression (Cesero et al., 1972, *apud* Cesero and Ponte, 1997) while the age of the Afligidos Formation confirms the Paleozoic age previously reported for that unit.

Data from the Aliança and Itaparica formations combined with results obtained by Silva et al. (2006b) raise important implications for the paleogeographic schemes established previously, as these sedimentary units were traditionally considered to be of Neojurassic age.

The spatial extent and temporal reach of the sedimentary basins implicit in this notion should be, therefore, reviewed in light of Triassic ages found widely spread over Brazil's northeastern region and its correlated regions in northwestern Africa.

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