Diagenesis and Provenance of the Sandstones of the Rift
Tectonosequence of Araripe and Rio do Peixe basins, NE Brazil

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ABSTRACT

Rio do Peixe and Araripe basins are part of the set of interior basins of northeastern Brazil. They are aligned along the Trend-Cariri Potiguar and are genetically related to Early Cretaceous rifting. With respect to the lithostratigraphy, the studied interval corresponds to Antenor Navarro, Sousa and Rio Piranhas formations, in the Rio do Peixe Basin, and Missão Velha and Abaiara formations in Araripe Basin, that outcropping in the central-west of Cariri Valley. The diagenetic and provenance studies of sandstones belonging to the Rift Tectonosequence allowed associating the studied formations in each basin, the specific phases of evolution of the rift stage.

KEYWORDS: Diagenesis, Provenance, Araripe Basin, Rio do Peixe Basin

1. Introduction

Rio do Peixe and Araripe basins, along with the other basins that comprise the set of interior basins of northeastern Brazil (Iguatu, Ico, Lavras da Mangabeira, and others) are a series of sedimentary basins of small to medium size (Castro et al., 1999), which are aligned along the Trend-Cariri Potiguar (Matos 1992, 1999).

The origin of these intracratonic basins is directly linked to tectonic forces associated with the rifting that shaped the current continental margin as a result of the separation of the South America and Africa continents during Early Cretaceous. Matos (1992), using a simple model, suggests that the tectonic evolution to the basins of the Cariri Rift Valley was a result of NW-SE distension that reactivated a sigmoidal shear zone of neoproterozoic age. This same author states that, in a generical way, these basins are made of half-grabens with variable geometry, with dips towards SE. Françolin et al. (1994) propose a more complex tectonic evolution. For these authors, the basins of the Cariri Rift Valley suffered a lateral E-W displacement along the Malta Fault. As such, its shape, location and stratigraphic stacking would be strongly controlled by pre-existing regional lineaments of Precambrian basement (Matos 1992, 1999), in the Borborema Province.

2. Rio do Peixe and Araripe Basins

Rio do Peixe Basin is located at the northwest boundary of the Paraíba State with the Ceará State, encompassing the towns of Sousa, Uiraúna, Poço, Brejo das Freiras, Trunfo, Santa Helena and Pombal, more precisely between 37° 47' 00" and 38° 50' 00" west longitude meridians, and between 06° 25' 00" and 06° 50' 00" south latitude parallels (Córdoba, 2008; Nunes da Silva, 2009; Srivastava & Carvalho, 2004). This basin is divided into four minor basins that correspond to half-grabens of Pombal, Sousa, Brejo das Freiras and Icozinho, separated by highs of crystalline basement. Its main faults are controlled by shear zones of Portalegre (NE-SW) and Patos (EW). Theses half-grabens comprise an area of about 1,250 km², and the largest Sousa half-graben, with 675 km².
Araripe Basin is the largest of the interior basins of Northeast Brazil, with the following geographic coordinates: 38 ° 30 and '40 ° 55' west longitude, and 7 ° 07 and '7 ° 49' south latitude (Ponte & Ponte Filho, 1996). Its occurrence area extends from the Araripe Plateau to the Cariri Valley, with a total area of 9,000 km² (Assine, 1992).

The Araripe Plateau is the geomorphological feature that most stands out in the region, providing an extensive tabular surface located among the states of Ceará, Pernambuco and Piauí. This basin presents a length of 160 km from east to west (major axis) and about 50 km from north to south (Kellner, 2002), and is bordered by steep erosional scarps (Assine, 2007).

### FIG.1

Location and geological maps of the study area: A) Location map of the basins of the Rio do Peixe and Araripe in the context of Northeast Brazil, (B) Geological map with location of studied outcrops in the Rio do Peixe Basin (Nunes da Silva, 2009), and C) Geological map with the location of outcrops studied in the central-western Araripe Basin (Modified Projeto Bacias Interiores; Aquino, 2009).

### 3. Rift Tectonosequence: Facies and Depositional Systems

The facies analysis of the studied sandstones in the Rio do Peixe Basin identified nine distinct facies, with one composed by conglomerates, four by sandstones and four by pelites. Associations of these facies allowed interpreting that the depositional setting established during the deposition of Antenor Navarro and Sousa formations was represented by fluvial distributary systems. These systems were laterally associated with alluvial fans providing from the failed margin, represented by facies of Rio Piranhas.
Formation. The studied sandstones of Araripe Basin, in turn, consist of ten facies of which one is composed by conglomerates, seven by sandstones, and two by pelites. The facies analysis allowed to interpret that the lower section of Missão Velha Formation represents meandering to braided fluvial systems, that the upper section of Missão Velha Formation consists of braided fluvial systems, and that Abaiara Formation represents deltaic systems that evolve at the end of this unit to meandering fluvial systems.

4. Petrographic and Diagenetic Analysis

In terms of petrography, the studied sandstones in both basins exhibit grains with variable mineralogical composition with the predominance of quartz, feldspar and rock fragments. In all studied sandstones, muscovite, biotite, chlorite, tourmaline, zircon and titanite are present, but in minor quantities. Particularly in sandstones of Araripe Basin also occur staurolite, garnet and epidote. The matrix identified in all studied rocks is formed by infiltrated clay. Cements evidenced in the rocks of all formations of Rio do Peixe Basin are represented by ferruginous and carbonate cements, and quartz overgrowths. In Araripe Basin, the rocks of Missão Velha Formation exhibit ferruginous cements, as well as quartz and feldspar overgrowths. The rocks of Abaiara Formation, in turn, contain besides quartz overgrowths, ferruginous cements and clay minerals. The modal analysis allowed classifying the studied lithotypes, in both basins, as Quartzarenites.

Based on the diagenetic analysis of studied rocks, it was possible to identify nine distinct processes that were grouped in eo, meso and telodiagenetic stages. The eodiagenetic stage is marked by mechanical infiltration of clays and the beginning of mechanical compaction. These processes, mainly the mechanical infiltration of clays, acted with more intensity in sandstones belonging to Rio do Peixe Basin. The mesodiagenetic stage is characterized by the continuity of mechanical compaction and the beginning of chemical compaction, quartz and feldspar overgrowths, generation of authigenic kaolinite, alteration of the grains to chlorite and illite, and finally, precipitation of opaque minerals processes. These diagenetic events have acted differently on the rocks of studied basins. Mesodiagenetic processes that have acted more significantly in the sandstones of Rio do Peixe Basin, were the precipitation of mosaics of calcite in the interstitial spaces and the alteration of the grains and the matrix to chlorite and illite. In Araripe Basin, in turn, the sandstones were mainly subjected to quartz and feldspar overgrowths and to dissolution of feldspars with the generation of secondary porosity, which explains the higher values obtained for the porosity in this basin. The telodiagenetic stage is represented by the partial oxidation of grains, matrix and cement; this stage is quite evident in the Rio do Peixe Basin.

5. Provenance Studies

The provenance studies using QtFL and QmFLt diagrams (Dickinson & Suczek, 1979) revealed that the studied rocks show continental origin, with most of them indicating the interior craton provenance. The application of these diagrams also allowed highlighting those rocks with greater mineralogical maturity and chemical stability, which focus on Sousa and Rio Piranhas formations, in Rio do Peixe Basin, and in the lower section of Missão Velha Formation and in the Abaiara Formation in Araripe Basin. The rocks of Antenor Navarro Formation in Rio do Peixe Basin, and those of the upper section of Missão Velha Formation in Araripe Basin were whose samples showed comparatively lower mineralogical maturity and chemical stability.
The shortest mineralogical maturity and chemical stability found in sandstones of Antenor Navarro Formation can be explained by the fact that they represent the proximal portions of a distributary fluvial system, areas adjacent to sources composed of rocks rich in feldspar. For the rocks of Sousa Formation, higher values may be explained by the greater distance of sediment transport. In the case of sandstones of Rio Piranhas Formation, that characterize a alluvial fan systems providing from failed margins, the higher values of mineralogical maturity and chemical stability can be explain by the fact of the source rocks are poor in feldspar. In Araripe Basin, the interpretation of the results was mainly based on depositional systems since the geology of source area has not proved to be a conclusive factor. The sandstones of the lower section of Mission Velha Formation represent sandy meandering fluvial systems; the ones of upper section of Missão Velha Formation characterize sandy and gravelly braided fluvial systems, and the sandstones and pelites of Abaiara Formation represent sandy meandering fluvial and deltaic systems. The lowest mineralogical maturity and chemical stability shown in the upper section of Missão Velha Formation can be explained by the fact that this system be related to more proximal compared with other formations. The results based on values of mineralogical maturity and chemical stability allowed associating the studied formations to each specific phase of the Rift Stage. Thus it was possible to relate the lower section of Missão Velha Formation in Araripe Basin to the Rift Initiation Phase, the upper section of Missão Velha Formation in Araripe Basin and Antenor Navarro Formation in Rio do Peixe Basin to Rift Climax Phase, and the Sousa and Rio Piranhas formations in Rio do Peixe Basin and Abaiara Formation in Araripe Basin, to a Filling Rift Phase.

6. Conclusions

Diagenetic and petrographic studies of sandstones belonging to the Rift Tectonosequence of Rio do Peixe and Araripe basins allowed understanding that these rocks were buried to depths related to mesodiagenetic zone, since they were affected by processes such as chemical compaction and quartz and feldspar overgrowths. These studies also showed similarities and differences between the processes that acted in the sandstones of the different studied basins. The provenance studies, in turn, made it possible to associate the studied formations in each of the basins to specific stages of Stage Rift evolution.

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