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Continental carbonates from Itaboraí Formation in southeastern, Brazil

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ABSTRACT

Since the discovery of the massive South Atlantic hydrocarbon reservoirs (Pre-Salt), the interest in these terrestrial carbonates has increased. In Brazil few examples of continental carbonates are known, and solely the occurrence described in this study can be recognized as continental thermal carbonate or travertine. The occurrence is part of the sedimentary sequence of the Itaboraí Formation, deposited in Itaboraí Basin, located in Rio de Janeiro state, about 60 km from the city of Rio de Janeiro. The basin dates back to the Paleocene due to its vertebrate fossil content, which can be found in a small half-graben basin (1.5 km × 0.5 km). Despite the small size of the basin, it represents a huge source of geological information for its diverse fossil assemblage, the occurrence of travertine and the exposition of alkaline dyke. Most of the studies regarding the basin are related to the extensive fossil community from the lake-fill facies succession, which are not directly related to the travertine deposition. The present study conducted a sedimentological investigation applying petrography, facies association and isotope analysis as its methodology. As a result, four distinct facies associations were described: Thermal Springs, Alluvial, Palustrine/Lacustrine and Fissural. Sedimentation succession allowed the study to recognize sedimentation and tectonic relationship. The origin of the thermal activity is probably related to the tectonic pulses of the hemi-graben system, so in these conditions two different contexts for travertine deposition associated to the flexural and active borders of the basin were established. The petrography exhibited shrubs textures with remarking crystalline quality indicating a major abiotic influence during the process of precipitation. The stable isotope ratios provided contrasting results against those expected for a thermal carbonate signature, but not so different from those expected for meteoric carbonate signature, indicating a mixture of both processes.

1. Introduction

The continental carbonates in the last decade has became an object of major interest in the scientific and industrial community due to the discovery of the pre-salt plays in South Atlantic. It represent a challenge mainly because those carbonates have received minor attention comparing to the marine carbonates and also, only few reservoirs are known. In Brazil, besides the recently discovered reservoirs, only few examples of continental carbonates are documented, the occurrence in Itaboraí Basin is the only one that could be recognized, so far as continental thermal carbonate or travertine. The occurrence is part of the sedimentary sequence of the Itaboraí Formation, deposited in the São José de Itaboraí Basin (SJIB), located in Rio de Janeiro state, about 60 km from the city of Rio de Janeiro (Riccomini et al., 2004).

It is considered continental carbonate any type of rock formed by precipitating calcium carbonate and calcium/magnesium under the strictly influence of continental water (Alonso-Zarza and Tanner, 2009). Continental carbonates are separated informally in travertines, precipitated from hot springs, tufas, precipitated from low temperature sources, such as lakes and rivers (meteogene travertine), and speleothems precipitated from water in low to high temperature in caves or karst fracture systems (Pentecost, 1995; Ford and Pedley, 1996).

In general terms, Itaboraí Formation deposits are composed of travertine, pisolites, carbonate breccias, marl and lake/marsh

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eocenic deposits. In association with the precipitation of carbonates, amorphous silica (chalcedony) can also be observed (Sant'Anna et al., 2004).

Travertine occurs mainly as fine laminated deposits, crystalline crust deposits and veins in the context of hotspring carbonates. In areas near the border of the basin, carbonate breccias can be found, while in the regions less affected by tectonic influence finely laminated lacustrine deposits are found. Carbonates are present as crystalline crusts and veins from hotspring affiliation and marls as massive deposits with high fossil content of mollusks and gastropods (Sant'Anna et al., 2004; Bergqvist et al., 2008). SJIB is the single Brazilian deposit to register the first mammal's irradiation after KT extinction around 65 Ma.

In this paper, the term travertine will be exclusively used as a reference to thermal deposits described in different sites as Cambazlı, a fissure-ridge travertine in Gediz Graben, Turkey (Selim and Yanik, 2009), Lianchangping hot springs in Yunnan, China (Wang et al., 2015) and Süttő Travertine Complex, Hungary (Pazonyi, 2014). Some authors also use the term to describe precipitated deposits in ambient temperature usually associated with macrophytes, invertebrates and bacteria, which preserve isotopic signature compatible with the thermal water source (Pentecost and Viles, 1994; Özkul et al., 2014). The term tufa (Pedley, 1990; Capezzuoli et al., 2014) will be applied to precipitated carbonates at low temperatures with macrophytes, invertebrates and bacteria association, whereas the term travertine will be used to describe deposits without macro and microbiological traces associated with high temperature water sources.

The article focuses in the study of travertine occurrences in southeast of Brazil, where are deposited inside a graben system and has its formation conditioned by fault reactivation processes. The purpose of this study was to understand the basin carbonates development supported with facies and isotopes analysis and obtain better comprehension of the diagenetic processes, as well.

2. Regional setting

During late Paleocene the southeastern margin of Brazil was widely passive. At the time, São José de Itaboraí Basin (SJIB) was starting to be formed as a result of the settlement of southeastern Brazil's Continental Rift - CRSB (Riccomini et al., 1989; Ferrari, 2001). CRSB consists of a series of cenozoic grabens in southeastern Brazil from Paraná to the north of Rio de Janeiro and coinciding with the extension of Serra do Mar and, partially, of Serra da Mantiqueira mountain range with a structural orientation that runs parallel to those scarpments and the Atlantic coast. The basin formed in the grabens displays alluvial, fluvial, lacustrine and palustrine sedimentation, fed by waters that have originated from and flowed through distinct lithologies of grounding, such as marble, igneous rock and pre-cambrian metamorphic rock associated with the Ribeira Orogen Belt and with the geomorphological constitution of Serra do Mar and Serra da Mantiqueira mountain range. The sedimentation process occurred in a subtropical environment tending to aridity with mild temperatures and low relative humidity. The intensive hydrothermal activity associated with magmatic events in the basins of Volta Redonda and São José de Itaboraí (Sant'anna and Riccomini, 2008) resulted in the increase of calcium, bicarbonate ions and silica concentration in the superficial and underground waters in the basins. The high content of bicarbonate, high pH and high temperatures from the waters led to the formation of thermal carbonate deposits (travertine) in SJIB, a unique condition in Brazil.

JSIB is located in the municipality of Itaboraí, in the state of Rio de Janeiro, southeastern Brazil (Fig. 1), and is recognized as one of the smallest sedimentary basins of Brazil. It consists of a 1 km^2 elliptical hemi-graben linked to Guanabara Graben in the tectonic context of Ribeira orogen belt (Heilbron et al., 1995; Mohriak, 2003; Martins et al., 2004). During the Cenozoic, in response to the tectonic rifting between Brazil and Africa, a distensive zone settled in the onshore portion adjacent to the Atlantic Ocean, the RCSB. The

Fig. 1. Satellite image of the Itaboraí Sedimentary Basin, marked by the boundaries of the Paleontological Park of São José de Itaboraí- City of Itaboraí - RJ.

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