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# Palynology of carcinolites and limestones from the Baunilha Grande Ecofacies of the Pirabas Formation (Miocene of Pará state, northeastern Brazil)

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ABSTRACT

The Pirabas Formation records important transgressive/regressive marine events in northern Brazil during the Miocene. Here, we present the results of a palynological analysis of four samples from finely stratified gray limestone and associated carbonate concretions bearing decapod crustacean remains. These sampled strata are representatives of the Baunilha Grande Ecofacies, and our analysis enhances the knowledge of local biostratigraphy and paleoecology.

The palynoflora is dominated by taxa typical of Neogene tropical areas, such as *Zonocostites ramonae* (the most common species), together with *Retitricolpites* and *Retitricolporites* genera. Commonly represented are the smooth and apiculate trilete/monolete spores (*Polypodiisporites*, *Verrucosisporites*, *Magnastriatites*, and *Deltoidospora*), in conjunction with some freshwater algae (*Ovoidites* and *Botryococcus*). Gymnosperm pollen grains were absent. Marine microplankton (dinoflagellate cysts, acritarchs and foraminiferal test linings) are scarce, although present in all samples.

The presence of the index species, *Malvacipolloides maristellae* and *Pachydermites diederixii*, co-occurring with *Zonocostites ramonae* and *Lanagiopollis crassa*, suggests that these sediments and concretions belong to the "T-13 *Malvacipolloides maristellae*" palynozone (Jaramillo et al., 2011), considered as late-Early Miocene in age. Palynological and sedimentological evidence further points to a predominantly continental depositional environment with a weak marine influence, as indicated by the persistent presence of sparse dinoflagellate cysts, acritarchs and foraminiferal test linings, typical of a mangrove environment.



## 1. Introduction

The Pirabas Formation, defined by Maury (1925), represents one of the most important manifestations of a marine transgressive event in northern Brazil during the Miocene. This formation is ~700 m in thickness and extends for approximately 160 km inland from the Bragantina Coast (Fig. 1). It mainly consists of richly fossiliferous limestones indicative of a warm, shallow marine depositional environment (Ferreira and Cunha, 1957; Petri, 1957; Ferreira, 1966, 1980, 1982; Ferreira and Francisco, 1988). The abundant and diversified fossil content has served as the basis for the definition of three ecological facies in the Pirabas Formation, as follows: Castelo Ecofacies (indicative of storm wave activity on continental and carbonate platforms), Capanema Ecofacies (lagoon), and Baunilha Grande Ecofacies (open marine, lagoon, and mangrove) (Ferreira, 1966, 1980, 1982; Ferreira and Cassab, 1985; Ferreira and Francisco, 1988) (Fig. 2A). Góes et al. (1990) investigated depositional and paleontological aspects of the Pirabas Formation; they concluded that the formation accumulated on a carbonate platform, as well as in lagoons and intertidal zones with mangroves, thus corroborating previous interpretations. In the Baunilha Grande Ecofacies, which is investigated here, the most conspicuous and abundant components are carcinolites. These are centimeter-thick carbonate concretions that contain decapod

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crustacean remains. The genesis of the carcinolites includes processes initiated with the death of crustaceans. In the adipocere (decomposition of carcasses initiated by chemical reactions), the gas expelled by the organic matter and the dissolved salts in the environment induce $CaCO_3$ precipitation and form the concretion around the carcass ($NH_3 + Ca^{2+} + HCO_3 \rightarrow CaCO_3 + H_2O$). The thickness of concretions depends on the rate of decay because microbial action can accelerate the decomposition process and $CaCO_3$ precipitation. The diagenetic features suggest that the carcinolites nucleated in sequential stages, which included the dissolution processes of the original carapace, and the recrystallization of the carbonate of the carapaces in thin layers with prismatic grains. Macroscopically, they are characterized by the black color of the carcasses, phosphatization, silicification (occurring locally), and compression of the carapaces (Távora and Viana, 2003; Távora and Miranda, 2004).

In Brazil, carcinolites have only been recorded in the Baunilha stream, Quatipuru county, northeastern Pará state. They form distinctive components of the Baunilha Grande Ecofacies of the Pirabas Formation, which is characterized by finely stratified gray limestones and black mudstones, both bearing carcinolites (Fig. 2B).

Previous palynological investigations of the Baunilha Grande Ecofacies were confined to the black mudstones that outcrop in some localities of the Pará state littoral zone (Leite et al., 1997a, b; Leite, 2004; Rossetti and Goes, 2004; Aguilera et al., 2013). The present paper is the first palynological study of the carcinolites and the associated sedimentary rocks (i.e., carcinolites related with the finely stratified gray limestones and black mudstones). The present study aims to characterize the Pirabas sequence biostratigraphically – more specifically, palynostratigraphically – and to correlate the strata within and beyond the Pará-Maranhão Basin. We aim to elucidate the depositional environment of the Baunilha Grande Ecofacies and to confirm whether the carcinolites are genuinely *in situ* concretions, contemporaneous with sedimentation.

## 2. Material and methods

Prior to initiating this study, a comprehensive review of all of the outcrops of the Pirabas Formation's Baunilha Grande Ecofacies throughout the Pará-Maranhão Basin was performed by one of the authors (Tavora, V.A). During three fieldtrips in 1998, he collected 122 carcinolites and 11 associated gray limestone samples from the Baunilha stream locality. The carcinolites were used for detailed study of the decapod crustaceans conducted by Távora and Silva (2002) and Távora and Viana (2003).

For the present palynological analysis, 11 gray limestone and 4 carbonate concretions, all representative of the Baunilha Grande Ecofacies were processed. However, from the sampled sequence (Fig. 2B), only four samples proved productive palynologically, containing abundant and fairly well-preserved palynoflora. Two of these are carcinolites (samples MG-3017 and MG-3020), and the other two are gray limestones (MG-3018 and MG-3028). Palynomorphs in the studied material are illustrated by the light photomicrographs in Plates 1–3.

Samples were subjected to conventional physico-chemical techniques (e.g., Uesugui, 1979; Phipps and Playford, 1984; Wood

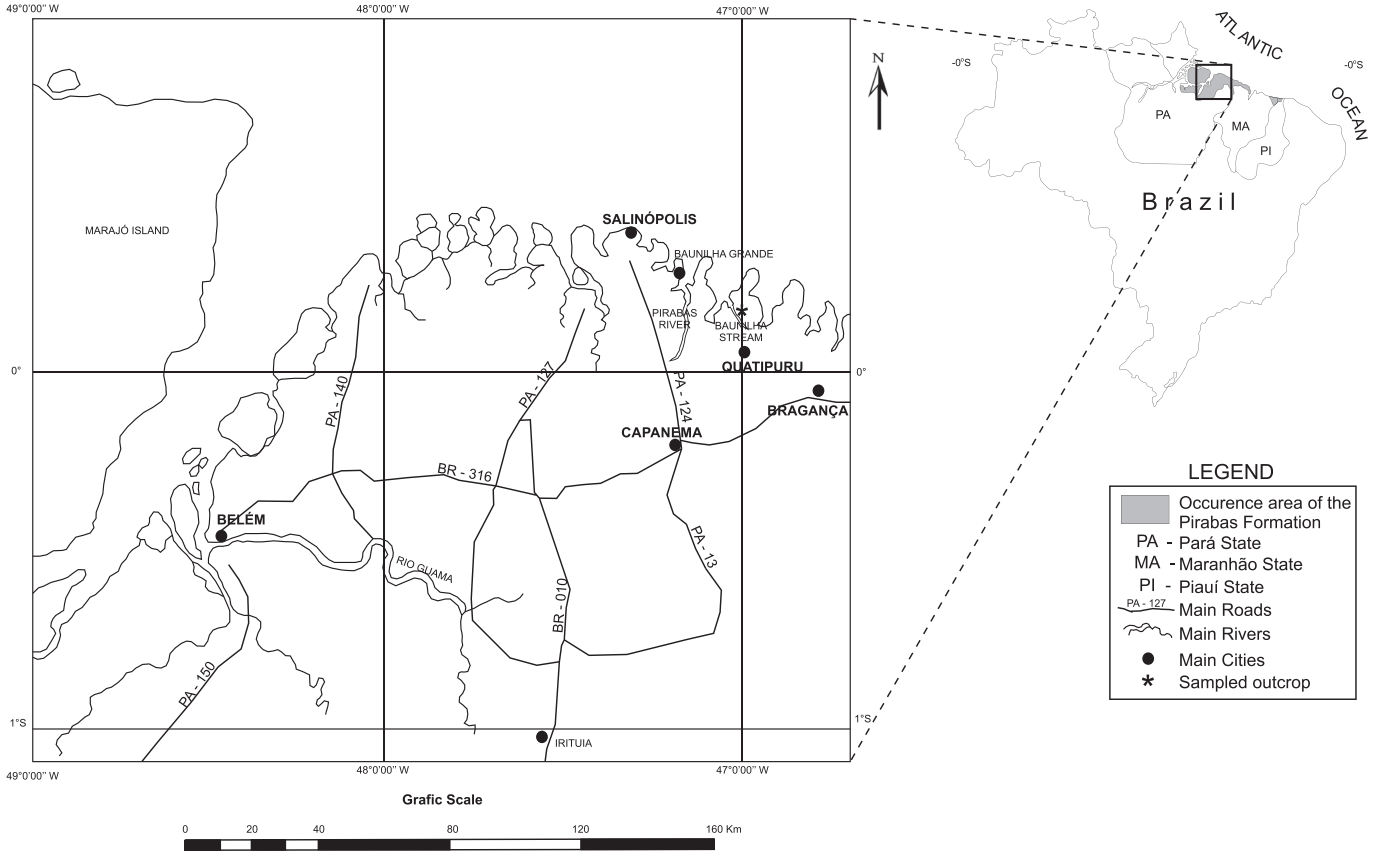


**Fig. 1.** Map showing the coverage of the Pirabas Formation.