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Fossilized excreta associated to dinosaurs in Brazil

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ABSTRACT

This work provides an updated register of the main occurrences of fossilized excreta (coprolites and urolites) associated with dinosaurs found in the Brazil. The goal is to provide a relevant guide to the interpretation of the environment in the context of Gondwana. In four geographic areas, the excreta are recovered from Cretaceous sedimentary deposits in outcrops of the Bauru and São Luis basins and the Upper Jurassic aeolian deposits of the Parana Basin in the state of São Paulo. The coprolites were analyzed by X-ray diffraction and X-ray fluorescence methods. The results of these analyses reveal compositions that differ from the surrounding matrix, indicating a partial substitution of the organic material due to the feeding habits of the producers. Additionally, we describe the urolite excavations in epirelief and hyporelief, the result of gravitational flow the impact from urine jets on sand. These are associated with ornithopod and theropod dinosaur footprints preserved in the aeolian flagstones of the Botucatu Formation, Parana Basin.

1. Introduction

The invertebrates and vertebrates metabolic processes occur with all molecular compounds after assimilation. Proteins generate catabolites (waste coming from the metabolism) that need to be eliminated. Urine and feces comprise the final products that are deposited into the environment through the excretory system (Begon et al., 1994; Fritz et al., 2010). Urolites and coprolites are fossilized body fluids; classified as biogenic structures, resulting from heterotrophic activity in the biosphere and preserved in sedimentary rocks throughout the Phanerozoic.

Most of the time it is difficult to identify the producer species of the fossilized excreta (Chin, 1997). Nevertheless these remains provide evidence of feeding habits and behaviors of animals since the Silurian (Hunt et al., 1994). Since the Late Paleozoic, many terrestrial tetrapods, such as labyrinthodonts, procolophonids and mammal-like reptiles disappeared or declined and dinosaurs evolved to occupy the empty ecospace in the Late Triassic (Tucker and Benton, 1982; Benton, 1985). As a result, dinosaur excreta are well documented during the Mesozoic including ornithopod coprolites from the Middle Jurassic of North Yorkshire, England (Hill, 1976) to urolites preserved in the Upper Jurassic in the Morrison Formation from the United States (McCarville and Bishop, 2002) and in the Botucatu Formation from Brazil (Fernandes et al., 2004). However, the most of the evidence for the Mesozoic coprolites comes from a few highly productive Cretaceous localities like those associated with the Lower Cretaceous theropod dinosaurs in (Bertrand, 1903; Jain, 1989), the Upper Cretaceous sauropods in the Lameta Beds in India (Matley, 1939), and the Upper Cretaceous hadrosaur, *Maiasauria peeblesorum* from the Two Medicine Formation in the United States (Chin, 2007).

The first occurrence of coprolites associated with nonmarine tetrapods in Brazil was documented by Huene (1935). Most of these were associated with a dicynodont fauna (Souto, 2001), in the Middle Triassic Santa Maria Formation in Rio Grande do Sul State. However, discoveries of excreta associated with dinosaurs were only made in Brazil at the beginning of this century. Here, we describe and analyze fossilized vertebrate excreta associated with different groups of dinosaurs (specifically, sauropod coprolites) from outcrops within the Bauru Basin in the states of Minas Gerais and Mato Grosso and from an inshore outcrop of the São Luis Basin in the state of Maranhão. Urolites are only preserved in aeolian sandstones that would have been accumulated between the Late

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Jurassic and Early Cretaceous (Renne et al., 1992; Turner et al., 1994). They are associated with a theropod dinosaur fossil track site in Araraquara County, in the state of São Paulo (Fig. 1A–C).

1.1. Geological setting

In the state of Maranhão coprolites in the Coringa flagstone, are located on the east side of Cajual Island in São Marcos Bay a present day wave dominated coastal environment (Fig. 1A). The area comprising the outcrop consists of a large exposed bone-bed in the Alcantara Formation. The unit consisting of alternating beds of fine-grained reddish sandstones, siltstones and mudstones was deposited in a near shore environment subject to tidal currents (Holz et al., 2001). A palynologycal analysis indicates that the sediments area Cenomanian in age, whereas the sequences of the more inland Itapecuru Group are considered to be Albian in age (Carvalho and Pedrão, 1998). The coprolites found in association with the aforementioned large bone bed with fossilized remains of fishes, crocodylomorphs, theropod dinosaurs (*Carcharodontosaurus, Spinosaurus and Sigilmassaurus*), sauropod dinosaurs (Titanosaurus), and plants (Medeiros and Schultz, 2001; Carvalho and Silva, 1992).

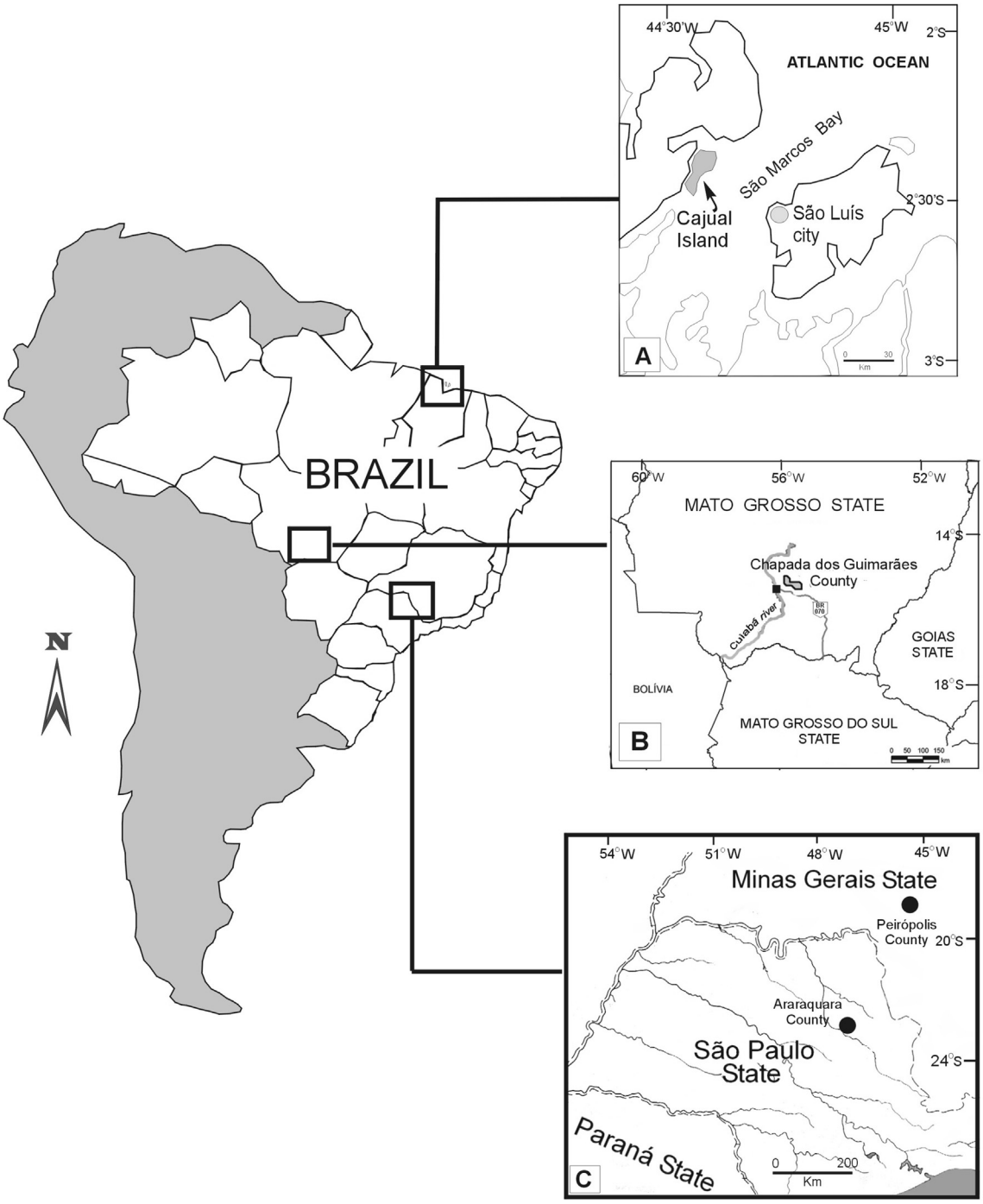

Fig. 1. Map showing location of studied excreta sites in Brazilian territory: A – Cajual Island, in the State of Maranhão, B – Chapada dos Guimarães County, in the state of Mato Grosso and C – Outcrops of Peirópolis County, (Minas Gerais state) and the Araraquara County (São Paulo state).