

**Primeiro registro de um terópode (Dinosauria, Theropoda) do Neocretáceo do Grupo Bauru, sul de Goiás, Brasil**

**First record of a theropod (Dinosauria, Theropoda) from the Late Cretaceous of the Bauru Group, southern Goiás State, Brazil**

**Primer registro de un terópodo (Dinosauria, Theropoda) del Cretácico Tardío del Grupo Bauru, sur del Estado de Goiás, Brasil**

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## **Resumo**

O objetivo deste artigo é descrever o primeiro registro de um dinossauro carnívoro terópode do Neocretáceo da Formação Adamantina (Grupo Bauru, Bacia do Paraná) do sul do estado de Goiás região Centro-Oeste do Brasil. A metodologia deste trabalho foi baseada levantamento bibliográfico sobre as características de dentes de terópodes e a geologia da região, além da descrição e comparações morfológicas. Esse espécime foi encontrado em um sítio da geodiversidade denominado Serra da Portaria, no Parque Estadual de Paraúna, município de Paraúna onde afloram residuais da Formação Adamantina. O espécime, um dente fragmentário coberto por óxido de ferro, mas apresentando uma coroa parcialmente preservada e foi atribuído como percentente à um terópode indeterminado por possuir coroa e seção transversal comprimida labiolingualmente. Par ao Grupo Bauru no estado de Goiás são conhecidos somente restos de dinossauros herbívoros sauropods para as formações Adamantina e Marília, o dente aqui descrito é primeiro registro osteológico de um terópode do sul de Goiás.

**Palavras chave:** Dinossauro terópode; Formação Adamantina; Sul do estado de Goiás; Neocretáceo; Brasil.

## **Abstract**

The objective of this article is to describe the first record of a theropod carnivorous dinosaur from the Late Cretaceous of the Adamantina Formation (Bauru Group, Paraná Basin) in the south of the state of Goiás in the Midwest region of Brazil. The methodology of this work was based on a bibliographic survey about the characteristics of teeth of theropods and the geology of the region, in addition to the description and morphological comparisons. This specimen was found in a geodiversity site called Serra da Portaria, in the Paraúna State Park, municipality of Paraúna, where residuals from the Adamantina Formation is exposed. The

specimen, a fragmentary tooth covered with iron oxide, but with a partially preserved crown, was assigned as a percentage to an undetermined theropod for having a labiolingually compressed crown and cross section. In addition to the Bauru Group in the state of Goiás, only remnants of sauropod herbivorous dinosaurs are known for the Adamantina and Marília formations, the tooth described here is the first osteological record of a theropod from the south of Goiás.

**Keywords:** Theropod dinosaur; Adamantina Formation; Southern Goiás state; Late cretaceous; Brazil.

### **Resumen**

El propósito de este artículo es describir el primer registro de un dinosaurio carnívoro terópodo del neocretáceo de la Formación Adamantina (Grupo Bauru, Cuenca Paraná) en el sur del estado de Goiás en la región del Medio Oeste de Brasil. La metodología de este trabajo se basó en una encuesta bibliográfica sobre las características de los dientes de los terópodos y la geología de la región, además de la descripción y las comparaciones morfológicas. Este espécimen fue encontrado en un sitio de la geodiversidad Serra da Portaria, en el Parque Estatal de Paraúna, municipalidad de Paraúna, donde emergen los residuos de la Formación Adamantina. El espécimen, un diente fragmentario cubierto con óxido de hierro, pero con una corona parcialmente preservada, se asignó como porcentaje a un terópodo indeterminado por tener una corona y sección transversal comprimida labiolingualmente. Además del Grupo Bauru en el estado de Goiás, solo los restos de dinosaurios herbívoros saurópodos son conocidos por las formaciones Adamantina y Marília, el diente descrito aquí es el primer registro osteológico de un terópodo del sur de Goiás.

**Palabras clave:** Dinosaurio terópodo; Formación Adamantina, Sur del estado de Goiás; Cretácico tardío; Brasil.

### **1. Introduction**

In 2018, a field team of the Biological Sciences course of the Universidade Estadual de Goiás, *Campus* Quirinópolis, discovered an isolated tooth at the geodiversity site Serra da Portaria, located at the State Park of Paraúna, municipality of Paraúna. The specimen was recovered in the rocks of the Adamantina Formation (Bauru Group, *sensu* Fernandes & Coimbra, 1996).

An extensive and diverse record of carnivorous theropod dinosaurs from the Bauru Group has previously been catalogued. These specimens have been found at different localities in western São Paulo State and in the Triângulo Mineiro region, southeastern Brazil (Bittencourt & Langer, 2011; Brusatte, Candeiro & Simbras, 2017). Teeth are the most abundant fossil elements of Bauru Group theropods. This is because their teeth are also composed of hydroxyapatite, which renders them more resistant to taphonomic destruction (Chandler, 1990; Currie, Rigby & Sloan, 1990/).

Theropod teeth are some of the most important fossils found in the Late Cretaceous rocks of the Bauru Group, especially in the Adamantina and Marília formations, as reported by many authors (*e.g.*, Kellner & Campos, 2000; Candeiro *et al.*, 2012). Some materials have been assigned to more inclusive groups inside Ceratosauria and Tetanurae (Kellner & Campos, 2000; Geroto, Bertini, & Franco-Rosas, 2010; Candeiro *et al.*, 2012). The dinosaur fauna from the Bauru Group of southern Goiás State is poorly known and only a few mentions of sauropod and theropod records from this area were made by Weishampel *et al.* (2004); however, these authors do not report the existence of specific osteological or ichnological specimens. The first dinosaur remains figured and described from the region were assigned to Titanosauriformes indet. and Titanosauria indet. by Candeiro *et al.* (2018).

The objective of this article is to describe the first record of a carnivorous theropod dinosaur from the Late Cretaceous of the Adamantina Formation (Bauru Group, Paraná Basin) in southern Goiás State, Brazil. This record enhances the scientific knowledge of the reptile fauna of this newly discovered fossiliferous region of Central Brazil.

## **2. Material and Method**

### **Material**

The specimen is housed at Paleontology and Evolution Laboratory of the Geology Course, *Campus* Aparecida de Goiânia, Universidade Federal de Goiás under the number Paleo-UFG / V-0032-36. The method of this work was based on morphological description (*sensu* Currie *et al.*, 1990) and comparisons.

## Method

The research potential of southern Goiás State led the team of the of the Universidade Federal de Goiás and Universidade Estadual de Goiás to perform an exploratory fieldwork between the years of 2018 and 2019. Some new materials were collected at the region Parque Estadual de Paraúna (Adamantina Formation, Bauru Group). This study had a bibliographic research on the works that approach the paleontology and geology of the region. The main articles with morphological data on the teeth of theropods were used that provided a basis for anatomical comparisons and correct identification of the studied specimens. Paleo-UFG/V0035 was photographed on a high resolution digital camera.

The isolated teeth of theropods have diagnostic characteristics that were recognized in the classic work by Currie *et al.* (1990), which has been built upon by subsequent authors (e.g., Ruiz-Omeñaca, Canudo & Cuenca-Bescós, 1997; Sankey, Brinkman, Guenther & Currie, 2002; Candeiro *et al.* 2012). Characteristics of isolated teeth with informative value are mainly: (1) lateral compression, (2) crown curvature, (3) presence and constitution of the enamel, (4) and cross section. The denticles (shape, density) are important characteristics in the methodology, but were not considered for the specimen studied here because the denticles are absent.

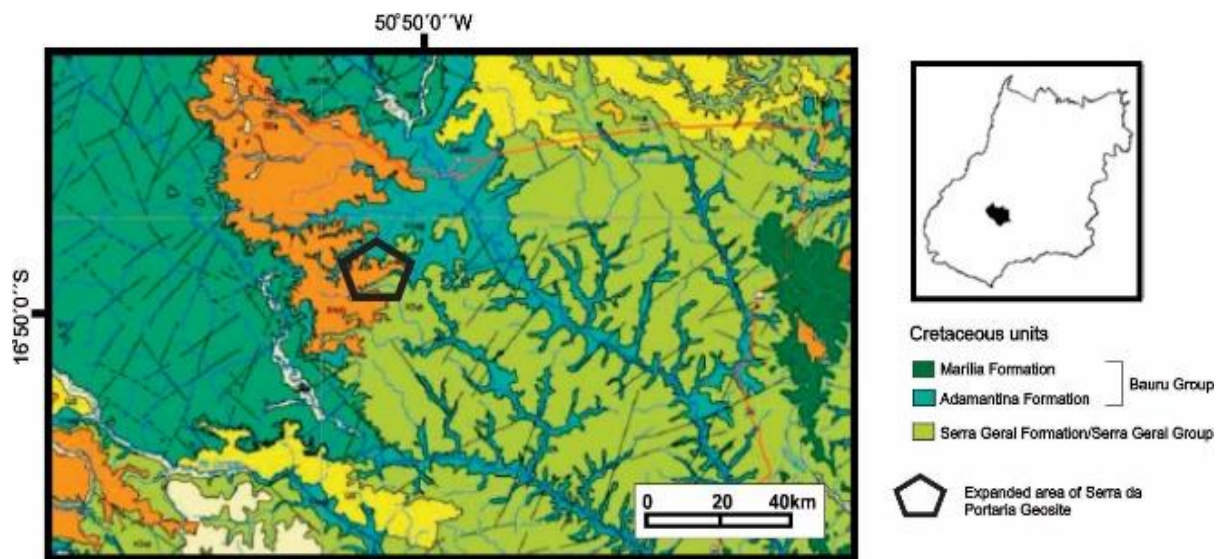
### 3. Geological Setting

Soares Landim, Fúlfaro & Neto (1980) suggested a stratigraphic arrangement of the Bauru Group that includes, in ascending stratigraphic order: the Adamantina Formation, Uberaba Formation, and Marília Formation. The group crops out irregularly in southern Goiás State, Triângulo Mineiro region, Mato Grosso do Sul State, and western São Paulo State (*sensu* Fernandes & Coimbra, 1996).

The Bauru Group is well-exposed in southern Goiás State. The outcrops are found in the State Park of Paraúna, where the Adamantina Formation rocks overly the Lower Cretaceous basalts of the Serra Geral Formation (Serra Geral Group, Paraná Basin) (*sensu* CPRM — Serviço Geológico do Brasil, 2004).

Soares *et al.* (1980) described the Adamantina Formation (Fig. 1). The rocks are composed of reddish fluvio-lacustrine sandstones deposited during warm and humid past climate events (Soares *et al.*, 1980; Barcelos, 1984).

**Figure 1.** Geological and localization of Serra da Portaria geodiversity site (adapted from CPRM, 2004).



Source: Authors.

The fossil record of Goiás State is diverse and, although including few taxa at this point in time, it includes plants, bioturbations, ichnofossils, mollusks, and vertebrates (Santos-Pereira Figueiredo-Lima, & Candeiro, 2016; Ferreira *et al.*, 2016; Candeiro *et al.*, 2018a,b). According to Dias-Brito *et al.* (2001), the deposition of the Adamantina Formation occurred during the Turonian-Santonian stages of the Late Cretaceous.

#### 4. Characterization of the Geodiversity site Serra da Portaria

The geodiversity site Serra da Portaria is located 38km North of the urban center of Paraúna town and is part of the Cerrado biome. To arrive at the geodiversity site it is necessary to climb part of the valley to reach the tabular plateau of Serra da Portaria.

The coordinates of the outcrop are: Lat.: -16.968471527 Long.: -50.696025848.

At the area of paleontological interest an isolated tooth was found in the pelite layers of the Adamantina Formation (Turonian-Santonian). The bedding includes reddish sediments that are fine-to-medium grained and rich in iron oxide.

Local vegetation at the geodiversity site area is mainly composed of “campo limpo” (open grasslands). There are two well-defined seasons – a rainy summer and a very dry winter (Ab´Saber, 1982). The climate is tropical semi-humid and the average temperature of the coldest month is higher than 18° C, while the average temperature of the warmest month is

around 30° C; annual average temperature is 22° C with rainfall all-year round (Ab´Saber, 1983).

To date, only one fossil has been discovered at the geodiversity site: an isolated tooth that is moderately preserved due its severe wear (Ferreira, 2016). The geodiversity site Serra da Portaria is registered at the online platform Geossit, maintained by the *Companhia de Pesquisa de Recursos Minerais*.

Geossit is a Web tool developed to manage the inventory, qualification, and quantitative evaluation of geodiversity site and geodiversity sites in the Brazilian territory (CPRM: <https://www.cprm.gov.br/geossit/>).

## 5. Systematic Paleontology

The following is a description of the theropod specimen housed at UFG from the geodiversity site Serra da Portaria, in the State Park of Paraúna, municipality of Paraúna, Goiás state.

Dinosauria Owen, 1842

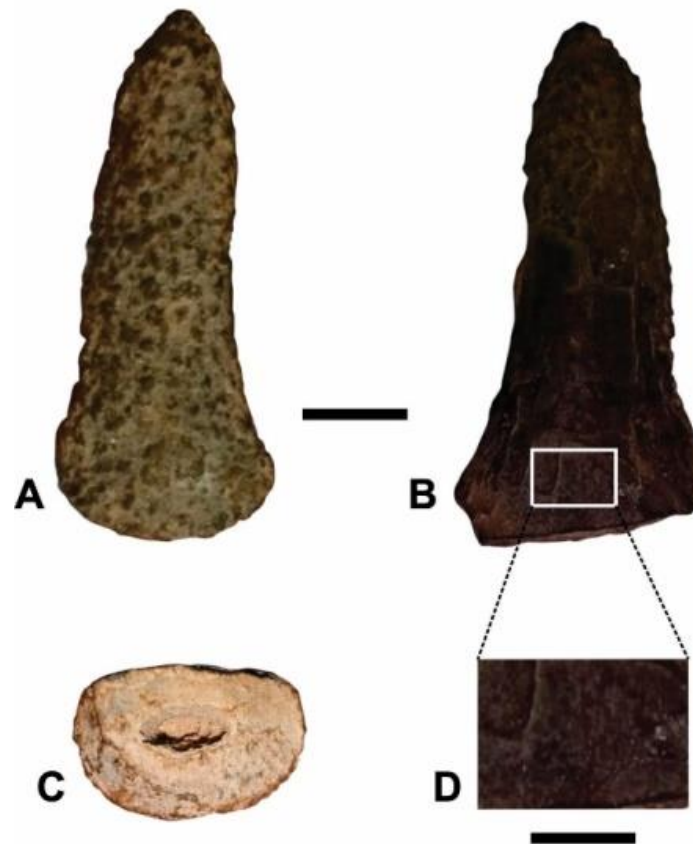
Saurischia Seeley, 1988

Theropoda Marsh, 1881

Theropoda indet. (Figure 2a-d)



**Figure 2.** Theropod tooth from the Adamantina Formation of the Serra da Portaria Geodiversity site of Paraúna municipality: a) lingual? face; b) labial? face; c) cross-section of the base; d) fine-grained detail of enamel surface. Scale bar 20mm.



Source: Authors.

Paleo-UFG/V0035 (Fig. 2a, b) is an incomplete, medium-sized tooth lacking the apical portion. The tooth is labiolingually compressed and has very little curvature. The wear on the anterior and posterior borders indicates the action of taphonomic processes that may have destroyed taxonomically important features such as denticles. Enamel is absent on the labial? surface but present on the basal portion of the tooth. The basal *cross section* is *compressed* labio-lingually (Fig. 2c). The remaining enamel has a fine-grained appearance (Fig. 2d), and it is not possible to observe the presence of ornaments or wrinkles.

## 6. Discussion

According to Currie *et al.* (1990) and Sankey *et al.* (2002), theropod teeth are characterized by labiolingual compression, a highly compressed cross-section, and a crown covered by enamel. The cross-section compression of teeth is a common feature among



theropods (Farlow *et al.*, 1991; Rauhut & Werner, 1995). Despite the fragmentary nature of the specimen Paleo-UFG/V0035, it exhibits the above mentioned theropod characters. Nevertheless, it is not possible to observe ornaments or wrinkles that are typical of particular theropod groups (*e.g.*, Spinosauridae: fluted, Carcharodontosauridae: wrinkles; Candeiro, Currie & Bergqvist, 2012) since the crown enamel is partially worn.

The theropods from the Bauru Group include members of Ceratosauria (Abelisauria) and Tetanurae (Carcharodontosauridae, Coelurosauria, Maniraptora, Unenlagiidae; references in Brusatte *et al.*, 2017). Although it is not possible to assign the specimen Paleo-UFG/V0035 to a more inclusive taxonomic level, this new fossil indicates that theropods was also geographically distributed during the Late Cretaceous in areas of the Bauru Group that formed in today's southern Goiás State.

The described dinosaur fauna from the strata of the Bauru Group in southern Goiás so far includes only sauropod records. Weishampel (1990) and Weishampel *et al.* (2004) reported the possible occurrence of fossil remains of titanosaur and theropod dinosaurs in this region. Weishampel (1990: p. 135) was the first formal publication to mention the occurrence of *cf. Titanosaurus* sp., *Antarctosaurus brasiliensis*, and Theropoda indet. in Goiás State. Later, Weishampel *et al.* (2004, p. 601) published a more updated study and reassigned these materials to *Antarctosaurus brasiliensis*, *Lithostrotia* indet. (= *cf. Titanosaurus* sp.), and Theropoda indet. However, none of these studies document the existence of specific osteological remains. The present description of Paleo-UFG/V0035 recovered from the rocks of the Adamantina Formation in the geodiversity site Serra da Portaria, State Park of Paraúna, is the first clearly documented osteological record of a theropod from the Upper Cretaceous of southern Goiás State.

Ferreira & Lima (2017) describes the geological characteristics of the geodiversity site Serra da Portaria as well as of other geodiversity sites. The study reports the presence of rocks from the Adamantina Formation and although it does not mention any record of fossil materials, it surely indicates the scientific potential of the geodiversity sites in the State Park of Paraúna. The description of Paleo-UFG/V0035 demonstrates the potential for more fossil discoveries in the State Park of Paraúna.

## 7. Conclusions and Suggestions

Here, we describe for the first time the presence of theropod dinosaurs in the Late Cretaceous rocks of the Adamantina Formation in the State Park of Paraúna, southern Goiás

State. The tooth specimen is of special importance since it is the first theropod record known from southern Goiás State.

It is possible to conclude that the area of the State Park of Paraúna has fossiliferous potential and is also possibly valuable for geoscientific and geoconservational activities.

The rocks of the Upper Cretaceous of the Bauru Group in Central Brazil often yield theropod teeth. The first record of this dinosaur group in the state of Goiás expands its distribution. New research and prospecting in the state are important, as they provide new discoveries and increase the scientific knowledge of regional paleontology, in addition to demonstrating the state's paleontological potential.

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