

**AN ENIGMATIC TOOTH OF ABELISAUURIDAE FROM PEIRÓPOLIS
PALEONTOLOGICAL SITE (MARÍLIA FORMATION, BAURU GROUP) WITH
CHARACTERS OF TROODONTIDADE**

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ABSTRACT. In this work, the results of an analysis of an isolated tooth of theropod dinosaur, found in the Paleontological Site of Peirópolis, in the state of Minas Gerais, correspondent to the Marília Formation, a component of an important Brazilian basin, where relevant fossil assemblages were found. Through the morphological analysis and comparison of the tooth with previous examples, besides the assistance of an extensor database, the sample in question was framed in a family.

Keywords. Marília Formation: Abelisauridae: tooth: Peirópolis: Maastrichtian

**UM DENTE ENIGMÁTICO DE ABELISAUURIDAE DO SÍTIO
PALEONTOLOGÓGICO DE PEIRÓPOLIS (FORMAÇÃO MARÍLIA, GRUPO
BAURU) COM CARACTERES DE TROODONTIDADE**

Resumo. Neste trabalho, os resultados da análise de um dente isolado de dinossauro terópode, encontrado no Sítio Paleontológico de Peirópolis, no estado de Minas Gerais, correspondente à Formação Marília, componente de uma importante bacia brasileira, onde importantes assembléias fósseis foram achados. Através da análise morfológica e comparação do dente com exemplos anteriores, além do auxílio de um banco de dados extensor, a amostra em questão foi enquadrada em uma família.

Palavras-chave. Formação Marília: Abelisauridae: dente: Peirópolis: Maastrichtiano

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INTRODUCTION

In 2013, a field team from the Geology Laboratory of the Geography Course of the Universidade Federal de Uberlândia discovered at Price's "Point 1", in Peirópolis city, Uberaba municipality, a small theropod dinosaur tooth. This tooth appears to bear characters from both Laurasian and Gondwanan theropods. The Peirópolis region is known for having the largest record of carnivorous dinosaur teeth of Brazil, totaling more than 120 specimens. Unfortunately, it is very difficult to assign dinosaur teeth to genera or families; yet, these specimens have some taxonomic utility, and can often be assigned to broad taxonomic groups based on reliable morphological characters (Currie et al., 1990; Fiorillo & Currie, 1998; Sankey et al., 2002; Candeiro et al., 2012; Torices et al., 2015). Here, we aim to identify the relationships of the new tooth from Peirópolis.

LOCALITY, MATERIALS AND METHODS

Locality

The classic fossil deposit "Point 1 Price" is located at the rural area of Peirópolis, 12 km away from the urban area of Uberaba town, Minas Gerais State. This locality is found in rocks of the Bauru Group (*sensu* Fernandes & Coimbra, 1996), a sequence of sedimentary rocks from the Upper Cretaceous. In Minas Gerais, the Bauru Group is formed by continental sediments of the Adamantina, Uberaba, and Marília formations, which span from the Turonian to the Maastrichtian (Dias-Brito et al., 2001; Brusatte et al., 2017). The theropod tooth is from the continental deposits of the Marília Formation, as seen below at Figure 1. The age of these deposits is assigned to the Maastrichtian based on their microfossil record (Gobbo-Rodrigues et al., 1999; Dias-Brito et al., 2001), vertebrate fossils (Fernandes & Coimbra, 1996, 2000), and because they stratigraphically overlie the latest Santonian-Maastrichtian Adamantina Formation (Zaher et al., 2006); see review in Brusatte et al., (2017).

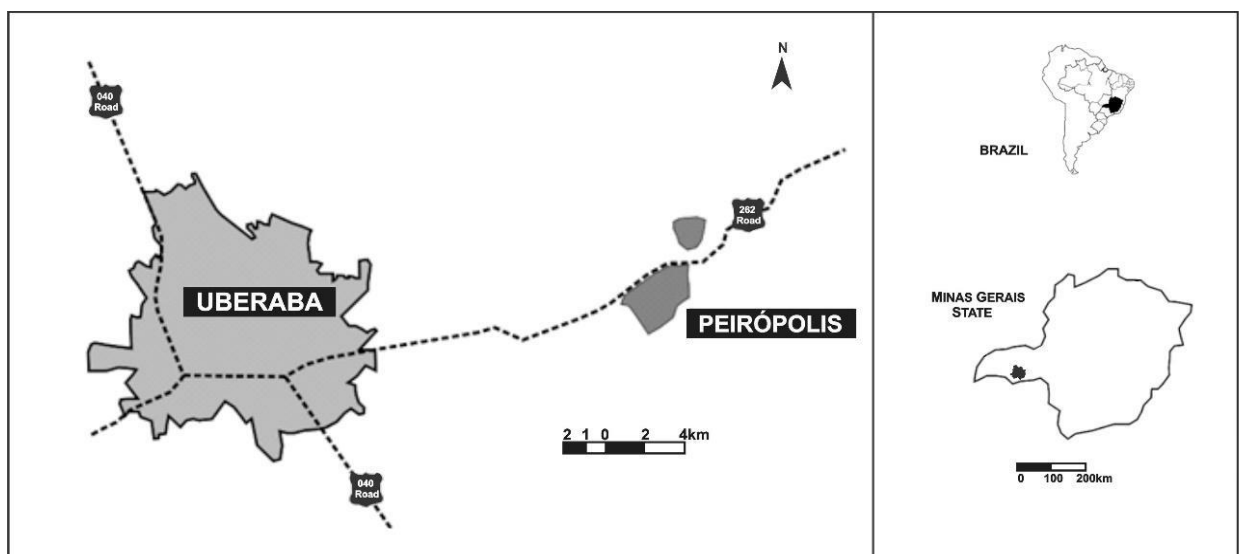


FIGURA 1 - Mapa de localização. Localização do dente de Abelisauridae no Sítio Paleontológico de Peirópolis.

FIGURE 1- Location map. Abelisauridae tooth location from Peirópolis Paleontological Site.

Materials

The studied tooth, UFU-Geo-PV-14, is housed at the Geology Laboratory of the Geography Course/Pontal Campus of Universidade Federal de Uberlândia.

Methods

It was measured with a digital caliper, and its measurements were inserted into a dataset of teeth representing taxa from across theropod phylogeny. This dataset was presented by Hendrickx et al. (2015), which built upon the earlier studies of Smith et al. (2005) and Larson & Currie (2013). In this dataset, all teeth were scored for six variables (CBL, CBW, CH, AL, MC, and DC, the latter two measuring the density of serrations per 5 mm at the midpoint of the mesial and distal carinae, respectively; see Hendricks et al. (2015) for full explanation of these features).

Analyses

The dataset was log-transformed, and we then performed multivariate analyses (Principal Components Analysis, Cluster Analysis, and Discriminant Function Analysis) on this dataset in PAST v.2.17 and 3.0 (Hammer et al., 2001) to determine the most likely classification of the tooth.

Results

SYSTEMATIC PALEONTOLOGY

Theropoda Marsh, 1881

Abelisauridae Bonaparte and Novas, 1985

Gen. et sp. indet.

Description

UFU-Geo-PV-14 is a small tooth with a partially broken basal portion, but most of the crown is preserved (Fig. 2). The specimen is not filled with sediment, which makes it possible to observe internal grooves on the compact-spongy bone tissue and growth lines on the transverse section of the crown's base. The tooth has a crown base length (CBL) of 10 mm, crown base width (CBW) of 4.9 mm, crown height (CH) of 19.2 mm, and apical length (AL) of 20.2 mm. The enamel surface texture is smooth. The cross section is quite labiolingually compressed, with the mesial and distal carinae coinciding with the mesial and distal edges, respectively. In labial and lingual views, the tooth is slightly recurved and almost triangular-shaped (Fig. 2). The carinae bear denticles from the base to the apex. On the distal carina there are 1.5 denticles/mm, and on the mesial carina there are 2 denticles/mm. All denticles are subquadrangular and are slightly inclined relative to the long axis of the carina, relatively large, very sharp-edged, and have something of a hook-like form projected towards the tooth apex. The mesial carina is mildly curved, whereas the distal carina is more strongly curved.

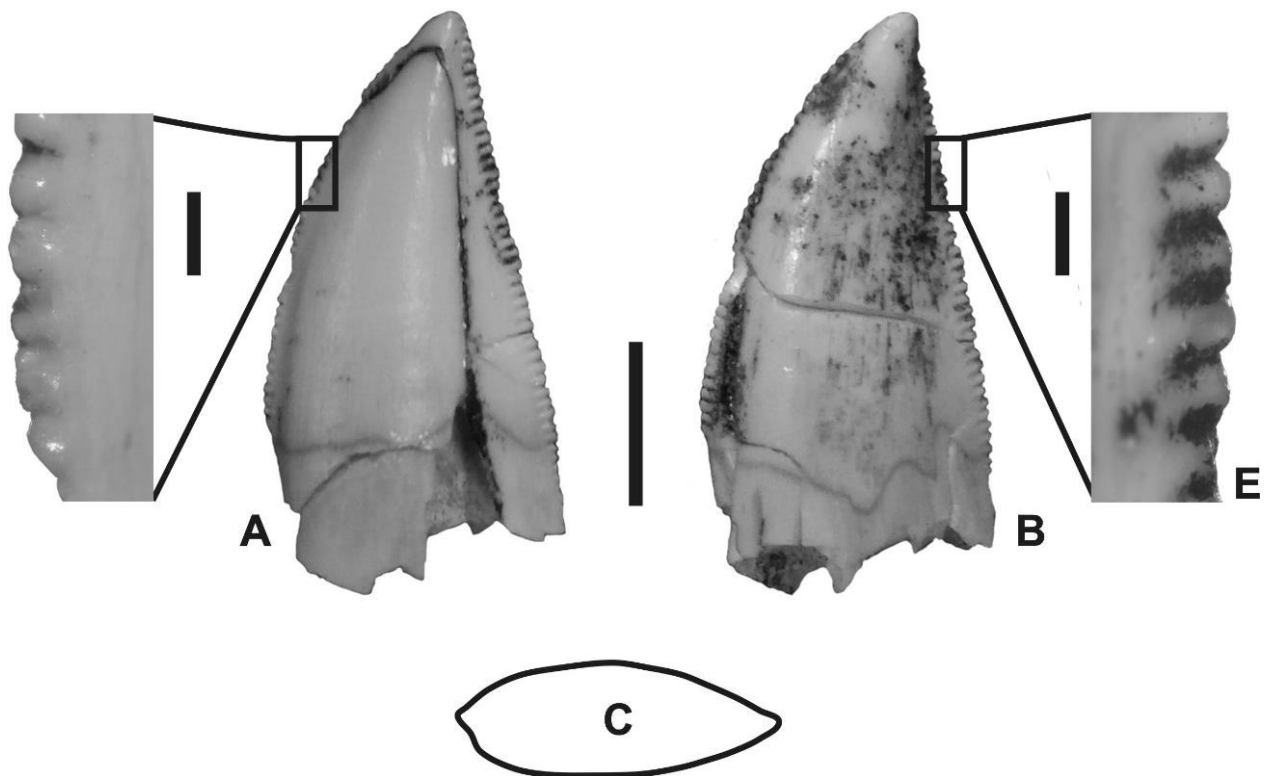


FIGURE 2 - Abelisauridae tooth UFU-Geo-PV-14. (A) labial and (B) lingual face; (C) cross-section of base; (D) posterior denticles and (E) anterior denticles. Scale bar: A, B and C = 50mm, D and E = 0.5mm.

FIGURA 2 - Dente de Abelisauridae UFU-Geo-PV-14. (A) face labial e (B) face lingual; (C) seção transversal da base; (D) dentículos posteriores e (E) dentículos anteriores. Barra de escala: A, B e C = 50 mm, D e E = 0,5 mm.

In order to more conclusively identify UFU-Geo-PV-14, it was included in a large dataset of nearly 1,000 teeth representing taxa from across theropod phylogeny, which were scored for six variables. Three multivariate analyses based on this dataset were performed then.

First, the log-transformed dataset to principal components analysis (PCA) was subjected, with missing values for measurements estimated with a mean value for that measurement across the sample and the utilization of a correlation matrix. In the resulting two-dimensional morphospace (Fig. 3), UFU-Geo-PV-14 plots within the convex hull (maximum morphospace occupation area) of abelisaurids only. When 95% confidence intervals are calculated, once again the tooth falls within the morphospace envelope of abelisaurids only.

Second, the log-transformed dataset was used to conduct a clustering analysis, using the paired group algorithm and the correlation similarity measure. This analysis finds that UFU-Geo-PV-14 is most similar to teeth of *Abelisaurus* and *Majungasaurus*.

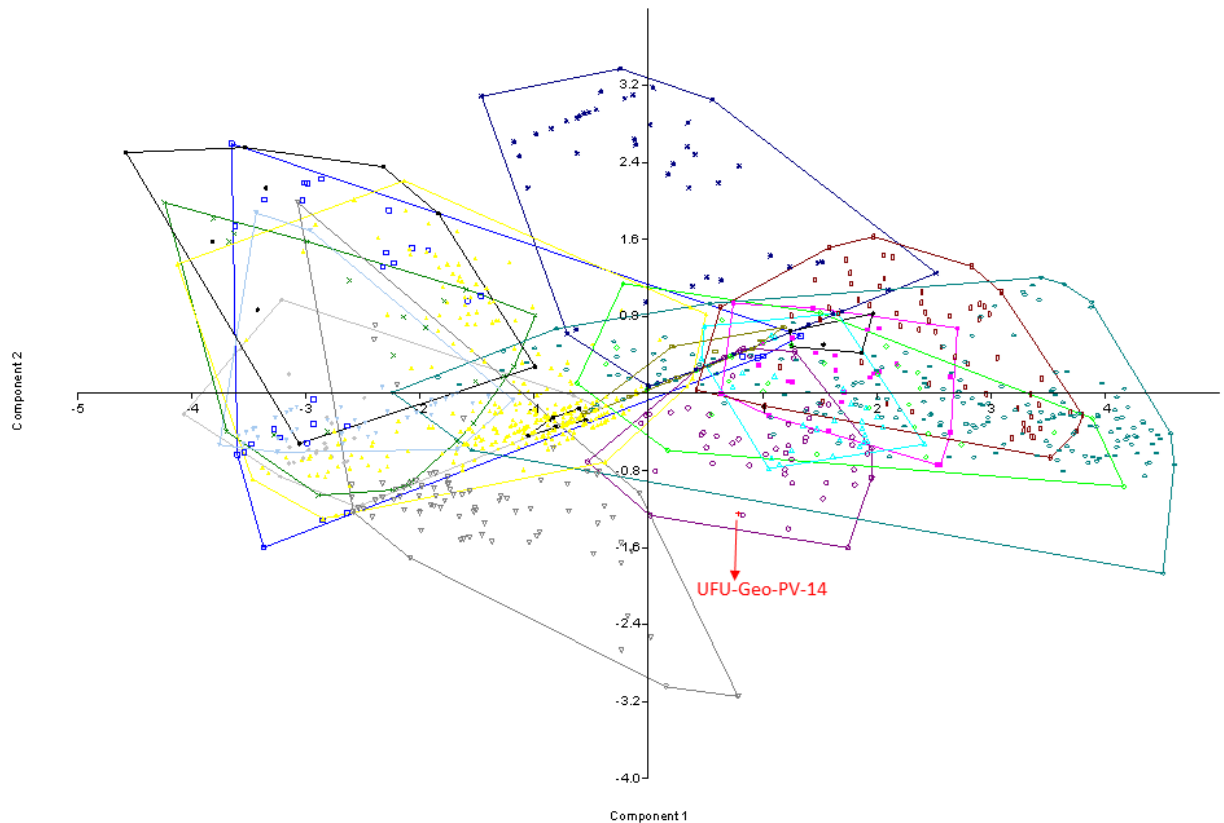


FIGURE 3 - Graphic PCA morphospace of UFU-Geo-PV-14.

FIGURA 3 - PCA de morfoespaço UFU-Geo-PV-14

Third, the log-transformed dataset was used to conduct a discriminant analysis. This technique uses predetermined groups (in this case, taxonomic groups) to create a morphospace in which these groups are maximally separated from each other. Teeth of unknown affinities, such as UFU-Geo-PV-14, can then be classified according to which group it is most similar to, in the discriminant morphospace. In this case, the analysis classifies 66.53% of teeth correctly, and identifies UFU-Geo-PV-14 as an abelisaurid tooth. However, when convex hulls are plotted in the discriminant morphospace, UFU-Geo-PV-14 falls within an empty area of space between abelisaurids and troodontids. When 95% confidence intervals are plotted, the tooth is placed on the border of the CIs for abelisaurids and troodontids.

In sum, these analyses provide evidence that UFU-Geo-PV-14 is most likely an abelisaurid. However, because the discriminant function analysis places the tooth as something of an intermediate between abelisaurids and troodontids in discriminant morphospace, it could be argued that the tooth belongs to either an aberrant abelisaurid that is dentally convergent with some troodontids, or a rare record of a Gondwanan troodontid with teeth similar to abelisaurids. Given the weight of evidence, we prefer the first explanation, but we cannot completely rule out the second. Regardless, this analysis demonstrates that the teeth of some abelisaurids and some troodontids are very similar to each other, despite the great differences in phylogenetic position and body size of these clades. This sometimes makes it difficult to distinguish individual teeth of these animals.

DISCUSSION OF RESULTS

Gondwan theropods are represented by Abelisauridae, Alvarezsauridae, Carcharodontosauridae, Spinosauridae, and Coelurosauria. The tooth does not exhibit derivative characters that allow its inclusion in a specific subject neither is possible to safely assign it to a taxon. It differs from the Carcharodontosauridae (*Carcharodontosaurus saharicus*, *Giganotosaurus carolinii*; sensu Sereno et al., 1996) – by the absence of oblique folds in the enamel – and from the Spinosauridae (*Irritator challengeri*, *Spinosaurus*; Sues et al., 2002).

Unlike Spinosaurinae teeth, UFU-Geo-PV-14 is a coarsely serrated tooth, does not represent a considerable conodonty, nor rounded sections nor a reasonable higher crown, general features of this specific Family (Martínez et al. 2016). However it presents smooth flutes on both sides of the crown in mesial and lateral teeth is a synapomorphy of Spinosaurida (Hendrickx et al. 2015), as could be seen in the smooth striations on the crown, but as suggested by Sereno et al. (1998), that feature should not be diagnostic for them.

The denticles near the tooth tip, proximal and middle parts of the anterior carina, seems to point towards the apex of the crown, such as *Carcharodontosaurus* previously examples studied by Hendrickx et al., (2015). However, the tooth has convex lingual and labial faces of the crown, but are compressed along the carina margins, this type of cross-section is different from that of a carcharodontosaurid. These specimens teeth differ from other theropods because it has lower crowns, and different kinds of wrinkles (Candeiro et al. 2006).

UFU-Geo-PV-14 is slightly laterally flattened, and shares a few of Troodontidae features, what could've caused the dataset to put it in between in these groups on the graphics above (Fig. 4). The inclination of the keel should also be considered, and the tooth presents basal constriction, another correspondent attribute, however, the interdenticle slits are not deep and accentuated (Geroto et al. 2014), this tooth has very slightly hooked and pointed denticles, what represents a synapomorphy of Abelisauroida.

The characters exhibited by the low crown tooth from UFU-Geo-PV-14 clearly indicate that it represents an Abelisauridae. Bonaparte and Novas (1985), Smith and Dalla-Vechia (2006) and Candeiro (2007) noted the presence of a low crown in the Abelisauridae teeth and regard it as a diagnostic character of the Family. UFU-Geo-PV-14 tooth shared abelisaurid morphology pointed by Candeiro (2007) slightly curved and labiolingually compressed with a low crown profile; in basal cross-sections of the dentary and maxillary teeth, it is observable the labiolingual compression with borders markedly compressed and the slightly concave lingual and facial surfaces; the tooth denticles of abelisaurids are subquadrangular shape; the interdenticular spaces between tooth denticles are shallow compared to other theropods.

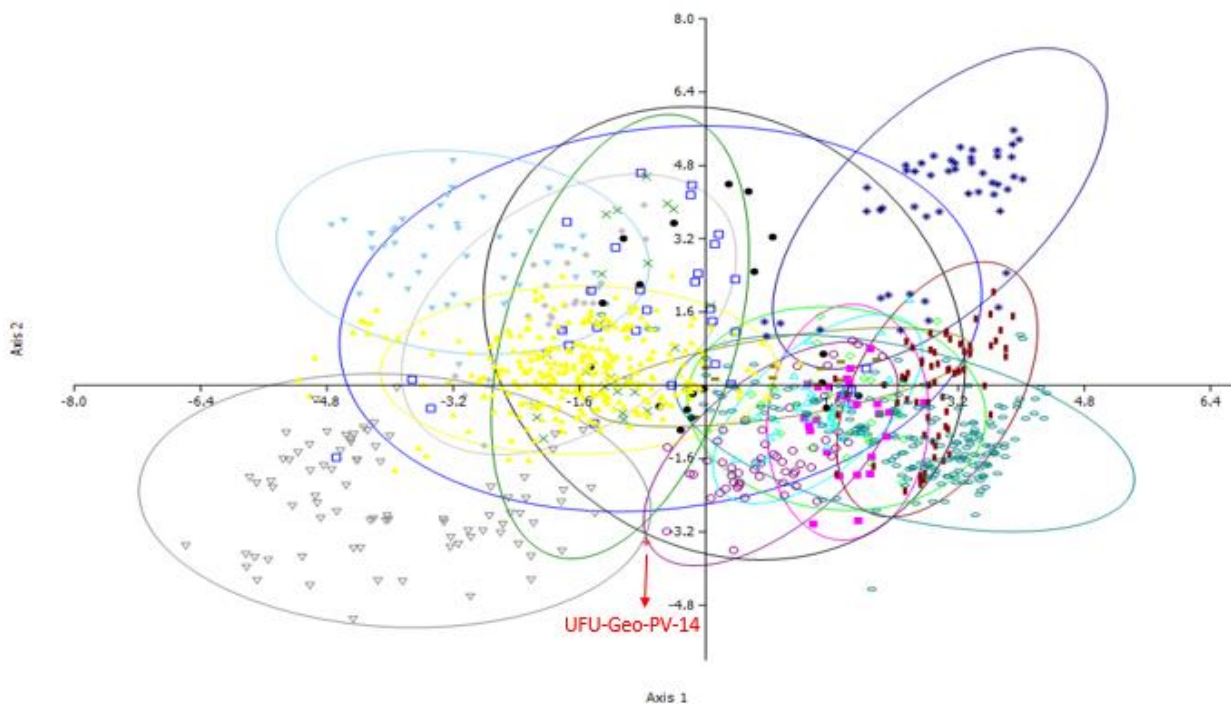


FIGURE 4 - Graphic discriminant function analysis morphospace from UFU-GeoPV-14.

FIGURA 4 - Morfoespaço de análise de função discriminante gráfica do UFU-GeoPV-14.

FINAL REMARKS

There are records of abelisaurid theropods in the areas bearing sediments from the Marília Formation in Peirópolis (Novas et al., 2008; Candeiro et al., 2012; Martinelli and Teixeira, 2015), as well as in other geologic units from the Upper Cretaceous of South America. However, these teeth were not yet described.

UFU-Geo-PV-14 is an additional abelisaurid tooth reported to the Marília Formation of Peirópolis area. Others Abelisauridae teeth were described from the Triângulo Mineiro region and western São Paulo State (see Candeiro et al., 2006, 2008, 2012). The Marília Formation abelisaurids are limited skeletal remains. Novas et al. (2008) described a dorsal vertebra, distal femur, and pedal phalanx. Machado et al. (2013) described a right tibia. Méndez et al. (2014) recently described postcranial remains represented by a partial axis, partial pelvis, and fibula. UFU-Geo-PV-14 support of enigmatic Abelisauridae tooth with Laurasian Troodontidae theropod in Peirópolis Site during the end of the Cretaceous.

ACKNOWLEDGMENTS

CRAC was financially supported by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq)/Bolsista de Produtividade em Pesquisa. SLB's collaborative work with CRAC was funded by a grant from the Fundação de Amparo a Pesquisa de Goiás (FAPEG) and Newton Fund to be researching in Southern Goiás state.

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