



First Record of Sauropod Remains from the Maastrichtian Marília Formation (Bauru Group) of Monte Alegre de Minas Since Friderich von Huene's Description in 1931
Os Primeiros Registros de Saurópodes Provenientes do Maastrichtiano da Formação Marília (Grupo Bauru) de Monte Alegre de Minas Desde a Descrição de Friderich von Huene em 1931

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Abstract

After 86 years since the historical work by von Huene describing dinosaur remains from the Marília Formation (Bauru Group) from the Monte Alegre de Minas municipality, new bone fragments from the same locality are presented here. The materials were identified as a part of a prezygapophysis and the margin of a robust bone. The fragmentary condition of these specimens did not allow a more specific assignment, but it was possible to identify characters that are present both in titanosaurids and sauropods.

Keywords: Sauropod; biodiversity; Triângulo Mineiro region; Late Cretaceous

Resumo

Após 86 anos, do trabalho histórico de von Huene que descreveu restos de dinossauros da Formação Marília (Grupo Bauru) de município de Monte Alegre de Minas, aqui se reportam fragmentos de ossos tentativamente atribuídos como uma parte de pré-zigapófise e borda de um osso robusto. O estado muito fragmentário de preservação destes materiais dificulta uma atribuição mais específica, mas estes apresentam características respectivas de dinossauros titanosaurídeos e saurópodes.

Palavras-chave: Saurópode; biodiversidade; região do Triângulo Mineiro; Neocretáceo

1 Introduction

The dinosaur remains from the Monte Alegre de Minas municipality were identified by Friderich von Huene in 1931 when he first discovered fossil remains in the rocks of the Maastrichtian of Marília Formation (Bauru Group) in the Triângulo Mineiro region (Fernandes & Coimbra, 1996). After a long period without new paleontological findings from the same region, this contribution confirms the paleontological potential of these rocks as dinosaur remain-bearing levels. New field works were conducted in the same area where von Huene made his findings, and two more specimens were discovered: the articular facet of a prezygapophysis and the margin of an unidentified sinuous and robust bone. Although fragmentary, this new material adds, for the first time since 1931, new dinosaur specimens to the records of western Minas Gerais State.

The goal of the present study is to describe and compare these two new dinosaur specimens. These findings add new dinosaur materials to the records of this region.

1.1 Brief History of the Geology and Paleontology of Monte Alegre de Minas

Titanosauria is the only sauropod clade with records from the Bauru Group of Central Brazil. Many isolated remains from the Triângulo Mineiro region have been described thus far (e.g., von Huene, 1931; Kellner & Campos, 2000; Bertini *et al.*, 2001; Santucci & Bertini, 2001; Almeida *et al.*, 2004; Marinho & Candeiro, 2005; Lopes & Buchmann, 2008; Santucci, 2008; Candeiro, 2010; Bittencourt & Langer, 2011). The following taxa have been formally described to this geological unit: *Maxakalisaurus topai* Kellner, Campos, Azevedo, Trotta, Henriques, Graik & Silva 2006, from the Adamantina Formation of the municipality of Prata; *Baurutitan britoi* Kellner, Campos & Trotta 2005, *Trigonosaurus pricei* Campos, Kellner, Bertini & Santucci 2005, and *Uberabatitan ribeiroi* Salgado & Carvalho, 2008, from the Marília Formation of the municipality of Uberaba.

The first fossils from the Triângulo Mineiro region described by *Friedrich* von Huene (1931)

were found in the municipality of Monte Alegre de Minas at the beginning of the last century. This region showed a great potential for the exploration of limestone surface deposits and, until today, limestone mining operations are still active. von Huene (1931) has briefly mentioned the femur of a titanosaur dinosaur found by the Comissão Geográfica e Geológica de São Paulo (Geographic and Geologic Commission of São Paulo), however, the author does not give a detailed description of the specimen. This material has been used as reference by many historical studies on fossils from the Bauru Group of the Triângulo Mineiro region (e.g. Kellner & Campos, 2000; Candeiro *et al.*, 2004; Candeiro, 2005, 2007; Peyerl *et al.*, 2015).

The first verified mention of fossil materials from the Late Cretaceous of the Triângulo Mineiro region was made by the paleontologist Frederich von Huene in 1931, who reported the herbivorous titanosaurid dinosaur fossils found in the region of Monte Alegre de Minas. During the 1940s and 1950s, many important studies (e.g., Price, 1945, 1950a, b, 1951, 1955) were published about the fossils from the Uberaba and the Marília formations. These works comprise the most important systematic studies about the reptile fauna from Peirópolis/Uberaba, in the Triângulo Mineiro region.

According to Figueirôa (1997), the first geological surveys to the Triângulo Mineiro region were based on three main lines of action: territorial demarcation, exploration of minerals for industrial use, and offering of general services. Moreover, important studies were made during this period in order to delimit the frontiers between the states of São Paulo and Minas Gerais. The southern border of the Triângulo Mineiro region is limitrophe with the São Paulo State, and it was part of an important area of mineral resources and of significant interest to the surveys made by the Comissão Geográfica e Geológica de São Paulo (Figueirôa, 1997; Candeiro *et al.*, 2014).

Milward (1935) was the first to mention the great extension of the outcrops in the Triângulo Mineiro region. These outcrops are characterized by elevated lowlands and steep slopes. The geological unit was formed by fluvial systems that eroded and

exposed the outcrops throughout a large area across the geographical boundaries of the Triângulo Mineiro region that are delimited by the rivers Rio Grande, Rio Paranaíba, and Rio Araguari.

Hasui (1969) described the western portion of the Marília Formation in the Triângulo Mineiro region where rocks composed of clay were predominant, indicating the past occurrence of short periods of erosive phases that could be interpreted as alternate floods and sedimentation. This author was the first to systematically describe the stratigraphic units that outcrop in the Triângulo Mineiro region, and characterized these rocks as the Bauru and Uberaba formations.

2 Geological Setting

The Marília Formation (Bauru Group) (Fig. 1) is subdivided in the Ponte Alta, Serra da Galga

and Echaporã members (Figure 1) (Barcelos, 1984). According to Batezelli (2003), this geological unit is composed of calciferous sandstones (Ponte Alta Member), conglomerates, conglomerate sandstones, claystones, and siltstones, associated with calcretes and silcretes (Serra da Galga Member), as well as of sandstones and conglomerates cemented by calcium carbonate (Echaporã Member). The deposition of the Marília Formation occurred by the association of alluvial fan, fluvial, and ephemeral lake systems (Barcelos, 1984; Fernandes & Coimbra, 2000; Goldberg & Garcia, 2000). Aeolian sand sheet deposits indicate the periodicity of the sedimentation episodes and soil development (Dal' Bó, 2009; Basilici *et al.*, 2009), and the presence of an alluvial braided river (Batezelli & Ladeira, 2016). Dias-Brito *et al.* (2001) suggest that the Marília Formation is of Maastrichtian age.

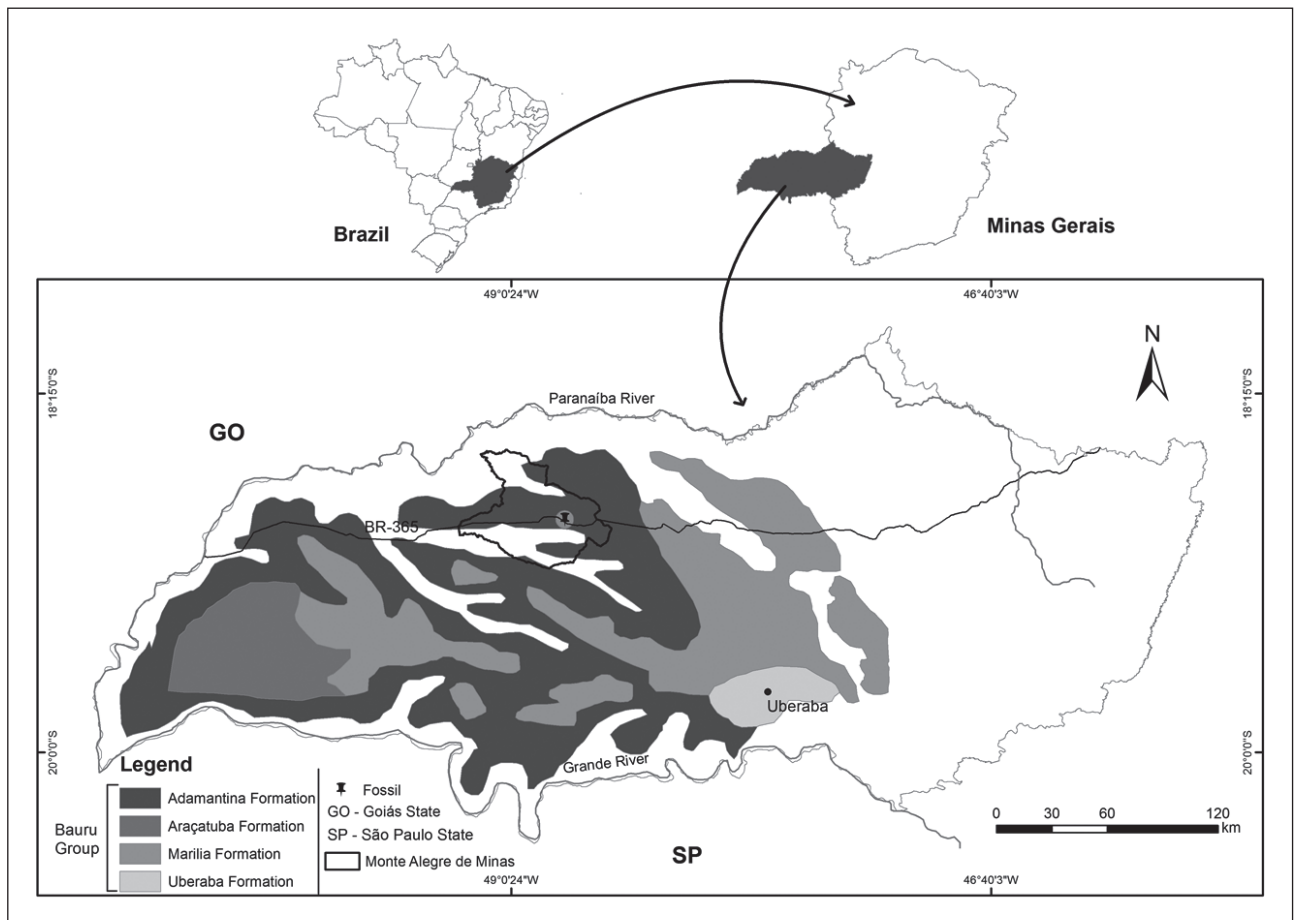


Figure 1 Lithostratigraphic map of the Bauru Group (modified from Batezelli, 2015).

In this region, the Marília Formation outcrops reach 3 m in thickness (Fig. 2) and are characterized by massive sandstone facies (Sm) (Miall, 1996). These sandstones are reddish in color, fine to medium-grained, poorly-sorted, showing dispersed clasts, and cemented by calcium carbonate (CaCO₃) with two levels of powdery calcrete. The sedimentary structures were completely obliterated by the pedogenetic paleoprocesses and the cementation by CaCO₃. The fossil remains are located in the lower levels of the deposit.

3 Material

Institutional abbreviation – All fossil material were collected during a field work carried out in 2013 and are from the outcrops of the Marília Formation in the municipality of Monte Alegre de Minas. The specimens are permanently deposited in the collection “Paleontologia Universidade Federal

de Goiás – Coleção de Vertebrados / Paleo-UFG/V” of the laboratory Laboratório de Paleontologia e Evolução of the Universidade Federal de Goiás. The specimens described here are labeled as Paleo-UFG/V-0020 and Paleo-UFG/V-0021.

Locality – Both specimens described here were recovered from a carbonate-cemented sandy deposit of the Marília Formation (Alves & Candeiro, 2013), located approximately 30 km west of the urban area of Monte Alegre de Minas.

4 Systematic Palaeontology

- Dinosauria Owen, 1842
- Saurischia Seeley, 1888
- Sauropoda Marsh, 1878
- Titanosauria Bonaparte & Coria, 1993
- Titanosauria indet.

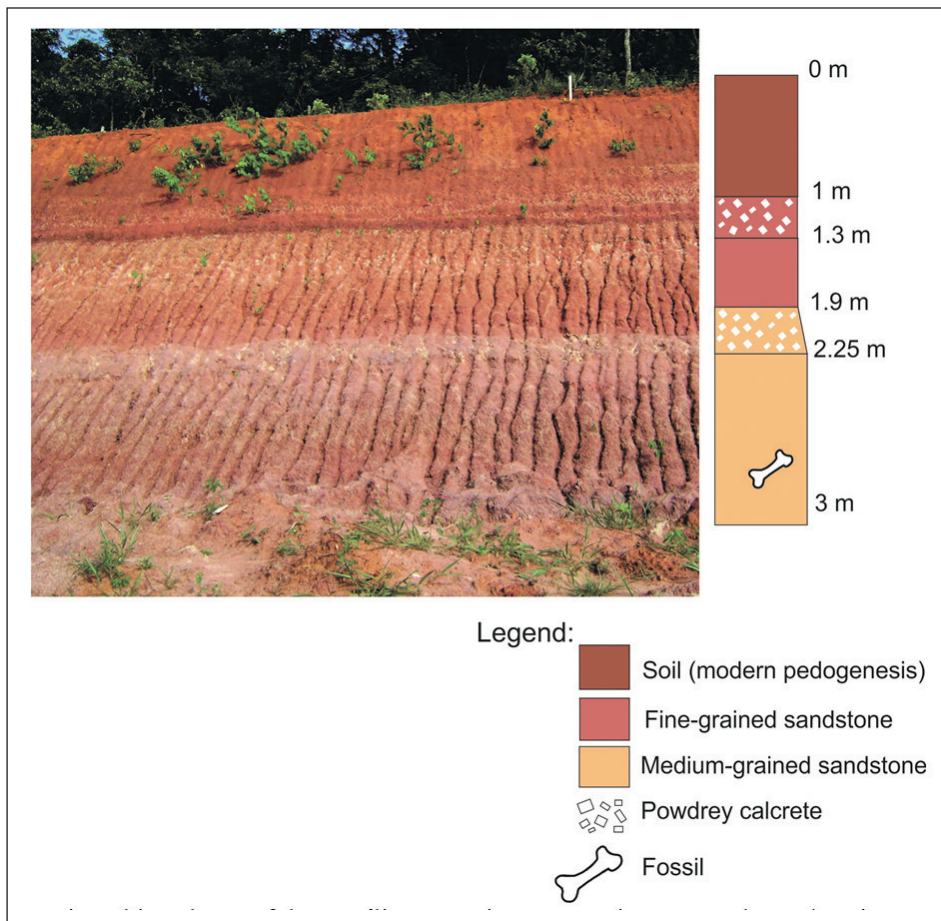


Figure 2 Stratigraphic column of the Marília Formation outcrop in Monte Alegre de Minas.

Specimen – Paleo-UFG/V-0020 consists of a part of a prezygapophysis (Fig. 3A).

Description. Paleo-UFG/V-0020 is a poorly preserved fragment of bone – the preservation state is similar to the one seen on *Rocasaurus muniozi* Salgado & Azpilicueta, 2000, *Gondwanatian faustoi* Kellner & Azevedo, 1999, *Baurutitan britoi* Kellner, Campos & Trotta, 2005, and *Trigonosaurus pricei* Campos, Kellner, Bertini & Santucci, 2005 – and corresponds to the articular portion of a prezygapophysis anterodorsally projected, with its extremity dorsally oriented as seen on the caudal vertebrae of titanosaurids (Salgado *et al.*, 1997; Powell, 2003; Campos *et al.*, 2005). The edge of the body of the prezygapophysis is slightly inclined forward. The partially preserved prezygapophysis is relatively long (110 mm). The articular facet of the prezygapophysis has a suboval shape, being slightly larger on its anteroposterior dorsoventral diameter. The comparisons between this specimen and the prezygapophyses of other titanosaurids, such as *Aeolosaurus rionegrinus* Powell, 1987, *Gondwanatian faustoi* Kellner & Azevedo, 1999, *Baurutitan britoi* Kellner *et al.*, 2005, *Rocasaurus muniozi* Salgado & Azpilicueta, 2000, and *Trigonosaurus pricei* Campos *et al.*, 2005, indicate that the material described here is part of a caudal vertebra, possibly fitting in the interval among the seventh and the tenth caudal vertebrae (Salgado & Azpilicueta, 2000; Campos *et al.*, 2005).

? Sauropoda indet.

Specimen – Paleo-UFG/V-0021 is the margin of a robust bone (Fig. 3B).

Description – Paleo-UFG/V-0021 is tentatively interpreted as the distal portion of a robust bone (e.g. pubis, humerus, coracoid) of an unidentified dinosaur. The caudal portion of the material is poorly preserved and the original compact trabecular bone surface observed along the whole specimen is very common in bones of saurischian dinosaurs. The well-structured spongy and trabecular structure seen on the lateral aspect of the material is similar to the specimens of Sauropoda studied by Wilson & Sereno (1998), Wedel (2007), Company (2011), and Wilson *et al.* (2011). The specimen is slightly curved and lateromedially compressed. The medial margin of the bone is better preserved than the lateral margin. The medial margin extends about 84 mm more distally than the lateral margin. The maximum length (proximodistal) of the specimen is 64 mm. The distal surface is irregular in cross-section view and the long axis is transversely oriented (62 mm mediolaterally and 75 mm craniocaudally). Although distally incomplete, it is noticeable that this dinosaur bone is robust and sinuous, especially along its distal margin.

5 Discussion

Although fragmentary, the material described here show anatomical information that allows

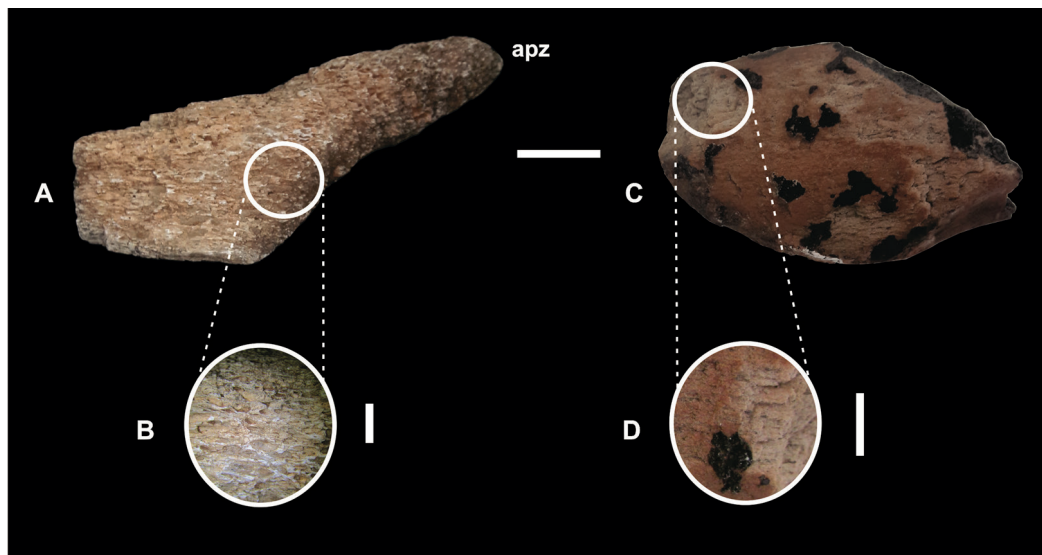


Figure 3 Isolated sauropod bones from Monte Alegre de Minas municipality, Triângulo Mineiro region: A, prezygapophysis (Paleo-UFG/V-0020) in right lateral view, B, trabecular bone; C, margin of robust bone (Paleo-UFG/V-0021) in lateral view, D, compact trabecular bone (scale bar: A, C, D = 2.0 mm and in B = 0.2 mm; abbreviation: articular facet of the prezygapophysis).

an approximate taxonomic identification. The prezygapophysis (Paleo-UFG/V-0020) presents the following characters used by Powell (2003) to the diagnosis of Titanosauria: enlarged prezygapophyses in the anterior caudal vertebrae and prezigapophyses with anteroposteriorly elongated articular facets. This is in agreement with the proposals made by Powell (2003) and Salgado & Coria (1993) regarding the characteristics of the prezygapophyses of this taxon. By considering the anterodorsal projection of the prezygapophysis with a dorsally oriented apex observed in the specimen Paleo-UFG/V-0020, it was possible to make a preliminary identification of this material as a Titanosauria. The record of the sauropod fauna known from the Triângulo Mineiro region is exclusively formed by species and isolated, fragmentary specimens of titanosaurids (see Candeiro, 2007; Gil & Candeiro, 2014; Martinelli & Teixeira, 2015). Therefore, it would be reasonable to assign Paleo-UFG/V-0020 to this taxon. Besides, most of saurischian dinosaurs have presacral vertebrae with well developed spongy structure (Wilson & Sereno, 1998; Wedel, 2007; Company, 2011; Wilson *et al.*, 2011). Paleo-UFG/V-0021 presents this same characteristic and, although it is very fragmentary, we believe that it is more parsimonious to preliminary consider this specimen as an indeterminate Sauropoda due its compressed camellate structure than to assign it to a more inclusive taxonomic level.

The taxonomy of Paleo-UFG/V-0020 and Paleo-UFG/V-0021 supports the presence of dinosaurs in the region of Monte Alegre de Minas and, together with the previous records from the rocks of the Bauru Group reported by von Huene (1931), it shows the importance of this classic paleontological area of the Triângulo Mineiro region. In addition, we emphasize that the municipality of Monte Alegre was the first locality where the occurrence of dinosaurs in the Triângulo Mineiro region was first discovered in 1930, and only 14 years later Price (1945) published his discoveries made on the municipality of Uberaba.

6 Conclusion

The specimen Paleo-UFG/V-0020 consists of an incomplete prezygapophysis assigned to Titano-

sauria while the specimen Paleo-UFG/V-0021 was assigned to ?Sauropoda indet. The presence of these taxa in the Marília Formation, in Monte Alegre de Minas, provides new faunal data to this paleontological unit after 86 years. The dinosaur fauna from this region is known for consisting of sauropod remains, and the Monte Alegre de Minas municipality outcrops have been showing the same sauropod elements than other areas of the Triângulo Mineiro region. Moreover, these records are from one of the few localities where dinosaur remains are found in the conglomerate levels from the Marília Formation in the Triângulo Mineiro region.

In summary, as previously mentioned, the fragments of sauropod remains from the Maastrichtian faunal assemblage of Monte Alegre municipality are very inconsistent and biased. However, despite the fragmentary condition of the two specimens described here, it was possible to acquire new information about the Late Cretaceous dinosaurs of the Marília Formation from the Monte Alegre locality, providing further data on the sauropod fauna of Minas Gerais State.

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