

## BAURU GROUP (LATE CRETACEOUS) VERTEBRATES FROM TRIÂNGULO MINEIRO REGION AND WESTERN SÃO PAULO STATE, BRAZIL: AN INTRODUCTION

### Vertebrados do Grupo Bauru (neocretáceo) da região Triângulo Mineiro e oeste do estado de São Paulo, Brasil: uma introdução

Carlos Roberto dos Anjos Candei

Programa de Pós-Graduação em Geologia, Setor III Paleontologia e Estratigrafia do  
Departamento de Geologia da Universidade Federal do Rio de Janeiro  
[candei@yahoo.com.br](mailto:candei@yahoo.com.br), [candei@ras.ufu.br](mailto:candei@ras.ufu.br)

Artigo recebido em 25/11/2004 e aceito para publicação em 06/02/2005

**RESUMO:** *Nas regiões do Triângulo Mineiro (Minas Gerais) e Oeste do Estado de São Paulo tem sido descoberto desde o século passado uma rica e diversa fauna de vertebrados fósseis do Neocretáceo, provenientes das formações Adamantina, Uberaba e Marília (Grupo Bauru). Neste trabalho é apresentada uma listagem dos fósseis vertebrados encontrados nessas regiões nas unidades do Grupo Bauru. Para isso foi utilizada a mais recente definição aceita para cada unidade geológica e para os níveis taxonômico hierárquicos conhecidos. A partir do presente estudo foi possível compreender o posicionamento estratigráfico dos vétebrados do Neocretáceo do Grupo Bauru.*

**Palavras chaves:** Cretáceo, Grupo Bauru, Triângulo Mineiro, Oeste do Estado de São Paulo, Vertebrados.

**ABSTRACT:** *The Triângulo Mineiro (Minas Gerais State) and western São Paulo State have a rich and diverse fauna of Late Cretaceous vertebrates from Adamantina, Uberaba and Marília formations (Bauru Group). This paper attempts to list the vertebrate fauna known from each formation within the Triângulo Mineiro region and western São Paulo using the most recent and accepted definition for each formation or higher taxonomical group. The faunal list produced now gives us a clearer understanding of the stratigraphical distribution of the Bauru Group vertebrates.*

**Key Words:** Cretaceous, Bauru Group, Triângulo Mineiro, western São Paulo State, Vertebrates.

---

## 1 – INTRODUCTION

The Bauru Group of southern (Fig. 1) and central Brazil contains one of the richest Late Cretaceous vertebrate assemblages in the country (see summary Tab. 1). Vertebrate bearing strata of fluvial, eolian and lacustrine facies are exposed over

an area of 240,000km<sup>2</sup>, which includes Goiás, Mato Grosso do Sul, Minas Gerais, Paraná and São Paulo states (*sensu* BARCELOS, 1984).

Vertebrate bones in this area were first discovered in 1911 near the town of São José do Rio Preto (São Paulo State). During the nineteen-for-

ties, Llewellyn Ivor Price searched the vertebrate-bearing deposits of the Marília Formation in the Triângulo Mineiro region. These sites were revisited after an interruption of more than 20 years. These eolian and fluvio-lacustrine sediments have yielded abundant dinosaurs bones, including partial skeletons, eggs and teeth associated with remains of other vertebrates and microvertebrate assemblages (BERTINI et al. 1993; DIAS-BRITO et al. 2001; KELLNER, 1996). The vertebrate assemblage includes at least 24 valid taxa.

The best-known vertebrate taxa occur in the Adamantina and Marília formations of Triângulo Mineiro (Minas Gerais State) and western São Paulo State. The Uberaba Formation, restricted to the Triângulo Mineiro region, includes only a few vertebrate taxa. In the Uberaba Formation rare records of dinosaurs consist mainly of footprints and isolated bones.

## 2 – OBJECTIVE

This paper compares the current knowledge of the fauna of the Bauru Group with previously reported vertebrate fossil finds in the Triângulo Mineiro region and western São Paulo State.

## 3 – METHODOLOGY

A preliminary list of the vertebrates from the Bauru Group was compiled by visits to all relevant geological entities. Bibliographical data were assembled by intensive research. All the systematic terminology used in this work following Holtz (2000), Powell (2003) and Sereno (1999).

## 4 – GEOLOGICAL AND PALEONTOLOGICAL SETTING

The Bauru Group is an important dinosaur-bearing unit in the south-central portion of the Bauru Basin that ranges in age from Turonian to late Maastriichtian (Figs. 1 and 2). According Fernandes and Coimbra (1996) it comprises a southeastward-thinning, continental rock that is exposed in modern

drainages throughout south-central Brazil. It conformably overlies with magmatic rocks of the Jurassic-Cretaceous Serra Geral Formation (São Bento Group, Paraná Basin). It has been a source of important dinosaur and other fossil vertebrates (Fig. 3a,b,c,d), invertebrates, and plant discoveries since the early part of the 20<sup>th</sup> century.

Fernandes and Coimbra (1996) included in ascending order the Adamantina, Uberaba and Marília formations in the Bauru Group. This stratigraphic arrangement which is used here, and it is widely accepted. The base of the group (Adamantina Formation) is conformable on the basaltic rocks of Serra Geral Formation (São Bento Group, Paraná Basin).

### 4.1 – Adamantina Formation

The Adamantina Formation is exposed in the States of Goiás, São Paulo and in the Triângulo Mineiro region, Minas Gerais State. Its sediments are fluvial-lacustrine reddish clays and sands, deposited during warm and humid climatic events (SOARES et al. 1980; SUGUIO; BARCELOS, 1983). Based primarily on its vertebrate fossil contents, the Adamantina sediments were deposited during the Turonian-Santonian (DIAS-BRITO et al. 2001). Resting on a calcium carbonate cemented conglomerate is a succession of very fine sandstones. The formation is about 200m thick yielding carophyceae, ostracods, ceratodontids, lepisosteids, osteoglossids, characids and siluriform fishes, lizards, turtles (e.g. *Roxochelys harissi*, Fig.3b), crocodiles (e.g. *Baurusuchus pachecoi*, Fig. 3c) abelisaur and carcharodontosaur theropods, as well as a number of titanosaurs including “*Titanosaurus*” (Monte Alto areas in São Paulo State), *Aeolosaurus* (Álvares Machado and Monte Alto areas, São Paulo State), “*Antarctosaurus*” (São José do Rio Preto areas, São Paulo State) and *Gondwanatitan faustoi* (Álvares Machado area, Fig. 3d) (CANDEIRO et al. 2002; SANTUCCI, 2002). There are still other occurrences of titanosaurs remains in the areas of São José do Rio Preto and Pacaembu Paulista, São Paulo State and in the Prata Paleontological Site, Minas Gerais State.

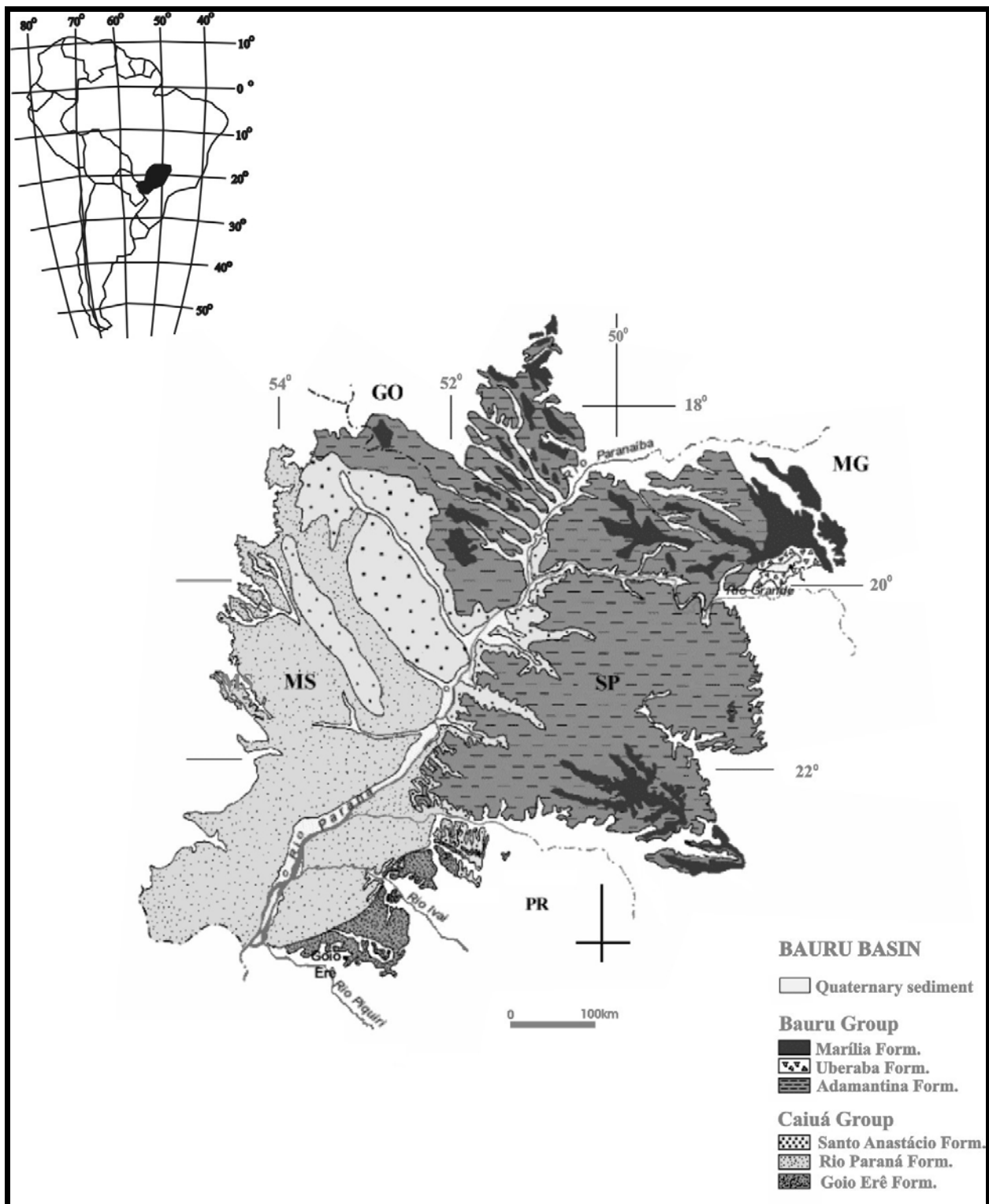


Figure 1 – Geologic map of the Bauru Basin (Modified from FERNANDES; COIMBRA, 1996).

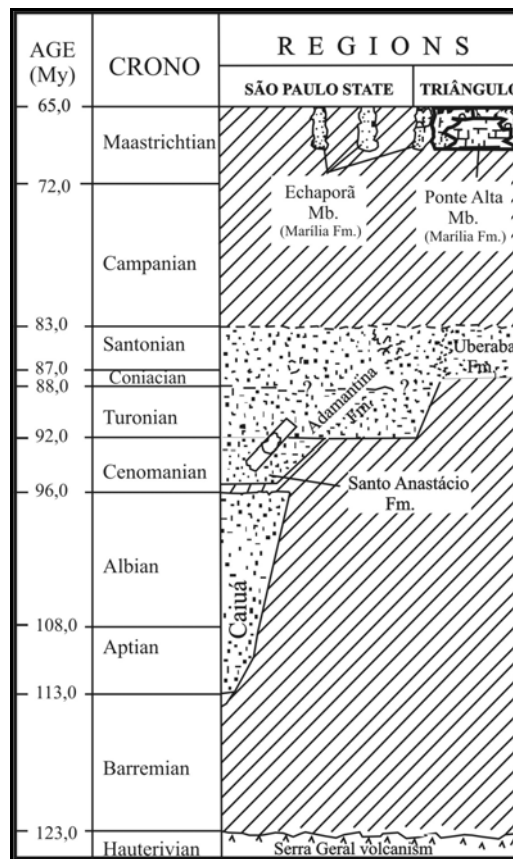


Figure 2 – Chronolithostratigraphic chart for the Bauru Group in the Triângulo Mineiro and western São Paulo State regions (modified from DIAS-BRITO et al. 2001).

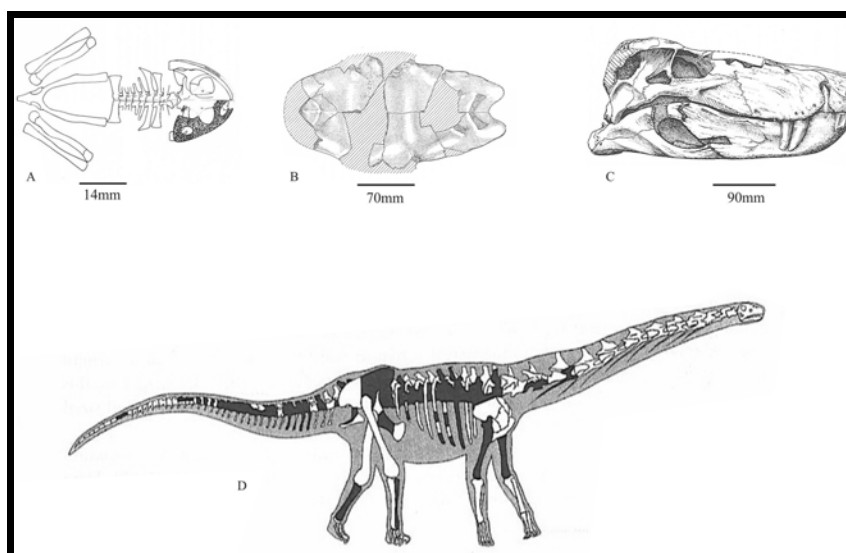


Figure 3 – Some vertebrate taxa from Bauru Group. **A**, reconstitution of the frog *Baurubatrachus pricei*; **B**, plastron of the chelonian *Roxochelys harrisi*; **C**, cranium of the crocodile *Baurusuchus pachecoi*; **D**, reconstitution of the herbivore dinosaur *Godwanatitan faustoi* (Modified from **A**, BAEZ; PERI, 1989; **B** and **C**, PRICE, 1945; 1953; **D**, KELLNER; AZEVEDO, 1999 not scaled).

Table 1 – Fossil vertebrates (exclusive ichnofossils) from Bauru Group, abbreviations: TM, Triângulo Mineiro, WSP, western São Paulo State.

<b>Adamantina Formation</b>	<b>Uberaba Formation</b>
DIPNOI	REPTILIA
Neoceratodontidae (WSP)	Chelonia (TM)
OSTEICHTHYES	Titanosauria indet. (TM)
<i>Lepidosteus cominato</i> (WSP)	
Osteoglossidae (WSP)	<b>Marília Formation</b>
Siluriformes (WSP)	OSTEICHTHYES
AMPHIBIA	Lepisosteiformes (TM)
Anura indet. (WSP)	Characiformes (TM)
REPTILIA	Siluriformes (TM)
Chelonia	Perciformes (TM)
<i>Roxochelys harrisi</i> (WSP)	AMPHIBIA
<i>Roxochelys wanderleyi</i> (WSP)	<i>Baurubatrachus pricei</i> (TM)
<i>Roxochelys elegans</i> (WSP)	Anura indet. (WSP)
<i>Bauruemys brasiliensis</i> (WSP)	REPTILIA
cf. <i>Podocnemis</i> (WSP)	Chelonia (TM)
Crocodyliformes	Archosauromorpha
<i>Baurusuchus pachecoi</i> (WSP)	Lepidosauria
<i>Mariliasuchus amarali</i> (WSP)	<i>Pristiguana brasiliensis</i> (TM)
<i>Sphagesaurus huenei</i> (WSP)	Crocodilia
<i>Stratiotosuchus maxhechti</i> (WSP)	<i>Itasuchus jesuionoi</i> (TM)
Dinosauria	<i>Peirosaurus tormini</i> (TM)
Titanosauria (TM, WSP)	<i>Maraliasuchus amarali</i> (WSP)
“ <i>Antarctosaurus</i> ” <i>brasiliensis</i> (WSP)	Saurischia
<i>Godwanatitan faustoi</i> (WSP)	Titanosauria indet. (TM, WSP)
<i>Aeolosaurus</i> (TM, WSP)	<i>Aeolosaurus</i> (TM)
Abelisauridae (TM, WSP)	Theropoda
Carcharodontosauridae (TM, WSP)	Abelisauridae (TM)
MAMMALIA	Carcharodontosauridae (TM)
Mammalia indet. (WSP)	

#### 4.2 – Uberaba Formation

This formation is mainly exposed in the Uberaba areas, Minas Gerais State. Lithologically

these strata are composed of freshwater limestones, sandstones, and based conglomerate, all cemented by carbonate (CaCO<sub>3</sub>) together with volcanoclastic sediments (BARCELOS, 1984). The Uberaba For-

mation is up to 140 m thick (FERNANDES; COIMBRA, 1996). According to Dias-Brito et al. (2001), this formation is Coniacian-Santonian in age. Among the fossils collected in these sediments are microfossils, titanosaurids and indeterminate dinosaur remains, turtles and icnofossils.

#### 4.3 – Marília Formation

The Marília Formation is exposed in Goiás and São Paulo States and in the Triângulo Mineiro region. The Marília Formation consists of fine to medium sandstones intercalated by conglomerate levels. The sandstones are cemented and contain concretions of calcium carbonate (FÚLFARO; BARCELOS, 1991). The formation thickness is estimated at 180m in Minas Gerais State (FERNANDES; COIMBRA, 1996). Dias-Brito et al. (2001) assigned a Late Maastrichtian age to Marília Formation. This lithic unit yielded ostracods, charophyceae, frogs (*Baurubatrachus pricei*, Fig. 3a), chelonian, crocodylians, abelisaurids and carcharodontosaur theropods. The Titanosauria are represented by *Aeolosaurus* (Peirópolis Site, Minas Gerais State) and “*Titanosaurus*” (Peirópolis Site; Monte Alto, São Paulo State). The remains of titanosaurs are particularly abundant in the regions of Monte Alegre de Minas, the Peirópolis Site, Uberaba-Uberlândia highway (“Posto Cinquentão”), and Campina Verde in Minas Gerais State (BERTINI; CAMPOS, 1985; CANDEIRO, 2002; CANDEIRO et al. in press.; HUENE, 1931; KELLNER, 1996; KELLNER; CAMPOS, 2000; MARINHO, 2003; POWELL, 1986, 1987, 2003; SANTUCCI, 2002; SANTUCCI; BERTINI, 2002).

#### 5 – DISCUSSION

The vertebrate paleontological resources of the Bauru Group area have been recognized since the 1880s. Although the great abundance and broad diversity of dinosaurs from the Bauru Group are renowned, the beds also yielded an impressive and important array of nondinosaurian vertebrates (Table 1) and invertebrates, micro, and trace fossils (see references BERTINI et al. 1993; DIAS-BRITO et

al. 2001; KELLNER, 1996). Ornithischian dinosaurs are not represented in the Bauru Group. Whereas the literature on the systematics and taxonomy of fossils from Bauru Group is significant, there have been relatively few paleoecologic studies (COIMBRA; FERNANDES, 1995; GOLDBERG; GARCIA, 2000).

Within the three formations of the Bauru Group in Triângulo Mineiro and São Paulo State, dinosaur fossils are most abundant in the Adamantina Formation, a prolific fossil-producing unit that has yielded almost 18 vertebrate taxa of Turonian-Santonian age. On average, a new dinosaur is found in the Adamantina Formation each year. No other Cretaceous rock unit in Brazil has yielded as many dinosaurs. Coimbra and Fernandes (1995) and Goldberg and Garcia (2000) attributed this abundance of dinosaurs in the Adamantina Formation to a unique combination of depositional parameters within a lacustrine, fluvial and eolic environment.

Although far fewer vertebrate species have been found in the Marília Formation of Triângulo Mineiro and its lithostratigraphic equivalent than in the Uberaba Formation, sauropod dinosaurs attributable to Titanosauria indet. have been collected from the former rock unit (see WILSON; UPCHURCH, 2003).

The Marília Formation (Tab. 1) has yielded important dinosaur remains since Llewellyn Ivor Price made significant vertebrate discoveries in 1940. The fauna includes six different taxa of vertebrates. Vertebrate remains are found throughout the Peirópolis Site and western São Paulo State. The most representative groups of vertebrates are dinosaur and crocodile remains. The Marília Formation is renowned for the dinosaur eggs preserved in it. (MAGALHÃES-RIBEIRO, 2002a,b).

#### 6 – CONCLUSION

The Late Cretaceous Bauru Group of Triângulo Mineiro region and western São Paulo State ranks among the Brazilian’s most productive dinosaur-bearing formations. Paleontologists have

scoured the Bauru Group since the early years of the 20th century, and they have discovered and described a wide array of vertebrate taxa. The numerous bone beds preserved within the group provide important clues that pertain to various aspects of the vertebrates from Late Cretaceous of Brazil. The Bauru Group vertebrates list includes aquatic and terrestrial fauna. Taxonomic designations are made at the most inclusive level given in the literature.

#### ACKNOWLEDGMENTS

I wish to thank to Silvina de Valais (Museo Paleontológico Egidio Feruglio, Trelew, Chubut, Patagonia, Argentina) for criticisms and suggestions that have greatly improved the manuscript. Flávio Oliveira (Instituto de Biologia, Universidade Federal de Uberlândia) offered insightful comments on the references. Dr. Thomas Rich (Victoria of Museum, Melbourne, Victoria, Australia) made criticisms, observations and correction of grammar. I am also grateful to the anonymous reviewers, and to Editor Committee of Revista Sociedade & Natureza who provided helpful critiques on the manuscript. This work was possible with the relief fund of a CAPES/ Brazil Doctorate fellowship.

#### REFERENCES

BAEZ, A.M.; PERI, S. *Baurubatrachus pricei*, nov. gen. et sp., un anuro del Cretacico Superior de Minas Gerais. **Anais da Academia Brasileira de Ciências**, Rio de Janeiro, v.61, p.447-458, 1989.

BARCELOS, J. H. **Reconstrução paleogeográfica da sedimentação do Grupo Bauru baseada na sua redefinição estratigráfica parcial em território paulista e no estudo preliminar fora do estado de São Paulo**. 1984. 190f. Tese de Livre Docência – Departamento de Geociências de Rio Claro, Universidade Estadual Paulista de Rio Claro, 1984.

BERTINI, R. J.; CAMPOS, D. A. Ovos de dinossauro da formação Uberaba, Cretáceo Superior do estado de Minas Gerais. In: CONGRESSO

BRASILEIRO DE PALEONTOLOGIA, 9. Fortaleza. **Resumos...** Fortaleza: UFCE, 1985, p.19.

BERTINI, R. J. et al. The vertebrate fauna of the Adamantina and Marília Formations, Late Cretaceous of the Paraná Basin, Southerneast Brazil. **Neus Jahrbuch fur Mineralogie, Geologie und Paläe-ontologie**, Stuttgart, v.188 n.1, p.71-101, mar. 1993.

CANDEIRO, C. R. A. **Dentes de Theropoda da Formação Marília (Santoniano-Maastrichtiano), Bacia Bauru, Região de Peirópolis, Uberaba, Minas Gerais, Brasil**. Dissertação de Mestrado, Universidade Federal do Rio de Janeiro, 2002, p.136.

CANDEIRO, R. et al. Novos achados de Dinosauria no oeste do estado de São Paulo, na Formação Adamantina (Bacia Bauru), Cretáceo Superior. In: SIMPÓSIO SOBRE O CRETÁCEO DO BRASIL E II SIMPÓSIO SOBRE EL CRETÁCICO DE AMÉRICA DEL SUR, 6, São Pedro. **Boletim...** São Pedro: UNESP/Rio Claro, 2002. p.409-413.

CANDEIRO, C.R.A. et al. Dinosaur remains from Western São Paulo State, Brazil (Bauru Basin, Adamantina Formation, Upper Cretaceous). **Journal of South American Earth Science**, Columbia, South Carolina, in press.

COIMBRA, A. M.; FERNANDES, L. A. Paleogeografia e considerações paleoecológicas sobre a Bacia Bauru (Cretáceo Superior). CONGRESO ARGENTINO DE PALEONTOLOGÍA Y BIOESTRATIGRAFÍA, 6, Trelew. **Actas...** Trelew, 1995, p.85-90.

DIAS-BRITO, D. et al. Grupo Bauru: uma unidade continental do Cretáceo do Brasil – Concepções baseadas em dados micropaleontológicos, isotópicos e estratigráficos. **Revue Paléobiologie**, Genebra, v.20, p.245-304, 2001.

FERNANDES, L. A.; COIMBRA, A. M. A Bacia Bauru (Cretáceo Superior, Brasil). **Anais da Academia Brasileira de Ciências**, Rio de Janeiro, v.68, n.2, p.195-205, jul. 1996.

FÚLFARO, V. J.; BARCELOS, J. H. Grupo Bauru no Triângulo Mineiro: uma nova visão litoestratigráfica. In: SIMPÓSIO DE GEOLOGIA DO SUDESTE, 2, São Paulo. **Atas...** São Paulo: Sociedade Brasileira de Geologia/Núcleo SP-RJ, 1991, p.59-66.

GOLDBERG, K.; GARCIA, A.J.V. Paleobiogeography of the Bauru Group, a dinosaur-bearing Cretaceous unit. Northeastern Paraná Basin, Brazil. **Cretaceous Research**, London, v.21, p.241-254, dez. 2000.

HOLTZ, JR. T. R. A new phylogeny of the carnivorous dinosaurs. **Gaia**, Lisboa, v.15: 5-61, 2000.

HUENE, F. Verchiedene mesozoische wirbeltierreste aus sudamarika. **Neus Jahrbuch fur Mineralogie, Geologie und Paläeontologie**, Stuttgart, v.66(b), p.181-198, 1931.

KELLNER, A. W. A. Remarks on Brazilian dinosaurs. **Memory of Queensland Museum**, Brisbane, v.3, p.611-626, ago. 1996.

KELLNER, A. W.; CAMPOS, D. A. Brief Review of Dinosaur Studies and Perspectives in Brazil. **Academia Brasileira de Ciências**, Rio de Janeiro, v.72, n.4, p.509-538, dez. 2000.

KELLNER, A. W. A.; AZEVEDO, S. A. K. A new sauropod dinosaur (Titanosauria) from the Late Cretaceous of Brazil. **National Science Museum Monographs**, Tokyo, v.1, p.111-142, jan. 1999.

MAGALHÃES-RIBEIRO, C. M. **Ovos e cascas de ovos de dinossauros da região de Uberaba, Minas Gerais (Formação Marília, Bacia Bauru, Cretáceo, Superior)**. Tese de Doutorado, Universidade Federal do Rio de Janeiro, 2002a.

MAGALHÃES RIBEIRO, C. M. Ovo e fragmentos de cascas de ovos de dinossauros, provenientes da região de Peirópolis, Uberaba, Minas Gerais. **Arquivos do Museu Nacional**, Rio de Janeiro, v.60, p.223-228, 2002b.

MARINHO, T. S. **As ocorrências fossilíferas do Cretáceo Superior nos Municípios do Prata e Monte Alegre de Minas, no Triângulo Mineiro**. 2003. 20p. Monografia (Graduação) – Instituto de Biologia, Universidade Federal de Uberlândia, Uberlândia, 2003.

POWELL, J. E. **Revisión de los titanosáuridos de América del Sur**. 1986. 340p. Tese de Doutorado, Universidad Nacional de Tucumán, 1986.

POWELL, J. E. Morfologia del esqueleto axial de los dinosaurios Titanosaurios (Saurischia, Sauropoda) del estado de Minas Gerais, Brasil. In: CONGRESSO BRASILEIRO DE PALEONTOLOGIA, 10, Rio de Janeiro. **Anais...** Rio de Janeiro: Academia Brasileira de Ciências, 1987, p.155-171.

POWELL, J. E. Revision of South American Titanosaurid dinosaurs: Paleobiological, Paleobiogeographical and Phylogenetic aspects. **Records of the Queen Victoria Museum**, Melbourne, v.111, p.173, jul. 2003.

PRICE, L. I. A new reptile from the Upper Cretaceous of Brazil. Serviço Geológico Mineralogia, Rio de Janeiro, v.25, p.1-8, 1945.

PRICE, L. I. Quelônios da Formação Bauru, Cretáceo Terrestre do Brasil Meridional. **Boletim da Divisão de Geologia e Mineralogia**, Rio de Janeiro, v.147, p.1-39, 1953.

SANTUCCI, R. M. **Revisão dos titanosaurídeos do Cretáceo Superior do Brasil**. 2002. 179p. Dissertação de Mestrado, Universidade Estadual Paulista, Rio Claro, 2002.

SANTUCCI, R. M., BERTINI, R. J. Distribuição estratiográfica dos titanossauros do grupo Bauru, Cretáceo Superior Continental do Sudeste do Brasil. In: SIMPÓSIO SOBRE O CRETÁCEO DO BRASIL E II SIMPÓSIO SOBRE EL CRETÁCICO DE AMÉRICA DEL SUR, 6, São Pedro. **Boletim...** Rio Claro: UNESP/Rio Claro, 2002. p.401-408.



SERENO, P. C. et. al. A long-snouted predatory dinosaur from Africa and the evolution of spinosaurids. **Science**, Washington, v.282, p.1298-1302, 1998.

SOARES, P. C. et. al. F. Ensaio de caracterização estratigráfica do Cretáceo no Estado de São Paulo: Grupo Bauru. **Revista Brasileira de Geociências**, São Paulo, v.10, n.3, p.177-185, set. 1980.

SUGUIO, K.; BARCELOS, J. H. Calcretes of the Bauru Group (Cretaceous) Brazil: petrology and geological significance. **Instituto de Geociências/ USP Boletim**, v.14, p.31-47, 1983.

WILSON, J. A.; UPCHURCH, P. A revision of *Titanosaurus* Ludekker (Dinosauria – Sauropoda), the first dinosaur genus with a ‘Gondwanan’ distribution. **Journal of Systematic Paleontology**, Londres, v.1, n.3, p.125-160, set. 2003.