

# *Geopark Uberaba: Relevance of the Geological Heritage*

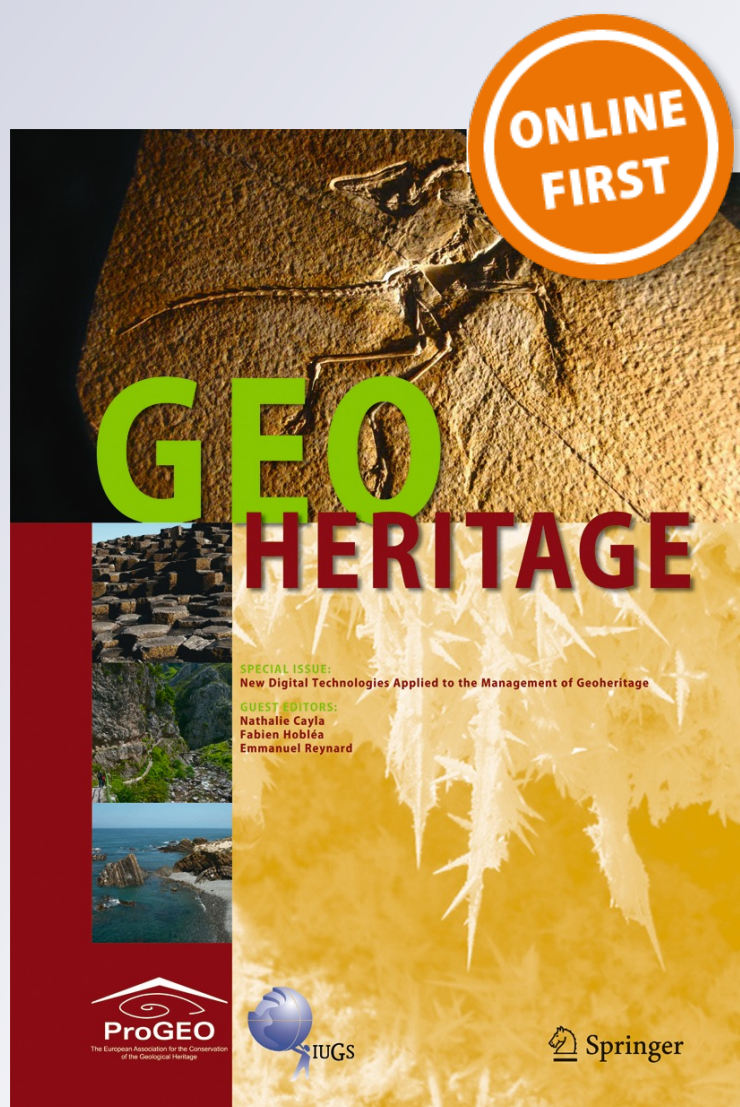
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# Geopark Uberaba: Relevance of the Geological Heritage

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**Abstract** The Uberaba region (Minas Gerais, Brazil) has become famous for its significant paleontological investigation, which has been conducted there since the mid 1940s. Several taxa, especially of vertebrates, unique in the paleobiological record, come from its fossiliferous outcrops, associated with Uberaba and Marília formations (Bauru Basin). Among these, the dinosaurs are especially important, as they are exceptionally well preserved and diversified, allowing the description of several species and consolidating Uberaba as the Land of Brazilian Dinosaurs. The establishment, in 1991, of the Paleontological Research Center Llewellyn Ivor Price and Dinosaur Museum, in the neighborhood of Peirópolis, allowed the establishment of research and educational actions to the preservation of the geological heritage that transformed the local conditions through geotourism. Besides the fossiliferous content, the diverse geosites also comprise the important moments of the geological history, making them extremely relevant places of the geological heritage, in accordance with what is expected from a geopark. In 2010, the Paleontological Research Center L.I. Price and the Dinosaur Museum became part of the Cultural and Scientific Complex of Peirópolis of

the Federal University of Triângulo Mineiro. The Geopark Uberaba–Land of Brazilian Dinosaurs was created in that same year, prompted by the Geopark Project of the Geological Service of Brazil. The integration of the geological heritage to the historical and cultural attributes of national significance allowed the building of a unique identity for this territory. Nowadays, in Uberaba, fossils are no longer limited to scientific knowledge; they symbolize the socioeconomic and environmental development tools, which are allowing the sustainable regional development.

**Keywords** Geopark Uberaba · Geological Heritage · Land of Brazilian Dinosaurs · Fossil · Paleontological Center Price · Dinosaur Museum

## Introduction

The city of Uberaba, located in the region of the Triângulo Mineiro–Minas Gerais–Brazil (Fig. 1), integrates the neighborhood of Peirópolis, 20 km away from the city, its greatest paleontology reference. The history, development, and relevance of the fossil studies in Uberaba are intrinsically linked to the activities conducted in this place, especially since the mid 1940s, due the mining activities.

Agriculture, cattle ranching, and limestone extraction were the main sources of economic revenue for Peirópolis between 1889 and 1960.

During that time, the Neighborhood had over 600 inhabitants, and the railway was the guide of development in Peirópolis, moving people and products.

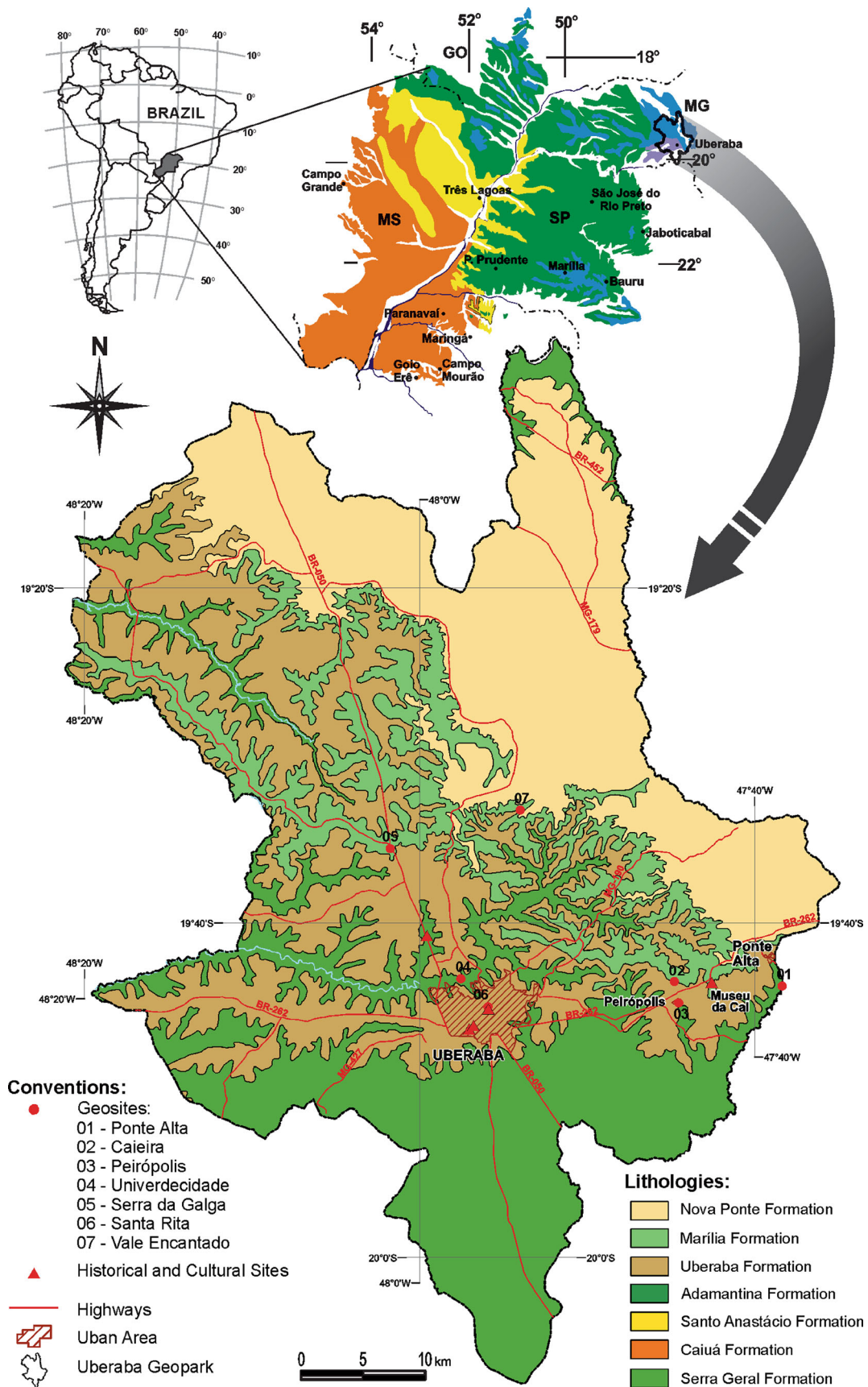
The decline of agricultural production, the shutdown of the limestone quarries, and the complete halt of the railway in the 1980s led to economical collapse, and Peirópolis was nearly abandoned as most inhabitants left for bigger cities.

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**Fig. 1** Map of the location and geology of the Geopark Uberaba with its geosites (Ribeiro et al. 2012)

Economic and development redemption in fact, of Peirópolis existence itself began in 1946, with the first systematic paleontology conducted by the paleontologist Llewellyn Ivor Price, from the Geology and Mining Division (DGM), Rio de Janeiro, currently the National Department of Mineral Production (DNPM). Attracted by the sedimentary rocks associated with limestone extraction, Price started his investigations in 1946 at the site called *Caieira*, in the vicinity of Peirópolis. He worked yearly in several sites of the region until 1974, with samples being stored at the DGM in Rio de Janeiro.

When L. Price died, in 1980, paleontological researches were interrupted. In 1988, thanks to local activism in Peirópolis, the Paleontological Research Center Llewellyn Ivor Price (CPPLIP) and Dinosaur Museum (MD) were created.

In 1991, the revitalization of the old train station in Peirópolis started, and in July 1992, the CPPLIP was opened and the first exhibition of the MD took place. The idea was to enrich local identity and allows a conscious about the importance of paleontological studies and of geoconservation policies.

Later, several initiatives have been consolidating the research, education, protection of geological heritage, and popularization of the fossil science. Enhanced by the magic of dinosaurs and the appeal they exert on people, these activities have transformed the local conditions. Nowadays, geotourism is the main source of income for the community.

Parallel to the Convention of Digne-les-Bains (France), the “Declaration of the Rights of the Memory of the Earth” was the starting point for the elaboration of the Geopark concept by UNESCO, the work of the CPPLIP and MD was a pioneering effort in Brazil. At that time, the value and significance of the geological heritage of the Uberaba region were highlighted.

In 2010, the union between the Paleontological Research CPPLIP/MD and the National Network of Paleontology was resulted in the creation of the Cultural and Scientific Complex of Peirópolis (CCCCP) of the Federal University of the Triângulo Mineiro (UFTM).

In 2012, the creation of the Geopark Uberaba–Land of the Brazilian Dinosaurs (GULBD) was proposed, in accordance with the initiatives of the *Geoparks* project of the Geological Service of Brazil (CPRM).

## Regional Geology

The region of Uberaba is in the context of the Bauru Basin (Fernandes and Coimbra 1996) (Fig. 1), which, in the state of Minas Gerais, occurs only in Triângulo Mineiro. Its substrate is the Serra Geral Formation predominantly composed of basaltic rocks. Dias-Brito et al. (2001) suggested, based on

an extensive micropaleontological study, that the suprabasaltic Neocretaceous sequence had two temporal sedimentation intervals, Turonian–Santonian, the age to which the Uberaba Formation belongs, and Maastrichtian, attributed to the Marília Formation, in Minas Gerais. Both are fluvial deposits in a context of arid climate.

## Geology of the Geopark

The area of the GULBD is comprised of the Serra Geral, Uberaba, and Marília (Ponte Alta and Serra da Galga members) formations. At altitudes of over 980 m, there are tertiary sediments attributed to Nova Ponte Formation. Some quaternary, unconsolidated sandy deposits associated with recent fluvial valleys also occur (Fig. 1).

### *Serra Geral Formation*

It embraces the substrate of the Bauru Basin, being overlapped by sedimentary sequences that constitute the lithologies observed in the area of the Geopark. The Serra Geral Formation is in direct contact with the Uberaba Formation, through a basal conglomerate composed of angled and subrounded basalt, sandstone, and quartz clasts. Its outcrops are located in the drainage, highway, and railway outcrops, with a better distribution in the southern portion of the municipality. It consists of black to dark gray basalt with fine phaneritic to aphanitic texture. Sometimes, it displays vesiculated levels filled with calcite, zeolite, chalcedony, and quartz, occasionally interstratified with sandstone lenses.

### *Uberaba Formation*

It is represented in the study area by metric sandstone strata with a greenish clay-silt matrix and fine plane-parallel lamination. There are levels of siltstone, mudstone, sandstone, and sandy conglomerates, which derive from the reworking of volcanic rocks and other non-volcanic sources. There is carbonate cementation throughout the whole sequence, shales, sandstone, and rudaceous levels. The best outcrops are in the valley of the Uberaba river, in the urban perimeter of the city, and in the neighborhood of Peirópolis.

The Uberaba Formation is characterized by a *braided* fluvial system. Analyses of the association of charophyte and ostracode microfossils indicate an age of 83 million years (Dias-Brito et al. 2001). The fossil assemblage comprises mainly of dinosaurs, with several records of eggs and bone elements.

### *Marília Formation*

Within the Uberaba domain, the Marília Formation is subdivided into Ponte Alta and Serra da Galga members,

although Andreis et al. (1999) stated that this formation should not be partitioned and that the carbonate levels have a freatic origin. The carbonate facies predominate in Ponte Alta Member while the clastic one in the Serra da Galga Member, allowing the characterization of a depositional model of alluvial fans dominated by braided fluvial channels, small lakes, and lagoons in arid climate.

The lithologies of the Ponte Alta Member are sandy to conglomeratic limestone, interpreted as calcrete. The best exposures occur in the quarries of Ponte Alta, Peirópolis, Mangabeira, and Cinquentão. Outcrops are also found at BR 050, Km 153, and BR 262 close to Peirópolis.

Economically, it is the most important unit. Its carbonate rocks have several uses, such as manufacture of burnt lime, cement production, and soil correction.

The Serra da Galga Member is a siliciclastic sequence with cyclic successions of clast-supported conglomerates and medium to coarse sandstone; trough-cross-stratifications are frequent. There are also pelitic deposits defined as channel abandonment facies. The vast majority of the fossils discovered in the municipality of Uberaba since 1945, especially in the sites of Peirópolis and Serra da Galga (153 km of the BR 050), is attributed to this unit, making it the most relevant in the context of geological heritage.

#### *Cenozoic Cover–Nova Ponte Formation*

The Nova Ponte Formation (Ferrari 1989) is dated as post-Cretaceous and is composed of pebbles and friable sandy levels that reach 50 m in thickness. It is a non-fossiliferous lithostratigraphic unit. Geomorphologically, they comprise extensive of flat surfaces known as *chapadões* and are genetically associated to the South-American denudation cycle (King 1965).

#### *Quaternary Deposits*

They are composed of pebbles, slightly-consolidated sandy sediments with round and angled clasts.

A thickness level of between 0.60 and 1.70 m, containing *Eremotherium laurillardii* (Martinelli et al. 2012) fossils, was described in the urban area of Uberaba. It displays a restricted distribution and possibly comprises of a halostratigraphic unit.

### **Paleontology in Uberaba**

The main geodiversity elements in Uberaba are the fossils. The collection of the CCCP was approximately 4,000 specimens in an excellent state of conservation and associated with the Uberaba formation and Marília Formation (Serra da Galga Member). This represents over 90 % of the collected specimens in the region.

They are found in a paleoenvironmental context that comprises of fine sandstones deposited by flash floods in alluvial plains after long drought events. Lakes and rivers were rare, usually drying after the long periods of drought. This was a restrictive factor for the fauna and flora, which were probably adapted to the harsh conditions of this extremely arid environment (Fig. 2).

The paleobiological records are unarticulated and fragmented bones, resulting from high-energy depositional environments. Articulated findings are rare, like *Uberabasuchus terrificus* (Carvalho et al. 2004), which has approximately 60 % of articulated skeleton (Fig. 3).

#### Fossil Assemblage of Uberaba

The most frequent groups are reptiles (lizards, turtles, crocodylomorphs, and dinosaurs), but fish, amphibians, birds, and mammals, as-well-as mollusks, crustaceans, pteridophytas, and ichnofossils can also be found. Undoubtedly, dinosaurs are, among these, the most emblematic and, in this case, the most valuable representatives of the local geodiversity. Seven dinosaur groups of theropods and sauropods were described in the region of Uberaba. Among them, *Uberabatitan ribeiroi* is one of the most representative species (Figs. 4 and 5).

Three turtle species, four crocodylomorph species, and a single lizard species were found. There are two important amphibian fossils, with the most representative being *Uberabatrachus carvalhoi* (Báez et al. 2012) (Fig. 6). Fossils attributed to Mesozoic birds and pleistocenic/holocenic mastofauna are also part of the local paleobiota.

The fossil eggs found in Uberaba belong to sauropods (Fig. 7). They are attributed to Titanosauria dinosaurs.

Among the theropod dinosaurs, three main groups were described: Abelisauria, Megaraptora, and Maniraptora.

The Abelisauria are represented by several teeth and post-cranial bones. A vertebral fragment related to Megaraptora



**Fig. 2** Paleoenvironmental reconstruction of the Uberaba region at the end of the Cretaceous, 70 million years ago (Image: Rodolfo Nogueira)



**Fig. 3** *Uberabasuchus terrificus* fossil (Carvalho et al. 2004) found during the excavations in September 2000

was found more recently. The Maniraptora record includes a claw and a scapula of small-sized taxa.

### Relevant Actions to the Geopark Uberaba

In accordance with the guidelines for Geoparks, especially those of the European Network, GULBD has an area of 4,540.51 km<sup>2</sup> that comprises the entire Uberaba municipality. It contains several geological-paleontological geosites of scientific importance and historic-cultural sites, comprising a large territory to allow economic activity through tourism (Fig. 1).

Among the activities designed for a geopark, Uberaba-Peirópolis has already a paleontological research center; consistent educational projects; geotourism activities to generate income for the inhabitants, especially for those from Peirópolis; valuation initiatives, and geoconservation-oriented public policies (Ribeiro et al. 2011a). It also represents a proposal for a regional development plan that is integrated with other local assets, such as agribusiness and religious expression.



**Fig. 4** Excavation of *Uberabatitan ribeiroi* (Salgado and Carvalho 2008)



**Fig. 5** Reconstruction of *Uberabatitan ribeiroi* (Salgado and Carvalho 2008) in the region of Uberaba, 65 million years ago (Image: Rodolfo Nogueira)

### Research and the Significance of the Geological Heritage

The annual excavations are the main spotlight among the initiatives carried out at the geopark. This allowed an expressive increase of the paleontological collection of the CPPLIP/CCCCP. The fossils found in the excavations are quickly prepared and available for identification. In the last 20 years, a series of technical-scientific cooperation exchanges and projects have been established with Brazilian and foreign universities, research centers, and museums.

The studies of the paleontological record and its geological context have improved the understanding of the depositional environments in which the fossils are found, as well as the paleobiological diversity, which allows a more faithful reconstruction of the ecosystems at the end of the Cretaceous.

As a result, more than 170 researches were published in books, journals, and scientific events. The scientific collection of the Cultural and Scientific Complex of Peirópolis allowed the development of undergraduate, master, and doctoral



**Fig. 6** Digital reconstruction of *Uberabatrachus carvalhoi* (Báez et al. 2012) (Image: Rodolfo Nogueira)

**Fig. 7** Coprolite (*left*) and egg (*right*) attributed to *Titanosauria*



studies. Special note should be made to the large number of discoveries related to dinosaurs, which make Uberaba a national reference center for this fossil group.

#### Educational Programs

Many educational projects, especially the ones oriented towards elementary and high schools, have emphasized the importance to value, conserve, and popularize the paleontological heritage and the areas in which they occur. The practical initiatives at excavations in the laboratories and with the exhibitions at the MD have brought excellent results.

The University Student Training Program (PROTEU), in its 12th edition had already trained students from several universities around the country. It comprises theoretical and practical activities, excavations and preparation of fossils, guided readings and discussions, workshops on paleoart, and on how to deal with museum visitors. The results are amazing, with several students that have attended PROTEU being today professors in prestigious Brazilian universities.

Dinosaur Week is the most effective and complete educational program for children and teenagers that is conducted in Uberaba. It is carried out annually for 5 days in which paleontology is explained in a didactic and fun way. The program comprises visits to excavation sites and to the MD, talks, pedagogic workshops, and recreational activities with themes as dinosaurs, paleontology, and environmental preservation. There have been 20 events so far, some of them with 8,000 students, which turned it into the largest paleontology educational event in Brazil (Fig. 8). There is also the “Geology with an Emphasis on Paleontology” course of the National Program of Access to Technical Education and Employment (PRONATEC), with a workload of 1,452 h. Created by the Federal Government in 2011, its goal is to provide professional and technological education courses.

#### The Popularization of Paleontology and Geotourism

Paleontology and geology have an important role nowadays. They are no longer a hermetic science, restricted to scientists, and universities. Everybody is interested in the history of the Earth and its inhabitants during the geological past. To bring this history to an increasing and diverse public is necessary the popularization of the paleontological knowledge. This is the most important premise of the MD (Ribeiro et al. 2011b) (Fig. 9a).

Dinosaurs were always the main protagonists of the tourism aspect (Lopes and Ribeiro 2006), becoming one of the most relevant groups in recent times. They are in the imagination of millions of people in the whole world. They are paleontology’s emblematic animals and have a big appeal with the public, promoting a cultural industry without precedent (Winter et al. 2012).

In this context, the Geopark Uberaba has a great importance, as the fossils are attributed to dinosaurs. They are exceptionally well preserved and are found in quantity and



**Fig. 8** Dinosaur Week—Peirópolis, the largest event of paleontology education oriented to students and fans of the theme

diversity, allowing the description of several species and making Uberaba the *Land of Brazilian Dinosaurs*.

The exhibition in the MD comprises the geology and, especially, the paleontology of Uberaba region. It is one of the most interesting, up-to-date, and didactic exhibitions in the nation's countryside (Fig. 9b). The central theme is the fossils and the landscapes of the region of Uberaba 70 million years ago, presented as dioramas. It allows the visitor to return to an ancient time through the diversity of carnivorous and herbivorous dinosaurs. Among the attractions are spherical eggs of large dinosaurs of up to 20 cm in diameter. Another important display is a replica in panel form, the first in Brazil that shows a titanosaur dinosaur 12 m in length and in which one can see the bone elements, the muscle mass, and the skin. A life reconstruction of the Maniraptora or dinobird of Peirópolis is especially interesting, because it is a feathered animal and can lead the tourist to think about the evolution of life forms. The preparation of fossils, one of the steps in paleontological research, can be seen through a glass wall.

The museum has received more than one million and two hundred thousand visitors from approximately 1,250 Brazilian cities and 44 countries. Today, Peirópolis economy is based on services and products associated with the geotourism (Santos and Carvalho 2008). The neighborhood offers services and a structure that is appropriate for the approximately 50,000 annual visitors.

Through the popularization of fossils and paleontology as a touristic attraction, the conservation of the heritage itself can be a factor in the sustainable development and cultural identity. Geotourism is a profitable economic activity, is a civic issue, and demands a reorientation of public policies (Ribeiro et al. 2011b).

#### Geoconservation—Public Policies for the Protection of Geodiversity

One of the main problems in the Geopark Uberaba area comes from the policies and actions needed to maintain

the integrity of the landscape heritage and the geodiversity present in the municipality. Because of that, several places with paleontological potential in the municipality of Uberaba, especially Peirópolis, are protected by city laws. Valuation initiatives for the Geological Heritage are presented through sites registered by the Brazilian Commission of Geological and Paleobiological Sites (SIGEP) and the CPRM.

#### *Natural Monument of Peirópolis—City law # 10,339*

City law # 10,339, from March 29, 2009, created the Natural Monument of Peirópolis (MNP) (Fig. 10). This guideline, supported by the National System of Conservation Units (SNUC) law—Federal Law # 9,985/00, ensures the protection of the areas surrounding Peirópolis where the relevant outcrops are located. It expressly forbids any activities that are not research, education, popularization, or geotourism, with the exception of agropastoral activities.

#### *Valuation Initiatives for the Geological Heritage*

“Sítio Peirópolis and Serra da Galga – Land of Brazilian Dinosaurs”, catalogued as #28 by the SIGEP, is available in the Internet (<http://sigep.cprm.gov.br/sitio028/sitio028.pdf>) and is printed in volume II of SIGEP (Winge and et al. 2009).

This initiative was important to the preservation of the Geological Heritage as there is the description of the geosites. It constitutes an essential step for geoconservation public policies. It was the starting point for the inclusion of Uberaba as a potential geopark by the CPRM.

In 2012, CPRM published the book *Geoparks of Brazil—Proposals*. It collected 17 projects, among them Geopark Uberaba—Land of Brazilian Dinosaurs (Ribeiro et al. 2012) corroborating in an effective way the consolidation of the geopark.

**Fig. 9** a External view of the MD. b Main exhibition room of the MD





## Infrastructure, Logistics, Historical-Cultural Values and Tourism

The city of Uberaba is connected to the main consumer centers of the country by an excellent structure that comprises a good highway network, airport, bus station, and excellent hotel and gastronomical logistic.

Uberaba has an expressive and ever-increasing number of visitors and tourists that go there for many reasons, such as business tourism, due to the significant economic growth; Geotourism based on Peirópolis; and agribusiness and religious events.

One of the important tourism-related events in Uberaba is the cattle ranching fairs, like Expozebu (the largest zebu cattle exhibition in the world), which is held annually in May, attracting people from many states and more than 20 countries. During this event, educational and social projects, like “Zebu in School”, are carried out. The city is also sought by thousands of followers of Chico Xavier, a spiritual leader in Brazil, chosen as “The Mineiro of the Century” and “The Greatest Brazilian of All Time”. There are also festivals related to the Catholic Church.

The integration of historical and cultural values with the relevance of the geological heritage creates a unique identity for the municipality, which must be better explored as an element of regional development, enhancing sustainable activities, and the quality of life of a larger number of citizens.

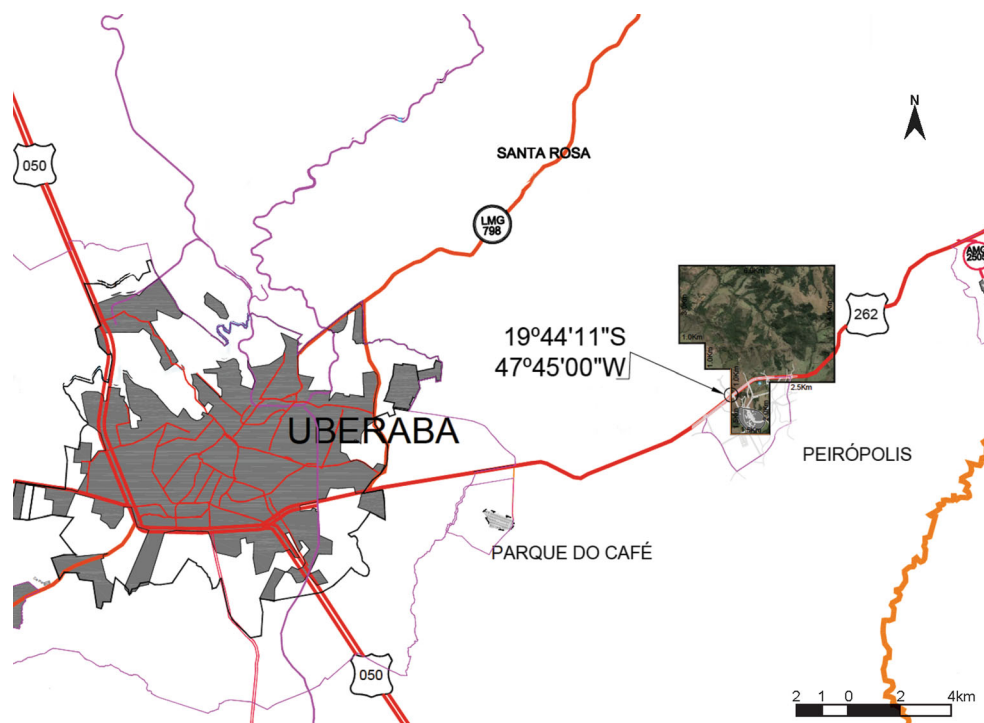
## Geosites Description

To set-up GULBD, seven geosites have been identified and described according to methodologies coined by Brilha (2005) and Pereira and Brilha (2008): Ponte Alta, Caieira, Peirópolis, Univerdecidade, Serra da Galga, Vale Encantado, and Santa Rita. Five more historical-cultural sites were inventoried and described (Fig. 1).

### *Ponte Alta Geosite*

It is located in Ponte Alta, in the city of Uberaba in a region known as *Cachoeirão do Ponte Alta* with an altitude of 802 m and coordinates  $19^{\circ} 43' 43.92''$  S– $47^{\circ} 38' 23.13''$  W. It was labeled as a site of tectonic type of touristic and educational interest, and also regional relevance. Its access is easy due to paved roads that almost lead you up there. Historically, it is used for leisure, entertainment, and extreme sports. It has an exceptional landscape view, and you can find waterfalls of 30 m high, where the Atlantic Forest biome is preserved (Fig. 11), that turns it ideal for environmental educational projects. In the geological context, it is exceptional. In only 3 m thick of the outcrop, three types of rocks can be observed: sedimentary, metamorphic, and igneous. This geological section composes a time gap in which we can observe the moment when an eolian dune from “Botucatu desert” was interstratified by two basalts levels. It is the result of the same tectonic event that fragmented Gondwana, separating South America from Africa.

**Fig. 10** Map of the location of the MNP





**Fig. 11** Ponte Alta Geosite

### *Caieira Geosite*

It is located in Peirópolis, in Uberaba with an average altitude of 900 m. Its coordinates are 19° 43' 26.89" S–47° 44' 47.45" W. The geosite was classified as a paleontological site, presenting scientific, educational, touristic, and cultural interest and is internationally relevant. It has a great historical value due to the lime cycle. It is the place where Llewellyn I. Price began his systematic research in the county in 1946 (Fig. 12), and thus also known as Price's Point 1. It lies stratigraphically in the contact between the Ponte Alta and Serra da Galga members (Marília Formation). It is one of the most relevant sites regarding the occurrences of vertebrates from Brazilian continental Cretaceous. Eight new species are designated to it: *Trigonosaurus pricei*, *Baurutitan britoi*, *Uberabasuchus terrificus*, *Peirosaurus tormini*, *Itasuchus jesuinoi*, *Peiropemys mezzalirai*, *Pricemys caiera*, and *Uberabatrachus carvalhoi*. The following can also be listed as belonging to the site: *Aelosaurus*, maniraptoriform, and the first dinosaur egg species of the country. It is one of the most visited geosites since its purposes include science, education, and tourism.

### *Peirópolis Geosite*

Peirópolis is a rural neighborhood in the city of Uberaba. It has 836 m in altitude and can be represented by the coordinates 19° 44' 35.06" S–47° 44' 35.08" W. It is classified as a paleontological geosite, has scientific, educational, and touristic interest and is internationally relevant. It represents the headquarters of palaeontology in Uberaba (Fig. 13). As a result of its representativeness, it was selected to receive all the resources provided from Project “Uberaba Land of Dinosaurs - Research, Education, Tourism and Socio-Environmental Sustainability” founded by the Ministry of



**Fig. 12** Caieira Geosite or Price's Point 1

Science, Technology and Innovation (MCTI). It represents the first financial vigorous action towards the implementation of Geopark Uberaba. The purpose is to execute part of the planning of this geosite (Fig. 14). The project “Cretaceous in Uberaba”, inserted in this geosite, has several reconstructions of the Cretaceous biota in their living environment.

### *Univerdecidade Geosite*

It is located in Univerdecidade neighborhood, in Uberaba, near Uberaba river, north of the city, in a place specially organized to a technological, educational, and touristic activities (Fig. 15). It has an altitude of 743 m and coordinates 19° 43' 17.70" S–47° 57' 30.59" W. It was classified as a sedimentological geosite of scientific, educational, and touristic interest, with regional relevance. It holds one of the main entrances to the northern entrance to the city. There, one can find the Environmental Educational Centre and Touristic Information.

Within the geological context, it represents the transition of Serra Geral Formation, with two possible basalt flows in the Uberaba Formation. The possibility of a direct



**Fig. 13** Peirópolis Geosite



**Fig. 14** Perspective of the “Peirópolis Geosite Project”

observation of the contact between these units allows us to understand an important moment of the geological evolution of the Bauru Basin. The Uberaba formation presents several records of Titanosauria in the city, associated with the construction of buildings, a soccer stadium, a hospital, and an adductor. More recently, a theropod Megaraptor was identified.

#### *Serra da Galga Geosite*

This Serra da Galga geosite was notable for the discovery of the fossil *Uberabatitan ribeiroi*, Brazil's largest dinosaur, and also for holding one of the most significant paleontological sites described in SIGEP n° 28. It is located on the federal highway BR 050 KM 153, about 30 km north from the city of Uberaba. The coordinates are 19° 35' 32.39" S–48° 1' 42.80" W and the altitude is 840 m. It is classified as a paleontological geosite and has scientific and educational interest and is

internationally relevant. It also has a historical relevance, because of the first fossils found in Uberaba, in 1945, and the important discovery of the first dinosaur egg in South America, that comes from this region. It has a diversified paleobiota, which has been described in a large number of scientific publications.

In this geosite is located the type section of Serra da Galga Member and partially silicified carbonates (calcretes and silcretes) of Ponte Alta Member (Fig. 16). The outcrop enables a good understanding of the last deposition episodes in the Late Cretaceous. Among the various excavation sites in the city, perhaps it is the only one that enables the prospection work during all year. This aspect gives it the opportunity to develop educational projects and touristic full time tours. The access is easy and fast, as the outcrop is part of the highway section. It is less than 1 km away from the federal highway police station and 700 m from a gas station and restaurant, which offers logistics for food and restroom.

**Fig. 15** Univerdecidade Geosite—Outcrop Uberaba Formation (*left*) and spheroidal basalts from Serra Geral Formation (*right*)



**Fig. 16** Serra da Galga Geosite—Km 153 Br 050



*Vale Encantado Geosite*

It is located 18 km north from the city of Uberaba, in a rural stretch, with an altitude of 886 m and coordinates of 19° 33' 13" S–47° 53' 59" W. It is rated as a stratigraphic geosite, with touristic and educational interest of local relevance. This geosite is a Private Natural Heritage Reserve (PRNP) with an area of 38 ha devoted to environmental preservation. Established by IEF 070/2004, on the initiative of its owner, it composes of a place of great landscape beauty marked by preserved areas with high biodiversity of the *cerrado* and its water fountains (Fig. 17).

Several environmental educational projects, especially for students of secondary and college education are developed there. It has a good logistics for tourists with a typical local food restaurant, leisure, and entertainment areas with a bucolic atmosphere. Its geological setting consists of sandstones, conglomerates, silcretes, and calcretes of the Marília Formation, which can be observed in the most important waterfall, where enjoyment and knowledge are connected.

**Fig. 17** Vale Encantado waterfall (left) and view of restaurant (right)



*Santa Rita Geosite*

It is positioned in a strategic setting in Uberaba. It is opposite to the City Market in the center of the city, with the coordinates of 19° 44' 58" S–47° 55' 53" W and altitude of 764 m. This geological geosite has historical and cultural relevance, because of the outcrop of the Uberaba Formation and also due the Santa Rita Church, built in 1854, and where Uberaba had its settlement. It became a cathedral in 1896. It has undergone several changes, but its original style was preserved. It was declared a National Historic Landmark in 1939 and in 1987, the cathedral was transformed into a Museum of Sacred Art (Fig. 18). Its collection, which has plenty of Baroque artefacts of the eighteenth and nineteenth centuries, gathers specimens donated by the Metropolitan Curia.

In the yard of Santa Rita Cathedral, there are outcrops of metric thickness that consist of greenish sandstones of Uberaba Formation. The outcrops represent an important period of tectono-sedimentary evolution of the Bauru Basin in its NNE portion, considering it has a different petrological



**Fig. 18** Santa Rita Museum of Sacred Art

composition, consisted of volcanoclastic rocks (epiclastic) where one can find clasts of alkaline rocks.

## Conclusion

The conceptual model proposed to Geoparks is extremely innovative, because it allows the preservation of natural resources, focused on the geological heritage value, to become the protagonist of sustainable development. The diverse historical, cultural, and ecological aspects must, whenever possible, be added to provide greater consistence and attractiveness to the region.

Undoubtedly, it is the most efficient way to bring the general public close to the geosciences, in special to the geodiversity attributes. It is an essential action to the valuation of our cultural goods and the consequent popularization of science.

The history of Peirópolis between the beginning of the twentieth century and the 1980s is an undisputed proof that fossils were fundamental for the recovery of growth when the local economy had collapsed.

The implementation of the Paleontological Research CPPLIP and MD in 1991 allowed a series of actions to be taken, such as the restart of paleontological research with systematic excavations; substantial scientific production; development of several educational programs, such as the PROTEU and Dinosaur Week; the popularization of geology and paleontology with exhibitions in the MD; and the adoption of geoconservation public policies, like the creation of the Natural Monument of Peirópolis; as well as actions with the SIGEP and the CPRM to consolidate the importance of paleontological sites.

Today, geotourism is the main income-and job-generating activity in Peirópolis, with approximately 100 direct jobs fomenting the local economy through hostels, restaurants, pubs, ice cream parlors, culinary crafts, and souvenirs. These

activities have ensured a good quality of life to the local inhabitants.

The creation of GULBD, based mainly on the relevance of the paleontological record, is rescuing the relevance of the geological heritage as the main tool for social and economic revitalization and generation of sustainable development.

The Peirópolis community, the Federal University of the Triângulo Mineiro, the municipality of Uberaba, and several private institutions are partners in the Geopark Uberaba, because they believe that the geological heritage, focused on the dinosaur theme, may be not only an asset for the social and economic development of the neighborhood, but also an additional element in the integral development of the city through tourism.

The infrastructure presented in Uberaba comprises a good highway network, airport, bus station, and excellent hotel and gastronomical logistic, and the fact that there are 2,100 municipalities within a distance of 500 km of Uberaba, that together represent more than 70 % of the Gross Domestic Product of Brazil, with a consumer market of more than 50 million people. These are strong elements to make this project viable.

We proposed that the initiatives already in development, centered on paleontology, may be integrated with others, such as cattle ranching, which makes Uberaba the world capital of zebu cattle, or the religious universe, having Chico Xavier as its maximum expression in Brazil.

The whole county of Uberaba, 4,540.51 km<sup>2</sup>, was determined as a geopark area. Twelve sites were reported, being seven geosites inventoried and described.

The geopark will be a definite reality when there is an integration of the potential assets of the municipality with the geological heritage, allowing the creation of a unique identity for the entire territory and making Uberaba a highly competitive touristic destination.

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