A survey of the paleontological heritage of Paraná State, Brazil

Christopher Vinicius Santos1, Antonio Liccardo1

1UEPG - Universidade Estadual de Ponta Grossa. Av. General Carlos Cavalcanti, 4748 - Uvaranas, Ponta Grossa – PR, Brazil, CEP 84.030-900

Abstract

The state of Paraná has a considerable area with sedimentary outcrop rocks from the Paraná Sedimentary Basins (Paleozoic and Mesozoic) and Bauru (Mesozoic), Curitiba Basin (Cenozoic), and metasedimentary basement rocks (Proterozoic) with fossiliferous content. The state’s paleofauna and paleoflora, geologically distributed over more than one billion years, are diversified and acknowledged in several scientific publications. On this regard, a survey of the main collections and paleontological sites in Paraná state was conducted to provide a basis for the conception of a geoscience museum and with the scope of presenting representative fossils of the geological history of this region. The methodological procedures consisted of literature search, consultations with paleontologists, visits to various state institutions and a selection of the samples in different sectors of the State University of Ponta Grossa (UEPG). The surveyed set of paleontological collections and sites indicate the heritage that is known by the state research institutions and museums and allowed to organize and quantify the set of fossils that comprise the collection of the UEPG’s Museum of Natural Sciences, which now exhibits to the public the evolutionary history of Paraná’s fossils. The survey identified 25 geosites in the state and 10 museological institutions located in 20 municipalities, which represent the most valuable scientific and educational paleontological heritage, as emphasized in this text.

1. Introduction

In Paraná State (southern Brazil) important fossils are found in its territory, indicating the existence of a significant geological, paleontological and cultural heritage, which is acknowledged in various recent scientific publications (e.g. Bosetti 2007, Liccardo and Weinschütz 2010, Manzig and Weinschütz 2012, Sedor et al. 2017, Kellner et al. 2019, Langer et al. 2019, Fraga and Vega 2020). The paleofauna and paleoflora in Paraná State are diversified, with important discoveries having been recorded in the past years but still unknown to the public in general. Fossil representatives of the different geological periods are found, which together tell the evolution of life on Earth, from the Proterozoic period (about 1.1 billion years ago) to the Cenozoic (Pleistocene, until 11,700 years ago).

This work aimed to conduct a data survey of the in situ paleontological heritage (paleontological sites) and ex situ (paleontological collections) in the state of Paraná in order to provide a detailed picture of this heritage and define the representativeness of the fossils on display at the Museu de Ciências Naturais (MCN) [Museum of Natural Sciences] of the State University of Ponta Grossa (UEPG).

The records of fossils found in the rocks of the studied region indicate different paleoenvironments, paleoclimates and distinct stages of life evolution in the past, which characterize an in situ geological heritage, that is, the outcrop areas that preserve these records or geosites. Brilha (2005) considers as geosites locations of occurrence of one or more elements of geodiversity (outcrops formed by the action of natural processes or human intervention), geographically well-defined and which have a significant value from the scientific, didactic, historical, touristic, or other, viewpoint. Rocks, minerals or fossils collected and preserved in collections comprise the ex situ geological heritage (Ponciano et al. 2011, Viana and Carvalho 2019) and its scientific/cultural contents refer directly to the geological characteristics of the geosites.

In Paraná, the stromatolites in meta limestones and marbles of the Crystallin Basement are the most ancient fossils, roughly 1.1 billion of years ago, and are located in the First Plateau of Paraná, in the rocks of the Capiúr Formation (Guimarães et al. 2002, Piekarz 2011).

In the Paraná Sedimentary Basin, in the region that comprises the Second Plateau of the state, there are numerous fossiliferous records along each lithostratigraphic unit (Furnas, Ponta Grossa, Itararé, Rio Bonito, Palermo, Irati, Serra Alta, Teresina, Rio do Rasto, Botucatu Formations) that date back between 419 and 65 million of years ago. Since the discovery of the first fossils in Paraná State (late...
nineteenth century), the Second Plateau has been the focus of numerous paleontological researches that revealed important scientific discoveries throughout the geological units cited (e.g., Mac Gregor 1908, Clarke 1913, Rosler 1974, Matsumura et al. 2013). The most representative fossils of this region are ichnofossils and invertebrates of the Devonian period (Furnas and Ponta Grossa Formations), plant fragments of the Permian Period (Rio Bonito Formation), mesosaurs and crustaceous of the Permian Period (Iratí Formation), silicified woods and stromatolites and invertebrates of the Permian period (Teresina Formation) and amphibians, fishes and plant leaves of the Permian (Rio do Rasto Formation), found the in the Second Plateau of Paraná.

In the Bauru Sedimentary Basin, Third Plateau, in the Mesozoic period, sedimentary rocks of the Goio-erê Formation (Guabirotuba Formation – Paleogene, 66 to 23 million of years). In addition to these, fossils of Pleistocene mammals (2.5 million of years to 11,000 years) were found in alluvial deposits in lizards, pterosaurs and dinosaurs dated 145 to 66 million years ago. Also found in rocks of this formation are ichnofossils of Tetrapoda (Silva 2002, Langer et al. 2019).

Finally, from the Cenozoic times, there are records of fossils of crocodylomorphs, testudines, mammals and gigantic birds of the Curitiba Sedimentary Basin (Guabirotuba Formation – Paleogene, 66 to 23 million of years). In addition to these, fossils of Pleistocene mammals (2.5 million of years to 11,000 years) were found in alluvial deposits in Chopolínho and Pinhão (Third Plateau), recorded by Pillati and Bortoli (1978) and Sedor and Born (1999), as well as records of vertebrates and invertebrates in several caves in Paraná (Sedor et al. 2004).

2. Material and methods

Ponciano et al. (2011) identified a possibility of classifying the geological/paleontological heritage as in situ in the case of geosites and ex situ heritage for the cases where the material was removed from the place of origin and kept in museums and scientific collections. In the case of paleontological heritage, the connection between the samples in museums and their places of origin (geosites) is very close, which requires a constant correlation between the sample contents and their geological context if an exhibition is considered.

Firstly, a survey of the main paleontological sites of the state of Paraná was conducted, based on the database available from the Brazilian Commission of Geological and Paleobiological Sites (SIGEP, terminated in 2013). According to the publications “Sítios geológicos e paleontológicos do Brasil” [Geological and paleontological sites in Brazil] volumes I, II and III, published between 2002 and 2013, three major sites in Paraná have been found to date. In addition to these three sites identified by SIGEP, other important outcrops and collections were acknowledged in several scientific publications, which, after analysis and selection, were incorporated to this study. Field activities for recognition of these locations were performed for data collection, image recording and videos.

After the geosites’ identification, a search for the paleontological collections in the state was carried out. We visited the major research institutions on paleontology, among them, the Federal University of Paraná (UFPR), State University of the Midwest (UNICENTRO), State University of Ponta Grossa (UEPG), which have paleontological collections available to public visitors. Regarding other institutions, e.g., State University of Londrina (UEL), State University of Paraná (UNESPAR) and the Paleontological Museum of Cruzeiro do Oeste, we contacted the coordinators to obtain information about the collections. The relevant data were then organized to allow an appropriate selection and geologically identified according to the maps available from the Institute of Water Bodies and Lands (IAT).

3. Results and discussion

Fossils, records of any kind of life on Earth as belonging to a geological period before the present one (Holocene), i.e., remains and traces of animals and plants older than 11,000 years (Branco 2014) are considered as Natural and Cultural Heritage, article 216 of Brazil’s Constitution (Brasil 2016), included as “Union’s Assets” and protected by law 4.146/42 (Brasil 1942). Furthermore, due to their scientific and cultural value, they represent the Planet’s Biological Memory, which must be preserved for future generations.

Every fossil is a scientific and cultural heritage by definition, but for the development of this work a broad criterion of representativeness was used in the selection of the main fossils found in Paraná which could concisely present the biogeographic history of this region and the scientific evolution. Museological criteria were considered, such as aesthetics, to exhibit it as a collection piece. Thus, a total of 25 fossiliferous deposits of great importance in the state and ten collections from public institutions that preserve important fossils were identified, comprising 20 municipalities (Table 1).

Table 2 describes the paleontological sites of the greatest scientific and educational importance in the state, the geological unit where the fossils are found, the municipality and the geographic coordinates of each geosite. This survey can be useful in the development of future measures of protection of paleontological sites in Paraná. The collected data were synthetized in a map (Figure 1), which shows the geographic distribution of the paleontological sites and collections in the state. This link between the location and institutional preservation, in universities or public museums, for example, where the fossils can be safeguarded for future generations to appreciate and learn from them is of vital importance (Page 2018). On this regard, the Museum of Natural Sciences of UEPG is near the Campus site of UEPG (100 meters away), having fossils of Devonian invertebrates. Part of the material that has been removed over the years is housed or exposed in this museum.

According to Page (2018), the five main factors of degradation of fossiliferous deposits are: 1. Natural degradation and vegetation growth – including chemical and physical actions, weathering and erosion; 2. Agricultural, forestry and other land management practices or contamination of sites and hiding by tree cover; 3. Engineering works, including infrastructure, industrial and housing construction works and coastal protection works / flood protection works – which includes physical damages, filling and contamination, removal, hiding and burial; 4. Extraction of mineral aggregates and restoration of work sites (comprising wastes removal) – which includes physical damages, filling, hiding, burial or removal of deposits; 5. Excessive or improper use - including physical damages, exhaustion / removal of deposits and/or loss of important specimens of interest to the global market and private collections.
Table 1: Main paleontological sites in Paraná State

| Town/Site                                    | Age       | Stratigraphic Unit   | Coordinates          | Fossil type                                                                 | References                                      |
|---------------------------------------------|-----------|----------------------|----------------------|-----------------------------------------------------------------------------|------------------------------------------------|
| Almirante Tamandaré                         | Proterozoic| Capirú Formation     | 25°18.801′ S 49°17.930′ W | Columnar stromatolites                                                      | Guimarães, Neto & Siqueira, 2002; Piekarz, 2011. |
| Parque Aníbal Curu                          |           |                      |                      |                                                                             |                                                 |
| Campo Largo/Rio da Prata                    | Proterozoic| Cameronha Formation  | 25°27′32′ S 49°31′55′ W |                                                                             |                                                 |
| Balsa Nova/São Luiz do Purunã                | Devonian  | Passa Dois Group     | 25°28′03′S 49°39′28′W | Bodies of Beltaneliiformis organisms                                         | Drefahl & Silva, 2007.                         |
| São João do Triunfo/Tibagi Site              | Devonian  | Passa Dois Group     | 25°04′17.8′S 50°06′23.4′W | Plant imprints assigned to Psilophytales                                    | Rodrigues, Pereira, Bergamaschi, 1989.         |
| Figueira/Coal Mine                           | Permian   | Guatá Group          | 25°10′48′S 50°08′47′W | Detailed classification of asteroid and ophiurid fossils of the following species: Paranaster crucis; Magnasterella darwini; Encrinaster pontis and Marginix notatus | Horodyński, Bosetti, Myczynski, 2006; Bosetti, Horodyński, Matsumura & Junior, 2013. |
| Estrada do Alegado                          | Devonian  | Ponta Grossa Formation| 25°05′33′S 50°06′20.3′W | In the outcrop area are found species of bivalve and univalve brachiopods, multi-elements of crinoids and trilobites ichnogenus Zoophycos isp. | Horodyński, Bosetti, Myczynski, 2006; Bosetti, Horodyński, Matsumura & Junior, 2013. |
| Sant'ana Airport                             | Devonian  | Ponta Grossa Formation| 25°18′51′S 50°05′33′S | Detailed classification of asteroid and ophiurid fossils of the following species: Paranaster crucis; Magnasterella darwini; Encrinaster pontis and Marginix notatus | Clarke, 1913 Fraga & Vega, 2020.               |
| Caniú River Railway extension               | Devonian  | Ponta Grossa Formation| 25°03′50.0′S 50°07′58.2′W | Examples of fossils found in the outcrop sections: Bivalve Brachiopods, Australospinifer iheringi; Australospinifer iheringii; Orbiculoidea spp; Gigadiscina collis; Derbybina sp; Derbybina whititorum; Urville Schuchertella sp. such as Tentaculites sp., in addition to Crinoid pluricellular, Pygymum of trilobe Calmody, Ichnogenus Zoophycos isp. | Bosetti, Horodyński, Matsumura & Junior, 2013. |
| Jaguariaíva-Arapoti Railway Extension        | Devonian  | Ponta Grossa Formation| 24°14′50.5′S 49°43′18′W | Diverse invertebrate fossils (Conululida, Brachiopoda Articulata and Inarticulata, Mollusca Bivalvia and Gastropoda, Tentaculitoidea, Trilobita and Crinoida). Asteroids and Ophiuroids are also found. Microfossils: plant cuticles, sporoforms, Chitinozoa, Acritarch, Tasmensae and scale-codonts. Among ichnofossils are the ichnogenera Planolites sp., Paleoplyes sp., Bergaueria sp. and Zoophycos sp. | Clarke, 1913 Bolzon, Azevedo, Assine, 2013 (SIGEP). Fernandes (1996) Fraga & Vega, 2020. |
| Tabi/Titytuba Transbrasiliana Highway        | Devonian  | Ponta Grossa Formation| 24°23′55′S 50°20′16′W | Vascular plants: Spongiophyton lenticulare; Palaeostigma wardi Irregular Haplosigma; Sphenophytales; Palaeostigma wardi Irregular Haplosigma; Sphenophytales; Palaeostigma wardi Irregular Haplosigma. | Matsumura, Iannuzzi, Bosetti, 2013. |
| Wolff Site                                   | Devonian  | Ponta Grossa Formation| 24°33′42′S 50°31′00′W | Vascular plants: Spongiophyton lenticulare; Palaeostigma wardi Irregular Haplosigma; Sphenophytales; Palaeostigma wardi Irregular Haplosigma. | Matsumura, Iannuzzi, Bosetti, 2013. |
| São João do Triunfo/Permian Flora            | Permian   | Rio Bonito Formation | 25°40′58″S 0°17′49″W | Plants assigned to the following species: Stephophyllum brasiliensis; Annularia occidentalis and Annularia readii. | Rosler, 1974                                    |
| Figueira/Coal Mine                           | Permian   | Rio Bonito Formation | 23°49′17.4″S 50°24′59.4″W | Paleoflora examples: Lycophytes of the genus Brasioliodendron, Subligenicula and Lagerportisporites. Sphenophytes: Paracalamites australis, Sphenophyllum brasiliensis, Annularia occidentalis. Phyliciae: Arterotheca derbyi. Pterididensp: Pecopteris cambuyensis, Sphenopteris lobifolia and Glossopteris communis. Coniferous genera such as Parano cladus, Buriadana Paranopernum | Branco & Rösler (2004) |
| Irati/Gutierrez Station                      | Permian   | Irati Formation      | 25°31′4.4″S 50′39′28.3″W | Mesosaurus tenuidentes; Stereosternum tumidum and Crustaceous                  | Mc Gregor, 1908 Gervais, 1864,.. |
| São Mateus do Sul/Petroxix                   | Permian   | Irati Formation      | 25°51′39″S 50′23′50″W, | Mesosaurus tenuidentes; Stereosternum tumidum and Crustaceous                  | Mendes, 1954                                   |
### Table 1: Main paleontological sites in Paraná State (continued)

| Town/Site | Age       | Stratigraphic Unit | Coordinates                  | Fossil type                                                                 | References                                                                 |
|-----------|-----------|--------------------|------------------------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| Prudentópolis / Prud 1 Quarry | Permian   | Teresina Passa Dois Group | 25°12'30.8"S 50°57'12.4"W | Bivalves in limestones, coquinas                                            | Neves, Rohn & Simões, 2010                                               |
| Prudentópolis / Prud 2 Quarry | Permian   | Teresina Formation Passa Dois Group | 25°12'25.1"S 50°56'56.4"W | Bivalves in limestones, coquinas                                            | Neves, Rohn & Simões, 2010                                               |
| Prudentópolis / “Pineiro de Pedra” [Stone Pine Tree] | Permian   | Teresina Formation Passa Dois Group | 25°22'12"S 51°00'58"W | Fossil trunks of conifers                                                    | Pontes-Filho et al. 2019                                                 |
| Jacarezinho/Bony Fish | Permian   | Rio do Rasto Formation Passa Dois Group | 23°10'08.40"S 49°57'49.48"W | Shark fin spines of the following species: Sphenacanthus riorastoensis and Sphenacanthus riorastoensis | Pauliv et al, 2012                                                        |
| Mauá da Serra – Ortígio- ra (Serra do Cadeado) | Permian   | Rio do Rasto Formation Passa Dois Group | 23°45'35"S 53º03'53"W | Paleontological record of plants (Schizoneura, Glossopteris, Paracalamites, Pecopteris), bivalves (Leinzia, Palaeomutula, Terraia), gastropods, conchostraceans (Pseudestheria, Monoleiolophus, Euestheria, Asmussia, Liograpta), oysters and some insects, and an especially significant fauna of tetrapods. This includes the dicyodont Endothiodon, a small-to-medium size terrestrial herbivore, and two forms of temnospondyl "amphibians", one with long rostrum, Australerpeton cosgriffi, and another with short rostrum. | Langer et al, 2009 (SIGEP)                                                |
| Canoas/ Indianópolis | Cretaceous | Rio Paraná Formation Caiuá Group | 23°40'26.9"S 52°37'02.9"W; 23°25'39.23"S 52°38'0.4"W | Ichnifossils assigned to small theropods, and primitive mammals.               | Leonardi, 1977                                                           |
| Cruzeiro do Oeste | Cretaceous | Goio-Érê Formation Caiuá Group | 23°45'35"S 53º03'53"W | Pterosaur: Caiuajara dobruskii                                                | Manzig et al, 2014                                                         |
| | | | | | Iguanid lizard: Gueragama sulamericana                                           | Simões et al, 2015                                                           |
| | | | | | Dinosaur (theropod): Vespersaurus paranaenses                                     | Langer et al, 2019                                                          |
| | | | | | Pterosaur: Keresdrakon vilsoni                                                 | Kelner et al, 2019                                                          |
| Curitiba | Paleogene | Guabirotuba Formation | 25°30'30"S 49°20'30"W | First discovery: Ziphodont type tooth assigned to Crocodilomorph.           | Liccardo & Weinschütz, 2010                                               |
| | | | | | Guabirotuba Fauna: Mammals (Cingulata, No-toungulata, Astrapotheria and Metatheria), Fossil remains of seven armored xenarths are identified, including a description of a new species and genus named Prooecoleophorus carlinii. The Guabirotuba ungulates are assigned to Interatheriidae, Oldfieldthomasiidae and Astrapotheria. The metatherian mammals are represented by one spara-rassodont, one paleotentoid and one argyrolagioid. | Sedor et al, 2017                                                          |
| Chopinzinho | Pleistocene | Recent sediments s | 24°46'31.0"S 49°06'45.0"W | Tooth fragment, Pleistocene mastofauna of the genus Tapirus                   | Pillati & Bortoli. 1978                                                   |
| Cero Azul/ “Caverna Toco-que-rá-ba" (Cave) | Pleistocene | Recent sediments in caves of the Votuverava Formation of the Açu Group. | 25°51'24"S 52°32'11"W | Mastodont: Stegomastodon waringi                                               | Sedor, Born & Santos, 2004                                                 |

### Table 2: Main paleontological collections in Paraná State.

| Collections | Institution | Location | Coordinates |
|-------------|-------------|----------|-------------|
| 1 Museum of Natural Sciences | UEPG | Ponta Grossa | 25°05'29.1"S 50°06'13.3"W |
| 2 Laboratory of Paleontology and Stratigraphy | UEPG | Ponta Grossa | 25°05'22.6"S 50°05'38.1"W |
| 3 Campos Gerais Museum | UEPG | Ponta Grossa | 25°05'47.4"S 50°09'31.2"W |
| 4 Museum of Natural Sciences | UPPR | Curitiba | 25°26'51.3"S 49°13'58.3"W |
| 5 Laboratory of Paleontology | UPPR | Curitiba | 25°27'04.5"S 49°13'53.9"W |
| 6 Museum of Natural Sciences | UNICENTRO | Guarapuava | 25°21'07.0"S 51°28'14.5"W |
| 7 Museum of Geosciences | UNICENTRO | Irati | 25°32'00.5"S 50°39'24.7"W |
| 8 Museum of Geology | UEL | Londrina | 23°10'35.9"S 51°12'05.1"W |
| 9 Cruzeiro do Oeste Museum | City Museum | Cruzeiro do Oeste | 23°46'37.0"S 53°03'57.2"W |
| 10 Museum and Laboratory of Geology | UNESP | Campo Mourão | 24°02'36.5"S 52°23'12.7"W |
Table 2 describes the location of the collections found with samples of high scientific and educational value not only in the state of Paraná but from other Brazilian and world regions. The collections are visited by students from primary and secondary schools, high school, and universities, and the community in general.

According to Mansur et al. (2013), the environment of a collection represents a safety area because the collection can be easily recorded, documented and undergo interventions to maintain its integrity and appropriate housing. In the most institutions, ex situ paleontological heritage is protected by the trustee systems in force and by the codes of conduct and guidelines set out by the Brazilian Museum Institute, Law 11.904 of January 14, 2009 (Brasil 2013). These management, preservation, documentation, disclosure and protection procedures must ensure perfect preservation, representation and communication of existing materials (Viana and Carvalho 2019). According to these authors, musealization must therefore potentialize the educational content of the fossil and strengthen the actions of preservation of the cultural heritage.

Carvalho (2016) emphasizes that fossils represent two important elements for the management of a territory and are inseparable from the paleontological heritage. The first one is social identity, in which the record of life in a scale of time much larger than the historical time, allows a valorization of the geographic space and the communities that exist there, enhancing the feeling of belonging. The second element is economic relevance, because people’s interest in paleontology allows the development of job-generating activities in the cultural industry and geotourism.

The first definition of geotourism appeared in England (Hose 1995) proposing to “facilitate understanding and provide service facilities for tourists to acquire knowledge of the geology and geomorphology of the site, going beyond mere spectators of an aesthetic beauty”. Thus, the essential idea of geotourism is to aggregate the scientific knowledge to the natural and cultural heritage in a pleasant and understandable manner, valuing it and allowing touristic visitation to occur in a sustainable way (Jorge and Guerra 2016). This tourism segment has used the interpretation of the cultural/scientific content offered by fossils in collections or in geosites as a strategy for valuing the heritage and contributing for its popularization and preservation. Geotourism is closely linked to the strategies of preservation of the geological and paleontological heritage.

4. Conclusion

The survey of the main paleontological collections and sites in Paraná identified 25 geosites and 10 museological institutions located in 20 municipalities, which represent the most valuable scientific and educational paleontological
heritage, comprising the main fossils that cover the geological timeline known in the state, from Proterozoic to Cenozoic. This selection illustrates the conception of the paleontological exhibition of the UEPG’s Museum of Natural Sciences, which seeks to show the biological memory of Paraná.

The paleontological heritage of the state is diversified, and the institutions that preserve it not only exhibit it according to the evolution timeline over the geological timeline, but fulfill a major role in the preservation of ex situ heritage. The surveyed data set indicated the potential educational value of the collections, and the correlation between the fossil and the geosites is shown to be essential to understanding the territory.

Public communication of geoscientific information in museums requires synthesis surveys like the present one for the development of an effective planning and directed to different target audiences among visitors. This set of information can also provide different usages such as the production of catalogues, communication and educational materials based on the data presented here, which also serves as support to appropriate touristic releases.

There is a strong potential for inclusion of this heritage in the development of geotourism in Paraná, and this survey may provide the basis for future actions of protection and preservation of the sites of great paleontological importance and offer access to geoscientific knowledge to the population in general.

The paleontological exhibitions of various institutions in Paraná ensure preservation of the heritage and its scientific-educational communication but tend to underestimate the geotouristic potential of the collections and the geosites as well. A refinement of this analysis may contribute to strategies developed to reframe the paleontological heritage considering the relationship between geotourism and paleontology.

Acknowledgements

The authors gratefully acknowledge the financial support granted by Araucária Foundation for the research, and also wish to thank the Laboratory of Paleontology and Stratigraphy and the Campos Gerais Museum of UEPG, the Laboratory of Paleontology and the Museum of Natural Sciences of UFPR and their respective coordinators, Élvio Bosetti, Nilton Chaves, Cristina Vega and Fernando Sedor for the information provided and access to the collections.

References

Bolzon R.T., Azevedo I., Assine M.L. 2002. Sítios Geológicos e paleontológicos do Brasil. Brasília, CNPM, CPRM. v. 2. 515 p.

Bosetti E.P., Horodyski R.S., Matsumura W.M.K., Myszynski Junior J.M., Bolzon R.T., Azevedo I., Assine M.L. 2006. Tafonomia de alta qualidade: Uma proposta de pesquisa. In: Guerra A.J.T., Jorge M.C.O. (org.). Geoturismo, geoconservação: abordagens geográficas e geológicas. São Paulo, Oficina de textos, 163-195 p.

Clarke J.M. 1913. Fósseis de Paraná. Monografia. Serviço Geológico e Mineralógico do Brasil, Rio de Janeiro, 353 p.

Diefenthal M., Silva R.C. 2007. Ocorrências de fósseis ediacarianos na Formação Capiru (Proterozoico) nas regiões de Morro Azul e Morro Grande: leste do Paraná. Boletim Paranaense de Geociências, n. 51, 77-88. http://dx.doi.org/10.5380/geo.v51i0.4172

Horodyski R.S., Bosetti E.P., Myshinsky L.J. 2013. Icnofósseis Devonianos de São Luiz do Purunã – PR. Available on line at: http://www.cprm.gov.br/propostas/Icnofossos_Devonianos_S_Luiz_Puruna_PR.htm; (accessed on 20 March 2020)

Guimarães G.B., Assine M.L., Guimarães Netto R., Melo M.S., Góis J.R. 2013. Icnofósseis Devonianos de São Luiz do Purunã – PR. Sítios Geológicos e Paleontológicos do Brasil. CNPM, CPRM, SIGEP. Proposta de Sítio Geológico ou Paleobiológico do Brasil. Available on line at: http://sigeo.cprm.gov.br/propostas/Icnofossos_Devonianos_S_Luiz_Puruna_PR.htm; (accessed on 20 March 2020)

Guimarães S.B., Reis Neto J.M., Siqueira R.B.L. 2002. Caracterização dos estromatólitos da formação Capiru (Proterozoico) nas regiões de Morro Azul e Morro Grande: leste do paraná. Boletim Paranense de Geociências, n. 51, 77-88. http://dx.doi.org/10.5380/ecol.v51i0.4172

Langer M.C., Elltik E., Bittencourt J.S., Rohn R. 2009. Serra do Cadeado, PR: uma janela paleobiológica para o Permiano continental sul-americano. In: Winge M., Schobbenhaus C., Souza C.R.G., Fernandes A.C.S., Queiroz E.T., Berbert-Born M., Campos D.A. (ed.). Sítios Geológicos e paleontológicos do Brasil. Brasília, CPRM. v. 2. 515 p. Available on line at: http://rigeo.cprm.gov.br/sisp/handle/doc/19865 / (accessed on 01 March 2020).

Branco R.F., Rösler O. 2004. The paleoflora of Figueira in the context of the Neopaleozoic of the Paraná Basin, Brazil. Terrae 1, 44-51. Available on line at: https://www.ige.unicamp.br/terrae/V2/PDF-N2/branco.pdf / (accessed on 03 March 2021).

Branco R.F., Rösler O. 2004. The paleoflora of Figueira in the context of the Neopaleozoic of the Paraná Basin, Brazil. Terrae 1, 44-51. Available on line at: https://www.ige.unicamp.br/terrae/V2/PDF-N2/branco.pdf / (accessed on 03 March 2021).

Branco R.F., Rösler O. 2004. The paleoflora of Figueira in the context of the Neopaleozoic of the Paraná Basin, Brazil. Terrae 1, 44-51. Available on line at: https://www.ige.unicamp.br/terrae/V2/PDF-N2/branco.pdf / (accessed on 03 March 2021).

Branco R.F., Rösler O. 2004. The paleoflora of Figueira in the context of the Neopaleozoic of the Paraná Basin, Brazil. Terrae 1, 44-51. Available on line at: https://www.ige.unicamp.br/terrae/V2/PDF-N2/branco.pdf / (accessed on 03 March 2021).
The paleontological heritage of Paraná, Brazil

Langer M.C., Martins N.O., Manzig P.C., Ferreira S.G., Marsola J.C.A., Fortes E., Lima R., Sant'ana L.C.F., Vidal L.S., Lorençato R.H.S., Eczurra M.D. 2019. A new desert-dwelling dinosaur (Theropoda, Noasauridae) from the Cretaceous of southern Brazil. Scientific Reports, 9, 9379. https://doi.org/10.1038/s41598-019-45306-9

Leonardi G. 1977. Two new ichnofaunas, vertebrates and invertebrates, in the eolian Cretaceous sandstones of the Caiuá Formation in northeast Paraná. In: Simpósio de Geologia Regional, 1, São Paulo, 112-128.

Liccado A., Weinschütz L.C. 2010. Registro inédito de fósseis de vertebrados na Bacia Sedimentar de Curitiba (PR). Revista Brasileira de Geociências, 40, 3, 330-338. Available on line at: http://ppegeo.igc.usp.br/index.php/rgb/article/view/7760 / (accessed on 01 March 2021).

Mac Gregor J.H. 1908. Mesosaurus brasiliensis nov. sp., Parte II. In: Mac Gregor J.H. 1908. Relatório final da Comissão de Estudos das Minas de Carvão de Pedra do Brasil. DNPM, Rio de Janeiro, Parte II, 303-617.

Mansur K.L., Ponciano L.C.M.O., Castro A.R.S.F., Machado D.M.C., Fonseca V.M.M., Kunzler J. 2011. Patrimônio geológico-paleontológico in situ e ex situ: definições, vantagens, desvantagens e estratégias de conservação. In: Carvalho I.S., Srivastava N.K., Strohschoen J.O., Lana C.C. (org.). Paleontologia: Cenários da Vida. Rio de Janeiro, Interiência, 15, 3, 243-250. DOI:10.4072/rbp.2012.3.01

Piekarz, J.F. 2011. Geoturismo no Karst. Curitiba, Mineroxar. 121 p.

Pillati F., Bortoli C. 1978. Presença de Haplomastodon, um mastodonte quaternário no Paraná. Acta Geológica Leopoldensia, 7, 5, 3-13.

Ponciano L.C.M.O., Castro A.R.S.F., Machado D.M.C., Fonseca V.M.M., Kunzler J. 2011. Patrimônio geológico-paleontológico in situ e ex situ: definições, vantagens, desvantagens e estratégias de conservação. In: Carvalho I.S., Srivastava N.K., Strohschoen J.O., Lana C.C. (org.). Paleontologia: Cenários da Vida. Rio de Janeiro, Interiência, 15, 3, 243-250. DOI:10.4072/rbp.2012.3.01

Portes-Filho A., Liccardo A., Rogoski C.A., Branco F.R., Piekarz G.F., Guimarães G.B. 2019. Painel geoturístico. O Pinheiro de Pedra. Instituto de Terras, Cartografia e Geologia do Paraná. Curitiba, PR.

Rodrigues M.M.A., Pereira E., Bergamaschi S. 1989. Ocorrência de psilophytales na formação Furnas, bordo leste da Bacia fazer Paraná. Boletim IG-USP. Publicação Especial, São Paulo, 7, 35-43. http://dx.doi.org/10.11606/issn.2317-8078.v0i7p35-43

Rosler O. 1974. Novas Espécies de Sphenophyta na Formação Rio Bonito (Permanio) no estado do Paraná. Boletim IG. Instituto de Geociências USP, São Paulo, 5, 17-28. Available on line at: http://ppegeo.igc.usp.br/index.php/bigusp/article/view/341 / (accessed on 01 March 2021).

Rosler O. 1974. Novas Espécies de Sphenophyta na Formação Rio Bonito (Permanio) no estado do Paraná. Boletim IG-USP. Publicação Especial, São Paulo, 7, 35-43. http://dx.doi.org/10.11606/issn.2317-8078.v0i7p35-43

Sedor F.A., Born P. 1999. Novas ocorrências de mamíferos pleistocênicos no Estado do Paraná. In: Congresso Brasileiro de Paleontologia, Crato (Ceará), 16, p. 103-104.

Sedor F.A., Born P., Santos F.M.S. 2004. Fósseis pleistocênicos de Scelidodon (Mylodontidae) e Tapirus (Tapiridae) em cavernas paraanaenses (PR, sul do Brasil). Acta Biológica Paranaense, Curitiba, 33, (1, 2, 3, 4), 121-128. https://doi.org/10.4072/rbp.2012.3.01

Sedor F.A., Oliveira E.V., Silva D.D., Fernandes L.A., Ribeiro A.M., Dias E.V. 2017. A New South American Paleogene Land Mammal Fauna, Guabirotuba Formation (Southern Brazil). Journal of Mammalian Evolution, 24, 39-55.

Silva R.C. 2002. Pegadas fósseis de tetrápode da Bacia do Paraná, Brasil. 2002. Graduação work. Setor de Ciências Biológicas, Departamento de Zoologia, Universidade Federal do Paraná, 63 p. Available on line at: http://hdl.handle.net/1884/36790 / (accessed on 01 March 2021).

Silva R.C. 2002. Pegadas fósseis de tetrápode da Bacia do Paraná, Brasil. 2002. Graduação work. Setor de Ciências Biológicas, Departamento de Zoologia, Universidade Federal do Paraná, 63 p. Available on line at: http://hdl.handle.net/1884/36790 / (accessed on 01 March 2021).

Simões T., Wilner E., Caldwell M., Weinschütz L., Kellner A. 2015. A new species of Sphenacanthus (Chondrichthyes, Elasmobranchii) from the Rio do Rasto Formation (Paraná Basin), southern Brazil. Revista brasileira de paleontologia, 15, 3, 243-250. DOI:10.4072/rbp.2012.3.01

Viana M.S.S., Carvalho I.S. 2019. Patrimônio paleontológico. Rio de Janeiro, Interiência, 158 p.

Page K.N. 2018. Fossils, heritage and conservation: managing demands on a precious resource. In: Reynard E.M., Brilha J. (org.). Geoheritage: assessment, protection, and management. Amsterdã. Elsevier. p. 107-128.
