

Ubirajara: The dilemma of the Brazilian fossil curator

By Caiubi Emanuel Souza Kuhn¹, Ismar de Souza Carvalho², Fábio Augusto Gomes Vieira Reis³, André Luis Spisila⁴, Marjorie Csekö Nolasco⁵, and Abdelmajid Hach Hach⁶

¹Universidade Federal de Mato Grosso. Rua Quarenta e Nove, 2367 - Boa Esperança, 78060-900 Cuiabá, Estado do Mato Grosso, Brazil. Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP). Av. 24 A, 1515, 13506-692, Bela Vista, Rio Claro, Estado de São Paulo, Brazil. Tubingen University, 94-96, 72076 Tübingen, Germany. Orcid: 0000-0003-1434-9433. E-mail: caiubigeologia@hotmail.com

²Universidade Federal do Rio de Janeiro, Departamento de Geologia, CCMN/IGEO, 21.910-200 Cidade Universitária, Ilha do Fundão, Estado do Rio de Janeiro, Brazil. Universidade de Coimbra, Centro de Geociências, Rua Silvío Lima 3030-790 Coimbra, Portugal. Orcid: 0000-0002-1811-0588. E-mail: ismar@geologia.ufrj.br

³Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP). Departamento de Engenharia Ambiental (DEA) e Centro de Pesquisa em Ciências Naturais Aplicadas (Unespetro). Av. 24 A, 1515, 13506-692, Bela Vista, Rio Claro, Estado de São Paulo, Brazil. Orcid: 0000-0003-3918-6861. E-mail: fabio.reis@unesp.br

⁴CPRM - Serviço Geológico do Brasil. Rua Voluntários da Pátria, 475 - 1º andar cj. 10, 80020-926 Curitiba, Estado do Paraná, Brazil. Orcid: 0000-0003-1650-6594. E-mail: andre.spisila@cprm.gov.br

⁵Universidade Estadual de Feira de Santana. Av. Transnordestina, s/n - Feira de Santana, 44036-900 Novo Horizonte, Estado da Bahia, Brazil. Orcid: 0000-0002-6085-1558. E-mail: mcn@uefs.br

⁶Centro Universitário de Curitiba, Unicuritiba. R. Chile, 1678 - Rebouças, Curitiba - PR, 80220-181. Brazil. Orcid: 0009-0007-5610-6591 e-mail: Abdelmajid.hach@unicuritiba.com.br

Received February 2023. Accepted September 2023.



This article discusses the case of the *Ubirajara* fossil based on the legislation in force in Brazil. Consequently, recent publications that report the normative structure of the country and what procedures have been performed in similar cases are analyzed. The results suggest that while the pre-published description of the fossil incorrectly reported that the fossil legally left Brazil as mineral heritage, later information indicated that the material may have been exported legally as an ornamental rock, or else that the fossil might have been illegally exported. Another point considered is that following the description of this new species, the specimen's legal framework changed; therefore, it must be returned to Brazil because it is a holotype, which has a specific legal status. The present evaluation indicates the need to update Brazilian legal regulations to establish criteria and procedures for the management of fossils and reinforces the need to create an international legal framework that addresses the elements of geodiversity.

Kuhn, C. E. S., Carvalho, I. S., Reis, F. A. G. V., Spisila, A. L., Nolasco, M. C., and Hach, A. H. 2023. *Ubirajara*: The dilemma of the Brazilian fossil curator. *Geological Curator* 11 (7):469-479. <https://doi.org/10.55468/GC1463>

Introduction

Recording Earth's geological memory entails dilemmas that sometimes prove insurmountable, as materializing memory through rocks, minerals, fossils, or even historical events and processes implies introducing value to what will be preserved. This is the conceptual basis of geological heritage, which values situations of exceptional landscapes, outcrops or, in *ex situ* cases, objects that are relevant to understanding the environmental transformations to which our planet has been and is subject.

The preservation of memory has an implication for the selectivity of what is preserved. Considering that everything that exists is relevant and that demands physical immobilization, *in situ* or *ex situ*, means removing the meaning of exceptionality itself. Without performing selectivity, memory itself disappears because the infinite accumulation of objects prevents the creation of space for the new.

Within the scope of curatorship, there lies an important issue that clearly delimits the function of the curator: defining what is important or not in the constitution of institutional collections and how they should be used. The clipping of the visible world carried out by museum collections is shown to have a practical and clearly fractal function in terms of the real representation of nature (Lima and Carvalho 2022). In this way, the collections that have objects related to geology and paleontology are fractions of what exists in nature and enable actions of educational and/or scientific interest.

In Brazil, there are legal provisions for both the constitution and management of objects of scientific or cultural interest, as well as for the preservation of *ex situ* geological heritage. However, in some areas, such as paleontology, the ambiguity in the legal normative documents that allow conflicting interpretations of the legal framework has favored a scenario of legal instability.

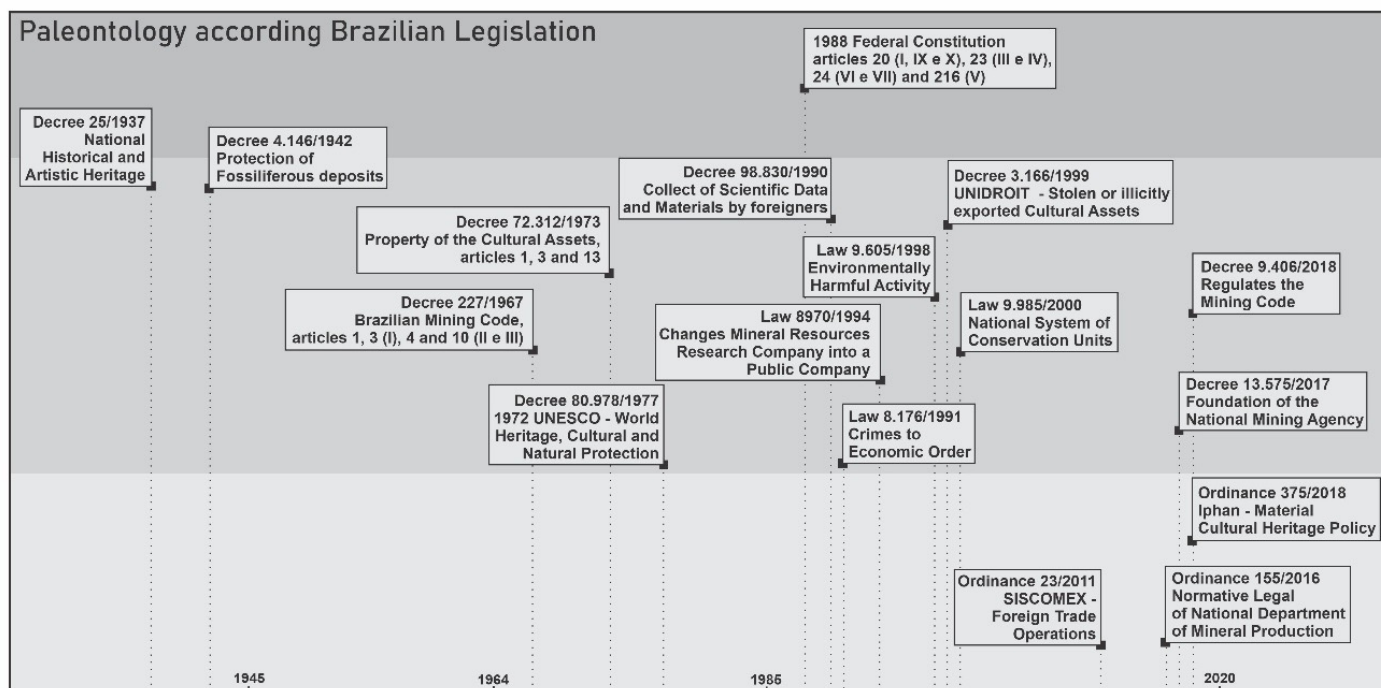


Figure 1. Brazilian legal framework, whose numerous laws and decrees overlap and generate conflicts regarding the protection of the Brazilian fossil heritage (Kuhn *et al.* 2022b).

The legislation on fossils in Brazil was first established in 1942 by Decree No. 4,146 (Brazil 1942), which establishes fossils as the nation's heritage and that the extraction of fossil specimens depends on prior authorization from the National Department of Mineral Production (currently, the National Mining Agency - ANM). Other laws, decrees and normative documents were created after that date and currently constitute the country's legal normative set on the subject (Figure 1). Kuhn *et al.* (2022b) have presented a summary of the current Brazilian legislation, demonstrating that fossils are considered mineral natural heritage that, exceptionally, can be considered cultural heritage.

The discovery of fossils in Brazilian territory has thus become a legal problem in recent years that directly interferes with scientific research actions, education in the geosciences, the preservation of geological heritage and even the legal stability of mining companies in sedimentary areas (Lima and Carvalho 2020a,b,c; Kuhn *et al.* 2022a,b).

This study presents a critical reflection on the dilemmas found in contemporary curatorial actions of geological materials in Brazil. Based on a summary of current Brazilian legislation, the situation of the fossil *Ubirajara jubatus* is analyzed, which effectively summarizes the difficulties in reconciling the preservation of geological heritage with the promotion of local actions that are aimed at sustainable development.

***Ubirajara*: Scientifically relevant fossil or the synthesis of an imaginary dinosaur?**

Ubirajara jubatus is a new genus and species of compsognathid theropod representing the first Gondwanan nonavian theropod with preserved filamentous integumentary structures (Smyth *et al.* 2020). In addition to its importance to evolutionary studies, it is also important to the Brazilian paleontological imagination. It represents the synthesis of modern interpretations of dinosaurs, as living animals related to birds.

There are few studies that assess the actual quantity and diversity of dinosaur genera that have already been described and scientifically validated. In an analysis by Wang and Dodson (2006), the diversity of nonavian dinosaurs was estimated at 1,850 genera, including those not yet discovered. The statistical calculation made by these authors was based on data from specimens already described and a mathematical analysis predicting new discoveries. In 2006, a critical evaluation showed that of the 540 genera and 800 species of dinosaurs proposed since 1824, 285 genera and 336 species were probably valid. Later data, such as those indicated by Mark Norell (Treviño 2018), suggest that 50 new dinosaurs have been named per year, information reinforced by Brusatte (2019). This exponential increase in the discovery of new dinosaurs introduces important aspects for paleobiodiversity studies, as there are questions about the validity of many of the new described species (Benton 2008, 2015; Benton *et al.* 2011; Tennant *et al.* 2018).

The increase of new dinosaur species is directly related to the popular interest in this group of extinct animals. Thomson (2005) has carried out a detailed analysis of the causes of the growing public interest in this type of fossil. Part of the reason for their hold on our collective imagination may be that, of all extinct organisms, dinosaurs are the most paradoxical. The secret of the fascination with dinosaurs is that they are half real and half not real, resulting in a tension that gives them a particularly exotic nature. The power that is symbolized by these large animals and their strangeness comprise the key to understanding their popular success.

Such power lies behind all questions concerning curatorial problems of vertebrate paleontology and its fossils: the social recognition of scientists, the possibility of new financial support for scientific research and the prestige for institutions that house new specimens. This results in constant conflicts of interest that mix legality, geoethics and fake information (Carvalho and Leonardi 2022).

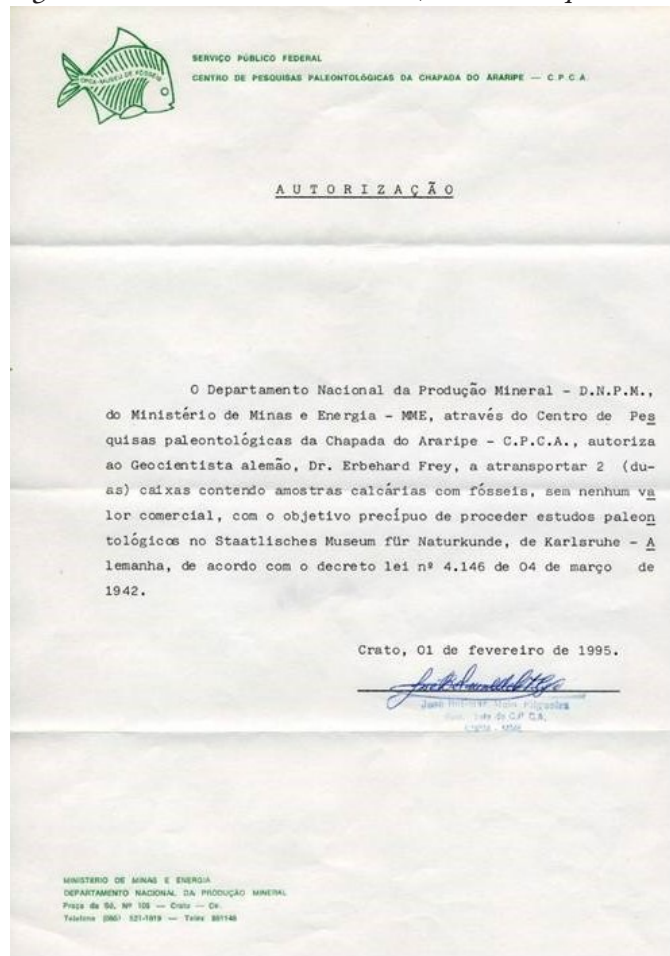
The description of the *Ubirajara jubatus* from the Lower Cretaceous of the Araripe Basin (Smyth *et al.* 2020) illustrates the modern dilemma of how best practices are used to protect ex situ geological heritage. Although this fossil is real, well-described and should be considered a valid species, this article has been withdrawn at the request of the editor (Elsevier, Cretaceous Research) due to an allegation of possible illegality in the export of the holotype, following campaigns carried out by some Brazilian paleontologists on social networks. Thus, *Ubirajara* has been transformed into a not-real species in the twilight existence of the reality of geological time. To be or not to be has been re-defined by prejudice, legal statements, pride and disputes among paleontologists.

Brazilian legislation, publications and paleontological conflicts

The first Brazilian legislation concerning fossil protection is Decree 4.146 (Brazil 1942). This decree indicates that fossils are patrimony of the nation, as all mineral heritage. The Decree No. 227/1967 Mining Code reinforces the understanding of fossils as mineral heritage. According to Article 4 "A deposit is considered to be any individualized mass of mineral or fossil substance, arising on the surface or existing inside the earth, and which has economic value; and mine, the deposit in progress, even if suspended". Law No. 13,575/2017, which created the National Mining Agency (ANM), consolidates the understanding established in Article 2 as a function of the agency "XIII - regulate, guide and supervise the extraction and collection of fossil specimens referred to in item III of the caput of article 10 of Decree No. 227, of February 28, 1967 (Mining Code), and Decree No. 4,146, of March 4, 1942, and

adopt measures to promote its preservation".

Figure 2. Authorization of DNPM (National Department



of Mineral Production, in the present ANM, National Mineral Agency) that permitted the export of the fossils within which *Ubirajara jubatus* was initially thought to be included. (<https://revistagalileu.globo.com/Ciencia/noticia/2020/12/apos-polemica-artigo-sobre-novo-dinossauro-brasileiro-e-despublicado.html>)

Although in the initial description *Ubirajara* was considered legally obtained, based on the 1995 DNPM authorization (Figure 2), it was subsequently verified that the fossil had been imported in 2006 and was acquired by State Museum of Natural History Karlsruhe (SMNK) in 2009.

An important document is Decree no. 72,312 (Brazil 1973); it protects collections and rare samples from zoology, botany, mineralogy, anatomy and paleontology from illegal export (article 1). Another aspect of Brazilian legislation concerning fossil protection is related to holotype specimens. The Science and Technology Ministry has suggested that where joint expeditions recognise a new species, the holotype should be returned and housed in a Brazilian collection (Brazil 1990).

The analysis performed by Kuhn *et al.* (2022b) indicates



Figure 3. Fossil of the *Ubirajara jubatus*, in limestone rock in the traditional shape of cariri stone ornamental rock slabs (Photo Joédson Alves). (<https://agenciabrasil.ebc.com.br/geral/noticia/2023-06/alemanha-devolve-fossil-ubirajara-jubatus-ao-cariri-cearense>)

that fossil material, according to Brazilian legislation, can be treated in three different ways: a) they can be considered as a mineral resource and be used to produce mineral goods such as cement, ornamental rocks, among others; b) they can be considered as a mineral resource, governed by Law No. 13,575/2017, article 2, by item XIII, when intended for museums and research institutions; c) they can be considered as cultural heritage, when it complies with the provisions of cultural legislation.

In Brazil, the commercialization of Brazilian fossils for purposes of scientific collections is not regulated, and because fossils are the union's heritage, there is no person authorized in the national territory to sell specimens to scientific collections. However, Brazilian legislation allows the sale of ornamental rocks composed of fossils. According to the National Mining Agency "the removal, according to the legal regimes provided for in the Mining Code, of fossils that are not destined for Museums, Educational Establishments or other scientific purposes is permitted" (ANM 2021). According to official Brazilian foreign trade statistics, between 2001 and 2018, 576 tons of limestones were exported as ornamental rocks from Ceará State, the region where the *Ubirajara* rocks originate, to countries such as South Africa, the Netherlands Antilles, Belgium, Chile, Spain, the United States, France, Italy, Holland and Portugal (Brazil 2023).

The limestones of the Cariri region are rich in fossils. As an example, it is possible to see this in the Sobral City Hall, where fossils of fish, algae, seeds, plants, as well as some vertebrae, are visible on the floor (Sobral 2023). The use of rocks with fossils as ornamental rocks is also observed in other regions of Brazil, such as the Museum of Tomorrow, in Rio de Janeiro, where there are floors full of gastropod fossils (Polck *et al.* 2018), or in shopping malls in the city of São Paulo, covered with stromatolites (Sal-lun Filho and Fairchild 2005; Liccardo *et al.* 2012) or as a façade covering in Rio de Janeiro buildings (Medeiros and Polck 2017).

The *Ubirajara* fossil was found in a laminated limestone slab (Figure 3), that is, in rocks that are extracted to be used as ornamental rocks. Although the material may have been illegally exported from Brazil, with the specific aim of commercializing it for scientific purposes, there is also the possibility that the material was legally exported as ornamental rock.

It is a fact that among the ornamental rocks exported, countless fossils have left Brazil legally. Likewise, countless fossils are found in ornamental rocks sold in Brazil. At this point, a second debate arises: should anyone who acquires an ornamental rock and identifies a fossil then use it to make a floor or should they keep it for scientific collection purposes? This dilemma makes the legal de-

bate about Brazilian fossils even more complex.

In some countries, e.g. the United States of America, Germany and the United Kingdom, there is no legal obstacle to the sale of privately-owned fossils. In Brazil, there are also no restrictions on sales of fossils extracted in other countries. As a result, it is common to find companies selling fossils from Morocco (FosseisBrasil 2023; Terrabrasiliedidaticos 2023). Thus, the existence of scientific ethics in not studying commercialized materials conflicts with aspects of local legislation and the cultural elements of each country. The uncertainty about the fossil's 2006 import into Germany was the pretext on which the repatriation of the fossil to Brazil was based (Greshko 2022), not the circumstance that it was obtained from a commercial source. In fact, the main question is not centered on the commercialization or not of fossils, but on the need to comply or not with the legislation of another country.

According to Brazilian legislation (Ordinance No. 55 of March 14, 1990 of the Ministry of Science and Technology), such fossil types (neotypes and holotypes) must remain in Brazil. This requalification requires that it be listed in accordance with legal procedures different from the previous ones and compliance with the legal procedures established by Ordinance no. 55 of March 14, 1990 of the Ministry of Science and Technology (currently Ministry of Science, Technology and Innovation), which determines that, through the co-participant and responsible Brazilian institution, it will retain, from the fossil material collected, neotypes and all type material, for allocation to Brazilian scientific institutions (Chap. VII, 39, Items c, e). In this way, even if the fossil had legally been exported as ornamental rock, it would ultimately have to return to Brazil after the description of the species.

This is one of the challenges in the curatorial procedures involving fossils — although it is possible to donate them for scientific and educational purposes, when a new species (and consequently a new holotype) is recognized, it is necessary that it should be returned and housed in a Brazilian scientific institution.

In no other similar case in recent years has an article on Brazilian fossils been retracted. One can cite, as an example of the lack of concern for heritage in this situation, an analysis of the two-year time interval (2020 to 2022) of 62 articles in scientific journals by Brazilian and foreign researchers. Except for a publication with wide visibility in newspapers and magazines (*Cretapalpus vittari* defined by Downen and Selden 2021), in no other case were complaints or public denouncements made about the relevance of the origin of the fossil. Also noteworthy is the publication of a new species of Ephemeroptera

(*Protoligoneuria heloisae* defined by Storari *et al.* 2021) or a fossil plant (Gobo *et al.* 2023) whose holotypes are in collections abroad and for which there have been no denouncements by Brazilian academics. We emphasize that all these would also be cases for requesting a return.

Incorrect information about the legality of the material certainly presents an ethical problem. The withdrawal of the manuscript presents new challenges for science and for researchers, the description and the species officially ceased to exist; however, it is impossible for any researcher to describe the same specimen without there being a very high percentage of plagiarism in relation to the previous description and new, related legal problems.

A holotype is a scientific reference to a new fossil specimen, and it is necessary to follow international rules when naming and protecting a sample. One principle is to include the holotype in a public collection of educational or research institutions, and the case of *Ubirajara jubatus* had followed these basic principles.

Thus, the main question concerning the curatorial care of this specimen is where it should be housed. Based on the legal procedures concerning the sampling and export of the fossil, where it was recognized as a new type in paleontology, it should be returned to Brazil and housed in a Brazilian institution. However, the public repository in Brazil should not be confused with public availability in a museum exhibition. A holotype must be maintained under special conservation and storage conditions that can be incompatible with its public exhibition, through following established principles of curatorship techniques.

Therefore, some authors (Caetano *et al.* 2023) considered that '*Ubirajara*' and '*Ubirajara jubatus*' are names that absolutely have no relevance for nomenclatural purposes and any reference to specimen SMNK PAL 29241 as '*Ubirajara*' should enclose the name in quotes and indicate that it is an unavailable name in the Code sense. It is only appropriate, both in this case and in the case for example of *Protoligoneuria heloisae* (Storari *et al.* 2021), to request their return to Brazil, which represents a discussion within the legal forum. Recently, the return to Brazil of *Ubirajara jubatus* was concluded and the fossil will be housed in the Cariri Museum in Brazil.

***Ubirajara* and new possibilities for Brazilian fossil protection**

Legislation analysis performed by Kuhn *et al.* (2022a) has shown that fossils are not cultural heritage. Based on the Brazilian Mining Code, they are a mineral heritage subject to the control of the Agência Nacional de Mineração. This is also recognized by the Institute of National



Figure 4. Laminated limestone tailings from the Crato Formation in a location with mineral extraction rights (Distrito Mineiro de Nova Olinda, Ceará - Brazil) and where most of the fossils that result in legal litigation originate. Actions that select the fossils suited for sale in this type of waste are the solution for improving the region's social and economic conditions, as well as for advancing actions aimed at protecting the heritage of fossils.

Historical and Artistic Heritage (Iphan), which has stated in Portaria nº 375, from September 19, 2018, that although fossils can be considered part of Brazilian cultural heritage (Iphan 2018) and are eligible for preservation and protection, they are also a mineral resource and are thus not necessarily subject to current geoconservation models (Kuhn *et al.* 2022a), as suggested by Carmo *et al.* (2010), Carvalho (1993, 2018), Carvalho *et al.* (2021), Viana and Carvalho (2019), Henriques and Pena dos Reis (2015, 2019), and Page (2003, 2018).

The definition's context, Decree No. 4,146 (Brazil 1942), identifies fossils as materials belonging to vertebrates dissociated from the rock and unrelated to the existence of other legal provisions related to mining rights. This decree was established as a form of protection for a large number of bones of the Quaternary megafauna of Araxá (Minas Gerais State, Brazil), which were immersed in unconsolidated clayey sediments. However, in most cases, fossils are elements of rocks and as such are governed by

the Mining Code (Kuhn *et al.* 2022a).

Unlike the situation observed in relation to the megafauna of Araxá, the region where the fossil of *Ubirajara* comes from presents a high concentration and quality of fossils; it has always generated concerns of a heritage nature, either through the destruction of fossils during mining routines or for the illegal shipment of this material abroad. In this case, there is a dialectical relationship between fossil abundance and mineral extraction activity. It is through the opening of new mining fronts in laminated limestone, with the exposure of an infinity of bedding planes and the generation of new exposure surfaces, that fossils are found. The industrial activity of mining is simultaneously what makes new discoveries of fossils possible and what destroys them through the use of rocks for utilitarian purposes (Carvalho *et al.* 2022).

A quantitative study of areas with mining authorizations (process number DNPM/800.024.1998), with a detailed control of the spatial distributions and levels of the main

occurrences with fossils in the mining district of Nova Olinda (State of Ceará), has demonstrated that in a test area of 70 hectares, in just one day, it is possible to collect 4,000 specimens of macrofossils exposed in the tailings of a mining area (Figure 4). This amount corresponds to approximately 960,000 fossils per year in just 10% of the mineral concession area authorized by the federal government (Carvalho *et al.* 2022). This leads to the need for new theoretical reflections (Carvalho *et al.* 2020; Henriques *et al.* 2020) and propositions about the validity of the current Brazilian legal system, which allows the commercialization of rocks with fossil content but criminalizes the sale of a fossil object. There is, therefore, a mistaken perception that the presence of this lithological element (fossil) must be preserved in its entirety and completeness.

From an ethical point of view, what is the most appropriate use of a common fossil content? Can it be marketed as cement or ornamental rock or due to the occurrence of the fossil itself? The criteria and flows of possible destinations for the use of fossil material need to be better discussed and clarified in Brazil.

The use of waste from quarries in the Araripe Basin region should be reassessed, as fossil excavation does not actively occur to locate fossils. The discoveries and results from the opening of new mining fronts for the commercialization of Pedra Cariri and fossils are in this context, especially in the large volume of waste resulting from this type of mining. The commercial use of fossils found in these wastes, which are crushed for the production of cement or used as raw material for landfills, would result in greater social and economic benefits for the entire region and for Brazilian paleontology, as previously proposed by eminent Brazilian paleontologists (Lima 1990; Jasper 2010). In addition to the greater possibility of finding new, scientifically-relevant specimens, it would result in a better fate for paleontological heritage than simply being lost due to disposal.

This situation demonstrates the great importance of assigning monetary value to fossils, similar to art objects, as this implies issues of property insurance due to the monetary value of collections and objects. In geological heritage analysis and valuation projects (Brilha 2005; Viana and Carvalho 2019), quantification based on monetary value is not carried out. Quantitative and qualitative assessments are made based on abstract values such as scientific importance, potential for tourism and educational use, risk of degradation and geological diversity. It is important that there be a valuation from a financial point of view, which would even guide the storage conditions and choices of the most appropriate place as a holotype repos-

itory, akin to minerals, rocks and objects of art.

Another relevant point is that not all fossils should be available for public viewing, as is the case of holotypes, given the possibility of their loss or degradation. The construction of replicas is an alternative that makes it possible to disseminate new species to several museums, following all curatorship criteria.

The case of Brazilian legislation illustrates a global problem. There is a lack of international regulations that establish criteria for managing geodiversity and protecting geological heritage. In the case of biodiversity, an international convention guides the global legal scenario (UN 2023), but geodiversity still lacks a similar document (Kuhn *et al.* 2022b).

Minerals and fossils as *ex situ* elements of geodiversity often have a restricted occurrence. Access to rocks and fossils in museums is an instrument for popularizing science and making it possible for anyone to learn about the history of the planet. Geological time records do not occur continuously in any country in the world. Thus, the exchange of scientific collections is a necessary activity for providing access to this knowledge and the history of the evolution of life to all people on the planet.

The use of natural resources derived from geodiversity also occurs unevenly, according to the consumption pattern of each country. These resources are limited and nonrenewable. Hence, at the international level, the construction of a UN convention or one of its agencies could be a long-term solution to resolve conflicts related to abiotic natural heritage, that is, geodiversity, in which fossils constitute one of the elements. This could be a way to establish an international legal basis that allows for the demarcation of limits between the different destinations of and possible uses for fossiliferous content.

Conclusions

Ubirajara should be considered not only a fossil that belongs to Brazil but also a fossil that belongs to science that is housed in a scientific institution in Brazil. Partnership and confidence among Brazilian and foreign scientists and institutions comprise the first step toward the improvement of knowledge. An important aspect, at this point, is related to the access to fossils among researchers from different institutions. The judicial complaint and judicialization of issues that are of interest to science and geological heritage can result in improperly curtailing research possibilities for different national and international research groups via a policy of restricting research and knowledge. This kind of action has no legal basis in legislation, nor does it contribute to scientific advances or

to the dissemination of science.

This situation demonstrates the need for an international convention that addresses not only the protection of fossil heritage, but also geodiversity more broadly. Only with the creation of international parameters for the protection of geological heritage, based on an international convention, will it be possible to build adequate mechanisms for heritage management, based on internationally accepted parameters.

The issue of fossils, as heritage sites subject to full preservation and as constituent elements of rocks capable of generating relevant economic resources through their commercial use, is the most complex issue in Brazilian heritage preservation legislation.

This issue of the preservation of fossils leads to new challenges in the management of paleontological heritage in areas with intense mining activity. These new challenges imply the following actions:

- The creation of a register of the scientific collections existing in museums and educational institutions, national and international, to register legally-collected fossils.
- Strengthening the management and inspection mechanisms of the National Mining Agency (ANM) for quarries where fossils occur frequently.
- Organizing, maintaining and feeding the public record of potentially fossiliferous areas managed by the ANM, with an obligation for registration and specific authorization for carrying out scientific research and with spatial demarcations and designated times for the authorization of surveys and research.
- Establishing criteria for the identification of fossils that have a relevant scientific character.
- Creating criteria and establishing paleontological follow-up programs with educational actions in mining activities located in sedimentary areas, recognizing the value of the workers who work in these places as collaborators in Brazilian science.
- Establishing a legally-qualified professional agency in the area of paleontology to monitor mining work or other engineering activities in places with the potential for, or where there are, relevant fossil records.
- Proposing the definition of criteria that include the monetary value of any object considered a fossil, including parameters similar to those carried out when measuring mineral deposits.
- Discussing and presenting solutions for the best use

of mineral waste in fossiliferous areas, enabling the commercialization of fossils that do not represent types of scientific relevance or examples of exceptional existence.

- Requiring, to enable the commercialization mentioned in the previous item, the issuance of a report by a legally-qualified professional in the area of paleontology linked to an educational or museum institution, after due analysis of the focal material.

Regarding educational actions, expanding those already mentioned in the item that proposes the creation of paleontological monitoring programs with educational actions in active mining areas, we include the following proposals:

- Stimulus for the use of fossils in heritage education actions across Brazilian society.
- Valuation of activities in the tertiary sector that allow an increase in paleontological scientific tourism, especially in regions with geoparks.

With regard to the situation of the *Ubirajara jubatus*, we highlight the following requirements:

- The need to build an international understanding on how to proceed with similar cases, aiming to solve problems in relation to the authorship of the description of the species, and at the same time respect for national legislation.
- Establishment of an international convention on geodiversity.
- Evaluation of the appropriate repository for the fossil of *Ubirajara jubatus* and other holotypes in Brazilian territory.
- Production of a replica of the *Ubirajara jubatus* rather than allowing the holotype to be made available in museum exhibitions, to guarantee the best chances for its preservation and reduce the potential for damage to or loss of the fossil due to inadequate transport or storage conditions.

Acknowledgements

We thank the reviewers and editors for their contributions to improving the text of the manuscript. To the Brazilian Federation of Geologists (FEBRAGEO) for creating the working group to discuss legislation on fossils in Brazil. To the Federal Council of Engineering and Agronomy (CONFEA) for creating the working group, to discuss nonstatutory details on fossils and geological and mineral heritage in Brazil. To the Carlos Chagas Filho

Foundation for Research Support of the State of Rio de Janeiro (Faperj, Proc. E-26/200.828/2021, Brazil, to I.S.C.), the National Council for Scientific and Technological Development (CNPq, Brazil 316574/2021-0 to F.A.G.V.R. and 303596/2016-3 to I.S.C.).

References

- ANM 2021. Exportação de fósseis. Análise de Impacto Regulatório – AIR, N° de controle: 001.
- BENTON, M. J. 2008. Fossil quality and naming dinosaurs. *Biology Letters* 4 (6), 729–732. doi: 10.1098/rsbl.2008.0402.
- BENTON, M. J. 2015. Palaeodiversity and formation counts: redundancy or bias? *Palaeontology* 58 (6), 1003–1029. doi: 10.1111/pala.12191.
- BENTON, M. J., DUNHILL, A. M., LLOYD, G. T. and MARX, F. G. 2011. Assessing the quality of the fossil record: insights from vertebrates. *Geological Society, London, Special Publications* 358 (1), 63–94. doi: 10.1144/sp358.6.
- BRAZIL 1942. Decreto-Lei N° 4.146, de 4 de março de 1942. Dispõe sobre a proteção dos depósitos fossilíferos. <https://www2.camara.leg.br/legin/fed/declei/1940-1949/decreto-lei-4146-4-marco1942-414164-norma-pe.html#:~:text=EMENTA%3A%20Disp%C3%B5e%20sobre%20a%20prote%C3%A7%C3%A3o%20dos%20dep%C3%B3sitos%20fossil%C3%ADferos> Accessed 10/02/2023.
- BRAZIL 1973. Decreto N° 72.312, de 31 de maio de 1973 Promulga a Convenção sobre as Medidas a serem Adotadas para Proibir e Impedir e Importação, Exportação e Transferência de Propriedades Ilícitas dos Bens Culturais. http://www.planalto.gov.br/ccivil_03/decreto/1970-1979/D72312.html#:~:text=DECRETO/20N/C2/BA.,Propriedade/20Il/C3/ADcitas/20dos/20Bens/20Culturais Accessed 10/02/2023.
- BRAZIL 1990. Portaria n. 55 de 14 de março de 1990 do Ministério da Ciência e Tecnologia. https://antigo.mctic.gov.br/mctic/opencms/legislacao/portarias/migracao/Portaria_MCT_n_55_de_14031990.html Accessed 10/02/2023.
- BRAZIL 2023. Conexstar. <http://comexstat.mdic.gov.br/pt/home> Accessed 10/09/2023.
- BRILHA, J. 2005. *Patrimônio Geológico e Geoconservação: a conservação da natureza na sua vertente geológica*. Viseu, Portugal: Palimage Editores. 189 pages.
- BRUSATTE, S. 2019. *Ascensão e queda dos dinossauros: Uma nova história de um mundo perdido*. Rio de Janeiro, Brazil: Editora Record. 335 pages.
- CAETANO, J. M. V., DELCOURT, R. and PONCIANO, L. C. M. O. 2023. A taxon with no name: ‘*Ubirajara jubatus*’ (Saurischia: Compsognathidae) is an unavailable name and has no nomenclatural relevance. *Zootaxa* 5254 (3): 443–446. <https://doi.org/10.11646/zootaxa.5254.3.10>
- CARMO, D. A., CARVALHO, I. S., SANTUCCI, R. M. and SILVA, M. A. 2010. Jazigos fossilíferos do Brasil: legislação e cooperação científica internacional. In I.S. Carvalho (ed.), *Paleontologia: conceitos e métodos*. Rio de Janeiro, Brazil: Editora Interciência Ltda. 561–584 pages.
- CARVALHO, I. S. 1993. Aspectos legais da comercialização de fósseis e sua influência na pesquisa e no ensino de Paleontologia no Brasil. *Cadernos IG/UNICAMP* 3 (1), 91–105.
- CARVALHO, I. S. 2018. Fósseis: Importância econômica e social do patrimônio paleontológico. In A.J.T. Guerra and M.C.O. Jorge (eds.), *Geoturismo, geodiversidade, geoconservação: abordagens geográficas e geológicas*. São Paulo, Brazil: Oficina de Textos. 163–200 pages.
- CARVALHO, I. S. and LEONARDI, G. 2022. The invisibles of science and the paleontological heritage: The Brazilian study case. *Geoheritage* 14, 107. <https://doi.org/10.1007/s12371-022-00737-1>
- CARVALHO, I. S., HENRIQUES, M. H., CASTRO, A. R. S. F. and FÉLIX, Y. R. 2020. Promotion of the Geological Heritage of Araripe Unesco Global Geopark, Brazil: the Casa da Pedra Reference Center. *Geoheritage* 12, 17. <https://doi.org/10.1007/s12371-020-00452-9>
- CARVALHO, I. S., RAMINELLI, R., HENRIQUES, M. H. P., SOARES, R. C., ANDRADE, J. A. F. G. and FREITAS, F. I. 2021. The Araripe Geopark (NE Brazil): Discovering the Earth’s past as a driver of economic and social transformation. *Geoheritage* 13, 1–16. <https://doi.org/10.1007/s12371-021-00586-4>
- CARVALHO, I. S., ANDRADE, J. A. F. G., FREITAS, F. I. and HENRIQUES, M. H. P. 2022. A importância da mineração para o patrimônio fossilífero: estudo de caso do Araripe Global UNESCO Geopark. In VI Simpósio Brasileiro de Patrimônio Geológico, São Paulo, 2022. *Boletim de Resumos*. 64–65.
- DOWNEN, M. R. and SELDEN, P. A. 2021. The earliest palpimanid spider (Araneae: Palpimanidae), from the Crato Fossil-Lagerstätte (Cretaceous, Brazil). *Journal of Arachnology* 49, 91–97. <https://doi.org/10.1636/JoA-S-19-059>
- FOSSEISBRASIL 2023. Kit Didático Fósseis do Marrocos REF010. <https://www.fosseisbrasil.com.br/produtos/kit-didatico-fosseis-do-marrocos-ref010/> Accessed 10/09/2023.
- GOBO, W. V., KUNZMANN, L., IANNUZZI, R., SANTOS, T. B., CONCEIÇÃO, D. M., NASCIMENTO Jr., D. R., SILVA FILHO, W. F., BACHELIER, J. B. and COIFFARD, C. 2023. A new remarkable Early Cretaceous nelumbonaceous fossil bridges the gap between herbaceous aquatic and woody protealeans. *Scientific Reports* 13, 8978 <https://doi.org/10.1038/s41598-023-33356-z>
- GRESHKO, M. 2022. Unique “spear lord” dinosaur to be returned to Brazil. National Geographic. <https://www.nationalgeographic.com/science/article/unique-spear-lord-dinosaur-to-be-returned-to->

- [brazil#:~:text=In%20what%20may%20prove%20to,than%20100%20million%20years%20ago](#) Accessed 20/07/2022.
- HENRIQUES, M. H. and PENA DOS REIS, R. 2015. Framing the palaeontological heritage within the geological heritage: an integrative vision. *Geoheritage* 7, 249–259. <https://doi.org/10.1007/s12371-014-0141-9>
- HENRIQUES, M. H. and PENA DOS REIS, R. 2019. Improving geoconservation of the palaeontological heritage through a semiotic vision. *Spanish J. Palaeontol.* 34(1): 95–102. <https://doi.org/10.7203/sjp.34.1.15248>
- HENRIQUES M. H., CASTRO A. R. S. F., FÉLIX Y. R. and CARVALHO I. S. 2020. Promoting sustainability in a low density territory through geoheritage: Casa da Pedra case-study (Araripe Geopark, NE Brazil). *Resour Policy* 67:101684–101711. <https://doi.org/10.1016/j.resourpol.2020.101684>
- IPHAN 2018. Portaria nº 375, de 19/09/2018. https://www.in.gov.br/materia/-/asset_publisher/Kujrw0TZC2Mb/content/id/41601_273/do1-2018-09-20-portaria-n-375-de-19-de-setembro-de2018-41601031 Accessed 21/09/2021.
- JASPER, A. 2010. Legislação para exploração (Mineração) e venda de fósseis: caracterização da realidade Brasileira. *Geonomos* https://www.in.gov.br/materia/-/asset_publisher/Kujrw0TZC2Mb/content/id/41601_273/do1-2018-09-20-portaria-n-375-de-19-de-setembro-de2018-41601031 (1), 38–40.
- KUHN, C. E. S., SANTOS, F. R. P., JESUZ, C. R., KOLYA, A. A. and REIS, F. A. G. V. 2022a. Public policies for geodiversity in Brazil. *Geoheritage* 14, 74. <https://doi.org/10.1007/s12371-022-00705-9>
- KUHN, C. E. S., CARVALHO, I. S., REIS, F. A. G. V., SPISILA, A. L., and NOLASCO, M. C. 2022b. Are fossils mineral or cultural heritage? The perspective of Brazilian legislation. *Geoheritage* 14, 85. <https://doi.org/10.1007/s12371-022-00719-3>
- LICCARDO, A., MANTESSO-NETO V. and PIEKARZ, G. F. 2012. Geoturismo Urbano – Educação e Cultura. *Anuário do Instituto de Geociências* 35 (1), 133-141.
- LIMA, M. R. 1990. Comercialização de fósseis no Brasil: prós e contras. I Simpósio sobre a Bacia do Araripe e Bacias Interiores do Nordeste: Crato. *Departamento Nacional da Produção* 1, 37–40.
- LIMA, J. T. M. and CARVALHO, I. S. 2020a. Geological or cultural heritage? The *ex situ* scientific collections as a remnant of nature and culture. *Geoheritage* 12 (3),1–10. <https://doi.org/10.1007/s12371-020-00448-5>
- LIMA, J. T. M. and CARVALHO, I. S. 2020b. Políticas de curadoria e preservação em acervos de ciência e tecnologia: uma análise comparativa da gestão de coleções de geologia e paleontologia no Brasil. *Boletim do Centro Português de Geo-História e Pré-História* 2 (1),17–27.
- LIMA, J. T. M. and CARVALHO, I. S. 2020c. Research and educational geological collections in Brazil: the conflict between the field's paradigms of heritage's conservation and geology. *Geoheritage* 12 (72), 1–12. <https://doi.org/10.1007/s12371-020-00497-w>
- LIMA, J. T. M. and CARVALHO, I. S. 2022. A comunicação, a divulgação e a política da valorização nas coleções científicas de paleontologia e geologia em âmbito universitário. *Museologia e Patrimônio* 15, 203-242.
- MEDEIROS, M. A. M. and POLCK, M. A. R. 2017. Geoturismo paleontológico no centro histórico do Rio de Janeiro. *Geociências* 36 (1), 118-137.
- PAGE, K. 2003. The protection of Jurassic sites and fossils: challenges for global Jurassic science (including a proposed statement on the conservation of palaeontological heritage and stratotypes). *Rivista Italiana Paleontol. Strat.* 110, 373–379. <https://doi.org/10.13130/2039-4942/6313>
- PAGE, K. 2018. Fossils, heritage and conservation: managing demands on a precious resource. In E. Reynard J. and Brilha. (eds.), *Geoheritage. Assessment, Protection, and Management*. Netherlands: Elsevier. 107–128 pages. <https://doi.org/10.1016/B978-0-12-809531-7.00006-X>.
- POLCK, M. A. R., DE ARAÚJO-JÚNIOR H. I., MEDEIROS M. A. M. and MONTEIRO, M. A. S. 2018. Caminhando Sobre o Passado no Museu do Amanhã. *Anuário do Instituto de Geociências* 41 (1), 382-400.
- SALLUN FILHO, W. and FAIRCHILD, T. R. 2005. Um passeio pelo passado no shopping: estromatólitos no Brasil. *Ciência Hoje* 37, 22-29.
- SMYTH, R. S. H., MARTILL, D. M., FREY, E., RIVERA, S., HÉCTOR, E. and LENZ, N. 2020. WITHDRAWN: A maned theropod dinosaur from Gondwana with elaborate integumentary structures. *Cretaceous Research*, 104686. <https://doi.org/10.1016/j.cretres.2020.104686>
- SOBRAL 2023. Fósseis são encontrados no piso do jardim sensorial da Sala Verde. <https://www.sobral.ce.gov.br/informes/principais/fosseis-sao-encontrados-no-piso-do-jardim-sensorial-da-sala-verde> Accessed 10/09/2023.
- STORARI, A. P., GODUNKO, R. J., SALLES, F. F., SARAIVA, A. A. F., STANICZEK, A. H. and RODRIGUES, T. 2021. An overview of the Hexagenitidae (Ephemeroptera) from the Crato Formation (Aptian, Lower Cretaceous) of Brazil, with the description of a new species, *Historical Biology* 34 (5), 875-884. <https://doi.org/10.1080/08912963.2021.1952196>.
- TENNANT, J. P., CHIARENZA, A. A. and BARON, M. 2018. How has our knowledge of dinosaur diversity through geologic time changed through research history? *PeerJ*. 6:e4417. <https://doi.org/10.7717/peerj.4417>.
- TERRABRASILIESDIDATICOS 2023. Kit de Invertebrados Fósseis de Marrocos. <https://terrabilisdidaticos.com.br/produto/kit-de-invertebrados-fosseis-de-marrocos/> Accessed 10/09/2023.
- THOMSON, K. 2005. Dinosaurs as a cultural phenomenon. *American Scientist* 93 (3) <https://www.american>

canscientist.org/article/dinosaurs-as-a-cultural-phenomenon. Accessed 10/02/2023.

TREVIÑO, J. 2018. How are dinosaurs named? New species get identified and named every year, even though you've probably never heard of them. *Popular Science*, <https://www.popsci.com/how-are-dinosaurs-named/#:~:text=About%20%2C20%20extinct%20dinosaurs%20have,dinosaurs%20are%20named%20each%20year>. Accessed 10/02/2023.

UN 2023. Convention on biological diversity. <https://www.cbd.int/convention/> Accessed 06/02/2023.

VIANA, M. S. S. and CARVALHO, I. S. 2019. *Patrimônio Paleontológico*. Rio de Janeiro, Brazil: Editora Interciência. 158 pages.

WANG, S. C. and DODSON, P. 2006. Estimating the diversity of dinosaurs. *PNAS* **103** (37), 13601-13605. <https://doi.org/10.1073/pnas.0606028103>