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ORIGINAL ARTICLE

Curatorial Management on Geological and Paleontological Collections in Brazil: Integrative Policies for the Ex Situ Geoheritage

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Abstract

Numerous challenges are associated with scientific collection management including available resources, strategy development, communication, conservation plans, incorporation policies and other issues arising in day-to-day operations. All of these actions are part of ex situ geological and paleontological collections each with their own problems and solutions. This study carries out a comparative investigation of integrative strategies (databases and networks) in Brazilian geology and paleontology collections related to the university environment. A survey submitted to curators from 41 collections at 23 different institutions from Brazil allowed gathering information about their curatorial practices. The collected data used quantitative and qualitative methodologies, drawing parallel to the literature when appropriate. The analysis of these Brazilian collections shows how transdisciplinary innovation transforms museological environments, based on networks and database systems, enabling best practices. Whether through collection networks, systems or databases, interdisciplinary work permeates the entire life of the scientific object and, therefore, is considered a fundamental action in its maintenance and management. It became clear that the national reality, permeated with museological solutions, could easily be interpreted and adapted for similar collections, agreeing on best practices to the preservation of ex situ paleontological and geological heritage.

Keywords Collection management · Geological heritage · Palaeontological heritage · Curatorship

Introduction

This study performed an analysis of the best practices for the preservation of ex situ heritage. This typology of heritage is as important as *in situ* heritage for geoconservation or geological heritage and demands to be studied with the same intensity.

Geological heritage refers to a collection of diverse geodiversity elements, divided into two categories: *in situ* and *ex situ* elements. This concept has been discussed for quite some time (Caetano and Ponciano 2021; Lima 2021; Lima and Carvalho 2022b; Lima and Carvalho 2020a; Lima and Carvalho 2020b; Lima and Carvalho 2020c; Brilha 2018; Brilha 2016; Brilha 2005; Azevedo 2018; Carvalho 2018; Mansur 2018; Brilha and Reynard 2018; Wever and Guiraud 2018; Vilas-Boas et al. 2013; Ponciano et al. 2011; Carcavilla et al. 2007; Jakubowski 2004; Nieto 2002). Therefore, we considered *in situ* elements as part of geodiversity with a high degree of scientific value, as is the example of geosites. *Ex situ* elements also participate in geodiversity; although they are not *in loco*, they maintain their high scientific value when integrated to scientific collections (Caetano and Ponciano 2021; Lima 2021; Lima and Carvalho 2020a, 2020b; Ponciano et al. 2011; Brilha 2016).

A sample from a collection, regardless of its type, is a way of valuing and accepting the object as heritage (Azevedo 2018). When an object is placed in the context of a scientific collection, it is automatically considered protected by the institution guarding it. The preservation of the sample and its

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components is a method of safeguarding scientific history's testimony. This safety highlights the historical and cultural value, as well as its scientific and academic ones (Kunzler et al. 2014).

It is a common practice in academic research to create and maintain collections of various types (Lima and Carvalho 2020b; Almeida 2001; Lima and Sborja 2022). Scientific collections, whether in universities or museums, are closely linked to scientific knowledge production (Lima and Granato 2017; Novaes 2018). They exhibit inherent dynamics, which become apparent in the institutions' continuous pursuit of innovation and creativity. University collections are mostly formed for educational and research purposes (Clercq and Lourenço 2003). Ultimately, we could consider that museums and university collections guarantee research and the production of pure scientific capital. Understanding the contextualisation, and even the didactic emphasis, is crucial to grasp the extent of their devaluation within the university administration and their functionality in scientific research (Ribeiro 2013; Novaes 2018); this can lead to many major problems faced by curators.

The Federal Brazilian Constitution of 1988 provides the protection of the cultural heritage of science, such as the geological and paleontological ones, in article 216 (Brasil 1988; Viana and Carvalho 2019). The mission of geological and paleontological collections, in addition to taxonomic, biostratigraphy, search for mineral resources and evolutionary studies, is to identify gaps in knowledge about life, as well as priority areas for species and cultural conservation. They support educational activities and the delivery of critical social services while also providing a valuable historical record on various aspects of life. Some of these activities would not be possible, or even accessible for *in situ* heritage, thus emphasising the importance of *ex situ* heritage.

Geological collections represent a compilation of geological items with scientific worth and knowledge that are invaluable to comprehending Earth and formation, geology and history (Almeida 2022; Gomes and Freitas 2018; Azevedo 2013). To classify this typology of heritage, there are distinct terms, mining heritage, movable geological heritage and paleontological heritage, always used through a hierarchy where the geological heritage is a larger "umbrella" (Carvalho et al. 2020; ASGMI 2018; Souza and Miranda 2007).

The paleontological heritage can be understood as part of the geological heritage (Wever and Guiraud 2018) and, at other times, it is seen as a separate modality. It has unique characteristics in terms of ownership, conservation, use and legal protection, but these are also the characteristics that bring it closer to geological heritage (Delvene et al. 2018; Castro et al. 2018; Carvalho 2022; Kuhn et al. 2022; Henriques 2022). Complementarily, Law number 9.394, December 20th, 1996, establishes the guidelines and bases of national education. In this context, the role of higher education institutions is reaffirmed along with instruction, research and extension activities, which make up the support tripod of universities, including the promotion and dissemination of cultural, technical and scientific heritage. Universities must facilitate the communication and, at the same time, the preservation of their heritage (Brasil 1996; Santos et al. 2016, 2019; Albani et al. 2020; Lima and Carvalho 2020b, 2022b; Sborja and Lima 2022).

The geological and paleontological collections have great potential in several research fields, but this can only be realised if the information on origin and acquisition is available, emphasising the importance of institutions in safeguarding these assets. They can aid in the comprehension of events such as exploration trips and the complexities of relationships between collectors and specialists (Lima and Granato 2017). Geological collections serve as a record of the history of science, tracing the underlying scientific paradigm and providing material for future comparative study (Wever and Guiraud 2018; Azevedo 2018).

Some terminology stands out when we deal with the management of *ex situ* scientific collections. There is no management without a manager and here we will refer to this professional by their most common title, curator. They are a specialist, responsible for the custody, maintenance, definition of use criteria and selection of materials for the collection and actions aimed at education and research (Carvalho and Fernandes 2004; Veitenheimer-Mendes et al. 2009). Likewise, curatorships are the actions related to them, with the purpose of analysing, conserving, organising and even enriching a collection (Rupp 2011). In collections of rocks, minerals and fossils at universities or similar institutions, the curator is usually an academic who shares their research with this function (Cundiff 2011).

The management of collections is an integral part of the musealisation processes. It encompasses the formulation of policies, strategies, processes and procedures concerning the development, information, access and preservation of collections within a specific institution. These policies establish the purpose of the collections and their specific criteria, practices and processes, as well as the maintenance and preservation details, which are approved by the curator and implemented by the institution (Alves 2019; Augustin and Barbosa 2018; Augustin 2017).

Collection management policies are a comprehensive approach that encompasses a system for the acquisition, recording, conservation, loan and disposal of museum cultural objects. The primary objective of these policies is to preserve and disseminate these objects, ensuring their longevity and accessibility to the public (Lima and Carvalho 2022a). The integrated management of information relating to different collections is a concern that has been gaining ground in recent years, probably, due to the understanding of

the institutions responsible for them as centres of knowledge production (Henriques 2010; Henriques and Pena 2015; Henriques et al. 2011; Serôdio 2018).

Method

The research methodology used in this study was qualitative, which allowed a subjective exploration of the themes while maintaining clarity and depth in the analysis. The corpus of the study consisted of bibliographic research, document analysis and face-to-face interviews with curators responsible for the policies of geology and paleontology collections in universities and related institutions in Brazil.

This paper highlights some of the various data generated during a doctoral research. The findings and results presented are an integral part of a larger doctoral study conducted by Lima in 2021. This comprehensive research endeavour encompasses a wide range of geological investigations, and this paper offers a focused glimpse into the valuable data obtained from the study. The questionnaire (supplementary material) that supported the collected data shows an overview of the research.

Identifying the type of collection management was essential for a reliable data collection and an initial quantitative analysis. The choice of collections was made based on a list created with data collected in 2018, containing all Brazilian geology and paleontology collections that were kept in a university or similar institution,[1] with registration in a virtual environment. Finally, recognising the difficulties in applying the questionnaire at a national level, it was decided to carry out the technical visits within the limitations of time, financial investment of the trip and positive response for participation by the invited curators. A route from north to south of the country was made in order to cover the maximum number of collections in a stipulated period of time, where the interviews were scheduled. By conducting the interviews in person, the study aimed to reduce the potential for information omission and gain a more accurate understanding of the curators' processes.

The study's questionnaire was designed with both quantitative and qualitative components and focused on two main groups: "collection management" and "database." The former aimed to understand the various characters involved in the day-to-day management of the collections, as well as whether the institution had integrated management of the geology and paleontology collections. The latter group aimed to assess the institution's knowledge of its assets, inventorying practices and the use of databases for controlling, inserting and retrieving intrinsic and extrinsic information.

Between August 2018 and November 2019, 41 collections from 23 different institutions (Fig. 1) across Brazil were visited, including both didactic and research collections. The curators responsible for these collections were primarily from public and private universities at the federal or state level, which allowed for a comparison of preservation practices across similar management styles. Notably, the study was not limited to museum collections.

Regarding the representativeness of the interviews, it must be considered that Brazil has 26 states and a Federal District; the portion represented in this analysis comes from the states of Acre, Alagoas, Bahia, Federal District, Minas Gerais, Rio de Janeiro, Rio Grande do South, Rio Grande do Norte, São Paulo, Pará and Pernambuco. This selection, despite not covering all Brazilian states, testifies to the diverse reality present in the parameter collections.

In addition to the geographic distribution of the collections, it was possible to note that these collections represent different degrees of management; that is, the realities experienced cover a spectrum large enough to clearly reach other collections not interviewed. Differences in the amount of investment, number and training of professionals, size of collections, dissemination and valuation of the same are some of the topics worked on here, which allow understanding of the representativeness of the chosen parameter collections.

Data collection was intrinsic to the questionnaire application. More details about question selection and hypotheses are available in the supplementary material. Data analysis followed a systematic approach subdivided by themes addressed in the questionnaire. The questions were based on meticulous research of curatorship and preservation practices in geology and paleontology collections at Brazilian universities and related institutions. Themes were derived from interviews during technical visits, conversations with professionals and analysis of relevant bibliography.

The chosen methodology for data collection involved personal interviews with curators responsible for preservation policies to reduce information omissions common in form-based interviews and gain accurate insights into their processes. Due to COVID-19 restrictions, some interviews were conducted online. Two situations were formed: in-person questionnaire application and online questionnaire filling. In all face-to-face technical visits, meetings with the technical team and collection visits were scheduled. The questionnaire was completed during the visit. When a technical visit was not possible, the questionnaire was provided, and curators added the information, clarifying any

[1] In this article, similar institutions refer to those connected to the university environment. These institutions engage in projects with the university, facilitating the development of collection management actions.

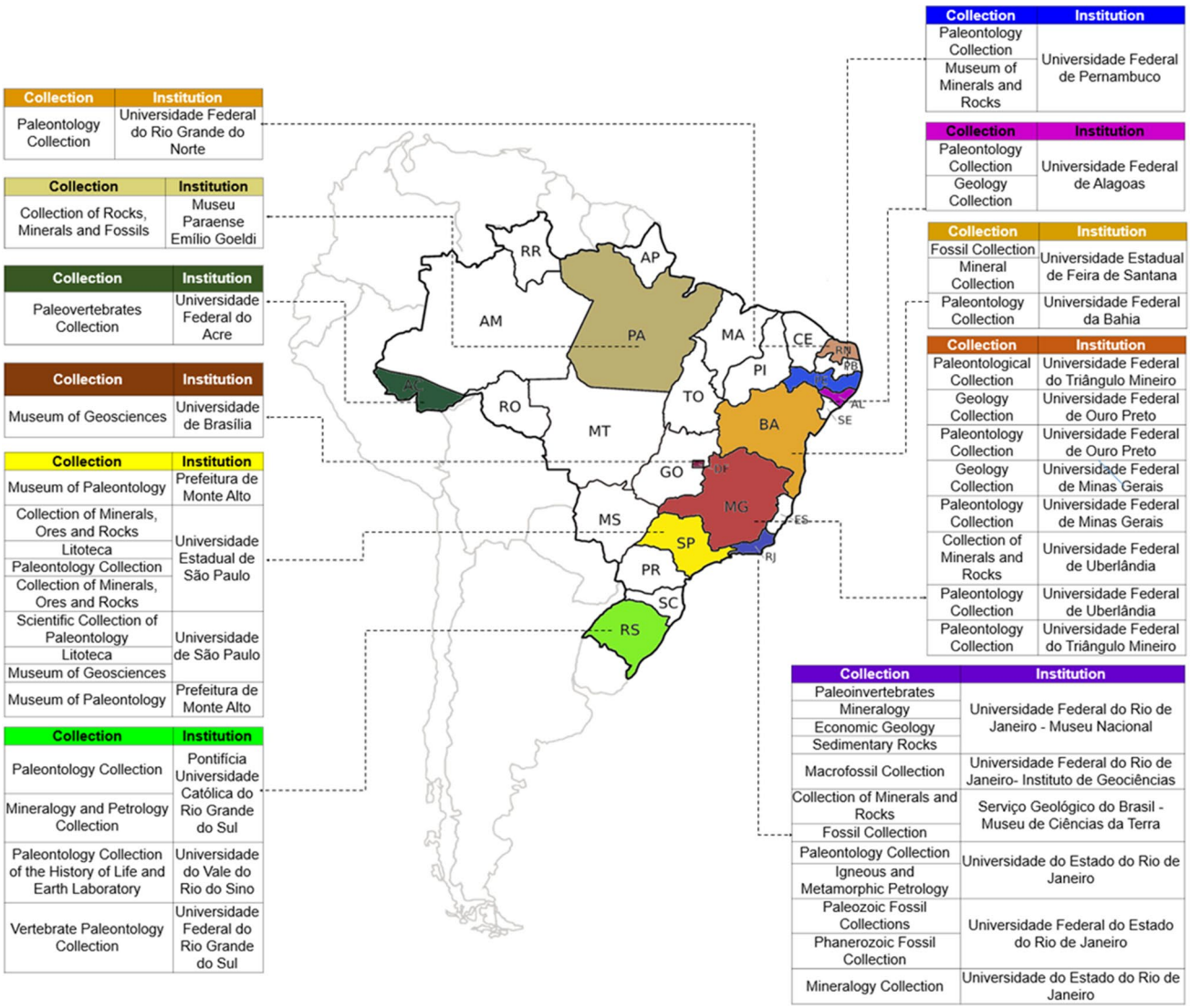

Fig. 1 Chart of the analysed collections from Brazil to evaluate the *ex situ* geoheritage preservation. These are important collections because they are closely linked to the academic production of university institutions

questions through email communication. The collected information was sent back to the curators for validation.

Data treatment took into account the structure prepared in the first phase, where the questions to be asked, the hypotheses related to them and the objective of each question were structured. Within the analysis, it was decided to treat the data considering the blocks of questions. When necessary, the calculations made mainly took into account the mean and median of the collected data. In these cases, the information presented in text form was grouped and accounted for in order to arrive at a representative percentage of the response. When the curator or team did not respond to a specific question, it was removed from the calculation while maintaining a conservative statistic.

Finally, with the data already analysed, it was possible to compare the pre-established hypotheses with the final data. Such information then enabled the conception of the national panorama represented through the collections.

Background

The integrated view of collection management has created a greater focus on their informative potential, contributing to a more efficient management. Several international organisations share this vision, including the United Nations Educational, Scientific and Cultural Organization (UNESCO), the International Council of Museums (ICOM), the International

Committee for Documentation (CIDOC) and the International Council on Monuments and Sites (ICOMOS) (Serôdio 2018).

The integrative work has been applied and perceived in the field of heritage, in Brazil, at different levels. More recently, through Decree n° 10.175, of December 13, 2019, an Inter-Ministerial Working Group on Federal Museums was established. This group is composed of representatives of the Brazilian Institute of Museums (IBRAM); the Civil House; the Ministry of Tourism; the Ministry of Science, Technology, Innovation and Communications; the Ministry of Defense; the Ministry of Education; the Ministry of the Environment; and the Attorney General's Office. Because of a demand at the national level, the Working Group (GT) has the objective of elaborating studies and proposing measures for the museums' management, aiming at improving the organisation, management and preservation. The creation of the GT had as its starting point Judgment n° 1243, of May 29, 2019 (Process n° TC 041.083/2018-0), of the Federal Audit Court. It recommended to IBRAM, after the fire at the National Museum linked to Universidade Federal do Rio de Janeiro (UFRJ) took place in September 2018, the coordination of a working group to identify federal museums subject to the most diverse risks. The recent action proved vital in raising awareness among national collection managers about their responsibilities and the importance of implementing and maintaining an integrated management policy that aligns with the country's daily problems (Brasil 2019a, 2019b, 2019c).

The advantages of multidisciplinary work, as opposed to isolated individual efforts, become evident within this integrated management model. This network organisational approach redefines the concept of citizenship, harnessing its creative and collaborative potential. One such benefit is the institutionalisation of partnership systems through networks (Alves 2012). An integrated collection, building and staff management is likely to be less expensive and more efficient. Furthermore, centralised management models increase the institution's potential by considering it to belong to the entire university rather than just a specific department (Torres 2017).

There are numerous proposals for collection integration, but for geological and paleontological collections, this is uncommon. According to Serôdio (2018), before implementing any methodology, it is necessary to understand the reality of the collections; for this, surveys of existing resources in the area are present. The preliminary diagnosis aims to contribute to reflection and discussion on the significance of management issues in the daily lives of geological and paleontological collections, in Brazil.

Collection management is a unified internal system for the acquisition, documentation, conservation, loan and disposal of musealised assets, aiming at preserving and providing conditions for disseminating those (Augustin and Barbosa 2018).

An interspersed perspective of collection management does not involve suppressing or replacing specific and fundamental methodologies used in different types of collections. Instead, it adopts a hybrid and non-exclusive technical and tool approach. This approach is based on standardising procedures and utilising computerised systems for information description and retrieval, incorporating multiple parameters. In other words, it seeks to integrate different methodologies while maintaining their unique characteristics and utilises modern technology to enhance efficiency and accessibility in managing collections (Monteiro and Bevilacqua 2011).

Integrated management does not require assimilating all actions under a single physical building or location. Workgroups can collaborate virtually, bringing together collections and institutions located in different places, even across states or countries. The primary tool for integrated management is databases, which can coexist in various institutions. These databases facilitate seamless collaboration and information sharing, enabling a unified approach to managing collections despite geographical differences.

In discussing networks, it is essential to distinguish between two key concepts: systems and networks themselves. A system typically features a hierarchical arrangement, where rules are established and enforced from above. On the other hand, a network is characterised by its horizontal structure, fostering less bureaucratic relationships and promoting direct interactions among its elements. This encourages innovative solutions and responses to problems in a more democratic manner. Consequently, in a system, the primary focus is on achieving specific objectives, whereas in a network, the emphasis lies on the active participation of its components (Tolentino 2013; Novaes 2018).

Our focus here is to deal with databases and networks as possible solutions to the problems encountered in collections. Actions in integrated management, such as using Networks, Systems or Databases, often rely on established practices. For instance, conducting an inventory typically precedes the development of a structured database. It is crucial not to overlook these foundational steps and consider the entire process when investing in such solutions.

Integrated management of collections encompasses a range of strategies and procedures adopted by institutions responsible for preservation. Its primary aim is to streamline and enhance workflows and information dissemination (Monteiro and Bevilacqua 2011). By implementing integrated management, institutions can achieve more efficient and effective management of their collections, ultimately leading to improved preservation and accessibility.

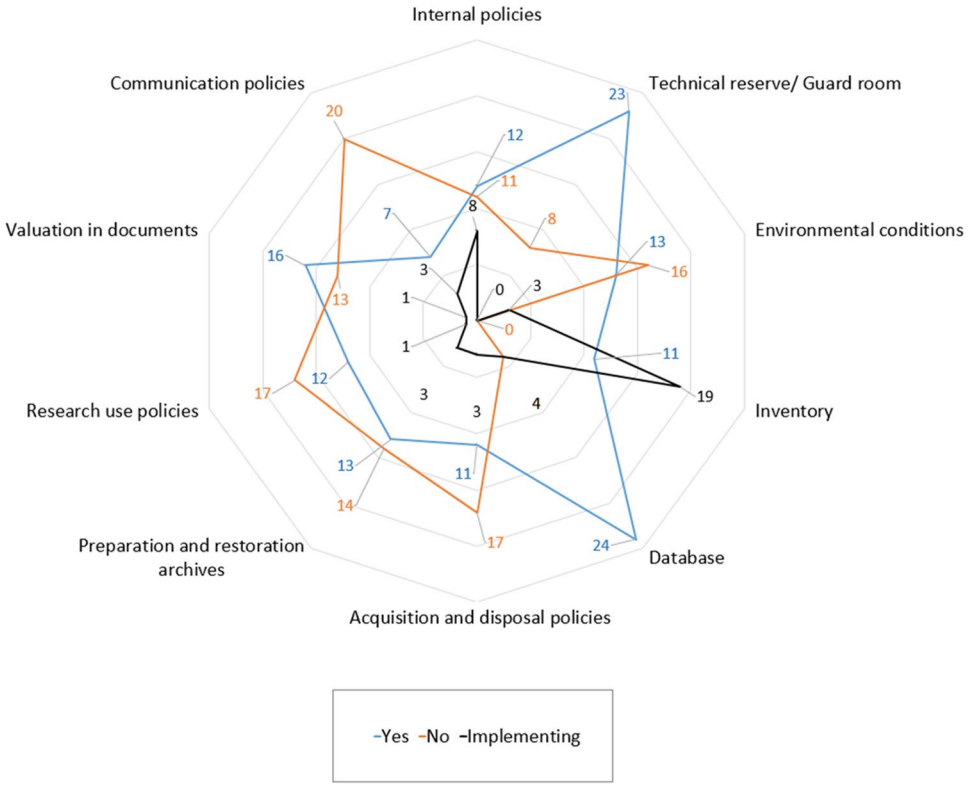

Fig. 2 Graph showing the affirmative and negative answers for the existence of preservation and curation practices at the Brazilian universities

An integrated database for several collections with varying characteristics is a massive undertaking, but it is not impossible. It should allow for the creation of information so that researchers, curators, managers and citizens can understand the available data and thus become acquainted with the object. It must also consider and bring together the various collections' signs and meanings, allowing their managers to communicate in a common language, and finally play an important role in preservation policy (Alves 2012). Connecting collections of different typologies can be a difficult work. The principle of interoperability is critical in a database, with the goal of achieving effective integration between the various platforms. It is a set of mediation mechanisms allowing communication between different systems, whether computerised or not (Martins et al. 2018).

The purpose of this brief analysis of integrated databases was to reflect and add proposals and aspects that may be on the agenda of discussions by many professionals. Improving collection organisation, control and management; expanding communication of information about scientific objects; and developing public policies can facilitate access and help in the preservation of public heritage.

Defining what we mean by a network is essential. According to Novaes (2018), a network comprises integrated, unstructured or restructured elements. In the author's example, a network develops through collaborative activities, where elements come together, new components are added and new connections are formed. Additionally, the reevaluation of existing components allows for reinterpretations and adjustments to certain aspects and members of the network.

In the current Brazilian scenario, the adoption of networking, as a way of enhancing practices for the valuation of university heritage, is a path followed by several researchers. Through cooperation and connectivity networks, it becomes possible to dynamise the aspects of the musealisation process (research, documentation, conservation, communication) of the scientific-cultural heritage. A network is more than the sum of its members; it consists of a synergistic system that enhances its actions. They are already a reality in many institutions.

Studies like this on the *ex situ* heritage are very important because they allow the geoconservation and preservation of the geological heritage, just as it is for the *in situ* heritage. In this context, geological collections, which often operate alone and have several problems already reported here, would benefit from an integrated network in several ways. Networking importance is an essential part of strategic and operational instruments in the process of preserving and promoting university heritage. Its assets, as a whole, should be possible to share, preserve and frequently research. Networks are tools for cooperation and development that can lessen disparities and inequalities and even help restore the institution's standing in society.

Results and Discussion

Based on the questionnaire applied to curators, it was possible to assemble a graph (Fig. 2) indicating how curatorial practices are intertwined.

Figure 2 shows the questions; clockwise, they were (Internal policies) Do you have a Museological Plan or Internal Regulations?; (Guard room/RT) Has RT/Guard room (exclusive to the collection); (Environmental condition) Do the objects have adequate environmental conditions?; (Inventory) Is the collection inventoried?; (Database) Do you have a database?; (Acquisition and disposal policy) Is there a purchase and disposal policy?; (Documentation of preparation and restoration) Are specimen restorations and preparations documented?; (Research use policy) Is there a search use policy?; (Valuation in documents) Are there publications/internal documents that talk about the values attributed to that collection?; and (Communication policies) Is there a policy for disclosing the collections?. The total number of respondents was 41 collections, with the difference between the sums of negatives and under construction attributed to negative responses.

Aiming to quantify the practices, a calculation was made that allowed evaluating, by assigning points, the requirements set out in Fig. 2. The evaluation gave 1 point for affirmatives, no points for negatives and half a point for options that have a partial answer, thus totalling 10 maximum points. The median (is the value that separates the higher half and the lower half of a sample. The median shows a value closer to what an average reference value would be, taking into account all the scores assigned to the collections) of the 41 collections is 4.5 points, showing that, in general, preservation and curation practices are not as present.

Of the seven collections that do not have any bond or heritage professionals, only one is above the median. Demonstrating that the absence of a professional directly affects preservation and curatorship practices. The collections were analysed and divided into two groups "with professionals/link" and "without professionals/link". Values of 4.5 were obtained for the median and approximately 5.04 for the average of the group with the presence of professionals/link and 4.00 for the median and approximately 3.67 for the average of the other group. It was evident that those with the presence of a heritage professional, either directly or indirectly, had more practices that corroborate for a more effective construction of preservation and curatorship policies. It should be noted that the direct or indirect presence of heritage professionals does not guarantee the preservation of the collections; however, this presence tends to generate positive results in terms of the application of methodologies for managing and preserving the assets.

The analysis of the collected data reveals that collections with integrated management practices generally exhibit more robust preservation and curation policies. Interestingly, only ten institutions provided positive responses regarding the existence of integrated management processes. This suggests that there is considerable room for improvement in implementing integrated management approaches across institutions, which could significantly enhance their preservation and curation efforts.

Integrated management is intrinsic to collections and their administration policy. Ideally, collections should have integrated management practices in place to ensure effective preservation, curation and administration of their holdings. However, the survey data revealed that, at the time of the survey, many collections had not fully implemented integrated management approaches. In summary, while integrated management is considered essential for collections, the survey findings indicate that it is not yet widely adopted across the institutions surveyed. The low number of positive responses suggests that there is a need for more efforts to promote and implement integrated management practices in museums and other cultural heritage institutions.

Databases and Network as Possible Solutions

This overview of the curatorial practices of geology and paleontology collections in the university environment, in Brazil, allows us to visualise a variety of actions with the integrative potential. However, we will observe that this potential is still incipient when we deal with the two practices analysed here: the construction of networks and databases.

For an efficient management, with an information system as an integrator of the parts, it is necessary to take into account several factors. Interaction and integration represent the two strongest pillars in the implementation of systems/networks and depend on a series of actions to make them a reality. Implementing a system that includes an inventory and comprehensive documentation, preferably covering the entire collection, represents a significant step forward for collections that currently lack complete inventories. However, the absence of a complete inventory cannot be used as a justification for not planning its implementation. On the contrary, the importance of such a system reinforces the need for careful planning and execution to ensure the efficient management and preservation of cultural assets. Proper planning is essential for overcoming any obstacles or challenges and for effectively integrating the inventory and documentation into the collection management processes.

It is possible to infer from Fig. 2 that collections that share curation systems and practices tend to contribute more

actively to each other. They also can facilitate the exchange and retrieval of information by complementing data from the assets. It is in the recuperation of data that their primary function lies, for example, an object without its provenance, which can rarely be valued as useful for a scientific collection. The absence of heritage professionals and specialised technical labour is a reality in these collections. An integrated management proposal does not have the ability to suppress general needs, including documentation. Instead, it aims to address and fulfill those needs more effectively and comprehensively. Documentation remains a crucial component of integrated management, as it provides the foundation for understanding, preserving and curating collections. The proposal seeks to streamline and improve the documentation process, making it more efficient and integrated within the broader management framework. By doing so, it enhances the collection's accessibility, accountability and long-term preservation.

Among the practices highlighted as part of an effective curation and preservation policy, the presence of a database was one of the most common, with 28 positive responses and 6 still in development. However, the curators did not always present softwares suitable for this task; sometimes what existed was an Excel spreadsheet, with little or no way of efficiently retrieving information.

Several databases were cited in the interviews (Paleo Base; Acervus; Specify; Lund; Tainacan; Pergamo and Omeka), in addition to those made especially for collections/universities. Examples of paleontological and/or geological databases are common. However, there are few existing examples that integrate geological to paleontological collections. In our research, approximately 65.85% of the collections reported having a database, but the majority does not integrate the data at any level.

The majority of databases used by the analysed collections do not integrate their data with others, even within the same institution. From this, it can be inferred that the advantages of integrating collections from the same institution are not perceived as a solution or a positive initiative to be planned and implemented. This situation is likely due to curators having diverse functions and lacking the time, professionals, investment and incentive to pursue integration. Despite the potential benefits, prioritising or mandating this activity for collections is not currently considered a necessity.

When exploring the tools used by the collections, it is worth mentioning three of them due to their characteristics that allow an integrative approach between the collections.

The Geological Survey of Brazil (CPRM) Paleo database is specialised in paleontological assets and is a Brazilian initiative for data integration between different institutions (Ghilardi et al. 2012). The CPRM geosciences system allows access to the most complete and updated collection of data and geological information of the Brazilian territory, integrating several databases including the Paleo base. The integration between geology and paleontology platforms is a highlight of the Geoscience System of the Geological Survey of Brazil (GeoSGB).

The Universidade Federal do Rio Grande do Norte (UFRN) uses the Acervus as a management system for the university's museum, artistic and historical collections, including the paleontological collections of Câmera Cascudo Museum. The information available to the public is minimal; however, they stand out as an effort to disseminate and make data available for different typologies of collections.

A freely available solution regarding a virtual management methodology is the Digital Tainacan repository, used by the Universidade de Brasilia. This tool has the potential for managing and digitally recording multiple collections. It is free, easy-to-use software, contextualised in the needs of Brazilian institutions and flexible for the needs of any type of collection (Gomes and Freitas 2018).

Another aspect to discuss here is the museological cooperation networks. In the proposed framework of the questionnaire (see supplemental material), we asked curators about the presence of collaboration networks in their collections. Initially, the aim was to quantitatively assess the existence of integration, not to make qualitative judgments. After gathering all the data, we conducted a cross-reference with questions seeking qualitative information regarding the efficiency of this management approach. Whenever there was uncertainty, we reached out to curators again for clarification.

Only three of the universities (Universidade Federal do Rio Grande do Norte, Universidade Federal de Pernambuco and Universidade Federal de Ouro Preto) mentioned the role of a network in managing their collections, although still incipient. Our observation revealed that while there were collection systems and networks at universities, they did not always extend to geology and paleontology collections. Nevertheless, recognising their significance for progress in management policies represents a step forward towards a more integrated future. Integrating geology and paleontology collections into these systems and networks can bring about numerous benefits and facilitate better management practices in the field.

The Universidade Federal do Rio Grande do Norte (UFRN) Network of Museums, created in 2014, specifically deals only with museums (according to the current definition of museums in Law n° 11.904/2009). One of the Network's objectives is to promote cooperation between museums, with a view to developing museological, educational and cultural actions, guided by the principle of inseparability of teaching, research and extension, in addition to stimulating, mediating and establishing, in the context of its museological units, partnerships with researchers, institutions, social and/or

cultural organisations and museum, educational and memory cooperation that are interested in social development and democratisation of access to cultural and in academic, scientific, cultural and technological development (UFRN 2014).

The paleontological collection at the Câmara Cascudo Museum benefits from the network as it provides support for educational and museological staff. However, other paleontology and geology collections within the institution, not affiliated with the museum, do not receive the same advantages from the UFRN museum network, primarily because they are not officially recognised as part of it. This lack of recognition can hinder their integration and access to the resources and support provided by the network.

A network of collections (and museums) can provide a discussion space for dialogue between professionals from different collections within a common environment. In addition to defining common procedures, adopting controlled nomenclatures to classify collections and establishing the exchange of information and collections, the network can be used to build common agendas for action, such as promoting an inventory of the heritage in each collection and how it can be used by the community (Serres 2012).

The Universidade Federal de Pernambuco (UFPE) Network of Museums, Visitable Scientific Collections and Art Galleries has several museums and collections associated with them. It aims at contributing to the maintenance, protection, support, security and provision of adequate technical conditions for the functioning and preservation of museums, visitable collections and art galleries of the University.

Both UFPE collections (Paleontology Collection and Museum of Minerals and Rocks) analysed here are participants of the reported network. Among the benefits is the communication of collections on the network's website, increasing their reach to researchers and visitors. The recognition by the university's management was also perceived through the establishment of public notices for funding, partially motivated by the network's work in the dissemination of the needs of collections and museums. The benefits for the *ex situ* collection in this case are clear, as they involve the possibility of meeting an existing financial demand in all analysed collections.

Centres or collections of a museological, documentary and memoir nature form the Universidade Federal de Ouro (UFOP) Preto Museum Collections Network. It aims to subsidise the development of a preservationist and dissemination policy for UFOP's museological collections. At the time of the interviews, UFOP was still in the process of creating a network of museums and collections. Today, the network presents in its virtual space the possibility of publicising events related to collections and the centralisation of appointments for research and visits. Despite being initial, this step is essential for the preservation of *ex situ* collections, as the valuation of collections is only possible with the recognition of the societies that are reflected in it.

Of particular note is the System of Museums, Collections and Cultural Heritage (Simap) of the Universidade Federal do Rio de Janeiro (UFRJ). Among the objectives of this system are key questions for the preservation, documentation, enrichment and communication of the institution's collections, as well as the implementation of policies and actions that are part of the scientific and artistic collections, museums and science spaces at UFRJ. The objectives of SIMAP also include the promotion, on its own initiative or in collaboration with governmental and non-governmental bodies engaged in education and cultural, artistic and scientific communication, policies, plans, programs and projects aimed at student access to our museums and science spaces, showing that integration goes beyond the conversation between collections and starts with a positioning of integration at inter-institutional levels (Lima et al. 2022).

Conclusion

Objects collected with the intention of integrating a collection undergo resignifications that can impact their preservation effectiveness. However, we should not disregard the significance of *ex situ* geological and paleontological heritage in safeguarding these elements on multiple levels. For instance, assets originating from outcrops may face threats like increased exploitation, urban expansion, weathering and erosion, which would hinder their value and study if they remained *in situ*. Moving them to a controlled environment within a collection ensures their protection and enables valuable research opportunities that might not have been possible otherwise.

University scientific collections contain rare specimens, and the methodology to preserve and disseminate them is inherent in their existence, allowing access to information that would otherwise be unavailable to other researchers. It is within this environment that scientific knowledge can be expanded, with the introduction of new analyses of the materials that comprise these collections, with the goal of improving the field of knowledge and strengthening the social and scientific functions of the collections. *Ex situ* collections are thus unparalleled in terms of geological and paleontological heritage.

The collections presented here constitute the *ex situ* geological and paleontological heritage. As musealised objects are removed from their original contexts, they present some valuation problems, such as the contextualisation of extrinsic information and its faithful maintenance. The databases presented here as part of the solution of integrative policies act directly on this problem. We cannot rule out that the

existence of these collections is a way of preserving this heritage. For those objects whose disconnection from their original context weakens their inherent meanings during the musealisation process, the integration of scenic elements and new technologies provides a means of revitalising their significant power, albeit partially. These enhancements offer opportunities to reconnect the objects with their historical and cultural context, enriching the visitor's experience and understanding of their significance.

The evaluation of university collection emphasises the collaborative work by institutions that preserve geological and paleontological heritage. Universities, in Brazil, generally have a very similar methodology for managing and preserving their heritage. However, there is no document at such a comprehensive level dealing with the standardisation of curation procedures for them. What there is, in addition to common sense, are individualised policies, not always written, that curators conduct through their experiences and vaguely disseminated knowledge from other institutions.

In this study, we have achieved a reflection and discussion of various aspects of curatorship present in geology and paleontology at university and related collections in Brazil. Managers can rely on these results, as an analysis of the tools and actions used effectively for the preservation and valorisation, thus enabling the communication of good practices especially in the integrative policies theme.

The survey of these institutions and the subsequent application of the questionnaire proved to be fundamental for the intended comparative methodology. Such comparisons made the positive practices evident, and allowed the visualisation of a methodology applicable to collections that share the same type of management and typology. It was in the integrated systems through networks or databases that the potential for synergy between curatorial and preservation practices stood out.

We propose a comprehensive analysis of preservation practices, guided by the critical perspective prevalent in the heritage field's paradigms. While it is evident that curatorship and preservation policies are crucial for the diverse benefits they bring to a collection, it is equally important to take into account the factors that may lead to the irreversible loss of this heritage.

The reality demonstrated here through the collections emphasises the integrated work within the institutions that safeguard the geological and paleontological heritage. Whether through networks, systems or databases, the interdisciplinary work permeates the entire history of the asset and, therefore, is considered a fundamental action in its maintenance and management.

The geological and paleontological heritage is extremely vulnerable and threatened. The main concern about it is a lack of understanding about its existence and significance. This vulnerability highlights the significance of each scientific collection and confirms the need for its existence. It is critical to establish public awareness and valuation policies with the goal of preserving and serving as a national heritage, such as the ones analysed here.

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Declarations

Competing Interests None.

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