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REVIEW ARTICLE

Geological or Cultural Heritage? The Ex Situ Scientific Collections as a Remnant of Nature and Culture

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Abstract
Scientific heritage, here analysed in its subdivisions of geological and palaeontological heritage, is recognized by its embedded values in scientific collections. More specifically, ex situ scientific collections are remnants of nature and, as such, are sometimes considered geological heritage or elements of cultural heritage, depending on the perception of the researchers on geological heritage. They are a powerful resource for education, promoting creativity and social coherence. In a collection, the concepts of preservation and valuation are interwoven and mutually beneficial in relation to themselves. For an object to be considered as heritage, it is necessary to recognize value on it. If only one person recognizes it as such, it is not enough, since heritage is necessarily a collective concept. The act of being preserved is not the same as having its values recognized by the fields of geology and palaeontology. Different values can be attributed to heritage, such as economic, political, cultural, scientific, spiritual and aesthetic. It is the same in ex situ scientific collections. Geological materials are usually linked to ideas and concepts of nature, but this does not prevent them from receiving two or more values at the same time. This analysis proposes a better understanding on the dynamics of the preservation between in situ and ex situ items, as far as its recognition as heritage and its valuation in the geological field. Our purpose here is to thread through the definitions of cultural, geological and palaeontological heritage, to find an understanding of an integrated heritage, especially in ex situ collections.

Keywords Geological heritage · Palaeontological heritage · Ex situ preservation · Collections

Introduction

The cultural heritage of science and technology is more diverse, more complex and multi-layered and as such is more difficult to define than industrial heritage or natural heritage. This type of heritage is the collective legacy of the society, the identity they intend to preserve, shared by the scientific community. It includes material and immaterial knowledge about life, nature and the universe. Some examples are artefacts, specimens, laboratories, observatories, landscapes, gardens, collections, research, documents and books. This definition includes a variety of sites and objects, which show an integrated perspective of what authors from the field consider to be scientific heritage (Lourenço and Wilson 2013).

One is used to understand the scientific heritage as part of archaeology, geology and palaeontology collections, not infrequently mixed together under one's curation. Within this idea, the cultural heritage collections of science and technology can be considered tangible and intangible legacy. They are related to the scientific and technological knowledge produced by humanity in all areas of knowledge. They refer to the memory and action of professionals in spaces of production of scientific knowledge, scientific dynamics, technological development and teaching. The geological and palaeontological collections are testimonies of the scientific process, so it is evident that it is also part of this heritage (Araújo et al. 2017).

In this paper, we will focus on issues related to the fields of palaeontology and geology. They are complex fields whose objects of study are intertwined at various levels. It is common among these academic fields to build and maintain collections of various types. Within the universe of collections'

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preservation, the universities, in general, have greatly contributed to the construction of cultural heritage. This practice is guided by many reasons, among them the considerable quantity of samples from field work, one of the most common ways of acquisition of the rocks, minerals or fossils.

Collections are, in general, a gathering of items which preserve their individuality and are organized in an intentional way, according to a specific logic. The collection process starts from the selection of its components by signification (meaning), directly linked to its valuation. As culture is a developing set of processes and values, always changing; so therefore, the conservation of cultural heritage must follow this flow. To better understand the collections and its preservation, it is necessary to understand how the values are attributed and to determine how the process of analysis and construction of cultural meanings happens.

Collection can be considered any set of natural or artificial objects, held temporarily or permanently out of the circuit of economic activities, subjected to special protection in an enclosed space prepared for this purpose, and exposed, totally or partially to the public eye. The concepts of preservation, exhibition and collection are intertwined; so to be considered a cultural good belonging to a collection, the object must have a 'special protection' and be exposed to the public (Pomian 1985). Although museum collections are usually linked to the communication process of exhibition, scientific research collections tend not to exhibit their items to the public eye. They are more commonly only visited by researchers and students, also characterizing the process of communication.

Collections are representations of memory, and they carry values assigned by their collectors, this being just an individual or a social group. When the collector withdraws from an object its value of use and associates it with a symbolic value, this institutes a character of exceptionality to this object. Collections contain intrinsic values assigned by those who assembled them. So the collector is always an interlocutor between the society and the strive for the preservation of memory (Ribeiro 2010). Geology and palaeontology collections are no exception.

Collections of scientific heritage attest to diversity and the world's history as a direct result of the scientific evidence. They are a powerful resource for education, promoting creativity and social coherence. To lucubrate about collections and their processes is not something new; however, only a few collections are deeply studied concerning their management and preservation. The increase in research, within the scope of scientific collections, has enabled a greater visibility of the problems and solutions of their preservation.

The assemblage of objects and the formation of collections occur due to the intentions of an individual or a group that attributes meanings to them thus constructing a narrative. These items now bear witness to an event, set as a document (Silva 2014). In a specific approach, inserting palaeontological objects into scientific collections allows their recognition as heritage of national science. The act of being in a collection is in itself a way of valuing and accepting the object as heritage, regardless of the type of collection. It is noticed that the collections are intrinsically linked to the values and thus in consequence to heritage (Kunzler et al. 2014).

The life cycle of the collection analysed here involves activities such as collection or acquisition, incorporation, study of the specimen, dissemination and other actions. This movement of the cultural good is understood as being vital for maintaining the values associated with it. Collections that are not exhibited or studied lose their scientific, cultural and leisure value (Barbosa 2000). The values attributed to geological collections often come from the curators who collected them and from other professionals who work with them. They reflect not only the reality of a professional but often the reality of an entire field or discipline. Each sample carries in itself intrinsic information of the field practices and the curating which permeates it.

Geological scientific collections range from meteorites to fossils, of various sizes and represent different geological times. The use of these objects is conditioned not only to their intrinsic interest but also as a source of specific chemical or physical materials or as indicators of extrinsic processes and parameters (Wever and Guiraud 2018). The life of an object linked to scientific and technological production sites (laboratories, research institutes, universities and similar institutions) consists of their creation or acquisition, use and disposal, all of it away from the general public. These entities do not have the routine of associating with institutions of preservation and memory (Granato et al. 2018). Therefore, preservation practices, as valuation of the cultural goods, are not current in scientific institutions, as they are in museological institutions.

The scientific collections, whether in universities or in museums, are constantly built in association with the production of scientific knowledge (Lima and Granato 2017). University collections stand out from others in their intrinsic dynamicity present in the constant search for innovation and creativity in the scope of the institution. The university is an instrument for the preservation and dissemination of knowledge (De Clercq and Lourenço 2003). Scientific collections result from research, but also form the basis for further research. Collections of scientific instruments synthesize the historical aspect of use and utility of scientific collections. The collections of geology and palaeontology are inseparable from the scientific practices that helped to form them and vice versa (Wever and Guiraud 2018).

An object, when inserted in the context of a scientific collection, is automatically considered to be guarded by its guardian (curator). The preservation of the item and the components added to it is a way of protecting the testimony of the scientific history. This protection results in highlighting the historical

value of this cultural good associated with its scientific and academic value (Kunzler et al. 2014).

Brief History of Scientific Collections

To better comprehend scientific collections, it is necessary to understand its origins. Collecting is a habit present in all cultures that dates as far back as the very existence of human beings. This practice was soon incorporated into modern cultures around the world.

The guided uses of collections throughout history are perceived differently by distinctive people, according to their temporality. For example, the offerings in the temples of antiquity turned to the gaze of the gods; the spoils of wars in triumphal processions were directed to the gaze of the jubilant people as dominion over the enemy; the relics and treasures in churches and monasteries were directed to the eyes of the multitude of devout pilgrims; and, the microcosmic curiosities in private rooms were directed to the gaze of distinguished and select individuals (Uzeda 2018).

It is easy to associate collections to museums, mostly because of its interception through history, although they existed well before the advent of museums. There are records of groupings of objects intended to assist in teaching, dating back at least 2000 BC, with even older archives (Lourenço 2003). One of the most important vestiges of an institution with similar characteristics to the current conception of museums dates back to the third century BC. It was a place devoted to erudition and research, in Alexandria, which had meeting rooms, laboratories, observatories, botanical gardens, zoos and the famous library. This place came to be known as *Mouseion* or House of the Muses (Veitenheimer-Mendes et al. 2009). Even at this time, it was already possible to notice some strong traces of collections and their connection to places soon to be institutions of science.

The relation of the first scientific collection in a university environment can be comprehended through its origin. Before the founding of the universities, there was already the cultivation of medicinal plants in cloisters of monasteries and Arab schools with the intention of teaching. The first botanical gardens, in the middle of the sixteenth century at the universities of Padua and Pisa, not only served the purpose of teaching but also included fossils in their collections. Simultaneously, in 1594, the anatomical theatres in the universities of Padua and at Leyden were created, which contained anatomical specimens, wax models, zoological material, fossils and curiosities (De Clercq and Lourenço 2003). It becomes clear that the history of scientific collections is intrinsic to the history of the universities and higher education, and thus cannot be easily dissociated from one another. The associations are not limited to the origin of collections; there are other important periods.

The tradition of possession and collection of unusual, ancient and interesting objects by political and religious figures happened throughout history for various reasons, including those linked to the great discoveries and technological advances. The emergence of scientific thinking from humanism in the Renaissance is directly related to the search for rationality (Vieira et al. 2007). Europe between the sixteenth and seventeenth centuries was marked by the great exploratory voyages to the East, Africa and the Americas. Those who returned successfully allowed their noble patrons to own several objects of different natures (Azevedo 2013). The Era of Navigations contributed to the construction, multiplication and maintenance of Cabinets of Curiosities. These offices served the aristocracy as a way of demonstrating, understanding and possessing knowledge (Caple 2000; Suano 1986). These were also known as Chamber of Wonders or Curiosities Hall. In these, the objects were exhibited in two categories, *naturalia* and *artificialia*. Among them were a variety of objects, such as exotic plants and animals, embryonic deformities (fetuses of poorly developed animals), ceramics, scrolls, ritualistic vestments, fossils and shells, as well as unusual rocks or minerals (Gomes 2010; Silva 2014). The more exotic it was, the more representative of the unknown world. They were assembled as private exhibitions in salons and noble residences, enabling the first mineralogical collections (Azevedo 2013).

With the advance of the seventeenth century, the Cabinets of Curiosities were being replaced by the Encyclopedic Museums (with exhibitions organized using the rational thinking). Gradually, the rationalization, control and exploitation of natural resources would transform the way man sees the world, reflecting this in the organization and display of the museological spaces (Silva 2014). The private collections became public in the eighteenth century, making the first museums for the purpose of instructing and providing leisure. During this period, it became generally popular for collections to be organized and presented in a rational way, contrasting the unclassified layout of the Cabinets of Curiosities (Veitenheimer-Mendes et al. 2009; Caple 2000).

It is noteworthy that the first modern museum created, the Ashmolean Museum (Oxford, England), within the Oxford University, opened to the public in 1683 (Vieira et al. 2007; Lourenço 2003; Silva 2014). The creation of this museum was related to the principle of public access to collections, turning them toward the teaching and diffusion of knowledge (Vieira et al. 2007). The space included a natural history school, a chemistry laboratory and an exhibition hall. This model of museum was followed by several successive university museums (Lourenço 2003). The rational organization of collections, mainly biological, was marked by the strong influence of the classification works of the Natural Sciences, such as *Species Plactarum* (1753) and *Systema Naturae* (1758) written by *Carolus Linnaeus*; and the Encyclopaedia of Sciences, Arts and Crafts (1751 to 1772), idealized by Diderot (Veitenheimer-Mendes et al.; Silva 2014).

The first museums recognized as scientific were expressions of pride of the nations that possessed them, emphasizing and giving visibility to their technological evolution and the natural order of scientific and social things. The main purpose of these institutions was to impress and inspire the visitor through the exhibition of the object, contributing to the museum's vision as a place of knowledge (Gregory and Miler 1998).

The French Revolution in 1789 directly influenced the creation of the Louvre Museum, as a place of public access, in 1793. It concentrated scientific and artistic collections from the monarchs, to encourage educational and cultural activities. This milestone is a reference for the emergence of national museums and the state's responsibility for the preservation and diffusion of national cultural goods (Silva 2014).

Charles Darwin's Origin of the Species, in the nineteenth century, gave a new perspective, giving biological evolution the primordial role in the way the scientific collections were organized and displayed (Veitenheimer-Mendes et al. 2009). However, it is necessary to highlight that the influence of Charles Darwin on museums at that period was not totally accepted by all institutions; some of them were strongly anti-Darwin at this time. Over time, Darwin's ideas were increasingly permeating the organizations of the collections.

In the late nineteenth and early twentieth centuries, other events contributed to the growth of geological collections, such as the significance given to research and empirically proven results, emphasizing that this movement contributed to the recognition of the museums as a place within the universities where theory came into practice (Azevedo 2013).

In the twentieth century, several scientific laboratories appeared in museums with the objective of studying and researching the assets of the collections (Veitenheimer-Mendes et al. 2009). This practice occurs to the present day. The implantation of scientific methods and their techniques for the development of areas of knowledge is strictly linked to the consolidation of the natural sciences (Pinto 2009). Knowing broadly of the history of scientific collections, one can enter the defining points about the preservation of geological objects.

In Situ and Ex Situ Preservation

Within geological practices, choosing whether or not the material should remain in situ is fundamental for the establishment of the preservation. In situ preservation is not always an effective method of preserving palaeontological heritage. The interference of nature and human action on the object can lead to destruction in loco and in certain cases to the complete loss of large fossiliferous deposits (Carvalho 2018).

In the context of this paper, the ex situ preservation is what will be mostly analysed. Some types of fossils should be kept in situ; an example is dinosaurs' footprints. Ex situ preservation occurs through the withdrawal of the fossil from its geological context toward a new reality, usually scientific collections and museum exhibitions, modifying its reality (Carvalho 2018). Despite the unavoidable loss of information by moving the item from in situ to the ex situ, what happens is that other meanings are attributed to it, compensating for this type of preservation (Loureiro 2012). It is worth noting that heritage as a process of preservation adds and does not exclude values.

Both in situ and ex situ preservation have their particularities, and in both cases, there are pros and cons. While with in situ preservation, it is possible to work contextualization in an immersed way, the ex situ preservation tends to prolong the existence of the object. Both should be considered complementary in order to highlight the potential of assets in all spheres, from the academic field to the public interest (Renaud 2002; Loureiro 2012; Carvalho 2018).

Several authors (Ponciano et al. 2011; Souza and Miranda 2007; Mansur et al. 2013) claim that the geological objects in scientific collections are protected against degradation, which in its in situ environment, it would not be. Withdrawing an object and guarding it in a palaeontological collection can be justified as a method of preservation, to protect it from the following cases: from exposure to natural weathering, to anthropogenic predation, illegal collection for non-scientific purposes, increased demand for geological resources, tourism and military activities, the implementation of major projects and structures, watershed management, deforestation, agriculture and intensive farming (Ponciano et al. 2011; Kunzler et al. 2014).

In situ preservation enhances sustainable development on the ground through geotourism and heritage educational projects (Mansur et al. 2013). In counterpoint to the loss of information in the ex situ, there are data that only can be acquired in in situ fossils, for example, the sedimentological and ecological context and also the mutual co-occurrence of taxa. It is not imperative to remove the object from the site and there are options for both cases. It can be inferred from a certain perspective traced through the definitions presented that a geological or palaeontological object can partially represent their respective heritages. From here on, we are only going to analyse the ex situ objects, extracted from nature and now belonging to a scientific reality.

Musealisation and the Ex Situ Preservation

Musealising an object is one of the oldest forms of preservation. This valuation process stems from the selection of a cultural good and recognition of its values, so it can be preserved in an institution, usually a museum or a collection. In this perspective, for an object to be considered musealised, it must be withdrawn from its original context and transferred to

another reality with the function of documenting the reality from which it was removed. For this, the object must be collected, classified, preserved and documented, becoming a research source or element of an exhibition (Mensch 1992).

This is exactly the practice through which the assets of the scientific collections pass through. Ex situ objects taken from their original context (musealised) can be studied as representative elements of the reality from which they were a part of, as heritages. Musealisation is the characterization process of the material and immaterial cultural experiences of humanity, where its cultural appropriation must end with its institutionalization. The process is defined through the elements which implement it. In this way, the heritage valuated will always have cultural values (Araújo and Granato 2017). Musealisation can also mean the selection and valuation of objects under the museological gaze, the very processes of preservation to which they are subjected, responsible for the attribution of values in detriment of the elements that were not selected (Cury 1999). In order to take advantage of the concepts and definitions presented, when any author refers to a museological institution or space, it will be possible to make a parallel with the scientific collections.

Cultural goods in museological collections as well as the objects preserved in laboratories find their common denominator in the practices of conservation, documentation and communication, to which they are submitted. The process of musealisation is not totally free of problems. The withdrawal of the objects from their original context, even if it is aimed at a special protection, leads to a potential loss of information, insofar as it decontextualizes the object of past environments (Araújo and Granato 2017). This concept is similar to Carvalho's (2018) perception about the ex situ preservation, since its objectives are mostly the same. So if one perceives musealisation as a process of preserving them, it is imperative to rethink the criteria that allow the loss of information in order to minimize them.

To answer if a scientific object of geological or palaeontological nature is a natural or cultural heritage, it is necessary to deepen these concepts. It is not possible to go further in this analysis without understanding the process of heritage valuation.

Valuation and Heritage

Before we enter into the questionings of the geological and natural heritage, one has to understand what is heritage. It is fundamental to analyse the objects that make up the scientific collections in order to understand why they are valuated as cultural or natural heritage. In this article, cultural goods should be understood as the product and testimony of the different traditions and intellectual achievements of the past, being the essential elements of the culture characterization. The importance of these objects, reflected in their definition, makes them immediately susceptible for preservation. So, it is understood that these objects considered cultural goods undergo a process of valuation, where the result is their recognition by society as heritage (Granato et al. 2005).

Preservation goes beyond the materiality of the cultural good; it comprises of not only the material dimension but also especially the intangibles aspects. The stories applied to objects, constructions and landscapes, by individuals and groups, constitute the currency in which the valuation of cultural heritage is negotiated (Avrami et al. 2000). The concept of heritage stands out in the valuation process. The word "heritage" is among the ones we use most frequently in daily life, either in the economic sense, real estate, family, cultural, architectural or artistic. There seems to be no limit to the process of qualification of that word (Gonçalves 2005).

The acts of preservation in geological collections with scientific, pedagogical, cultural or touristic values contribute to the understanding of the dialectic between the history of the Earth and anthropic occupation. Valuation is a process in which many geoscientists believe can be done by any professional in their field. However, due to its interdisciplinary character, this process should be attributed to an interdisciplinary professional, or even, as is more common, to several professionals (Pereira et al. 2016).

The multiplicity of heritages is explained in the last decades by the increase in academic dialogues in areas such as sociology, anthropology, linguistics and history, allowing discussions on processes of elaboration, negotiation and historical imposition of intersections and narratives leading to specific cuts of heritage categories, fruits of historical constructions in constant transformation (Gonçalves 2005, 2009; Junior and Araújo 2017; Lira 2012). The concept of heritage is intrinsic to societal habits of a certain time. Many are the everyday objects with the potential to become heritage; however, only some of these are identified, collected, documented and preserved. An object alone or a set of them can be interpreted in many ways. The space and the composition of the collections directly influence the way in which the object is analysed and the values identified in it.

By withdrawing the utilitarian value of an object and adding a symbolic value, the curator or collector confers it a singular character. The symbolic value attributed can be extended by categorizations or similarities to other objects (Ribeiro 2010). The objects of collections are deprived of utility and consequently of their use value. They acquire in the collections, the exchange value, which can also be seen as the market of buying and selling these cultural goods. This exchange value depends on the various meanings assigned to collection objects (Pomian 1985).

Once the object is considered part of a collection, the first step to its valuation has already been taken. But what are the reasons why an object is added to a collection? According to the Scottish Natural Heritage (2008), museological institutions usually acquire new cultural goods: to expose them,

when they aesthetically represent a situation appropriately; to complete a collection, due to its representativeness; to study or research, for its rare or exemplary characteristics; for its historical importance, usually linked to an expedition led by a recognized professional in the area; for didactic use, in practical demonstrations of the fields concepts; or for exchange among institutions.

The concepts of preservation and valuation are interwoven and mutually beneficial to themselves. The fact of being preserved does not always imply that the values recognized in them are those accepted by the fields of geology and palaeontology. Generally, for an object to be considered heritage, it is necessary to recognize value on it. If only one person recognizes it as such, it is not enough since heritage conceived here necessitates a collective stance.

Different values can be attributed to the heritage, such as economic, political, cultural, scientific, spiritual and aesthetic. In some cases, these values may refer to one or more ethical, cultural and epistemological ideas. The valuation process can be understood through several spheres of preservation, being presented in various ways, highlighting its fundamental role in decision-making. Actions in the preservation field, such as the inventorying, valuation and valorisation of this type of heritage, has been gaining support in the field of geosciences (Pereira et al. 2016).

Geological materials in collections are unique resources and must be respected by values that go beyond the scientific or the aesthetic; these objects are essential in the understanding of the world. There are five broad categories of values for this typology of items: (1) research applied to science, including building collections; (2) the cultural, relating the object to society; (3) the financial, established by its rarity and beauty; (4) the educational, used in universities and schools; and (5) the entertainment, also linked to the aesthetic value and appreciation of the object (Stanley 2004). None of these values exclude the other.

Geodiversity values are distinguished by their classification as intrinsic, cultural, aesthetic, economic, functional, scientific and educational. Irrespective of all the differences found in the various concepts of geological values, some values such as scientific, educational, touristic and cultural values are common to all (Nascimento et al. 2008). The process of valorization in geodiverse objects has already been discussed by several authors (Gray 2004; Brilha 2005, 2015; Nascimento et al. 2008), and therefore, it will not be deepened in this work.

Geological items can display different contents, reflecting diverse values which are not limited to scientific use only (Haag and Henriques 2016). All these values can and should be considered together, always adding to the object more information to demonstrate the importance of it being preserved. It can be perceived as a dilemma, of valuing scientific objects, by those who deal with them daily. This is justified by the difficulty of recognizing the heritage importance of daily objects; in other words, they can be produced again and repaired, thus allowing the possibility of substitution, taking from the object the possibility to be immediately considered heritage (Castro and Lima 2017).

It is the valuation of the cultural good that allows the recognition of it as heritage, leading to its preservation. There are several types of heritages; in this paper, the scientific ex situ collections, containing characteristics of the geological and palaeontological heritage, will be analysed through the definitions of cultural heritage and geological heritage.

Cultural and Natural Heritage

In a general view, cultural and natural heritages for a long time were seen as two distinct concepts that excluded one another. Nature was usually linked to the biotic concept of life and Earth, while culture was linked to human interactions. The introduction of the abiotic (geological) information is relatively new.

The definition of heritage is broad and its multifaceted character should be emphasized. Cultural heritage is rich in policies, norms and regulations. However, most of the literature that defines it is not academic but institutional or from regulatory agencies such as the United Nations Educational, Scientific and Cultural Organization (UNESCO) and national governments (Lourenço and Wilson 2013).

UNESCO (2019) divides the world heritage into two: cultural heritage and natural heritage. The former is composed of monuments, groups of buildings or sites that have an exceptional and universal historical, aesthetic, archaeological, scientific, ethnological or anthropological value. The latter includes exceptional physical, biological and geological formations, habitats of endangered animal and plant species, and areas of exceptional scientific and conservation value or exceptional aesthetics. In addition to this binary division, UNESCO still subdivides cultural heritage into material and immaterial.

The two typologies cited above function as an initial direction for an even more specific classification. Rather than treating this UNESCO proposal as a dichotomy, we must bear in mind that the classification of heritage is strictly connected with their valuation, so these values can be added and not excluded. Along history, it is not uncommon to observe along culture being regarded as the opposite of natural. In this perspective, natural was all that was not man-made, making it easy to classify geological objects (Mansur 2018). In other words, ex situ collections are a cutout of nature, so they can be valued as natural heritage.

There are other things to be considered: when the expedition or the field work is planned, a human component is integrated into it, giving a cultural and scientific value to them; also, this action is by itself a testimony of the scientific

practices of its time. Some examples of cultural heritage with polysemic character such as documents, knowledge, practices and cultural expressions can be defined as comprehensive and fragmented, allowing the wide perception of elements considered significant for society (Junior and Araújo 2017).

The concept of cultural heritage is usually associated with memory (as in the representation of something); in this context, preservation occurs due to the function of the senses that the objects awaken and the bonds that it maintain with cultural identities. The concept of cultural heritage tends to contemplate the most diverse forms of expression of the cultural goods of mankind. Traditionally, this concept continues being presented in a fragmented way, associated with the different areas of scientific knowledge (Pelegrini 2006). One example analysed here is the cultural heritage of science and technology, explained before.

On the other hand, natural heritage generally depends on balancing high-quality scientific research, disseminating knowledge to the general public and implementing effective legislative measures (Cachão and Silva 2004). In other words, cultural heritage is understood as being more subjective than natural heritage. All in all, with these definitions, a scientific, ex situ object that previously belonged to a collection and was seen as an element removed from nature and therefore a cultural heritage, can be considered natural and cultural heritage at the same time, without detriment of its representations.

Geological collections are notoriously recognized for their scientific, pedagogical, cultural and touristic values. It is undeniable that cultural goods composed of them can and should be part of both cultural and natural heritage. Its representativeness in the cultural heritage is major in the contribution to the understanding of the dialectic between the Earth's history and the anthropic occupation, while its representativeness in the natural heritage occurs through the intrinsic characteristics of its assets and the scientific and pedagogical values. The ex situ scientific collection can then be valued as a cultural heritage, as far as the product of the geological and academic production is concerned. These collections are also witnesses to the advancement of this community.

Geological and Palaeontological Heritage

The academic environment has in the last 10 years considerably increased the research, publication and dissemination of topics such as geoconservation, geological heritage, among others (Brilha and Reynard 2018). Although there is an increase in discussions, it is evident that the evolution of the concept of geological heritage took many years to begin to include ex situ objects in its scope (Brilha and Reynard 2018; Carcavilla et al. 2007; Mansur 2018).

The term geological heritage is systematically linked to the general concept of natural heritage, while palaeontological heritage is allocated as subcategories of the geological heritage (Souza and Miranda 2007). The term geological heritage or its derivative geoheritage is divided into its categories: in situ and ex situ elements. In situ elements are part of the geodiversity with a high degree of scientific value, as is the example of geosites. Ex situ elements are also part of the geodiversity, although not in loco; it maintains its high scientific value, as is the example of university collections (Brilha 2015). Thus, a hierarchy of the terms is made clear. One can infer that geological and palaeontological heritage can be both cultural and natural, depending on its nature.

The literature on geological heritage shows that it has several synonyms used by professionals from different areas of study. Among them, 'geoheritage' is very common in the English language. However, these synonyms do not function as substitutes, but as subdivisions of the term. The concept of 'geoheritage' is broader, being intrinsically related to the definition of geological sites (Meira and Morais 2016). The geological heritage comprises of all natural, non-renewable resources, including rock formations, sedimentary structures and packages, relief and landscape forms, mineral and fossiliferous deposits and collections of geological objects that have some scientific, cultural or recreational value (Nieto 2002).

Palaeontological heritage is sometimes understood as part of geological heritage (Wever and Guiraud 2018), and sometimes, it is viewed as a separate modality. Palaeontological heritage has unique characteristics in terms of possession, conservation, use and legal protection, which brings it closer to the geological heritage (Delvene et al. 2018). The interrelation of values in this heritage surpasses the boundaries of the geological heritage in its scientific, educational and cultural implications, and also in its conceptual delimitation (Cachão and Silva 2004). Palaeontological heritage goes beyond scientific collections of fossils in universities, museums and research institutes. The term also includes scientific publications, unpublished data, photographs, films, maps, reproductions (replicas, drawings, paintings), records of evolution of theories, scientific instruments and laboratories. They are selected based on criteria such as rarity, fragility, scientific potential, didactic potential, touristic potential, among others (Ponciano et al. 2011; Kunzler et al. 2014).

There are three criteria for selecting this type of heritage. To be considered a palaeontological heritage, the object needs to have one or more of these criteria. The first is the scientific, taxonomic, biostratigraphic, taphonomic, paleoecological, archaeological and geological information must be taken into account. The second is educational, taking into account the pedagogical, didactic and touristic potential. The third is cultural, where the natural environmental values, the sociogeographical situation, the historical value and the spiritual value must be evaluated. When the object has one or more of these criteria, it can be recognized as a palaeontological heritage (Cachão and Silva 2004).

The definitions presented are mainly related to the cultural heritage of science and technology, showing similarity not only in the objects that constitute them but also in the values usually associated with them. This allows one to emphasize that the items belonging to these categories naturally have a tendency to belong to more than one type of heritage.

The valuation process intrinsic to the heritage construction is a mechanism of affirmation and legitimization of the identity of certain social groups and subgroups in struggle with others or with themselves. These constructions are essentially social, used for the affirmation and legitimization of identities, usually linked to the attribution of values, uses and meanings to objects. In the context presented here, the valuation process can be understood as the reaffirmation of the curator's intention, in relation to their objects of study, demonstrating to their peers the importance of the theme (Pereiro 2006).

By now, it is clear that rocks, minerals and fossils in ex situ collections can be valued as geological or palaeontological heritage. These objects are usually linked to ideas and concepts of nature, but this does not prevent them from receiving geological and natural values at the same time.

Conclusion

In the current panorama, the ex situ collections with fossils, rocks and minerals are in the limbo of scientific heritage. Sometimes, authors find it difficult to say that they belong to the natural heritage because they are no longer in the original environment and have suffered various human interferences, for example, the field acquisition. The idea that the natural is opposed to all that man touches is not new and unfortunately remains as an active dichotomy in the minds of many. As far as the geological heritage is concerned, what exists is a historical academic aspect, which has always avoided including ex situ heritage. This separation is believed to be the same dichotomous thought between nature and man.

Starting from the best examples published in the literature and based on the author's experience, the present work proposes an analysis of mutual benefit in the understanding of heritage. It is observed in the critical reflection presented here that the ex situ (geological and palaeontological) cultural goods are an integral and inseparable part of the geological, cultural and scientific heritage. The questions and definitions presented so far corroborate a view of an integrated heritage. The presence of interdisciplinary professionals in scientific collections directly affects the valuation dynamics of its heritage, allowing the questioning about the need to fit the heritage into only one category. This practice then corroborates the view of integration between fields, so that cultural heritage can be seen as complementary to geological and vice versa.

The values identified and recognized by those who deal with them end up forming an initial plan in the process of valuing them. The ex situ, scientific collection of rocks and fossils can be valued as geological and cultural heritage. One should not deny the other. Values as seen here are tools to add and compose.

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