



Improving geoconservation of the palaeontological heritage through a semiotic vision

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ABSTRACT

The panoply of reasons that may attract people to fossils, which result from the meaning they attribute to these palaeontological objects, may contribute to endangering of the integrity of the fossil record. Semiotics can be of great help to assist geoconservation actions, usually based only on expertise statements, and are of particular relevance in palaeontological heritage inventory, evaluation, conservation, valuation and monitoring procedures.

This work argues that fossils can be envisaged as signs displaying different meanings among experts and non-specialists. Such meanings support the heritage contents and values attributable to any palaeontological object and are affected by the relevance of the meanings assigned to the objects by the scientific communities (*relevance grade*), and the public understanding of such meanings *as result of socialization and education (abstract perceptiveness)*. This integrated approach to the palaeontological heritage will be the most effective way of involving the community in all geoconservation actions and promote the sustainable use of fossils as natural resources by actors other than palaeontologists.

Keywords: Fossils, semiotics, signs, palaeontological heritage, heritage contents.

RESUMEN

Los diversos motivos por los que muchas personas se sienten atraídas por los fósiles son el resultado del significado que estas atribuyen a los objetos paleontológicos, y pueden ocasionalmente poner en peligro la integridad del registro fósil. La semiótica puede ser de gran utilidad para ayudar a seleccionar determinadas acciones de geoconservación, generalmente basadas solo en informes de expertos. Así mismo, puede ser de particular relevancia en los procedimientos de inventario, evaluación, conservación, valoración y monitoreo del patrimonio paleontológico.

Este trabajo sostiene que los fósiles pueden considerarse como signos, los cuales muestran diferentes significados para expertos y no especialistas. Tales significados respaldan los contenidos y valor del patrimonio vinculados a cualquier objeto paleontológico, y se ven afectados por la relevancia del significado atribuido a estos objetos por la comunidad científica (*grado de relevancia*) y por la comprensión que el público hace de tales significados, la cual resulta *de la socialización y la educación (percepción abstracta)*. Consideramos que un enfoque integrado del patrimonio paleontológico es la forma más efectiva de participación de la comunidad en todas las acciones de geoconservación, ya que contribuye a promover el uso sostenible de los fósiles como recursos naturales por parte de personas ajenas a la Paleontología.

Palabras clave: Fósiles, semiótica, signos, patrimonio paleontológico, contenidos patrimoniales.

1. INTRODUCTION

Fossils are natural objects that attract different groups of people in different ways, because of the different meanings that they attribute to them. For instance, a biostratigrapher sees in a fossil index, an invaluable proxy that can help him/her to assign an age to a stratigraphic unit; however, a trader may see in the same object a certain commercial value subject to the rules of supply and demand. The significance assigned to dinosaurs, the most popular fossil type among the public, has no parallel with that of any other fossil group. In that sense, fossils can be seen as signs (Page, 2018). According to Peirce (1998, p. 478), a sign may be defined “as anything which is so determined by something else, called its object, and so determines an effect upon a person, which effect I call its interpretant, that the latter is thereby mediately determined by the former”.

Semiotics is the study of signs and their meanings. Signs are therefore comprised of three inter-related parts: a sign, an object, and an interpretant (Atkin, 2013). According to Barbieri (2008), a semiotic system is a combination between two independent worlds, a world of entities that we call signs and a world of entities that represent their meanings. Both worlds are connected by the conventional rules of a code that are all produced by the same agent, i.e., by the same codemaker.

Fossils raise different meanings produced by different codemakers, from palaeontologists, who can see fossils as space-temporal signs of past life on earth, to geoscientists and naturalists, who can infer past climate and geographical features. The world of commercial traders may even assign fossils an economic value.

This polysemic perspective of fossils has always existed. For instance, the origin of the term ammonite dates back to Antiquity where the god Ammon was venerated in the middle of the oasis of Siouah (NW of Egypt). Pilgrims visited the site, which was actually a pyritized ammonite outcrop, to collect samples of so-called “Ammon’s horns”, which they later used as amulets or talismans (Thomel, 1980).

Astudillo (2010) also mentions that in Spain, until the mid-twentieth century, the echinoids of the genus *Micraster*, especially those of the species *M. coranginum*, were linked to various myths and sacred legends. He proposed the name Cultural Palaeontology to designate a new area of palaeontological study, of a fundamentally human nature, which considers fossils as objects of natural origin, with some sociocultural functions, according to the geographical place and the historical moment.

Other interpretations can be ascribed to fossils found in several Palaeolithic graves within and outside Europe (Demnard & Neraudeau, 2001), which display particular meaning for present-day archaeologists and certainly other meanings for the pre-historic communities that used them as funerary objects.

Some ichnofossils have also induced particular meanings to non-specialists, as is the case of the ancient folkloric legend of Pedra da Mua, related to a geosite near Espichel Cape (south Lisbon, Portugal), where Early Cretaceous dinosaur foot-prints were regarded by fishermen as a formal evidence of Our Lady, stepping down from the sea and who would have ridden on a mule to the platform above the cliffs (Antunes, 1976).

In ornamental rocks rich in bioclasts, the meanings of fossils may be even wider. The most notable occurrence of foraminifera as rock builders is probably the genus *Nummulites*. The name derives from Latin *nummus*, which means little coin, and *lithos*, which means stone. These macroforaminifera are major components in the Eocene limestone from which the pyramids of Egypt at Gizeh are built (Klemm & Klemm, 2010), as well as the vast majority of buildings that compose the monumental Girona in Spain (Dalmáu, 1970). The Greek geographer and historian Strabo (1st century) interpreted the *Nummulites* from the pyramids as petrified lentils that came from the remains of the food of the workers who built these pharaonic tombs (Belaústegui *et al.*, 2018).

The *lioz* is a limestone with Cretaceous rudists exploited and used as a construction and decorative material since the Middle Ages in Portugal, and widely disseminated in official buildings and churches in Brazil (Silva, 2019) (Fig. 1). It was, and is still, particularly appreciated by architects, but during the seventeenth and eighteenth centuries blocks of this *royal stone* were transported on vessels, serving firstly as ballast on the way to Brazil, then the blocks were used as building material. This ornamental stone is known in Spain as *Rojo Ereño* or *Rojo Bilbao* where it was exploited since Roman times (2nd century BC) until the end of the 1980s (Belaústegui *et al.*, 2018). The ornamental beauty of these stones lies in the contrast that occurs between the intense red of the micritic matrix and the white of the shell of rudists (due to recrystallization in calcite). Rudists included in the *lioz* and in the *Rojo Ereño* assume therefore different meanings (and values) for different social groups or interpreters over time and place.

2. THE FOSSIL RECORD IN DANGER

Semiotics has the merit of demonstrating that whatever is human involves signs (Petrilli, 2009). The different meanings attributed to fossils is a semiotic challenge; but it is also a serious problem for palaeontologists, as the multitude of reasons that may attract people to fossils may endanger the integrity of the fossil record that grounds the development of palaeontology and related sciences.



Figure 1. a) The use of *limestone* as construction and decorative ornamental rock of the Pavilion of Knowledge at Lisbon. b) The Cretaceous rudists of the access ramp are marked and the complementary information about this fossil group can be found along the entire route (photos by Vera Menino/Ciência Viva).

As exceptional representatives of past Earth's diversity, fossils display heritage value, thus requiring geoconservation measures like other components of the geodiversity of the planet that are unique or unrepeatable natural objects (Henriques & Pena dos Reis, 2015). However, the effective protection of the palaeontological heritage as part of the geological heritage needs the local

community's involvement in all geoconservation actions, i.e. inventory, evaluation, conservation, valuation and monitoring procedures, and not only at the final part of the process, when it is expected from local communities that the physical integrity of fossils is guaranteed (Tavares *et al.*, 2015).

Since any geoconservation action only based on the scientific value of fossils cannot assure its integrity, a narrow interpretation of fossils will prevent geoconservation fulfilling its social role: the increase of scientific research, the consolidation of nature conservation and land-use planning policies and the promotion of geoeducation and geotourism (Henriques *et al.*, 2011). Awareness of the relevance of conservation of the geological record, including the fossil record, can only be achieved if the geological objects displaying heritage contents are regarded as signs, which determine an effect upon a person or a social group, i.e. an interpretant (Peirce, 1998) or codemaker (Barbieri, 2008).

As pointed by Kiernan (2015, p. 190), “Recognising a place as being important and committing to its protective management is unlikely to be successful if the specific values that underlie that importance are not clearly understood and management strategies are not explicitly based on those values, nor if the diversity and changing nature of the beliefs held at a variety of scales—individuals, families, community groups, entire societies—is not acknowledged and its legitimacy recognized”.

3. FOSSILS AS MEANINGFUL OBJECTS

The meaning of a fossil depends on the contents that can be attributed to it by an interpretant; such content will affect its heritage value and geoconservation awareness (Pena dos Reis & Henriques, 2009). Geoheritage evaluations of the fossil record performed by geoscientists are exclusively focused on its heritage value assigned by the scientific community (e.g., Page, 2003, 2018). But the fossil record is much wider than the small portion which has until now been subject of palaeontological research. As part of the geological heritage of the Earth, i.e. as representation of the history of its palaeobiological diversity and evolution, the fossil record is of fundamental importance to past, present and future scientific studies, and therefore requires geoconservation measures. Such concern implies the assumption that geoconservation is a geoscience with a clear and deep social interrelation (Henriques *et al.*, 2011), which cannot ignore particular sociocultural ways of interpreting natural conditions by a community (Astudillo, 2010, 2018; Henriques & Brilha, 2017), i.e. the abstract perceptiveness induced by the geological objects, including fossils. The abstract perceptiveness is rooted in culturally specific values, norms, beliefs, and attitudes that we have learned and acquired throughout our socialization and education programs (O’Brien *et al.*, 2013).

An integrated approach to the inventory, evaluation, conservation, valuation and monitoring of the palaeontological heritage will be the most effective way of community’s involvement in all geoconservation actions

(Tavares *et al.*, 2015). Framed within a new paradigm of sustainability, which is rooted in an inextricably both cultural and scientific perspective through education and agency (Werlen *et al.*, 2016), this approach considers fossils as signs representing geological objects qualified within an open evaluation system based on the heritage content (Fig. 2).

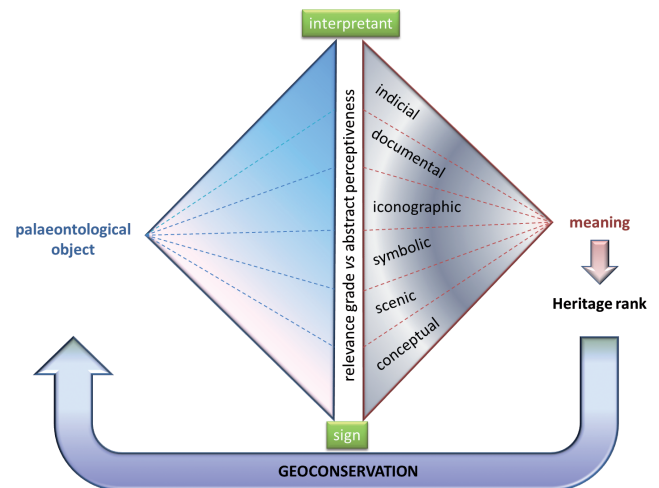


Figure 2. Fossils as geological objects representing signs, which raise different meanings produced by different interpretants or codemakers. The meaning of a fossil depends on its heritage content that will affect its heritage value and social geoconservation awareness.

4. GEOCONSERVATION AT A CROSSROADS

Different geoconservation visions for the palaeontological heritage yield different assessment methods and results. As represented in Table 1, categories of palaeontological heritage mainly based on specialists’ assessment (e.g., Page, 2003, 2018), clearly diverge from the heritage ranks arising from an integrated qualification and evaluation system for palaeontological heritage (e.g., Henriques & Pena dos Reis, 2015).

Palaeontologists can recognise in the fossil record the heritage value of index fossils supporting the biostratigraphic scales established for a basin and/or a region thus documenting major palaeobiotic changes that occurred over time in a basin or in a palaeogeographic domain, as well as specimens of typological importance for the definition of fossil species. These fossils correspond to palaeontological objects displaying documental and conceptual contents, respectively (Henriques & Pena dos Reis, 2015). For Page (2003, 2018), these correspond to fossils of category 3 (key specimens of stratigraphical or palaeobiological significance) and category 1 (specimens

of typological importance for the definition of fossil species), respectively.

Exceptionally well-preserved fossils are widely reproduced in illustrations for scientific papers and books, corresponding to specimens of category 2 (Page, 2003, 2018). By displaying real relation between the original organism and the result of the fossilization process, such specimens induce in a non-specialist interpretant another meaning; as it shows factual connection to its object, it corresponds to an index (Peirce, 1998), and therefore here they are qualified as displaying indicial heritage content (Henriques & Pena dos Reis, 2015).

The fossil record also includes trace fossils whose study usually requires highly specialized knowledge. By corresponding to palaeontological objects that show a clear physical relation between a given activity of biogenic origin and its effects, these may be considered icons (Peirce, 1998), thus displaying iconographic content (Henriques & Pena dos Reis, 2015).

But the fossil record of the Earth is not confined to the specific places where fossils remain *in situ*. The integrated qualification and evaluation system for palaeontological heritage also refers to fossil collections that are usually stored in museums and other institutions located in places inaccessible to the public but open for scientific study. Museums also frequently exhibit palaeontological objects providing recreational function for the general public. Well-preserved fossils of large dimensions are often displayed in scenarios that seek to replicate their former habitats, thus enhancing the understanding and appreciation of fossil specimens or assemblages by the public (Fig. 3). Fossils holding such heritage content of scenic nature are of great importance to raise awareness on the preservation of the palaeontological heritage, despite being usually relegated to a lower level by the scientific community (category 4 in Page, 2003, 2018). The same happens with fossils displaying iconographic and symbolic contents, which reinforces the importance of considering them as components of the palaeontological

Table 1. Heritage content types and corresponding main characteristics displayed by fossils according to the relevance grade and abstract perceptiveness. This perspective integrates expert and non-specialist interpretations of the fossil record. Categories of palaeontological heritage mainly based on specialists' assessment (from 1, the most important, to 4, the less important; based on Page, 2003, 2018) and heritage ranks framed within an integrated qualification and evaluation system for palaeontological heritage (from I, the less important, to III, the most important; based on Henriques & Pena dos Reis, 2015).

Content type	Relevance grade	Abstract perceptiveness	Main features	Code makers	Category	Rank
Indicial	Local	Material	Fossils displaying real relation between original organism and the result of the fossilization process; e.g. exceptionally well-preserved fossils	Experts and non-specialist	2	I
Iconographic	Local	Cognitive	Fossils displaying clear physical relation between a given activity of biogenic origin and its effects; e.g. trace fossils	Mainly experts		II
Symbolic	Local	Social	Fossils appreciated by the public with little or no background in Earth Sciences for reasons other than learning about palaeontology; e.g. fossils used as ornaments, offerings and tools	Mainly non-specialist	4	II
Documental	Regional	Demonstrative	Key specimens of stratigraphical or palaeobiological significance; e.g. index fossils	Mainly experts	3	II
Conceptual	Global	Cognitive	Specimens of typological importance for the definition of fossil species; e.g. type species		1	III
Scenic	Global	Social	Fossils with unusual morphological features providing high recreational function; e.g. dinosaurs and other large Mesozoic vertebrates displayed in Natural Museums	Mainly non-specialist	4	III

heritage. This is possible if the palaeontological heritage is analysed through a semiotic perspective, and its geoconservation is based on an integrated qualification and evaluation system.

5. FINAL REMARKS

Geoconservation based only on the relevance grade of objects (assigned by experts), despite their abstract perceptiveness (determined by the social use), is generally unsuccessful in terms of preservation of their integrity (Pena dos Reis & Henriques, 2009), and can hardly contribute to promote the sustainable use of fossils as natural resources by codemarkers other than palaeontologists. Awareness of the conservation of the palaeontological heritage can be increased if we look at palaeontological objects as signs and understand the different meanings assigned to fossils by culturally differentiated interpretants.

As pointed by Culler (1982, p. 188), a sign is “anything which determines something else (its interpretant) to refer to an object to which itself [*sic*] refers (its object) in the same way, the interpretant becoming in turn a sign, and so on ad infinitum”. Therefore, a sign does not have a definite meaning, for the meaning must be continuously qualified. As a result, a fossil merely used as ornament (i.e., holding symbolic content and practically useless for a palaeontologist) can, in a given social context, take other meanings. It can become efficiently used as an educational resource in the promotion of significant and relevant learning on palaeontology and on geoconservation (Henriques *et al.*, 2012), or it can be subject of new scientific interpretation, as is the case of *Lapillitibus montjuichensis* (new ichnogenus and new ichnospecies) recently described for specimens located in several old buildings from Barcelona, Spain (Belaústegui & Belaústegui, 2017). As argued by Astudillo (2010, p. 297), “fossils have been considered natural objects and inspiration of knowledge scientists, but also cultural objects and inspiration of



Figure 3. Public display of Cretaceous cephalopods at the Nautilus Geological Interpretation Centre (Geoparkea, Mutriku, Spain).

sociocultural knowledge”. An open system of qualification and evaluation of the palaeontological heritage that includes the different meanings assigned to fossils by culturally differentiated interpretants, allows continuity in the process of qualification of fossils, thus contributing to the promotion of sustainable use of fossils as natural resources by actors other than palaeontologists.

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