



# Assessment of the geological heritage of Cape Mondego Natural Monument (Central Portugal)

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## ABSTRACT

In the western coast of Portugal, Cape Mondego is a well-known set of outcrops due to its international stratigraphic relevance given by the establishment of two stratotypes: the Global Boundary Stratotype Section and Point (GSSP) for the base of the Bajocian Stage and the Auxiliary Stratotype Section and Point (ASSP) for the base of the Bathonian Stage.

The remarkable geodiversity of these Jurassic outcrops justifies the implementation of strategies in order to conserve and promote the geosites, which include a rich palaeontological record of macrofossils, microfossils and dinosaur footprints.

Based on the exceptional quality of the geological record, on its international importance and on its high scientific and educational values, this area was classified in 2007 as Natural Monument. However, no geosite systematic inventory was ever done.

In this work, a systematic identification, characterization and assessment of geosites was done in the Natural Monument. Based on fieldwork and published data, a first set of 32 potential geosites was identified taking into account their scientific, educational and touristic values. After the application of three criteria (representativeness, singularity and proximity) this group of 32 potential geosites was reduced to 12. These 12 geosites were assessed resulting on the establishment of a medium to high ranks for both educational and geotouristic potential uses. Based on this assessment, some valuing strategies were proposed, aiming at the sustainable use and the promotion of the Natural Monument geosites, within the scope of both educational and geotouristic activities addressed to secondary school students and the general public.

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## 1. Introduction

The Cape Mondego outcrops (western part of Boa Viagem Mountain, Portugal) embody a remarkable scientific importance. These Jurassic outcrops must be the object of geoconservation strategies regarding their conservation and management. Aiming the protection and safe guard of both the Bajocian GSSP and the surrounding outcrops with their fossil record and also the development of scientific research and educational activities, this area was classified as Natural Monument in 2007 and integrated into the Portuguese Network of Protected Areas. The Portuguese protected areas panorama settles the geological objects protection mainly onto the Natural Monument (7 in Portuguese mainland)

category, although there are other categories where those objects can be incorporated (Rocha, 2010). The majority of the Portuguese protected areas are focused on biological objects rather than geological, resulting on a higher number of protected areas based on bio aspects even though this trend has been facing some changes in recent years (Henriques, 2004). Regardless the vast scientific knowledge concerning the Jurassic relevance of Cape Mondego and the fact that it has been included in the inventory of the Portuguese geological heritage within the framework “Jurassic record in the Lusitanian Basin” (Brilha et al., 2005) and also the protection as Natural Monument, no systematic geosites inventory was ever carried out in this protected area.

Geoconservation encloses a set of strategies to support the geoheritage conservation, regarding the analysis of its values, as well as the evaluation of its vulnerability. A geoconservation strategy must combine a series of integrated phases, from which the combined result leads to the establishment of conservation, interpretation and management actions. The lack of the inventory

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stage is an inappropriate geoconservation project beginning and it may lead to an inadequate protection of the significant geological objects resulting, therefore, on the loss of integrity or even destruction. Lima et al. (2010) reiterated this idea pointing out some examples from five Portuguese Natural Monuments.

During the last years, several studies have been conducted regarding the assessment and management of geosites and also the definition of geoconservation strategies (e.g. Serrano and González-Trueba, 2005; Pereira et al., 2007; Reynard, 2009; Lima et al., 2010; Kavčič and Peljhan, 2010; Coratza et al., 2011; Fassoulas et al., 2011; Pellitero et al., 2011). There is also a great number of assessment methods to rank the different values of geosites from a particular territory (Grandgirard and Szepesi, 1997; Panizza and Piacente, 2003; Gray, 2004; Brilha, 2005; Reynard, 2005; Reis and Henriques, 2009).

The present work is focused on the identification, characterization and assessment of the geosites in Cape Mondego Natural Monument in order to contribute for the development of a future management plan, once no geoconservation strategy was ever made and no management plan was ever established by the national authority for this protected area. This work also aims to establish geoconservation proposals for the Natural Monument, as well as to suggest interpretation resources addressed to both educational and geotourism uses.

## 2. The study area

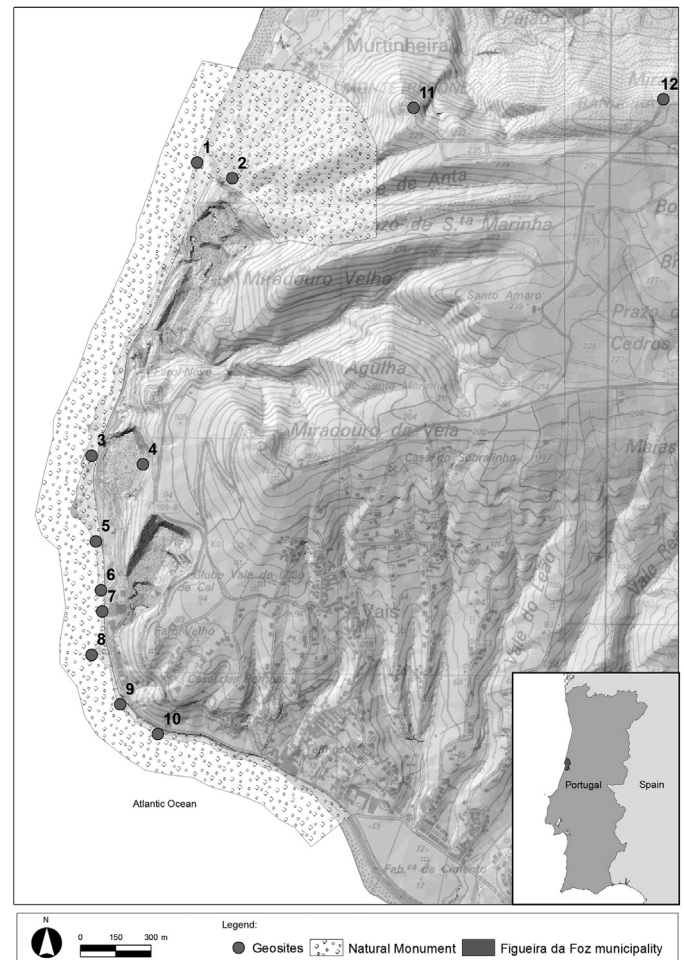
The Cape Mondego is located on the Atlantic coast of Central Portugal on the western border of Boa Viagem Mountain, 6 km northwest from Figueira da Foz and approximately half distance between Oporto and Lisbon (see Fig. 1). The Cape Mondego Natural Monument occupies an area of about 1.2 km<sup>2</sup> (58% onshore and 42% offshore).

The Cape Mondego is known worldwide due to the scientific importance of the Jurassic record and to the establishment of both the Global Boundary Stratotype Section and Point for the Bajocian Stage (Bajocian GSSP; Pavia and Enay, 1997) and the Auxiliary Stratotype Section and Point for the Bathonian Stage – Bathonian ASSP (Fernández-López et al., 2009).

The initial steps to promote the classification of Cape Mondego as a Natural Monument started in 1994. But it was only after more than a decade that the administrative process that lead to the creation of this Natural Monument was concluded with the publication of the Decree No. 82/2007 (Henriques, 2004, 2008). Some of the key-outcrops of Cape Mondego were then integrated into the Portuguese Network of Protected Areas. This legal status aimed the protection and safe guard of the Aalenian–Bajocian Stratotype, as well as the surrounding outcrops and their fossil record. The development of scientific research and educational activities are also mentioned as a primary aim in the legal document, which stresses the international importance of the geological record and its stratigraphic relevance.

## 3. Geological setting

The Cape Mondego section records a marine series of marly and limestone sediments representing the later Toarcian to middle Callovian times –185 to 140 Ma (Mouterde et al., 1978; Rocha et al., 1981; Henriques, 1998a,b), where particularly significant sedimentary, stratigraphic and palaeomagnetic data have been described (Henriques et al., 1988; Henriques, 2004), as well as relevant palaeontological data has been recognized: ammonites, brachiopods, benthic foraminifera, calcareous nanofossils, radiolaria and ichnofossils (Henriques, 2008). The highly significant biostratigraphic and biochronological values displayed by the



**Fig. 1.** Cape Mondego Natural Monument boundaries and geosites location represented on the topographical map of Figueira da Foz municipality. Geosites No. 1 – GSSP (Bajocian); No. 2 – Anta valley; No. 3 – ASSP (Bathonian); No. 4 – Middle-Upper Jurassic Discontinuity; No. 5 – Callovian stratigraphic and palaeontological record; No. 6 – Syn-rift deposits; No. 7 – Dinosaur footprint and ripples marks; No. 8 – Dinosaur footprints and mud cracks; No. 9 – Syn-rift deposits (climax); No. 10 – Fluvial-deltaic deposits; No. 11 – Monte Redondo panoramic view; No. 12 – Bandeira viewpoint.

ammonite record allowed the recognition of several biostratigraphic units, across the entire Middle Jurassic sediments.

The upper Jurassic sediments from Cape Mondego section represents the Lusitanian Basin second rifting episode (Reis, 2008), displaying diversified marginal depositional facies (lagoon, delta, estuarine), with abundant record of corals, echinoderms, brachiopods, crinoids and dinosaurs footprints. The rifting episode has lead to a widespread carbon deposition, which was an important mining resource during the 19th and 20th centuries.

From the scientific point of view, the geological importance of Cape Mondego outcrops is known since 1884 due to a research study focused on the presence of dinosaur footprints, which in reality was the first one carried out in Portugal and also one of the first to ever been published in Europe (Henriques, 1998a; Lockley et al., 1998; Holtz, 1998). During the 19th and 20th centuries several scientists discussed the ammonite record and its stratigraphic value, as well as the occurrence of other fossil groups: benthic foraminifera, calcareous nannoplankton and brachiopods (Rocha, 2010).

The occurrence of a particularly rich and diversified ammonite fossil record, the occurrence of calcareous nanofossils, the continuity of the stratigraphic record and the magnetostratigraphic polarity-reversal across the Aalenian–Bajocian boundary

supported the proposal of the establishment of the Bajocian Global Stratotype Section and Point (GSSP) at Cape Mondego outcrops, more exactly in Murtinheira section (Rocha et al., 1990; Henriques et al., 1994; Fig. 2).

The formal establishment of the Aalenian–Bajocian boundary (Bajocian GSSP), the first stage boundary established for the Jurassic System and the only one existing so far in Portugal, occurred in 1996 (Pavia and Enay, 1997). The GSSP was defined in the base of bed AB11, according to the biostratigraphic relevance of the Ammonoidea record, particularly due to the first occurrence of *Hyperlioceras* associations – *H. mundum* and related species (*H. furcatum*, *Braunsina aspera*, *B. elegantula*) and also to the late occurrence of *Graphoceras* and *Haplopleuroceras* (Henriques et al., 1994).

More recently, other fossil groups have been studied in detail across the GSSP (calcareous nannoplakton, benthic foraminifers and brachiopods), and the obtained results emphasize the relevance of the Aalenian–Bajocian boundary at Cape Mondego for global correlation (Canales and Henriques, 2008, 2013; Neto et al., 2011).

The international scientific significance of the Middle Jurassic of Cape Mondego section assumed a higher rank value with the establishment of the ASSP for the Bajocian–Bathonian boundary. The ASSP for the base of the Bathonian Stage established in 2008 provided complementary data (ammonite succession and biostratigraphic subdivision) to the Bathonian GSSP, which was defined at the base of limestone bed RB071 in the Ravin du Bès Section, Bas-Auran, in southern Subalpine Chains (France) (Fernández-López et al., 2009).

#### 4. Geosites inventory

In spite of the vast scientific documentation concerning the Jurassic relevance of Cape Mondego, no systematic inventory of geosites was ever made in the whole area of the Natural Monument.

After an initial identification of potential geosites using the methodology proposed by Brilha (2005) and adapted to the local specificities, 32 potential sites were defined. In order to select the most representative geosites of the Natural Monument, three criteria were applied to these 32 potential geosites: representativeness, singularity and proximity. The representativeness criterion is related with the appropriateness of the geosite to illustrate a geological process or feature, which brings a

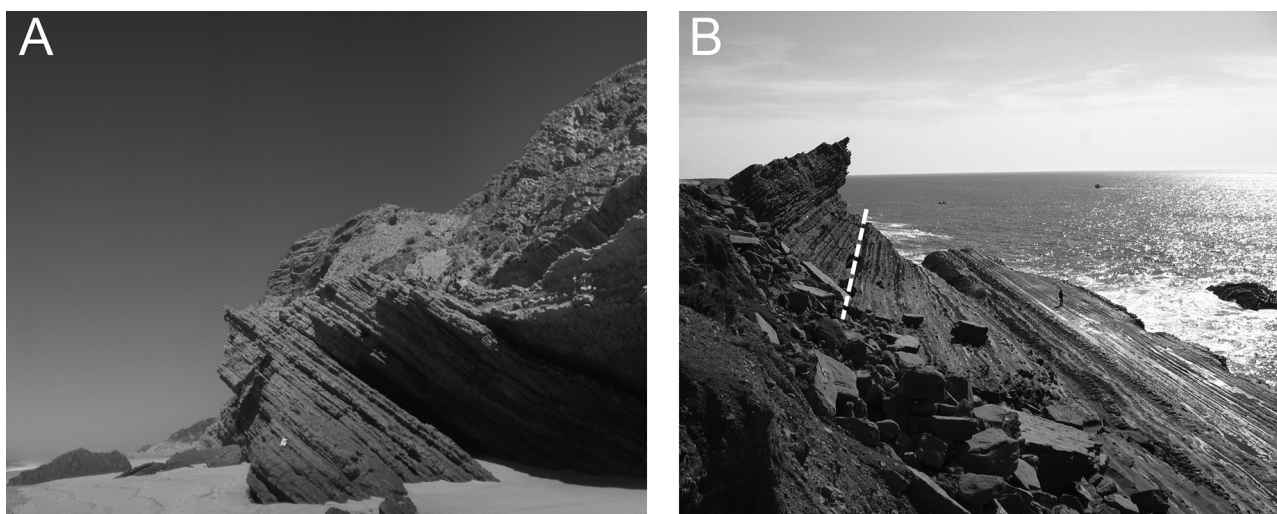
meaningful contribution to the understanding of the geological topic, process or feature. The singularity criterion regards the number of similar occurrences of a geological process or feature on a specific area. The proximity criterion considers the possibility of having different relevant geological processes or features that might be integrated in the same geosite. After applying these three criteria, the initial list of 32 potential sites was reduced to 12 geosites (Fig. 1). Two of these geosites are located outside the boundaries of the Natural Monument but they were selected because they are the best sites to have a general view over the entire area.

Aiming the potential use for educational and tourism purposes and also following the proposed evaluation system from Reis and Henriques (2009) for values or contents displayed by geological objects, the 12 geosites were classified according to the different types of contents. The proposed open system intends to qualify geological objects with heritage value according to its content, based on the relevance defined by scientific communities as well as the public understanding of geological objects, which is related with its social fruition. The quantification of the contents settles a base for grouping geological objects and they can be assumed as: Indicinal (geological objects as indexes – relevant to illustrated detailed geological features); Iconographic (e.g. Bandeira viewpoint); Symbolic (place used by the public due to other reasons different from the geological ones); Documental (a highly demonstrative record which is relevant for the understanding of significant geologic features on a regional scale – e.g. Cape Mondego outcrops); Scenic (high recreational function of a geological object/phenomena on a regional scale – e.g. Monte Redondo); Conceptual (singular geological occurrences that can be used as excellent examples of material and theoretical references for geology – e.g. GSSP and ASSP).

The scientific relevance of this Natural Monument was well demonstrated in the geological setting section. So, the scientific use for the 12 geosites is assumed without further considerations. However, for management purposes the potential educational and tourism uses of these geosites need to be assessed. Five geosites (No. 1, 7, 8, 9, and 10) are located near the seashore that might imply temporary use restrictions (Fig. 1).

##### 4.1. Assessment of the potential educational use

The Cape Mondego Natural Monument is mentioned in the national curriculum for several disciplines of the secondary



**Fig. 2.** Cape Mondego outcrops. (A) The Aalenian–Bajocian section at Cape Mondego outcrop – the white book is placed on the base of the bed AB11, where the Bajocian GSSP has been defined. (B) The Bajocian–Bathonian section – the dotted line shows the lower boundary on which the Bathonian ASSP was established.

education (Biology and Geology – 10th, 11th and 12th grades; Geology – 12th grade). This is clearly an evidence of the high educational relevance of this protected area for Geology education, when used as an educational resource accordingly articulated with activities integrated in the curriculum (Henriques et al., 2012). To assess the potential for educational use of the 12 geosites, the following criteria were evaluated (Table 1): accessibility, associated resources, viewing conditions, educational content, fragility and representativeness. These criteria were evaluated with a scale of one to five points, according to Braga (2002).

Accessibility is an important factor when considering the educational potential use of a geosite. Students need to reach a geosite safely, not spending too much time and usually in groups of about 40 elements. This criterion was evaluated considering that the best possibility (5 points) happens when a school bus easily reaches the geosite.

The association between geological contents and cultural components (existence of quarry buildings and the related mining history) was considered a good motivation to develop interdisciplinary educational activities. The distance between geological and cultural assets was used to rank this criterion.

The criterion viewing conditions expresses the quality of the geosite visualization. The higher rank means exceptional viewing conditions in the full extent of the geosite, together with the opportunity to observe all geological features or processes.

The educational criterion assesses the capability of a geosite to clearly exemplify educational contents to students and general public. The higher score is used for geosites with clear and easy geological contents allowing its educational use for all levels of teaching and also for the general public.

**Table 1**  
Criteria to assess the potential educational use of geosites.

	Points
<i>Accessibility (Ac) criterion</i>	
Direct access by municipal/national road	5
Less than a 1 km from any pathway for passenger vehicles (cat. D)	4
More than a 1 km from any pathway for passenger vehicles (cat. D)	3
Less than a 1 km from any pathway for vehicles (cat. D1, B)	2
Direct access on a non-paved road (cat. B)	1
<i>Association with other resources (Ar) criterion</i>	
Association with other features up to 500 m distance	5
Association with other features up to 1000 m distance	3
No associated features	1
<i>Viewing conditions (Vie) criterion</i>	
Exceptional viewing conditions (to the fullest extent and easily-observable)	5
Good viewing conditions (to the fullest extent but with some difficulty)	4
Median viewing conditions (not observable in the fullest extent)	3
<i>Educational content (Edu) criterion</i>	
Clearly exemplifies educational contents to any teaching level and to the general public	5
Clearly exemplifies educational contents to any teaching grade	4
Clearly exemplifies educational contents for graduate and post-graduate studies	3
<i>Fragility (Fra) criterion</i>	
Decametric dimension sites hardly affected by anthropogenic activities	5
Decametric to metric dimension sites moderately affected by anthropogenic activities	3
Metric dimension sites easily affected by any anthropogenic activity	1
<i>Representativeness (Rpr) criterion</i>	
Best example in Portugal of a geological process or feature	5
Best example in Cape Mondego of a geological process or feature	4
Representative of various geological contexts	3

The geosite fragility is closely linked to the negative impacts of anthropogenic activities that can lead to a series of events from minor damage or loss to partial or total destruction. The fragility was defined on a decametric to metric extent bases, in which geosites with decametric dimension that could hardly be affected by anthropogenic activities have a higher score, e.g. the GSSP and the ASSP geosites.

The calculation of the potential educational use (PEU) is based on the relative weights proposed by Braga (2002) and followed by Rocha (2010).

$$PEU = \frac{[(Ac \times 20) + (Ar \times 10) + (Vie \times 15) + (Edu \times 20) + (Fra \times 15) + (Rpr \times 20)]}{6}$$

The results were reclassified in order to get a qualitative perspective concerning the PEU for the 12 geosites (Table 2): low (<30), medium (30–60) and high (>60).

The majority of the Cape Mondego geosites present a high potential to be used for educational activities. Only 2 of them (Callovian stratigraphic and palaeontological record; Fluvial-deltaic deposits) have a medium PEU (Table 2).

#### 4.2. Assessment of the potential geotourism use

The geotourism potential of a geosite is commonly related to the presence of spectacular scenic aspects, once the landscapes are at the top of the hierarchy pyramid of features of geotourism interest (Newsome and Dowling, 2006). If the scientific importance is considered, a new perception can be added to the geological tourism resulting in a scientific geotourism – e.g. the GSSP and the ASSP do not have magnificent scenic value, even though they are important geological features that can support geotourism activities (Rocha, 2010).

Following Braga (2002), the assessment of the potential geotourism use (PGU) is based on 5 criteria (Table 3), four of them similar to the ones used for PEU evaluation.

The accessibility now considers that the target public will be travelling with their personal vehicles instead of the large capability vehicles (e.g. school buses) previously considered on the PEU assessment.

The spectacularly criterion tries to deal with an irrefutable subjectivity but with significant importance to evaluate tourism potential. Spectacularly assessment is based on the actual use of a geosite as an icon in tourism marketing strategies, campaigns and documents (Braga, 2002). To get a precise quantification of Cape Mondego usage as icon a wide group of supports that are published by tourism agencies were evaluated (Turismo Centro Portugal,

**Table 2**  
Results of the potential educational use (PEU) of the inventoried geosites.

Geosite name and number	Potential educational use (PEU)	Geosite PEU average weight
GSSP (Bajocian) – No. 1	High	65
Anta valley – No. 2	High	68
ASSP (Bathonian) – No. 3	High	65
Middle-Upper Jurassic Discontinuity – No. 4	High	63
Callovian stratigraphic and palaeontological record – No. 5	Medium	57
Syn-rift deposits – No. 6	High	63
Dinosaur footprint and ripple marks – No. 7	High	67
Dinosaur footprints and mud cracks – No. 8	High	67
Syn-rift deposits (climax) – No. 9	High	65
Fluvial-deltaic deposits – No. 10	Medium	59
Monte Redondo panoramic view – No. 11	High	63
Bandeira viewpoint – No. 12	High	68

**Table 3**  
Criteria and respective weight use for geotourism use assessment.

	Points
<i>Accessibility (Ac) criterion</i>	
Direct access by municipal/national road	5
Direct access by a pathway or a paved road	4
Direct access by a pathway or a non-paved road	3
Less than a 1 km distance from any pathway	2
More than a 1 km distance from any pathway	1
<i>Association with other resources (Ar) criterion</i>	
Association with other features up to 500 m distance	5
Association with other features up to 1000 m distance	3
No associated features	1
<i>Educational content (Edu) criterion</i>	
Clearly exemplifies educational contents to any teaching level and to the general public	5
Clearly exemplifies educational contents to any teaching grade	4
Clearly exemplifies educational contents for graduate and post-graduate studies	3
<i>Spectacularly (Spe) criterion</i>	
Used for national tourism iconography	5
Used for local tourism iconography	3
Not used for tourism iconography	1
<i>Fragility (Fra) criterion</i>	
Decametric dimension sites hardly affected by anthropogenic activities	5
Decametric to metric dimension sites moderately affected by anthropogenic activities	3
Metric dimension sites easily affected by any anthropogenic activity	1

Turismo de Portugal, Figueira Grande Turismo, and Figueira Digital). The sites that are national tourism symbols received a higher score.

The PGU calculation was based on the following formula:

$$PGU = \frac{[(Ac \times 25) + (Ar \times 20) + (Edu \times 5) + (Spe \times 30) + (Fra \times 20)]}{5}$$

The spectacularly criterion has the highest relative weight because it plays a decisive role in the promotion of geotourism activities. On the other hand, the educational content has the lowest weight as proposed by Rocha (2010). The resulting formula values were reclassified in order to obtain the rank on the PGU scales (Table 4), which vary from low (<30) to medium (30–60) and high (>60).

The 12 geosites of Cape Mondego are equally distributed between medium and high potential for tourism use.

**Table 4**  
Results of the potential geotourism use (PGU) of the inventoried geosites.

Geosite name and number	Potential geotourism use (PGU)	Geosite PGU average weight
GSSP (Bajocian) – No. 1	Medium	61
Anta valley – No. 2	High	64
ASSP (Bathonian) – No. 3	Medium	44
Middle-Upper Jurassic Discontinuity – No. 4	Medium	44
Callovian stratigraphic and palaeontological record – No. 5	Medium	42
Syn-rift deposits – No. 6	Medium	54
Dinosaur footprint and ripple marks – No. 7	High	69
Dinosaur footprints and mud cracks – No. 8	High	69
Syn-rift deposits (climax) – No. 9	High	51
Fluvial-deltaic deposits – No. 10	Medium	37
Monte Redondo panoramic view – No. 11	Medium	45
Bandeira viewpoint – No. 12	High	84

## 5. Valuing strategies

According to Brilha (2002) protected areas have potential importance for environmental education and they can also be used for increasing the public awareness for nature conservation. Gray (2008) takes in consideration the idea that geodiversity can be a used as a basis for the development of geotourism activities. In order to promote the use of the Cape Mondego geosites and geodiversity, several resources were developed addressed to general public and secondary school students.

### 5.1. The Geosites Map

The Geosites Map presents informative support about the geosites geographical location as well as a brief text description of the contents of each geosite. The 2 geosites related with scenic aspects but located outside the formal limits of the natural monument (Bandeira viewpoint and Monte Redondo panoramic view) were not included in this map.

### 5.2. Textbook

A simplified textbook was also produced in order to support educational activities developed by secondary school teachers (Fig. 3). Priority was given to the use of images, in favour of a better understanding of the significant features of each geosite.

### 5.3. Informative panel

Finally, an informative panel was created based on simple and understandable text, with some panoramic and detail images and a geosites location map (Fig. 4). This panel should be placed in the south entrance of the Natural Monument, a location highly visited by the public with good car parking facilities.

## 6. Conclusions

As it is argued in the Declaration of the Rights of the Memory of the Earth – Digne, human activities should preserve Nature in all its facets, in particular with respect to the Earth's geological heritage, its conservation and protection. The link between anthropogenic activity and sustainable use of geological values should be enhanced by the development of planning policies pointed to the geoconservation (Henriques et al., 2011). The existence of several threats to geodiversity integrity (Gray, 2011) requires the development of major geoconservation plans and valuing strategies, as geodiversity can provide a wide range of geosystem services with several associated goods and functions which are extremely important for human activities. The geosystem services values loss will increase, as geoconservation is not taken in account in sustainable management policies.

The Cape Mondego Natural Monument represents one of the fewest Portuguese protected areas created solely on geological values in order to guarantee the preservation of its exceptional geological heritage. The legal classification document highlights the exceptional quality of the geological record and stresses its unbeatable educational and scientific values.

The present work had intended to contribute to the conservation of Cape Mondego geosites and it is focussed on the following objectives: identification and characterization of geosites according to their potential use and the development of informative resources. The geosites identification and characterization took into account the potential educational and tourism uses and therefore the considered criteria and weights allowed the establishment of geosites ranking according to their potential uses.

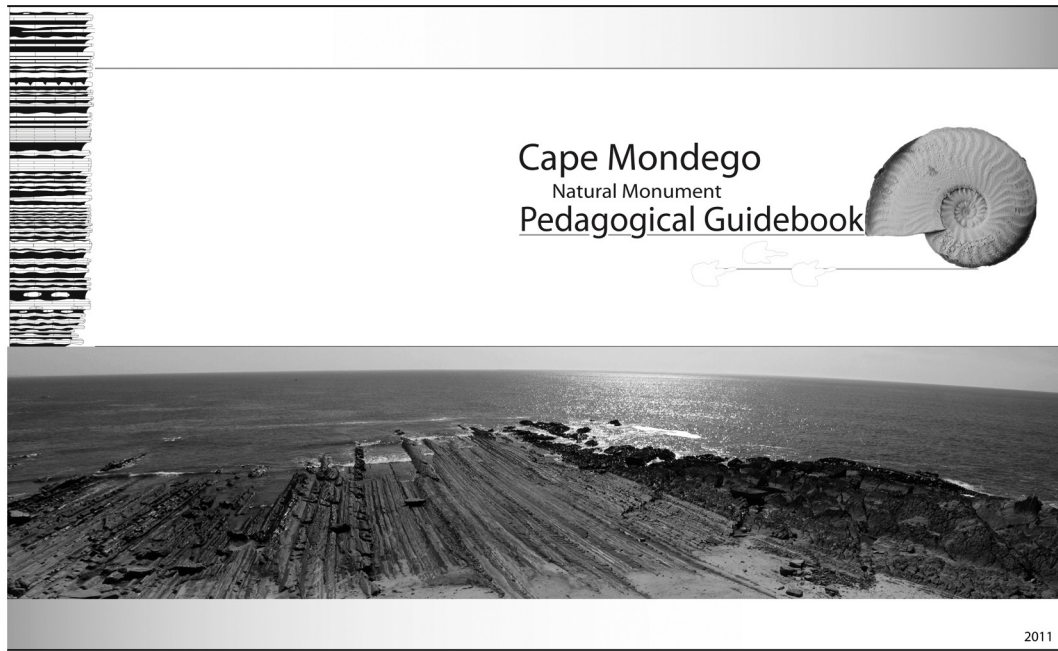



Fig. 3. Cape Mondego textbook front cover.



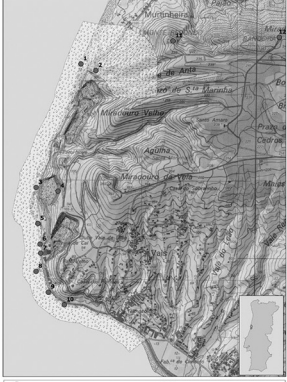
**Cape Mondego**  
Natural Monument

...a truly **Jurassic Park**  
from the **Dinosaurs** age...

From the sea cliffs of Cape Mondego to Bandeira viewpoint on the top of the mountain, there are rocks that were formed 161 million years ago.


The geological exceptionality of Cape Mondego led to its classification as a Natural Monument in 2007 and to the establishment of an international stratigraphic reference standard in 1996.

The geological heritage of Cape Mondego includes dinosaur footprints, macrofossils of ammonites, corals, plants, fish, and brachiopods and microfossils of foraminifers, calcareous nannoplakton, and radiolarians.




**Geosites**  
Enjoy some other sites of Cape Mondego...


- Anta valley
- Bandeira viewpoint
- Monte Redondo
- panoramic view



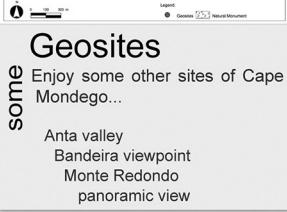
dinosaur footprint



ammonite



stratigraphic reference




In spite of its relative small area, the Natural Monument exhibits a remarkable geodiversity that must to be well known and preserved.


**Did you know...**

The Cape Mondego is one of the best places in the world to understand the formation of the Atlantic Ocean!

The first Portuguese coal mining company was located in Cape Mondego



dinosaur footprint trail



outcrops

Fig. 4. Cape Mondego informative panel.

The present study has some limitations: twelve geosites were considered, although only nine of them are located within the natural monument boundaries. Cape Mondego geological heritage is wider and holds more values than those, which were included in the assessed geosites list. The Cape Mondego scientific value has been expanding, as scientific communities are validating new scientific developments regarding the stratigraphic successions there recognized. Take the example of the GSSP establishment in 1996, which preceded the Bathonian ASSP establishment in 2008, more than a decade lag. Thus, the number of geosites defined in this work should not be seen as tight, but is likely to increase due to the dynamic character inherent to scientific knowledge production.

The geosite inventory is an important tool to define different protection levels and to support the implementation of conservation and management policies and strategies. It can be used to establish priorities for the application of protection measures and to support the definition of geoconservation strategies.

It is expected that the work now produced could contribute to the appreciation of the Cape Mondego geological importance, and that it increases public awareness about the importance of geoconservation policies for nature conservation and land-use management. The methodology applied to Cape Mondego geosites can be used as a support tool to assess geosites in other size areas and in other countries.

## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.pgeola.2013.04.005>. These data include Google maps of the most important areas described in this article.

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