

Finding Geological Heritage: Legal Issues on Private Property and Fieldwork. The Case of Outstanding Early Angiosperms (Barremian to Albian, Portugal)

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Abstract The Lower Cretaceous (Barremian to lower Albian) of Central Portugal yields some of the earliest and best-preserved angiosperms, which are excellent materials to study the mid-Cretaceous fast and huge diversification of angiosperms. Regional stratigraphic and sedimentological studies are crucial to enlighten the timing and environmental forcing factors of angiosperm evolution, namely geodynamics, magmatism, climate and oceanography. During a research project focusing upon these questions, access to an exploitation of mineral resources (a sand mine) was denied, leading to the present debate. National and international declarations and legislation increasingly commit states to consider geoheritage identification, protection and conservation as public interest. As scientific research is the first step within this process, access of researchers to a studied area should be the rule, regardless of legal tenure, with exceptions related to security matters or proprietary data.

Both Portuguese laws governing mineral resources and geoheritage recognise many geological materials (mineral resources, sites, outcrops, fossils etc.) as vulnerable and non-renewable, requiring precautionary and conservative management based in scientific knowledge, but only the mineral resources laws foresees restrictions to private property rights for geological fieldwork. To balance the private rights and the public interest, we propose that the law should concede access to private property for officially recognised researchers and/or researchers of officially recognised projects. For activities acquiring geological data, creating exposures or mineral extraction, concession contracts should include clauses to allow access to such researchers and, for major operations, the obligation to notify interesting geological finds. We believe that geoconservation and the sustainable use of mineral resources cannot be jeopardised by access restrictions to scientific fieldwork.

Keywords Fieldwork · Private Property · Early Cretaceous · Early Angiosperm

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Introduction

The broad concept of nature conservation is currently widely accepted at all levels of society, an acceptance increasing directly as a function of the awareness of the extension of anthropogenic impacts. Nevertheless, given the current dependence of human communities on natural resources, it is obvious that protective status can only be applied to fractions of the Earth's surface, selected as representative or exotic. In addition, the more physical and less biological components of the whole Earth system are artificially separated, probably as a result of an anthropocentric view, prone to create empathies with living creatures and to exploit

Earth as a “private domain”. Even so, and fortunately, the efforts of the scientific community to show the importance of the study, conservation and promotion of the geological heritage are reaching some successes, at a national (Portuguese, in the case) and International level.

Nevertheless, the success ratio is obviously reduced when the decision on a particular issue is a confrontation between science and power, such as economic, political, military, or simply the private property right. In this dispute, recent legislation actually tends towards the conservation of recognised items, such as the Rec(2004)3 from the European Council and the Portuguese Decree-Law 142/08 of July 24.

Regrettably, such an evolution is not clear with regard to the first step in a chain of technical acts that ultimately lead to conservation: basic field research. In this paper, we discuss the balance between the public interest and the private property rights, and particularly permission to access private land to conduct geological research. It is noteworthy that such access is legally established in Portugal in the context of concession contracts for the exploration of mineral resources: this means that public interest prevails over the private property rights only to assure economic profit or protect the so-called “national strategic interests”.

These reflections were triggered by an unusual case of a landowner who refused access to a key area for research, involving a scientific subject of worldwide relevance. This incident was exemplary due both to the sharp confrontation of positions and the magnitude of the scientific importance.

Studies of the Lusitanian Basin Lower Cretaceous, below detailed, include very promising areas for new finds of early angiosperms assemblages, including palynology, mesoflora and macroflora, with an undisputable global value for the understanding of one of the most extraordinary revolutions in the evolution of life on Earth: the explosive radiation of angiosperms in the Cretaceous.

Portuguese Sites for Lower Cretaceous Angiosperms and their Global Significance

Regional Stratigraphy

Paul Léon Choffat’s pioneering works are landmarks in the study of the Lusitanian Basin Lower Cretaceous (Choffat 1885, 1900, 1904). A formal lithostratigraphic framework is well established (Rey 1992a, b, 1993; Dinis 2001) (Fig. 1) and an updated stratigraphy was recently presented (Rey et al. 2006; Dinis et al. 2008). A sequence-stratigraphic scheme for the same sedimentary package was also proposed (Dinis et al. 2002; Rey et al. 2003). Therefore, the boundary between two distinct sectors can be established around latitude of the town of Caldas da Rainha, with the southern

sector preserving a more complete Lower Cretaceous record, and the northern one probably includes only the Berriasian *p.* and the uppermost Aptian to Albian.

The main unconformities in the Cretaceous record of the western Iberian margin are late Berriasian, intra-Barremian and late Aptian, considered as caused by basin shoulder uplift in an isostatic and thermal adjustment to extensional phases during the Atlantic rifting, including continental breakup and onset of ocean-floor spreading in three rift segments (Dinis and Rey 2001; Dinis et al. 2008).

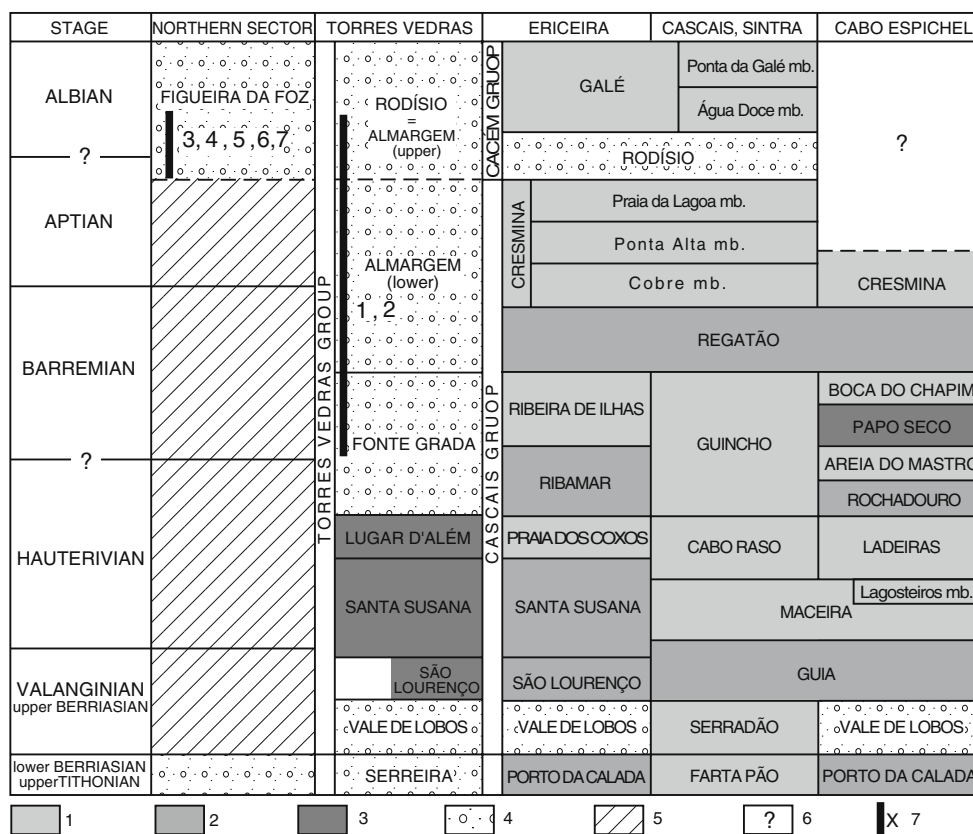
In a late- to post-rifting context, the basin was open to the SW, and between the main tectonic events a range of depositional environments from fully marine to non-marine shifted according to the sea-level changes. Available biostratigraphic data and the sequential approach presented in the above-mentioned papers allow good age accuracy for the units including marine or transitional beds, but age assignments of the proximal non-marine deposits are based in long-ranging *taxa* and stratigraphic basin-wide correlations.

Early Angiosperm Mesofloras in the Lusitanian Basin

The Portuguese Cretaceous exhibits an extensive fossil record of earliest angiosperm mesofloras. By mesoflora, we mean a set of botanical remains with a size above those classically studied by palynology (pollens and spores) and smaller than the (macro)flora studied by conventional macroscopic methods. It includes well-preserved reproductive organs like fruits, seeds and flowers that often have their three-dimensional form intact, being extremely relevant for palaeontological studies (taxonomy, evolution and palaeoenvironment). Due to its composition, specific sample preparation methods, and especially its relevance, the mesoflora is approached in detail in this work. Angiosperms are diverse and several specimens of reproductive organs are associated with in situ pollen grains (Friis et al. 1997, 1999, 2000, 2003, 2004, 2006, 2009a, b; Eriksson et al. 2000; von Balthazar et al. 2005). A recent review of the Cretaceous flora of Western Central Portugal was presented by Friis et al. (2009a). The main sites with assemblages of early angiosperms include Catefica, Torres Vedras, Famalicão, Vila Verde, Buarcos and several in the Juncal area (mainly Vale de Água), all located in Fig. 2. Their proposed stratigraphic distributions within the infill of the Lusitanian Basin are expressed in Fig. 1 and a selection of specimens representing the extraordinary diversity of basal angiosperms from the Barremian to Albian of Western Portugal is presented in Figs. 3 and 4.

These sites have exceptional importance for palaeobotany at a global level since “the oldest floras containing abundant angiosperm reproductive materials are from the Barremian or Aptian of Portugal” (Eriksson et al. 2000, p. 319), and “currently, the only other area that has produced Early

Fig. 1 Lithostratigraphy of the Lusitanian Basin Lower Cretaceous. 1 Marine and brackish carbonates, 2 near-shore mixed clastics/carbonates, 3 lagoon and near-shore clastics, 4 fluvial and estuarine clastics, 5 hiatus, 6 no record, 7 possible distribution of angiosperms mesoflora sites (see site numbers [x] and location in Fig. 2). Modified after Rey et al. (2003)



Cretaceous mesofossils floras with rich assemblages containing angiosperm remains is the Potomac Group sequence on the Atlantic Coastal Plain of eastern North America” (Friis et al. 2009a). In 1998, a major challenge to this timing was expressed when the *Archaeofructus* family was found in China and attributed to the Jurassic (Sun et al. 1998). However, the subsequent reappraisal of the stratigraphic position points to an Early Aptian or Barremian age (Swisher et al. 1999), similar to the considered Portuguese flora. On the other hand, the diversity of the Portuguese assemblages is far higher (Figs. 3 and 4) and the phylogenetic position of the *Archaeofructus* family as a basal angiosperm was challenged (Friis et al. 2003; Pennisi 2009). Besides the possibility of new finds, this statement points out the uncertainty of age assignments, mainly because the areas with the most interesting angiosperms assemblages are isolated from the marine to transitional beds and lacks independent dating.

The occurrence of tricolpates (up to 15%) in the angiosperm pollen records from the coastal area near Lisbon (Crismina section, Figs. 2b and 4i) and in the Algarve indicates a latest Aptian to early Albian age (Heimhofer et al. 2005, 2007) for levels considered as correlative of the above-mentioned mesoflora sites. However, the hiatus and a barren interval roughly corresponding to the early Aptian *p.p.* and (most of) the Late Aptian in the Lisbon area (Crismina), coupled with the age of the Algarve (Luz) section (Heimhofer et al. 2005,

2007; Rey 2006), allow an age as old as late Aptian for the flora including eudicots remains, namely tricolpate pollens.

In these circumstances, any contribution to regional stratigraphic correlations will help to constrain the ages of the site and, thus, the timing of angiosperms evolution and migration.

Angiosperm Evolution and the Importance of Portuguese Mesoflora Sites

The first major radiation of angiosperms marks a revolution in the ecosystems of the Earth, from a flora dominated by ferns, conifers and cycads to the modern terrestrial vegetation where angiosperms occur in almost all ecosystems and represent more than 85% of extant plant species. Nevertheless, many of the details of the angiosperms’ origin and early evolution (which Charles Darwin referred to as an “abominable mystery”; Davies et al. 2004) remain unclear (Frohlich and Chase 2007).

New ideas are currently emerging on phylogenetic relationships among seed plants, but in a recent note (Pennisi 2009) the Portuguese sites, along with some Chinese (Sun et al. 1998, 2002; Ji et al. 2004), were the only fossil records referred as major contributors in establishing the origin of flowering plants. Recent advances in analyses of DNA sequence data were not conclusive and the proposed pattern of relationships (Burleigh and Mathews 2004) is controversial

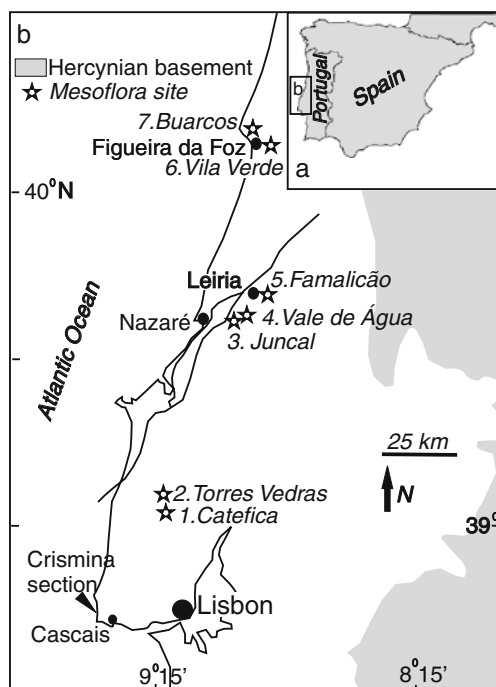


Fig. 2 a Location map of Western Portugal. b Mesozoic and Cenozoic (white) with the location of early angiosperms mesoflora sites and the Crismina section. Modified after Heimhofer et al. (2005)

in evolutionary terms because it does not show a clear position for the root of the angiosperm branch and it conflicts with stratigraphic evidence (Friis et al. 2006). Several authors suggest an origin for angiosperms in the Triassic or the Jurassic (e.g. Zavada 2007), but the first unequivocal records of angiosperms are Early Cretaceous (Friis et al. 2006), and, in particular, the earliest published mesofossil floras are those from the cited Portuguese localities and the flora from Northeast China. Even if the age of such evolutionary events is still under acute debate, a cautious examination of the fossil record shows that the first major radiation of angiosperm took place during the Early Cretaceous, with a poleward migration pattern of early angiosperms (Davies et al. 2004; Friis et al. 2005). A high rate of angiosperm diversification was suggested (Friis et al. 2006) for the early phases of evolution, but restricted to particular environments, with a patchy distribution and thus producing scarce fossils. It must be stressed that the cladistic interpretations, the molecular clock assumptions and the environmental conditions must be calibrated with independently dated fossils assemblages and geologically based palaeoenvironmental data.

Current Research on the Cretaceous Stratigraphy of the Torres Vedras Area

Research on Lower Cretaceous sedimentology, lithostratigraphy, palaeobotany and sequence stratigraphy are being

conducted in the key area of Torres Vedras, which includes two of the aforementioned early angiosperm macroflora sites. These works form part of a co-operative project between the Department of Earth Science of the University of Coimbra and the Department of Geology of the National Laboratory of Energy and Geology (Laboratório Nacional de Energia e Geologia, the Portuguese Geological Survey), within a project for the reappraisal of the 1:50,000 general geological maps, namely the implementation in the new editions of published cartography (Rey 1993). Among the targets, can be stressed the refinement of age assignments for the lithostratigraphic units. In the case of the exclusively continental Fonte Grada and Almargem formations (Fig. 5), this goal relies essentially on the sequence-stratigraphic correlations with the coastal section located to the SW and in the biostratigraphic potential of the palaeobotanical finds. Another important project carried on in the area is a Ph.D. (New University of Lisbon) by M.M. Mendes on the Palaeobotany of the Lower Cretaceous, mainly focused on primitive angiosperms (Fig. 4a–d).

In both projects, we try to solve uncertainties in the detailed lithostratigraphic location of the macroflora sites and find new palaeobotanical assemblages, due to their interest both to palaeontology and biostratigraphy. During fieldwork, one of us (J.D.) focused his efforts in a 500 by 300 m area with high potential, between two formerly studied palaeobotanical sites (palynology in Rey 1972; mesoflora and palynology in Friis et al. 1999). Within the above-mentioned Ph.D. project, the study of recently sampled palaeobotanical associations confirms the presence of angiosperms in a location about 1.5 km SE of the above-mentioned 500 m by 300 m area (personal communication of unpublished results by M.M. Mendes, September 2008). The areas of interest overlaps approximately the concession of a working sand pit. In order to access the quarry area, an appointment with the owner was scheduled and detailed explanations were given concerning the technical, scientific and academic purpose and interest of the studies. In this particular situation, the exploitation of the sand pit could not be inhibited by sampling for research purposes—on the contrary, as explained to the owner, as digging would create new exposures. Unfortunately, an uncompromising refusal was the result of contacts with the owner. This episode triggered the present paper.

The Juridical Statute of Geological Entities

The Legal Approach to Geological Sites: Mineral Resources and Heritage

In Portuguese law, geological entities (mineral bodies, sites, outcrops, fossils, etc.) have been traditionally referred to

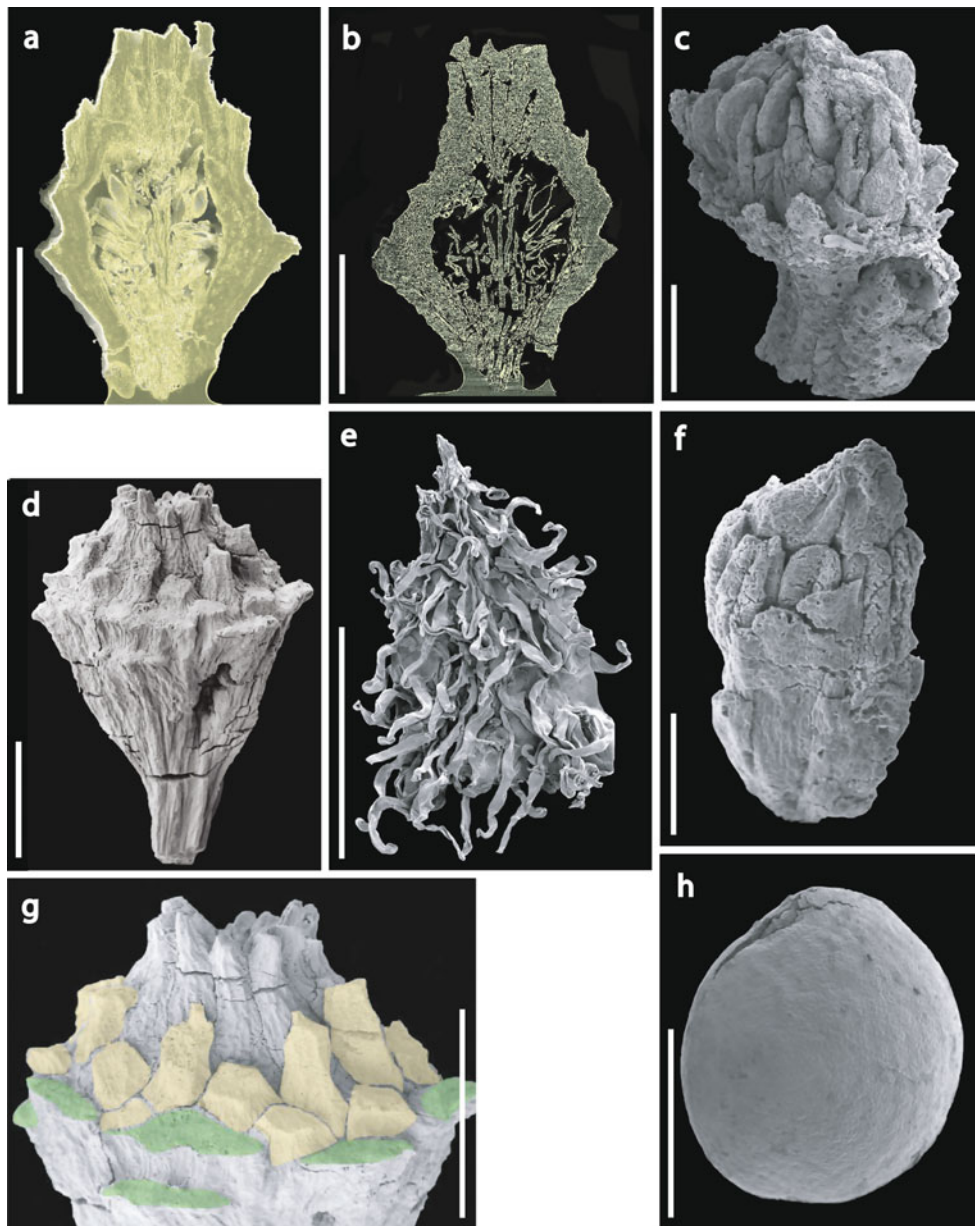
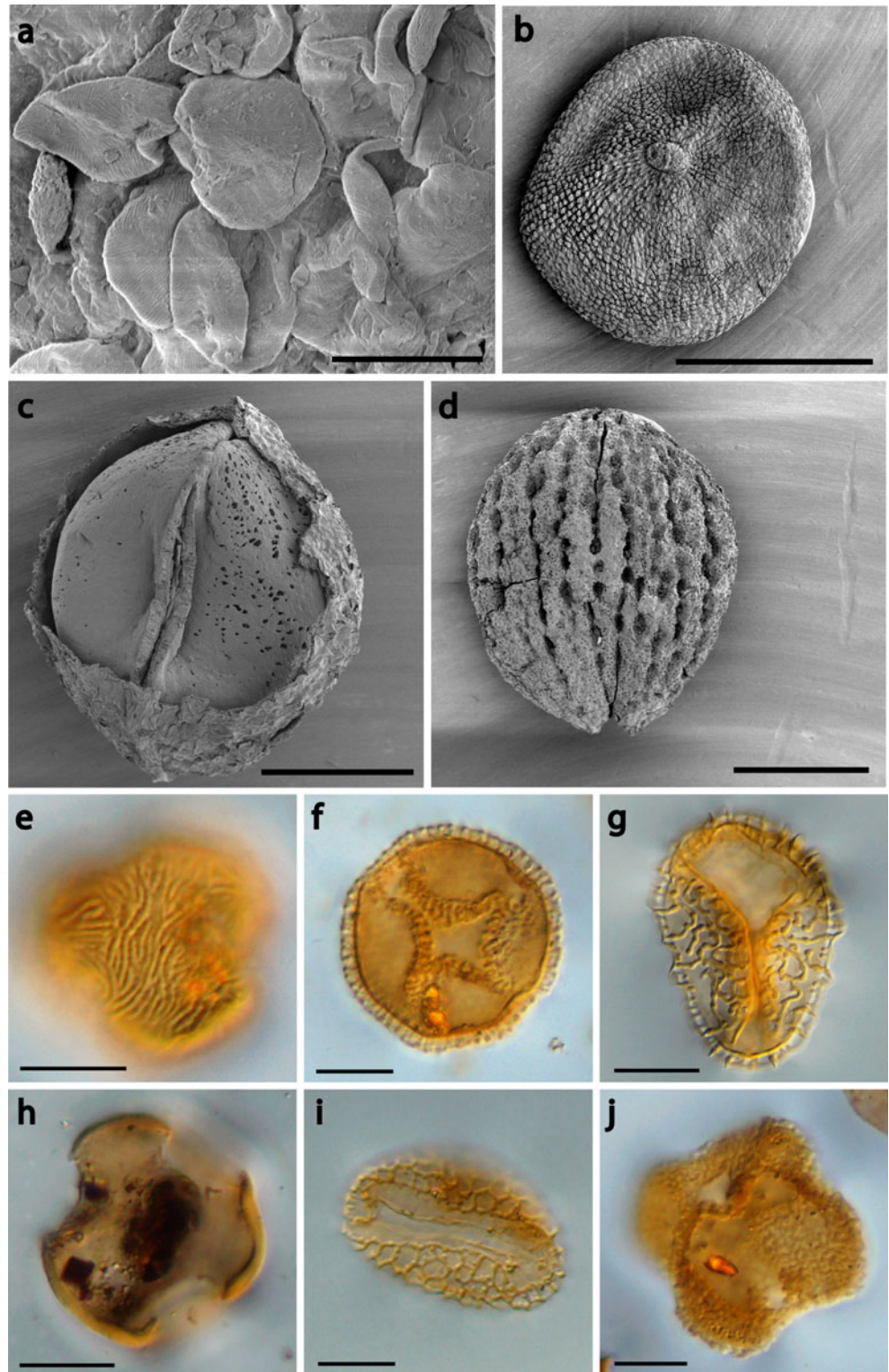


Fig. 3 Flowers, fruits, seeds and pollens, representing the extraordinary diversity of fossil basal angiosperms from the Barremian to Albian of Western Portugal. SEM micrographs, except **a** and **b**. **a, b, d, g** *Monetianthus mirus* Friis, Pedersen, von Balthazar, Grimm and Crane (Late Aptian–Early Albian), a fossil nymphaealean flower of Vale de Agua flora of Portugal; holotype (S122015); scale bars=1 mm (reproduced with permission from Friis et al. 2009b, The University of Chicago Press, USA). **c, e, f, h** From the Late Barremian–Aptian Torres Vedras mesofossil flora; scale bar=300 μm (reproduced with permission from Friis et al. 2009a, Elsevier B.V., Amsterdam, the Netherlands). **a** 3D reconstruction generated from synchrotron radiation X-ray tomographic microscopy (SRXTM) slices imaged on the TOMCAT beamline of the Swiss Light Source of the Paul Scherrer Institute. The flower is visualised from the inside, is segmented close to the centre and exposes two of the 12 locules in their full length and width. Each locule has several ovules. Ovules do not fill out the locule cavity, and placentation is laminar. The reconstruction was made by

Else Marie Friis using Avizo software; **b** SRXTM reconstruction; longitudinal section (narrow lateral orientation of specimen) close to the centre of the flower showing several septa and locules with many ovules; **c** hypogynous, bisexual trimerous flower with *Retimonocolpites*-type pollen in stamens. S101306; sample Torres Vedras 39; **d** lateral view showing gynoecium with inferior ovary, series of tepal and stamen bases/scars and tips of carpels; **e** fruit of *Appomattoxia* sp. with hooked spines and *Tucanopollis/Transitoripollis*-type pollen adhering to the surface. S136786; sample Torres Vedras 44; **f** hypogynous, bisexual and multicarpellate flower in lateral view showing remains of perianth, and stamens surrounding the central free carpels. S136716; sample Torres Vedras 299; **g** close-up of **d** showing upper part of the flower in more detail and coloured to show position of tepals (green) and stamens (yellow); **h** seed in lateral view with exotestal seed coat and wavy anticlinal cell walls. S136736; sample Torres Vedras 43

Fig. 4 Flower, fruits, seed and pollens, representing the extraordinary diversity of fossil basal angiosperms from the Barremian to Albian of Western Portugal. **a** to **d** SEM micrographs of ongoing research by M.M. Mendes; Late Aptian to Early Albian of Juncal mesofossil flora; P-numbers refer to specimens deposited in the collections of the Earth Sciences Department, Technology and Sciences College, New University of Lisbon (Portugal). **e–j** Photomicrographs of angiosperms pollens; *Cresmina* section; kindly provided by Uli Hemhofer (Ruhr-Universität, Bochum, Germany); scale bars are 10 μ m. **a** Striate pollen found in situ in a putative monocot flower (P0082). Scale bar=10 μ m; **b** seed related to Nymphaeales (P0070). Scale bar=0.5 mm; **c** fruit (inner part) (P0088). Scale bar=0.5 mm; **d** endocarp fruit (P0095). Scale bar=1 mm; **e** *Striatopollis trochuensis* Ward 1986, L–66, 158.8 m (Middle Albian); **f** *Asteropollis* cf. *asteroides* Hedlund and Norris 1968, L–16, 108.9 m (Early Albian); **g** *Dichastopollenites* sp., L–66, 158.8 m (Middle Albian); **h** *Tricolpites* sp., L–69, 163.9 m (Middle Albian); **i** *Retimonocolpites* sp. 4, L–52, 145.5 m (Middle Albian); **j** *Hammenia* aff. *fredericksburgensis* (Hedlund and Norris) Ward 1986, L–31, 121.1 m (Early Albian)



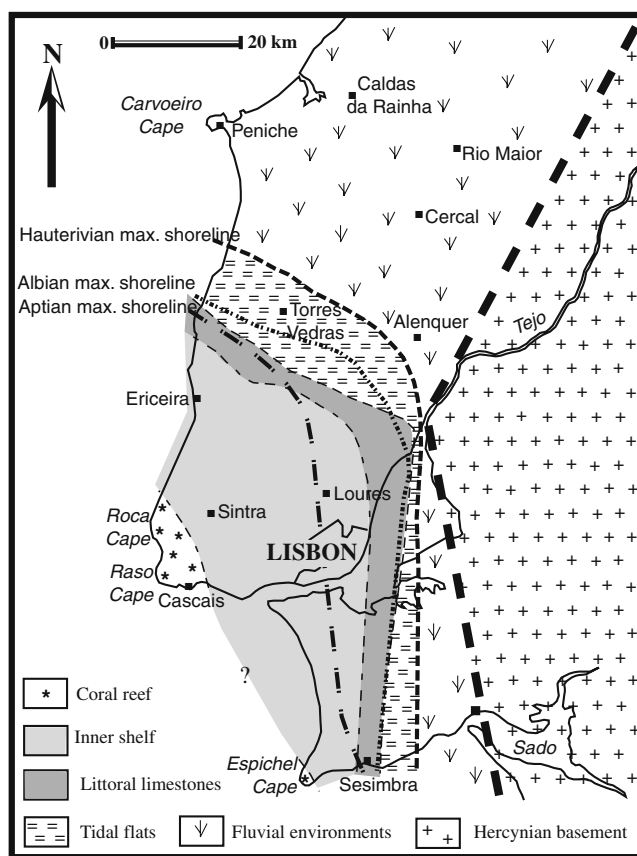


Fig. 5 Early Cretaceous transgressive maximums in the nowadays on-shore southern part of the Lusitanian Basin deposits: mid-Hauterivian (with a palaeoenvironmental sketch), Early Aptian and Late Albian. Notice that all the referred angiosperms mesoflora sites

are located in areas fully fluvial during the Barremian to Early Albian times, within the map or further north (compare with Fig. 2). Modified after Rey and Dinis (2004)

and understood essentially as mineral resources—meaning goods subject to exploitation and economic profitability. In fact, legislation has for centuries governed the activities of research, exploration and exploitation of such goods, regarding them as special interests for national economy, as currently expressed in the Decree-Law 90/90 of March 16 (General Regime for the Exploration and Exploitation of Geological Resources; mineral resources in English sense), the Decree-Law 109/94 of April 26 (Legal Regime for the Research, Exploration and Exploitation of Petroleum) and the Decree-Law 270/2001 of October 6 (Legal Regime for the Exploration and Exploitation of Mineral Masses—Quarries), as well as in other complementary legislation on this specific kind of resource. Within the strategic objective of a sustainable use of mineral resources, the National Programme of Territorial Planning (Law 58/2007 of September 4) points specifically to the definition of a policy for integrated management of those resources, namely based in the development of an inventory of prospective geological sites as a priority action.

However, the need to consider such sites as a value for society and a fundamental component of “respect towards nature”, which must be preserved for future

generations, is being more and more stressed. Together with the notion of mineral resources, the idea of geological heritage emerges in society, and for a few years it has become integrated into some formal documents—including recommendations and declarations from international or supra-national institutions.

The UNESCO *Convention concerning the Protection of the World Cultural and Natural Heritage*, adopted by the General Conference at its seventeenth session (Paris, 16 November 1972) states in the preamble that “the deterioration or disappearance of any item of the natural heritage constitutes a harmful impoverishment of the heritage of all the nations of the World”, and in its Article 2 recognises that geological and physiographical formations can have outstanding universal value from the point of view of science or conservation as natural heritage. The 1991 Digne “Declaration of the Rights of Memory of the Earth” established the definition of geological heritage and states that the people and the governments are but the custodians of such non-renewable heritage.

In spite of these broad statements, geological heritage in some countries only recently became recognised as an

autonomous concept and started its integration in legal frameworks. A remarkable step was the 2004 Council of Europe's *Recommendation for the Conservation of the Geological Heritage and Areas of Special Geological Interest* (Rec(2004) 3, of May 5th), "recognising that the conservation and management of geological heritage need to be integrated by governments in their national goals and programmes", urging governments to "identify in their territories areas of special geological interest" and "develop national strategies and guidelines for the protection and management of areas of special geological interest embodying the principles of inventory development, site classification...". Furthermore, governments of member states should achieve those goals by "developing and implementing new laws if such areas cannot be protected by existing laws", "strengthening existing laws to increase protection" and through "implementation of new or existing laws for the protection of areas of geological importance, to be linked to national site inventories and national site databases."

Also the International Union for Conservation of Nature, the world's oldest and largest global environmental network, in its World Conservation Congress held in Barcelona in October 2008, established the promotion of "conservation of geodiversity and geological heritage" as a goal of the organisation (motion CGR4.MOT055), trying to "achieve the widest possible involvement of government, independent sector groups and international organisations around the world."

This new reality—the awareness of the existence of a *geological heritage*—required different and renewed measures for geosites, namely the adoption of measures aiming its *protection, conservation and management*, which only laws can grant.

As to geoconservation in Portugal, until recently no law has discriminated geological heritage as an autonomous value within natural heritage, clearly subordinated to the biological heritage (Henriques 2004). However, the Portuguese Basic Law on the Environment (Law 11/87 of April 7, see details in Dias and Mendes 2002) started its pathway to the recognition of geoheritage through the National Strategy for the Conservation of Nature and Biodiversity (Council of Ministers Resolution 152/2001 of October 11), where it becomes a national goal referred to as the need to "promote the scientific research and the knowledge on natural heritage", "improve all over the national territory actions specifically for...the conservation and promotion of the landscape heritage and the remarkable elements of the geological, geomorphological and palaeontological heritage" and "improve the articulation and co-operation between the central, regional and local administration". In this respect, the Madeira Autonomous Region has been a pioneer, having a regional decree (24/2004/M of August 20) with more specific rules concerning (1) the competence

for the promotion of concrete measures of protection, (2) the definition of what constitutes an infraction and even (3) the amount of penalties.

From the National Strategy for the Conservation of Nature and Biodiversity resulted the recent Legal Regime on the Conservation of Nature and Biodiversity (Decree-Law 142/2008 of July 24), that finally established geological heritage and geosites as autonomous concepts, both included explicitly in the definition of natural values and implicitly in the definition of natural heritage. This legal keystone also defines the different designations that confer different statutory protection, extinguishing some designations and creating new ones. This implies that for geosites that possessed any the now abolished designation (status) a new application file should be presented for regaining legal protection. Even if this can involve some time gap in legal protection, it is also an opportunity for a renewal of geoheritage analysis. Unfortunately, the same law did not recognise the concept of geodiversity, thus amputating the document's scope of one of the perspectives that can be used to argue for geoconservation.

Geoconservation can be assumed as mandatory by law since Decree-Law 142/2008 of July 24 article 4th assumes (1) the "Principle of the social and public function of natural heritage", (2) the "Principle of identification, imposing the promotion of the knowledge, classification and registration of the natural values that integrates the natural heritage", (3) leading to the implementation of the "Principle of protection, imposing an effective safeguard of the most significant values of our natural heritage". The same Decree-law states that "should be classified as protected areas...natural occurrences that have, by its rarity, scientific values, ecological...a special relevance demanding specific measures of conservation and management ..." (article 10th, #2) and attributes these functions to the Institute for the Conservation of Nature and Biodiversity (ICNB) as national authority, in collaboration with local (municipal) and regional administration.

Regional Planning and the Case of the Municipal Management Plan

The implementation of political statements and a high-level legal framework is basically achieved by a system of legal instruments of regional planning and management of different nature and rank. The recognition of the geological heritage was also included as a target in the National Programme of Territorial Planning (Law 58/2007 of September 4), that explicitly refers to the need to "complete and update the geological mapping on the 1:50,000 scale" and "identify and classify the remarkable elements of the geological and mining heritage". This programme is in the scope of the Basic Law of Territorial Planning and Urbanism (Law 48/98 of August 11, see details in Correia 2003).

The Decree-Law 142/2008 of July 24 refers to the possibility or even requires management plans for most categories of protected area at a national level, but for categories of regional and local level the Municipal Management Plan (PDM), as well as possible specific plans, prevails if included in the classification application. The same law gave competence to the regional and local authorities to present applications files for classification of geosites and participate in the planning and management of protected areas of national rank. The PDM is a detailed, fine-scale, instrument for prospective land use, with a technical scheme imposing a field survey articulated with remote sensing and with a geological component. It can even establish areas reserved and protected for future exploitation of mineral resources, based on the evaluation of known or merely presumed volumes. Unfortunately, many of the PDMs currently in force have very poor or no geological content.

Environmental laws (also managing matters related to the geological heritage conservation) and regional and urban planning laws overlap and sometimes contradict one another in the application process that can concede a licence for a project (Dias and Mendes 2002). Local (municipal) authorities may play a key role on the implementation of such legal goal, namely by (1) its capability to grant many types of licences, concessions and contracts linked with the land use, (2) the protective, preventive and forecasting capability of the PDMs, (3) the detailed knowledge of the area, and, last, but not least, (4) the motivation for the promotion of local values (some with global importance).

Considering the above-mentioned legal strategies and guidelines, as well as many positive cases of co-operation between the Earth Sciences community and the municipal authorities (e.g. the Arouca Municipality, Portugal; see Brilha 2008), we believe that future editions of PDMs will provide excellent opportunities to study, classify, protect and manage many elements of special geological interest.

The Identification of Geological Heritage, Property Rights and Scientific Research

Problems Involved with the Identification of Geological Entities

It is actually more difficult to identify something (an entity) that may be considered as geological heritage than other values or materials that have already acquired an undeniable juridical status, such as *biodiversity* or *cultural heritage* (built or portable). In fact, this kind of goods already holds a strong juridical safeguard in different national legal regimens (Abaide 2009), given the wide awareness of their significance in society (especially the cultural heritage), or from the proximity between Humankind and these “subjects”.

Besides, there is still the fact that, due to the specificity of the subjects, it is certainly easier for the community to recognise their special value: the value of a stone axe, a roman coin, a mediaeval castle, the rain forest as the planet’s lung, the almost extinct Iberian linx (*Linx pardinus*), or the codfish stocks is more perceptible than the value of entities integrating geological heritage. In fact, only quite rare geological entities have its scientific or economic value recognised by the general public, (like “precious” rocks or dinosaur bones), with the overwhelming majority not being recognised as valuable. This means that, accepting that it is necessary and possible to inform the general public of the interest and value of geological heritage, certain entities requires the intervention as mediator of expert geologists (Reis and Henriques 2009) who must have resources and means for their investigation – educational, human, financial and legal.

As in many other countries, namely in most European ones, Portuguese statutes that specifically require the identification and protection of geosites are clearly separated from mineral extraction legislation. This foresees the establishment of contracts for the attribution of *exploration* and *research* rights that can eventually lead to the attribution of *exploitation rights* over mineral resources that integrate the public domain (rocks, minerals *s.s.*, hydromineral resources, geothermic resources), as well as it requires the attribution of *exploitation rights* and *establishment licences* on all the others (mineral masses and spring waters). Such *constitution of rights* must balance the public interest and private ownership rights.

The mineral extraction legislation clearly distinguishes the *research and exploration* phase from the *economic exploitation* phase—this seen as a later step, providing that the former allowed the detection (characterisation and evaluation) of resources with economic potential. Due to the non-renewable nature of mineral resources, contracts for the research and exploration, and exploitation imposes limitations on the rights of the operators. By requiring methods that optimise the exploitation and do not threaten later evolution in exploitation, as well as imposing environmental protection measures, such clauses are a case of public interest prevailing over private profit.

Although it is not mentioned in the Portuguese legislation applicable to mineral resources, another phase should also be distinguished, which precedes the other two and may be referred to as the improvement of the general geological knowledge of a territory. Such task, it must be emphasised, inevitably includes field studies, like recognition, cartography, sampling, essays, etc., and cannot be scientifically correct if pieces of the territory are omitted or are rendered inaccessible. This phase is frequently achieved

by scientific researchers (e.g. academic or governmental institutions) and used as a background for the research and exploration phase referred to in the legislation, and a fundamental contribution for the evaluation (in the sense of the determination of the discovery's economic value). We can conclude that scientific geological research is, after all, the initial step for the economic exploitation of mineral resources, as recognised in most of the countries where it is one of the justifications for public funding (e.g. to geological surveys and universities).

In the scope of the research, exploration and exploitation of mineral resources, the legislation establishes particular regimes of access to private property, namely in areas specified in licences and contracts. However, the same does not occur when only the needs for basic scientific investigation are at stake, including research to “complete and update the geological mapping on the 1:50,000 scale” and “identify and classify the remarkable elements of the geological and mining heritage” (Law 58/2007 of September 4), as is the case of the aforementioned projects on the Cretaceous of the Lusitanian Basin.

The geological field work within scientific research—as shown, an activity with clear relevance and public interest—poses specific juridical problems, namely because it can imply activities carried on in privately owned properties. We must keep in mind that private property is a fundamental right, similar to the rights, liberties and warranties protected, as such, in the Constitution of the Portuguese Republic.

Since contradictory interests can emerge between *scientific research* and *private property*, can this conflict be resolved through the imposition of restrictions on the rights of private landowners, this done in the name of the public good, as research is regarded as such by society? This question can be addressed by statute, in a manner similar to that with research, exploration and exploitation at sites with exploitable economic mineral resources.

Restrictions to the Land Property Rights Related to Mineral Resources

In many countries, even those with a strong tradition of private property like Portugal, the land surface can be considered as private, but mineral resources as in the public domain. The concept of private property, in Portugal, as in other developed countries with the western civilization matrix, is currently evolving from an absolute and individual sense towards a “social function”, where the public interests diminish the rights of the owner (Abaide 2009). Activities indispensable to the exploitation of mineral resources, although usually giving compensations, impose restrictions to the property right, namely the *temporary occupation* of ground, the application of *administrative restrictions* and

even in extreme cases the *expropriation of land for public utility* reasons (as in Spain and Brazil; Abaide 2009). Specifically, the legislation foresees that the holder of a right for research, exploration and exploitation of mineral resources has the faculty to *occupy temporarily* the lands necessary to the accomplishment of those activities, provided he pays a rent and a caution for covering possible losses. When the lands subject to expropriation are private property, the legislation foresees the need for the *owner or tenant's authorisation*, but also that, otherwise, it may be subject to *judicial mandate*. Administrative restrictions can be imposed on the lands bearing mineral resources in order to preserve their possible exploration, research and exploitation.

Finally, expropriation is seen as a means for acquiring lands where mineral resources exist whenever the owner refuses to explore them on his own, does not allow the exploitation by others, or tries to impose unacceptable conditions.

In territorial planning, the government may define areas with restraints on land use aiming to prevent or minimise the activities that can later difficult the exploitation of mineral resources: if the mineral masses are recognised, as the more restrictive “captive” *areas*; if the existence of mineral resources is only presumed, as *reserves* for later exploitation of materials with special interest for the national or regional economy. Such restrictions can be defined even at local (municipal) level (in the PDM), frequently without detailed geological knowledge. Accordingly, the delimitation of these areas imposes important restraints on land property rights.

Restrictions to the Land Property Right Related to Scientific Research

Regarding geological fieldwork for scientific research, three questions arise immediately: (1) if the legislation foresees access to private properties, and, if yes, (2) who can use such licence and (3) the issuer of such kind of authorisation. Most authorities opine that the answer to the first question is so far a negative one, an opinion strengthened by the fact that basic research does not lead straightforwardly to any subsequent mineral exploitation of the site, a situation that would require the establishment of real rights.

The above-mentioned Legal Regime on the Conservation of Nature and Biodiversity (Decree-Law 142/2008 of July 24) imposes the need to give legal protection to entities recognised as geological heritage, be they in private or public property (article 10th, #3).

A high-level legal base for the creation of statutory restrictions to the land property right, aiming scientific research, are the constitutional norms stating that (1) the state should protect the environment, namely by assuring scientific studies, and that (2) the exploitation of natural resources must be subjected to the public interest, such as environmental protection. This means that all geological

materials, in abstract and even before characterization, has potential interest as geoheritage, belong to the domain of public interest and, so, deserve the efforts of public organisations for their preservation.

Internationally widespread environmental impacts studies provide an analogy to our proposals. In fact, the activities dealing with the exploitation of mineral resources (mineral extraction industry) and civil engineering works that involve excavation have to promote previous impact studies that can—we think it should—include the search, study and classification of geological heritage. It can also be stressed that such measures could be efficient for geological sites with economic, ecological or heritage value.

Another possible contribution for the identification of geological heritage would be the establishment of a legal framework identical to the one currently applicable to archaeological heritage. The Base Law for Politics and the Regime for the Protection and Promotion of the Cultural Heritage (Law 107/2001, of September 8), states:

“In any place where the existence of traces, goods or other archaeological traces may be presumed, there may be established with preventive and temporary character, by the competent organ of cultural heritage administration, an archaeological protection reserve, allowing the execution of emergency works in order to determine its interest.”

The establishing of similar reserves, necessarily implying restrictions of property rights, with possibilities for the payment of compensation, should be considered for geological heritage sites. Thus making possible their adequate study and protection, and eventual conservation and management. Naturally, after the identification of scientific value and its inclusion in an inventory, the lands containing geological heritage, although being private property, may be subject to restrictions, namely of administrative character, in the case of recognised public interest, *delimitation of preservation areas* and even the *expropriation due to public interest*.

On the other hand, an early technical-scientific knowledge or evaluation can minimise the restrictions on property rights or on the execution of public works due to possible occurrences of mineral resources or geological heritage, and even so increasing the knowledge on the Earth-Science issues. In this sense, scientific research is an instrument to avoid restrictions based merely on the precautionary principle, which may eventually prove unnecessary.

Licensing Geological Fieldwork for Scientific Research: A Proposal

Portuguese legislation relating to geology does not expressly recognise scientific research in the field, leaving this important question as an unconsidered issue. On the

contrary, some European juridical frameworks subject this activity to a special licence (for scientific purposes), as in some German and Italian regional laws (Ramos 1994), whose applied duration may coincide with the period of commercial extraction.

Although we may conclude, given the above legal framework and the absence of specific regulation, that a special *licence to undertake research fieldwork* is unnecessary in Portugal, in fact the non-existence of such licence had limited the exercise of this activity. We believe that the main reason why that licence was not created is because it establishes that public interest can rule over private owner in some degree.

However, we must consider that private property rights are constitutionally protected and subject to a particular regime—implying that any restriction must obey the “principle of adequacy” by having suitability, necessity and proportionality *stricto sensu*. It must also respected the principle of proportionality, that determines that restrictions to the property right must be only those shown adequate and necessary to the ends aimed, and that an equilibrium exists between the benefit to the public good (in this case, the benefits coming from a better identification and recognition of both geoscience sites of interest and mineral resources) and the costs incurred by the private owner. This means that a measure can only be adopted if balanced and not obviously excessive, as could be the case of a *generic recognition of the public interest* of geological fieldwork for scientific research.

On the contrary, the recognition of the public interest of a *given* scientific research may justify the imposition of restrictions on private owners’ right, namely by conceding the entrance in private property, even with the opposition of the owner. Consequently, such recognition should be the task of an official agency certifying *specific research projects* or issuing a permit to recognise a *researcher* or *field geologist*. This may be accomplished through the establishment of a system based on some kind of evaluation committee involving official institutions. As a preliminary proposal, it should include the Laboratório Nacional de Energia e Geologia (Portuguese Geological Survey), governmental agencies regulating the exploitation of mineral resources and public works, universities and research institutions, as well as professional associations and scientific societies.

In most countries it is normal that researchers of the geological survey, and increasingly of nature conservation agencies, use an official card allowing free entrance in any kind of property. It is the case, for instance, in France with the researchers involved in the general geological mapping under the auspices of the Bureau de Recherches Géologiques et Minières (BRGM; the French Geological Survey). This position is probably related with the historical strategy of this bureau: the general geologic knowledge is

vital not only to exploit the mineral resources, but also to land planning and environmental management. In the USA, each state has slightly different approaches, but for example the researchers of the Virginia Division of Mineral Resources have immunity from prosecution for trespass (Code of Virginia, 45.1–389: “No criminal action for trespass shall lie against the State Geologist, or any agent or employee of the State Geologist, on account of lawful acts done in the performance of their duties, including entry upon the lands of any person or persons for the purpose of performing such duties.”).

In order to evaluate its potential public interest, it is convenient to consider the established fieldwork practice of geologists or associated experts, systematically related to:

1. the general knowledge of a territory, usually associated to state institutions with that specific goal (like the *Serviços Geológicos de Portugal/Instituto Geológico e Mineiro/Divisão de Geologia do Instituto Nacional de Engenharia, Tecnologia e Inovação/Laboratório Nacional de Energia e Geologia*, the successive designations of the Portuguese Geological Survey);
2. orientated scientific research, which is related to the institutions mentioned in 1., as well as universities and state laboratories;
3. research on and exploration for mineral resources and the environmental studies for major engineering projects, mostly performed by private corporations.

With the first two, where research is at stake in public institutions, it is easier to determine their public interest, justifying the imposition of restriction on private land. Even for fieldwork not leading to the exploitation of mineral resources, like environmental impact studies or pre-contract explorations, it should be considered the possibility of recognition or certification as scientific research of public interest.

We believe that a real improvement in science and sustainable development can be achieved by legislation allowing geological scientific researches to access private property, namely through an official title of field researcher (or geologist) and or the recognition of public interest on research projects.

Notification of New Finds with Special Geological Interest

New finds of materials with special geological interest, potentially to be considered as geological heritage, are very likely to happen during the mineral exploration and exploitation or construction works. Civil engineering, hydrogeology, quarrying, mining, oil industry, etc. include inevitably geological works like digging, drilling, in situ analysis, remote sensing and geophysics. On the other hand, those activities depend on rights granted by the state. In these circumstances, the fate of

newly discovered items depends a great deal on what is expressed in the clauses in licences, concessions, contracts, etc., but also on general rules consecrated a priori by law.

In agreement with the above-mentioned legal principles, the sites with special geological interest, even if not yet found and studied, should be considered as state property. Accordingly, its economic exploitation is reserved for the state, thus there is an obligation to notify officialdom of new finds, as with archaeological finds (Dinis et al. 2005; Abaide 2009). However, the efficiency of this mechanism is dubious, because in many cases the co-operation of most of the people, institutions and companies is required, and because a specialised knowledge is required to identify materials of value. So, we envisage two scenarios to fit the Portuguese situation, both relying on the state’s powers to approve and control concessions as a means to insure the notification of new geological finds. The details of possible penalties in case of breach of contract are outside the scope of this work, but we believe penalties could be employed on active and future concessions contracts for the exploitation of mineral resources.

Most operators with mineral concessions do not have human resources with scientific skills prepared to deal with this specific question. In this case, the role of external geologists becomes crucial and the quarry operator must, at least, grant access to authorised researchers, even though under reasonable security restrictions.

Differently, major concessions or projects (e.g. civil engineering, hydrogeology, quarrying, mining and oil industry) usually have clauses imposing the delivery to the supervising authorities of research and exploration data and/or environmental impact reports. This implies the participation of qualified geologists or analogous. We believe that in such cases the obligation to notify the authorities of finds (that qualify as geoheritage) should be included in any contract or concession. As usually specified in clauses of the contract for other specialties (like archaeology), external experts may have to be involved in fieldwork and, naturally, specialists must later examine the sites or collected materials.

Conclusions

During recent decades, geological heritage has become increasingly recognised as an important part of the natural heritage. Thus, its identification, protection and conservation are essential within the respect for nature and towards sustainable development, representing a capital objective for Mankind, to be achieved by the international community and, in particular, through states, as recognised by national and international agreements and laws.

The scientific research is the initial and one of the fundamental steps towards site conservation and eventually

the promotion of geological heritage. Actually, the vast majority of objects which constitute geological heritage, exist at various scales, and are (excepting museum specimens) field features, and consequently geoconservation implies the definition of protected areas.

We compare the Portuguese legal approach and research needs where geoheritage is concerned with, on the other hand, the exploitation of mineral resources. For the last one mentioned, the law foresees restrictions on private ownership in order to allow the exploration of economic mineral prospects, as well as imposes on operators regulations that promote efficient and environmentally friendly extraction methods. Restriction on private owners in the context of mineral exploration had a fundamental reason: to allow full access to the prospective mineral areas, unrestrained by the limitations of private property. Legally, it corresponds to the primacy of the public interest over private privileges.

From the above comparison we can conclude that two aspects can be seen as common:

1. an approach of many geological entities as unique, vulnerable and non-renewable features, needing a precautionary and conservative management based in scientific knowledge, and,
2. the need for the access of researchers to all parts of a studied area, regardless of legal tenure, in order to achieve the desired accurate scientific knowledge.

Concerning the Portuguese law applicable to geological heritage, the first item is currently included in recent decrees, but its real practice depends on the submission of sites of remarkable value to justify creating protected areas. This brings us to the second item, because the identification of a geological interest/site as outstanding is scientifically based and in many cases cannot be accomplished without a comprehensive regional study, obviously comprising unrestricted fieldwork. However, the same ensemble of laws does not foresee such a need, allowing private owners to deny access to researchers, thus jeopardising the entire conservation process.

So, following our earlier proposals (Dinis et al. 2005), recently also sustained by the study of the legal framework of several countries (Abaide 2009), we propose that legal measures should be put forward to balance private rights and the public interest, in particular by ensuring access to private property by officially recognised researchers, and/or researchers involved in officially recognised projects.

Notification of finds of special geological interest would be a helpful step for geological research and heritage conservation. Recalling that the large majority of the activities potentially revealing geological information depends on state concession to perform those acts, we propose that (1) all the concessions imply the full access for scientific research and (2) for major civil works and mineral exploitations, clauses

implying the notification of geological finds should be included in licences, concessions, contracts etc.

The above-mentioned reality is here illustrated by a situation in which the owner of a concession for sand-mining denied access to research geologists, an event that occurred during a project focusing on the Lower Cretaceous (Barremian to Albian) of central Portugal. These rocks enclose some of the earliest and best-preserved primitive angiosperms assemblages, considered as outstanding to gain insights into the time, speed and environmental forcing of the mid-Cretaceous fast and intense angiosperms diversification that lead to the enormous present-day diversity. Studies on regional stratigraphy are crucial to independently date the sites and consequently the evolutionary events. Sequence stratigraphy and sedimentological works will improve the palaeoenvironmental interpretations and clarify the links with Atlantic tectonic and magmatic events, as well as with regional and global climatic and oceanographic changes.

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