Revista de la Sociedad Geológica de España 26 (2)

ISSN (versión impresa): 0214-2708
ISSN (Internet): 2255-1379

BETWEEN HISTORY AND CONTEMPORANEOUS GEOLOGY: REVISITING A "CLASSICAL" (GEO) SITE FROM THE UPPER CRETACEOUS OF PORTUGAL

Entre historia y geología contemporánea: reconsideración de un (geo)sitio "clásico" del Cretácico Superior de Portugal

Pedro M. Callapez[1,2], José M. Brandão[3], Vanda F. Santos[2,4] and Celeste R. Gomes[1,2]

[1]*Departamento de Ciências da Terra, Universidade de Coimbra, Largo Marquês de Pombal, 3001-401 Coimbra, Portugal. callapez@dct.uc.pt.*
[2]*Centro de Geofísica da Universidade de Coimbra (CGUC - FCT).*
[3]*Centro de Estudos de História e Filosofia da Ciência, Universidade de Évora / Rede HetSci.*
[4]*Museu Nacional de História Natural e da Ciência, Rua da Escola Politécnica 58, 1250-102 Lisboa, Portugal.*

Abstract: *The history of geology intends to research biographies, ideas and controversies that have contributed to the epistemological building of knowledge, and to the products of fieldwork and laboratory investigation, and related written production on geosciences. A transversal research of all these elements allows revealing itineraries, outcrops and sites where pioneer studies have been done. Many of them still exist nowadays and are suitable for teaching and outreach activities of geoscientific literacy. An excellent example of this close link between history of geology and geoheritage can be explored in the "classical" outcrops of Salmanha (Figueira da Foz, West Central Portugal), where highly fossiliferous Upper Cretaceous carbonate units have been studied since the mid 19th century. Extensively described by Paul Choffat, from 1886 onwards, its stratigraphic sections and Cenomanian-Turonian faunas were major contributions for the scientific knowledge of that time, and can still be used as a source of information for modern workers and as an important resource for teaching and touristic activities.*

Key-words: *History of geology; geoheritage; Upper Cretaceous; Figueira da Foz; Portugal.*

Resumen: *La historia de la geología tiene como principales objetos de estudio las personalidades, ideas y controversias inherentes al proceso de construcción del conocimiento especializado y los productos de la investigación de campo y laboratorio, así como la producción documental asociada a las geociencias. El estudio de estos elementos revela itinerarios, afloramientos y lugares donde se realizaron estudios pioneros, muchos de los cuales siguen siendo accesibles y adecuados para las actividades educativas y de difusión y alfabetización en geociencias. Un excelente ejemplo de este estrecho vínculo entre la historia de la geología y el patrimonio geológico se puede observar en los afloramientos "clásicos" de Salmanha (Figueira da Foz), cuyas unidades carbonatadas fosilíferas del Cretácico Superior se han estudiado desde mediados del siglo XIX. Las descripciones de las secciones estratigráficas y faunas del Cenomaniense-Turoniense por Paul Choffat, desde 1886 en adelante, contribuyeron significativamente al conocimiento científico de la época, y aún siguen siendo utilizadas como una fuente de información para los investigadores actuales y un importante recurso para la enseñanza y las actividades geoturísticas.*

Palabras clave: *Historia de la geología; patrimonio geológico; Cretácico Superior; Figueira da Foz; Portugal.*

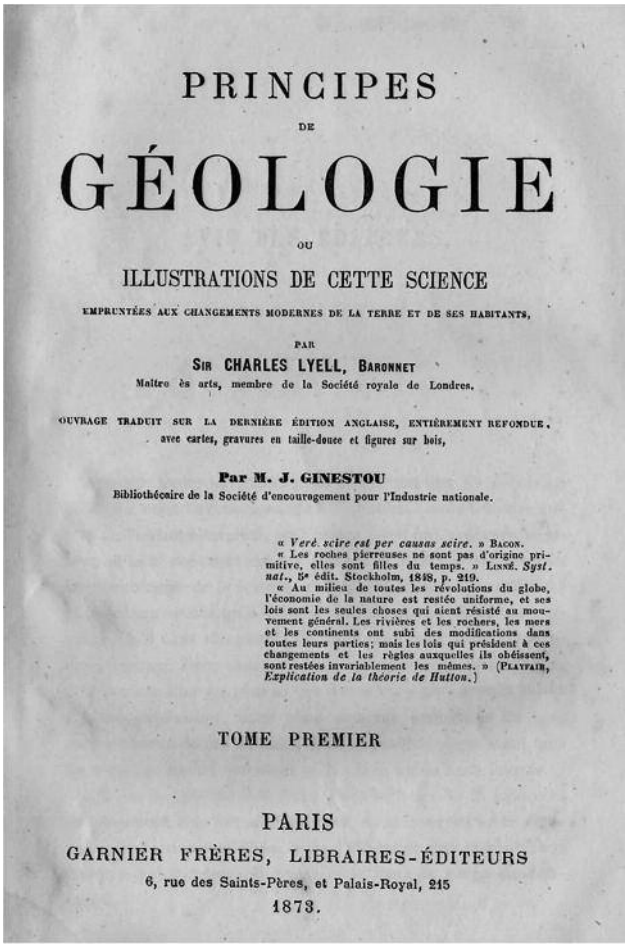
Callapez, P.M., Brandão, J.M., Santos, V.F, Gomes, C.R. (2013): Between history and contemporaneous geology: revisiting a "classical" (geo) site from the Upper Cretaceous of Portugal. *Revista de la Sociedad Geológica de España*, 26 (2): 5-12.

As a major branch of scientific knowledge, modern geology has more than two centuries of history. Except a few early ideas and basic concepts dating from the Classical Antiquity and the Renaissance, the *corpus* of its epistemological framework started to be built during the Enlightenment, but experienced its most noteworthy developments with the industrial growth of the nineteenth century. Since these distant times of unexpected discoveries, a huge amount of scientific work has been done, exploring new perspectives and theories to explain the morphology and structure of the Earth, its history and past living beings. One of the main advances was the contribution of early geognostic studies to understand the meaning of fossils, and their primacy as tools to establish interregional correlations between distant formations with the same relative ages (Rudwick, 1996).

Being a specific field of the history of science, the history of geology intends to research the biographies and the scientific interactions of those who have spent their lifetimes trying to understand structural and dynamic aspects of the planet. This has been achieved side to side with studies on the evolution of ideas, concepts and controversies, especially for those whose fieldworks and current paradigms have been widely accepted and set the trend. Thus, from a descriptive point of view, its historiography can be looked as a testimony of an unbroken chain of failures and advances in scientific process, where the role of many important contributors has deserved accurate biographic investigations (*The founders of Geology* in the sense of Geikie, 1897).

In those areas where many of the "classical" places originally visited by pioneer generations of geologists are no longer accessible, there may also be a large number of other sites which survived more or less unaltered, despite decades of anthropic pressure. In the perspective of David Oldroyd (1990), a conscientious return to these old sites is proved to be essential for the modern historiographers of geology, in order to review and contextualize the history of scientific works and gathered collections, but also due to the demand for scientific-cultural education that these places can easily satisfy.

These on site data collection should be integrated with the collections of minerals, rocks and fossils already gathered from previous studies, many of them centenary examples classified following old taxonomic practices, as well as good-quality specimens no longer available at the field. They still are sources of renewed geologic knowledge and pragmatic information resources for the history of geology (Jackson, 1999). Manuals and other scientific texts are also an additional object of study (Fig. 1), as they act as the main vehicle for circulation and transfer of specialized knowledge between distinct science production centers (Gavroglu, 2007; Gavroglu et al. 2008).



PRINCIPES
DE
GÉOLOGIE
OU
ILLUSTRATIONS DE CETTE SCIENCE
EMPRUNTÉES AUX CHANGEMENTS MODERNES DE LA TERRE ET DE SES HABITANTS,
PAR
SIR CHARLES LYELL, BARONNET
Maître ès arts, membre de la Société royale de Londres.
OUVRAGE TRADUIT SUR LA DERNIÈRE ÉDITION ANGLAISE, ENTIÈREMENT REFONDUE, avec cartes, gravures en taille-douce et figures sur bois,
Par M. J. GINESTOU
Bibliothécaire de la Société d'encouragement pour l'Industrie nationale.
« *Veré scire est per causas scire.* » BACON.
« Les roches pierreuses ne sont pas d'origine primitive, elles sont filles du temps. » LINNÉ. *Syst. nat.*, 5e édit. Stockholm, 1848, p. 219.
« Au milieu de toutes les révolutions du globe, l'économie de la nature est restée uniforme, et ses lois sont les seules choses qui aient résisté au mouvement général. Les rivières et les rochers, les mers et les continents ont subi des modifications dans toutes leurs parties; mais les lois qui présidaient à ces changements et les règles auxquelles ils obéissent, sont restées invariablement les mêmes. » (PLAYFAIR, *Explication de la théorie de Hutton.*)
TOME PREMIER
PARIS
GARNIER FRÈRES, LIBRAIRES-ÉDITEURS
6, rue des Saints-Pères, et Palais-Royal, 215
1873.

Fig. 1.- The *Principles of Geology* by Charles Lyell (1797-1875) have been repeatedly published since 1830-1833. The book is a mark in the history of geology, by its content as well as an example of a manual that influenced generations of worldwide geologists. Its French translations have been widely used in Portugal since the second half of nineteenth century.

Brief history of geoheritage

Some of the "classical" places described in early studies are remarkably adapted for the recognition and interpretation of geodiversity, architecture of geological processes, and palaeogeographic and biotic evolution. In this sense, they may be considered as cultural georesources prone for geoheritage conservation as "points of geological interest" (POGI'S) (Muñoz, 1988; Lleonart and Mata-Perelló, 2004). Of substantial importance are those with a history of descriptions contemporary to the "golden age" of palaeontological taxonomy, but also to the definition of stages and their stratotypes, chronostratigraphic scales, or early cartographic works. These attributes are valuable additions from a historical point of view (Ayala-Carcedo, 2000), especially if linked with the moveable geoheritage preserved in museums (Brandão, 2008).

The face of the natural heritage represented by worldwide museum collections is considered by many as absolute testimony of geodiversity, and its intrinsic value has been enhanced as part of a "cult" that contributes for its preservation and outreach. However, the paradigm that results from the enhancement of the virtues of conservation, interpretation and enjoyment of the natural environments out-of-doors still feeds the false dichotomy that opposes traditional museums and collections to new forms of presentation of geodiversity. Nevertheless, the

conceptual system of geoheritage involves both the moveable and the *in situ* environments, as two complementary facets of a whole strategy. For that purpose, the interdisciplinary view with the history of geology and palaeontology can be a noteworthy advance in a sense of complementarity, and a way to reduce apparent distance between the *in situ* geoheritage and the related museum collections and scientific publications disseminated outside.

The study of all these subjects has an obvious interest for the modern and contemporaneous history of science and its relationship with socioeconomic and cultural impacts. Many of these topics also have relevance for geoheritage and its importance for educational and cultural activities, because many concepts in geology contain a significant degree of abstraction and their comprehension can be facilitated with a historical approach, both in formal and non-formal educational settings.

Importance of the "classical" sites

It is known that many European "classical" geological sites have been revisited thousands of times by successive generations of collectors, geologists and school groups since their discovery in the eighteenth or nineteenth centuries. Their geological materials and contexts have been fully described for scientific purposes and their fossils, rocks or minerals are housed in museums, but also disseminated as didactic materials or personal collections. In any of these situations, there is a close and obvious relationship between the importance of these "classical" contexts as geoheritage, and their historical contribution for the development and epistemology of Earth sciences.

The understanding of the link between the history of geology and geoheritage, both *in situ* and *ex situ* as a methodological approach to reveal natural contexts and sites related to the geology of Portugal, is necessary as a proper planning of future activities.

There is a variety of subjects from the history of science that can be used as contributions to reveal 'points of geological interest' (POGI's). These subjects complement physical attributes already used by many, towards the identification of geoheritage *in situ* to preserve treasures of Earth legacy: samples, structures, and landscapes from present and past. Amongst them stand out the historical scientific researches concerning the site area and their importance for the local and regional socioeconomic development (economy, tourism, environment, education, science), as well as the scientific background of pioneers and further contributors, with emphasis on their importance to science and to the advance of knowledge on the geological setting. Other significant subjects to be considered are the importance of earth-sciences' evolution for the development of new ideas and models on local and regional geology, the relevance of the local geology for the development of new theories and new methodological approaches, and the contributions towards the scientific and cultural enhancement of historical geological collections.

Application to a palaeontological site

The Meso-Cenozoic sedimentary units of central west Portugal have several noteworthy examples of "classical" sites with historical background, singular relevance as geoheritage, and suitable educational approaches. The Upper Cretaceous formations stand out amongst them. They have been known since the early studies undertaken by Daniel Sharpe (1806-1856). This English pioneer on invertebrate palaeontology and president of the Geological Society of London spent several periods in Portugal taking care of business and travelling (Pinto, 1932), but also researching and collecting samples on the Palaeozoic and Mesozoic units of Oporto, Lisbon and intermediate areas, namely its Cretaceous units and fossil faunas (Fig. 2).

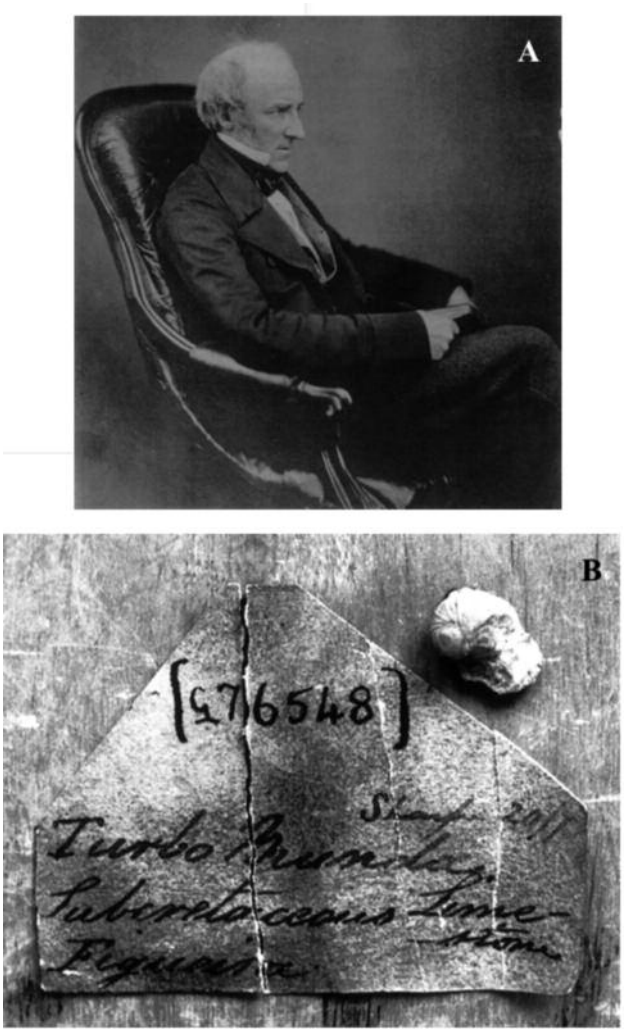


Fig. 2.- A - Daniel Sharpe (1806-1856) pioneer of the Portuguese geology (photo: courtesy of the Geological Society of London); B - Type and original label of *Otostoma mundae* from the lower Turonian of Figueira da Foz and housed on the British Museum (Natural History).

The Cenomanian-Turonian platform carbonates from the Baixo Mondego region of Western Central Portugal are some of the best examples of these units historically known since the Earth-Sciences' gold age. Here, the fossiliferous limestone and marly beds of the Costa d'Arnes Formation

(Rocha et al., 1981) display a set of large outcrops located in the "classical" areas of Figueira da Foz, Santa Catarina (fortress), Salmanha and Fontela (Fig. 3). These exposures have been widely studied since 1849. They have revealed a 65 meters thick stratigraphic succession with ammonites and abundant benthic invertebrates of middle Cenomanian to early Turonian age (Soares, 1980; Callapez & Soares, 2001; Callapez, 2003) (Figs. 4, 5).

The local sequences of shallow marine carbonated facies were fully studied by the Swiss geologist Paul Choffat (1849-1919) of the Portuguese Geological Survey (Fig. 6), and used to correlate faunal associations of the Tethyan and Temperate domains, during the Cenomanian-Turonian (Berthou, 1984; Callapez, 2008; Barroso-Barcenilla et al., 2011). Its early studies included the description of a remarkable ammonite fauna and the recognition of the genus *Vascoceras* Choffat, 1898 (Fig. 7), representative of the Vascoceratidae, one of the main mid-Cretaceous cephalopod families (Berthou et al., 1985; Callapez et al., 2001).

This significant palaeontological evidence was fully recorded in several historical collections gathered since the 1840s decade. They have been housed in Lisbon, at the *Museu Geológico* (the museum of the former Geological Survey of Portugal; Paul Choffat collection) and also in the

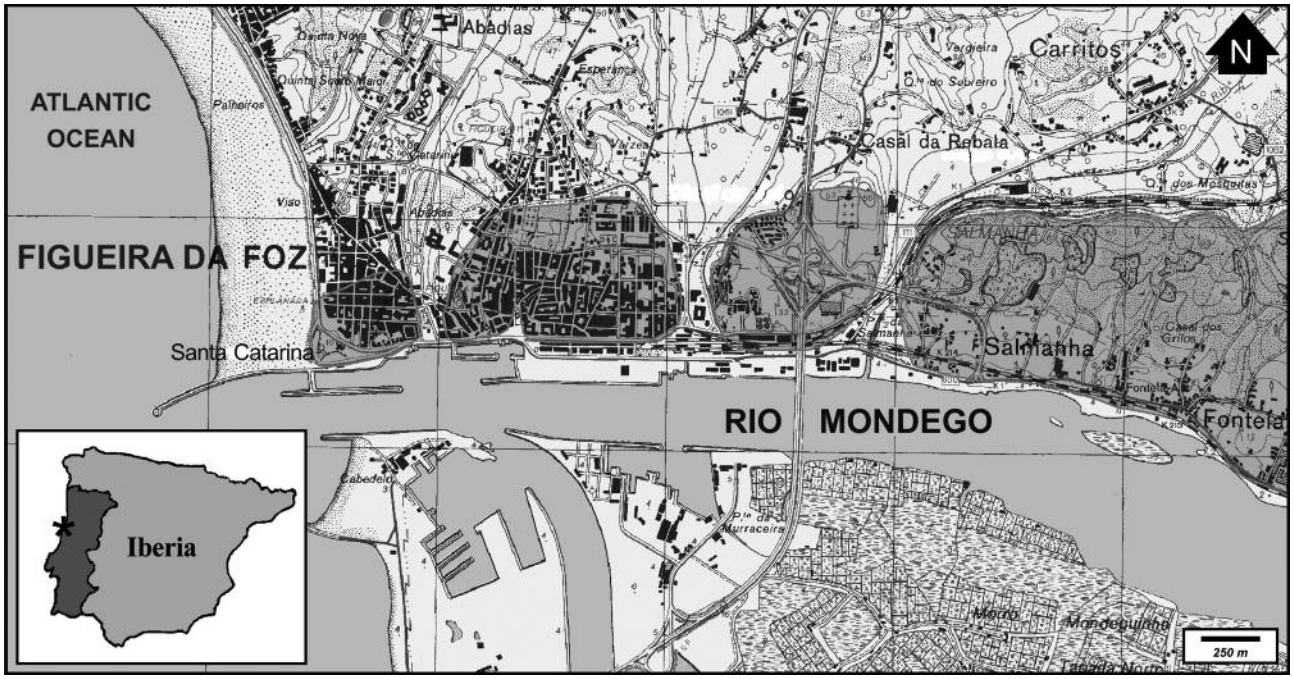


Fig. 3.- General map of the coastal town of Figueira da Foz and the Rio Mondego estuary, showing the "classical" localities of Santa Catarina (fortress), Salmanha and Fontela, and location of the Cenomanian-Turonian Costa d'Arnes Fm. (geologic data plotted on the 1/25.000 topographic map nº239 of Instituto Geográfico do Exército).

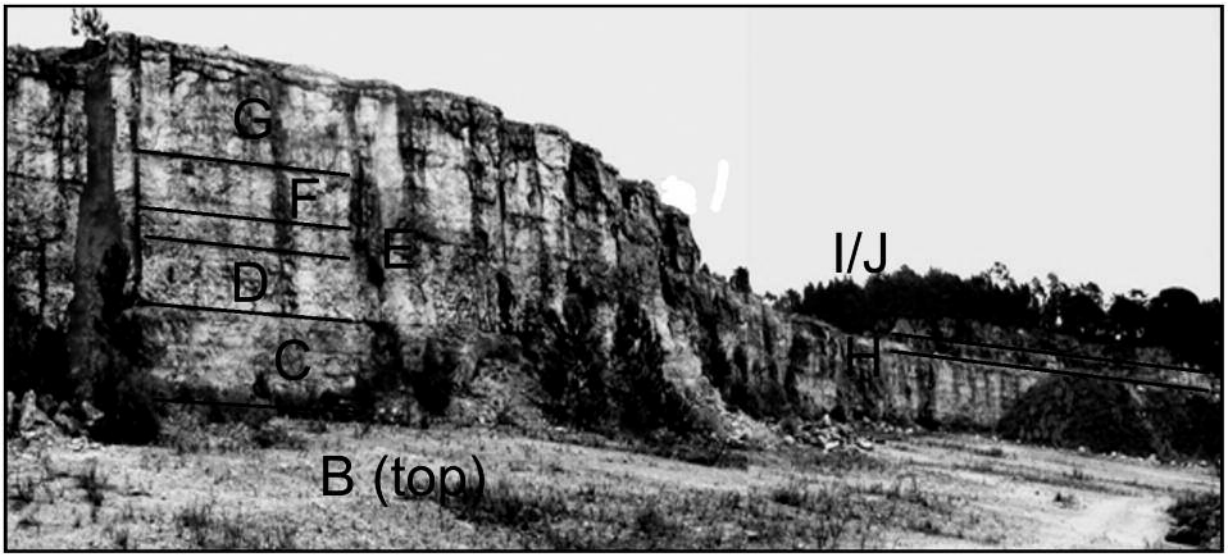


Fig. 4.- The main quarry of Salmanha (Figueira da Foz) and several of the Cenomanian units studied since the mid nineteenth century (beds "B" to "O" after P. Choffat, 1900; "E" thickness = 1 m).

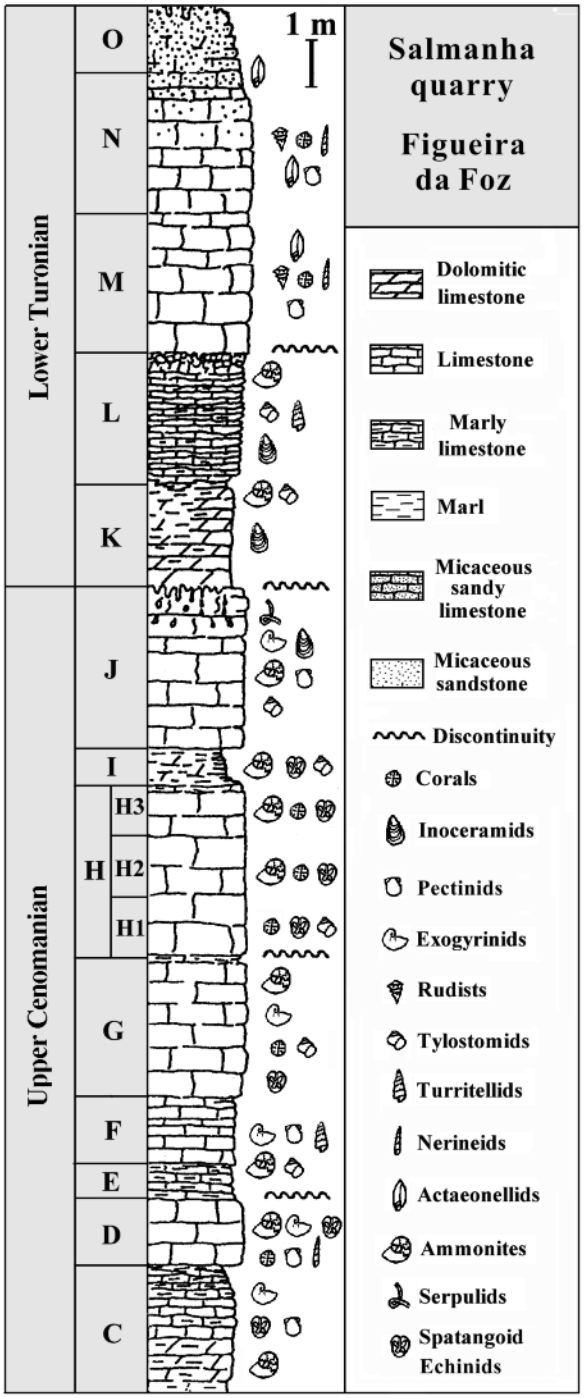


Fig. 5.- Stratigraphic section showing the upper Cenomanian and lower Turonian platform carbonates of Salmanha (Figueira da Foz) and their most common fossil invertebrates.

Museu Nacional de História Natural e da Ciência (University of Lisbon; nineteenth century specimens from the Geological Survey, and Pierre-Yves Berthou collection). Other additional collections have been held at the University of Coimbra and British Museum (Natural History), including that of Daniel Sharpe offered to the Geological Society of London in the year of his death, and therein deposited (Pinto, 1932).

At the same time, the current scientific work has resulted in several monographs dedicated to the Cretaceous

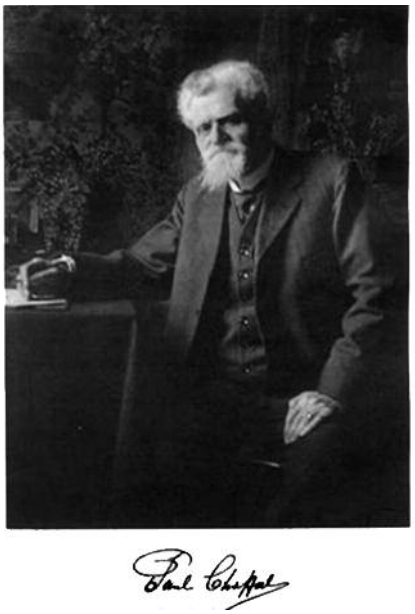


Fig. 6.- Paul Choffat in mid 1919, soon before his death (Photo: AHGM, LNEG).

stratigraphy and palaeontology of Figueira da Foz and other regional sections. The works of Daniel Sharpe (1849a,b,c), Paul Choffat (1886, 1898, 1900, 1902, 1927), Perceval de Loriol (1887-88), Gaston de Saporta (1894) and Henri Sauvage (1897-98), among others, are excellent examples of this rich bibliographic background and historical setting that allow us to acknowledge the importance of the area from the point of view of geoheritage (Fig. 8).

All these works generated taxonomic collections with type specimens housed in museums, and accessible to the general public. Side to side with this rich historical background of scientific studies, the "classical" outcrops of Figueira da Foz have been visited during many field excursions, among them scholar groups of geology and biology interested in practical concepts and *in situ* observations of sedimentary rocks, stratigraphic principles and fossil record.

Aspects of earth sciences' history, with emphasis on the history of the area, have been frequently used as a complementary methodology for non-formal teaching procedures. These approaches include, for instance: (1) the principles of historical geology and its synthesis in the local stratigraphic sections; (2) the historical evolution of Portuguese geology and its response to the introduction of new concepts and ideas; (3) Daniel Sharpe, Paul Choffat and the beginning of Mesozoic studies in Portugal; (4) the importance of stratigraphic historical collections for scientific knowledge, with emphasis on the Upper Cretaceous ones, and (5) the relevance of museum collections as part of geoheritage, and as an important tool for education and research towards geoconservation.

Conclusions

The epistemology of Earth Sciences (history, methods and evolution of knowledge) is a valuable issue that can be

Fig. 7.- The upper Cenomanian Vascoceratid ammonite *Vascoceras gamai* Choffat, 1898. Specimens from Salmanha, Figueira da Foz, (unit "E" of Choffat, 1900). The *derivatio nominis* is an homage made by Paul Choffat to the late XV and XVI Portuguese explorer D. Vasco da Gama, Earl of Vidigueira (Alentejo), 400 years after his successful departure to discover the maritime way to India.

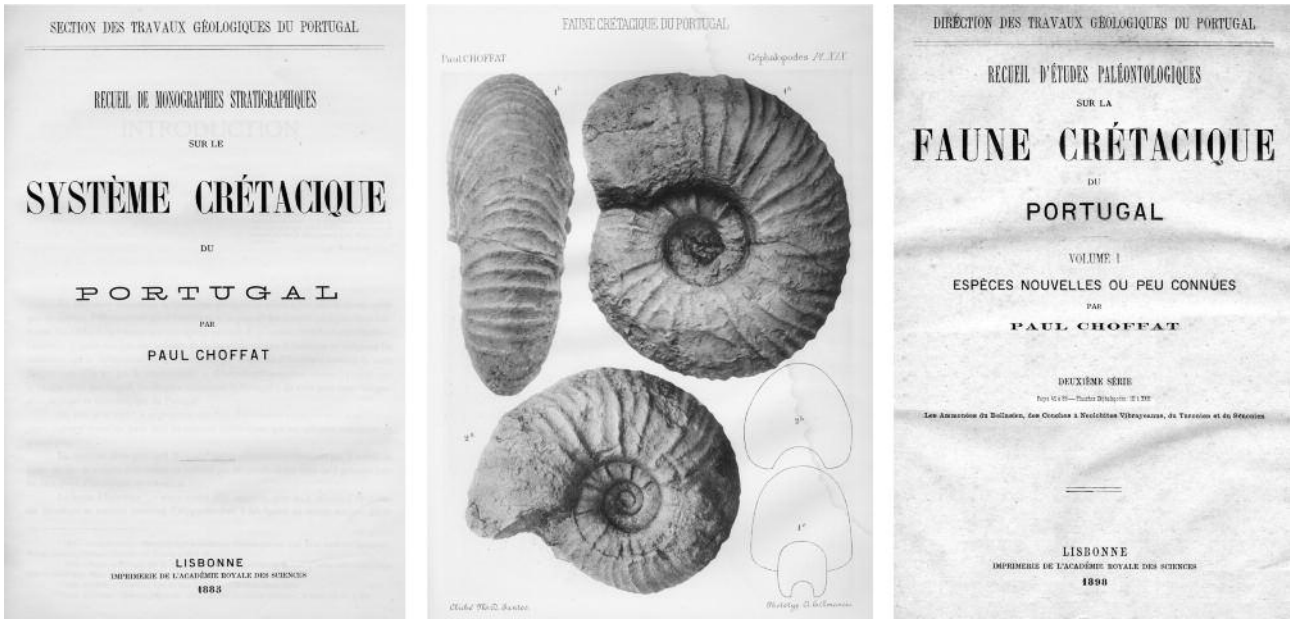


Fig. 8.- Front pages and monograph plate by Paul Choffat, describing the Upper Cretaceous of Portugal, and the section and faunas of Figueira da Foz focused on this paper. The figured specimens are *Pachydesmoceras* cf. *denisonianum* (Stoliczka, 1865) from the upper Cenomanian unit "J".

used for the selection and characterization of POGI's. This interdisciplinary view based on the history of geology and palaeontology has a special significance when it comes to "classical" sites with a long and rich background of scientific studies, museum collections and publications. From this point of view, its developments are congruent with the purposes and the specific conceptual system of geoheritage. At the same time, this methodology reduces the traditional gap between the "cult" of museum collections as absolute testimony of geodiversity, and the worship of geoheritage

preserved *in situ*. After all, these are two sides of the same coin. Thus, against this apparent antagonism, the interdisciplinary view opposes complementarity, mingling knowledge and efforts within the understanding of the history of Earth and life, and conservation of the natural heritage.

The same approaches of historical perspective can also be useful both for geoconservation and teaching of natural sciences, using the geological sites and their contexts as valuable didactic materials for interdisciplinary strategies. They have a wide field of application in the geology of Portugal, as demonstrated for the example of the Upper Cretaceous of Figueira da Foz.

Acknowledgements

The authors are grateful to Dr. José Garcia Hidalgo-Pallarés and other IBERCRETA members of Alcalá de Henares University. We also thank to Dr. Luis Miguel Nieto Albert, to Dr. Enrique Díaz Martínez and to an anonymous reviewer for important and helpful comments that have clearly improved this paper. The study was funded by the Centro de Geofísica da Universidade de Coimbra - CGUC (FCT).

References

Ayala-Carcedo, F. (2000): Patrimonio natural y cultural y desarrollo sostenible: el patrimonio geológico y minero. *Temas Geológico-Mineros*, 31: 17-39.

Barroso-Barcenilla, F., Callapez, P.M., Soares, A.F. & Segura, M. (2011): Cephalopod associations and depositional sequences from the upper Cenomanian and lower Turonian of the Iberian Peninsula (Spain and Portugal). *Journal of Iberian Geology,* 37: 9-28.

Berthou, P.-Y. (1984): Albian-Turonian stage boundaries and subdivisions in the Western Portuguese Basin, with special emphasis on the Cenomanian-Turonian boundary in the Ammonite Facies and Rudist Facies. *Bulletin of the Geological Society of Denmark*, 33: 41-45.

Berthou, P.-Y., Chancellor, G. & Lauverjat, J. (1985): Revision of the Cenomanian-Turonian Ammonite *Vascoceras* Choffat, 1898, from Portugal. *Comunicações dos Serviços Geol*ógicos de *Portugal*, 71: 55-79.

Brandão, J.M. (2008): Colecções e exposições de Geociências: velhas ferramentas, novos olhares. *Geonovas*, 21: 31-39.

Callapez, P.M. (2003): The Cenomanian-Turonian transition in West Central Portugal: ammonites and biostratigraphy. *Ciências da Terra*, 15: 53-70.

Callapez, P.M. (2008): Palaeobiogeographic evolution and marine faunas of the Mid-Cretaceous Western Portuguese Carbonate Platform. *Thalassas*, 24: 29-52.

Callapez, P.M. & Soares, A.F. (2001): *Fósseis de Portugal: Ammonóides do Cretácico superior (Cenomaniano-Turoniano).* Museu Mineralógico e Geológico da Universidade de Coimbra, Ediliber Press, Coimbra, 106 p.

Choffat, L.P. (1886): *Recueil d'études paléontologiques sur la Faune Crétacique du Portugal, vol. I - Espèces nouvelles ou peu connues.* Section des Travaux Géologiques du Portugal, Lisbonne, 40 p.

Choffat, L.P. (1898): *Recueil d'études paléontologiques sur la Faune Crétacique du Portugal, vol. II - Les Ammonées du Bellasien, des Couches à* Neolobites vibrayeanus*, du Turonien et du Sénonien*. Section des Travaux Géologiques du Portugal, Lisbonne, 45 p.

Choffat, L.P. (1900): *Recueil de monographies stratigraphiques sur le Système Crétacique du Portugal - Deuxième étude - Le Crétacé supérieur au Nord du Tage.* Direction des Services Géologiques du Portugal, Lisbonne, 287 p.

Choffat, L.P. (1902): *Recueil d'études paléontologiques sur la Faune Crétacique du Portugal, vols. III-IV - Mollusques du Sénonien à faciès fluviomarin - Espèces nouvelles ou peu connues*. Direction des Services Géologiques du Portugal, Lisbonne, 84 p.

Choffat, L.P. (1927): *Cartas e cortes geológicos feitos debaixo da direcção de Paul Choffat – Distritos de Leiria e Coimbra*. Serviços Geológicos de Portugal. Lisboa.

Gavroglu, K. (2007): *O passado das ciências como história*. Porto Editora, Porto, 302 p.

Gavroglu, K., Papanelopoulou, F., Simões, A., Carneiro, A., Diogo, M.P., Sanchéz, J.R.B., Belmar, A.G. & Nieto-Galan, A. (2008): Science and technology in the European periphery: some historiographical reflections. *History of Science*, 46: 1-23.

Geikie, A. (1897): *The founders of Geology*. Macmillan Ed., London, 313 p.

Gohau, G. (1988): *História da Geologia*. Publicações Europa-América, Mem-Martins, 204 p.

Jackson, P. (1999): Geological museums and their collections: rich sources for historians of geology. *Annals of Science*, 56: 417-431.

Lleonart, R.M. & Mata-Perelló, J. (2004): El patrimonio geológico en una nueva clasificación de los recursos geológicos. In: *El Patrimonio Geológico: Cultura, Turismo y Medio Ambiente* (F.G. Mondéjar & A. Ramo, Eds.), Universidad de Murcia, Murcia, 197-202.

Loriol, P. de (1887-88): *Recueil d'études paléontologiques sur la faune Crétacique du Portugal, vol. II-D. Description des Echinodermes*. Commission des Travaux Géologiques du Portugal, Lisbonne, 122 p.

Muñoz, E.E. (1988): Georrecursos culturales. *Geologia Ambiental*. Instituto Geológico y Minero de España, Madrid, 85-100.

Oldroyd, D.R. (1990): *The Highlands controversy: Constructing geological knowledge through fieldwork in nineteenth-century Britain*. University of Chicago Press, Chicago, 438 p.

Pinto, R.S. (1932): Daniel Sharpe e a geologia portuguesa. *Anais da Faculdade de Ciências do Porto*, 17: 193-203.

Rocha, R.B., Manupella, G., Mouterde, R., Ruget, C. & Zbyszewski, G. (1981): *Carta Geológica de Portugal na escala de 1:50.000. Notícia explicativa da folha 19-C Figueira da Foz*. Serviços Geológicos de Portugal, Lisboa, 126 p.

Rudwick, M. (1996): Minerals, strata and fossils. In: *Cultures of Natural History* (N. Jardine; J.A. Secord, & E.C. Spary, Eds.). Cambridge University Press, 266-286.

Saporta, M. de (1894): *Flore fossile du Portugal. Nouvelles contributions à la flore mésozoïque accompagnées d'une notice stratigraphique par P. Choffat*. Direction des Services Géologiques du Portugal, Lisbonne, 288 p.

Sauvage, H. (1897-98): *Vertébrés fossiles du Portugal. Contributions à l'étude des poissons et des reptiles du Jurassique et du Crétacé*. Direction des Travaux Géologiques du Portugal, Lisbonne, 47 p.

Sharpe, D. (1849a): On *Tylostoma*, a proposed genus of gasteropodous molluscs. *Quarterly Journal of the Geological Society of London*, 5: 375-380.

Sharpe, D. (1849b): Remarks on the genus *Nerinea*, with an account of the species found in Portugal. *Quarterly Journal of the Geological Society of London*, 6: 101-115.

Sharpe, D. (1849c): On the secondary district of Portugal which lies on the North of the Tagus. *Quarterly Journal of the Geological Society of London*, 6: 135-201.

Soares, A.F. (1980): A «Formação Carbonatada» na região do Baixo-Mondego. *Comunicações dos Serviços Geológicos de Portugal*, 66: 99-109.

Manuscrito recibido el 24/09/2013
Recibida la revisión el 11/11/2013
Aceptado el manuscrito revisado el 11/11/2013