

AMBER IN PORTUGAL: STATE OF THE ART

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INTRODUCTION

Amber is a fossilized resin with properties similar to amorphous polymeric glass that commonly preserves abundant insects and spiders in fine detail, significantly impacting our knowledge on arthropod evolution since the Cretaceous (Martínez-Delclòs *et al.*, 2004; Grimaldi & Engel, 2005; Labandeira, 2014). In addition, the physical properties of amber have allowed the elaboration of beads and other personal ornaments from it since prehistoric times. Indeed, amber is a peculiar and commonly exotic material in archeological contexts and thus important to study ancient population contacts (Vilaça *et al.*, 2002; Álvarez-Fernández *et al.*, 2005a-b; Murillo-Barroso & Martínón-Torres, 2012; Rocha *et al.*, 2015; Odriozola *et al.*, 2017); the present review is limited to the prehistoric amber, but amber artifacts were also deposited during the Protohistoric period, mainly in funerary contexts. Due to its scientific

importance, namely paleontological, amber in geological deposits in the north and northeast of the Iberian Peninsula has received attention in the last decades, but that from Portugal remains unstudied. The present contribution aims to be the starting point to study Portuguese amber from the geological and paleontological perspectives.

PALEONTOLOGICAL LOCALITIES

The first reports of Portuguese amber lacked any detail (e.g., Zincken, 1867; Calderón, 1898). For example, Calderón (1910), in his review about the minerals of Spain, also cited three Portuguese amber localities previously known from other sources. This classic Spanish author did not examine any Portuguese amber samples. The localities cited are Mondego (herein considered as Cape Mondego) and Valverde (herein considered the locality with this name close to Alcanede) (small pieces of transparent, yellow amber) found in coal considered Jurassic in age, but most likely of the Cretaceous period, and Monchique (a piece shaped as a “peppercorn”) considered Cretaceous in age. The great abundance of Cretaceous amber in the rest of the Iberian Peninsula, and the absence of Jurassic amber (Peñalver & Delclòs, 2010), strongly suggests that this coal was not well-dated in the beginning of the XX century. No other relevant details were provided by Calderón. The location of Monchique is dubious because the geology of the region where the village of the same name is located does not present Cretaceous exposures.

Ferreira (1966) cited amber in Algueirão area (Sintra) and in the coast slope in Santa Cruz beach (Fig. 1A). La Baume (1935) added to the list the occurrence of amber around Figueira da Foz.

More than three decades ago, an important, rich amber outcrop was discovered near Sangalhos during the construction of the A1 dual carriageway (Artur Sá, per. comm., 2018), but the locality was neither excavated nor investigated and, to our knowledge, there are no samples housed in any museum. Another locality of Mesozoic amber, but providing small pieces, occurs in Catefica (Torres Vedras).

The list is completed with discoveries done by Portuguese amateurs in the last decade (see Fig. 2) and available at some websites. Apparently, the most important and rich amber-bearing area in Portugal corresponds to Estoril-Cascais, near Lisbon (São João do Estoril and São Pedro do Estoril beaches) (sources: the web of Mr. Roland Altmann and several reports at <https://www.mindat.org/>). Cascais amber occurs in Cretaceous sandstones, sometimes associated to fossil tree trunks (Alexandre Manuel Pedroso, per. comm., 2018), and it is red in color (Figs. 2.1–2.4) as is typical for the Cretaceous amber of Spain. According to the pictures available at <https://www.mindat.org/>, the amber occurring therein is flattened, kidney-shaped and translucent, sometimes trapezoid in shape and intensely fractured as typically observed in Cretaceous amber found within sandstones (Fig. 2.2). Potentially, the amber from the Estoril-Cascais area could provide abundant arthropods as bioinclusions, as occurs in some Spanish Cretaceous outcrops such as those of Peñacerrada, El Soplao and San Just. The first and unique bioinclusion found in Portuguese amber to date is from Cascais, as informed by Mr. Roland Altmann; it is a complete specimen of winged insect (Diptera: Nematocera) (see Fig. 2.7). In addition, the pieces of this amber lacking bioinclusions could be prepared (infilling the fissures with a synthetic resin in vacuum conditions) in order to be used in jewelry. Lastly, the same amateurs mentioned above also found medium-sized pieces of Cretaceous amber in Sesimbra (Setúbal region; Figs. 2.5 & 2.6), Aptian–Albian in age as the amber from Cascais (Roland Altmann, per. comm., 2018), and scarce amber, brown in color and without brightness, in Cape Espichel (Rui Nunes, per. comm., 2018) and in Magoito beach (Roland Altmann, per. comm., 2018).

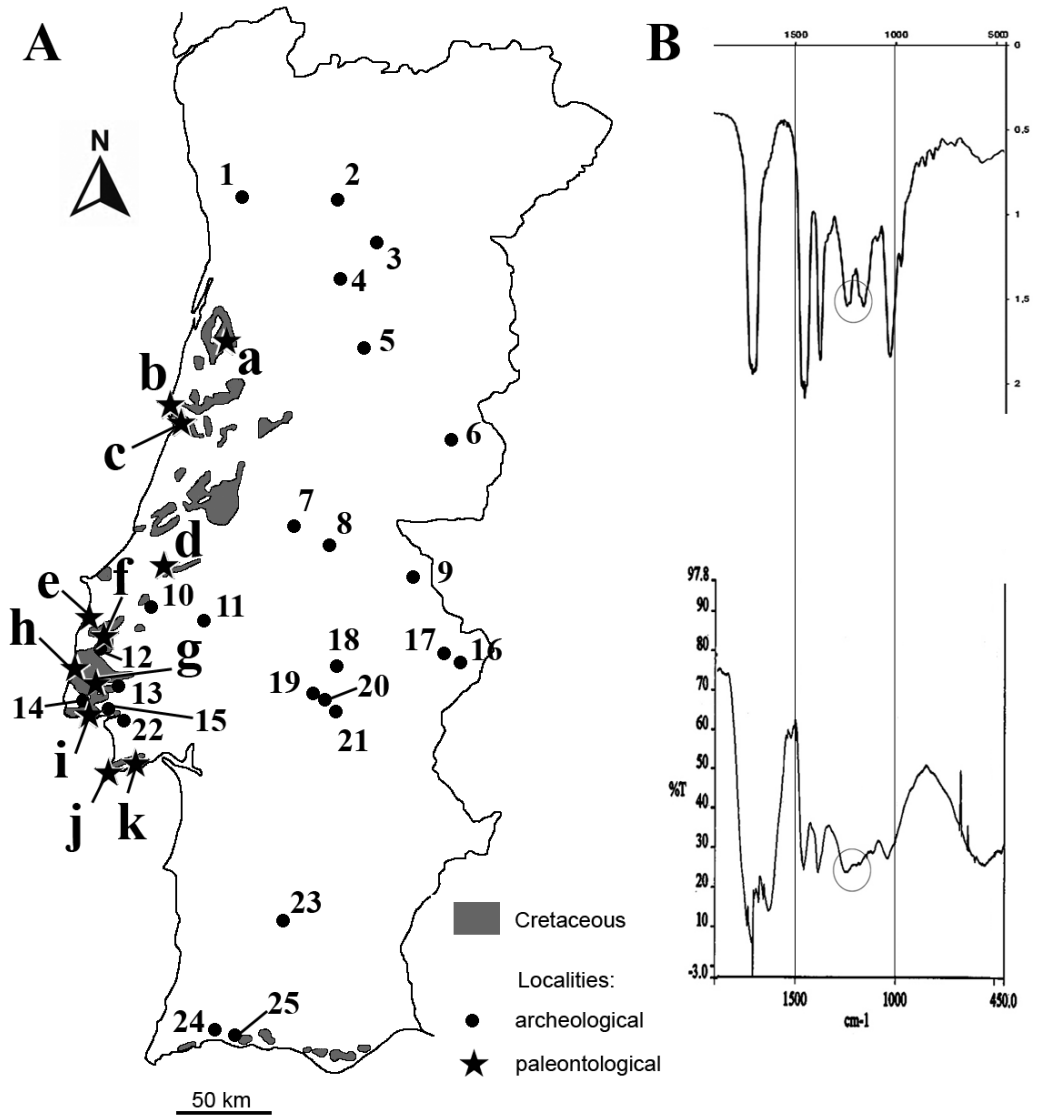


Figure 1. A) Map showing the paleontological (a k: a-Sangalhos, b-Mondego [not located in the village of the same name, but in the Cape Mondego, near to a main Cretaceous exposure and Figueira da Foz], c-Figueira da Foz, d-Valverde [there are several villages with this name in Portugal and has been indicated in the map the one close to a Cretaceous exposure, near Alcanede, but maybe it corresponds to Vale Verde, close to Guia, Algarve], e-Santa Cruz beach, f-Catefica, g-Algueirão area, h-Magoito beach, i-Estoril-Cascais area, j-Cape Espichel, k-Sesimbra) and archeological (1-25, see correspondence with the numbers in the list present in the text) amber localities in the context of the main Cretaceous exposures, B) Fourier-transform infrared spectroscopy (FTIR) spectra of Cretaceous amber from Camijanes (Cantabria, northern Spain) (above) and archeological sample from Mamoa V Chã de Arcas (Loivos do Monte, Baião, Portugal) compared. Note the different absorption maxima at the encircled sections. Map redrawn from www.lneg.pt/iedt/projectos/334/paginas/24/ (2010 edition); the dubious locality named "Monchique" is not represented. Spectrum of the archeological sample from Vilaça *et al.* (2002).

These twelve localities, except to Monchique, have been located in a map with the main Cretaceous exposures represented (Fig. 1A).

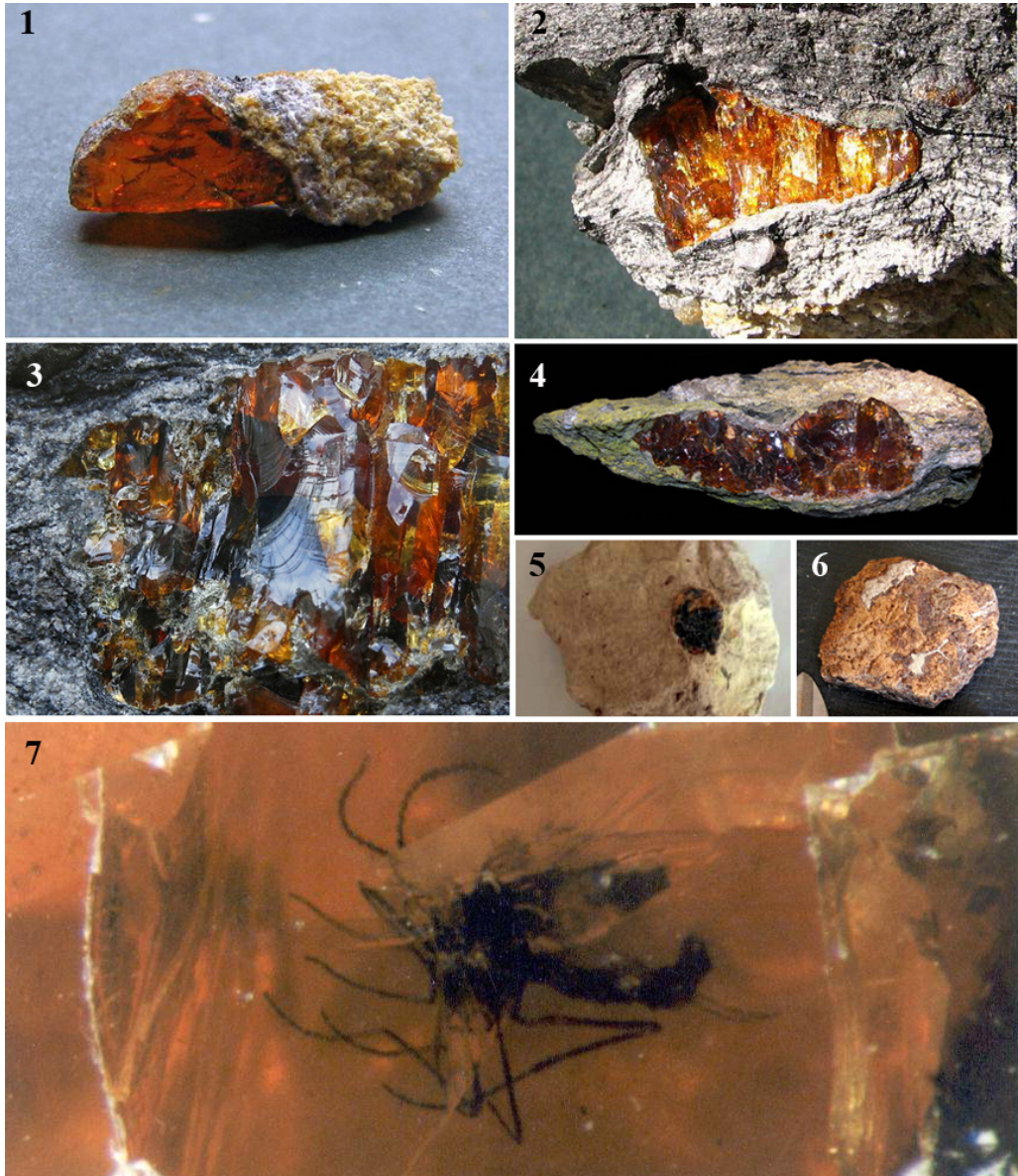


Figure 2. Cretaceous amber pieces from Cascais (1 4 and 7) and Sesimbra (5 6), present in the Portuguese private collections of Alexandre Manuel Pedroso (1 2), Rui Nunes (3 4) and Roland Altmann (5 7). Photograph 7 shows a complete adult dipteran of the suborder Nematocera. Fields of view: 24 mm, 35 mm, 30 mm, 100 mm, 50 mm, 50 mm an ca. 4 mm, respectively (photographs taken by the respective owners).

ARCHEOLOGICAL SITES

The first review on archeological amber in Portugal was published by Ferreira (1966) with the citation of five prehistoric sites dated as Neolithic to Chalcolithic. Later, Vilaça *et al.* (2002) extended the list of prehistoric amber spatially to the north and temporally to the Late Bronze Age. Three more recent articles reviewed the occurrences of archeological amber listing the known localities (Murillo-Barroso & Martín-Torres, 2012; Rocha *et al.*, 2015; Odriozola *et al.*, 2017).

The list of the 25 archeological sites, from north to south (by Vilaça *et al.*, 2002, with updates), is as follows (Fig. 1A): 1) Monte da Pena (see Odriozola *et al.*, 2017), 2) Mamoá V de Chã de Arcas, 3) Orca de Seixas, 4) Senhora da Guia, 5) Anta do Pinheiro dos Abraços, 6) Moreirinha, 7) Castelo Velho do Caratão (see Cruz *et al.*, 2015), 8) Anta do Vale das Antas, 9) Anta dos Pombais, 10) Pragança (see Odriozola *et al.*, 2017), 11) Cabeço da Amoreira, 12) Cabecinho da Capitôa (see Sousa, 2008), 13) Gruta do Correio-Mor (Loures) (see Cardoso, 2003), 14) Bela Vista, 15) Gruta artificial de S. Paulo (see de Barros & Espírito Santo, 1997), 16) Atalaião (=Atalaia dos Sapateiros), 17) Anta Grande da Comenda da Igreja, 18) Anta da Capela (see Odriozola *et al.*, 2017), 19) Anta Grande do Zambujeiro (the richest, with fifty amber beads discovered), 20) Corôa do Frade (see Arnaud, 1979), 21) Quinta do Marcelo in Almada (see Cardoso, 2004), 22) Alcarapinha, 23) Barranco da Nora Velha, and 24 25) Monumento 3 de Alcalar and Monumento 4 de Alcalar (see Morán & Parreira, 2004), sometimes named as Alcalá instead of Alcalar.

The archeological Portuguese ambers analyzed, which comprise only a part of the total occurrences, corresponded to simetite, and succinite in minor proportion (Beck & Vilaça, 1995; Vilaça *et al.*, 2002; Murillo-Barroso & Martín-Torres, 2012; Odriozola *et al.*, 2017). An alleged amber piece from Castelo de Matos (Figueiral & Queiroga, 1988) turned out to be quartz microcrystalline varieties (orange chalcédony or carnelian) (Vilaça *et al.*, 2002).

DISCUSSION

Only twelve paleontological amber outcrops or amber-bearing areas (the eleven localities of the Fig. 1A plus Monchique) are known in Portugal to date, based on old reports in the literature, data reported in web databases by amateurs and personal communications. Apparently, all of them are Cretaceous in age and poor in amber. Vilaça *et al.* (2002) referred to the lack of amber samples housed at the most important Portuguese collections in museums of Natural History, in general, and of Mineralogy/Geology in particular, but in the last decade some Portuguese amateurs have collected interesting pieces close to Estoril-Cascais, near Lisbon, and from Sesimbra. The Geomining Museum (IGME, Madrid), a reference for geological samples in the Iberian Peninsula, lacks Portuguese amber pieces in its collections as well. In the present preliminary study, samples have not been available for direct analysis.

The heritage status of the Portuguese Cretaceous amber outcrops differs from that of the Spanish ones. The latter have recently been deemed as the best protected when compared to the heritage status of the major Cretaceous amber outcrops worldwide (Rodrigo *et al.*, 2018). These authors pointed out that the Portuguese amber outcrops could be considered under the protection designation called *Natural monument*, according to the Decree Law 142/2008; the protection designation is suitable for a locality that should be conserved due to its uniqueness or rarity, or for its esthetic, scientific and/or cultural singularity. Perhaps the area of Estoril-Cascais could be considered of importance for a special protection. Pedra da Mua in the southern cliff of Lagosteiros beach is protected as a natural monument since

1997, as it contains notable fossils as dinosaur footprints. Thus, the new discoveries of amber in Cape Espichel enrich its scientific importance.

Regarding the archeological amber, there are abundant prehistoric pieces of diverse age (Fig. 3) and these have been studied in some detail, but an important proportion awaits to be analyzed with infrared or Raman spectroscopy. The lack of infrared or Raman spectra of ambers from Portuguese geological deposits keeps limiting the research. A fragment of amber from a megalithic monument in Mamoia V de Chã de Arcas (Loivos do Monte, Baião) shows a Fourier-transform infrared spectroscopy (FTIR) spectrum differing from that typical of Baltic amber as indicated by Vilaça *et al.* (2002), *i.e.*, it lacks the single absorption maximum near 1160 cm^{-1} preceded by a clear "shoulder" and an absorption occurrence near 890 cm^{-1} . These authors noted the similitude of the studied spectrum with that typical of Sicilian amber, a provenance also detected in Spanish archaeological ambers from the Neolithic onwards (Murillo-Barroso and Martín-Torres, 2012), and therefore indicated a Sicilian origin or from a local deposit of fossil resin chemically similar to Italian amber. Moreover, Vilaça *et al.* (2002) noted the problematic lack of infrared spectra of local ambers at that time, what prevented comparisons. Comparison of the Mamoia V de Chã de Arcas amber spectrum with that of Cretaceous ambers from the northeastern Iberian Peninsula (an example is present in the Fig. 1B) shows that it is not local amber of Cretaceous age, although performing the first analyses of Portuguese paleontological ambers is necessary.

Furthermore, Vilaça *et al.* (2002) pointed out the possible circulation of unworked amber in Portugal to make ornaments locally based on the characteristics of the Mesolithic piece of Cabeço da Amoreira, but, pending further infrared analyses, and considering its early date, we hypothesize that could correspond to local Cretaceous amber, similarly as has been discovered from Paleolithic amber fragments without defined shape (Álvarez-Fernández *et al.*, 2005a-b; Peñalver *et al.*, 2007, 2017; Corchón *et al.*, 2008), and a slab of amber with anthropic scratches (Peñalver *et al.*, 2017; Corchón *et al.*, 2008), but also from a Megalithic amber bead (Murillo-Barroso *et al.*, in press), all these types from northern Spain. Apart from the infrared analyses, there are other types of evidence that could indicate a local origin of the amber, such as some peculiar cortices originated by fungal invasion of the original resin during the Cretaceous (Speranza *et al.*, 2015; Peñalver *et al.*, 2017).

The map in Fig. 1A provides new evidence to better conduct future research. Interestingly, around Lisbon there is a concentration of main Cretaceous exposures, *i.e.*, eight paleontological amber outcrops and six archeological localities that yielded amber artifacts. However, from these archeological localities, Pragança yielded artifacts (Fig. 3.1) made with succinite (Odrizola *et al.*, 2017). The bead from the tholos of Bela Vista was lost, but it was found again as was reported by João Luís Cardoso in 2005, thus it awaits analysis. Regarding to the remaining four archeological localities, a cave built during the Late Neolithic and used until the initial Bronze Age (loc. # 15), one locality documented in a Late Neolithic/Chalcolithic context (loc. # 13; see Fig. 3.6), another one in a Late Bronze context (loc. # 12) and the last in a Megalithic context (loc. # 22), all of them await to be analyzed as well and, possibly, some contain local Cretaceous amber. A second apparently interesting area to study is that of the archeological localities of Monumento 3 de Alcalar (Figs. 3.2 & 3.3) and Monumento 4 de Alcalar, but the analyses conducted by Odrizola *et al.* (2017) indicated that the amber found is of the simetite type.

CONCLUSIONS

The Portuguese amber present in geological deposits needs to be prospected in order to assess its abundance and scientific importance. Gathering samples under stratigraphic control is mandatory. The

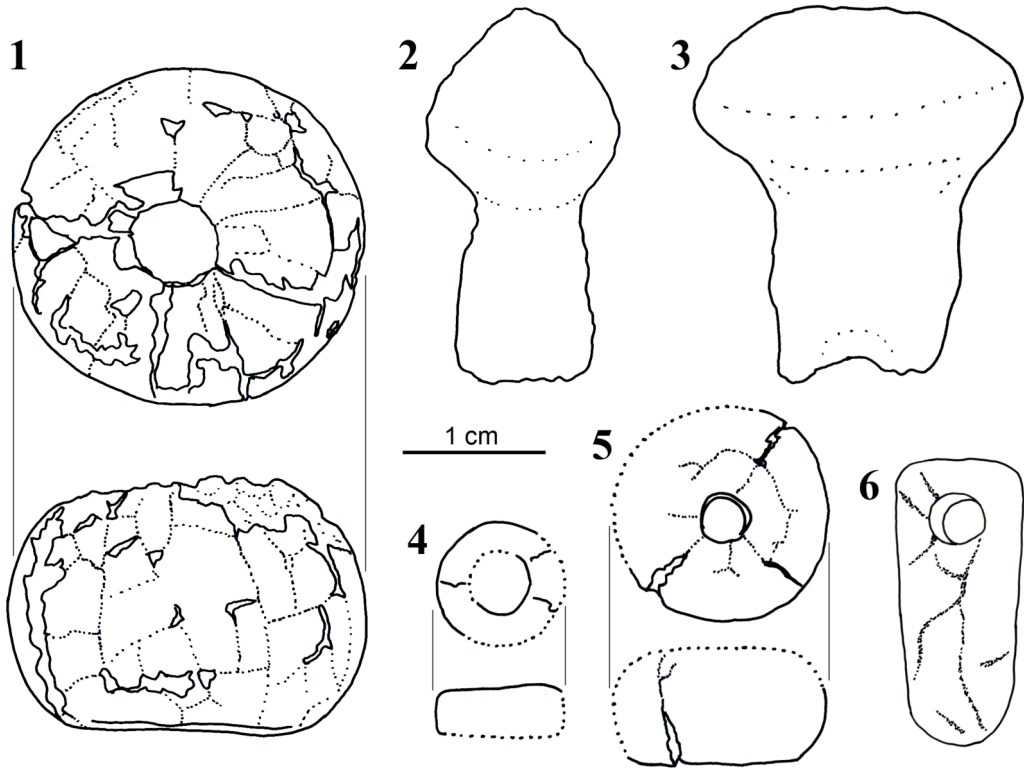


Figure 3. Some amber artifacts from Portuguese archeological sites. 1) Pragança, 2–3) Monumento 3 de Alcalar, 4) Moreirinha, 5) Senhora da Guia and 6) Gruta do Correio-Mor. Illustrations 1–3 redrawn from figures in Odriozola *et al.* (2017), 4–5 from Vilaça *et al.* (2002) and 6 from Cardoso (2003).

search of bioinclusions in this amber will be of great relevance for research in arthropod evolution, due to their location in the west of the Iberian Peninsula and their potential comparison with the well-known paleoentomofaunas from the north and northeastern Iberian Peninsula.

As indicated by Vilaça *et al.* (2002), an important goal is treating the occurrences of paleontological and archeological localities in the Iberian Peninsula as a single unit, instead of analyzing the data segregated by countries. The present contribution is an attempt to impulse the study of the Portuguese amber to accomplish further synthesis of the whole Iberian amber and the comparison of the two types of occurrences, paleontological and archeological, in order to elucidate the local or exotic amber proveniences and ancient population contacts. Thus far, none of the Portuguese prehistoric amber pieces analyzed was made with local Cretaceous amber.

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