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Local amber in a Palaeolithic context in Cantabrian Spain: the case of La Garma A

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Abstract

It is important to determine the geological sources of Palaeolithic ambers in the south of Europe in order to understand the mobility and interchanges of prehistoric societies. Fourier transform infrared (FTIR) spectroscopy analysis carried out on Upper Palaeolithic ambers from La Garma A cave (Cantabria, Northern Spain) allowed us to identify their source area. Their diagnostic features were found to be similar to the amber obtained in the Lower Cretaceous outcrops close to this archaeological site, and to differ clearly from Baltic amber, which has been generally suggested as the amber found in European prehistoric sites. These results show that the origin of the Gravettian amber found in La Garma A is local and, consequently, a hypothetical contact route is not required to be able to account for the presence of this material in the Iberian Palaeolithic context studied here. For the first time it has been demonstrated that the provenance of an archaeological amber in the Iberian Peninsula is local, with both geographical and spectroscopical evidences. Our study also concludes that the archaeological amber of La Garma A possibly belongs to an araucariacean resin that originated from the coniferous forests which grew in the northeast portion of the Iberian Plate c.110-million years ago.

Keywords: Infrared spectroscopy; Amber; Cretaceous; Upper Palaeolithic; Gravettian; Spain

1. Introduction

Fourier transform infrared (FTIR) spectra provide a rapid and suitable method for identifying fossil resins, and constitute the best known and most widely used method for archaeological and palaeontological amber identification [21]. This method is also being used to identify and compare geographical varieties of resin samples [17]. Baltic amber, which is called succinite, has a particular FTIR spectrum [13]. Succinite appears in the geological strata of a vast area, including the Baltic countries, Byelorussia, the Ukraine, northeastern Yakuty, etc., but has never been found in south of the Alps [20]. During the Würm glaciation (Wisconsin in the USA, Weichselian in Central Europe) in the Pleistocene, the amber outcrops in Northern Europe were covered with ice, but we cannot discard the hypothesis that in some periods amber could be obtained in some meridional outcrops of the Baltic region.

Spanish Mesozoic ambers have different chemical compounds than the Eocene Baltic amber. For this reason the Spanish and Baltic ambers show dissimilar FTIR spectra [1,17,20]. Baltic amber is characterized by a single absorption maximum in the carbon–oxygen single-bond range near 1160 cm^{-1} and is preceded by a broad shoulder called the "Baltic shoulder" [12]. Baltic amber is further distinguished by a distinct absorption at 890 cm^{-1} that indicates out-of-plane vibrational frequencies of an exocyclic methylene group $=CH_2$ [13]. In contrast, Spanish Cretaceous ambers show two intensive absorptions at 1150–1250 cm^{-1}, very different from the "Baltic shoulder".

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Southern Europe and the Mediterranean regions received Baltic amber by interchange routes during the Bronze Age and later, as shown by FTIR analyses [3,10,14]. Nevertheless, up to now the origin of the oldest archaeological ambers found in south European excavations of Palaeolithic sites has remained uncertain. Some research indicated a possible local origin for some archaeological ambers found in the south of Europe, for example Angelini and Bellintani [3], because the spectra obtained were found to be atypical of Baltic amber. A clear similarity, however, is necessary between the diagnostic ranges of both archaeological and local amber spectra to conclude a local origin. Infrared spectra of six pieces of Magdalenian amber, found in the Champréveyres site in Switzerland, were compared by Beck [9] to those of local amber. He determined that one of the pieces was originally Baltic amber. In contrast, the other five pieces showed spectral features that suggest an origin in a local Flysch source. The spectral similarities between the two kinds of ambers were not completely decisive, but this has been up to now the best correspondence between local and archaeological amber in a Palaeolithic context far from the Baltic region.

During the last 10 years some archaeological amber samples from the Iberian Peninsula, younger than a Palaeolithic age, have been analysed using FTIR in an attempt to determine their geographical origin. However, the origin of the majority of Iberian amber found in archaeological contexts remains obscure. A fragment of a bead found in the megalithic monument of Mamoa V de Chã de Arcas (Northern Portugal) has recently been analysed [22] and found to represent amber other than succinite; the authors have suggested that it might be of an autochthonous origin. Amber found in the Dolmen of Alberite in Villamartín, Province of Cádiz (Southern Spain), dated about 6th–5th millennium B.P., was studied by Domínguez-Bella et al. [15]. This amber turned out to be simetite, a variety of amber different from succinite (Baltic amber). FTIR analyses of some amber pieces recovered from four Bronze Age contexts, located in Catalonia (Northern Spain) and in central Portugal, confirmed their Baltic origin [11,19,22].

In this article, we study some Palaeolithic amber pieces found in the same sedimentological layer of the La Garma A site (Province of Cantabria) and the palaeontological amber specimens found in some of the nearby Cantabrian localities (Fig. 1). The study compares and discusses the FTIR spectra of all these amber samples in order to determine the geographical origin of the amber from the La Garma site.

2. La Garma and La Garma A

Monte de la Garma is the name of a hill 186 m high, situated about 5 km from the mouth of the River Miera, on the eastern side of the Santander Bay (Cantabria, Northern Spain) (Fig. 2). This small hill contains a complex cave system and an archaeological site that is among the most spectacular in European prehistory, both because of the importance of some of its components and because of the unusually complete sequence of occupations that have been documented. Such occupations range from the Lower Palaeolithic to the Middle Ages. The sites discovered so far in Monte de la Garma are the caves of El Truchiro, El Mar, La Garma A, La Garma B, La Garma C, La Garma D, El Valladar, Peredo, and the open air site of Alto de La Garma. In 1995, the deepest levels of the system, the Intermediate and Lower Galleries, were explored. At present they can only be reached through the entrance of La Garma A (Fig. 2). In these galleries, an important series of Upper Palaeolithic deposits and cave art were found. Three occupation areas of Middle Magdalenian Age cover almost 1000 m^2 of the Lower Gallery, in the form of floors covered by thousands of animal bones, lithic and bone assemblages, objects of adornment and magnificent examples of portable art. The wall paintings and other signs of human use of the underground environment complete the evidence discovered [4–8,18].

La Garma A is a small cave located in the lower part of the La Garma hill, 80 m above sea level (Fig. 2). The cave entrance faces SSW and leads into a small chamber (4×2 m), orientated along a SW–NE bearing. On the left, at the end of the chamber, a narrow passage 1.2 m wide connects with a second larger chamber (6.5×2.0 m), on the same bearing as the first. This leads into a third chamber of a similar size, and a narrow high level passage which is the only way to the interior of the cave system at the present time. The archaeological excavations carried out between 1995 and 2005 in the first two chambers and outside the entrance succeeded in documenting a deposit with a stratigraphy over 6 m thick, which begins in the Lower Palaeolithic and includes most of the classic Upper Palaeolithic sequence (Aurignacian, Gravettian, Solutrean, Magdalenian, transition to the Azilian), as well as a Mesolithic shell midden, some Neolithic evidence, burial structures and layers corresponding to the Chalcolithic and Bronze Age, and some Medieval remains on the surface [7,8].

3. The amber in Layer F of La Garma A

The amber pieces studied here (Fig. 3A,B) were discovered in Layer F, a yellowish clay layer 2.5–25 cm thick. The results of the sedimentological study being carried out are not yet available, but the morphological and textural evidence of this deposit suggests that it was formed as a result of the accumulation of allochthonous detritus brought into the interior of the cave during slow sedimentation episodes, and characterized by low energy processes.

Layer F is ascribed to the Late Gravettian, but has yielded few lithic or bone artefacts. A number of Gravettian points are the most significant pieces in the lithic assemblage, whereas some sagaies have been found in the bone assemblage. Equally, some evidences of portable art have been recovered, especially an ibex metacarpal perforated in its distal epiphysis and decorated on its two faces with incisions, and pendants made out of shells. The few animal remains found indicate the consumption of red deer and horse, whereas the malacological fauna mostly consists of *Patella vulgata* and *Littorina* sp. A sample of the perforated ibex metacarpal has been dated to $21{,}650 \pm 760$ BP (AA-45566) ($24{,}102 \pm 1040$ cal BC, according to the CalPal 2005_SFCP curve) [23].

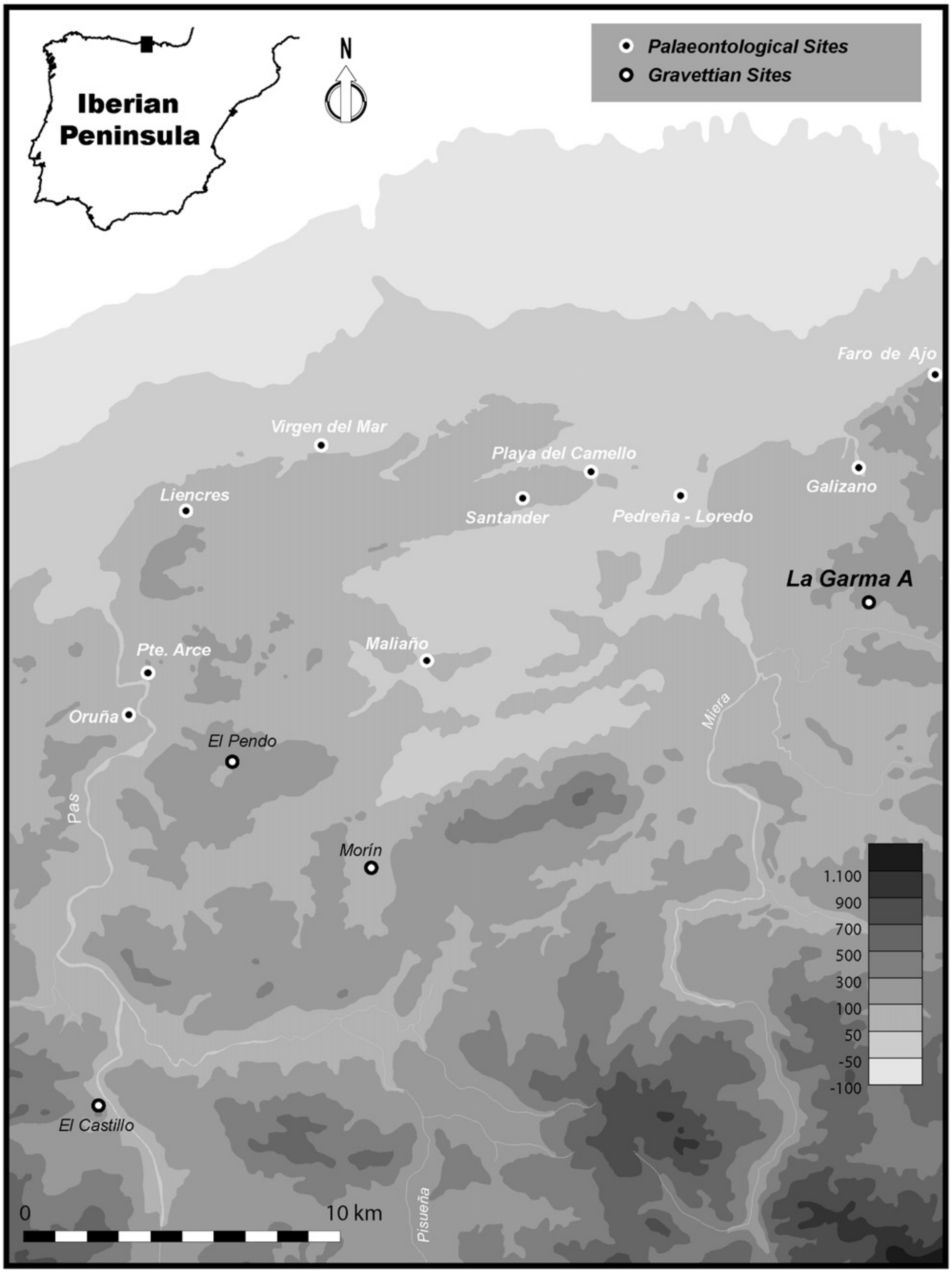

Fig. 1. Geographic location of the Gravettian archaeological sites with amber remains and natural sources of Cretaceous amber in the surrounding area. Drawing by L. Teira.

The pieces of amber that were recovered from Layer F came from square 12G; two are from sector 2 and one from sector 3. The three small pieces (the largest is only $25 \times 8 \times 8$ mm) were found in the 2001 excavations and came, precisely, from the thinnest part of the sedimentological layer. They each have a different colour, ranging from dark red to pale red, and are semitransparent or have a transparent aspect. The degradation that occurred in the secondary burial affected mainly the external surface, which appears as a thin layer with low transparency, with pale brown coloration, and a system of fine cracks (Fig. 3A,B). Darkening and crazing are typical degradations of amber specimens that have been exposed to oxidation [16]. The La Garma A pieces became very fragile and they are now fragmented. They were not treated with any preservative or hardening products to conserve them, as these can distort the FTIR spectra if present. The occurrence of the three pieces in a small area may indicate that they originated from a bigger piece manipulated by humans, perhaps to make ornaments. The different colour intensity and transparency showed by them could have been caused by small differences in the chemical microenvironments during the time of burial in the cave. Other possibilities are that the pieces belong to different amber masses or are from different sources. The features of the three FTIR spectra

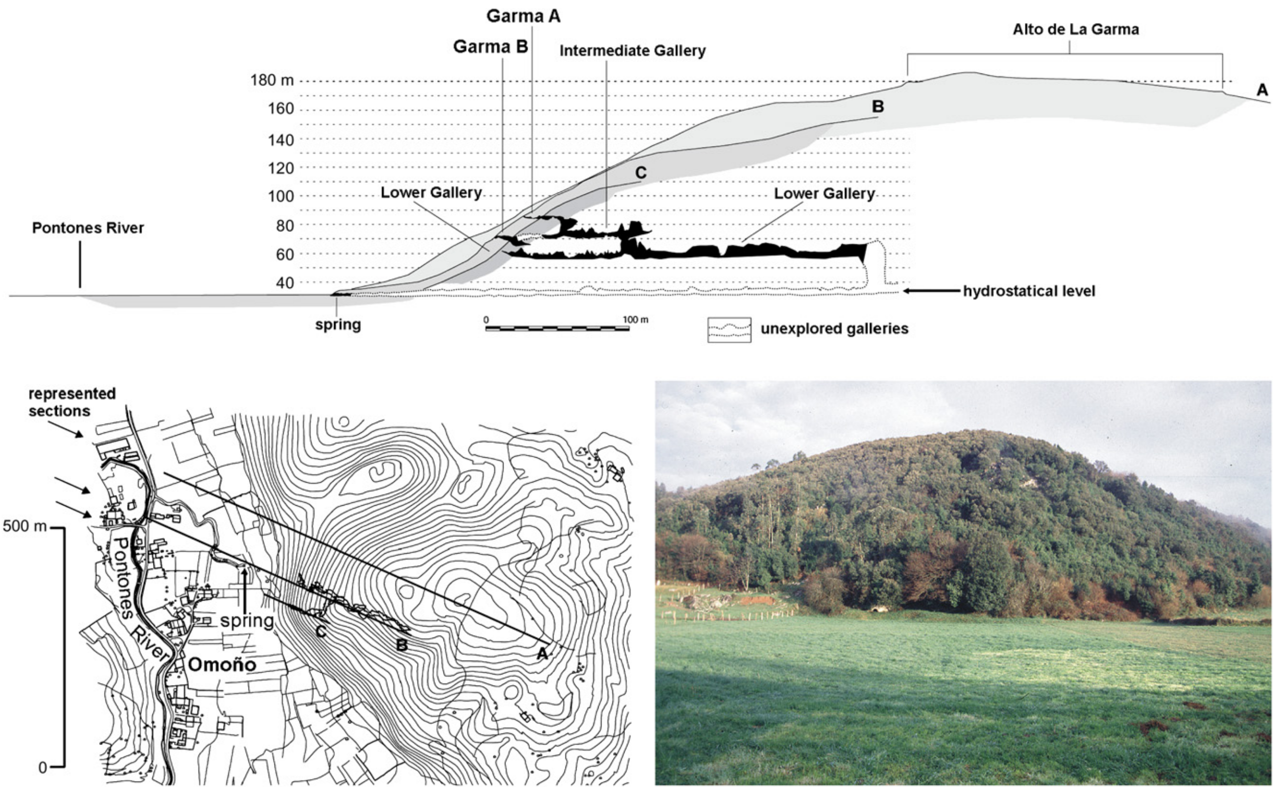

Fig. 2. Sections, map, and panoramic view of La Garma hill, showing the position of the main archaeological sites and karstic galleries. Drawing by L. Teira.

may indicate distinct geological sources if they show diagnostic differences, which are clarified in the following sections.

4. Palaeontological outcrops

Near La Garma A cave some palaeontological sources of Cretaceous amber have been found. Fig. 1 shows a reconstruction of the Central Area of the Cantabrian Spain during the maximum cold episode of the last glacial period, with indication of the palaeontological outcrops exposed today as natural sources of Cretaceous amber in the surrounding area, and the hypothetical seaside and main rivers. A few kilometers north of the cave, in the cliffs of the present seaside, are located the Pedreña-Loredo, the Galizano and the Faro de Ajo amber outcrops, which provide red and yellow pieces of amber (Fig. 3C,D) (Manuel Díaz and Alberto Cobos, pers. com.). An important area with abundant amber is also located near La Garma A, no more than 15 km to the west, around Santander and mainly near the seaside (e.g. Isla de La Virgen del Mar, Maliaño and Playa del Camello outcrops). The amber ''nodules'' or kidney shaped lumps (Fig. 3C), sometimes several centimeters in diameter, are Albian-Aptian (Lower Cretaceous) in age, and are found in dolostones and sandstones with rich organic matter content. The exhumation of these amber sources is usually caused today by weathering.

5. Infrared analysis

The FTIR spectra were obtained with an infrared Fourier Bomem DA3 spectrometer, in the Molecular Spectrometry Unit of the SCT-UB. The information shown by the spectrum is characteristic of each substance, so it permits molecule characterization with a high degree of specificity. This technique is usually used for qualitative analysis, but it is not commonly used for quantitative analysis, due to its relatively low sensitivity with amber.

We analysed three amber samples (a few milligrams) from the La Garma A cave, found during the 2001 excavations (Fig. 3A,B). To make a comparison with the local Cretaceous ambers and Baltic amber (Tertiary), three palaeontological samples near La Garma A and a sample of Bitterfeld amber were analysed. The three palaeontological Spanish samples are from the Faro de Ajo outcrop (Fig. 3D), northeast of La Garma Hill, and from the Playa del Camello (Fig. 3C) and the Maliaño outcrops, northeastern and southwestern seashore, respectively, of the city of Santander. Bitterfeld succinite is Baltic amber that was re-deposited during the Lower Miocene and it appears today near the locality of the same name (Germany). After Stout et al. [21] the Bitterfeld spectra resemble those of typical Baltic succinite with some small differences: the carbonyl band is more sharply split into two distinct absorptions at 1700 cm^{-1} (carboxylic acids) and 1735 cm^{-1} (carboxylic esters) spectral ranges. FTIR spectra of other Baltic ambers are widely published in the literature [12,13,17].

Six FTIR spectra obtained are shown in Fig. 4 for comparison (the spectrum of Faro de Ajo amber is similar to that of the Playa del Camello and the Maliaño spectra, and it has been obviated in the figure). A first noticeable result is that the FTIR spectra of the three archaeological pieces are practically identical.

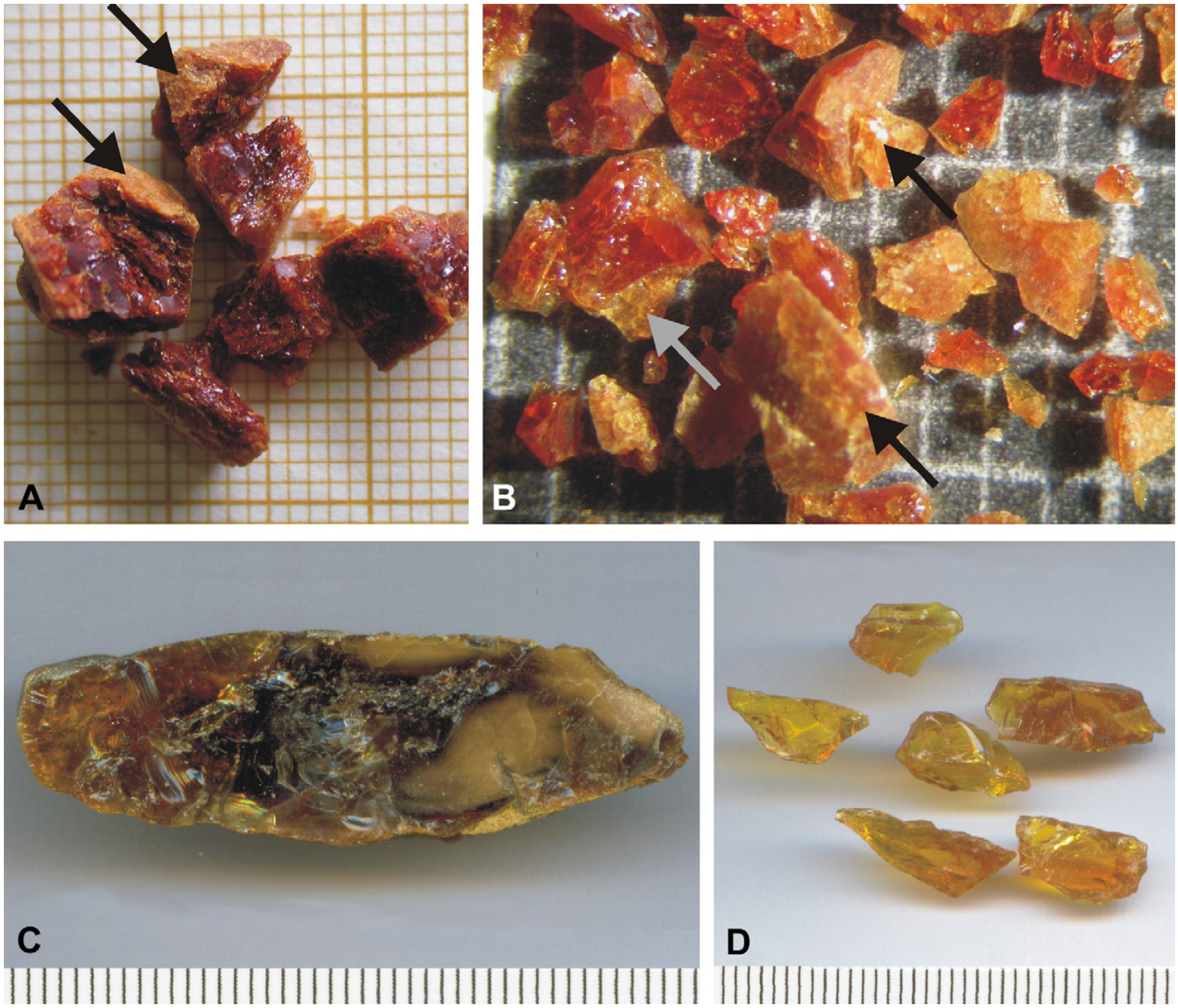

Fig. 3. (A,B) Two of the three archaeological amber pieces analysed (A, La Garma 1 sample; B, La Garma 3 sample; see Fig. 4), the arrows indicate the external surface with low transparency, pale brown coloration, and a system of fine cracks, (C,D) palaeontological amber from Cantabria Province (C, section of a ''nodule'' of red amber from the Playa del Camello site; D, transparent, yellow fragments of amber from the Faro de Ajo cliff). Millimetrical scales.

Remarkable differences exist in the ranges of wavenumbers at about 1500–1650 cm^{-1} and around 1414 cm^{-1} between palaeontological and archaeological ambers. These differences were possibly caused by the formation of carboxylic acids due to oxidation (Núria Ferrer, pers. com.) that perhaps occurred during the exhumation of the amber pieces in the Palaeolithic.

The resemblance between the Spanish palaeontological and archaeological amber FTIR spectra in the diagnostic ranges is particularly notable. These spectral ranges are 1150–1250 cm^{-1} and 889–890 cm^{-1}. In contrast, the FTIR spectra in the diagnostic ranges are particularly different when we compare the Spanish ambers, both palaeontological and archaeological, and the Bitterfeld amber. This last amber shows the typical ''Baltic shoulder'' (Fig. 4) at 1150–1250 cm^{-1}, a horizontal part followed by an absorption maximum, and the typical intensive absorption near 890 cm^{-1} which is a consequence of an exocyclic carbon–carbon double bond. In these diagnostic ranges, the Spanish ambers show two intensive absorptions at 1150–1250 cm^{-1}, very different from the ''Baltic shoulder'', and without any remarkable absorption near 890 cm^{-1}.

6. Discussion of results and conclusions

We conclude that the amber pieces found in the La Garma A cave are non-Baltic succinite, as shown by the FTIR spectra carried out. The similarities of their infrared spectra to the Cretaceous amber samples studied indicate that this archaeological amber had a local origin; in other words, it is autochthonous. The proximity of some palaeontological sources of Cretaceous amber reinforces the hypothesis that the amber was obtained near the cave by Palaeolithic humans. For the first time it has been demonstrated that the provenance of an archaeological amber in the Iberian Peninsula is local, with both geographical and spectroscopical evidences.

Despite the differences in colour and transparency of the archaeological amber pieces, their infrared spectra are very similar, which indicates that the three archaeological pieces

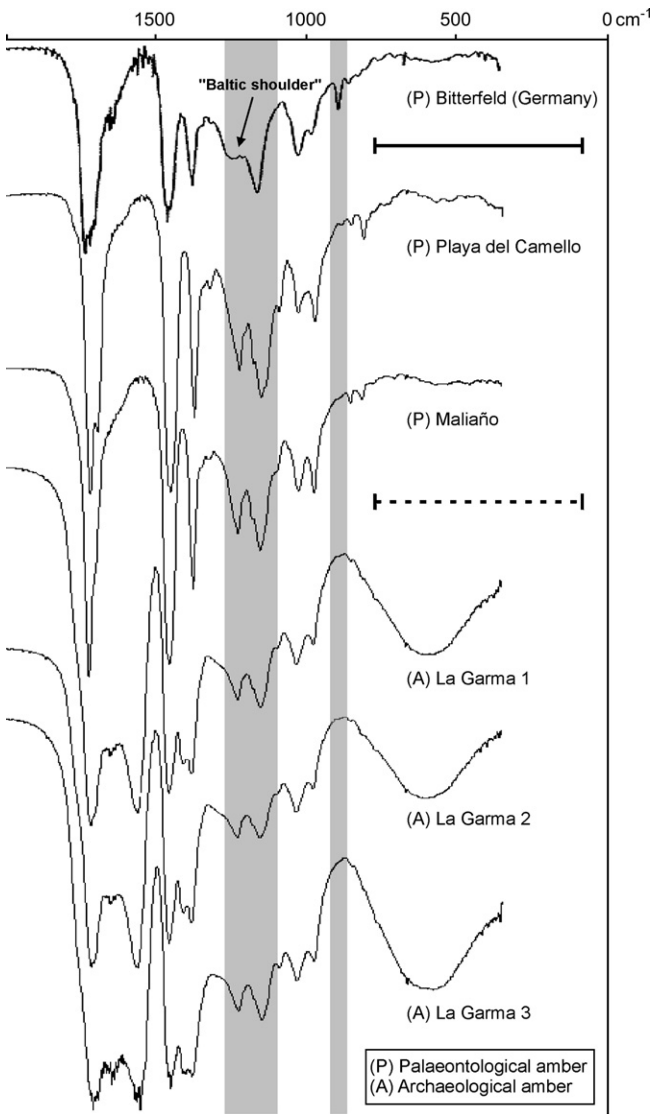

Fig. 4. Comparison between the FTIR spectrum of the Baltic succinite (Bitterfeld, Germany) and the palaeontological and archaeological Spanish amber spectra of samples from the Cantabria Province.

are fragments of the same amber mass or, at least, the three pieces belong to the same palaeontological outcrop. The spectra of ''La Garma 1'' and ''La Garma 2'' (Fig. 4) are especially similar.

The similarities, both in appearance and infrared spectra, of the palaeontological amber from Álava [1] in the north of Spain and the amber found in the La Garma A cave indicate an origin for these ambers from the same tree resin producer. Based on the biochemistry and the presence of a large quantity of inaperturate pollen grains, Alonso et al. [1] proposed an araucariacean origin for the Álava amber. In consequence, the La Garma A amber possibly also had an araucariacean origin and originated from the coniferous forests which grew, during the Lower Cretaceous, in the northeast portion of the Iberian Plate.

In Europe amber was used from the beginning of the Upper Palaeolithic, but in the Iberian Peninsula there is no evidence that Baltic amber was used until the Chalcolithic [2]. According to the results obtained, a hypothetical interchange route is not required to be able to account for the presence of this material, which is commonly considered exotic for the south of Europe. Our results provide new data about the prehistoric assortment and the use of amber in the Iberian Peninsula, where only a few studies have been carried out up to the present time on younger archaeological ambers.

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