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Amber Networks in Prehistory: North-Eastern Iberia as a Case Study

Mercedes Murillo-Barroso[1], Mercedes Navero Rosales[1], Paloma González-Marcén[2] and Marcos Martinón-Torres[3]

[1]*Department of Prehistory and Archaeology, University of Granada, Spain*
[2]*Department of Prehistory, Autonomous University of Barcelona, Spain*
[3]*McDonald Institute for Archaeological Research, University of Cambridge, UK*
Corresponding Author: Mercedes Murillo-Barroso; Email: murillobarroso@ugr.es

This study concerns prehistoric amber networks in north-eastern Iberia, emphasizing its distinct exchange dynamics compared to other regions of the Iberian Peninsula. Baltic amber dominated assemblages in this area from the Late Neolithic to the Bronze Age, contrasting with the prevalence of Sicilian amber in southern Iberia, or Cretaceous Iberian amber in the northern region. The findings underscore the region's connection to southern France, with the Pyrenees serving as a cultural conduit, unlike the river Ebro, which acted as a boundary. Here the authors present the results of a Fourier transform infrared spectrometry (FTIR) analysis of twenty-one amber beads, primarily from collective burials. Eighteen were made of Baltic succinite. Baltic amber may have begun to arrive as early as 3634–3363 cal BC*, and continued to be used until the Late Bronze Age. Exceptions included a unique spacer-bead made of gum and two bolus pigments misidentified as amber. The results highlight Iberia's regional diversity in raw material sourcing and exchange, reflecting distinct sociocultural dynamics and challenging linear narratives of Iberian prehistory.*

Keywords: succinite, amber, late prehistory, north-eastern Iberia, provenance, FTIR

Introduction

Inter-cultural contact and exchange networks are recurrent subjects in prehistoric research, as they potentially played a decisive role in shaping social structures. Support networks can be crucial in times of adversity, but exchange can also lead to relationships of inequality and dependency if access to them is restricted, or if exchanges are unequal. Determining the origin of raw materials or finished goods can be a useful starting point to investigate the movement of people, the transmission of knowledge, and, most importantly, the development of social relationships among the groups involved in these exchanges.

The importance and dynamism of the trading networks across the western Mediterranean is reflected in the multiple systems operating simultaneously between 3500 and 2200 cal BC, engaging different regions of Iberia (Broodbank, 2013; Murillo-Barroso et al., 2018b, 2023; Broodbank & Lucarini, 2020). On the one hand, the southern half of Iberia, North Africa, and Sicily were

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involved in the exchange of ostrich eggshell, ivory, and Sicilian amber (simetite)—all materials that are only rarely documented, if ever, in northern Iberian areas (Schuhmacher, 2017; Murillo-Barroso et al., 2018b; Odriozola et al., 2019a). At the same time, copper objects and Bell Beaker pottery, assumed to have originated in Iberia, are documented in north-western Africa, supposedly having been exchanged for ivory or ostrich eggs (Harrison & Gilman, 1977). On the other hand, north-eastern Iberia, southern France, Sardinia, and Italy were involved in the exchange of obsidian, flint, and Baltic amber (Villalba, 2003; Vaquer & Lea, 2011; Pétrequin et al., 2012; Terradas et al., 2016), which in turn is only exceptionally recovered in the southern half of Iberia.

Against this background, the north-eastern region of the Iberian Peninsula is a particularly interesting area for the study of amber for two main reasons. First, on the basis of the evidence available so far, this area appears to follow a different tradition from the rest of the Iberian Peninsula (and particularly from the southern half) in terms of consumption patterns. Specifically, amber objects increase significantly during the third millennium BC and decrease dramatically (if not altogether) after 2200 BC until approximately 1300 BC. However, in the north-eastern Iberian Peninsula, with some very early exceptions (Murillo-Barroso et al., 2023), the vast majority of objects seem to date to the second millennium BC (Murillo-Barroso et al., 2018b). Second, due to its greater continental connection with southern France, the north-eastern part of the Iberian Peninsula is one of the regions where the first imports of Baltic amber are documented (Murillo-Barroso et al., 2023). It is precisely Baltic amber, not Sicilian amber, that predominates in the north-eastern Iberian Peninsula, unlike in the southern half of the peninsula, where Sicilian amber is documented for the first time in the fourth millennium BC and widely used during the third millennium BC. Therefore, north-eastern Iberia is a crucial target area to document the arrival of this new type of amber, replacing ambers from other sources from approximately 1300 BC onwards.

Since Jordi Rovira i Port published an article on amber and glass paste objects from the north-eastern Iberian Peninsula nearly thirty years ago (Rovira i Port, 1994), no comprehensive work has been published on the amber recovered from this region, and their connection to different regional traditions and their respective contact networks, with the exception of highly localized studies on a bead from Forat de Conqueta (Núñez et al., 2022) and another from Cova del Frare (Murillo-Barroso et al., 2023).

In this article, we present new data and review all the evidence available for amber finds in late prehistoric north-eastern Iberia, documenting their current state of preservation, discussing their possible chronological attribution, and submitting the results of provenance analyses of all available objects within the framework of the exchange systems identified in different regions of the Iberian Peninsula.

Archaeological Background

In his pioneering work, Rovira i Port (1994) mentioned fourteen archaeological sites from which he documented forty amber items (Figure 1). In some cases, he cites references from classic works of the early twentieth century, although these references do not always correspond with the material remains that are currently kept in museums. Most of these sites with amber pieces are caves (some of them used for funerary purposes) and megalithic tombs in which multiple individuals were buried, making it impossible to associate the amber

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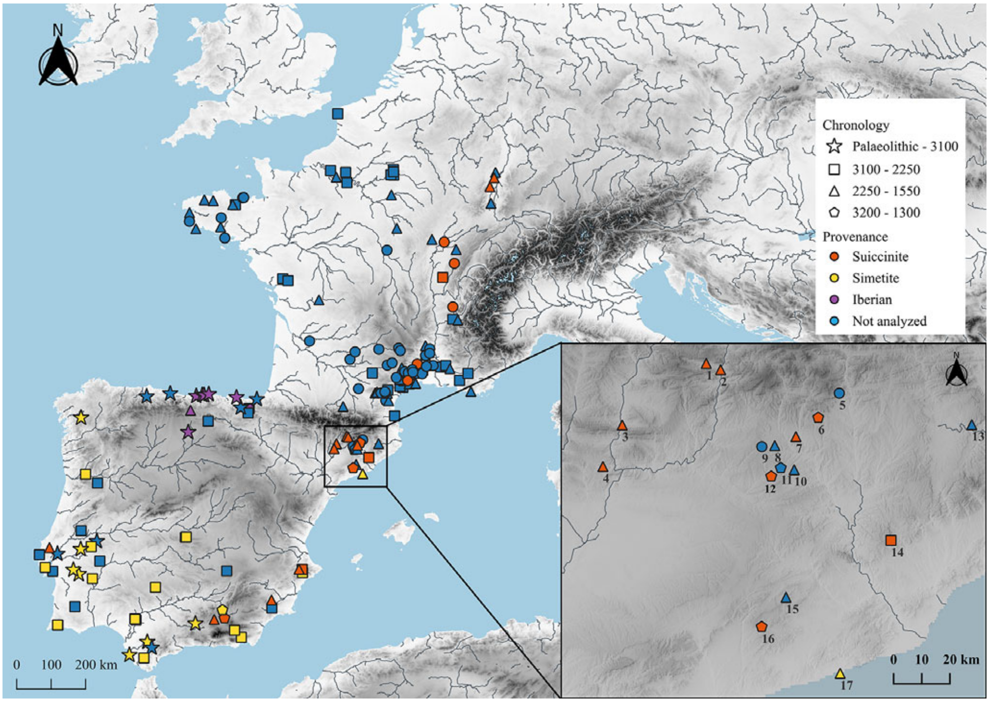

Figure 1. *Amber finds in north-eastern Iberia and France. Bottom right: archaeological sites in north-eastern Iberia. 1. Pedra Cabana (El Vilar de Cabo, Lleida); 2. Cabana del Moro de Colomera (Organyà, Lleida); 3. La Cueva de Muricecs; 4. La Cova del Forat de Conqueta (Santa Linya, Lleida); 5. Can Maurí (Berga, Barcelona); 6. El Bosc (Correà, Barcelona); 7. La Fossa del Gegant (Solsona, Lleida); 8. Bullons (Solsona, Lleida); 9. Cal Rajolí (Solsona, Lleida); 10. Can Cuca (Solsona, Lleida); 11. Collet (Solsona, Lleida); 12. La Pera (Solsona, Lleida); 13. Les Pixarelles (Tavertet, Barcelona); 14. Cova del Frare (Matadepera, Barcelona); 15. Cova de la Roca del Frare (La Llacuna, Barcelona); 16. Cova de El Garrofet (Querol, Tarragona); 17. Cova del Gegant (Sitges, Barcelona).*

objects directly with specific individuals. The material culture of these sites can mostly be placed within the Bronze Age, although in some cases there are also artefacts dating to as early as the Copper Age or as late as the Early Iron Age, such as the glass paste beads of orientalizing style at El Bosc, which suggests continuity in use of these tombs and caves, and defies any attempt at dating the amber with precision (see Supplementary Material S1 for further description of the archaeological contexts).

After Rovira i Port's 1994 publication, amber beads were discovered in three additional sites: the Muricecs cave, where the most substantial collection of amber beads in the region was found, consisting of over 135 beads (Gallart i Fernàndez, 2006; Murillo-Barroso & Martinón-Torres, 2012); the Forat de la Conqueta cave, where a disc-shaped bead and a spacer bead were recovered (González-Marcén et al., 2010; Núñez et al., 2022); and the Cova del Gegant, which yielded two more beads (Daura et al., 2010; Odriozola et al., 2019a).

We revisited all the contexts published by Rovira i Port, as well as some of the new ones, and all the preserved amber pieces were analysed using Fourier transform infrared spectrometry (FTIR) to determine the origin of the raw material used. A detailed description

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of each of the sites, their associated material culture, and the amber beads can be found in Supplementary Material S1.

Materials and Methods

For this study, a total of twenty-one pieces from six sites were analysed (Figure 2), to which we can add the previously published analyses of another four sites (Table 1).

The samples were analysed at the Centro de Instrumentación Científica of the University of Granada using a FTIR-6200 type A with an attenuated total reflectance attachment. Each sample was analysed fifty times in the range of 4000-400 cm^{-1} with a resolution of 4 cm^{-1}. The spectra are presented in infrared transmission.

Samples 2508d and 2508e from Cabana del Moro de Colomera were also analysed using a scanning electron microscope with energy-dispersive X-ray spectroscopy (SEM-EDS) at the Laboratorio de Microscopía Electrónica y Microanálisis (MicroLab) of the Instituto de Historia, CSIC (IH, CSIC) in Madrid. For this, a variable pressure SEM Hitachi S-3400n (Type II) was used, with secondary electron and backscattered electron detectors. For EDS analysis, a Bruker Quantax 4010 (SDD) detector coupled to the SEM was used, with a Bruker AXS SVE III processor.

Results

The analysed samples can be classified into three groups: i) two samples that were catalogued as amber but turned out not to be amber; ii) pieces that appeared to be amber with a characteristic translucent aspect; and iii) a surface degradation layer from which an independent sample could be taken from one of the beads from El Bosc. We will

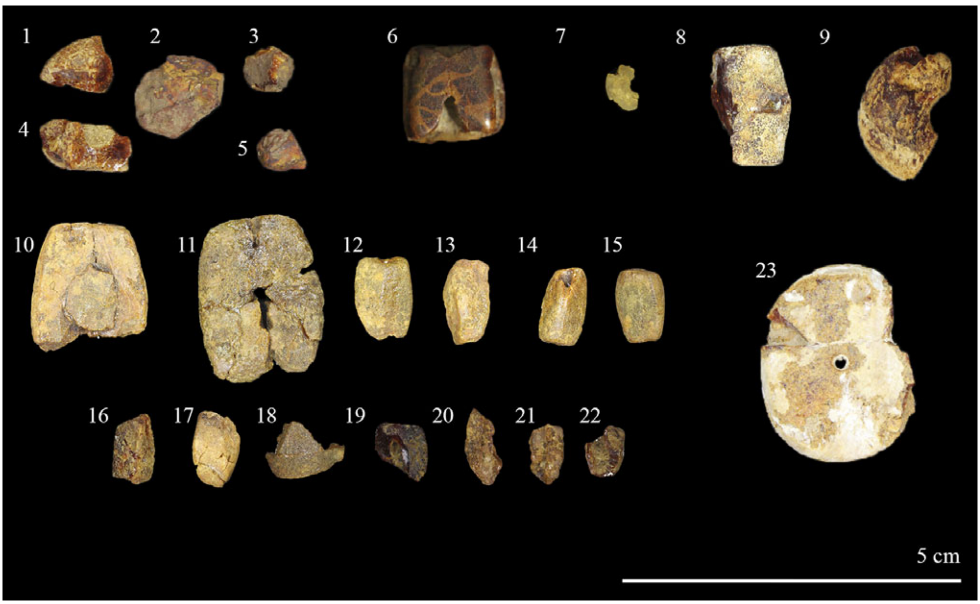

__Figure 2.__ Materials analysed. 1. 2508a, 2. 2508e, 3. 2508c, 4. 2508b and 5. 2508d from Cabana del Moro de Colomera; 6. 1339 and 7. 4855 from Forat de la Conqueta; 8. bead from Fossa del Gegant; 9. G/33 from El Garrofet; 10. 1837_1, 11. 1837_2 and 1837_16 (two fragments), 12. 1837_15, 13. 1837_6, 14. 1837_7, 15. 1837_8, 16. 1837_9, 17. 1837_12, 18. 1837_13, 19. 1837_14, 20. 1837_16, 21. 1837_17 and 22. 1837_18 from El Bosc (note that 20 and 21 are two fragments of the same bead); and 23. 3434 from La Pera.

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Table 1. *Analysed amber objects.*

Site	Samples analysed	Location	Reference
Cabana del Moro de Colomera	5 fragments: 2508a, 2508b, 2508c, 2508d, 2508e	Museu de Solsona, Diocesà i Comarcal	This article
El Bosc de Correà	11 beads: 1837_1, 1837_2, 1837_5, 1837_7, 1837_9, 1837_12, 1837_13, 1837_14, 1837_16, 1837_17, 1837_18	Museu de Solsona, Diocesà i Comarcal	This article
La Fossa del Gegant	1 bead	Museu de Solsona, Diocesà i Comarcal	This article
La Pera	1 bead: no. 3434	Museu de Solsona, Diocesà i Comarcal	This article
Cova del Garrofet	1 bead: G/333	Vinseum	This article
Forat de la Conqueta	2 beads: 4855, 1339	Museu de Lleida	This article
Pedra Cabana	2 fragments	Lost	Rovira i Port, 1994
Cova de Muricecs	135 beads	Museu de Valls	Murillo-Barroso & Martinón-Torres, 2012
Cova del Frare	1 bead	Museu de Terrassa	Murillo-Barroso et al., 2023
Cova del Gegant	2 beads	–	Odriozola et al., 2019a

discuss their results in turn. The raw data for all the spectra are available as Supplementary Material S2.

Samples without amber-like appearance

Beads 2508d and 2508e from Cabana del Moro de Colomera are reddish in colour but not translucent, and the analyses confirmed that they are not amber objects, as initially suspected. The resulting spectra did not show the characteristic amber peaks at ~3500, ~2900, and ~1700 cm^{-1}, nor the typical ancient resin peaks at ~1450 and ~1380 cm^{-1} corresponding to -CH2- and -CH3- bending modes. In both cases, the spectra were very similar (Table 2; Figure 3), suggesting that they were made of the same raw material. The SEM-EDS analyses showed an elemental composition mainly consisting of FeO (64.8 per cent) with impurities of SiO_2 (10.9 per cent) and Al_2O_3 (20.8 per cent). This composition is very similar to that of red ochre and also compatible with the pigment red bolus—an iron aluminium silicate. The FTIR spectra of the samples from Cabana del Moro de Colomera shows a higher affinity with the latter (Table 2) (Čiuladienė et al., 2018). The main difference lies in the presence of O–H stretching bands at 3689 and 3616 cm^{-1}, characteristic of kaolin ($Al_2Si_2O_5(OH)_4$), which are present in both the Cabana del Moro de Colomera samples and red bolus pigment spectra but absent in the spectra of hematite or red ochre. The asymmetric Si–O–Si stretching band at 1000 cm^{-1} observed in the Cabana del Moro de Colomera and red bolus

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Table 2. *Main peaks of FTIR spectra from samples at Cabana Moro de Colomera.*

Site	Sample ID	Main peaks at cm^{-1}													Reference
Cabana del Moro de Colomera	2508d	3693	3619			1001	910		794	752	679	525	455(s)		This article
	2508e	3693	3619			1000	909		794	752	682	525	462(s)		This article
Red bolus		3689	3616			1001	913		795		694	526	464		Čiuladienė et al, 2018: 246
Hematite				1432	1028			876				519		431	Čiuladienė et al, 2018: 246
Red ochre					1030				795			531		431	Čiuladienė et al, 2018: 246

S = secondary peaks

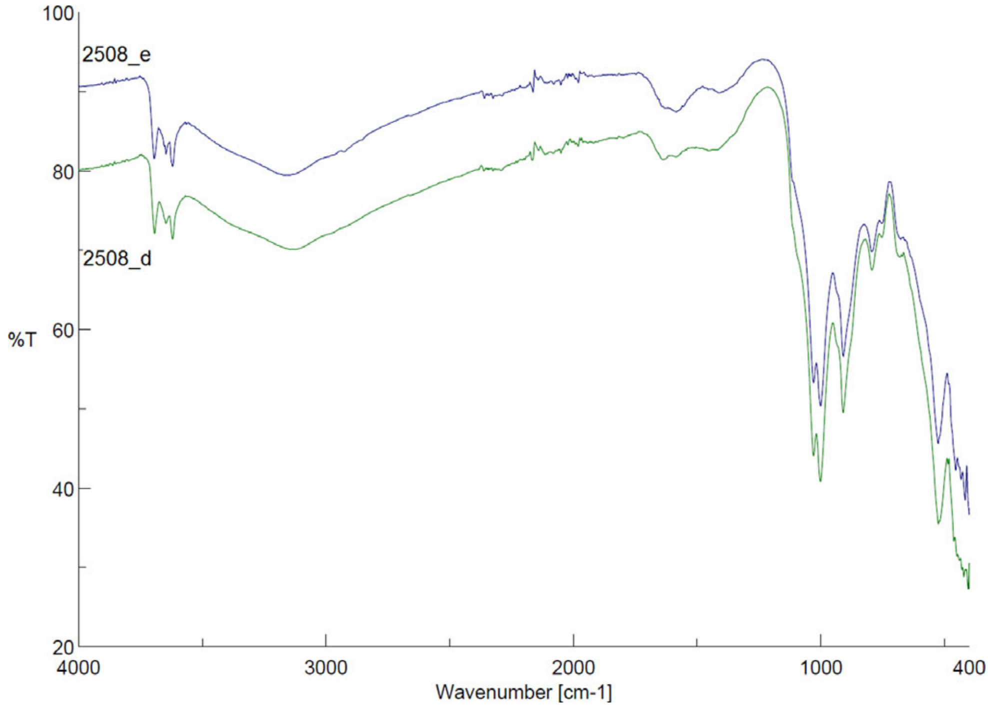

Figure 3. *FTIR spectra of samples 2508_d and 2508_e from Cabana del Moro de Colomera.*

pigment spectra might be related to the stretching band at 1028 cm^{-1} of the hematite and red ochre spectra, and the absorption peaks at 523, 455, and 429 cm^{-1} are due to Fe–O vibrations (Čiuladienė et al., 2018, 2021). Therefore, we believe that the samples from Cabana del Moro de Colomera could be fragments of red bolus pigment, similar to ochre.

Samples apparently made of amber

The remaining analysed samples exhibit the characteristic spectrum of amber, confirming that they are indeed made of this fossil resin. Notably, there is a high degree of homogeneity among all the samples—except for one of the beads from Forat de la Conqueta, discussed below. In almost all

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cases, the samples appear to be made of the same type of amber (Table 3; Figure 4; Supplementary Material S2).

In all cases, a strong peak is observed at ~2925 cm^{-1} and a secondary peak at 2866 ±4 cm^{-1}, corresponding to methylene groups. The band at ~1708 cm^{-1} corresponds to carbonyl groups, and the bands at ~1448 and ~1376 cm^{-1} can be attributed to alkyl groups, with the band at ~1448 cm^{-1} corresponding to -CH2- and -CH3- bending (δ), and the band at ~1376 cm^{-1} being due solely to -CH3 bending. These characteristics are common to all ambers. Two other bands, at ~1020 and ~976 cm^{-1}, are also consistently present in amber spectra and can be assigned to different C-O bonds (Rodríguez Montoro, 2013). The band at 886±4 cm^{-1} corresponds to exocyclic methylene groups, to C-H bending, and is commonly found in amber spectra, although tests by Guiliano and colleagues (2007) showed that this band can disappear due to exposure to heat.

The most interesting spectral region for defining different amber species, and therefore for determining their provenance, is the broad range between 1500 and 900 cm^{-1}. This is known as the amber 'fingerprint' region, where different species exhibit distinct patterns. The distinct spectrum of Baltic amber is characterized by a strong absorption peak at ~1157 cm^{-1}, which can be attributed to the stretching of the single C-O ester bond, preceded by a horizontal band between ~1250 and 1180 cm^{-1} that may have a greater or lesser slope depending on the conservation conditions of the piece (Beck et al., 1964, 1965; Beck, 1982). This exclusive feature is referred to as the 'Baltic shoulder', which, together with the presence of succinic acid, is a diagnostic marker of Baltic succinite.

As we can see, the 'Baltic shoulder' is clearly identified in all the analysed samples bar one, and all the peaks match those of the reference spectrum of Baltic amber. In the case of bead 4855 from Forat de la Conqueta, the spectrum shows the 'Baltic shoulder' but also two additional peaks at 1641 and 1562 cm^{-1}, which can be attributed to a degradation process (see below) and therefore do not compromise the provenance attribution. Therefore, Baltic succinite can be proposed as the raw material used for all the analysed amber samples, except for one.

The only piece that differs from the rest is the spacer-bead 1339 from Forat de la Conqueta. Its spectrum is characterized by intense absorption peaks at 2922 and 2855 cm^{-1}, related to single C-H bonds produced by methylene groups, and an O-H bending band at 1644 cm^{-1}. The spectral range of 1550–650 cm^{-1} contains the largest number of absorption features, with peaks at 1575, 1418, 1023, 876, 824, and 669 cm^{-1}. These bands can be assigned to the C-H bending motions of methyl and methylene functional groups, and to absorption bands generally assigned to C-O single bonds, such as the intense band at 1023 cm^{-1} from the -O-CH_3 and -O-CH_2-CH_3 ester groups, although not all absorption features in this range can be assigned to a specific molecular functional group (Tappert et al., 2011). The spectrum also has shoulders or secondary peaks at 1701 cm^{-1}, associated with carboxylic acid groups, at 1258 cm^{-1} associated with the *vs* (C-O) bond, at 1154 cm^{-1}, which can be attributed to the stretching of the single C-O ester bond, and at 1104 cm^{-1} (Table 3; Supplementary Material S2).

The spectrum is mostly characterized by a very large hydroxyl peak at ~3400 cm^{-1} which is attributed to the symmetrical stretching of O-H bonds. This peak is characteristic of gums (Tappert et al., 2011; Thombare et al., 2023), whereas it is weaker in resins and volatile-rich resins or in younger ambers such as Baltic succinite, while it is absent in older Cretaceous Iberian ambers. The similarity with the FTIR spectra of gum is strong (Figure 5). However, it shows two peaks at 1644 and 1575 cm^{-1} that are usually absent in gum

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Table 3. *FTIR results of analysed amber samples.*

Site	Sample ID	Main peaks at cm^{-1}												
Cabana del Moro de Colomera	2508a	1708				1449		1376		1159		1021		881
	2508b	1708				1449		1377		1159		1015	978 (s)	889
	2508c	1706				1449		1378		1158		1009		890
Sepulcro Tumular I de El Bosc	1837_1	1707				1448		1375		1159		1017	978	887 (s)
	1837_2	1707				1449		1375		1159		1018	975	888 (s)
	1837_5	1704				1450		1373		1159		1021	973	888 (s)
	1837_7	1708				1448		1375		1159		1018	975	887 (s)
	1837_9	1717				1448		1381		1159		1022	974	885 (s)
	1837_12	1707				1448		1375		1159		1025	976	880
	1837_12_wl	1706	1646	1559		1447		1375		1158		1020	976 (s)	888
	1837_12_wl	1709	1647	1565		1447		1378		1158		1021	978 (s)	888
	1837_13	1708				1448		1375		1159		1018	977	887 (s)
	1837_14	1705				1448		1375		1159		1018	977	888 (s)
	1837_16	1705				1455		1375		1159		1017	978	888
	1837_17	1708				1449		1375		1159		1019	978	887 (s)
	1837_18	1706				1448		1375		1159		1017	977	886
La Fossa del Gegant		1709				1449		1376		1157		1016	978	885
La Pera	3434	1707				1450		1377		1159		1016	974	889
Cova del Frare	325	1705				1451		1376		1150		1022	978	
El Garrofet	G/333	1707				1449		1377		1158		1020	979 (s)	890
Forat de la Conqueta	4855	1706	1641	1562		1446		1377		1156		1021	979 (s)	887
	1339		1644	1575	1545 (s)		1418		1258 (s)	1154 (s)	1104 (s)	1023		876

S = secondary peaks, wl = weathered layer

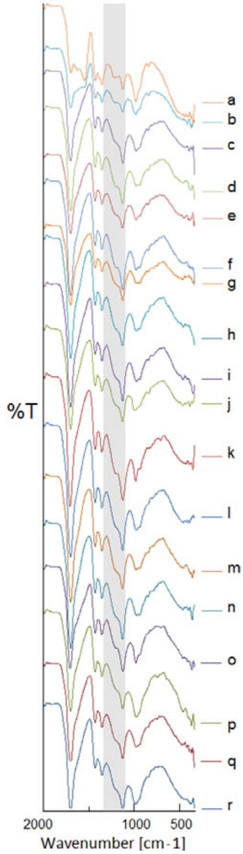

Figure 4. *FTIR spectra of amber samples. a) Forat de La Conqueta_485;5; b) El Garrofet; c) Fosa del Gegant; d) La Pera_3434; e) El Bosc_18; f) El Bosc_17; g) El Bosc_16; h) El Bosc_14; i) El Bosc_13; j) El Bosc_12; k) El Bosc_9; l) El Bosc_7; m) El Bosc_5; n) El Bosc_2; o) El Bosc_1; p) Cabana del Moro de Colomera 2508_c; q) Cabana del Moro de Colomera 2508_b; r) Cabana del Moro de Colomera 2508_a. The 'Baltic shoulder' is highlighted in light grey for the sake of clarity.*

samples but present in weathered amber samples (see below), so their presence may be related to the degradation processes of the raw material. The characteristic 'Baltic shoulder' is absent in this sample.

Surface oxidation layer

In the case of bead 1837_12 from El Bosc, we were able to extract two samples from the surface oxidation layer and a third one from the amber core, allowing us to evaluate the spectral changes associated to post-depositional weathering.

The spectrum of the amber core, like those of the previous samples, corresponds to the succinite spectrum, presenting the characteristic 'Baltic shoulder' (Table 3; Figure 6). In the spectra from the weathered layer, the 'Baltic shoulder' is still visible but it shows a slight upward slope rather than being flat. Beck et al. (1965) proposed that this horizontal band would fade slightly, resulting in a downward slope, due to oxidation. This is indeed the case for some of the samples reported above (Figure 6). However, in the case of bead 1837_12, the pattern is precisely the opposite: instead of a downward slope, the shoulder has become more pronounced, almost forming a secondary peak. Experimental studies and further analyses of amber cores *vs* weathered surfaces would be needed to determine under what weathering conditions this band fades or becomes more pronounced, and to what extent soil aridity, ambient humidity, or salinity may contribute in either direction.

Besides this feature, the main spectral alteration appears in the range between 1750 and 500 cm^{-1}, where peaks appear at ~1645 and ~1560 cm^{-1} that may be related to acidic carboxylic groups (Rodríguez Montoro, 2013). These features are also found in sample 4855 from Forat de la Conqueta, which also shows signs of surface degradation.

Discussion

It is striking that out of the thirty-one prehistoric amber beads analysed from the north-eastern Iberian Peninsula, twenty-nine have a Baltic origin. This pattern contrasts significantly with other regions of Iberia, where Baltic amber is scarcely present before 1550 BC, when it occurs in association with broader socio-economic

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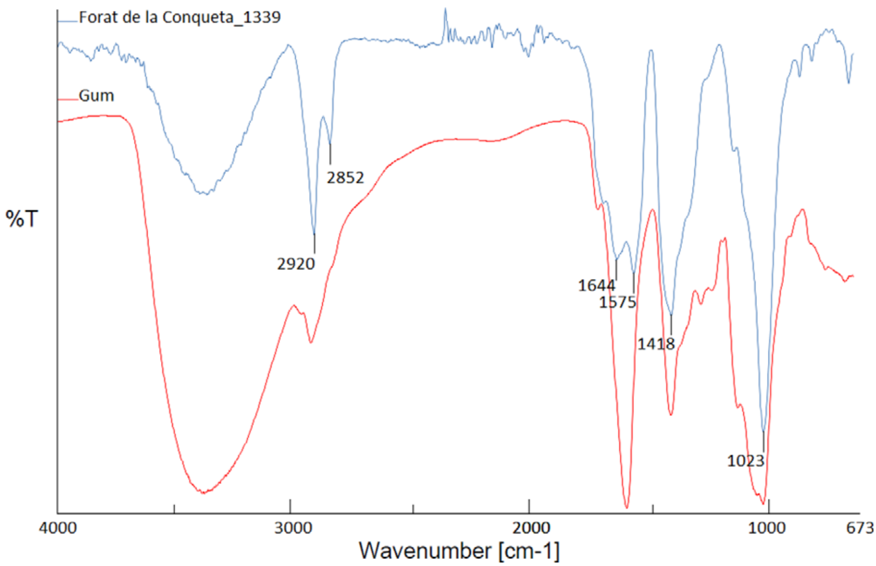

Figure 5. *FTIR spectrum of sample 1339 from Forat de la Conqueta compared to the FTIR spectrum of a gum sample from Tappert et al., 2011.*

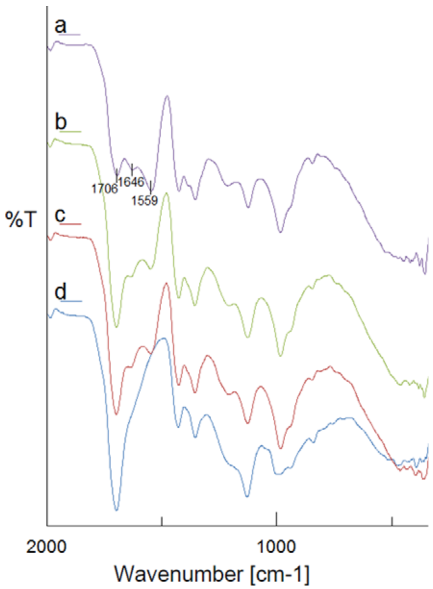

Figure 6. *FTIR spectra of sample 4855 from Forat de La Conqueta (a) compared to the weathered layer from the El Bosc_12 bead (b, c) and the amber core of the same bead (d).*

changes occurring during the Late Bronze Age/Early Iron Age. In the southern half of Iberia, most prehistoric amber, at least since the second half of the fourth millennium BC, originates in Sicily (Murillo-Barroso et al., 2018a). One bead from La Almoloya and another bead from Cueva de las Ventanas, dated to the middle of the second millennium BC, are the only examples of Bronze Age Baltic amber recovered in the southern half of Iberia out of the more than 200 beads analysed in the area. In addition, two beads found in the megalithic structures of Llano de la Sabina can be proposed as having a Baltic origin. However, these graves were reused during the Early Iron Age, making it difficult to assign them securely to a chronological phase. On the Cantabrian coast and in the northern Iberian region, only the bead from the Larrate dolmen (which accounts for 12 per cent of the analysed beads in the region) can be considered Baltic; it was recovered from the outer area of the tumulus and hence its chronological attribution is not entirely certain (Álvarez-Fernández et al., 2005; Murillo-Barroso et al., 2018b). While we cannot be sure that all the analysed beads from the north-eastern Iberian region can be dated to before 1550 BC (see Supplementary Material S1), it is nonetheless evident from the amber data

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that southern and north-eastern Iberia were part of different exchange networks. The frequency and spatial distribution of Baltic amber in France suggests that it may have entered from the north following fluvial routes, with a significant concentration of amber objects the southern area (du Gardin, 1986, 2003) (Figure 1). The close contacts between these communities and those in north-eastern Iberia would have facilitated the arrival of Baltic amber in the Iberian Peninsula. Interestingly, while natural passageways across the Pyrenees allowed the movement of amber, the river Ebro appears to have served as a stronger cultural boundary.

Special mention should be made of the site of Forat de la Conqueta, which has a broad chronology (3400–1100 BC) and where two completely different beads were recovered. The first is a simple and common type in the Iberian Peninsula; despite showing slight surface degradation, the spectrum clearly displays the main characteristics of Baltic succinite. The second item, a spacer-bead, is likely to have been highly valued, as it was repaired and reused after it was broken (Martínez-Moreno, 2010; Núñez et al., 2022). This type of spacer-bead is well-documented in the Iberian Peninsula in other raw materials, but it had not been previously documented in amber (Carrasco Rus et al., 2009). The only other possible exception might be the now lost spacer-bead from Les Pixarelles, for which only a brief description is available (Rovira i Port, 1994: 72). Conversely, amber spacer-beads are more commonly documented in Europe, from Greece to Britain, being particularly frequent in Germany and France (du Gardin, 1986, 2003). In France, at least forty-nine spacer-beads are known, and all the French beads analysed to date have been shown to be of Baltic origin (Pétrequin et al., 1987).

It would thus seem reasonable to propose an exogenous (and possibly Baltic) origin for the spacer-bead from Forat de la Conqueta (Núñez et al., 2022). However, our FTIR spectrum does not show the characteristic 'Baltic shoulder', and instead bears a clear similarity to that of gum, a distinctive type of exudate that occurs together with resins in several taxa. Although these exudates are often not physically distinguishable from resins, their FTIR spectra are characterized by a very large hydroxyl peak at ~3400 cm^{-1} that does not occur in resins. At the same time, the FTIR spectra of gums from different species are very similar to each other; compositionally, they are primarily polysaccharide derivates with considerably lower amounts of terpenoids (Tappert et al., 2011).

When not fossilized, gum and volatile resins are more commonly used as adhesives than as raw materials for making beads. The Forat de la Conqueta bead does not appear to have any coating, as is known from other examples in Iberia (Odriozola et al., 2019b, 2024). It was most probably made of gum, although the possibility that it was coated with some type of gum that would have acted as an adhesive when it was repaired cannot be entirely discarded. In any case, it is evident from both its typology and treatment that this bead differs from the other objects documented in north-eastern Iberia, and particularly from the disc-shaped bead recovered at the same site.

All in all, our review of the amber objects from north-eastern Iberia highlights the regional diversity that characterizes the prehistory of the Iberian Peninsula and is evident in the technological, social, and cultural traditions that developed in its different areas (e.g. Lillios et al., 2016; Blanco-González et al., 2018), including the different social value given to specific materials. Access to 'exotic' materials as markers of social status has been related to the increase of social stratification in southern Iberia during the Copper Age. This trend would have been broken by the

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emerging Bronze Age elites (particularly evident in the El Argar society), who established new ideological and symbolic expressions whereby the role played by amber (and 'exotica') in the materialization of power was replaced by other raw materials, especially metals (Costa et al., 2011; Murillo-Barroso & Montero-Ruiz, 2017). These social and cultural regions also developed different exchange networks. In particular, north-eastern Iberia shows a distinct tradition characterized by exchange networks oriented primarily towards southern France and the interior of the continent, rather than towards the western Mediterranean and North Africa. Even during the Palaeolithic, the lithic industry shows clear influences from southern France, albeit with local variations that reflect adaptations to the specific environmental and social conditions of the Iberian region. This suggests the existence of contact networks, shared traditions, and a flow of materials and technical knowledge between the two regions, facilitated by geographical proximity and the relative ease of communication through the Pyrenees, which acted as a fluid conduit.

The Neolithic and Copper Age in the Iberian Peninsula are marked by the intensification of exchange networks and the increased complexity of social structures. During the Neolithic and Copper Age, in north-eastern Iberia and southern France, communities known as 'Sepulcros de Fossa' (4200–3500 cal BC) and 'Veraza' (3500–2300 cal BC) developed, sharing a similar material culture on both sides of the Pyrenees and exchanging raw materials (Martín-Cólliga et al., 2002), as evidenced by the presence of variscite from Can Tintorer (Gavá) in French megaliths or the arrival of flint from Vaucluse (France) in north-eastern Iberia (Herbaut & Querré, 2004; Vaquer & Lea, 2011; Mangado Llach et al., 2016). Obsidian from Lipari and Pantelleria, which circulated in the central Mediterranean, also reached the Chasséen communities in France and, sporadically, the 'Sepulcros de Fossa' on both sides of the Pyrenees (Lea, 2012; Gibaja et al., 2014; Terradas et al., 2014). However, these raw materials do not seem to cross the river Ebro barrier, as they are absent in the southern peninsula, whose communities are more oriented toward relations with North African populations. The relationships of the people in the southern peninsula with African populations facilitated the arrival of ivory, ostrich eggs, and Sicilian amber—raw materials that are, in turn, absent or very rare in north-eastern Iberia. Regarding amber specifically, the Sicilian sources documented for the southern Iberian amber artefacts contrast with the Baltic origin of the artefacts in north-eastern Iberia (Murillo-Barroso et al., 2018b), again reinforcing this regional diversity of exchange networks (Figure 1).

The close relationships between communities on both sides of the Pyrenees have also been used to explain the concurrent technological development of metallurgy and the social value of copper among the communities of north-eastern Iberia (Soriano, 2013; Montes-Landa et al., 2020, 2021), and it is in this context that the early arrival of Baltic amber in north-eastern Iberia and its abundant presence in this region during recent prehistory should be understood.

The general distribution pattern of amber beads in Iberia, concentrated along the coastal regions with a significant scarcity of finds in Central Iberia, supports the idea of maritime contacts with several sites possibly acting as 'attractors' of exotic materials in the areas of Lisbon, the Guadalquivir Valley and the Gulf of Cádiz, the south-east and the north-east, where the main clusters of objects are concentrated (Figure 1). The question of whether amber arrived in a raw state or as finished objects remains open, given the absence of evidence for amber bead production in the Iberian

Peninsula. However, the general typological differences between the beads of northern Europe and those in the Iberian north-east (du Gardin, 1995) suggest a possible regional tradition, and the existence of amber workshops in the peninsula.

Conclusions

A detailed review of the amber finds recovered in the north-eastern Iberian Peninsula, and extensive provenance analysis using FTIR, have allowed us to identify the majority of them as Baltic succinite. Importantly, this is possible even in weathered samples, which show bands at ~1646 and ~1559 cm^{-1}, but without detracting from their identification. There are very few exceptions to this pattern: on the one hand, two samples from Pedra Cabana, erroneously classified as amber in previous work, are shown to be made of a red bolus pigment; on the other hand, gum was identified in the spacer-bead from Forat de la Conqueta, a typologically unique bead that is morphologically related to French and Central European beads. The local significance of this bead is also evident by the fact that it was repaired and reused after its fracture.

The review of the relevant archaeological contexts (Supplementary Material S1) shows that all the beads come from collective funerary contexts. In no case can the beads be associated with specific individuals, which prevents us from making interpretations about the social value of amber in terms of gender and age, as proposed for later contexts (Vallejo-Casas et al., 2024). Many of these contexts present a broad stratigraphic sequence, meaning that the beads cannot always be assigned to a specific time period. Nevertheless, the pieces with a clearer chronological attribution allow us to propose an emerging picture.

The arrival of Baltic amber in the Iberian north-east likely began in the Late Neolithic, with the earliest evidence recovered from the burial at Cova del Frare (3634–3363 cal BC) (Murillo-Barroso et al., 2023). Baltic amber continued to be used by Chalcolithic communities, as likely evidenced by the site of La Fossa del Gegant, and especially during the Middle and Late Bronze Age, as indicated by the contexts of Pedra Cabana, Cabana del Moro de Colomera, Cova de la Roca del Frare, Cova de Muricecs, and, possibly, Les Pixarelles. Inevitably, a less precise chronology, spanning from the Late Chalcolithic to the Late Bronze Age, is provided by the sites of El Bosc, La Pera, and Forat de la Conqueta, some of which may extend into the Early Iron Age, as in the case of El Garrofet.

Overall, the studied contexts indicate a continuous use of Baltic amber from its first appearance in the Late Neolithic. The only exception is the bead from Cova del Gegant, which spans a wide chronology from the Chalcolithic to the Middle Ages, and is thought to have a Sicilian origin (Odriozola et al., 2019a).

Continuity in the virtually exclusive use of Baltic amber is all the more remarkable when one bears in mind that geological amber is available locally, and it stands in strong contrast with other regions of the Iberian Peninsula, namely the southern half and the northern strip, where either local amber resources (northern strip) or Sicilian amber (southern half) predominated. Chronologically, the peak of amber use in the southern half of the peninsula occurred during the Chalcolithic (3200–2200 BC). During the Early and Middle Bronze Age (2200–1500 BC), while amber was prevalent in the north-east, hardly any amber beads are known in the southern half of Iberia. It is not until the Late Bronze Age that Baltic amber begins to be documented abundantly across the rest of the Iberian Peninsula, eventually replacing the previously documented Sicilian or local ambers.

These regional differences in amber consumption extend to other raw materials (ivory, ostrich eggshells, variscite, flint, obsidian) and reflect the distinct regional dynamics and, consequently, the contact networks operating in different territories of the Iberian Peninsula. This challenges unilineal explanations about the technological and social development of Iberian communities, highlighting that their various regional trajectories can only be understood in relation to the specific sociocultural and environmental factors for each area.

Supplementary Material

The supplementary material for this article can be found at http://doi.org/10.1017/eaa.2025.12.

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Biographical Notes

Mercedes Murillo-Barroso is senior lecturer at the University of Granada. Her research interests include early metallurgy, provenance studies, and the inception and development of technologies and networks and their impact on social structures.

Address: Departamento de Prehistoria y Arqueología. Universidad de Granada, Campus de Cartuja, s/n 18011-Granada, Spain. [email: murillobarroso@ugr.es]. ORCID: 0000-0002-2271-291X.

Mercedes Navero Rosales is a PhD candidate at the University of Granada supported by a scholarship from the Spanish Government (*Formación de Personal Investigador*, FPI Programme). Her ongoing research focuses on social network analysis in Iberian late prehistory as well as provenance analysis of exotic materials such as amber or ivory integrating archaeometrical analyses with social issues.

Address: Departamento de Prehistoria y Arqueología. Universidad de Granada, Campus de Cartuja, s/n 18011 Granada, Spain. [email: mercenavero@ugr.es]. ORCID: 0009-0009-1253-0889.

Paloma González-Marcén is professor at the Autonomous University of Barcelona. Her research is focused on public archaeology as well as theoretical and methodological aspects of archaeological research, especially related to gender and feminist archaeology.

Address: Departamento de Prehistoria. Universidad Autónoma de Barcelona, Edifici B, 08193-Bellaterra, Spain. [email: paloma.gonzalez@uab.cat]. ORCID: 0000-0002-9410-8826.

Marcos Martinón-Torres is Pitt-Rivers professor of archaeological science. His main research interests include material culture, technologies, and knowledge transmission.

Address: McDonald Institute for Archaeological Research, University of Cambridge, Downing Street, Cambridge, CB2 3ER, UK. [email: m.martinon-torres@arch.cam.ac.uk]. ORCID: 0000-0003-2124-2837.

Les réseaux de l’ambre en préhistoire : le nord-est de l’Ibérie comme étude de cas

Cette étude sur les réseaux d’ambre préhistorique dans le nord-est de l’Ibérie souligne que cette région appartenait à un système d’échange distinct des autres régions de la péninsule ibérique. L’ambre balte domine les ensembles de cette région du Néolithique final à l’âge de Bronze tandis que l’ambre sicilien prédomine en Ibérie méridionale et que l’ambre du Crétacé ibérique prévaut dans le nord. Les données font ressortir les liens avec le sud de la France, les Pyrénées servant de conduit culturel alors que l’Èbre formait une frontière. Les auteurs de cet article présentent les résultats d’une analyse par spectroscopie infrarouge à transformée de Fourier (IRTF, FTIR en anglais) de vingt et une perles d’ambre provenant majoritairement de sépultures collectives. Dix-huit étaient en succinite balte. L’ambre balte émerge en Ibérie nord-orientale dès 3634–3363 cal BC et continue à être utilisé jusqu’au Bronze final. Les exceptions sont une perle d’espacement de type unique en résine de gomme et deux exemplaires en pigment de bolus identifiés par erreur comme de l’ambre. Les résultats font ressortir la diversité régionale de l’Ibérie en matière d’approvisionnement et d’échange de matières premières, indiquant que des dynamiques socioculturelles distinctes étaient en opération et remettant en question une représentation linéaire de la préhistoire ibérique. Translation by Madeleine Hummler

Mots-clés: succinite, ambre, préhistoire tardive, nord-est de l’Ibérie, provenance, IRTF (FTIR)

Prähistorische Bernsteinnetzwerke: Nordost-Iberien als Fallstudie

Diese Studie betrifft die prähistorischen Bernsteinnetzwerke im Nordosten der iberischen Halbinsel, welche die unterschiedliche Austauschdynamik in dieser Gegend im Vergleich zu anderen Gebieten der Halbinsel betont. Baltischer Bernstein kommt überwiegend in den spätneolithischen und bronzezeitlichen Befunden des iberischen Nordostens vor, im Gegensatz zum Süden, wo sizilianischer Bernstein dominiert, oder zum Norden, wo kretazeischer Bernstein vorherrscht. Die Ergebnisse der Untersuchung unterstreichen die Verbindung der Region mit Südfrankreich, wobei die Pyrenäen als kultureller Übermittler dienten, im Gegensatz zum Ebro, der eine Grenze darstellte. Die Verfasser bewerten die Ergebnisse einer Fourier-Transform-Infrarot-Spektrometrischen (FTIR) Untersuchung von einundzwanzig Bernsteinperlen, die vor allem aus kollektiven Gräbern stammen. Achtzehn davon wurden aus baltischem Succinit hergestellt. Baltischer Bernstein tauchte wahrscheinlich um 3634–3363 cal BC im Nordosten der iberischen Halbinsel auf und wurde bis in die Spätbronzezeit verwendet. Ausnahmen waren eine einzigartige Abstandsperle aus Pflanzensaft (Gummi) und zwei Exemplare aus Bolus-Pigmente, die falsch als Bernstein identifiziert wurden. Die Ergebnisse illustrieren die regionale Vielfalt der Beschaffung und des Austauschs des Rohstoffs in Iberien, widerspiegeln die unterschiedlichen soziokulturelle Dynamiken in der iberischen Halbinsel und stellen lineare Schilderungen der iberischen Vorgeschichte infrage. Translation by Madeleine Hummler

Stichworte: Succinit, Bernstein, spätere Vorgeschichte, Nordosten der iberischen Halbinsel, Herkunft, FTIR