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The early Upper Palaeolithic of Cova de les Cendres (Alicante, Spain)

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ABSTRACT

This paper presents a synthesis of the Early Upper Palaeolithic of Cova de les Cendres. Points of special attention are the sedimentary and micromorphological characterisation of level XVI, the analysis of the vegetal and animal resources and their incidence on the economy of the Gravettian human groups, and the characterisation of the landscape during this period. Furthermore, the paper offers important information of the lithic and bone assemblages, economic behaviour and radiocarbon dates of sub-levels XVIA and XVIB, related to the Gravettian, and XVIC and XVID, corresponding to the Aurignacian. Finally, the Gravettian and Aurignacian regional contexts in the Mediterranean Basin of the Iberian Peninsula are discussed, and the recent proposals for regional technological variation in the Iberian Gravettian industries are critically evaluated.

1. Introduction

The Gravettian in the Iberian Mediterranean area has received greater attention in recent years. The industries attributed to the Gravettian have been noted at various sites, such as Nerja (Aura et al., 2010, 2012), Bajondillo (Cortés, 2007, 2010), Palomar (de la Peña and Vega Toscano, 2013), La Boja and Finca de Doña Martina (Zilhão et al., 2017) and Arenal de Fonseca (Utrilla et al., 2010; Domingo Martínez et al., 2013). Previously excavated assemblages have also been revised, such as that of Malladetes (de la Peña, 2013a), and their lithic tools have been studied in detail, both in terms of backed points (Roman and Villaverde, 2006) and splintered pieces (de la Peña, 2011). Within the framework of these contributions, overall assessments aimed at establishing the current state of research on the Gravettian in various areas of the Mediterranean Iberia have been made (Fullola et al., 2007; Villaverde et al., 2007; Cortés et al., 2012; de la Peña, 2013b; de la Peña and Vega Toscano, 2013; Villaverde and Roman, 2013), even going so far as to compare Portuguese Southern Atlantic seaboard sites with Mediterranean ones (Bicho et al., 2013; Marreiros et al., 2013, 2015). Other sites previously excavated have provided levels that have been related to the Gravettian. Of those, it is worth noting l'Arbreda (Soler and Maroto, 1987; Wood et al., 2014), Reclau Viver, Barranc Blanc (Fullola et al., 2005), Beneito (Iturbe et al., 1993) and Parpalló (Millares, 1982). Other references either refer to small assemblages or those lacking absolute chronologies (for a review, see Fullola et al., 2007; Villaverde and Roman, 2013; Cortés et al., 2012). Two new sites that were discovered in the past few years are found in the same geographical area as Cendres. On the one

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hand, there is Barriada, which has a good range of dates but a scarce associated lithic industry (Fernández-López de Pablo et al., 2014), and on the other hand, there is Comte, for which there are dates and associated lithic materials, as well as parietal art (Casabó et al., 2016).

Two topics have aroused particular interest in relation to the southern half of the Iberian Peninsula: determining the timing of the beginning of the Upper Palaeolithic, especially in terms of the central and southern Mediterranean, and the degree of differentiation or variation between Gravettian industries. The former is of interest because it may allow for a seriation of the Gravettian to be put forward — although the main problem when attempting to do this lies in the consistency of the associated stratigraphic sequences, given the age of some of the excavations or the scarcity presented by some of the collections — and because, ultimately, it refers to the existence (or lack of) an Aurignacian phase in this region. The latter topic is of interest because from the works conducted in the peninsular Southwest, the existence of regional differentiations has been proposed. This suggestion is based on the typological characteristics of Vale Boi (Marreiros et al., 2015), which can be linked to those of the other Atlantic sites, in particular to Morín (Bradtmöller et al., 2016).

At Cendres, the recent expansion of the test pit from the Gravettian levels provides new and relevant information supported by a large number of chronometric dates, allowing for further discussion on the two issues mencioned above. This expansion has led to a reorganisation of the material previously published (Villaverde and Roman, 2004) and, given the significance of the sequence and the wealth of some of its levels, provides further data with which to assess the technological and typological variability presented by the Gravettian in the southern Iberian Peninsula.

2. Location and description of the excavated area

Approximately 60 m above sea level, Cova de les Cendres is located in Punta de Moraira (Teulada-Moraira, Alicante) on an escarpment coinciding with the current coast line. It is a wide, east-facing cavity that is more than 1000 m^2 in surface. The cavity comprises two large areas: one open and well lit, in which large zenithal detachment blocks are visible, and another interior one, poorly lit because of a marked reduction of the height of the vault, which then opens up again as one moves deeper into the cave (Fig. 1).

The first fieldwork at this location dates back to 1974 and 1975, when a couple of test excavations took place (Llobregat et al., 1982). The Neolithic levels were excavated from 1981 onwards, and this was done in the so-called sector A, which was approximately 20 m^2 (Bernabeu and Molina, 2009). A small test pit of the Palaeolithic levels was also opened up then, and starting in 1995, excavations took place in sector B, the aim of which was to reach the Pleistocene

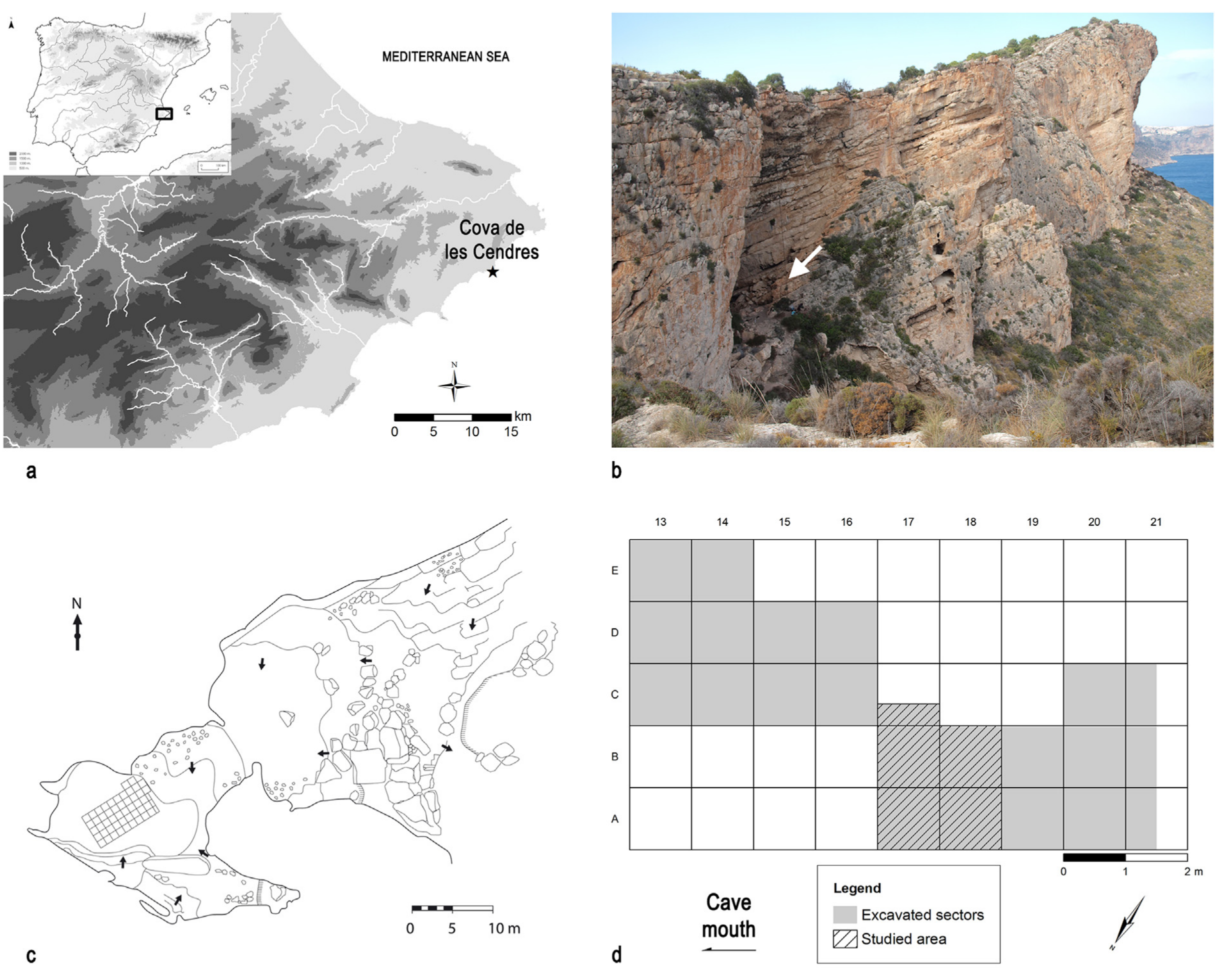

Fig. 1. a) Map showing the location of Cova de les Cendres in the Iberian Peninsula. b) View of the cliffs in which the cave is located (arrow points to the cave mouth) (photo: C. Real). c) Plan of the cave (arrows show the dip in the floor). d) Excavated area with indication of squares studied in the paper.

Table 1
Cova de les Cendres. Synthesis of the stratigraphic and sedimentary field description of the Pleistocene sequence with the archaeological period and the chronological limits.

LEVEL	STRATIGRAPHIC AND SEDIMENTARY DESCRIPTION	ARCHAEOLOGICAL PERIOD	ka BP
IX	Silty sand with some stones. Brown (10YR 4/4)	Final Upper Magdalenian	12,47
X	Sandy silty clay laminations with some stones and organophosphatic inclusions. Greyish (10YR 5/2) and reddish-orange (7.5 YR 6/6)	Upper Magdalenian	–
XI	Stones and gravels of subangular-to-angular morphology with clayey silts and sands. Brown (5YR 4/2)	Upper Magdalenian	13.1–13.3
XII A	Silty clayey sands with stones and blocks with organophosphate laminations, high organic material	Middle Magdalenian	13.4–16.0
XII B	content. Brown (7.5YR 3/4)	Lower Magdalenian?	
XIII	Silty clayey sands with some stones and several charcoal fragments. Dark brown (10YR 4/2).	Solutrean	18.7–18.9
XIV	Sandy silty clay laminations and some gravels, high organic material and organophosphatic inclusions. Dark brown (10YR 2/1) and reddish brown (5YR 4/6)	Solutrean	20.2–20.3
XV	Sandy clay with gravels and many charcoal and bone remains. Brown (10YR 4/3)	Gravetian	20.8–21.2
XVI A	Clayey silt laminations with sands, high organic material content. Dark brown (10YR 2/2), brown (7.5YR 6/6) and some greyish (7.5YR 6/1).	Gravetian	22.7–24.8
XVI B	Sandy clays with some gravels and stones. Brown (7.5YR 4/3)	Gravetian	25.6–26.0
XVI C	Clayey silt with sand laminations, high organic material content. Dark brown (7.5YR 3/3), grey (7.5YR 6/2) and brown (7.5YR 4/6).	Late/Evolved Aurignacian	26.9–28.7
XVI D	Silty clays with some blocks. Dark brown (7.5YR 2.5/3)	Late/Evolved Aurignacian	31,1
XVII	Silty clays with blocks. Brown (5YR 4/6)	?	–

levels, an area which initially spread over 22 m^2 (Villaverde et al., 1999, 2010 and 2012).

The Palaeolithic sequence at Cendres is one of the most complete for the Mediterranean Peninsula and comprises levels from various phases of the Magdalenian, Solutrean and Gravettian and a mostly industrially undefined Upper Palaeolithic that could be described as evolved Aurignacian (Table 1 and Fig. 2).

The levels under study here are the lower ones (XV, XVI and XVII), and these were excavated over an area slightly bigger than 4 m^2. In this small zone, taking into account the total surface area available, the bottom of what appears to be the base of the filling — or a phase of rock fall that was consolidated by a stalagmitic cap — was reached. The average depth of these levels is around 1.6 m.

The excavation of levels XV, XVI and XVII took place between 1998 and 2017. First squares A, B and C-17 were excavated, the latter only to 0.25 m^2, and this was followed by the extension of squares A and B-18. The archaeological materials from level XVI recovered in the first stage of the excavations were studied and published by Villaverde and Roman (2004). Other published works have included preliminary data on the fauna excavated from those levels (Villaverde et al., 2007), as well as on the vegetation (Villaverde et al., 2010) and microfauna (Tormo, 2010).

In light of the results obtained during the enlargement of the excavation area, the aim of the present study is to review the totality of the Gravettian industry previously analysed in 2004. An important series of dates are also presented here, which allow for the chronology of these levels to be precisely set. Given the wealth of materials and their wide chronological span, the data presented here are of great value to the study of the beginning of the Upper Palaeolithic sequence. Although we focus on level XVI, the dates and an assessment of the industries from levels XV and XVII are also included here. This allows for the spread of the Gravettian sequence to be better determined and for the changes that took place at the base of level XVI, which we link to the Aurignacian, to be better understood; it also allows for a fuller understanding of level XVII, for which a cultural ascription could not be established.

A part of the faunal study is currently underway, which is why only the characterisation of sub-level XVIA is included in the present study. In any case, given the scarcity of archaeozoological information available for the start of the Upper Palaeolithic in the Mediterranean region, we deemed the study of this sub-level to be of particular importance. Finally, the data obtained have been complemented with those obtained from the anthracological analyses of the levels noted above. These, together with the contributions provided by the carpological study and that of the phytoliths from sub-level XVIA, will help in the characterisation of the palaeoenvironment and economy during the Gravettian pase that shows the greatest intense human occupations events.

3. Radiocarbon dating

The succession of the levels of Early Upper Palaeolithic of Cendres, sustained by a rich series of absolute dates, provides us with a sufficiently robust chronological framework against which to assess the evolution of the Gravettian and Aurignacian industries, providing new information regarding the early Upper Palaeolithic in the region.

Two criteria have been followed for the selection of the samples. Some samples were selected from different levels once the charcoals had been taxonomically identified and the states of conservation/alteration had been evaluated as appropriate. Others were selected directly based on their stratigraphic profile, looking to specify the upper and lower chronological limits of the different sedimentary units.

In terms of the chronology, Cendres' 24 ^{14}C dates for levels XV and XVI represent one of the richest series of this kind for the Iberian Peninsula and are of special relevance in terms of the coherence they present in relation to the stratigraphic and archaeological sequence (Table 2). Two of the dates must be excluded. The first date is incoherent in terms of the level in which it was found because the area from where the charcoal was extracted from coincided with a burrow that was not initially identified. The second charcoal dated is that of a *Rosmarinus,* recovered from square A-17, and its date contradicted that obtained from another sample from the same level and layer, suggesting it is an intrusion from level XV. Level XV has produced three dates from the end of the Gravettian, placing it approximately between 24,640 and 26,495 cal. BP. Sub-level XVIA has seven dates that approximately range between 26,750 and 29,170 cal. BP (Beta-295,148 is not considered). There are five dates from sub-level XVIB, all falling between 29,350 and 31,000 cal. BP. Sub-level XVIC possesses six dates that are older than those known for the Gravettian in the Peninsula, placing this sub-level between 30,780 and 34,140 cal. BP. Lastly, there is one date for sub-level XVID, between 34,620 and 35,340 cal. BP, which, like the sub-level above, is Aurignacian.

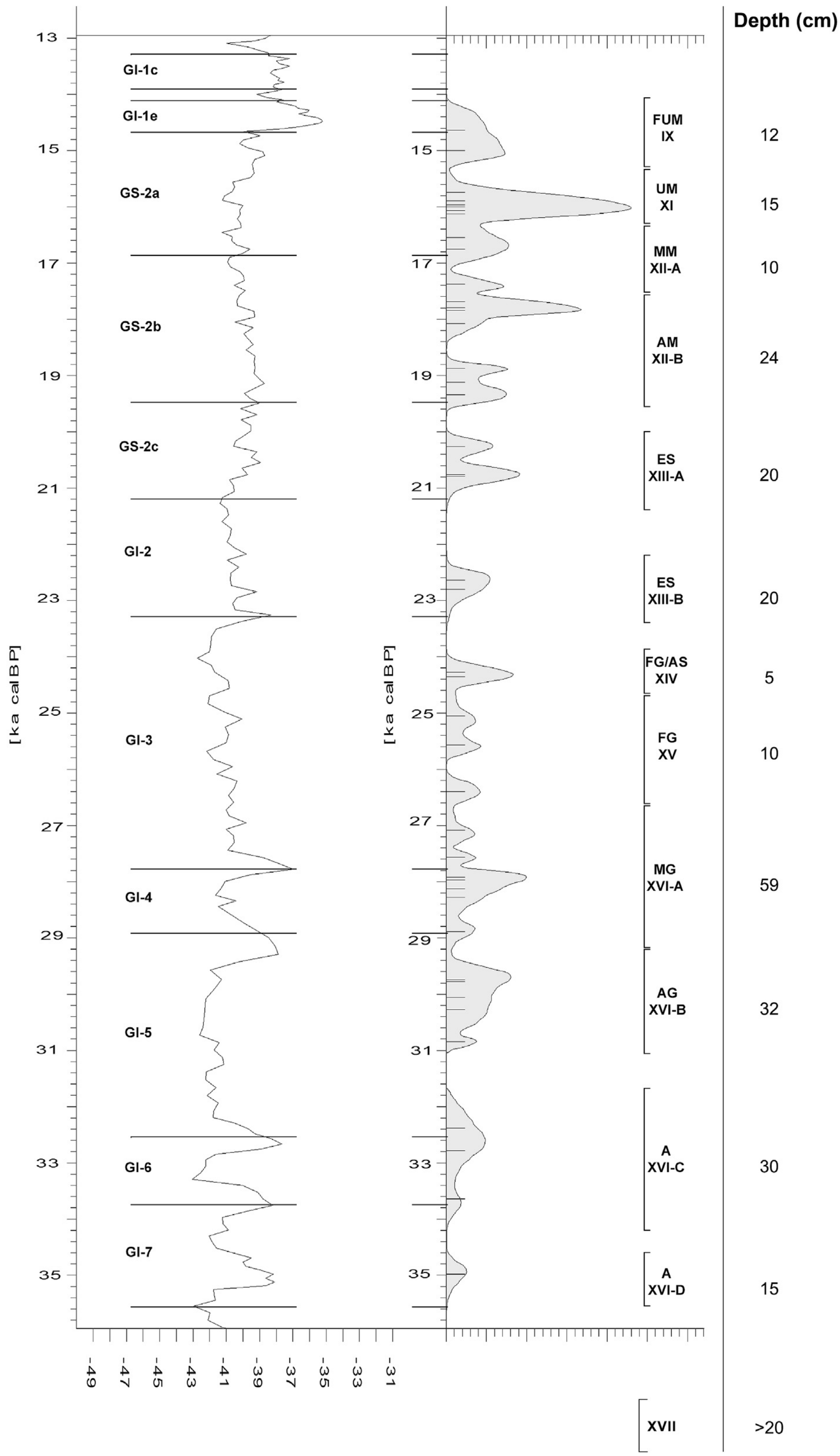

Fig. 2. Cova de les Cendres. Correlation between Greenland Interstadials and Upper Palaeolithic periods (chronological limits are indicated).

Table 2
Radiocarbon dates from the archaeological sequence of Cova de les Cendres. Samples with * were selected directly on stratigraphic profil.

Sample		Level	Lab #	Age BP	Age cal BP (95%)	δ 13C	Taxon
A/B-17	2015.1.1 *	XV	Beta-437,194	22,190 ± 80	26,495–26,285	−23.4 ‰	*Pinus nigra-sylvestris*
A-17	70	XV	Beta-142,282	21,230 ± 80	25,820–25,340	−22.6 ‰	*Pinus nigra-sylvestris*
A-18/19	M-12 *	XIV-XV	Beta-287,546	20,800 ± 110	25,480–24,640	−23.2 ‰	*Pinus nigra-sylvestris*
A/B-17	2015.2.3 *	XVIA	Beta-437,195	22,750 ± 110	27,430–26,750	−24.6 ‰	*Pinus nigra-sylvestris*
A-18/19	M-13 *	Borrow	Beta-287,547	16,460 ± 60	20,080–19,640	−22.8 ‰	*Pinus nigra-sylvestris*
A-17	73	XVIA	Beta-303419	23,350 ± 100	27,750–27,390	−23.7 ‰	*Quercus perennifolio*
A-18/19	M-14 *	XVIA	Beta-287,548	23,920 ± 100	28,230–27,710	−24.4 ‰	*Pinus nigra-sylvestris*
A-18/19	M-15 *	XVIA	Beta-287,549	23,860 ± 100	28,140–27,700	−23.7 ‰	*Pinus nigra-sylvestris*
A-17	75	XVIA	Beta-142,283	24,240 ± 220	28,760–27,800	−24.1 ‰	*Pinus nigra-sylvestris*
A-17	78	XVIA	Beta-155,606	24,080 ± 150	28,510–27,750	−23.5 ‰	*Pinus nigra-sylvestris*
A-17	78	XVIA	Beta-295,148	21,880 ± 100	26,320–25,880	−23.2 ‰	*Rosmarinun*
A/B-17	2015.3.3 *	XVIA	Beta-437,196	24,850 ± 110	29,170–28,610	−24.5 ‰	*Pinus nigra-sylvestris*
A/B-17	2015.4.1 *	XVIB	Beta-437,197	26,020 ± 130	30,780–29,780	−21.7 ‰	*Pinus nigra-sylvestris*
A/B-17	2015.5.1 *	XVIB	Beta-437,198	26,580 ± 90	31,000–30,680	−23.9 ‰	*Pinus nigra-sylvestris*
A-17	84	XVIB	Beta-437,823	25,590 ± 100	30,150–29,350	−25.1 ‰	*Acer* sp.
B-17	85	XVIB	Beta-189,078	25,850 ± 260	30,790–29,350	−22.6 ‰	*Pinus nigra-sylvestris*
B-17	88	XVIB	Beta-287,537	25,600 ± 140	30,280–29,280	−23.8 ‰	*Pinus nigra-sylvestris*
A/B-17	2015.6 *	XVIC	Beta-437,199	28,450 ± 110	32,960–31,800	−23.7 ‰	Fabaceae
B-17	91	XVIC	Beta-437,193	28,690 ± 160	33,380–32,181	−24.0 ‰	*Pinus nigra-sylvestris*
B-18	35/UE36	XVIC	VERA-6427A	29,270 ± 260	33,960–32,680	−22.8 ± 1.6	*Pinus nigra-sylvestris*
B-18	35/UE36	XVIC	VERA-6427ABOxSC	29,490 ± 260	34,140–33,100	−21.0 ± 1.2	
B-18	37/UE41	XVIC	VERA-6428A	26,970 ± 190	31,280–30,780	−21.9 ± 0.9	*Pinus nigra-sylvestris*
B-18	37/UE41	XVIC	VERA-6428ABOxSC	27,560 ± 240	31,880–31,020	−22.7 ± 0.6	
B-18	39/UE45	XVID	Beta-458,346	31,080 ± 170	35,340–34,620	−21.5 ‰	*Juniperus* sp.

4. Stratigraphy, sediments and soil micromorphology of level XVI

4.1. Introduction and methods

Cova de les Cendres belongs to an old karst conduit formed in the marly limestone cliffs of the Late Cretaceous (Bernabeu and Molina, 2009). The dense network of diaclases, fractures and fissures that structures the rock has facilitated the block breakdown of the roof and walls that has conditioned the morphology of the cavity. In the inner sector, some speleothems, mainly flowstones, can be seen on the walls.

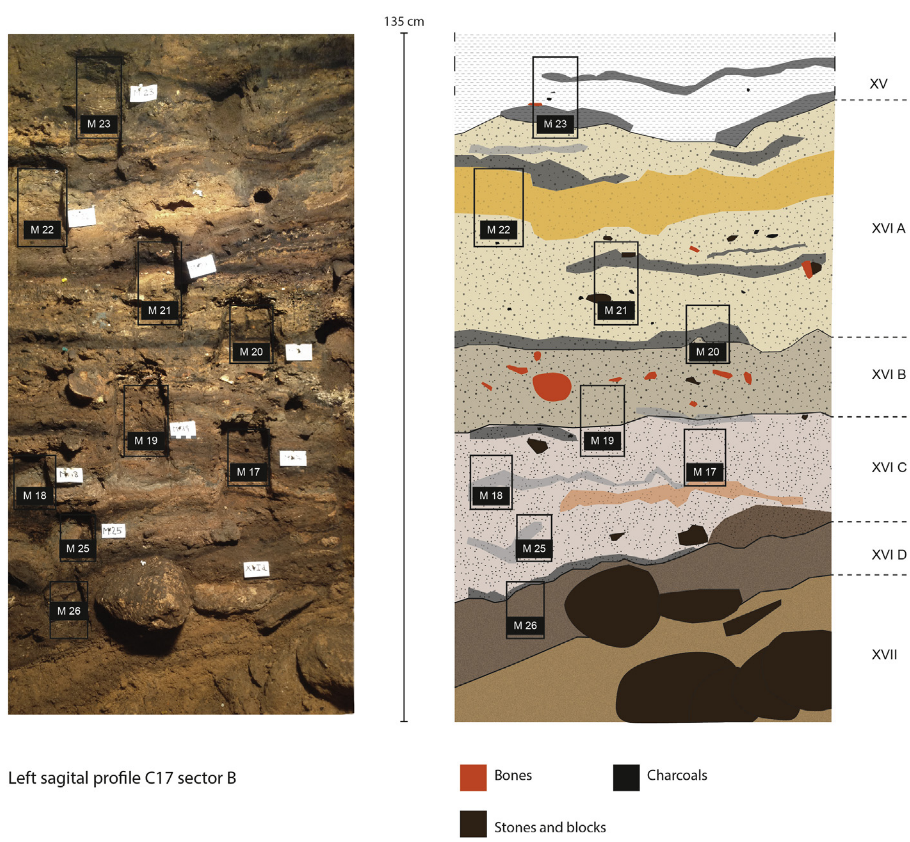

Fig. 3. Profile C-17 and micromorphological sampling of level XVI.

The area analysed in this article corresponds to the innermost area of the cavity (see Fig. 1). The methodology we used consisted mainly of stratigraphic-sedimentary field descriptions and the application of micromorphology to the levels that include the sequence of XVI.

Eleven undisturbed blocks were taken for micromorphological analyses with the help of boxes and gypsum plaster. They were air-dried and impregnated with polyester resin. Thin sections (13.3 × 5.5 cm and 20 μm thick) were obtained from the materials, following the procedure described in Benyarku and Stoops (2005). They were studied under a polarising microscope at magnifications between 25× and 400×, using plane-polarised light (PPL), crossed-polarised light (XPL) and oblique incident light (OIL). They were described using the guidelines given by Bullock et al. (1985) and Stoops (2003).

The sedimentary record of level XVI reaches an average depth of 135 cm. The field description of the archaeological sequence focuses mainly on profile C-17, where it is more detailed, and also on profile B-18 (Fig. 3).

The following sub-levels have been distinguished, from top to bottom:

- XVIA. Thickness: 59 cm. Formed by a series of clayey silt laminations with sands that have a high content of very dark brown (10YR 2/2) (5 cm), brown (7.5YR 6/6) (5–7 cm) and some greyish (7.5YR 6/1) (2 cm) organic material. Toward the bottom, there is a brown (7.5YR 4/4) sandy clay matrix with some laminations of sub-rounded morphology gravels with an increase of charcoals and bones. This matrix ends with a lamination with a high organic content that is also dark brown (10YR 2/2). There is erosive contact with respect to level XV. It can be dated between 26.7 and 29.1 ka cal. BP. Cultural context: Gravettian
- XVIB. Thickness: 25 cm. Formed by brown (7.5YR 4/3) sandy clays, with some gravels and stones of sub-angular-to-sub-rounded morphology, charcoal and bone remains. Some dark brown (10YR 2/2) and very organic laminations appear in the bottom sub-level. Diffuse boundaries. It can be dated between 29.3 and 31 ka cal. BP. Cultural context: Gravettian
- XVIC. Thickness: 18–36 cm. Clayey silt with sand laminations, also with a high content of organic material. Sharp boundaries. Some blocks of sub-rounded and sub-angular morphology appear dispersed throughout it, and it contains speleothem fragments as well. The laminations are thin and dark brown

Table 3
Synthesis of the microstratigraphic sequence of Cendres XVI in correlation to the stratigraphic field sequence.

Profile and sample number	Microfacies	Microfacies type	Processes	Stratigraphic levels
	Mf.1	Guano + runoff		
C-17. M.23	Mf.2	Bat and bird guano	Guano	
	Mf.3	Bat guano		
	Mf.4	Mineralised and charred guano		
	Mf.5	Mineralised and charred guano		
	Mf.6	Rubified guano		
	Mf.7	Mineralised and charred guano	Combustion of guano	
C-17. M.22	Mf.8	Rubified guano		
	Mf.9	Mineralised and charred guano		
	Mf.10	Rubified guano		XVIA
	Mf.11	Bat and bird guano		
	Mf.12	Bat guano	Guano	
	Mf.13	Bat and bird guano		
	Mf.14	Runoff		
C-17. M.21	Mf.15	Bat and bird guano		
	Mf.16	Runoff	Runoff and guano episodes	
	Mf.17	Bat and bird guano		
	Mf.18	Runoff		
	Mf.19	Bat guano		
	Mf.20	Runoff		
C-17. M.20	Mf.21	Bat and bird guano	Runoff and guano episodes	
	Mf.22	Runoff/mass disp.		
	Mf.23	Runoff		
	Mf.24	Bat and bird guano		XVIB
	Mf.25	Bat and bird guano		
C-17. M.19	Mf.26	Guano + runoff	Guano and reworked	
	Mf.27	Guano + runoff	episodes by runoff	
	Mf.28	Mineralised guano		
	Mf.29	Bat guano		
	Mf.30	Bat and bird guano		
	Mf.31	Bat and bird guano		
C-17. M.17 - 18	Mf.32	Mineralised and charred guano		
	Mf.33	Rubified guano	Guano	
	Mf.34	Guano + runoff	and guano combustion	XVIC
	Mf.35	Bat and bird guano	episodes	
C-17.M.25	Mf.36	Mineralised and charred guano		
	Mf.37	Rubified guano		
	Mf.38	Bat and bird guano		
C-17.M.26	Mf.39	Guano + runoff		
	Mf.40	Bat and bird guano		
	Mf.41	Bat guano		
B-18. M.27	Mf.42	Bat and bird guano	Guano and reworked	XVID
	Mf.43	Bat and bird guano	episodes by runoff	
	Mf.44	Guano + runoff		
B-18. M.28	Mf.45	Bat and bird guano		
	Mf.46	Bat guano		

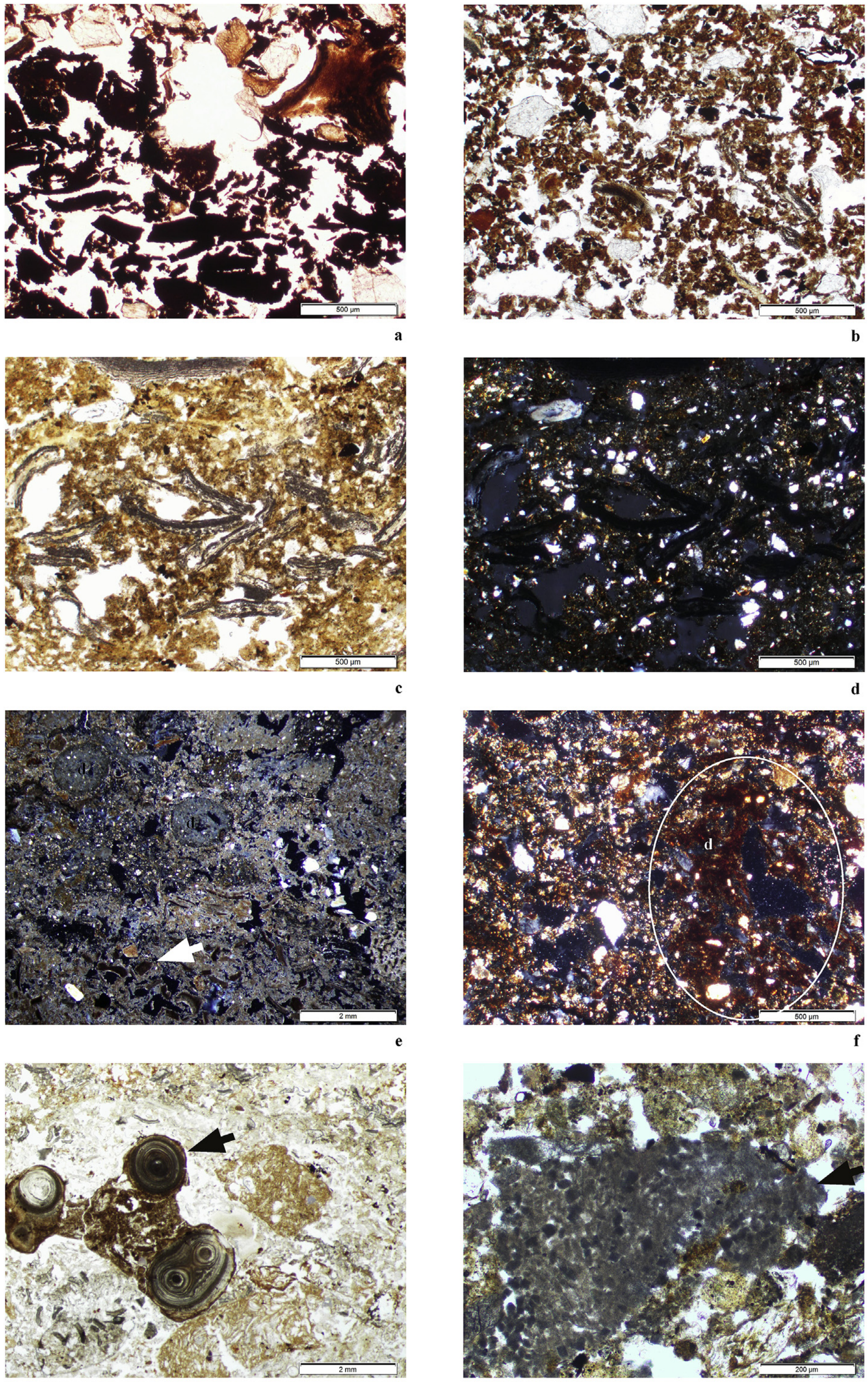

Fig. 4. Cendres XVI: micrographs. a) XVIA. Mf.12. Chitin remains with organic material. PPL; b) XVIA Mf.13. Slightly oxidised guano. PPL; c) XVIA. Mf.2. Phosphatised silty clays. PPL; d) XVIA. Mf.2. Same as (c) in XPL. Undifferentiated b-fabric is distinguished in the phosphated zones; e) XVIA. Mf.4. Mineralised and charred guano residues. Micritic calcitic accumulation with droppings (d) and plant residues (arrow). XPL; f) XVIA. Mf.8. Rubified guano residues. Note the iron oxides in the groundmass and dropping (d, circle). XPL; g) XVIC. Mf.35. Stalactite fragments in guano (arrow). PPL; h) XVIB. Mf.22. Aggregate of wood ashes (prismatic calcitic pseudomorphs) (arrow). PPL.

(7.5YR 3/3), grey (7.5YR 6/2) and brown (7.5YR 4/6). It can be dated between 31 and 34.1 ka cal. BP. Cultural context: Evolved Aurignacian.

- XVID. Thickness: around 15 cm. Dark brown (7.5YR 2.5/3) silty clays with some blocks of sub-rounded morphology in the top of the sub-level and some thin, clayey silt of organic material laminations in the bottom, especially in profile B-18, where erosive contact is seen. Dated between 34.6 and 35.3 ka cal. BP. Cultural context: Evolved Aurignacian.

In general, the laminations tend to have a tabular geometry.

At the end of the sequence a new level, named XVII, appears; although it is currently under study, its field description is included here because it is mentioned in some parts of this paper. It is distinguished by its sharp contact with respect to level XVI. It is composed of silty clays (5YR 4/6) with scattered blocks and fragments of speleothems. At the moment, it has a thickness of 23 cm.

4.2. Micromorphological analysis

Forty-six microstratigraphic units were identified in the 11 thin sections analysed. These microfacies are classified into the groups described in Table 3. Guano accumulations appear in all sub-levels and runoff episodes are mostly at the bottom of XVIA and XVIB and, to a lesser extent, in XVIC and XVID. The results of the study of the microfacies are presented in the following sections.

4.2.1. Guano accumulations

This is a type of contribution that is prevalent throughout the level. The following types have been distinguished:

- Guano crust, of which two sub-types have been identified:

a) Droppings, chitin remains with clays. They appear in microfacies 3, 12, 19, 29, 41 and 46. Composed of mainly droppings (dark brown to black, 500 μm–1 mm, ellipsoids to sub-rounded with a convolute fabric composed of chitin fragments, with rather porous and finer material and sometimes containing quartz particles), chitin remains and a clay fraction with increasing sands. They have a single grain microstructure.

The internal structure of the guano crust and the composition of the excremental fragments suggest that it belonged to bats. Given its basic constituent — chitin — this would correspond mainly with insectivore species (Shahack-Gross et al., 2004; Sridhar et al., 2006; Bergadà et al., 2013), hence giving it its dark-to-black colour (Fig. 4a). It should be noted that toward the upper part of the level, there is a tendency for the remains to have a brown colour because the oxidation process of the organic matter is accentuated.

We highlight that in these microfacies, there is an increase of the sandy fraction, specifically that of the quartz grains arising from the own alteration of the guano. Here, this fraction results from the dust ingested by the bats (Shahack-Gross et al., 2004; Rellini et al., 2013).

b) Organophosphate silty clays and organic material. It is represented by microfacies 2, 11, 13, 15, 17, 21, 24, 25, 30, 31, 35, 38, 40, 42, 43 and 45.

They have a spongy microstructure, and there are different types of droppings, several fragments of bird eggshell, chitin, plant residues and phytoliths distributed throughout the groundmass. Some of these microfacies appear with slightly oxidised organic material (Fig. 4b), and others with phosphatised silty clays groundmass (Fig. 4c and d). We suggest that they correspond to bird and bat guano accumulations. There also are cryptocrystalline apatite nodules in the groundmass and yellow cryptocrystalline hypocoating, such as in phosphate-rich areas, which result from decomposition of organic material and its reaction with the limestone material, that is, calcite is replaced by apatite (Karkanas and Goldberg, 2010). Finally, there is the presence of iron oxides and amorphous components related to the decomposition and mineralisation of organic material.

- Guano and runoff

In some cases, these guano crusts appear affected by post-depositional runoff processes, as is the case in microfacies 1, 26, 27, 34, 39 and 44.

They are characterised by an increase of the sandy fraction with some orientation (usually poorly sorted and sub-angular to sub-rounded in shape) with gravels, as in microfacies 39 and 44, and they are also distinguished by a heterogeneous mixture of detrital material together with organic and excremental residues. In the case of microfacies 39, they appear with erosive contact.

- Combustion of guano

This is another post-depositional process that is located and characterised by two types of microfacies:

- Mineralised and charred guano residues, which are characterised by their blackish-grey colour and composed of micritic calcitic accumulations that have droppings dispersed in the groundmass alongside plant residues (Fig. 4e). Some of them appear to be charred. The bone fragments in general show combustion traces. This is the case in macrofacies 4, 5, 7, 9, 28, 32 and 36.
- Rubified guano residues present a reddish-brown colour and are formed by organophosphate silty clays and organic material with abundant traces of oxides, along with iron hydroxides in the form of nodules between 50 and 75 μm that are impregnating the groundmass. Rubefacted droppings were also found in microfacies 6, 8, 10, 33 and 37 (Fig. 4f). The fact that these two microfacies appear related indicates that the combustions are *in situ* and took place under oxidising conditions.

In some of these microfacies, traces of trampling have been documented, such as in 28.

There is great biological activity in all these guano accumulations. We would also like to highlight the presence of speleothem fragments — stalactites — (Fig. 4g) in these accumulations, especially those corresponding to sub-level XVIC.

4.2.2. Runoff

Detrital sedimentation is represented by runoff episodes. They are characterised by the predominance of fine and medium sands of a sub-rounded-to-sub-angular morphology that are constituted mainly by biomicritic marly limestone, quartz, feldspar, plagioclase and calcite; these appear, to a certain degree, to be sorted.

Most of the microfacies contain wood charcoals and bone remains, and this is where anthropic components are the most abundant. Sharp boundaries between the runoff and guano microfacies were noted. These episodes are represented in microfacies 14, 16, 18, 20, 22 and 23.

Some of them are interbedded sandy silt laminations (microfacies 14, 18 and 23) of little thickness and are well sorted; they were most likely produced by the flow of fine material in episodes of reactivations of waters (Karkanas and Goldberg, 2013). In microfacies 20 and 23, some guano residues that intercalated in the detrital matrix were observed.

Microfacies 22 that requires special since the noted reworked burned material was probably produced by a process related to mass displacement. The material is unsorted, and several rounded aggregates of wood ashes (prismatic calcitic pseudomorphs) (Fig. 4h) are mixed in with detrital material, which is all associated to vesicular voids that reflect a tendency for liquefaction (Bertran and Texier, 1999).

Table 4
Summary of the phytolith and mineralogical analysis giving sample provenance and description: calculation of the number of phytoliths per gram of sediment, total number of phytoliths morphologically identified and the percentage of weathered morphotypes (WM), silica skeletons (SS), diatoms and sponge spicules. Phytolith morphological distribution giving plant provenance information is also provided.

Procedence		AS53	AS54	AS55	AS56
		Level XVI-a	Level XVI-a	Level XVI-a	Level XVI-a
Sediment colour		Brownish	Brownish	Brown-blackish	Greyish
Phytoliths/g sed		2,520,000	4,293,000	3,901,000	5,526,000
Phytoliths identified		210	161	214	86
WM %		14.3	12.3	10.5	58.9
SK %		39.7	23.5	13.4	29.3
Diatom %		8.7	25.3	7	38.6
Sponge %		1.9	0.7	0.5	2.3
Mineral components FTIR		Cl(b), some Ca, Dah, Qz	Cl (nb) Ca(g), Dah, Qz	Cl (nb), Qz, some Dah, few Ca	Ca(a), Cl(b), Q, few Dah
Morphotypes	**Plant**				
Blocky Polyhedral	Probably bulliform cells	0,48	1,24	2,80	2,33
GSSCs oblongs	Grasses -mainly C_3 Pooideae	2,86	3,73	2,80	2,33
GSSCs rondels	Grasses -mainly C_4 Pooideae	11,43	24,84	27,10	8,14
GSSCs lobates	Grasses -mainly C_4 Panicoideae	0,48	0,00	0,93	0,00
GSSCs saddles	Grasses - C_4 Chloridoideae	0,00	1,24	0,00	0,00
Total grasses		**15,24**	**31,06**	**33,64**	**12,79**
Hat shape	Cyperaceae	0,00	0,00	0,47	1,16
Sedge achene	Fruit of the sedges	0,00	0,00	0,47	0,00
Total sedges		**0,00**	**0,00**	**0,93**	**1,16**
Cystolith	Epidermal tissues - leaves	2,86	0,00	0,00	0,00
Ellipsoids	Eudicotyledonous wood/bark	0,00	18,63	0,00	0,00
Parallelepiped blocky	Eudicotyledonous wood/bark	0,95	0,00	0,00	0,00
Sclereids	Sclerenchyma - ground tissue	0,00	0,00	1,40	0,00
Silica skeleton (indet)	Epidermal tissues	8,57	4,35	2,80	22,09
Silica skeleton sinuate	Epidermal tissues - leaves	4,76	15,53	0,00	0,00
Silica skeleton polyhedral	Epidermal tissues - leaves	0,48	0,00	0,00	0,00
Silica skeleton concave protuberances	Epidermal tissues - leaves?	1,43	0,00	0,93	0,00
Silica skeleton irregular sinuate (fruit)	Epidermal tissues - fruits and seeds	1,43	1,86	2,34	0,00
Silica skeleton sinuate dot-decoration	Epidermal tissues - fruits and seeds - *Celtis*?	8,10	8,07	0,00	1,16
Silica skeleton truncated	*Lithospermum* sp. seeds	2,86	0,00	0,00	0,00
Silica skeleton truncated cone in the middle	Epidermal tissues - fruits and seeds	13,33	6,21	0,93	1,16
Silica skeleton dendritic	Epidermal tissues - fruits and seeds	2,38	1,24	0,00	0,00
Spiny body	Pinaceae	3,33	0,62	1,40	0,00
Tracheids and vessels	Vascular tissues	0,48	0,00	0,00	1,16
Spheroids	Eudicotyledonous wood/bark	0,48	0,00	0,47	6,98
Total dicotyledonous plants		**51,43**	**56,52**	**10,28**	**32,56**
Long cell echinate	Mostly in monocotyledonous	2,86	4,35	6,07	19,77
Long cell wavy	Mostly in monocotyledonous	0,95	4,35	18,69	8,14
Total elongates with decoration margins		**3,81**	**8,70**	**24,77**	**27,91**
Elongates without decoration margins	Mostly in graminoids	19,05	0,62	21,03	15,12
Epidermal appendages	Epidermal appendages in flowering plants	5,24	1,24	6,07	9,30
Total of non-diagnostic		**24,29**	**1,86**	**27,10**	**24,42**
Bulbous	Non-diagnostic	0,48	0,00	0,00	0,00
Indeterminate	Non-diagnostic	1,90	0,00	1,40	1,16
Irregulars	Non-diagnostic	2,86	1,86	1,87	0,00
Total of non-identified		**5,24**	**1,86**	**3,27**	**1,16**

4.3. Sediment deposition, anthropic activity and palaeoenvironment

The sequence of Cendres XVI is complex and involves a variety of biogenic, detrital and anthropic processes and components that are sometimes combined or mixed.

The biogenic contribution — guano — dominates throughout the record (see Table 3). Two types have been distinguished, as follows:

a) Dark crusts formed mainly by droppings and chitin residues that can be attributed to bats.
b) Organophosphate crusts next to silty clays that make us think they correspond to accumulations of guano from birds and bats. Some appear slightly oxidised, and others have obvious traces of alteration.

The presence of crusts is indicative of their surface exposure, as well as of stability in the cave (Karkanas and Goldberg, 2010). Geogenic-type components that appear among the guano and that deserve to be emphasised are fragments of stalactites that also mark a stable and humid episode inside the cavity, especially in sub-level XVIC.

It is worth noting the great presence of eggshell fragments is indicative birds nesting. Given the location of the cave, it is not surprising to find that during the Upper Pleistocene, this was a well-established roost and nesting site for birds; this has also been documented at other archaeological sites, such as Gorham's Cave in

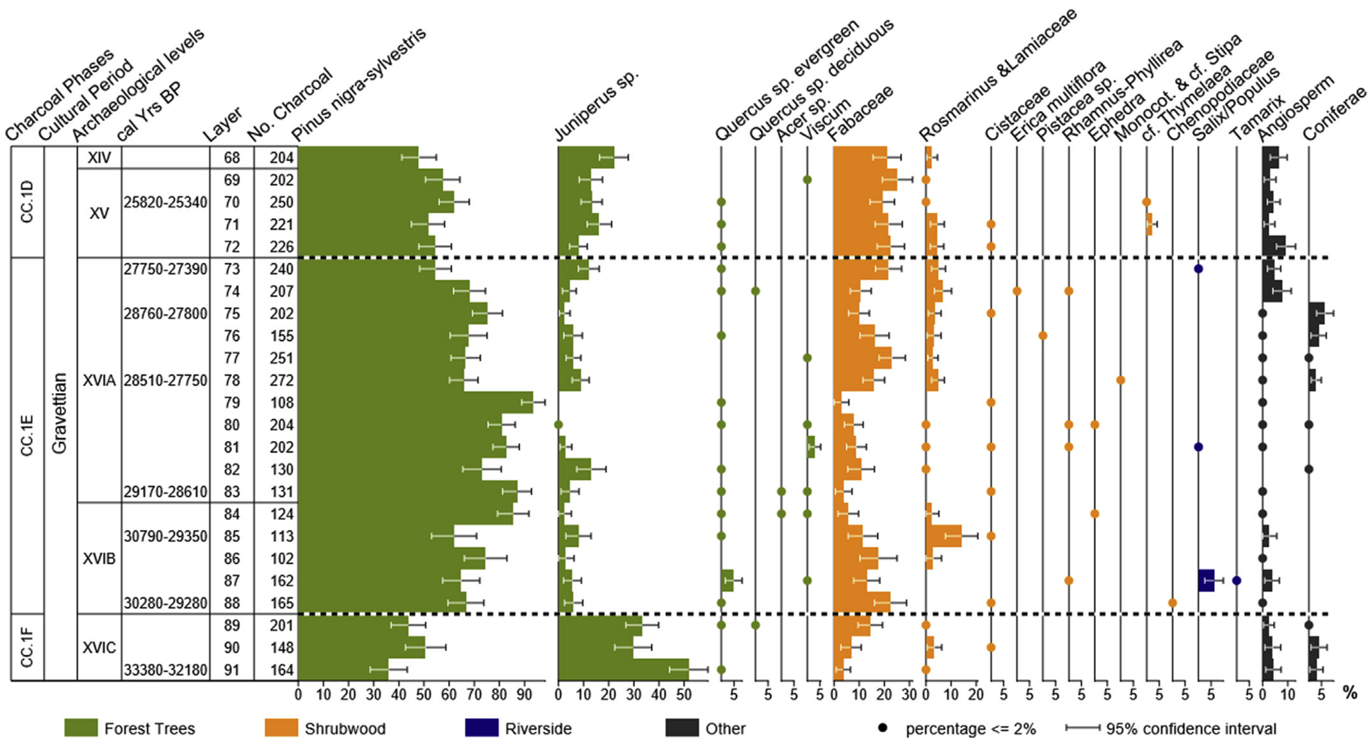

Fig. 5. Charcoal diagram from Gravettian levels of Cova de les Cendres.

Gibraltar (Macphail and Goldberg, 2000; Goldberg and Macphail, 2012) and Westbury Cave in Somerset, UK (Macphail and Goldberg, 1999).

These accumulations appear reworked by runoff and biological activity because they are an important source of nutrients.

Detrital sedimentation is located mainly at the bottom of sub-levels XVIA and XVIB as a result of the characteristic water circulation of these kinds of karstic systems, which during specific episodes, such as storm events, were reactivated. Also, some block breakdown is especially located in the top of XVID.

Finally, human activity, noted through the presence of wood charcoals, burned bones and ash remains, is well-documented, mainly in sub-levels XVIA and XVIB.

One aspect that deserves to be highlighted is the appearance of combustion in the bat and bird guano, which mainly appears in sub-level XVIA and in some episodes in XVIB and XVIC. The fact that ash, charred and rubified guano appear alongside burned bone remains, with a tendency to be a succession of single burning events (Mentzer, 2014), makes us think that humans are responsible for these combustions. In addition, XVIA is one of the sub-levels where there is more abundance of flint tools, as in sub-level XVIB. These human activities would force bats to leave the cave.

In other archaeological sites, guano combustion, most likely attributed to humans as well, has been noted at Gorham's Cave (Macphail and Goldberg, 2000) and in Arene Candide in Liguria, Italy (Macphail and Goldberg, 1999).

The environmental conditions that emerge from the sedimentary sequence analysed between 26.7 and 35.3 ka cal. BP, with some interruptions mainly between the Gravettian and Evolved Aurignacian, are generally humid.

In short, this sequence is characterised by stability in the environment and has a low presence of detrital inputs inside the cave, a fact that would make it a good refuge for birds to nest in, as well for bats.

4.4. FTIR mineralogical analyses

In parallel to the micromorphological analyses, mineralogical (Fourier Transform Infrared Spectra – FTIR) analyses were carried out on four samples from the Gravettian sub-level XVIA.

The FTIR analysis indicated that clay, calcite, dahllite (carbonate hydroxylapatite) and quartz were the main mineral components in all the samples but in different proportions (Table 4). Samples AS54 and AS56 presented the highest proportion of calcite. In sample AS54, the calcite detected was characterised as geogenic and the clay as unburnt (following Regev et al., 2010; Berna et al., 2007; respectively). Conversely, in sample AS56, the calcite was characterised as wood ash and the clay as having been exposed to high temperatures (following Regev et al., 2010; Berna et al., 2007; respectively). Sample AS53 showed the highest absorption peak of dahllite.

5. Plant resources

5.1. Macro-plants remains

A comprehensive study of the plant resources (wood, charcoal, seeds and fruits) from the Palaeolithic sequence of Cova de les Cendres is being carried out to document the importance of plants for Upper Palaeolithic societies (Badal and Carrión, 2001; Martínez Varea, 2016; Badal and Martínez Varea, 2017; Martínez Varea and Badal, 2017). Here, we present the new anthracological results from the Gravettian levels and the carpological data from sub-level XVIA. For the Gravettian, the average number of charcoal fragments larger than 2 mm per litre of sediment is around 120. A total of 20,472 carporemains were recovered from 882 L of sediment, representing a very high density of remains (23.21 per litre).

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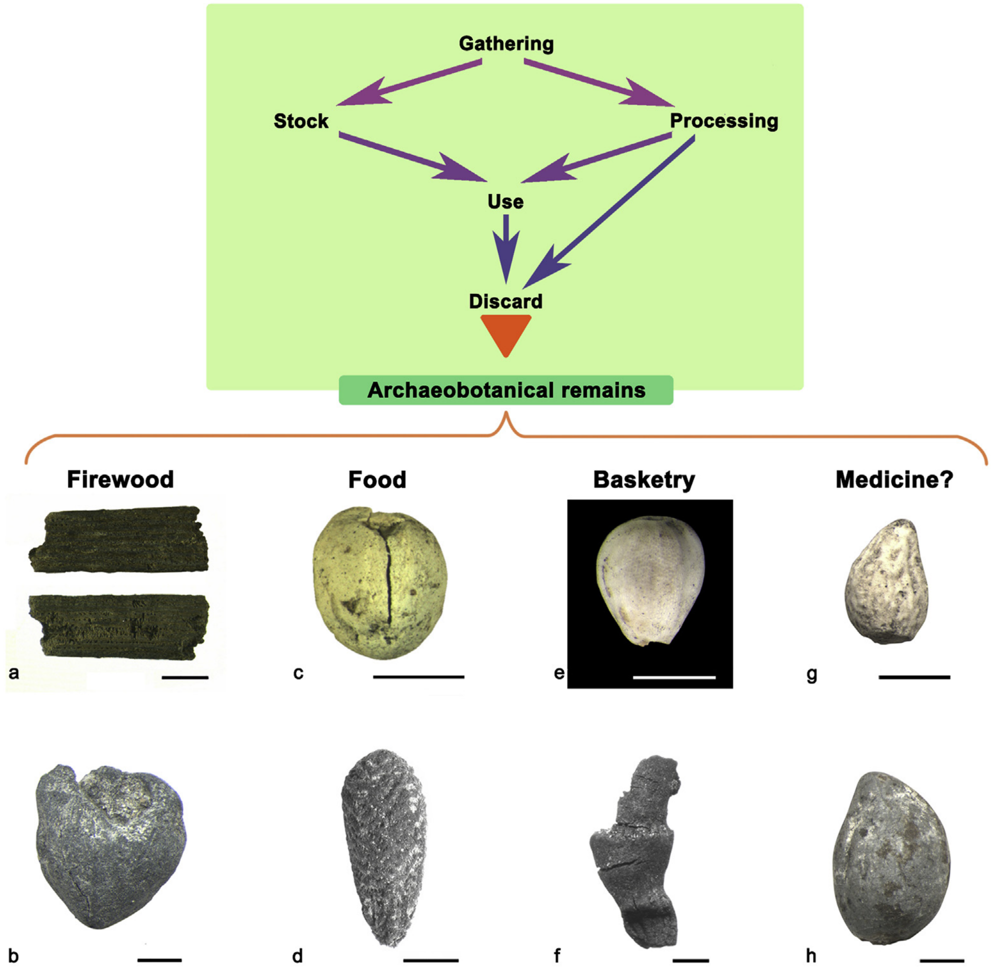

Fig. 6. Formation of the archaeobotanical assemblage and some macroremains identified: a) *Pinus* sp. needle; b) *Juniperus sabina*; c) *Vicia* sp.; d) *Sambucus* cf. *nigra*; e) *Eleocharis* sp.; f) *Stipa tenacissima* rhizome; g) *Buglossoides arvensis*; h) *Lithospermum officinale*.

5.1.1. Wood for burning and fruits as food — the management of plant resources during the Gravettian

There is no doubt that Palaeolithic groups knew about the plant environment surrounding them and used it accordingly: wood as fuel, fruits and leaves as food, wood and fibres for tool making and so forth. To a greater or lesser extent, all these uses are documented at Cova de les Cendres during the Gravettian.

5.1.1.1. Wood as fuel. Woody plants, from which firewood is sourced, are those most used in the lighting of fires. In the anthracological diagram (Fig. 5), which is obtained from the identification of the residues from the fire, the presence of a minimum of 19 woody plants and one herbaceous (monocot) plant can be noted. Despite this diversity, the bulk of the fuel used comprises only two kinds of plants: pines and junipers. For example, in sub-level XVIA, 1517 fragments of *Pinus nigra* and/or *P. sylvestris* (Salzmann pine/Scot pine) charcoal were identified alongside 1626 pine bark fragments, 24 needle fragments and three cone scales. This indicates that all parts of the pine were collected. In fact, it is possible that the human groups collected and stored the needles and pinecones so that they could be used to light fires in the short and medium term. The presence of the fragments of needles (Fig. 6a) and uncharred wood supports this hypothesis although their presence could also be because of them having fallen among the ashes or outside the hearth, where they would not have been exposed to the fire (Chrzavzez, 2013).

Juniperus sp. is the other main taxon used as fuel. A total of 124 charcoal fragments have been identified in sub-level XVIA. Here, 139 endocarps pertain to this genus, among which five different species could be identified: *J. sabina, J. oxycedrus, J. communis, J. phoenicea* and *J. thurifera*. As was the case with the pine trees, wood fragments were also recovered here, the presence of which could be interpreted as representing evidence of firewood storage at the cave, a hypothesis further strengthened by the presence of rodent bite marks on many endocarps that were partially consumed at the site prior to charring (Fig. 6b).

Pinus seeds and *Juniperus* fruits can be used for other purposes (Bouby, 2004; Humphrey et al., 2014; Morales et al., 2015), but we believe that their presence is linked to their use as fuel, without ruling out the idea that pine needles can — and may — have been used as insulating bedding.

5.1.1.2. Fruits as food. We believe that a considerable number of the taxa identified in the carpological assemblage were collected for subsistence purposes. The presence of charred seeds and fruits could be linked to these being discarded while the plants were being processed or consumed. In this sense, it is worth highlighting the presence of several herbaceous species of Fabaceae, of which 1370 remains have been found at Cendres (Fig. 6c). Within this family, the leaves, stems and seeds of several of its species are fit for

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consumption, and these are widely represented at many sites (Aura et al., 2005; Lev et al., 2005; Vaquer and Ruas, 2009). The seeds of *Sambucus nigra* (Fig. 6d) and *S. racemosa*, whose fruits are edible, could have also been consumed along with those of Rosaceae, whose fruits can be eaten without processing (Rivera and Obón, 1991). The presence of all these taxa is documented at other Upper Palaeolithic and Mesolithic sites in the Iberian Peninsula, and all have been interpreted similarly (Zapata, 2001; Pérez Jordà, 2006). The absence of these taxa in the anthracological assemblage indicates that perhaps these plants were somehow protected and hence not used to light fires. A similar sustainable plant management strategy was also argued for Nerja Cave in relation to stone pines (Badal, 2001).

5.1.1.3. Fibres for weaving and other uses. During the Palaeolithic, the use of cordage and baskets must have been indispensable, even if these have hardly been documented archaeologically (Nadel et al., 1994; Adovasio et al., 1996; Kvavadze et al., 2009; Hardy et al., 2013; Kilgore and Gonthier, 2014). We consider that the Cyperaceae seeds and the *Stipa tenacissima* rhizomes (Fig. 6e and f) from sub-level XVIA were discarded during the processing of stems and leaves that were used in the making of basketry and cordage or in the creation of bedding, as attested to at other sites (Sievers, 2006; Morales et al., 2015).

The medicinal use of plants is not easy to prove, but we must put forward these hypotheses given the importance of good health to all human groups. The seeds of *Ajuga chamaepitys, Echium vulgare, Lithospermum officinale* and *Buglossoides arvensis* (Fig. 6g and h) identified in sub-level XVIA could be placed in the medicinal category (Berdonces i Serra, 1998). The leaves of the latter are known to be a diuretic when consumed as a boiled infusion (http://www.pfaf.org). The same benefits are known with *Echium vulgare*, which was used by the Cherokee and Mohegan (http://naeb.brit.org/). The use of *Lithospermum officinalis* and *Echium* sp. seeds for medicinal purposes has been documented archaeologically during the Bronze Age (Baas 1980, cited in Pustovoytov et al., 2004; Baczyńska and Lityńska-Zając, 2005).

In sum, the archaeobotanical assemblage from the Gravettian levels at Cova de les Cendres is of immense importance and interest because a) it proves that plant resources were in use since the beginning of the Upper Palaeolithic, and b) there are only a few similarly dated assemblages comprising this much diversity and number of remains (Dolní Věstonice II - Mason et al., 1994; Pryor et al., 2013; Hohle Fels - Riehl et al., 2015).

5.1.2. The Gravettian and Aurignacian landscape

The anthracological assemblage from Cova de les Cendres, combined with the carpological data available for sub-level XVIA, provides high-resolution environmental information. Based on the presence and frequency of the taxa depicted in the diagram (Fig. 5), several anthracological phases can be discerned, and these are described as follows:

Phase CC.1F.

This Aurignacian phase is identified in sub-level XVIC and is characterised by the greater and similar presence of *Juniperus* and *Pinus nigra-sylvestris* (Salzmann pine and Scot pine). These are followed by smaller numbers of scrubland species, such as Fabaceae, *Rosmarinus officinalis*, Lamiaceae, Cistaceae and *Quercus* (evergreen and deciduous). This CC.1F phase has been interpreted as representing an open forest comprising Salzmann and/or Scot pines and junipers. We do not yet know which species of *Juniperus* are represented because the carpological analysis is currently underway, but it is likely that there are several represented, as is the case in sub-level XVIA, which is described below.

Phase CC.1E.

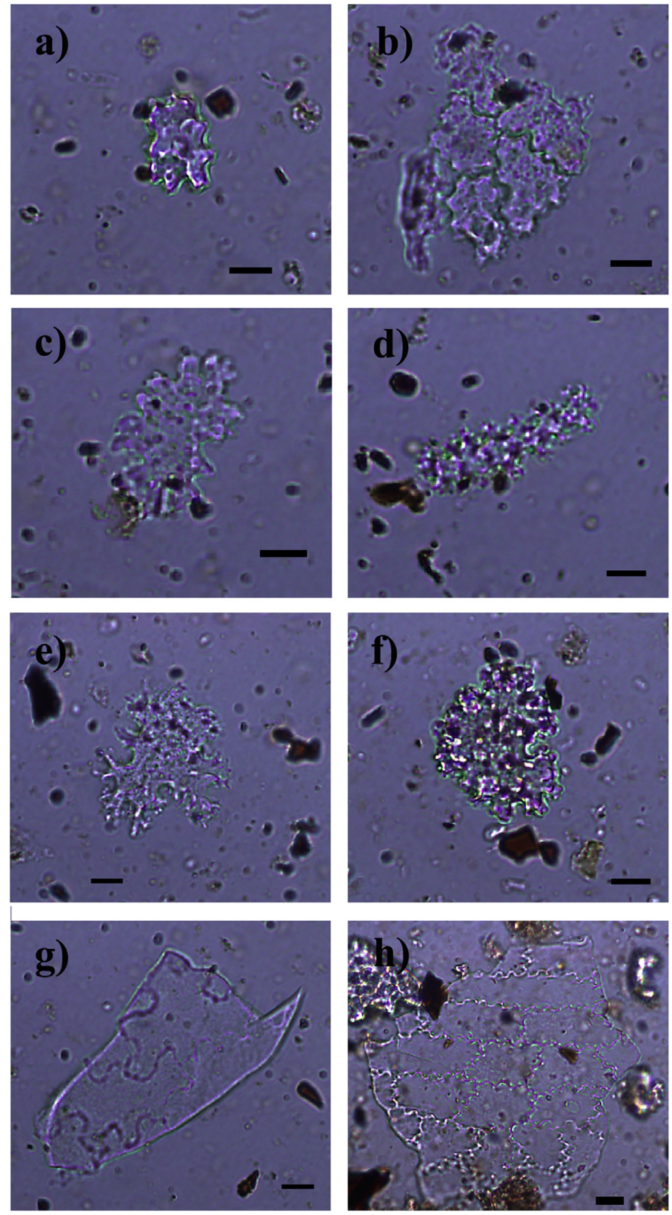

Fig. 7. Microphotographs of dicot phytoliths from the epidermal cells of leaves and fruits and seeds: a) seed-isolated epidermal cell of *Lithospermum* from sample AS 53; b) silica skeleton of *Lithospermum* from sample AS 53; c) fruit-isolated epidermal cell probably of *Celtis* from sample AS 53; d) spiny form, probably from the Pinaceae family from sample AS 53; e) isolated epidermal cell dendritic of dicot fruit from sample AS 53; f) isolated epidermal cell dendritic of dicot fruit from sample AS 53; g) silica skeleton sinuate from the leaves of dicots from sample AS53; h) silica skeleton sinuate dicot leaves from sample AS54. Scale bar represents 10 mm.

This Gravettian phase is represented in sub-levels XVIA and XVIB and is characterised by the predominant presence of *Pinus nigra* and/or *Pinus sylvestris*. These are followed by the large presence of *Juniperus*, of which, based on the carpological analysis carried out for sub-level XVIA, five species have been identified; three are cold-adapted species (*J. communis*, *J. sabina* and *J. thurifera*) and are currently found in Mediterranean high-mountain conditions, and the other two are warmer species: *J. oxycedrus* and *J. phoenicea*. In addition, the presence of Mediterranean taxa such as *Rosmarinus officinalis*, *Erica multiflora*, *Pistacia* sp., *Rhamnus-Phillyrea* and *Ephedra* is also noted. Lamiaceae and Caprifoliaceae seeds have also been identified among the

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carpological remains from XVIA, and these seeds match well with the charcoals recorded. Evergreen and deciduous *Quercus* are present but in small percentages.

Therefore, Phase CC.1E is interpreted as comprising Salzmann or Scot pines forests with an understory composed of five species of juniper trees and shrubs that are typical of a dry or sub-humid supra-Mediterranean climate. At present, this kind of forest is found in the mountains of the Iberian system, where annual average temperatures range between 8 and 12 °C. Therefore, during the period when the Gravettian levels were deposited (between circa 31 and 28 ky cal. BP), conditions would have been much colder than those currently prevalent in the area, where the average annual temperature is 17 °C.

Phase CC.1D.

Phase CC.1D corresponds to the final levels of the Gravettian (XV, XIV). This phase still comprises pines and junipers as its major taxa, but also sees an increase in the number of Fabaceae woody remains. The frequencies of other taxa remain the same. This phase can be interpreted as a retreat of the pine forest and the spread of open spaces covered in juniper trees and heliophilous bushes. The climatic conditions would have been similar to those described for the previous phase (CC.1E) because identical taxa with identical ecological requirements are noted here; however, the increase in juniper and shrubland can be interpreted as representing an increase in aridity, perhaps being a prelude to the Pleniglacial during the Solutrean.

In summary, anthracological and carpological data are good markers of local flora. The species identified here (*Pinus nigra* and/or *P. sylvestris* and *Juniperus sabina*, *J. thurifera* and *J. communis*) nowadays grow in the mountains, far from the Alicante coast, in the supra-Mediterranean or oro-Mediterranean belt. There, the mean annual temperature is around 8–10 °C, and the mean annual precipitation is around 500–600 mm (dry or sub-humid conditions). Winters are very cold, with frosts from November to May. Consequently, these could have been the prevailing bioclimatic conditions in the region of Cova de les Cendres during the Gravettian. Moreover, the AMS radiocarbon dates obtained from thermophilous species, such as *Quercus* sp. evergreen (23,350 ± 100 BP) and *Rosmarinus officinalis* (21,880 ± 100 BP), show that the coastline of Alicante was a refuge area for warm Mediterranean flora and that these plants grew there below the 40th parallel north during cold periods, even during the Pleniglacial.

There are few Gravettian sites in Iberia for which archaeobotanical analyses have been undertaken, so it is difficult to compare those from Cendres with others in the peninsula. At Cova de l'Arbreda (Ros i Mora, 1987), despite the few data available, there are also cold-adapted pine trees and junipers; the major difference between this site and Cova de les Cendres is the presence of birch, which has never been identified south of parallel 40°N. Sites south of this parallel possess similar flora to that from the Gravettian at Cova de les Cendres, given the persistence of warm-adapted species such as *Quercus* or *Pinus pinea* in the southern end of the Iberian Peninsula (Aura et al., 2002; Carrión et al., 2008).

5.2. Micro-plant remains: Phytolith analysis of the Gravettian sub-level XVIA

5.2.1. Materials and methods

Phytolith analyses were carried out on four samples from the Gravettian sub-level XVIA. Phytolith extraction was carried out at the Laboratory of Prehistory and Archaeology of the University of Barcelona, following the method developed by Katz et al. (2010). Morphological identification was based on our modern plant reference collection database (Albert et al., 2011, 2016 – phytcore.com). The standard literature (e.g., Twiss et al., 1969; Piperno, 1988, 2006; Mulholland and Rapp, 1992) was also consulted when necessary. Descriptions and naming of the phytoliths followed the International Code for Phytolith Nomenclature when possible (Madella et al., 2005).

5.2.2. Phytolith results

Phytoliths were identified in high numbers in all the samples analysed, ranging from 5,526,000 to 2,520,000 phytoliths per gram of sediment (phytoliths/g of sed.). Together with phytoliths, diatoms and sponge spicules were also detected (Table 4). Weathered morphotypes were identified in relatively low frequencies, save for sample AS56 (58.9%).

A high variety of phytolith morphotypes belonging to different plant types and plant parts were detected (Table 4). This is indicative of the wide range of plants exploited by the previous inhabitants of Cova de les Cendres during the occupation of XVIA.

Dicotyledonous plants (hereafter dicots) dominated the spectra, while grasses were also well-represented (Table 4). The dicot phytoliths identified were representative of the wood/bark of trees and/or shrubs, as well as of the epidermal, ground and vascular tissues of leaves and fruits. Phytoliths from the wood/bark of dicot plants were mainly identified in sample AS54, making up 22% of the total, and these had a spheroidal shape (ellipsoids).

Sample AS53 showed the highest frequencies of connected epidermal cell phytoliths (silica skeletons) that could belong to both leaves and fruits and seeds (Table 4). However, some of the fruit phytoliths were found to be isolated (see Fig. 7a). Fruit and seed phytoliths from dicots were identified in very high frequencies and presented different morphologies, which indicates that a large variety of fruit types were introduced by past inhabitants into the living areas of the cave (Fig. 7a–f). We have been able to identify at least three of these phytolith morphotypes: one has been classified as distinctive of the *Lithospermum* genus (Fig. 7a–b) (see Tsartsidou et al., 2015); the fruit silica skeletons with irregular sinuate outlines probably belong to the genus *Celtis* (Fig. 7c) (Piperno, 2006); and the spiny forms might also belong to the Pinaceae family (Fig. 7d) (Bozarth, 1992; Kerns et al., 2001; Blinnikov et al., 2002). This large presence and variety of silica skeletons and other dicot tissues are indicative of the intentional gathering and consumption of a large variety of plant foods. However, the presence of the fruits and seeds of dicot plants is not consistent throughout the occupation of this sub-level, being barely represented in the oldest occupation periods (samples AS55 and AS56). Conversely, dicot leaf phytoliths showing mainly polyhedral and sinuate shapes (Fig. 7g–h) were also well-represented in the more recent occupation times of XVIA, which can be seen in samples AS53 and AS54 (Fig. 7g–h).

Grass phytoliths were identified in all the samples, with higher frequencies noted in samples AS54 and AS55 (35% and 30%, respectively) (Table 4). Grass silica short cells (GSSCs) dominated among the grass phytoliths, and these came mainly from the C_3 grasses from the Pooideae subfamily, which are typical of northern hemisphere Mediterranean vegetation. The high frequencies of phytolith morphotypes from the inflorescence of grasses, regardless of the relatively low frequencies of grass phytoliths compared to those of dicots, might be indicative of some degree of seasonality because grasses in the western Mediterranean bloom during the spring and summer season.

The identification of sedges in the oldest deposits of XVIA (AS55 and AS56) indicates that during this occupation of the cave, wetlands were close by and people exploited this sort of landscape. The presence of diatoms (mainly in samples AS54 and AS56) and sponge spicules (but in much lesser frequencies) also supports the exploitation of wetlands or other humid zones by the inhabitants of the site during the Gravettian period.

Fig. 8. Raw materials types: 1: Local flint without fissures. 2: Local flint with fissures. 3: Mariola type without fissures. 4: Mariola type with fissures. 5: Serreta type without fissures. 6: Serreta type with fissures.

Table 5
Raw materials used in blanks (unretouched and retouched) and in brackets retouched material. L (Local flint), S (Serreta type), M (Mariola type), Q (Quartzite) and O (Others).

Blanks	XV					XVIA					XVIB				XVIC			
	L	S	M	Q	O	L	S	M	Q	O	L	S	M	O	L	S	M	O
Flakes	76 (7)	49 (3)	32 (2)	7	14	498 (38)	184 (44)	170 (15)	57	120 (9)	60 (2)	34 (4)	33 (4)	18	32 (4)	17 (4)	10 (1)	11
Splinters	2	7 (1)	1		1	35 (1)	32	18		4 (1)	2	14 (1)	1			3	2	
Laminar flakes	7 (1)	13 (1)	5 (1)		1	66 (6)	19 (6)	23 (2)	7	18 (3)	4 (2)	14 (2)	4 (1)	2	7 (1)	8 (2)	1	2
Blades	4 (2)	7 (6)				28 (12)	22 (11)	14 (6)		4 (1)	1	−2	2 (1)	2 (1)	1	2	1	
Blades	9 (1)	21 (4)	6 (2)		2	179 (47)	130 (52)	52 (7)	3	44 (20)	12 (4)	23 (15)	1	5 (2)	6 (4)	8 (1)	1	3
Cores	3	4 (1)	1			20 (1)	12 (2)	7		4 (1)	8 (1)	−2	2	1	1			1
Core tablets						1												
Core Semitablets	1					3	3										1	
Crested blades	1					4		1										
Semicrested blades		2 (1)			1	22 (3)	10 (4)	4	1									
Core flank	8 (1)	3	2		1	28 (9)	23 (6)	4 (1)			4 (3)	7 (2)		1		3 (1)		
Core transversal flank	1					5	7 (3)											
Core lateral flank	2	1	1		1	31 (2)	10	5				6 (1)	3		3 (1)	2	1	
Cornices	1				1	6		5										
Burin spall	2	4									4	5	1	1				
Thermal flakes	17	1	5		9						8	3		8	4	2		7
Debris	18	6	4		4						29	4	8		14	1		2

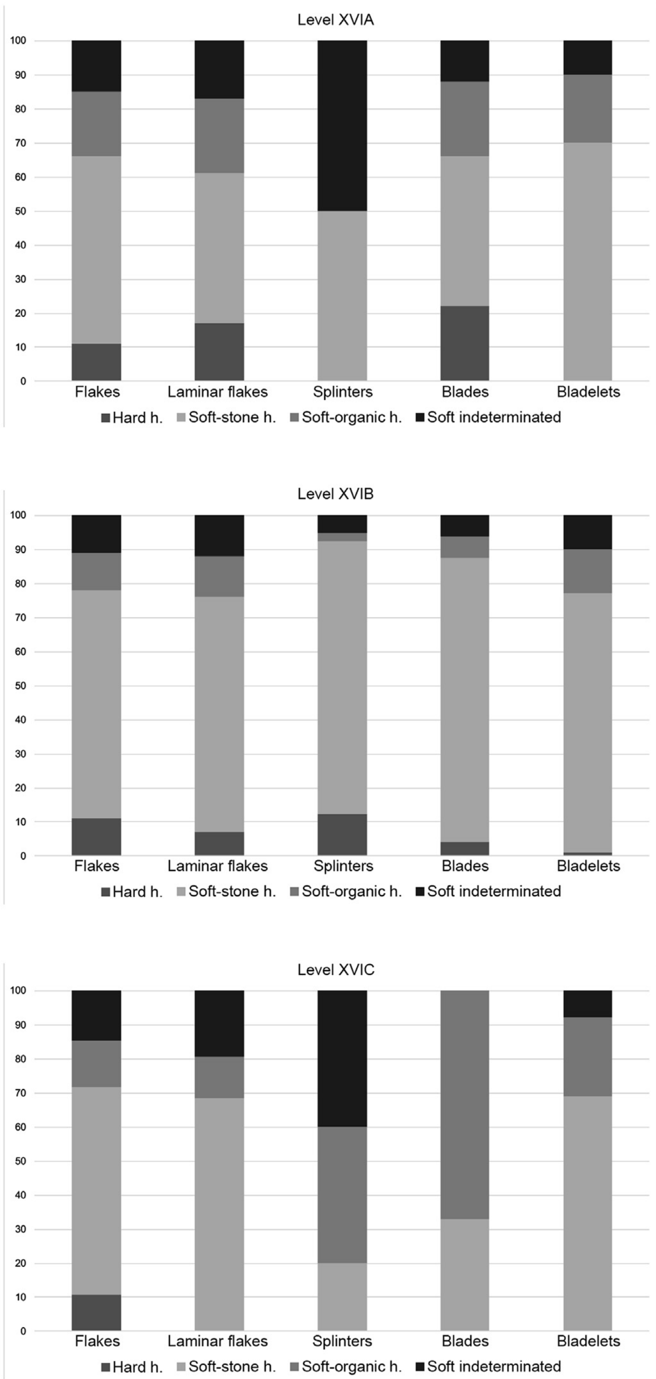

Fig. 9. Debitage technique by levels, indicating the type of hammer used.

6. Lithic assemblages

6.1. Technology and raw materials

The lithic industry from the lower levels (XV, XVI and XVII) comprises a total of 13,032 remains. Level XV comprises 1032 remains, of which 665 are chips; XVIA has 9881 lithic remains, of which 7509 are chips; XVIB comprises 1229 remains, of which 889 are chips. The number of lithic remains decreases considerably in XVIC, where 835 lithic remains were found, of which 677 are chips. This tendency continues to XVID, where a total of 27 remains were recorded, of which 15 are chips, and to XVII, with 28 remains (12 of which are chips).

6.1.1. Raw materials used as blanks

The most common raw material used throughout the whole sequence is flint, with slight shifts in terms of the proportions of the local and non-local varieties represented. Among the former, it is possible to distinguish different degrees of flint quality, given that some show many cracks and a tabular structure, which would have been of little utility for laminar knapping. On the other hand, some of the other types represented possess suitable structural properties for this kind of flint working. Local flint can be divided into two variants. On the one hand, one is of medium quality, fine-grained and opaque, though in some cases has translucent areas and a soft texture; the predominant colourations are light grey and white. They do not usually present fissures, and the cortex is usually semi-rounded and with brown or reddish colourations (Fig. 8). And on the other hand, there is one of worse quality in which the fissures abound and are often fractured by diaclases. It is usually opaque and fine-grained. The cortex is similar to the previous variant. This represents 41.1% of the total specimens in level XV, 48.7% in sub-level XVIA, 39.1% in XVIB and 43% in XVIC (these calculations did not take chips into account). In the two remaining sub-levels, the small number of pieces found does not allow for specific inferences to be made, besides simply quantifying them: of the 12 pieces found in XVID, five are on local flint, whereas in the case of XVII, it was six of the 16 pieces.

In terms of the non-local flint, most of these types coincide with the so-called Serreta and Mariola types (Menargues, 2005; García, 2005; Molina et al., 2010; Eixea et al., 2011, 2014; Molina, 2016). In relation to the first, macroscopically, they are characterised as fine-grained, with a smooth surface and microcrystalline structure. The colour is brown, black or grey with small dark speckles. Microscopically, spicule sections, inertites and the presence of microforaminifera indicate a marine formation environment. Within them, there are some types of a higher quality that are differentiated from others, in which the massive presence of fissures and diaclases prevents the development of knapping with sufficient guarantees. Regarding the second type, they are whitish cherts with brownish and yellowish tones. The study of its cortex indicates continental formation in an evaporitic sedimentary basin. Macroscopically, this chert is fine-grained and translucent. Microscopically, among the inclusions, some — acicular pseudomorphs (gypsum crystals), iron oxide cryptograins and some anhydritic components — indicate chert formation environments with high salinity levels. Two variants can be discriminated within this type: one features lighter colours, which could be because hematite or iron oxide grains are more abundant, and another features a mudstone texture, relicts of the original carbonate and macro-quartz particles, which gives it darker colours. As with the Serreta type, the two Mariola types differ in appearing less diaclases and are better for knapping than the others. In some cases, the convergence observed in certain varieties of Mariola and Serreta types requires them to classified as indeterminate (Molina, 2016).

The presence of the Serreta type oscillates between 33.5% (XVIB) and 21.3% (XVIA), whereas the Mariola type does so between 16.2% (XVIB) and 10.8% (XVIC). The source areas for these two varieties are located about 40–60 km from Cendres. Between 8.4% and 15.2% of the pieces are made from indeterminate flint. Jasper and quartzite are represented in very small numbers.

When analysing the raw materials used in the different types of blanks (Table 5), it was noted that laminar knapping, including laminar flakes, blades and bladelets, was mostly carried out using high-quality, non-local flint and local flint with less impurities and fissures. The good representation of core maintenance products on

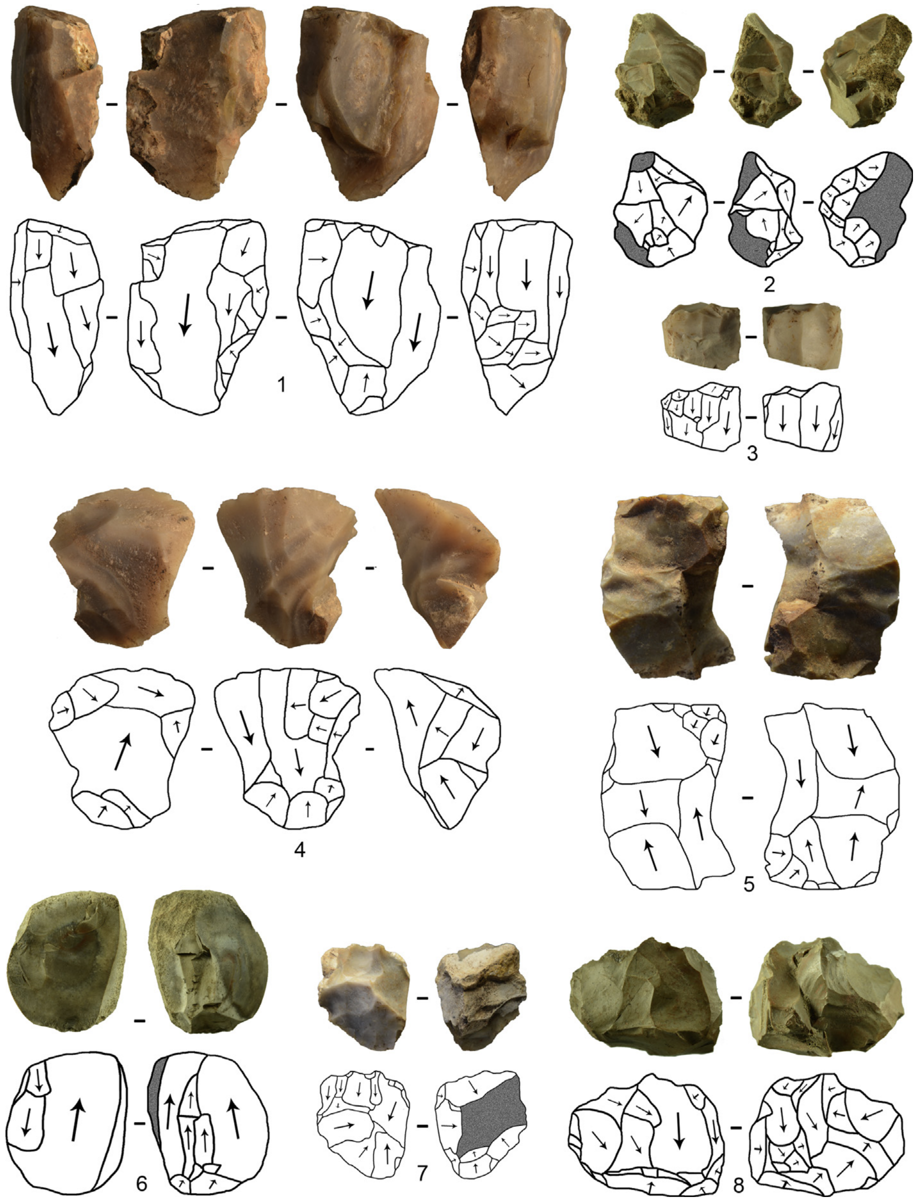

Fig. 10. Cores from sub-levels XVIA and XVIB. Prismatic core (1, 3, 5, 7). Multi-directional flake core (2). Pyramidal core (4). Laminar core. Reused in splintered piece (6). Flakes and laminar core (8).

local materials indicates the need for a greater maintenance of the laminar knapping. The diversification of the materials and laminar or flake knapping processes in sub-level XVIA could be reflecting longer occupation periods, which resulted in greater attention paid to local raw materials.

Along with the exposed raw materials, there are other types that could not be classified because of their degree of conservation and the phase in which the study of these materials is found. In addition to the flint, the other two lithologies, such as limestone and quartzite, have been determined but both with quantifications that are still anecdotic.

6.1.2. Characteristics of the debitage

The lithic assemblage, despite being mainly composed of flakes, is focused around laminar exploitation — especially if laminar flakes are taken into consideration — that is typical of a laminar technique linked to cores with short exploitation surfaces. Blade production is predominantly unipolar, especially in XVIA, where it reaches 76.4%. There is no bipolar knapping in XVIC, but the small number of pieces found leads us to treat this datum with caution. The greatest percentage for bipolar knapping is noted in XVIB, comprising 33% of the blade blanks. The blades and bladelets sections are triangular and trapezoidal, with a slight predominance of the former. No laminar knapping blanks are documented in level XVII, although caution is necessary because not many lithic remains were found there. The debitage technique presents variations between XV–XVIA and XVIB (Fig. 9). In the first two, the soft-stone, hammer-kind predominates, and its values are always above 44%; its use is especially important in XVIA, both on blades and other blanks. The increase takes place at the expense of the soft-organic hammer type, given that the proportions of hard percussion and indeterminate percussion show more or less similar values. However, soft organic percussion is more widespread in XVIB, especially in the removal of blades and bladelets. The notably smaller number

Table 6
Butts from levels XV and XVI. F (Flat), D (Dihedral), C (Cortical), Fc (Facetted), P (Punctiform), L (Linear), S (Smashed), B (Break) and Spp (Suppressed).

	XV									XVIA									XVIB									XVIC								
	F	D	C	Fc	P	L	S	B	Spp	F	D	C	Fc	P	L	S	B	Spp	F	D	C	Fc	P	L	S	B	Spp	F	D	C	Fc	P	L	S	B	Spp
Flakes	63	5	9	2	9	12	8	24	3	359	41	58	10	35	39	11	101	25	49	8	7	1	6	13	0	17	1	25	1	5	2	1	4	4	6	2
Laminar flakes	10	2	0	0	0	5	0	3	0	45	3	6	4	9	8	1	16	7	7	4	0	0	2	3	0	3	1	6	2	1	0	2	1	0	3	0
Splinters	1	0	0	0	0	3	2	3	1	11	2	0	0	18	9	5	29	3	8	0	1	0	1	0	0	6	1	1	0	0	0	0	2	0	2	0
Blades	8	0	0	1	0	0	0	0	1	24	0	5	3	6	1	3	7	3	3	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0
Bladelets	11	0	0	0	4	2	0	4	2	83	6	5	8	53	7	2	42	23	9	0	1	1	3	1	1	4	2	8	0	0	0	0	3	0	1	0

of splinters means that their oscillations are less statistically significant.

In XVIC, the debitage technique seems to be different based on the different blanks. In the case of the flakes, there is a predominance of soft mineral (28%) and soft organic (38%) percussion, whereas the hard hammer type is rarer (13%), whereas 'soft indeterminate' makes up the rest of the sample (22%). For laminar flakes, soft mineral percussion is the predominant kind (64%), with a small presence of soft organic (18%), and another 18% classed as 'soft indeterminate'. In the case of the bladelets, the predominant type of percussion is soft organic (55%), whereas there is much less of the soft mineral kind (27%). Here, 18% was also described as 'soft indeterminate'. The small size of the sample must, however, always be considered.

Lastly, the use of hard percussion was not detected in XVID, where it was all the soft variety; however, in XVII, both hard and soft organic percussions are noted similarly, although we must bear in mind that the sample only comprised six pieces.

The striking platforms, independent of the type of blank, are usually smooth and thin (less than 4 mm thick), with the exception of raw materials such as limestone, in which the thick type predominates. In the bladelets from XVIA, the punctiform platforms are of some relevance (Table 6).

Platform preparation by means of abrasion or thinning is rare in level XV. In the case of the flakes, 17% show abrasion and 5.2% thinning, and in the case of the laminar blanks, there seems to be more abrasion on the blades (50%) than on the bladelets (22%), whereas thinning is only observed on a single blade. In XVIA, the platform preparation is rare on the flakes; here, 24.4% of the platforms show abrasion and 5.9% thinning. On the laminar blanks, the presence of numerous blades showing abrasion (46.2%) and thinning (5.8%) continues to be the case. On the bladelets, abrasion increases up to 38.9%, whereas thinning is hardly present (2.2%). All this indicates that the platforms were more extensively prepared in the case of the laminar blanks. In XVIB, 75% of the blade platforms show abrasion. On the bladelets, abrasion is represented in 18.2% of the cases and thinning in 4.5%. Of the flakes, following the patterns observed in earlier levels, 38.7% have abrasions and 2.5% thinning, although these values are sometimes higher. In XVIC, the blades do not present platform preparation, whereas in the case of the bladelets and flakes, abrasion is represented in 41.7% and 34.6% of the cases, respectively. In XVID, the only abrasion found was on the platform of a laminar flake. In XVII, too, only one flake presented abrasion.

6.1.3. Dorsal surfaces and representation of the *chaîne opératoire*

In all the levels, the presence of pieces with cortical surfaces in excess of 20%, including some completely cortical, indicates that the totality of the *chaîne opératoire* is represented at the site. The proportion of cortex on the blades and bladelets is smaller, which indicates an initial debitage of the core, though with little preparation given the small number of crests and semi-crests and the presence of a cortex in some of the cores (Table 7). Retouched blanks show a greater proportion of non-cortical pieces, which translates into a choice of blanks further away from the cortex areas. The presence of a first-order laminar blank in XVIB confirms that little attention was paid when preparing the start of the laminar exploitation, taking advantage instead of the extended morphology of the short sides of some nodules to start the exploitation. In XVIC, *in situ* knapping also seems to be the case for the flakes, whereas laminar flakes, blades and bladelets either do not present a cortex or have a reduced one. Lastly, in level XVII, the refitting show that there were episodes of occupation when knapping processes took place *in situ*, further confirmed by the presence of cortical dorsal surfaces (two of the first order and seven with more than 20% of the cortex).

Table 7
Cortex presence on dorsal surface on the blanks by levels and in brackets retouched material.

	XV					XVIA					XVIB					XVIC				
	100%	<50%	50%–20%	<20%	0%	100%	<50%	50%–20%	<20%	0%	100%	<50%	50%–20%	>20%	0%	100%	<50%	50%–20%	>20%	0%
Flakes	5	22 (2)	13 (1)	20 (2)	118 (7)	35	786 (8)	131 (15)	159 (19)	620 (64)		8	30 (4)	21	113 (7)	3 (1)	10 (1)	10 (1)	9 (1)	43 (5)
Splinters				2	9 (1)		1	4	4	80 (2)			2		15 (1)					5
Laminar flakes		1	1	2	22 (3)	3	7 (1)	19 (2)	10 (1)	98 (17)		1	2		21 (5)			2	2	14 (3)
Blades			−1		10 (7)		1	6 (2)	8 (1)	54 (27)	1				6 (4)					8 (4)
Bladelets			2	1	35 (7)		8 (2)	9 (1)	21 (5)	370 (118)			3 (1)		38 (20)				2 (2)	16 (3)
Cores			2	2	4 (1)		4 (1)	10	4	25 (3)		1	5 (1)	3 (1)	4		1			1
Core maintenance products		1	2	4	16		6	20 (6)	34 (9)	126 (14)			4 (1)	4 (1)	13 (4)				3	7
Debris			3	2	27		8	14	21	104		4	13 (4)	4	23			1	3	13
Block								3												
Boulder						1														

Table 8
Average length and width of flakes by raw material and quality.

	Length	Width
Local	15.6	16.2
Local with fissures	20.3	19.8
Serreta	16.1	16.5
Serreta with fissures	23.9	20.9
Mariola	16.3	14.5
Mariola with fissures	22.3	22.0
Unknown	15.8	15.5
Limestone	27.0	25.6
Quartzite	24.1	24.7

Table 9
Average measures of blades and bladelets from level XVI by raw material.

	Local			Serreta			Mariola		
	L	W	T	L	W	T	L	W	T
Blades	32.8	14.54	4.32	33.89	14.75	4.67	31.36	16.18	5.79
Bladelets	15.8	7.0	2.14	14.4	6.4	2.03	13.8	6.36	2.58

Table 10
Types of cores.

	XV	XVIA	XVIB	XVIC	XVID	XVII
Blades/laminar flakes cores	–	6	6	–	–	–
Bladelet prismatic cores	4	15	2	–	–	–
Splinter cores	–	6	1	1	1	–
Burin-cores	2	3	–	–	–	–
Scraper-cores	1	3	–	–	–	–
Flakes discoid cores	–	1	1	1	2	–
Other flakes cores	1	3	2	–	–	
Shapeless/altered	–	3	–	–	–	–
Fragments	–	13	2	–	–	–
Total	8	53	14	2	3	–

6.1.4. Typometry of the lithic assemblage

The blanks are small because of the size of the raw material used. In addition, when the flint is of a better quality, with smaller rates of fissures and intrusions, it is smaller in size. This all influences the general size of production (Table 8). Technologically speaking, a significant portion of the knapping is aimed at laminar production, which due to the characteristics of the raw material, is to a great extent microlaminar and combined with the production of laminar flakes. The flakes are predominantly small in all the levels.

Table 11
Core maintenance products.

	XV	XVIA	XVIB	XVIC
Crested blades	1	6		
Semicrested blades	3	35		
Core lateral flanks	5	47	9	6
Core flanks	14	43	12	3
Transversal core flanks		9		
Cornices	2	12		
Core tablets		1		
C. Semitablets	1	6		1

In typometric terms, the laminar assemblage from level XVI (XV does not possess enough blanks) shows a predominance of bladelets (width <12 mm). The largest blades are those obtained from Serreta flint (L = 33.89 mm W = 14.75 mm T = 4.67 mm on average). In the case of the bladelets, those of greater size are made on local flint (L = 15.8 mm W = 7 mm T = 2.14 mm on average) (Table 9).

6.1.5. The cores and the chaîne opératoires (Fig. 10)

In levels XV through XVIB, there is a predominance of prismatic cores, which include in their final extractions laminar flakes and bladelets (Table 10). The splinter cores from sub-levels XVIA, XVIB and XVID constitute recycled parts of bladelet prismatic cores. Therefore, the laminar *chaîne opératoire* ramifies with the obtention of splinters.

Given the thinness of the industry as a whole, the scraper- and burin-cores are hardly represented in levels XV and XVIA. However, some bladelets transformed through retouch possess a burin spall morphology.

The small dimensions of the raw material were, without a doubt, the reason why the *chaîne opératoire* began with little preparation of the surface because in general, there are not many crests or semi-crests. There are some initial laminar-in-tendency extractions that tend to affect the short surface of the exploitation of the core, which generates a lateral plane used as a guide for the extraction of the initial blade or bladelet. There is also a setting off from a transversal fracture platform, which is perfectly visible from the existence of lateral meplats. On the other hand, negative scars from the extractions show the progressive step from the first blade extractions to bladelet extractions or from blades to laminar flakes when the length of the exploitation surface is shortened or small.

Some crests and semi-crests have been identified as coming in

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Table 12
Material retouched by levels with a detail of projectiles types.

	XV	%	XVIA	%	XVIB	%	XVIC	XVID	XVII
Endscrapers	2	**5**	18	**5.5**	3	**4.9**	2	1	0
Combinations	0		4	**1.2**	0		0	0	0
Perforators	1	**2.5**	0		0		0	0	0
Burins	0		15	**4.6**	3	**4.9**	1	0	0
Backed tools	3	**7,5**	55	**16.7**	10	**16.4**	0	0	0
Truncations	1	**2.5**	10	**3**	0		1	0	0
Pieces with retouches on one or two edges	11	**27.5**	56	**17**	9	**14.8**	4	0	0
Solutrean	1	**2.5**	0		0		0	0	0
Notches and Denticulates	0		6	**1.8**	1	**1.6**	0	0	0
Splintered pieces	9	**22.5**	55	**16.7**	9	**14.8**	4	0	0
Scrapers	1	**2,5**	1	**0.3**	1	**1.6**	0	0	1
Microlaminar tools	4	**10**	84	**25.5**	15	**24.6**	7	0	0
Various	0		9	**2.7**	0		0	0	0
Pieces with use retouches	7	**17.5**	16	**4.9**	10	**16.4**	4	2	1
Total	**40**		**329**		**61**		**23**	**3**	**2**
BACKED POINTS									
Gravettes	1	**2.5**	6	**1.8**	4	**6.6**			
Vachons			2	**0.6**					
Microgravettes	2	**5**	29	**8.8**	5	**8.2**			
Font-Yves	1	**2.5**	2	**0.6**					
Cendres type points			9	**2.7**	1	**1.6**			
Gravettian shouldered point			1	**0.3**					
MICROLAMINAR POINTS									
Truncated bladelets, triangles, rectangles			5	**1.5**					
Backed bladelets			23	**7**					
Pointed backed bladelets	1	**2.5**	26	**7.9**	6	**9.8**			
Bladelets with marginal direct retouches	1	**2.5**	12	**3.6**	1	**1.6**	2		
Pointed bladelets with marginal direct retouches			4	**1.2**	1	**1.6**			
Double backed bladelets			5	**1.5**	3	**4.9**			
Dufour bladelets					2	**3.3**	1		
Bladelets with marginal inverse retouches	2	**5**	9	**2.7**			4		

toward the beginning of the laminar exploitation. These are especially concentrated in XVIA, where semi-crests are much more abundant than crests. In the knapping process, maintenance focuses on the extraction of core flanks. Two types of flanks have been identified: those in which their extraction coincides with the main exploitation platform and transversal flanks, which represent a change in the direction of the extractions of the core. These are less numerous. Core tablets, semi-tablets and cornices are rather scarce and only found in XVIA (Table 11).

The presence of flake cores, generally with few extractions, indicates that a part of the production was destined to create blanks with these characteristics.

Therefore, laminar knapping takes place using prismatic cores, and its aim is fundamentally to later manufacture abrupt or simple retouched points, the latter to a lesser extent. Also, bladelets are occasionally obtained from burin-cores and scraper-cores. The proportion of laminar technique blanks — ones that do not fulfil the criteria of a double length with respect to width — is high and is once again a result of the initial size of the raw material. In XVIA and XVIB, there is an intensive recycling and use of the blanks and of the products of a certain size.

6.2. The retouched material (modified tools)

The analysis of the retouched material from the Cendres sequence allows for two great phases to be differentiated: one characterised by the presence of backed tools, both laminar and microlaminar (XV, XVIA and XVIB), and another (XVIC and XVID) in which these pieces cease to be present. There appears to be little occupation in level XVII, but it does not present backed tools either.

To classify the backed tools, a distinction has been made between Gravette points, microgravettes and pointed-backed bladelets, and within the latter, those pieces, given their very small size, stand out within the assemblage. To distinguish between the different variants, we have resorted to a typometric criterion, centred on the width of the pieces so that those wider than 8 mm have been classed as Gravettes, those between 5 and 8 mm as microgravettes and those smaller than 5 mm, which combine the back with pointing, as pointed-backed bladelets. The typometric criterion to distinguish between Gravettes and microgravettes has also been used by Soriano (1998) and O'Farrell (2004), although with some differences regarding the minimum width limit of the microgravettes because the former author places it between 4 and 8 mm, whereas the latter classifies them from 7 mm onwards. On the other hand, the lack of precision in the typology of Sonneville-Bordes and Perrot when distinguishing between the backed bladelet, which can be pointed or not, and the microgravette, both having a rectilinear back, has lead us to establish a size criterion to tell them apart when the former is pointed.

We, on the other hand, make a distinction between backed tools and points because the former includes non-pointed pieces, either because they are fractured or because they lack a pointed termination, whereas the latter comprise pieces whose point is created through marginal simple retouch, as would be the case for the finely retouched pointed bladelets, the Cendres-type points (Villaverde and Roman, 2004) or the Font-Yves points with a semi-abrupt retouch. The difficulty in classifying the pieces that only have their proximal or medial parts preserved has already been noted elsewhere, which, given the assemblage we are analysing here, implies that a part of those pieces may have been pointed pieces at some place in time.

Backed pieces (including the microlaminar ones) represent 10% of level XV, 34.7% of XVIA and 31.1% of XVIB, whereas these are not documented in XVIC, XVID and XVII. The points, both backed and with simple retouch (including also the microlaminar tools), are present in the following frequencies: 7.5% in level XV, 25.5% in XVIA

Fig. 11. Projectile points from level XVI. Cendres type point (1–6); Font-Yves point (7); Vachons point (8); Gravettes (9–14); Microgravettes (15–27); Pointed-backed bladelets (28–35); Bladelets with inverse marginal simple retouch (36–37); Double-backed pointed bladelets (38–41), and backed-pointed microbladelets (42–48). Scale bars 10 mm.

Table 13
Lengths of different points types. Measures are in mm (*: only one complete specimen).

	Maximum length	Minimum length	Average	*N*	Standar deviation
Gravettes	48.5	37.1	41.8	3	5.97
Vachons	27.6			1	
Microgravettes	44.6	19.3	30	8	8.6
Cendres type points	45.7	32.2	37.8	8	5.1
Pointed backed bladelets	26.3	11.8	18.5	9	5.16
Pointed backed microbladelets	12.3	9.8	11.1	3	1.26
Double backed points	38.5			1	

and 32.8% in XVIB; no pointed pieces were noted in the three lower levels. Because levels XV and XVIB have less than 100 pieces each (Table 12), their values must be considered as purely indicative; however, the presence of points and backed pieces in this part of the sequence, as well as their proportional representations, are nonetheless significant.

The similarities noted between XVIA and XVIB are significant: the microgravettes are present in similar numbers, and both have Cendres-type points, double-backed pointed bladelets and pointed bladelets with a marginal simple retouch.

Table 14
Average width and thickness of projectiles from level XVI. Without impact (W/I), with impact (I). Measures are in mm. Number of pieces in parentheses.

	Width		Thickness	
	W/I	I	W/I	I
Gravettes	9.47 (7)	10.3 (3)	3.04 (7)	4.2 (3)
Vachons	NA	8.3 (1)	NA	3.3 (1)
Microgravettes	6.35 (28)	5.85 (6)	2.94 (28)	2.56 (6)
Font-Yves	NA	9.2 (2)	NA	2.5 (2)
Cendres type points	12.7 (8)	13.3 (2)	4.86 (8)	5.65 (2)
Pointed backed bladelets	2.99 (26)	4.01 (6)	1.73 (26)	2.01 (6)
Double backed points	4.33 (3)	4.56 (5)	1.96 (3)	2.28 (5)

Table 15
The percentage of splinters is calculated with regard to the flakes, blades, bladelets-splinters, fragmented or complete, but with values exceeding 100 remains; the percentage of cores is calculated with respect classifiable cores, if there is 10 remains at least. The percentage of splintered pieces is showed if the assemblage exceeds 60 retouched pieces.

	XV		XVIA		XVIB		XVIC		XVID	XVII
Splinter cores	0		6	16.2	1	8.3	1		1	0
Splinters	11	3.5	89	4.5	17	6.3	5	3.6	1	0
Splintered pieces	9		55	16.7	9	14.7	4		0	0

These backed tools and their technological characteristics (Fig. 11) allow us to describe the XV, XVIA and XVIB as Gravettian techno-complexes although level XV displays some differences with respect to XVIA, both in terms of the impoverishment of the material and because of the absence of double-backed points and the smaller presence of pointed elements. To those data, it would be necessary to add the lack of endscrapers and burins and the high proportion of pieces with one or two retouched sides.

6.2.1. Double-backed pointed bladelets and backed pointed microbladelets (Fig. 10)

These are two variants whose evaluation deserves certain attention. In the case of the double-backed points, most of those documented at Cendres in XVIA and XVIB are fractured in the basal part, which makes it difficult to determine whether or not these were at some time pointed. The fact that of the eight pieces documented, six have impact fractures indicates that there is a variable clearly linked to the configuration of projectile points. Only one piece is complete for the whole of the small collection at Cendres, and it is the one that preserves the platform, and the abrupt bilateral retouch stops prior to reaching the proximal half of the bladelet. Only a single piece could be classified as pertaining to a double-backed double point; it has light distal and proximal fractures linked to the impact, but the double-pointed morphology is clearly visible. Strictly speaking, most of the pieces from Cendres could be separated morphologically from the double- and bipointed-backed points, considered typical of the Gravettian at Vale Boi (Marreiros et al., 2015) although the type would be represented at least by the piece noted above, which was found in XVIA. On the other hand, the measurements for the double-backed points from Cendres and Vale Boi do not differ much in relation to their width and thickness: the average width of the pieces from Cendres is 4.5 mm, whereas those from Vale Boi is 3.8 mm, and the average thickness at Cendres is 2.2 mm and 3.2 mm at Vale Boi. The steep retouch seems deeper or more invasive on the pieces from Vale Boi, and it sometimes modifies, in a very marked and irregular way, the edges of the points, which would explain their smaller width. It is important to point out that the double- and bipointed-backed points from Cendres do not agree with the oldest phase of the site.

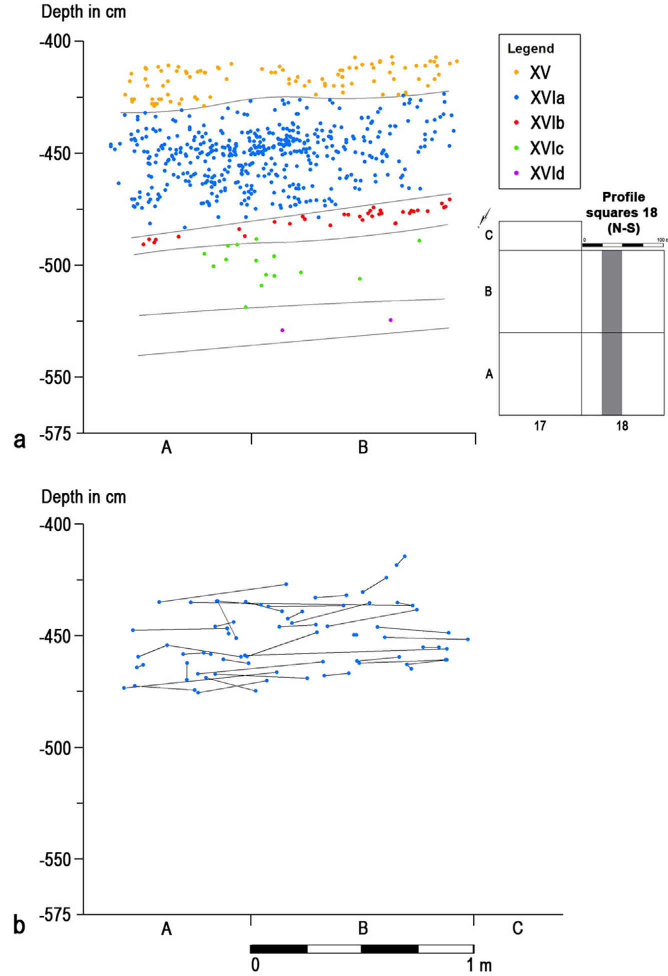

Fig. 12. a) Archaeostratigraphic profile of plotted remains from a strip of sub-squares. b) Vertical projection of refits and connection lines of sub-level XVIA.

Within the pointed-backed bladelet assemblage at Cendres, the presence of a small lot of very small pieces was noted. A total of 11 pieces were counted, of which 10 are from sub-level XVIA and one from XVIB. The width and thickness values are practically identical: 1.5 mm on average. The length of the whole ones is between 10 and 12 mm, which means that these pieces cannot be considered points destined to be hafted in an apical position in shafts. Therefore, this indicates the existence of lateral hafted armatures, typical of composite points or another type of composite tool. Their presence could be explained by the marked microlithic component of the points assemblage at Cendres.

For this to be better assessed, we present the lengths of the different whole point variants documented (Table 13). Although the number of complete points is reduced, the values not only confirm the typometric continuum of the three main variants (Gravettes, microgravettes and pointed-backed bladelets), but they also allow us to corroborate the short lengths of the points, with values in the case of the microgravettes normally below those noted by Soriano (1998) for Rabier — showing pieces between 38.7 and 48.7 mm long — but not the backed points from Paglicci, where, although their values are between 72 and 16 mm, the average for this site is 34.4 mm. The pointed bladelets by means of direct marginal simple retouch are hardly represented in XVIA and XVIB, in which large numbers of microlaminar backed points are found.

6.2.2. Impact fractures on the points

Although fractures arising from use on pieces such as projectiles only represent a small percentage of the whole assemblage, they nonetheless provide valuable information. A total of 25 projectiles in level XVI present impact fractures: six pointed-backed bladelets, six microgravettes, five double-backed points, three Gravettes, two Font-Yves points, two Cendres type points and one Vachons. The burin-like fracture is the predominant type (80%), which generally entails little loss of material. Bending fracture, flute-like pieces (20%), both those smaller and greater than 2 mm, have been noted, and these were used as pieces for hunting (Caspar and De Bie, 1996). Although these data must be considered with caution because we lack the experimentation that allows us to determine what caused the marks (Rots and Plisson, 2014; Coppe and Rots, 2017), as a whole, the ones noted here confirm the use of the different pieces from Cendres as projectile weapons.

In terms of the widths and thicknesses of the points from the different levels at Cendres, the variables that can be analysed in most of the pieces and their measurements are outlined in Table 14; a distinction is made between those points that display impact traces and those that do not. The variations noted in the thicknesses also apply to those of the widths; the differences between the pieces with and without impact are small; the double-backed pointed bladelets present similar measurements to those of single backed pointed bladelets; and the Cendres-type points have a greater width than that of the Gravettes and Font-Yves points, which might indicate a different hafting system.

6.2.3. Splintered pieces and splint production (Table 15)

The splintered pieces also must be discussed. How some of these pieces were used is not fully clear: they could have been tools used for percussion or splitting, as was suggested for a piece inserted into a bone that was found at Vale Boi (Bicho and Bao, 2007), or as blanks destined for extracting splinters. The careful experimental work carried out by de la Peña (2011) allows us to distinguish between three different kinds of objects: the splinter cores, the products from their splintering or splinters and pieces whose splintering reflects the use of the edges or the opposite ends of a flake or core in percussion actions. These three variants are present at Cendres although there is a clear predominance of splintered pieces in relation to splinter cores. There is no denying that in some cases, their classification is complicated, but the requirement for the identification of the splinter cores lies in the presence of scars that correspond in shape and size to those of the extracted splinters. Therefore, those pieces classified as splintered only include those in which the splintering affects both the ends and where the

Fig. 13. Bone industry (1–9) and ornaments (10–35).

scars are staggered and small, that is, they display a kind of retouch that resulted from use.

It is interesting to note how these types of pieces normally take advantage of the flanks, or even endscrapers and pieces with retouched edges, which agree with the idea of an intense recycling of the blanks of a certain size being linked to local flint and high-quality allochthonous varieties. The quantifications allow us to deduce a certain correlation between the greater documentation of splinter cores and their debitage and the continued presence of splintered pieces from levels XV to XVIC. In the latter, which comprises a small number of retouched pieces and little lithic material in general, the documentation of the three variants is significant.

6.2.4. *Other retouched material components*

The pieces with unilateral or bilateral retouch represent one of the largest groups in all the levels. If pieces with very marginal retouch or use are included in this category, they represent around 25% of the retouched pieces. Quantifying these pieces provides information on the importance of maintenance and consumption activities.

Endscrapers, burins and burins on truncation are never abundant, and in those levels with a greater number of pieces, combined they represent 10–13% of the retouched material. On the other hand, the absence of carinated or thick types among the scrapers does not help to delimit the substantial changes taking place at the base of the sequence with respect to the rest of the levels. The burins and scrapers show even proportions.

The microlaminar assemblage, though partly agreeing with the production of points, provides more information on the existence of the differences throughout the sequence because backed tools are not found from XVIC onwards, and retouched microbladelets are not found in the XVID and XVII. However, it is key to note that the absence of backed tools in XVIC includes tools on blades or flakes.

A Solutrean piece was found in level XV, which could be because of an intrusion from the Solutrean levels. It is an unifacial point fragment and laminar, which shows a burin-like impact fracture on its left side and is associated with a good development of the flat retouch on the left edge.

6.3. *Valuation of the integrity of the levels*

Only the results of the refitting study from sub-level XVIA are presented here because the rest of the levels are currently under study, along with data in relation to the vertical distribution of the materials.

The archaeostratigraphic study shows that the thickness of the levels is variable. The thickest levels are XVIA and XVII. There is a clear contrast between the wealth of the upper levels (XV, XVIA and XVIB), representing a palimpsest structure composed of repeated occupations, and the scarcity of remains in the lower levels (XVIC, XVID and XVII), which are linked to more sporadic occupation episodes. Sub-level XVIA, which has the largest number of pieces, has a central part with a greater density of remains (Fig. 12a) that could be linked to a greater occupation intensity.

The general slope of the levels is more pronounced in the cross-section (parallel to the mouth of the cave), with a dip toward the right sagittal profile. On the other hand, in a longitudinal sense (perpendicular to the mouth of the cave) it tends to go horizontality, although it may display a slight dip toward the mouth. This reflects a complex filling base, the evaluation of which is impossible currently. These tendencies influence the inclination of the refitting lines.

In terms of the refitting, it is first worth noting that in general, their percentage in XVIA is low (3.31%, with a total of 41 refits). This small number is partly because of the small excavation area, hardly 4 m^2, and the small dimensions of most of the lithic remains. In the same way, the palimpsest structure that seems to be present in XVIA does not help to demarcate the short-duration units.

The slopes of the refitting lines tend to be horizontal (Fig. 12b) or show a slight inclination that coincides with the natural slope of the level, which is significant from the point of view of a good general preservation of the sedimentary package.

The vertical displacements detected are relatively short (less than 15 cm), and within them, both bioturbations in the form of burrows (Araujo and Marcelino, 2003) and differential displacements linked to consolidation processes of the sedimentary column (Cahen and Moeyersons, 1977) or trampling (Marwick et al., 2017) may have intervened. In terms of the burrows, the excavation paid special attention to these kinds of alterations, detecting and separating the materials found associated with them; we, however, cannot rule out the possibility that some of these burrows may have gone unnoticed, given the nature of their filling.

7. The osseous industry

The industry of the Gravettian levels of Cova de les Cendres is composed of different technical products, mostly tools or fragments of tools (20), but also various waste products (25).

The equipment is composed of objects made mostly on bone. A total of 20 finished objects — 18 on bone and two on antler — have been identified. Most of them are double points or point fragments (18) (Fig. 13: 1–4 and 6). Within this typological category, it is difficult to separate distal or proximal fragments, and only in five cases does the degree of preservation allow us to precisely identify the type.

All points have their surface entirely covered with striations produced by scraping. From a typological point of view, the industry is made of five double points, one bevelled base point (Fig. 13:5), one awl and one chisel (Fig. 13:8). The chisel is from level XV, the proximal fragment of a rounded base point is from XVIB and

Table 16
Taxonomic distribution (NISP, %NISP, MNI) of bone remains from sub-level XVIA.

	NISP	%NISP	MNI				T MNI
			Y	SA	A	S	
DETERMINATES	5815	97,39					
Ungulates	436	7,50	5		5	2	12
Cervidae	9	0,15					
Cervus	345	5,93	2		2	2	6
Bos	7	0,12	1		1		2
Capra	62	1,07	1		1		2
Equus	13	0,22	1		1		2
Carnivores	57	0,98	1		6		7
Carnivora	1	0,02					
Vulpes	2	0,03			1		1
Lynx	40	0,69	1		2		3
Felis	10	0,17			1		1
Felinae	2	0,03					
Meles	1	0,02			1		1
Monachus	1	0,02			1		1
Oryctolagus	5150	88,56	8	4	68		80
Mauremys	16	0,28					2
Birds	156	2,68					
INDETERMINATES	**156**	**2,6**					
Large-sized	19	7,31					
Medium-sized	134	51,54					
Small-sized	3	1,15					
	5971						

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the rest of the material is from XVIA horizon.

The double points and the fragments are made on blanks or chips produced from long bones of medium-sized taxa, their sections are circular and their thorough finishes are achieved through scraping, as the striation stigma show us. A polygonal tendency can be observed on some of the ends. The bevelled base point is made on bone; it has a distal fracture, and the bevel is poorly marked. The awl (Fig. 13:7) is made on a bone chip of a certain size (6.8 × 1.3 cm). Its straight profile shows continuous, long scraping marks. These are parallel to each other and arranged in bands of an average density that extend across the piece.

Only one point is made on antler, two fragments corresponding to the same piece (Fig. 13: 9a and 9b). The chisel is made on a tine tip; it measures 7.9 × 1.9 cm and is less than 4 mm thick. We could note the presence of removal scars concentrated unifacially on its proximal part, and they are linked to cutting percussions. Furthermore, the saw-tooth fracture plane at the proximal end is associated to fracture techniques, such as breaking by percussion or bending to separate it from the whole antler. The crushing marks on the point can be seen on the distal end of the piece.

In terms of technical remains, there are a total of 25 identified within the assemblage: two on bone and 23 on antler. First, it is important to highlight with regard to the transformation of the bone that the assemblage of bone remains is very fragmented, so it is difficult to make the distinction between technical traces and those related to processing and butchering (Tartar, 2009:15–16). It would be ambiguous to only rely on the presence of fracture planes, so this is the reason why technical interaction was only established on the pieces that showed fracture planes associated to other technical marks such as striation due to scraping.

The two waste products on bone were made on one-fourth of long bone identified as a goat radius. The preserved surface has a longitudinal, continuous and covering striation scraping-type traces. These two pieces have also fracture plane stigmata on sawtooth that we associate to breaking by percussion or bending on the proximal end. The presence of these marks and their chronological order on the pieces allows us to conclude that first, the surface was scraped for some kind of preparation of bone selection as raw material (removal of periostium) related to the debitage by breakage itself by direct percussion.

Among the worked antler, the technological assemblage includes 16 remains from production sequences and seven blanks. These were technically transformed, but it was not possible to identify the exact procedures or methods.

Restricting ourselves to the description of the assemblage, we can point out four tines with proximal fracture planes that can be associated to block preparation by trimming to breakage by percussion or bending techniques. Regarding block preparation, we notice tines and tine tips with transversal fracture planes stigmata of sawtooth or ventral and proximal fracture planes associated to a discard once the debitage was initiated.

Among the blanks, we can distinguish anatomically shaped blanks, which, through segmentation sequences by percussion and bending techniques, the tine are separated from the beam (this kind of blank appears to be linked to the production of chisels), splinters (Pétillon and Ducasse, 2012: 435) are associated to direct percussion given the irregular shape of the blanks and marks of the kind of fracture planes on a barb come in at a $<45^{\circ}$ angle (Pétillon and Ducasse, 2012; Bauman and Maury, 2013). Indirect percussion was noted on a blank because it had continuous lateral and quite regular fracture planes, which indicate a longitudinal splitting, producing a bipartite blank (Tejero, 2013).

In summary, although it has been possible to identify different techniques of working of antler and bone, given the characteristics of the assemblage, it has not been possible to characterise the procedures nor specific transformation methods. Future experiments that incorporate other assemblages of similar periods in the Mediterranean area will enable us to further specify what was noted above.

8. Ornaments

Ornaments are documented in sub-levels XVIA, XVIB and XVIC at Cendres, although their numbers are only significant in the former (Fig. 13). The perforated shell of a *Theodoxus fluviatilis* was found in XVIB, whereas in XVIC, the presence of a perforated lynx canine was noted; in XVIA, a total of 33 objects were recorded, including 16 *Dentalium* sp. shells, six *Glycimeris insubrica* shells, four *Littorina obtusata* and four *Theodoxus fluviatilis* perforated shells, as well as three teeth (two perforated red deer atrophied canines and another pertaining to an unidentified herbivore showing an incision on its root).

Littorina obtusata and *Glycimeris insubrica* are also documented in the Gravettian levels of La Boja (Zilhão et al., 2017). These two species and *Theodoxus fluviatilis* are registered at the Gravettian of Comte (Casabó et al., 2016), and *Dentalium* sp., *Littorina obtusata* and *Theodoxus fluviatilis* are documented at the Gravettian of Nerja (Aura et al., 2010). The importance of red deer atrophied canines has been signalled in the meridional Gravettian of Europe (Vanhaeren, 2002). Similarly, *Littorina obtusata* and red deer atrophied canines are also common in the Cantabrian region (Álvarez, 2006).

1. The lynx canine (Fig. 13:10), given its position in the sequence (XVIC), is of special interest. It is the tooth of a young animal. On one of its two faces, the drilling was carried out through repetitive, deep lengthwise incisions followed by percussion; on the opposite side, the perforation came from a shallower and smaller incision, as well as percussion.
2. Four other perforated lynx canines have been found in early Upper Palaeolithic contexts in this region. Two pieces come from Beneito: although initially one was associated with the Middle Palaeolithic (D1) (Iturbe et al., 1993), it may have in fact come from the Aurignacian levels (Doménech, 2005: 202); the other was recovered from the Aurignacian levels B8/B9. In both cases, the bevelled root precedes the perforation. The other two pieces come from Forarada (Casabó, 2001): one from level VI (dated in 29,940 ± 150 BP) and the other from level Vb. The piece from Cendres' level XVIC hence confirms the presence of these types of ornaments in this region during the Aurignacian and the interest of human groups in them. Only another object of similar chronology is known at Roc de Combe (Vanhaeren and d'Errico, 2006).

9. Faunal study

The study centres only on XVIA, given the present state of analysis of the recovered remains. This sub-level represents the greatest concentration of lithic and bone industries found in the sequence.

9.1. Taxonomic and anatomical composition

A total of 9670 bone remains (Table 16) were analysed. Of these, 61.75% could be identified taxonomically and/or anatomically, of which 5815 could be fully determined (97.4%). Leporids represent more than half of the sample (88.6%) and are also the predominating taxon in terms of Minimum Number of Individual (MNI). If rabbit remains are excluded from the total count, the sample

Fig. 14. a) Rabbit bones with anthropic fractures from biting; b) cut marks on a rabbit femur; c, d) anthropic modifications on red deer long bones (metatarsal, humerus) and a horse phalanx.

comprises a large number of red deer remains (52%), followed by those of Spanish ibex (9.3%) and lynx (6%). The rest of the species identified each represent less than 3% of the total sample. In general, both adult and young individuals are represented, with the former especially prominent in the case of the lynx and rabbit. The bird remains are currently being researched, so only their total numbers are noted in the present study.

All parts of the skeleton of red deer and Spanish ibex are represented here, although the axial and cranial portions feature less prominently, likely because of the assemblage's high levels of fragmentation and the greater difficulties encountered when identifying these kinds of bones. Nonetheless, many axial elements were identified among the medium-sized indeterminate remains. Only a few fragments represent horses and aurochs, although all the elements for each of the taxa have been recorded.

In terms of the carnivores, most of the species identified are represented by at least one individual, as is the case with the seal, badger, fox and wildcat. The only carnivore to be represented by a greater number of remains and individuals is the lynx (NISP = 40; MNI = 3). Elements from of each of the anatomic groups have been identified for this carnivore.

Lastly, among the small prey, the rabbit is the most relevant species. Based on its element distributions, the fore and hind limbs represent the most important parts, together with the large number of mandibles found. On the other hand, the scarcity of rabbit elements pertaining to the axial skeleton is striking.

Two turtle (*Mauremys*) individuals represented by 16 remains (all from the plate) have also been identified.

9.2. Taphonomic study

Of the ungulate and carnivore bones, 72% have old fractures, of which at least 63% are fresh in origin. The presence of notches from percussions have also been noted, most of which have been observed on the long bones of red deer (Fig. 14c and d), such as the humerus, tibia or metatarsals, as well as on phalanges and on a calcaneum.

Percussion bone flakes because of impact have also been found. In terms of the anthropic modifications, close to 21% of the medium- and large-sized remains show fire-related alterations, in most cases covering all of the surface, showing in a brown and black colour. Lithic traces, including both cuts and scrapings, were recorded on 14% of the bones (Fig. 14d). Most of the traces were observed on red deer elements and medium-sized indeterminate remains. The cuts/scrapings on the Spanish ibex and lynx remains are also noteworthy. These are mostly located on long bones in the stylopodium and zeugopodium, although they have also been recorded on phalanges, mandibles and tarsals.

In terms of the leporids, around 80% of the remains show old breaks, of which 42% are fresh in origin and result from two anthropic actions: biting and flexing (Fig. 14a). Long bones and metapodia present repetitive and characteristic fracture types: diaphysis cylinders and fragments from articular areas where most notches have been observed. On the other hand, 7% of the remains show lithic traces (cuts or scrapings). It is also worth noting the presence of longitudinal scrapings in areas of the diaphysis and the presence of cuts close to articulations, especially on the humerus,

Table 17
Comparison of the archaeozoological studies and NISP data of the sites mentioned in the text.

	LEVEL	ORIGIN	NISP	Tp	Tm		Lp	OTHERS	NOTES	REFERENCES
ARBREDA	E	mostly anthropic	955	horse	red deer, spanish ibex, auroch, asno, wild boar, chamois	fox, lynx, wild cat	rabbit, hare		burned bones, some bites, without lithic and percussion marks	Estévez 1987
BENEITO	B7a, B7b	anthropic and others (rabbits)	3936	spanish ibex	red deer, chamois, horse, ass	wolf, fox, lynx, wild cat	rabbit, hare		butchery marks, carnivore marks	Martínez Valle 1996
FORADADA	V	mostly anthropic	227	red deer	spanish ibex, wild boar, horse, ass, auroch	lynx, wild cat, leopard	?		fractured bones, burned bones, lithic and carnivore marks	Pantoja et al., 2011
CENDRES	XVIA	anthropic	5659	red deer	red deer, spanich ibex, horse, auroch, tortoise	lynx, wild cat, fox, badger, seal	rabbit, hare	mollusc?	meat and marrow consumption, fracture and lithic marks, bites, burned bones	present work
PARPALLÓ	layers 9 and 10	anthropic?	3565	spanish ibex	red deer, auroch, horse, wild boar	lynx, wild cat	rabbit?			Davidson 1989
MALLADETES		mixed	85	red deer	spanish ibex, wild boar, auroch	wild cat	rabbit			Davidson 1989
COMTE	SU 1001	anthropic	?	red deer, spanish ibex	chamois, roe deer, horse, ass	lynx, wild cat	rabbit, hare		anthopic fractures, complete transport (ibex) and selective transport (red deer) human consumtion o lynx	Casabó et al., 2016
BARRIADA	A, B, C	mostly anthropic	57	red deer, spanish ibex	horse, auroch	–	rabbit	mollusc	fractures, percussion marks, bites on rabbit, without lithic marks	De Pablo et al., 2014
NERJA	NV 13	anthropic, carnivores, bird of prey (rabbits)	128	spanish ibex	red deer, horse, auroch, tortoise	hyena, lynx	rabbit	mollusc	non anthropic bite marks, digested bones	Aura et al., 2010, 2012
	NV 12, 11, 11	anthropic	1550	spanish ibex	red deer, horse, auroch	lynx, wild cat, seal	rabbit	mollusc	marrow and grease consumption	Aura et al., 2010, 2012

Table 18
Distribution of the remains according to Tp (main taxon), Tm (minority taxa) and Lp (leporids), in terms of NISP and %NISP, of the sites mentioned in the text.

	TP		TM		Lp		
	NISP	%NISP	NISP	%NISP	NISP	%NISP	
ARBREDA	220	23,04	160	16,75	575	60,21	955
BENEITO	177	4,50	132	3,35	3627	92,15	3936
CENDRES	345		164	2,90	5150	91,01	5659
PARPALLÓ	2145	60,17	1420	39,83	?		3565
MALLADETES	38	44,71	19	22,35	28	32,94	85
COMTE	?		?		?		?
BARRIADA	9	15,79	2	3,51	46	80,70	57
NERJA (NV13)	36	28,13	9	7,03	83	64,84	128
NERJA (NV12-10)	646	41,68	109	7,03	795	51,29	1550

femur and tibia (Fig. 14b). The bites/flexing, which in a number of cases happen together, are more frequently found on ribs, proximal areas of the ulna and femur and distal portions of the humerus and tibia, as well as on the diaphysis of metatarsals. Lastly, modifications arising from exposure to fire have been noted on 22% of the bones, with colourings in the brown to black spectrum and locations being especially on the surfaces of posterior zeugopodium and autopodium bones and phalanges in general.

Anthropic modifications have also been observed on some of the *Mauremys* plate fragments: two showed brown and black thermoalterations to their surfaces whereas another two had short, oblique cuts on their inside areas, one of which was also burnt.

9.3. Fish

A total of 2901 fish remains were counted, of which 90.8% could be determined taxonomically. The large number of Anguillidae bones is noteworthy (96.3%), although the remains of Salmonidae, Muguillidae and Sparidae have also been identified. Most of the elements are vertebrae (99%), so the number of individuals is quite small, with a maximum of 16. These fish remains may be representing occasional fishing activities in a lake area close to the cave (comment by R. Marlasca).

9.4. Malacofauna

A concentration of terrestrial malacofauna remains was noted, which could have been the result of human and localised consumption. These remains, however, are yet to be fully studied, so more detailed conclusions regarding their origin cannot be made at this point.

9.5. Final assessment and comparisons in the Iberian Mediterranean context

The analysed bone assemblage from XVIA appears to be completely human in origin because no other modifications produced by other predators, such as terrestrial carnivores or birds of prey, have been observed on the specimens. Having said this, the results from the taphonomic analyses on the bird, fish and mollusc remains are still pending. Rabbit bones modified through digestion have been noted, and given their small size, this could mean they were consumed by humans (Sanchis et al., 2016). The species obtained by the human groups all come from areas close to the settlement, where the prey were hunted and transported back to the cave complete; however, in the case of horses and aurochs, this cannot be fully confirmed. The animals were processed for consumption and possibly also to obtain raw materials such as skins and tendons or bones with which to make tools. Both the meat and marrow were consumed systematically, and in the case of small prey such as rabbit, so were the lesser dense articulations. The presence of cut marks on the turtle specimens indicates that perhaps these were processed and consumed as well. Likewise, modification due to the use of fire may have also played a part in the processing of the animals prior to their consumption, although this cannot be fully confirmed.

The finding of a single seal bone is particularly significant, its

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Table 19
Radiocarbon dating results for Early Upper Palaeolithic sites in the Iberian Mediterranean Basin. Charcoal: C; Bone: B.

SITE	LEVEL	REF. LAB.	BP	±	CAL. BP (95%)	METHOD	SAMPLE	REFERENCE
Arbreda	Sup	GIF-6420	20,130	220	24,760–23680	Conventional	C	Delibrias et al., 1987
Griera		GIF-6420	21,255	350	26,200–24760	Conventional	C	Fullola et al., 1994
Roc Melca		MC-2219	20,900	400	26,050–24760	Conventional	C	Soler, 1980
Barriada	A	Beta-296,222	22,750	110	27,430–26750	AMS	C	Fernández-López de Pablo et al., 2014
Barriada	B	Beta-296,223	25,260	120	29,660–28940	AMS	C	Fernández-López de Pablo et al., 2014
Barriada	C	Beta-362,534	27,140	160	31,300–30940	AMS	C	Fernández-López de Pablo et al., 2014
Beneito	VIII (4)		26,040	890	31,690–28330	Conv	C	Iturbe and Cortell, 1993
Comte	SU1001	Beta-413,715	25,050	100	29,430–28750	AMS	C	Casabó et al., 2016
Comte	SU1002	Beta-413,716	24,010	90	28,330–27770	AMS	C	Casabó et al., 2016
Malladetes	c12 (2,4.3,29)	Beta-155,607	25,120	240	29,720–28640	Conventional	C	Villaverde and Roman, 2004
Malladetes	XII	KN-1/926	29,690	560	34,820–32620	Conventional	C	Fortea and Jordá, 1976
Angel 1	10 med b	GrA-16961	25,330	190	29,890–28890	AMS	C	Utrilla and Domingo, 2002
Boja	SW18I	VERA-5789	27,620	230	31,800–31080	AMS	C	Lucena et al., 2012
Finca Doña Martina	7b	VERA-5368	26,990	220	31,290–30810	AMS	C	Villaverde and Roman, 2013
Nerja	V11	Beta-102023	24,730	250	29,320–28240	AMS	C	Jordá and Aura, 2008
Nerja	V13	Beta-189,080	24,200	200	28,700–27780	AMS	C	Jordá and Aura, 2006
Nerja	V11_13	Beta-131,576	24,480	110	28,710–28030	AMS	C	Arribas et al., 2005
Palomar	III	Beta-185,409	21,560	110	26,050–25650	AMS	B	de la Peña and Vega Toscano, 2013
Palomar	IV	Beta-85410	26,430	210	31,070–30270	AMS	B	de la Peña and Vega Toscano, 2013
Palomar	V	Beta-185,411	26,230	200	30,960–30000	AMS	B	de la Peña and Vega Toscano, 2013
Palomar	VI	Beta-185,412	28,050	230	32,650–31210	AMS	B	de la Peña and Vega Toscano, 2013

sole presence indicating that the use of marine resources was likely not worthwhile given the distance separating the cave from the coastline (between 15 and 20 km). Only a few *Sparidae* vertebrae have been found in addition to the single seal specimen.

All the above data agree with those already published regarding the Gravettian levels at Cendres (Pérez Ripoll, 2004, 2005–2006; Villaverde et al., 2007, 2010; Villaverde and Roman, 2013). The taxonomic composition is similar, save for wild boar, roe deer and wolf, which are all absent in this case. Another of the differences noted concerns the modifications produced by carnivores, as well as the presence of some coprolites, although these are linked to XVIC, which is currently under study and has produced less evidence of occupation.

The Peninsular Mediterranean context, in which the results from Cendres fall, has provided few data on the subsistence of Gravettian groups in the area. Faunal studies have only been carried out for the following sites (Table 17): L'Arbreda (Estévez, 1987), Cova del Parpalló (Davidson, 1989), Cova de les Malladetes (Davidson, 1989), Cova Beneito (Iturbe et al., 1993; Martínez Valle, 1996), Cova Foradada (Martínez Valle, 1997; Pantoja et al., 2011), Cova del Comte (Casabó et al., 2016), Cova de la Barriada (Fernández-López de Pablo et al., 2014) and Cueva de Nerja (Aura et al., 2010, 2012). Many of these studies, however, only provide very general taxonomic and taphonomic information and are many times lacking specific quantifications or data, making it difficult to compare these against those of Cendres.

On the one hand, there are those assemblages from old excavations or those partially analysed — as is the case of Arbreda, Beneito, Foradada, Malladetes or Nerja — or even cases (Parpalló) in which the Gravettian material has been studied alongside that from the Solutrean. On the other hand, there are two new recently published sites, Comte and Barriada, although the information found in the publications is very preliminary. Only basic taxonomic information and some general ideas about the origin of the accumulations, as well as some information about the processing, are thus far known about these sites; there is also no numerical data for these sites (Table 17). For this reason, we could highlight that in general, we see a broad taxonomic spectrum with a wide range of medium-sized ungulates and a smaller number of large-sized taxa, as well as a wide range of carnivores, along with various small-sized prey (leporids, birds, fish, turtles and molluscs). All studies highlight the quantitative importance of the leporids, with percentages coming in between 50 and 92% (Table 18), except at Malladetes, in which they only account for 33%; at Parpalló, there are no leporid remains because these were not collected. At Foradada, although it is known that lagomorph remains were found (Fumanal and Olmo, 1997), the most recent study does not include them in its taxonomic distribution (Pantoja et al., 2011). Red deer and Spanish ibex are generally found to be the main taxon, depending on the type of site, save for Arbreda, where horse was the most represented taxon in the earlier layers. In some cases, such as Comte or Barriada, both taxa (red deer and Spanish ibex) appear to be similarly important. However, it is important to emphasise the fact that although red deer or Spanish ibex always predominate across the spectrum, the number of secondary taxa together with the carnivores lessens their importance.

The taphonomic assessment indicated that prey animals were normally carried back to the site complete and processed there for meat and marrow, as attested to by the cut marks, percussion notches and bite marks in the case of the rabbit remains. The carnivores also appear to have been processed and consumed in this way, as noted at Beneito and Barriada. Some of the assemblages also show modifications produced by other predators, such as grooves on bone surfaces or digestive corrosion (Beneito, Foradada), so these could have been spaces shared temporally with other predators.

10. Evaluation of the sequence in its regional context: industrial evolution and chronology

The lower levels at Cendres provide interesting chronological data both in terms of the immediate territorial dimension and in terms of the early Upper Palaeolithic in the southern half of the Iberian Peninsula. When assessing these chronologies in terms of the rest of the dates from the Iberian Mediterranean, we have opted to stick to those dates that meet the requirements for them to be taken into account, avoiding wide indeterminate ranges or stratigraphic or industrial imprecisions. On the other hand, dates from sites in Catalonia have not been included here because the dated samples from Arbreda and Roc de la Melca, nor the results from the works currently underway at Balma de la Griera, can be considered representative of the north-eastern Peninsular Gravettian.

The dates from the central Mediterranean region (Table 19), which represent most of those available for the Iberian

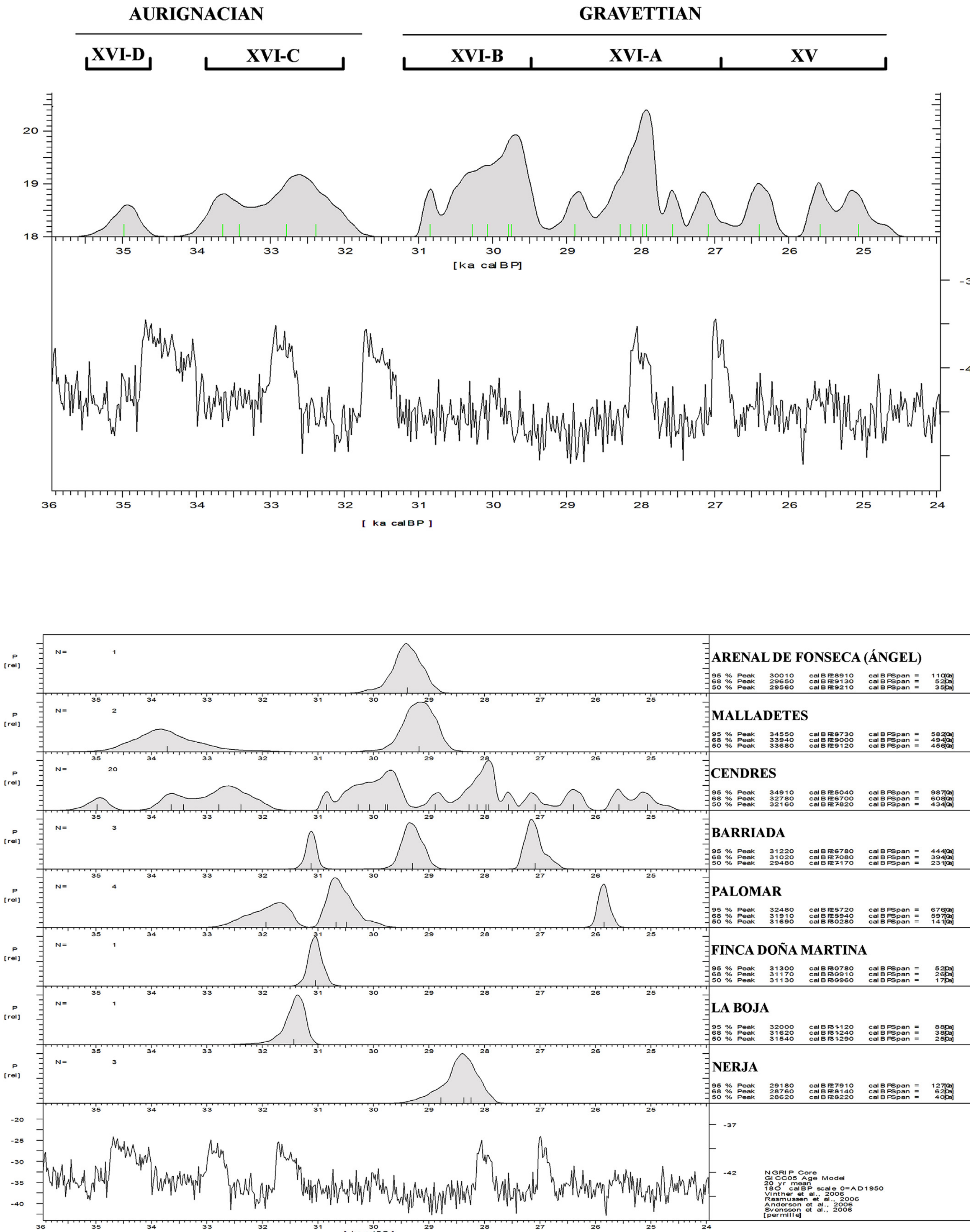

Fig. 15. a) Chronology of the Early Upper Palaeolithic of Cendres (Levels XV–XVI); b) comparison with other sites of the Iberian Mediterranean Basin. Calibration curve has been obtained with CalPal CalCurve; INTCAL13 (Weninger and Jöris, 2008).

Mediterranean, come from four sites: Barriada (Fernández-López de Pablo et al., 2014), Comte (Casabó et al., 2016), Cendres and Malladetes (Villaverde and Roman, 2004). Besides the two dates we excluded at Cendres, we have also not considered the date available for Beneito (Iturbe and Cortell, 1993) given its wide uncertainty range and the doubts surrounding its archaeological/industrial attribution.

In terms of the rest of the territories linked to the Iberian Mediterranean, the dates from Arenal de Fonseca in Aragón (Utrilla and Domingo, 2002) and Palomar in Castilla-La Mancha (de la Peña and Vega Toscano, 2013) appear to be unproblematic, except for level VI of the latter, which is attributed to the Middle Palaeolithic but could be linked to the Aurignacian. Recent excavations in the region of Murcia have produced new Gravettian dates: at the rockshelters of Finca Doña Martina and La Boja (Zilhão et al., 2017) and at the cave of Arco, but these have yet to be published. Two dates were already available for Finca Doña Martina and La Boja (Lucena et al., 2012; Villaverde and Roman, 2013). The dates from Bajondillo, Higueral de Valleja and some from Nerja in Andalusia have not been considered because these were obtained via Thermoluminescence and possess wide uncertainty ranges. For this territory, we have only considered three dates from Nerja (Arribas et al., 2005; Jordá and Aura, 2006, 2008).

Based on this selection, there are only eight sites in the whole of the Iberian Mediterranean area that provide dates — 31 in total and many from Cendres — to pinpoint the Gravettian sequence. Based on these data, the first conclusion we reach is that the earliest Gravettian in the Iberian Mediterranean dates from 31,800 to 29,280 cal. BP, a time in which Cendres and other sites confirm the existence of industrial assemblages in which backed pieces and other techno-typological characteristics linked to this industry are represented, as is the case in level V of Palomar and level OH13 of Boja.

In terms of the end of the Gravettian, this appears to be around 25,000 cal. BP, although dates and archaeological data are scarce for this time period. A date from level XV at Cendres, which offers the greatest stratigraphic certainty, and the most recent from Palomar appear to bring the end of the Gravettian cycle toward the millennium found between 24,800 and 25,800 cal. BP.

Levels with dates within this range are the most common and coincide with the most abundant evidence for occupation based on the density of remains and the variety of industrial components, as is the case of XVIA at Cendres in the central portion of this sequence, which can be dated between 26,000 and 29,000 cal. BP.

Prior to this, between 35,000 and 31,000 cal. BP, the dates from sub-levels XVIC and XVID at Cendres (Fig. 15), that from level XII at Malladetes or that from level VI at Palomar indicate the existence of leptolithic industries with techno-typological characteristics from the Late Aurignacian, in which backed pieces are absent or play a minor role. The same is noted at La Boja, although there are no dates available for it; this is also the case at other sites in the same region based on techno-typological and stratigraphic criteria, such as at Beneito (Iturbe et al., 1993) or Bajondillo (Cortés et al., 2008).

Generally speaking, this seriation agrees with the evolution of the Gravettian found for the rest of the Iberian Peninsula, and the chronologies earlier than 31,000 here too refer to the contexts from the Late/Evolved Aurignacian.

Sub-levels XVIC and XVID at Cendres share many similarities with the lower ones at Malladetes in sectors D, E and F or with levels XII-XIV from *Cata Este*. The density of lithic remains at both these sites indicates sporadic occupation episodes. Their industries are characterised by the small presence or total absence of backed pieces, showing a leptolithic component that matches their Late Aurignacian assignment. The typology of the bone point found in layer 22 at Malladetes, although not linked to the lithic remains from that layer and sector, is unequivocal in its cultural assignment (Tejero, 2013). Just over a metre separates the place where this piece was found and the layer in which the backed pieces are documented. Given the small amount of finds, occupations must have been short and sporadic. This same phenomenon was noted at the excavations in Fortea and Jordá (1976), but it is worth remembering that lithic material was found at these sites, including an endscaper on flake and a dihedral burin of angle. In sectors D, E and F, in depths between 3.25 and 5.5m, a total of 14 retouched pieces were found, among which were three endscrapers, a partially backed blade and various pieces with retouches on one edge. That is, there is no doubt that there was human occupation.

The chronology from the beginning of the Upper Palaeolithic sequence at Cendres and the sites at Rambla Perea (Zilhão et al., 2017) support that the date from level VI at Palomar could be Late Aurignacian, considering the small group of laminar pieces with semi-abrupt retouches found in this package coherent with this chronology (de la Peña, 2012).

If we stick to the Gravettian levels at Cendres, the changes noted in the backed points or pointed blades or bladelets could be considered significant when assessing the typological characterisation of these levels and when defining the little typological variation of this industry if we compare these changes to that of other more northern areas. There is hardly any variation from the Early to the Late Gravettian in this area of the Iberian Mediterranean, where there is a good presence of pointed tools, especially in relation to the microgravettes and pointed-backed bladelets.

In typological terms, and when comparing the data from Cendres with the rest of the central-southern Mediterranean or Atlantic regions, there is an overall sense that all the industries share a common techno-typological background. These industries have variations resulting more from the different availabilities of raw materials or site use than because of cultural factors: several types of backed points, with apex and lateral hafts linked to prismatic laminar knapping; the presence of splintered pieces, many of which are recycled, and knapping aimed at producing splinters; little variation in the bone industry, with a predominance of bone double points, linked apparently to maintenance tasks because the reduced calibre of their ends would not suit their use as projectiles. Given the small size of some of the assemblages, assessing the absence of certain types, such as double- and bipointed-backed points, the Cendres-type points, variations in the laminar components or the proportions of the burins and truncations must be done with caution; their absence, in our opinion, is not because of cultural variation. The limitation in terms of resource procurement, given the lack of faunal collections, represents another factor that prevents us from assessing this issue more thoroughly.

There are not many clearly defined stylistic features that can currently establish the evolution of the Gravettian in this area. On the other hand, the small number of Noailles burins helps set this region apart from the Cantabrian and the Pyrenean regions, hinting at the possibility that there may have been a certain degree of regional compartmentalisation of the Gravettian groups from very early on.

In this industrial context, the occupation density differences noted for levels XV, XVIA and XVIB are not matched by techno-typological changes, which would be better explained in terms of variations in territory occupation patterns than in terms of cultural modifications. The detailed study of the fauna and the plant resources will likely enable us to gain further insights into this area of research, helping us assess the degree of economic stability of the early Upper Palaeolithic groups in this region. At present, the sedimentological, micromorphological and plant data all note a change in the lower levels, where there is less evidence of human occupation. This change is noted from XVIC onwards and should be the focus of further studies based on the fauna recovered. Sub-evels XVIA and XVIB, on the other hand, are significant given their large anthropic accumulations, which indicate that the human groups frequenting the area used extensively the available animal and plant resources.

11. Discussion

As previously mentioned, the potentially habitable surface of Cova de les Cendres is around 1000 m^2. The data presented in this work are limited to an area of 4 m^2 that is located in the interior part of the cavity. The space would have very different lighting conditions compared to the present, given the wide Pleistocene and Holocene sequence accumulated later (more than 5.5 m thickness).

From an economic perspective, these considerations are important in assessing and synthesising the data that we have offered up to now, although they are less of a determinant in relation to the formation processes of the powerful stratigraphic unit XVI and the ecological valuation of the same.

The study of lithic material and bone industry is clearly significant to determine the unequal importance of human presence in the different levels and stratum presented. The highest densities coincide with XVIA and are indicative of a period of intense occupation of the cavity in which the different parts of the *chaîne opératoire* are registered, including the existence of objects of processing and manufacturing such as burins, endscrapers, splintered pieces and retouched blades and flakes, as well as abundant armament, with a considerable typological variety of points; bone artefacts for the most part apparently related to the work of the skin; and pieces of ornament. The raw materials indicate local exploitation combined with a significant presence of resources from the Mariola and Serreta areas, which are at a distance between 40 and 60 km. Both XV and XVIB show a much lower density of remains, and unless this circumstance is because of a change in the areas of occupation, this indicates the existence of a different occupation rate of the cavity. The lowest density of remains coincides with the Aurignacian sub-levels, XVIC and XVID. The decrease of the ornamental elements, as well as the smaller diversity of the lithic elements, in this regard is quite remarkable. Level XVII is especially poor in archaeological evidence, and for the moment, dating this level has proved difficult.

The results that emerge from the refitting study, mainly in the XVIA, agree with the data obtained from the microstratigraphic analysis of the studied sequence. It is a record formed mainly by biogenic register (guano) with a low detrital contribution, in which the sedimentation rate is slow. This can favour the tendency to create palimpsests and bioturbation traces in the different occupations.

From a paleoecological point of view, the greatest information comes from the XVIA, from which we have faunal, anthracological, carpological and phytolith data. The fauna remains studied indicate that the complete set of bones has an anthropic origin because until now, no evidence of the action of other predators has been found. The resources obtained through hunting come from different biotopes near the site, where there must have been high fauna diversity, as reflected in the taxonomic study of the sample. Thus, we have identified species that come from the middle mountain, such as goats, others from meadow or valleys, such as deer and others linked to wooded areas such as rabbits, lynx and wild boar. To these species are added other aquatic medium, both marine and freshwater, such as seal or trout or turtles and eels.

On the other hand, the transport of prey seems to be complete in most cases, including carnivores, although the data are insufficient for the horse and auroch. The exploitation is complete, with meat consumption and access to the marrow and fat, using horn, especially bones, for the manufacture of bone industry. The study of the bone surfaces does not, for the moment, allow for define the processing and/or cooking of foods using fire. No hearths have been located *in situ*. Nevertheless, combustion traces are located *in situ*, as seen in the micromorphological study, although the purposes could be related, for example, to cleaning activity.

The phytolith assemblage from XVIA, showing a high occurrence of fruits, leaves and wood of trees/shrubs, C_3 grasses and sedges, also indicates boundless habitat diversity in the surrounding areas of the site. All these different habitats might have provided a wide variety of plant resources and foods to the human groups inhabiting in the area. In this sub-level, from the carpological and anthracological data, it is possible to specify that the mean annual temperature was around 8–10 °C with a mean annual precipitation around 500–600 mm (dry or sub-humid conditions). Consequently, these could have been the prevailing bioclimatic conditions in the region of Cova de les Cendres during the Gravettian. In any case, for sub-level XVIC, the Aurignacian shows traits of greater dryness, indicated by the proportion of the *Juniperus* sp. That same physiognomy of more open landscape is also observed in level XV, the Final Gravettian, with the prominence of woody shrubs.

With the flora and the proportion of the taxa identified in the charcoal and the seeds, it is also possible to conclude that the landscape of pine forests and cold juniper at the XVIA, with more thermophilic shrubs and bushes, favoured the availability of resources. Organic vegetable remains indicate that Cova de les Cendres is a site where vegetables were stored and used for various purposes, such as making baskets, ropes and other objects. It is certain that the cave was occupied in the summer months or early autumn, indicated by the ripening of the fruits identified and the high presence of phytoliths from the grass inflorescence.

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