A mammoth (*Mammuthus primigenius* Blumenbach 1799, Proboscidea) calf tooth from the Mousterian of Arbreda Cave (Serinyà, NE Iberian Peninsula)

Un diente de cría de mamut (Mammuthus primigenius Blumenbach 1799, Proboscidea) procedente del Musteriense de la Cueva de la Arbreda (Serinyà, NE de la Península Ibérica)

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ABSTRACT

Mammoth calf remains are rare in the Iberian fossil record. In Catalonia, a dP2 from Teixoneres Cave (Moià) has just been reported (Álvarez-Lao *et al.*, 2017). In this paper, we present a new discovery of a mammoth calf from level J of Arbreda Cave. Its chronology is imprecise because of the lack of reliable absolute dates. However, the presence of Mousterian industry, ^{14}C results from the top of the overlying level (I) and U-series results at the base of the stratigraphic column allow us to conclude that the chronology must be related to the early MIS-3 or MIS-4, older than *c.* 44 ka BP.

The C5 EC135 2302 remain is a left dp3 of a mammoth calf that was around one year old at the time of death. Morphological and morphometric studies taxonomically attribute it to *Mammuthus primigenius* Blumenbach 1799. The faunal context of this remain is not like that of the typical Eurasian tundra-steppe environments, where cold-adapted faunas are clearly predominant. On the other hand, Arbreda's level J shows the typical record of the Last Glacial assemblages in Iberia, where eurythermic and temperate species dominate over cold-adapted faunas, which are represented only by a low percentage of identified remains. Following previous studies about cold-adapted faunas of the Iberian Peninsula, the Arbreda tooth is close to the second woolly mammoth dispersal episode but slightly older. In fact, the Arbreda mammoth remain teaches us that this second dispersal episode probably started earlier than was previously thought.

Keywords: Arbreda Cave; Mousterian; Woolly mammoth; *Mammuthus primigenius.*

RESUMEN

Los restos de crías de mamut son raros en el registro fósil de la Península Ibérica. Hasta ahora, en Cataluña, se conocen solo en la cueva de les Teixoneres (Moià), dónde se acaba de publicar una dP2 (Álvarez-Lao *et al*., 2017). En este artículo, se presenta un nuevo descubrimiento de un resto de cría de mamut procedente del nivel J de la cueva de la Arbreda. Su cronología es imprecisa por la falta de dataciones absolutas fiables. A pesar de todo, la presencia de industria lítica musteriense, las dataciones en ^{14}C de la parte alta del nivel supreyacente (I) y los resultados de las series de uranio en la base de la columna estratigráfica permiten afirmar una cronologia relacionada con el MIS-3 antiguo u MIS-4, con una antigüedad superior a los *c*. 44 ka BP.

La pieza C5 EC135 2302 es un dp3 izquierdo de mamut que perteneció a una cría de alrededor de un año de edad al momento de su muerte. Los estudios morfológicos y morfométricos señalan una atribución taxonómica a *Mammuthus primigenius* Blumenbach 1799. El contexto faunístico de este resto no es el de los típicos ambientes de tundra-estepa euroasiáticos, donde predominan las especies adaptadas al frío. Contrariamente, el nivel J de la Arbreda muestra un conjunto típico de las faunas del último glaciar ibérico donde las especies euritérmicas y de ambientes templados dominan sobre las de clima frío. Teniendo en cuenta los estudios previos sobre el registro fósil de las faunas adaptadas al frío en la Península Ibérica, el deinte de la Arbreda se sitúa cerca del segundo episodio dispersivo del mamut lanudo, aunque más antiguo. De hecho, el resto de mamut de la Arbreda nos explica que este evento dispersivo probablemente empezó con anterioridad a lo que se establecía.

Palabras clave: Cova de l'Arbreda; Musteriense; Mamut lanudo; *Mammuthus primigenius*.

Introduction

Quaternary proboscidean discoveries are not rare in the NE of Catalonia, where a large part of a *Mammuthus meridionalis* skeleton was found in the Incarcal Quarry (Mazo *et al*., 2003). *Palaeoloxodon antiquus* is not as well represented and only some tooth fragments were discovered in Mollet Cave (Serinyà) (Solés & Maroto, 2002) and Cau del Duc (Torroella de Montgrí) (Estévez, 1979). Some Middle Pleistocene proboscidean remains have also been recovered from the nearby municipality of Besalú, but their fragmentary conservation hinders a conclusive taxonomic attribution (Galobart *et al*., 1996).

Until recently, *Palaeoloxodon antiquus* was thought to be widely distributed within the Middle and Late Pleistocene interglacial periods in Europe because it was adapted to a temperate climate and parkland or wooded environments, and that its extinction took place at the end of MIS-5 (Kurtén, 1968; Mol *et al*., 2007). Lately, this belief has been challenged by some recent research at sites in the Atlantic Iberia and the Netherlands, where some remains indicate that this proboscidean persisted until MIS-3 (Mol *et al*., 2007; Stuart, 2005). Nevertheless, evidence of its existence in Italy (Grotta Guattari) after MIS-5 is weak.

It now seems clear that *Mammuthus primigenius* evolved in the Eurasian steppe from its ancestor *Mammuthus trogontherii* (Lister, 1996). The woolly mammoth has been associated with a cold, largely treeless environment, especially in the Mediterranean fringe of the Iberian Peninsula, where it has been related to the open landscapes of the last glaciation. However, its remains have sometimes been found in temperate, partly wooded conditions. In fact, in contrast to the Western-Central European assemblages, the Iberian *Mammuthus primigenius* assemblages show a different pattern because it involves a mixture of temperate and cold faunas (Álvarez-Lao & García, 2012).

Most of the woolly mammoth fossils of the Iberian Peninsula come from MIS-3 and MIS-2 contexts (Álvarez-Lao & García, 2011) located in the north (Cantabrian and Catalan areas). However, some of them have also been found in the central regions of Iberia (the Tagus estuary and the province of Madrid) and one of them was even found in the south (Padul Cave) (Álvarez-Lao *et al*., 2009; Álvarez-Lao & García, 2012). The discoveries of scarce *Mammuthus trogontherii* remains from the Middle Pleistocene of the Iberian Peninsula have been reported for the Guadix-Baza basins as well as for other sites in Cantabria, Toledo and Teruel (Ros-Montoya, 2010). Excavations in EDAR Culebro 1 (Madrid) have revealed the presence of mammoths in the Middle to Upper Pleistocene transition in central Spain (Manzano *et al*., 2011; Yravedra *et al*., 2014). The EDAR Culebro 1 mammoth has been classified as *Mammuthus primigenius* by Álvarez-Lao & García (2012). These authors agree with

the primitive features that mammoth remains from the Aldehuela, Arriaga and Butarque sites display (Jarama and Manzanares basins) (Álvarez-Lao & García, 2010; Sesé & Soto, 2002). Although there seems to be a continuous record, the most reliable scenario for a lineage that had evolved on the Eurasian steppe is that it would have dispersed into the Iberian Peninsula during cold episodes.

It is difficult to predict changes to the palaeobiogeographic limits of the *Mammuthus* genus during the Upper Pleistocene, and its record does not seem continuous. Some authors claim that its anecdotal presence in the Iberian Peninsula can be only explained by migratory waves, which most recently are those of MIS-3 (between 43–31 cal ka BP, including Heinrich Event 4) and MIS-2 (between 28–18 cal ka BP, including Heinrich Event 2 and the Last Glacial Maximum) (Álvarez-Lao & García, 2010; Álvarez-Lao & García, 2011).

The presence of *Mammuthus primigenius* is well documented in the Cantabrian passage, a geographical setting containing other typical taxa of the *Mammuthus-Coelodonta* faunal complex: woolly rhinoceros (*Coelodonta antiquitatis*), reindeer (*Rangifer tarandus*), saiga antelope (*Saiga tatarica*), wolverine (*Gulo gulo*) and arctic fox (*Alopex lagopus*) (Álvarez-Lao & García, 2010).

In Catalonia, the coexistence of woolly mammoths and woolly rhinos in MIS-3 has been well documented in the oryctocenosis of Riera dels Canyars (Gavà) (Daura *et al*., 2013) and Unit III of Teixoneres Cave (Moià) (Álvarez-Lao *et al*., 2017). Nonetheless, this association could already be present in MIS-4 of Riera de Sant Llorenç (Viladecans) (Daura *et al.*, 2013). Another remain that could belong to a *Mammuthus primigenius* is a humeral diaphysis recovered from level E of Abric Romaní (Capellades) (Rosell *et al*., 2012).

In the NE of Catalonia, *Mammuthus primigenius* remains are very scarce. The first of them were discovered by Francesc Xavier de Bolòs in the Clot del Llop site (Sant Andreu de Socarrats, Garrotxa), in the first half of the 19th century, for which we lack any chronological reference (Alsius, 1915). Nonetheless, during archaeological excavations in Cau de les Goges (Sant Julià de Ramis, Gironès) carried out between the end of the 19th and the beginning of the 20th century, a dental remain was recovered in a Solutrean context (Cabrera, 1919; Soler, 1997). In Arbreda Cave, the record of this proboscidean is dispersed in the stratigraphic record. An almost complete molar plate was recovered during excavations carried out by Josep Maria Corominas in 1972–73, in the Mousterian levels (layer 30 of Corominas, close to 6.00 metres deep). Estévez (1979) classified some pieces from the same Corominas excavation as proboscidean, scattered throughout the Solutrean, Gravettian and Mousterian levels. Although these remains have not been reviewed, recent archaeological excavations in Beta Sector have confirmed ivory fragments in the Solutrean culture levels. Previously, Maroto *et al*. (1996) had studied an ivory fragment from the Archaic Aurignacian (level H), now dated close to Heinrich event 4 (following the chronology of Sánchez Goñi & Harrison, 2010), but they did not exclude the possibility that it arrived there through the exchange of raw material with northern hunter-gatherer groups. In the following sections we will present a new mammoth calf premolar from Arbreda Cave, discovered in a Mousterian context (level J) and allowing us to complete the knowledge of this slippery taxon in the NE of the Iberian Peninsula.

Geographical and geological setting

Arbreda Cave is situated at 42º09'04''N and 2º44'45''E at an altitude of 206 m above sea level. This archaeological site is located very close to the village of Serinyà (Girona province, Catalonia, Spain) (Figure 1) in a Palaeolithic complex known as Reclau Caves, where more than fourteen cavities, including large caves and little hollows, have been discovered since the 1940s. In terms of dimensions and archaeopaleontological record, the most important caves are Arbreda, Mollet, Mollet III, Pau and Reclau Viver (Soler, 1999).

The presence of these rock shelters is connected to the geological framework of the Banyoles-Besalú Basin (Julià, 1980), which is a morphodynamic hydrogeological unit that has been active in lake formation from the Lower Pliocene to the Holocene thanks to the existence of a lower Lutetian carbonate and gypsum substrate (Pallí, 1972). These karstified water-bearing rocks contain confined aquifers connecting the places where water enters,
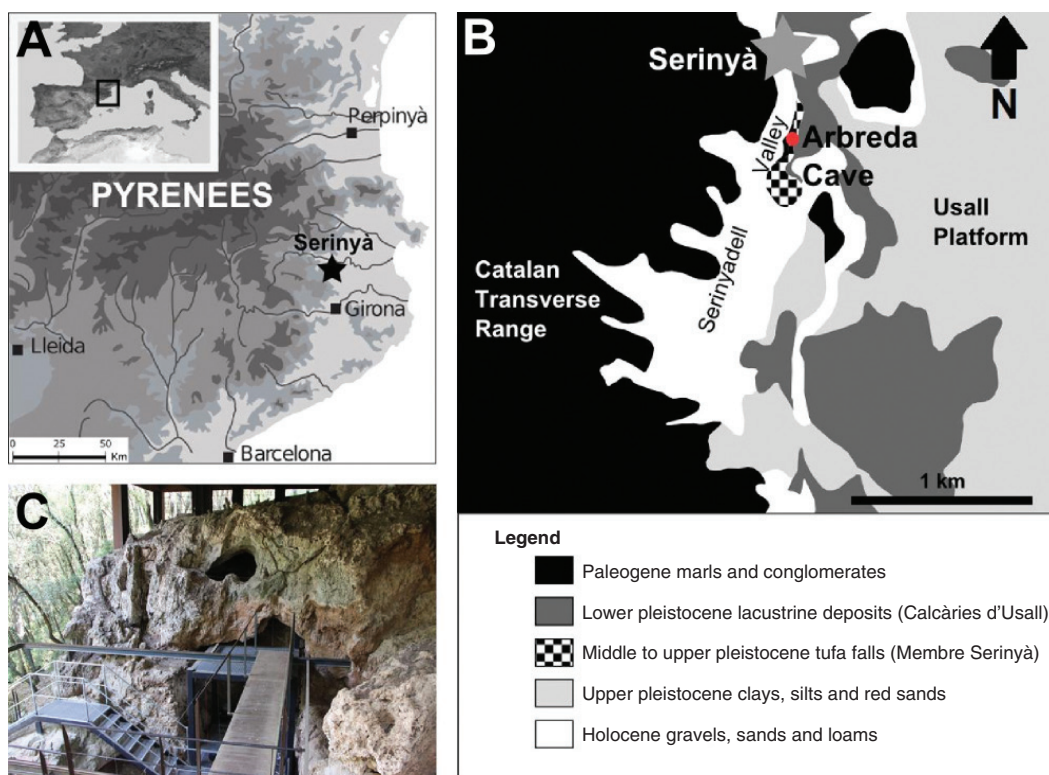
Figure 1.—Location of Arbreda Cave on the NE of the Iberian Peninsula (A); simplified geological map after ICC-SGC-1:25.000 Banyoles 295-2-1 (B); general view of the Arbreda site (taken by Narcís Soler) (C).

the pre-Pyrenean mountains of la Garrotxa, to the areas where it emerges, mostly in the Pla de l'Estany region (Sanz, 1985). The origin of these karst lakes is the collapse doline phenomenon, which creates funnel-shaped depressions (Roqué *et al*., 1999). The lakes' carbonate sedimentation can occur in a great variety of facies, from carbonate muds to the biogenic littoral stromatolites (Brusi *et al*., 1996; Brusi *et al*., 2005).

The Reclau Caves are located at the conjunction of the Usall platform and the Serinyadell River valley, forming a terrace 200 m long, 50 m wide and with a slope of about 10 m. The Usall platform is a structural plain of lacustrine origin formed during the last part of the Lower Pleistocene (Julià, 1980) (Figure 1). Water from Usall's springs flowed to the Serinyà area, where waterfalls built a fluvial travertine terrace between MIS-7 and MIS-6 (*c*. 215,000 and *c*. 134,000 BP) (Maroto, 2014). New U-Th analysis carried out in the tufa falls of Arbreda Cave have pushed back the oldest known datings of this geologic member, close to *c*. 254,000 BP (MIS-8).

The topography at the Reclau site favoured the creation of cavities and rock shelters whose height may have exceeded 12 metres and whose length was about 18 metres, as in Arbreda Cave (Soler & Soler, 2016). Until now, the caves have undergone several transformations that have changed their appearance in comparison with the original morphology. On the one hand, karstification processes, secondary travertine deposits and recrystallizations have helped to remodel the geomorphology of the place. On the other hand, roof collapses and detrital sediment inputs have filled the ancient empty spaces (Brusi *et al*., 2005).

Josep Maria Corominas first became involved in the archaeological works of Arbreda in collaboration with Josep Canal, José M. de Bedoya, Miquel Oliva and Pere Comas. In 1972, he started a 9-metre deep survey (called Alpha Sector) that revealed a long prehistoric stratigraphy. Since 1975, a team led by Narcís Soler has been following up on previous works by applying Laplace's method and enlarging the surface excavated by Corominas.

Arbreda Cave

Arbreda Cave contains the largest and most detailed stratigraphy of the Reclau site. Its chronology shows a sequence from the end of the Middle Pleistocene to the Holocene. In the Pleistocene stratigraphy, fourteen archaeopaleontological levels have been identified and partially excavated (Figure 2).

Neanderthal hunter-gatherers used this cavity for more than 100,000 years during the classic Mousterian until their disappearance, as attested
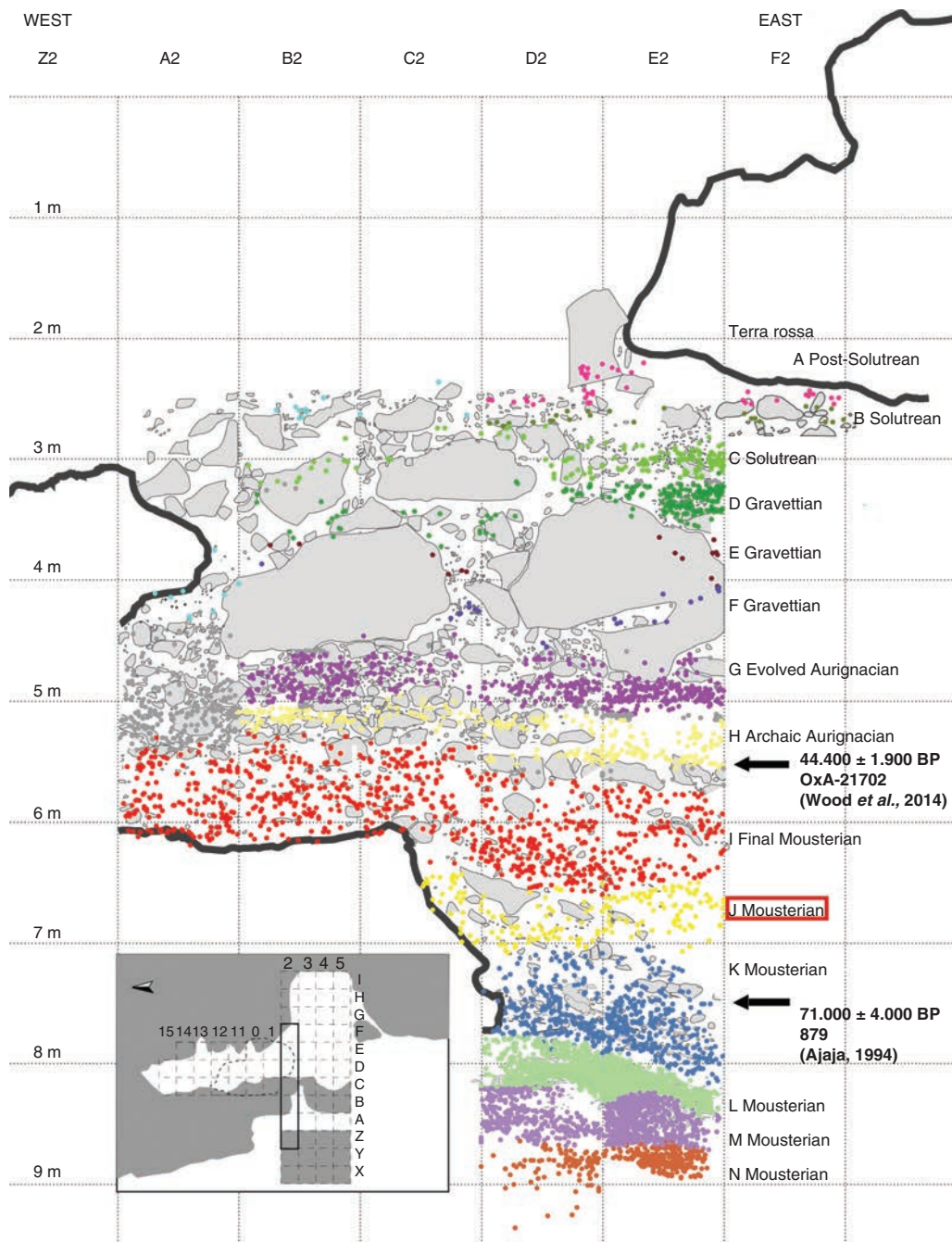

Figure 2.—Section of the Arbreda site (2/3) with the indication of all known archaeological levels. Coloured points represent objects recovered from the archaeological units. Each level is represented by one colour. Datings of table 1 are indicated.

by five Châtelperronian points discovered at the top of the final Mousterian (level I). At this point, they were suddenly replaced by modern anatomical humans (Bischoff *et al.*, 1989; Soler & Maroto, 1990), even if recent studies point to a rejuvenation of the Archaic Aurignacian level H (Wood *et al.*, 2014). This human replacement is documented by a cultural change in lithic technology, bone industry and exploitation of allochthonous raw materials (Maroto *et al.*, 1996; Ortega, 2002; Ortega *et al.*, 2005). Not only did Neanderthal replacement take place, big carnivore occupations also greatly decreased or even disappeared from the fossil record (Maroto *et al.*, 2001). Level G, with a chronology attributed to the Evolved Aurignacian, is the most impressive and the most intensively occupied layer, where a hearth and an adjacent cooking basin have been documented (Soler & Maroto, 1987). This level, dated at *c.* 32 ka BP (Soler *et al.*, 2014a), also contained a human molar germ, one of the most ancient anatomically modern human remains known in the Iberian Peninsula. Subsequently, human groups frequented the cavity during the Gravettian (levels D, E, F) and Solutrean (levels B, C) periods. Between the Final Gravettian and Solutrean periods, cold-adapted faunas such as musk-ox and reindeer appear on occasion, which might suggest the expansion of cold environmental contexts such as Heinrich Stadial 2 and the Last Glacial Maximum (Estévez, 1977; Estévez, 1978). Finally, at the end of the Upper Palaeolithic, scarce human occupations are grouped under the name of post-Solutrean (level A) (Soler *et al.*, 2014a), although recent excavations have accumulated evidence for short Magdalenian occupations that should be now specified by radiocarbon dating.

Archaeopalaeontological context of level J

Level J has not been well dated with radiometric methods, although an abundant classic Mousterian lithic industry has been recognized (Soler *et al.*, 2014a). Because the top of level I corresponds to a final Mousterian dated in *c.* 40,000 BP (Maroto *et al.*, 1996; Maroto *et al.*, 2012; Wood *et al.*, 2014), level J's Mousterian should exceed the ^{14}C limit. Up to now, neither U-Th nor OSL dating has been possible or has provided reliable results. Below that, level K is another poorly known Mousterian layer since it has been only excavated in the Alfa sector, which is a very little surface area with respect to the entire archaeological site. Nonetheless, in his PhD project, Omar Ajaja (1994) dated level K (Mousterian) using the U-Th method and obtained results between *c.* 80 and 70 ka BP in the most reliable samples (Figure 2; Table 1).

A clear stratigraphic disconformity isolates level J from level I and tells us about a (maybe relatively prolonged) period when erosive agents affected the filling of Arbreda Cave. Kehl *et al.* (2014) named level J layer B.2.1.1 in sedimentological terminology, in accordance with the high contents of medium and coarse sand grains accumulated inside the cave by fluvial processes. For example, a beaver (*Castor fiber*) molar from the same level J suggests that a humid fluvial ecosystem was present near the site (Soler *et al.*, 2014b; Cuenca-Bescós *et al.*, 2017). Some parts of J are also characterized by notable amounts of phosphates, whose origin is related to zoogenic inputs.

The most represented species is the cave bear (*Ursus spelaeus*). Modern excavations have unearthed nearly 1,300 remains of this animal only from this level (Soler *et al.*, 2014b). For thousands of

Table 1.—Chronological limits known for level J. We can use them as *ante quem* (from upperlying level, I) and *post quem* (from underlying level, K) references for the deposition of level J.

Level	Reference	Lab code	Method	Context	Profundity	Support	Date (BP)	Error
I (Final Mousterian)	Wood *et al.*, 2014	OxA-21702	Ultrafiltered collagen ^{14}C	A5 EA112	-5.57 m	Bone	44,400	1,900
K (Mousterian)	Ajaja, 1994	879	^{234}U/^{230}Th	B1R53 H38	-7.50 m	Bone	71,000	4,000

years, Arbreda Cave served bears as a den, in alternation with human occupations. Other identified carnivorous species are the spotted hyena (*Crocuta crocuta*) and the wolf (*Canis lupus*), whose remains are absolutely insignificant in terms of percentage when compared to the cave bear (Table 2).

The activity of bears in elaborating hibernation beds has probably mixed remains of Mousterian hunter-gatherer short-term stays, and it might also has destroyed archaeological structures like hearths and others, which could never have been documented by excavation.

Nonetheless, abundant lithic tools have been recovered. Among them, scrapers and denticulates constitute the majority of the retouched flakes. Human groups usually selected local and nearby (< 5 km) raw materials, like quartz and quartzite, to prepare these kinds of tools. Anthropogenic damage to faunal bones has been identified, but in scarce proportions. The existence of some ungulate species is basically confirmed by teeth remains, from both the Artiodactyla and Perissodactyla orders (*Bos primigenius*, *Capra pyrenaica*, *Cervus elaphus*, *Equus ferus* and *Equus hydruntinus*). From

Table 2.—Level J large mammals and their NISP (Number of Identified Specimens) significance calculated upon situated objects.

Species	NISP
Artiodactyla	
Bos primigenius	15
Capra pyrenaica	5
Cervus elaphus	50
Perissodactyla	
Equus ferus	14
Equus hydruntinus	1
Proboscidea	
Mammuthus primigenius	1
Carnivora	
Canis lupus	8
Crocuta crocuta	7
Ursus spelaeus	1268
Vulpes vulpes	1
Lagomorpha	
Lepus europaeus	7
Oryctolagus cuniculus	132
Rodentia	
Castor fiber	1
Primates	
Homo neanderthalensis	1

the same level comes a *Homo neanderthalensis* premolar excavated in 2011, close to the piece that we present in this paper (Soler *et al*., 2012; Soler *et al*., 2014a).

Materials and methods

Fieldwork was carried out using standard archaeological methods. The surface of the site was divided into one-metre squares and finds were plotted three dimensionally. Identified bones, fragments of unidentified bones (>3 cm), stone tools and other lithic fragments (>1 cm) were mapped *in situ* prior to removal. Sediments were washed and sieved using 5, 1 and 0.5 mm mesh screens.

Arbreda Cave is divided into four sectors as a result of the history of work at the site: Alfa Sector, Beta Sector, Beta East Sector and Gamma Sector. Beta Sector has been excavated in two phases, from 1975 to 1987 and from 1996 until the present time. It has a surface of approximately 20 m^2 and a long archaeo-stratigraphic record, from the Holocene to the Mousterian. The documentation taken in the field work is introduced in a data base and a GIS is used to create virtual models in 2D or 3D that help track the archaeological levels.

The elephantid remain analysed in this study was found previously by researchers of Arbreda Cave team in 2011 in square C5 (Beta Sector) nearly 6.75 metres deep.

Terminology of the morphological description follows Maglio (1973). Upper premolars are indicated by upper-case letters, lower ones by lower-case. The single most anterior and posterior plates, which are not fully attached to the root (talons/talonids), are indicated as 'x'. Laws' nomenclature for elephantid teeth and his age classes are also used (Laws, 1966).

To provide a quantitative and biometric description, we followed criteria detailed in Maglio (1973) and Lister (1996). Length has been taken parallel to the occlusal surface (A of Maglio). Width has been taken in plate 5 and height in plate 6. Because of the curvature of the dental piece, lamellar frequency is the average between those values taken from lingual and buccal sides. A sliding calliper in millimetres was used to take all measurements.

Results

Systematic palaeontology and morphometric description

Class MAMMALIA Linnaeus, 1756
Order PROBOSCIDEA Illiger, 1811
Superfamily ELEPHANTOIDEA Gray, 1821
Family ELEPHANTIDAE Gray, 1821
Genus *Mammuthus* Brookes, 1826
Species *M. primigenius* Blumenbach, 1799
Figure 3

Specimen C5 EC135 2302 is identified as a left lower dp3, which is a M_2 in the Laws system. This proboscidean tooth is almost complete, even though it shows only the crown plates and interplate cement. Although all plates are already fused, which means that the tooth was fully grown, it preserves only a thin layer of primary dentine beneath the enamel-dentine junction. All plates are eroded on their lateral sides (lingual and buccal) because no enamel is preserved at the lateral edges of the plates and erosion has exposed the dentine. All interplate gaps were filled with cement with the sole exception of the last gap, where the tooth was slightly broken. The lack of any fractured surface eliminates the possibility that the root disappeared due to biostratinomic factors. So, it is clear that the line in the base of the tooth reflects the smooth base of the crown.

This piece possesses eight plates, but the first and the last plates can be considered talonids. The first mesial plate is the most worn out, even though it seems to have a less prominent length than the others because the mesial enamel of this plate has also disappeared. Although we can report its existence, the distal plate has been partially broken. In conclusion, we can describe these two as talonids and the plate formula is x-6-x.

Metrically, Arbreda's tooth has reduced dimensions, which is demonstrated by its position in the lower range dimension values of length of *M. primigenius* dp3 specimens shown in Table 3. Moreover, it has the lowest width value of the sample, which is due to erosion suffered by the tooth. The result of the lamellar frequency calculation is close to other *Mammuthus primigenius* remains. Other metric values such as height, enamel thickness or hypsodonty index match well with typical *Mammuthus primigenius* values.
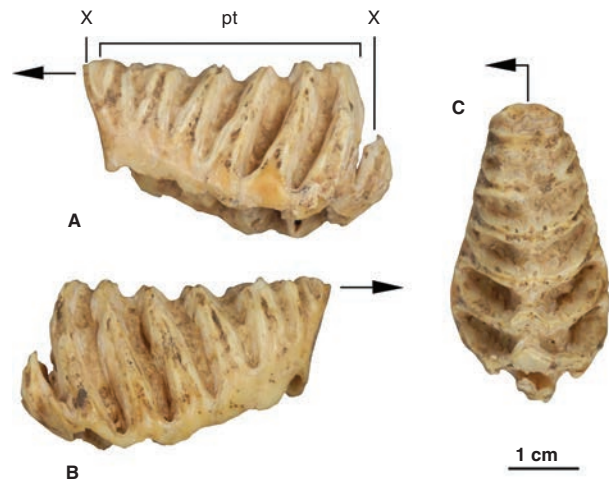

Figure 3.—Views of the C5 EC135 2302. Buccal view, the arrow points to the mesial end (A); lingual view, the arrow also points to the mesial end (B); occlusal view, the arrow points to the mesial end and then towards the buccal side (C). Abbreviations: **pt**, plates; **x**, talonid.

The degree of wear matches rather well with group III of Laws (1966). Generally, wear is not heavy and it is deeper in the first three mesial plates, shallower in the following two plates, and incipient in the sixth and seventh plates. We cannot know whether the distal talonid was worn or not because of the fragmentation. However, enamel examination tells us that the tooth had reached the full growth stage and the final fusion of all plates, which is said to take place in Laws' group IV.

Discussion

Deciduous *Palaeoloxodon antiquus* teeth are not abundant in the fossil record, but Guenther (1977) presents dP3 measurements for this species, which is larger than *Mammuthus primigenius*. *Palaeoloxodon antiquus* upper dP3 are larger than those of *Mammuthus primigenius*, which are larger than lower teeth of the same species. In the absence of published straight-tusked elephant dp3 samples, we expected that their dimensions would be higher than those *M. primigenius* dp3 in correspondence with the upper teeth of the former proboscidean. So, we defend that the Arbreda tooth, which can only be fitted with *Mammuthus primigenius* dp3, must belong to this species. Maschenko (2002) pointed to a lack of correlation between second generation

Table 3.—Comparison values of proboscidean dP3 and dp3 from different Eurasian localities. Abbreviations: **PN**, plate number; **L**, crown length; **W**, crown width; **H**, crown height; **LF**, lamellar frequency; **ET**, enamel thickness; **HI**, hypsodonty index.

Chronology	Locality & Reference	Species	Anatomy	PN	L	W	H	LF	ET	HI
Late Pleistocene	**Arbreda** (Spain) This paper	*M. primigenius*	dp3	x-6-x	44.7	24.8	24.5	15.2	1.2	0.9
	Goyet (Belgium) Comeyne, 2013	*M. primigenius*	dP3	7	50.5	18.4	25.9	14	-	-
			dp3	7-8	55-61.6	33.7-34.6	31.8-39.1	14-16	-	-
	Zemst IIB (Belgium) Germonpré, 1993	*M. primigenius*	dp3	7-9	44.5-60.0	29.3-35.2	31.6-37.2	14-16	0.7-0.9	-
	Krems-Wachtberg (Austria) Fladerer, 2003	*M primigenius*	dp3	x-7-x	57.5	32.8	c. 40	-	0.4-0.6	-
			dp3	x-7-xx	62	35.5	c. 33	-	0.7-1.0	-
	Berelekh (Russia) Urbanas, 1980	*M. primigenius*	dP3	8-10	41-61	33-37	-	-	0.7-1,3	-
			dp3	9-10	48.5-54	32-37.2	-	-	0.7-1.0	-
	Eliseevichi (Russia) Urbanas, 1980	*M. primigenius*	dP3	7-10	53-56.5	35.5-40	-	-	0.9-1.2	-
			dp3	7	52.3	34	-	-	0.9	-
	Oimiakon (Russia) Maschenko *et al.*, 2013	*M. primigenius*	dp3	8	56-57	35	-	-	1.3	-
	Sevsk (Russia) Maschenko *et al.*, 2006	*M. primigenius*	dP3	7-8	52-57	32-35	-	-	1.2	-
	Shanshenmiaozui (China) Tong & Chen, 2016	*M. primigenius*	dP3	x-7-x	55.2	34.7	-	12.7	-	-
	Central Russia Maschenko, 2002	*M. primigenius*	dP3	7-8	54-67	32-43	-	10.4-14.5	0.5-0.8	-
	Central Russia Maschenko *et al.*, 2005	*M. primigenius*	dp3	7-9	43.5-66	28.5-37	-	-	0.5-1.0	-
	Eastern Siberia Maschenko *et al.*, 2005	*M. primigenius*	dP3	7-9	53-56.5	28-40	-	-	0.7-1.3	-
	Eastern Siberia Maschenko *et al.*, 2005	*M. primigenius*	dp3	7-10	28.5-37	26-36	-	-	0.7-1.0	-
	Taubade (Germany) Guenther, 1977	*P. antiquus*	dP3	x-6-x	60-82	37-43	-	-	-	-
Early Pleistocene	**Dursunlu** (Turkey) Albayrak & Lister, 2012	*Mammuthus* sp.	dp3	x-5-x	57.2	36.5	32.8	10.4	1.38	0.9

molar dimensions and position in either the maxillar or the jaw. In line with studies by Haynes (1991), who said that maxillary teeth are wider, higher and larger than corresponding mandibular teeth, there is a trend, seen in our sample, where the lower values (< 50 mm) for lengths correspond to lower teeth (with the exception of Berelekh) and the higher values for widths to upper ones (Table 3).

Soler *et al*. (2012) declared that C5 EC135 2302 was a germ tooth because it lacked roots. We argue against this hypothesis because it is incoherent with the studies of the mammoth tooth ontogenesis. Classical studies (Haynes, 1991; Maschenko, 2002) and new technologies applied to mummified woolly mammoths (Rountrey *et al*., 2012) have shown that root genesis started before the cementum covering and the presence of wear. The possibility of a germ tooth must be rejected. Equally, the phase of wear and its corresponding age range are not consistent with a possible root resorption case, especially when the distal part of the occlusal surface had almost not been worn.

Level J has a singular geochemical footprint due to the increase of phosphorous levels below 6.3 meters dept (Kabiri, 1993). This enrichment is related to biogenic inputs like bat guano or the urine of larger mammals, such as cave bears or hyaenas. The phosphorous alterations have dissolved big travertines and affected faunal and lithic archaeological remains (Soler *et al*., 2010). Therefore, it is possible that a low pH level may have produced a differential conservation process and the root dentine could have been dissolved. For example, the presence of authigenic phosphates, like crandallite, seems to indicate lower values of pH in some moments of the lower Upper Pleistocene sequence, including level J (Kehl *et al*., 2014). This phenomenon has been observed in the aristocratic Gallic burial site in Clémency (Luxembourg), where only the enamel of the suid teeth have been conserved (Méniel, 1993). We argue that further taphonomic analysis must be done in this line of research.

The Arbreda tooth came from a young animal estimated to be between 1 and 2 years old. The tooth falls between groups III (because of the degree of wear) and IV (because of the full grown crown) of Laws (Metcalfe *et al*., 2010). Laws (1966) assigns age class III with an average age of about 1 year

(African elephant years), at the same time that Craig correlates it with approximately 1.7 years (Haynes, 1991). Maschenko (2002) published evidence that suggested an eruption and wear of woolly mammoth teeth earlier than *Loxodonta africana* and *Elephas maximus*. This author claimed that dp3 are completely formed at between eleven to fourteen months and that all plates have experienced wear. So, we attempt to establish an age of approximately one to one year and a half. In addition, Arbreda seems to be close to ZIN 28284 (1) dp3 of Kostionki 14, which is 10–12 months old (Maschenko, 2002), or with MK 1027 dp3 of Krems-Wachtberg, which is 6–12 months old (Fladerer, 2003). We suggest that the age of C5 EC135 2302 is around one year old, perhaps one year to one and a half at the most. It is possible that in that stage, dp2 was still present in the dental series showing deep wear, at the same time that dp4 was erupting, but was not worn Haynes (1991) uses the term Stage B to describe an age range where dp2 and dp3 are both worn.

Although it is evident that this piece had been brought inside the cave by some biogenic agent (carnivore-scavenger), we cannot ascertain if it was a carnivore (hyaena-wolf) or a human (Neanderthal). Recent studies situate *Ursus spelaeus* at the herbivore level in the trophic net (Münzel *et al*., 2014). Despite the abundance of ursine remains, it is impossible to correlate this animal with carnivore-scavenger behaviours. Moreover, it has been demonstrated that brown bears (*Ursus arctos*) do not transport carcasses into caves and do not generate skeletal accumulations in their dens (Sala & Arsuaga, 2013). More archaeological interventions in this level are needed to solve the taphonomic questions. In any case, mammoths were present in the palaeoenvironment at the time of level J's depositional context, given that Neanderthal humans had not developed the long-distance provision nets, like those that anatomically modern humans would develop in the Upper Palaeolithic (Ortega, 2002).

The increasing aridity, cooling and continentality during the late Middle Pleistocene and Late Pleistocene allowed the development of a new biome (the mammoth-steppe or tundra-steppe) which has no modern large-scale analogue. This biome expanded its geographical range in every

glacial period and appeared for the first time in MIS-12, between 480 and 400 ka BP. The reduction of the taiga forest belt pushed the origin of Artic faunas further south and south-west in the same way that species of steppe origin dispersed into northern and western regions of the Palaearctic. The mixing of these faunas with distinct environmental origins created a characteristic assemblage called the *Mammuthus-Coelodonta* faunal complex. Together with the woolly mammoth and the woolly rhinoceros, the most representative genera were *Ovibos*, *Rangifer*, *Saiga*, *Alopex*, *Bison* and *Equus* (Kahlke, 2014; Guthrie, 1982). In contrast, faunal compositions in which herbivores of temperate character were the most representative were dominant during the Last Glacial Maximum in the Iberian Peninsula. In these assemblages, cold-adapted faunas occur in low frequencies, mainly in the regions of Cantabria and Catalonia. This demonstrates the transitional character that these areas had during MIS-3, between the Eurasian steppe biome and the Iberian temperate refuge (Álvarez-Lao & García, 2012; Álvarez-Lao *et al*., 2017).

Although level J's chronology is not known precisely enough, this article confirms a very complex outlook for migration cycles of cold-adapted faunas in the Iberian Peninsula. As Álvarez-Lao & Garcia (2011) have argued, in the late Middle Pleistocene and Upper Pleistocene, cold-adapted faunas spread into the Iberian Peninsula by crossing over two points in the west and in the east of the Pyrenees. These authors established three wide-ranging, scattered episodes during which large cold-adapted mammals entered the Iberian Peninsula: between 200 and 100 ka BP and frequent occurrences between 42 and 31 cal ka BP (MIS-3) and between 25 and 18 cal ka BP (MIS-2). Arbreda cannot be situated within any of these ranges because level J has a chronology roughly between 70 ka BP and 44 ka BP. If the upper part of level I indicates an age of *c*. 45–41 cal ka BP (López-García *et al*., 2015), we must accept an older age for level J, with chronologies in early MIS-3 or MIS-4. Precisely, the oldest occurrence of the second Álvarez-Lao & Garcia episode is the dP2 of Unit III of Teixoneres Cave, which has a chronology from more than 51,000 ^{14}C BP to 44,210 cal BP (Talamo *et al*., 2016). Evidence

from Arbreda and Teixoneres pushes back the initial chronology of the second dispersal episode.

In level J of Arbreda, the dominance of red deer (*Cervus elaphus*) among herbivores can indicate a forested environment, even though it has been demonstrated that the red deer is a very adaptable eurythermic animal (Altuna, 1995). The auroch (*Bos primigenius*) prefers landscapes with sparse forests and forest steppes, wetlands and proximity to water courses (Auguste & Patou-Mathis, 1994). Although *Equus* sp. is able to live in varied conditions, its presence is mostly indicative of open meadows in proximity of the site (Arribas, 2004). Nowadays, beavers (*Castor fiber*) live in riverbanks and lake shores surrounded by forested areas (Cuenca-Bescós *et al*., 2017). So, the fauna association suggests a mosaic landscape with a high number of forested environments and a humid atmosphere around the cave, but also open landscapes not far from the site. Like many Iberian woolly mammoth assemblages, level J shows a dominance of temperate species and a low percentage of cold taxa, like *M. primigenius*. This assemblage does not reflect the typical composition of the Eurasian mammoth fauna and supports the idea of occasional arrivals of mammoths in the Iberian Peninsula.

Conclusions

The comparative morphometric study confirms that the C5 EC135 2302 molar belongs to a mammoth and not to a straight-tusked elephant. The archaeological and chronological context leaves few doubts that we are talking about a tooth of a woolly mammoth calf (*Mammuthus primigenius*).

There is evidence of this species in the Iberian Peninsula from the late Middle to early Late Pleistocene; however, most of the occurrences took place in MIS-3 and MIS-2. The Arbreda tooth demonstrates a complex trend of mammoth distribution on the south side of the Pyrenees in the Late Pleistocene. The stratigraphic position, uranium-thorium datings at the base of the known stratigraphic column and the chronology of the upper part of level I suggest an occurrence out of the three-episode proposal published by Álvarez-Lao & García (2011) and close to the Teixoneres Unit III occurrence (Álvarez-Lao *et al*., 2017). Thus, the second dispersal episode

of woolly mammoths in the Iberian Peninsula could have started earlier than previously thought, at least in the early MIS-3.

The palaeoenvironmental context is not a typical cold-adapted fauna association like those from Western Central Europe, dominated by reindeer. It is similar to the Iberian assemblages that were developed in a mosaic landscape where the proximity of different ecosystems offered the possibility of cohabitation in a reduced zone of fauna species that had different habitat preferences.

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