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Research Highlights

A partial skeleton of a mammoth and Mousterian lithics have been found in association

The Palaeolithic site at Edar Culebro dates at the beginning of the Upper Pleistocene

The green-bone fractures confirm that the bone marrow was consumed by Neanderthals

The lack of tooth marks suggests that carnivores did not operate in the site

Neanderthal and *Mammuthus* interactions at EDAR Culebro 1 (Madrid, Spain)

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ABSTRACT: The association between elephants of the *Mammuthus* and *Palaeoloxodon* types and lithic tools is a recurrent phenomenon in Pleistocene sites. This has been a heavily debated topic. Thanks to the latest discoveries of cut and percussion marks in several archaeological sites, direct evidence of butchery practices generated by humans on elephants has been identified. Indirect evidence may also suggest a type of feeding activity. In this paper, the open-air site of EDAR Culebro 1 (Madrid, Spain) is presented, as well as a discussion about the possible interactions occurring between Neanderthals and *Mammuthus* cf. *intermedius* at this archaeological site.

KEYWORDS: Neanderthals, Trampling Marks, Mammoth, OIS 5, Middle Palaeolithic.

Introduction

The role of humans in the formation of proboscidean bone accumulations during the Palaeolithic has been a heavily debated topic (Villa, 1990; Haynes, 1991, 2005; Fosse, 1998, Martos, 1998; Gaudzinski et al., 2005; Mussi, 2005; Villa et al., 2005; Mussi and Villa, 2005; Surovell and Waguespack, 2008; Boschian and Saccà, 2010). Characteristics such as cut marks, fracture patterns and percussion marks are helpful when identifying human intervention on elephant fossils.

During the last few years, the discovery of human-made marks on proboscidean bones from Pleistocene sites has become more common. Direct and indirect evidence of butchering activities are described at many Pleistocene sites.

The BK site of Olduvai Gorge (Tanzania), and Gesher Benot Ya'Akov (Israel), are the oldest sites where traces of human activity have been identified on proboscidean bones (Goren-Inbar et al., 1994; Domínguez Rodrigo et al., 2013). In the Acheulean open-air site of Revadim Quarry (Israel), several elephant bones showing evidence of hominin activity have been found (Rabinovich et al., 2012). The cut marks identified on two ribs and a scapula indicate filleting of meat. At Ambrona (Spain), possible cut marks on bones of *Palaeoloxodon antiquus* were also found (Shipman and Rose, 1983; Villa et al., 2005). Additionally, two femur epiphyses show fractures that may be associated with the extraction of bone marrow by humans (Villa et al., 2005). Disarticulation cut marks on elephant ribs and long bones diaphyses have been discovered at Castel di Guido (Italy) (Mussi, 2005; Saccà, 2012). In the Middle Pleistocene site of Bilzingsleben (Germany), cut marks have been described (Mania, 1990), and in Belchatów (Poland) striations on Mammuthus trogontherii ribs have been recorded. These marks are probably the result of flesh filleting (Pawlowska et al., 2013). Cut marks have also been described on other animals, such as hippopotamus or rhinoceros, in lower Palaeolithic sites in the Middle Awash valley of Ethiopia (Heinzelin et al., 2000), Buia (Eritrea) (Fiore et al., 2004), Koobi Fora I (Kenya) (Bunn, 1994), Olduvai, Tanzania (Domínguez Rodrigo et al., 2013), Boxgrove (England) (Parfitt and Roberts, 1998), Vallparadís, Spain (Martínez et al., 2010) and El Kherba (Algeria) (Sahnouni et al., 2013).

Butchering marks have also been recorded at Middle Palaeolithic sites. Several elephant bones with cut marks have been recovered from La Cotte de Saint Brelade (England) (Scott, 1980, 1986; Jones and Vincenet, 1986). At Kulna (Moravia) (Moncel, 2001) and Molodova I (Ukraine), cut marks identified on the bones suggest that mammoth meat was consumed by humans (Demay et al., 2012). Indirect evidence of meat exploitation is suggested at Spy (Belgium), where the skeletal profiles, the age of the elephants, and stable-isotope analysis of the Neanderthal bones suggested that a significant amount of mammoth meat was included in their diet (Germompre et al., 2012). Additionally, in Lehringen and Gröbern (Germany), the indirect evidence of use wear marks on lithic tools suggest exploitation of elephant meat (Movius, 1950; Weber, 2000).

The few cut marks found on bones from Upper Palaeolithic sites such as the Clovis sites (USA) (Haynes and Klimowicz, 2003), Krakow Spadzista Street B and Milovice G (Poland), Algar de Joao Ramos (Portugal), Grub-Kranawetberg (Austria), Gontsy, (Ukraine), and Kostenki, Spytihnev-Dochonce, Yudinovo and Lugovskoe (Russia), also suggest the exploitation of mammoths (Zbyszewski, 1943; Frison and Todd, 1986; Antunes and Cardoso, 1992; Saunders and Daeschler, 1994; Maschenko et al., 2003; Zenin et al., 2003; Iakovlevaa and Djindjian, 2005; Nývltová Fisáková, 2005; Svoboda et al., 2005; Germonpré et al., 2008; Hoffecker et al., 2010; Lawler, 2011; Bosch et al., 2012).

The region of Madrid (Spain) is an important location with regard to the accumulation of bones of large mammals associated with Lower-Middle Palaeolithic artefacts. Since the end of the 19th century (Prado, 1864), several prehistoric sites with mammoth and *Elephas* have been excavated (Santonja and Querol, 1980; Santonja et al., 1980; 2001; Panera and Rubio-Jara, 2002; Panera et al., 2013). Tafesa, Áridos 1 and 2 and PRERESA are the only Palaeolithic sites in this area where evidence of butchering activities on elephant bones are known (Yravedra, 2010; Yravedra et al., 2010, 2012). A total of 436 bones were recovered from the Acheulean open-air site of Tafesa. These consisted of remains of *Palaeoloxodon antiquus, Megaloceros savini* and *Bos/Bison.* They were found associated with lower Palaeolithic tools. Some cut and percussion marks were identified on cervid and bovid bones, as well as ambiguous cut marks on elephant bones (Yravedra, 2010). Evisceration cut marks, on the ventral sides of ribs, and filleting marks on a scapula, were identified in the Lower Palaeolithic site of Áridos 2 (Yravedra et al., 2010). The remains of a *Palaeoxodon antiquus* were found at the neighbouring site of Áridos 1. The skull was almost complete although highly fragmented (Soto, 1980). A total of 331 lithic artefacts were recovered from an overbank facies (Santonja and Querol, 1980; Pérez-González, 1980). Use-wear traces from meat and/or skin processing have been identified on 20 of those pieces (Ollé, 2005). At PRERESA, cut marks, green-bone fractures and percussion marks on a number of elephant bones indicate that meat and bone marrow were consumed by Neanderthals (Yravedra et al., 2012).

The data from EDAR Culebro 1 is presented in this paper. This site is located in the Natural Park to the South-East of Madrid. Remains of a *Mammuthus* cf. *intermedius* have been identified at this new site, which was associated with lithic artefacts manufactured by Neanderthals during the MIS 5. The *Mammuthus* cf. *intermedius* remains were generally well preserved, allowing the identification of marks on the bones. A discussion of the interpretation of the remains and the degree of human exploitation of this *Mammuthus* cf. *intermedius* will follow below.

The archaeological site of EDAR Culebro 1

EDAR Culebro 1 was found within Pleistocene deposits located towards the final stretch of the River Manzanares valley about 2.5 km from the mouth of the river Jarama (Fig. 1). This fluvial system is affected by synsedimentary subsidence due to evaporate dissolution, a well-known process in the large tertiary continental basins in Spain, such as the Madrid and Ebro basins (see Benito et al., 1998, 2000). The main anomalous morphostratigraphical features that produce this type of subsidence include great thickening of fluvial deposits and superposition of the deposits correlative to different terrace levels. Thus, upstream from the city of Madrid, laid over siliciclastic bedrock, twelve levels of perched alluvial terraces have been identified, +4-5 m the lower and +95 m the higher, with a maximum depth of 6-7 m (Pérez-González, 1994). Downstream, the terraces formed over evaporitic rocks are affected by the synsedimentary subsidence resulting in a huge thickness increase of tens of meters. The terraces involved constitute the youngest levels of the second half of the

Middle Pleistocene and the Upper Pleistocene. All these terraces constitute the Complex Terraces of Butarque (CTB) (Goy et al., 1989).

The site is located towards the upper third section of the CTB stratigraphic sequence (Fig. 2), on the right bank of the lower course of the River Manzanares. The sedimentary models of the CTB were established by Carrillo et al. (1978) and Arche (1986) at the gravel pits of PRERESA, near to EDAR Culebro 1. They differentiated a minimum of five fluvial cycles characterized by fining-upward sequences that start with channel facies of gravel and sand deposits and end with overbank facies. A large number of palaeontological and archaeological sites have been found in this fluvial facies and areas of subsident alluvial sedimentation. These sites have been the object of several archaeological excavations since the middle years of the 20th century (Rubio-Jara et al., 2002).

Fig 1

Fig 2

Seven stratigraphic units have been defined at EDAR Culebro (Manzano et al., 2011) (Fig.2). These are identified by their facies code, Sr, St, Sp, Fl and Fsm, according to the Miall classification (1996). The stratigraphic unit 2, with facies Sp and St, consists of laminated sands and floating gravels which form sandy bedforms of channel fills. The other units resemble overbank deposits. All the facies of the stratigraphic sequence have been deposited during a low flow regime.

An area 78 m^2 was excavated at EDAR Culebro 1 (Fig. 3). The lithic assemblage consists of 243 pieces recovered from Unit 2, the Unit where the *Mammuthus* bones were found, 22 pieces from Unit 3 and 12 pieces from Unit 4. The last two groups of lithic pieces could possibly have come from Unit 2 (Manzano et al., 2011). Post-depositional alterations such as water patina and rolling were identified in this collection, suggesting that fluvial processes may have caused deterioration. It is also suggested that the assemblage might have been lying in a secondary position, although not significantly displaced from its original one. The raw material is mainly flint of local origin (Manzano et al., 2011). The lithic industry from the site is characterised by a lack of large tools, as well as a large number of flakes (which represent more than one third of the assemblage) and a high percentage of knapping debris (which accounts for up to 50% of the assemblage). Retouched flakes represent less than 5% of the sample. The cores, which are less than 5% of the assemblage, were not exhaustively exploited. Discoid, bifacial and multifacial operative schemes have been identified.

The high rate of flakes and debris, as well as the presence of cores and nodules confirm that knapping works were carried out on the site, nevertheless, a direct relationship between the lithic tools and the bones cannot be assured.

Various distinctive remains of mammoth (*Mammuthus* cf. *intermedius*) such as a mandible with teeth were identified in the zooarchaeological study. An equid was also present, although only to its genus (*Equus* sp.). Additionally, one fragment of right calcaneus was identified as that of an individual of the deer family (*Cervidae*). No micro-mammals were found.

Pollen was recovered from two different stratigraphical levels (Fig. 2). Analysis suggests that the sequence at EDAR Culebro 1 is characterized by a progressive development of forest. According to the lithological sequence, two levels have been distinguished with pollen remains (Manzano et al., 2011). Unit 3 consists of levels of sand with clay lenses, suggesting the presence of temporary stagnant areas. This sequence was more humid towards the base of the sequence, showing a higher development of *Poaceae* and nitrophil taxons. Towards the top of this layer would have been drier, with steppe taxons and without *Poaceae*. *Juniperus* was better represented at this level. The forest cover was initially scarce, and consisted of *Olea* and *Ulmus; Juniperus* and *Rosacea* from the bush stratum, and the herbaceous plants, which dominate this first phase, are represented by *Chenopodiaceae, Poaceae, Solanaceae, Plantago* and *Rumex*. Aquatic elements were not recorded. This association indicates dry and warm conditions. The fluctuations are mainly a consequence of variations in the moisture rate (dry-wet-dry) are evident at this level.

The upper level corresponds to the Stratigraphic Unit 6 (Fig. 2). Despite its lithological homogeneity, it shows a lack of information from top to base of the sequence. Towards its base, the spectrum is defined by Mediterranean vegetation with *Olea* and *Pinus, Ulmus* and lack of aquatic plants. *Juniperus* is poorly represented and a major change in the representation of the herbaceous species is shown, with the absence of *Plantago* and the presence of *Rumex*. This data suggests that the conditions were drier than those detected so far.

Both sequences were developed under distinctly Mediterranean conditions, with variations of a higher or lower intensity depending on the presence of available water. Chronologically, the site is situated at the beginning of the Upper Pleistocene. Dates have been obtained by OSL (120.541±6.851 ky) (Manzano et al., 2011). Additionally, a date has been obtained by the amino acid racemization (AAR) technique from a molar of *Equus* sp. (133±28 and 105±10 ky BP) (Silva et al., 2013). Taphonomic analysis shows that the preservation of the faunal remains is good, and the bones attributed to EDAR Culebro have not been damaged by carnivores.

Fig. 3

Sample characteristics and method of analysis

A total 35 fragments of *Mammuthus* bones belonging to one single individual have been recovered from EDAR Culebro 1. These include cranium, tusk, rib, humerus and several fragments of long bone diaphyses such as tibiae (Fig. 4 and Table 1). According to the taxonomic identification of proboscideans, carried out by E. Soto (Manzano et al 2008), the remains belong to a sub-adult individual of *Mammuthus* cf. *intermedius* (Fig. 5). Nevertheless, D. Álvarez-Lao suggests that these remains belong to *Mammuthus primigenius* (Álvarez-Lao *et al*., 2011). Preservation of the bones is good, although in some cases stages of severe water alteration can be identified. Thus, light abrasion and polishing marks can be observed on some bones, such as the humerus, pelvis, mandible and some ribs. Polishing is more evident on the skull fragment, the tusk, some shafts and ribs. There are examples of dry fractures and rounded edges amongst the assemblage. The weathering identified on the bones does not seem to be substantial, as no chipping, fracturing or loss of the bone surface has occurred. Only the larger bones such as the humerus and mandible show cracking (Fig. 5, 9 and 10). However, this cracking is not due to weathering but to drying which affects the bones during the process of excavation. This cracking follows transverse rather than longitudinal lines, as would be observed in the case of natural sub aerial exposure.

Table 1

Fig 4

Fig 5

The bones were screened with hand lenses using a magnification of 10X, 15X and 20X at the Department of Prehistory and Archaeology, Autónoma University of Madrid according to the method of Blumenschine (1995). The bone surfaces were then directly analyzed for cut and/or trampling marks with an optical microscopy 40X in the Department of Prehistory, Complutense University of Madrid. The images were transmitted directly to a computer and processed with Motic Image Plus 2.0 Software.

Trampling marks were identified according to Olsen and Shipman (1988) and Domínguez-Rodrigo et al. (2009). Teeth and percussion marks were not identified. Breakage patterns were analyzed using a multifaceted analytical approach and included the analysis of notches and breakage planes. The notches were analyzed according to the experimental works carried out by Capaldo and Blumenschine (1994) and Galán et al. (2009). Breakage planes were analyzed following Villa and Mahieu (1991).

Results

The mammoth bones were analyzed. Trampling marks were evident on a number of bones, such as the tibia, the pelvis and some ribs. These consist of superimposed marks which do not follow a distinct pattern or direction, are U-shaped in section, flat based and without microgrooves. In some cases, a large number of these trampling marks can be observed. However, other elements show more clustered trampling marks which, in some cases, could be mistaken for cut marks. These however, do not meet the conditions for being considered real cut marks, as those detailed below.

A series of trampling marks on the edge of the fracture plane of a long bone fragment can be seen in fig. 6. The trampling marks are oriented in a slightly different manner, although they tend to be placed along the bone axis. They show variable lengths, up to 2 cm in some cases. There are crossed marks present (e.g. marks 3 and 4). The cross sections of these marks are open and U-shaped with flat bases (e.g. mark 5).

Fig 6

Among the long bones, the tibia shows the highest number of trampling marks. Some small marks can also be observed on the medial diaphysis of the humerus, oriented oblique to the bone axis and in several parallel series. These marks could be mistaken for cut marks due to their anatomical location and morphology. However this morphology is related to trampling marks, the marks are very small, very superficial, open and with a U-shaped section, without microstriations and are shallow.

Fig 7

Intensive trampling is usually seen on ribs, even on both sides in some cases. One of the ribs with trampling marks is illustrated in Fig. 8. Trampling marks on this bone are visible on one side, oriented slightly oblique to the rib axis. They are short, superficial, U-shaped marks with a flat base. In the case of the deepest mark slight microabrasions criss-crossing the mark are visible.

Fig 8

Despite the fact that no cut or percussion marks have been identified, and that the lithic industry might be not related to the *Mammuthus cf. intermedius* uncovered at EDAR Culebro 1 (Manzano et al., 2011), some evidence could suggest that the remains of this animal were effectively exploited by humans. Green fractures have been observed on some shafts, although these could not be taxonomically identified. The most evident green fracture pattern can be observed on the humerus shown in figs. 9 and 10. The bone was split open through an oblique fracture, allowing Neanderthals to exploit the marrow (Fig. 9 and 10). The trampling marks to the edge of the fracture (Fig. 11) suggest that trampling occurred after the bone had been split and that therefore the bone was not fractured by trampling.

Fig 9

Fig 10

Fig 11

Discussion and conclusions

In this paper we have presented a new site where evidence of lithic industry is found in the same stratigraphic unit as a single individual of *Mammuthus cf. intermedius / primigenius.* Unlike other occasions (Yravedra et al., 2010, 2012) in this instance we have presented mammoth remains with no percussion or cut marks.

However, the green bone fracture recorded on the humerus shown on Fig. 9, 10 and 11 is post-mortem, and can be interpreted as the result of Neanderthals exploiting bone marrow. Natural fractures of elephants limb bones can be spiral/helical, longitudinal or a mix of those types. Some occur when the bones are fresh or dry, and the limb bones are broken by trampling. Elephants and carnivores such hyenas can find themselves in this situation on waterhole sites (Conybear and Haynes, 1984; Haynes, 1988, 2005, 2006). However, evidence could suggest an anthropogenic fracture of the humerus. The natural breakage of limb bones and trampling is common in water sources, shelter areas and landscapes where the density of proboscidean population is high. On the contrary, finding broken bones of a single individual is uncommon. The density of the bones also suggests that the fractures are not natural. According to Haynes (2005) bones with higher density are less prone to breakage than those with lower density. In EDAR Culebro I low density elements such as ribs show no fractures. On the contrary, high density bones such as humerus and tibia are broken. It has been observed that tibias seldom break naturally (Haynes, 2005). With regard to carnivores, the presence of the complete distal of humerus epiphysis and the lack of tooth marks and coprolites suggests that this bone did not suffer from the attentions of carnivores, and the trampling marks on the edges of the bone suggest that trampling occurred after it was fractured. Moreover, water alteration such as polishing and abrasion, visible on some of the bones, has not been identified on this humerus. Nor were they identified on other elements such as the mandible and pelvis. This suggests that these remains were recovered close to their original location. Therefore, this is one more site in the Madrid area with possible evidence of proboscideans having been exploited by humans during the Pleistocene.

Nearby EDAR Culebro 1, lies the site of PRERESA. Remains of an elephant whose long bones were fractured by Neanderthals were identified at this site, suggesting exploitation of the bone marrow by these hominins (Yravedra et al., 2012). Bones were processed in order to extract marrow in other sites too, i.e. the Gravettian site of Krems-Wachtberg, in Austria (Fladerer et al., 2012). The same fracture patterns have been observed in these sites, as well as in EDAR Culebro 1, making this site part of the group of sites where evidence of exploitation of elephant bone marrow during the Upper Pleistocene have been identified.

The nutritious properties of animal fat should not be underestimated. Animal fat is a necessary resource for hunters-gatherers with diets rich in meat and low in carbohydrates (Jochim, 1976, 1981; Speth, 1983, 1987). Animal fats or lipids are highly calorific, and can replace the functions of carbohydrates -synthesising lipoproteins to absorb nutrients- and regulate the oxygen absorption. They are also important for correct cell membrane operation (Speth, 1983). The marrow found in the rear limbs, phalanges and jaw constitute the last deposits of fat that can be found in an animal. Additionally, bone marrow contains fatty acids that can be easily digested and taste good (Speth, 1990; 1997; Stiner, 1994; Mateos, 1999). Although it is not common practice, the breaking up of elephant limb bones to extract bone marrow has been documented among some present-day indigenous people (Clark, 1977; Crader, 1983; Villa et al., 2005), such as the Ba-Mbuti, a Pygmy people of Zaire (Turnbull, 1961; Duffy, 1985).

The lack of cut marks on the elephant bones means that it is impossible to know when exactly human beings had access to the carcass and so whether they exploited the meat of the elephant. There is not evidence to ascertain whether the elephant was hunted or scavenged. The lack of tooth marks suggests that carnivores did not scavenge on the animal. The individual was sub-adult at time of death, suggesting non-natural causes of death.

In any case the evidence presented only indicates the exploitation of bone marrow on this individual. It is possible to speculate on other possibilities, based on anthropological studies of the Bisa from Zambia and other South African peoples where it was observed that cut marks were not visible on the bones after the defleshing process (Crader, 1983; Haynes and Krasinski, 2010).

EDAR Culebro 1 is located in an area where elephant butchering has been recorded not only during the Middle but also during the Upper Pleistocene (Yravedra et al., 2010, 2012) therefore the hypothesis of meat exploitation of the elephant at EDAR should not be ruled out.

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Captions: Figures and tables

Figure 1. A. Location of the Complex Terrace of Butarque (CTB). On the Iberian Peninsula. B. Geological sketch of the valley of the River Manzanares around Madrid capital and position of the EDAR Culebro 1 site in the CTB.

Figure 2. Stratigraphical section of the EDAR Culebro 1 site.

Figure 3. Spatial dispersal of *Mammuthus* cf. *intermedius* remains associated with lithic industry

Figure 4. Anatomic representation of the elephant remains found at EDAR Culebro 1

Figure 5. Mandible of *Mammuthus* cf. *intermedius* identified in EDAR Culebro 1

Figure 6. Detail of trampling marks on a *Mammuthus* cf. *intermedius* long bone fragment.

Figure 7. Detail of the trampling marks identified on the *Mammuthus* cf. *intermedius* humerus.

Figure 8. Detail of trampling marks identified on a *Mammuthus* cf. *intermedius* rib.

Figure 9. Humerus of *Mammuthus intermedius* with oblique breakage plane, showing green fracture.

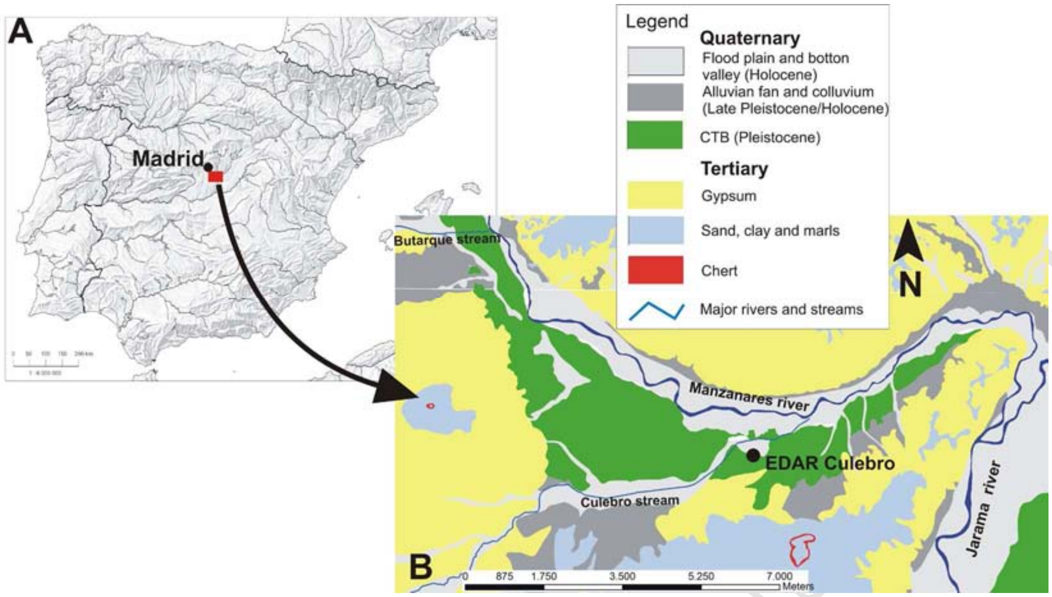
Figure 10. Detail of green fracture on *Mammuthus* cf. *intermedius* humerus

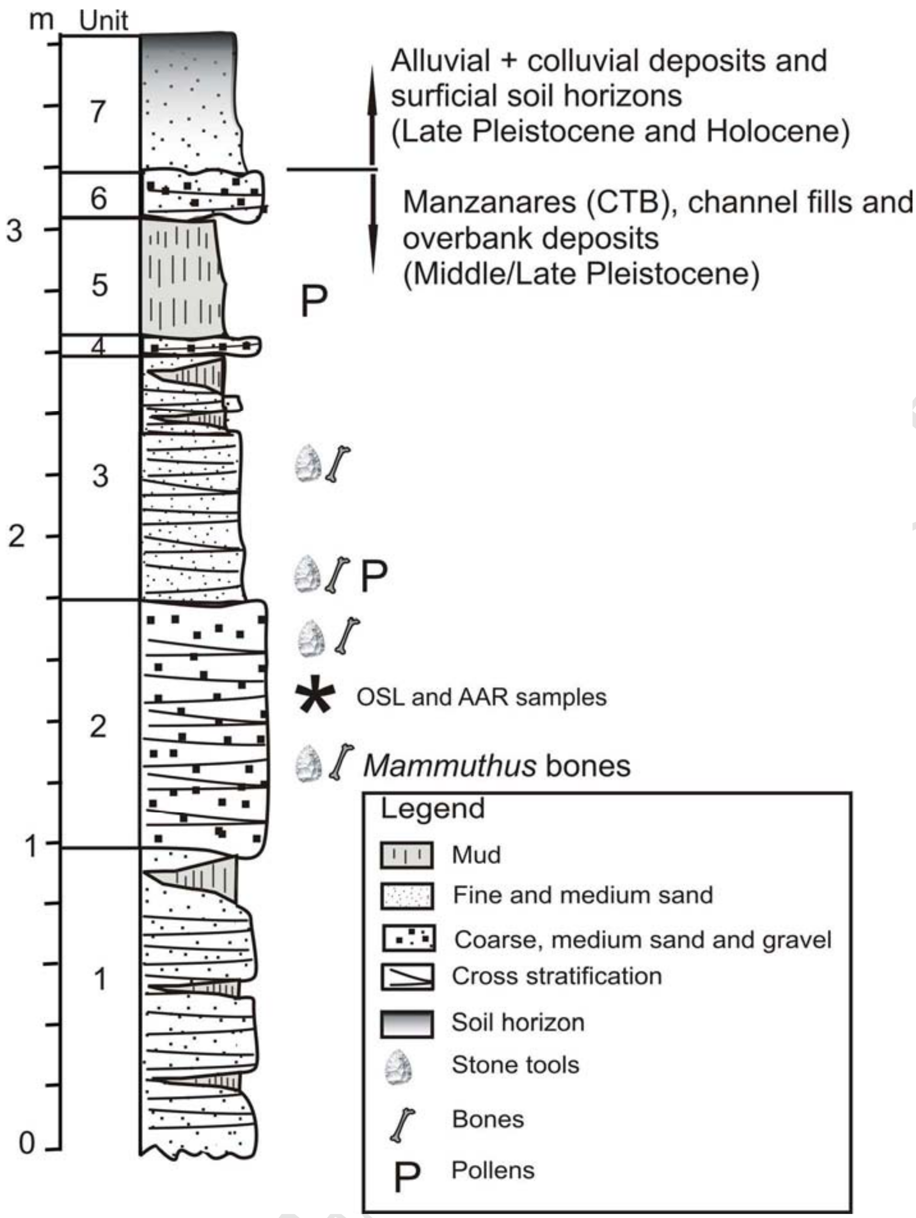
Figure 11. Detail of trampling marks associated with green fracture on humerus

Table 1. Taxonomic and Skeletal profiles identified in EDAR Culebro 1

	NR			**MNE**			**MNI**		
	Mammuthus	Large indet.	*Equus*	*Mammuthus*	Large indet.	*Equus*	*Mammuthus*	Large indet.	*Equus*
Tusk	2			1			1		
Craneal	1			1			1		
Maxilar	1			1			1		
Mandible	2			2			1		
Tooth	2		2	2		2	1		1
Vertebrae		1			1				
Rib	6		1	5		1	1		1
Humerus	2			1			1		
Ulna	1			1			1		
Metacarpal			1			1			1
Pelvis	1			1			1		
Tibia	2			1			1		
Axial indet.	7			1			1		
Shaft Indet. bones	8	1		1	1		1		
Carpal-tarsal		4			2				
Total	35	6	4	18	4	4	1adult		1 adult

Table 1. Taxonomic and Skeletal profiles identified in Edar Culebro 1


A
Madrid
Legend
Quaternary
Flood plain and botton valley (Holocene)
Alluvian fan and colluvium (Late Pleistocene/Holocene)
CTB (Pleistocene)
Tertiary
Gypsum
Sand, clay and marls
Chert
Major rivers and streams
N
Butarque stream
Manzanares river
EDAR Culebro
Culebro stream
Jarama river
B
0 875 1.750 3.500 5.250 7.000
Meters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Alluvial + colluvial deposits and
surficial soil horizons
(Late Pleistocene and Holocene)
Manzanares (CTB), channel fills and
overbank deposits
(Middle/Late Pleistocene)
P
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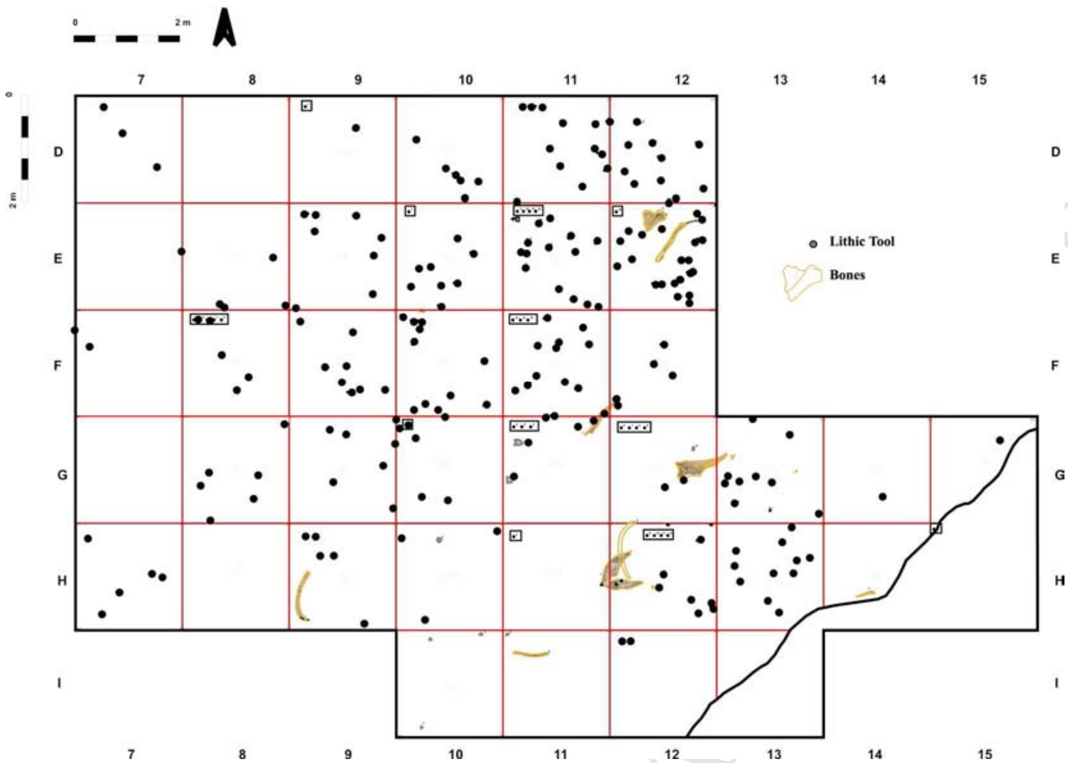
OSL and AAR samples
Mammuthus bones
Legend
Mud
Fine and medium sand
Coarse, medium sand and gravel
Cross stratification
Soil horizon
Stone tools
Bones
P
Pollens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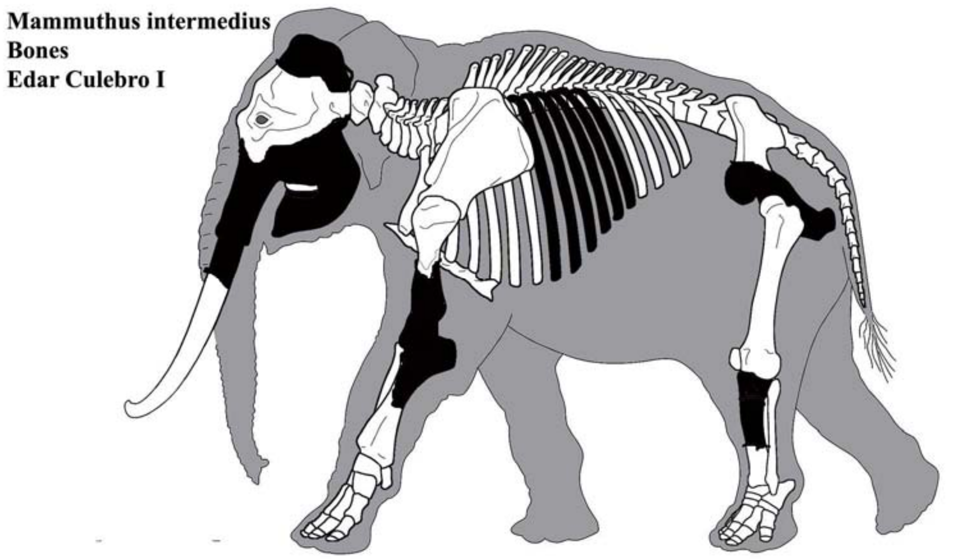
Bones


Mammuthus intermedius
Bones
Edar Culebro I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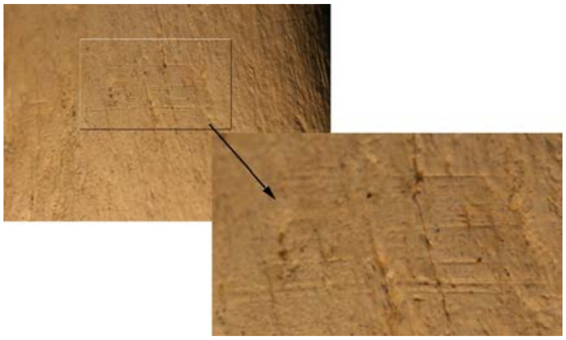
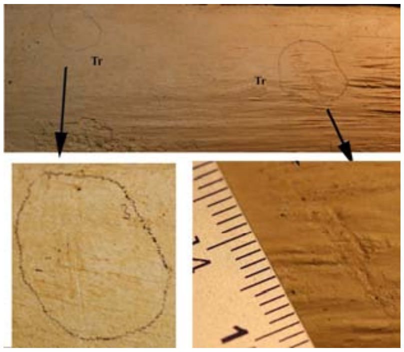
2cm

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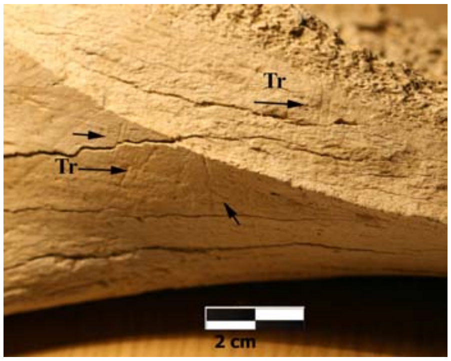
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