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Elephants and subsistence. Evidence of the human exploitation of extremely large mammal bones from the Middle Palaeolithic site of PRERESA (Madrid, Spain)

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ABSTRACT

The archaeological site at PRERESA (Madrid, Spain) has been dated to 84 ± 5.6 ka by optically stimulated luminescence (OSL) (MIS 5a). An area 255 m^2 was excavated and 754 lithic pieces were recovered, as well as a large amount of micro and macro vertebrate remains, including proboscidean bones. The aim of this paper is to outline the results of the taphonomic study of these remains. The identification of cut marks on a number of the bones recovered strengthens the theory that the exploitation of extremely large mammals was more than just a marginal practice before the Upper Palaeolithic. Additionally, the identification of green-bone fractures and percussion marks confirm for the first time, that the bone marrow of these taxa was also consumed. Few other cases of this practice have been identified, firstly because obtaining this substance would not be an easy matter, and secondly because similar nutritional needs can also be met by the consumption of brain matter, which is easier to acquire.

1. Introduction

100 years ago, exploitation of elephants during the Pleistocene was already recorded on the archaeological site of Torralba (Spain) (Cerralbo, 1913). Proboscidean bones have since been found associated with stone tools on several Pleistocene sites. However, it is very rare that direct evidence of human activity on these mammal bones have been found. Because of this, a number of authors have proposed that the exploitation of elephant meat was not a common activity before the time of the American Clovis hunters or the late Eurasian Upper Palaeolithic (Frison and Todd, 1986; Frison, 1989; Fosse, 1998; Villa et al., 2005; Gaudzinski et al., 2005 and Surovell and Waguespack, 2008).

Specifying the degree of human intervention on sites with both lithic industry and proboscidean bones has been inhibited by the poor state of preservation of most of the remains, and also because cut marks are rarely produced when defleshing or disarticulating elephants. Crader (1983) observed the Bisa people from Zambia quartering seven elephants with metal tools. According to Crader, just 15.3% of the bones showed cut or chop marks. Haynes and Krasinski (2010) also documented remains of African elephant carcass where cut marks may be rare or non-existent on bones stripped of meat as well as in disarticulation of elephant long bones. This is due to the thickness of the periostium and other tissues (Biberson and Aguirre, 1965; Clark, 1977; Haynes, 1991; Haynes and Krasinski, 2010), which hinder the contact between the lithic tool and the bone while bulk defleshing (Villa, 1990; Fosse, 1998; Mussi, 2005; Villa et al., 2005; Mussi and Villa, 2008). However, despite these circumstances, several cut marks were identified on a rhinoceros found on the Middle Palaeolithic site of Taubach (Bratlund, 1999), an animal which has similar characteristics to proboscideans.

Theory of the human exploitation of elephant carcasses has been based largely on sedimentary contexts and the spatial distribution of the lithic and bone remains, although some isotopic and use-wear analyses have also been carried out (Weber, 2000; Ollé, 2005; Mussi and Villa, 2008). However, elephant bones have been found alongside remains of other mammals consistent with the same ecosystems in several European open-air Middle Pleistocene sites which were interpreted as natural deposits. Thus, their association with lithic industry could be accidental (Domínguez-Rodrigo, 2008). Therefore, the best proof of the exploitation of pachyderms by humans is the presence of cut or percussion marks on their bones (Yravedra et al., 2010).

Because of the fact that the exploitation of elephant meat for food and of bones for making artefacts has been unequivocally

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stated just in a handful of sites, it has been interpreted that marrow consumption was seldom practiced on Middle and Lower Palaeolithic sites (Mussi and Villa, 2008). However, irrefutable proof of this has never been provided.

This paper outlines the discovery of elephant bones with defleshing and percussion marks at the Middle Palaeolithic site of PRERESA (Madrid, Spain), which has been dated to 84 ± 5.6 ka by OSL. This suggests that not only was the meat extracted from the carcass, but also that the bones were broken up for feeding purposes. This is highly remarkable considering the fact that all other archaeological instances of elephant bones with breaks and percussion marks, beyond any doubt, have previously been linked to the manufacturing of bone tools, except Castel di Guido where marrow extraction cannot be discarded. Bone implements have not been found at PRERESA. Flint and quartzite are readily available on the surroundings of the site. These raw materials seem to be more appropriate than bone for making the kind of tools usually recorded on Middle Palaeolithic assemblages, therefore making bone tools, as they are found along Europe, would not be necessary here (Segre and Ascenzi, 1984; Radmilli and Boschian, 1996; Villa et al., 1999, 2005; Anzidei et al., 2004; Gaudzinski et al., 2005). Furthermore, there are more that 50 known archaeological sites at the terraces of the rivers Manzanares and Jarama (Madrid basin) containing proboscidean bones in which not a single piece of worked bone has been recorded. Nevertheless, given that the broken elephant bones of PRERESA are relatively small diaphysis fragments and flakes, and that a spiral break of the shaft circumference would be enough to drain the marrow in liquid form, we cannot rule out that some of those bones were actually debris occurred during manufacturing bone tools.

2. The importance of consuming bone marrow

Animal fat is a resource highly appreciated by hunters-gatherers with diets rich in meat and low in carbohydrates (Jochim, 1976, 1981; Speth, 1983, 1987). Apart from their high calorie contribution, animal fats or lipids replace the functions of carbohydrates or glucides, synthesize lipoproteins to absorb nutrients such as vitamins A, D, E and K, regulate oxygen absorption and are important for cell membrane work (Speth, 1983). Most of the wild animals of the northern latitudes have scarcely any body fat, particularly during winter and early spring. Marrow then becomes an important source of lipids (Speth and Spielmann, 1983), which can be easily digested and tastes good (Speth, 1990; Stiner, 1994; Mateos, 1999). There are also important deposits of this kind of nutrients in brain matter that are stored independently of the nutritional state of the individual (Stiner, 1994).

In contrast to most other mammals, elephant bones lack the medullary cavity and instead have perforated bone tissue. The process of extracting marrow from elephant bones could be laborious. Although it has been confirmed that some present-day indigenous peoples, such as the Ba-Mbuti, a Pygmy people of Zaire (Turnbull, 1961; Duffy, 1984), or experimental practices (Haynes and Krasinski, 2010), break up elephant limb bones to extract bone marrow, this is not common practice (Clark, 1977; Crader, 1983; Villa et al., 2005). However, a relatively simple technique to obtain the marrow was described by Richard Thornton, David Livingstone's geologist on the Zambezi Expedition in 1859. This consists of partly splitting open the bone, then hanging it up in the sun for the oil to drain (Tabler, 1963). Containers would have been necessary in order to collect the draining liquid (Clark, 1977).

The lack of evidences of bone marrow exploitation on Clovis sites where mammoths were hunted is significant. That led Haynes (1991) to conclude that these human groups had access to other sources of carbohydrates. Haynes argues that the limb-bone marrow of sub-adult individuals would have had relatively little appeal, and that, due to their malnutrition, the marrow of adult individuals would have had poor nutritional value. Additionally, the faunal assemblages from these sites suggest that elephants were being hunted on a regular basis, which would lead to the conclusion that the hunters had sufficient food resources and did not need to go through the laborious marrow extraction process.

3. Pleistocene sites showing direct evidence of human exploitation of proboscideans

Gesher Benot Ya'Akov (Israel) is the oldest site in which cut marks on proboscidean bones have been identified (Goren-Inbar et al., 1994). An elephant skull was found upside-down over a large basalt core, surrounded by lithic tools. Some cut marks were identified on the nasal region and the posterior part of the skull, suggesting that the trunk was taken (Goren-Inbar et al., 1994).

There are several European sites dated to the second half of the Upper Pleistocene in which either cut or percussion marks have been recorded. Most of these can be found on the Iberian and Italian Peninsulas.

Remains of an *Elephas* (*Paleoloxodon*) *antiquus* found in Aridos 2 (Madrid) show cut marks. Those located on the ventral sides of the ribs are remarkable, as they were caused during evisceration. This suggests very early access to the carcass, as opposed to the hominins behaving as passive scavengers (Yravedra et al., 2010). Additionally, use-wear traces from meat processing were identified on eight lithic tools, including a hand-axe and a cleaver (Ollé, 2005). In Áridos 1 (Madrid), 200 m from Áridos 2, the articulated remains of an *E. antiquus* was found with its skull nearly complete, although highly fragmented (Soto, 1980), as well as 331 lithic pieces in overbank facies (Santonja and Querol, 1980; Pérez-González, 1980). In twenty of these pieces, use-wear traces from meat and/or skin processing have been identified (Ollé, 2005).

Torralba (Soria) became one of the paradigms on which the hunting-scavenging debate was based (Cerralbo, 1913; Howell, 1966; Butzer, 1972; Freeman, 1994; Binford, 1981; 1987). Cut marks were not found during the taphonomical studies carried out on the elephant bones deposited in the National Archaeological Museum (Yravedra personal observation). Similarly, evidences of worked elephant bones were not identified during the analyses carried out by Domínguez-Rodrigo (2005) on the remains from Torralba. In the nearby site of Ambrona, a large amount of *E.* (*Palaeoloxodon*) *antiquus* bones were also found. Unfortunately, the interpretation of this site is limited by the poor preservation of the cortical surface of the bone, as well as by post-depositional processes. None the less, a number of cut marks have been identified (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).

Many Pleistocene sites with lithic industry and proboscidean bones have been identified in Italy. Disarticulation cut marks on elephant ribs have been uncovered at Castel di Guido (Roma) (Mussi, 2005). However, after a preliminary taphonomic revision of the bone assemblage from this site, Boschian and Saccà (2010) have stated that abrasion processes have altered those possible cut marks substantially. Impact points and flake removal visible on the surfaces could be the result of bone marrow and perhaps meat extraction, as well as stone tool production (Radmilli and Boschian, 1996; Anconetani and Boschian, 1998). On the contrary, the high number of bifaces identified (99, regarding Radmilli and Boschian, 1996) – although not all of them are true bifaces (Villa et al., 2005) – reveals that the purpose of bone breaking by man was not necessarily for bone marrow extraction (Villa et al., 2005). Pending the conclusion of the taphonomic research, at least eight small fragments of elephant bone were transformed into tools at La

Polledrara (Roma) (Villa et al., 1999; Anzidei et al., 2004). However, no cut marks have been identified so far. Elephant bone bifaces have also been recorded at Fontana Ranuccio (Latium), although, again, no cut marks were noted (Segre and Ascenzi, 1984). A fragment of an intentionally broken elephant bone shaft has been recorded at Notarchirico (Venosa), although it was not specified whether there are percussion marks present or whether it was a green-bone fracture (Mussi, 2005: 408).

Mania (1990) has described cut marks on elephant bones at Bilzingsleben (Germany). Marks located on the surface of a flat foot bone have been identified as engravings.

Two Middle-Late Pleistocene sites show evidence that may suggest the hunting of proboscideans. The remains of twenty *Mammuthus primigenius* and several *Coelodonta antiquitatis* have been recorded at Cotte de St Brelade (Channel Island of Jersey). Cut marks and fractures on parietal bones of a number of skulls of *C. antiquitatis* indicate the consumption of meat and brain matter (Scott, 1980, 1986). Due to poor preservation of the bones, it is impossible to distinguish whether or not the remaining fractures were man-made. Scott suggests that the animals were thrown over a granite promontory rock herded by a human group (Scott, 1980: 146). It has been argued that the 281 cm by 2.5 cm spear found in association with an elephant at Lehringen (Germany) is proof that the animal was hunted (Movius, 1950; Adam, 1951; Tode, 1954; Thieme and Veil, 1985). This theory is not unanimously accepted among scholars (including Gamble, 1999), due to the lack of photographic and drawing records, and because the excavation took place prior to the advent of currently accepted excavation techniques (1948).

The almost complete skeleton of a *Palaeoloxodon antiquus* discovered at Gröbern (Germany), a site dated to the Eemian, was found associated with stone tools. Use-wear traces suggesting meat processing were identified on a number of these stone tools (Weber, 2000). These use-wear traces are the only evidence of human activity on elephant remains at this site.

Mammoth bones with cut marks have been identified at Byzovaya, Russia, nearby the northern Urals (Slimak et al., 2011), associated with Middle Palaeolithic lithic industry and dated to 28,500 years BP. Similar finds have been identified at the Gravettien sites of Spytihnev-Dochonce (Russia) (Nývltová Fisáková, 2008). In Krakow Spadzista, a mammoth rib fragment with a series of intentional notches on both edges, and another mammoth rib fragment with a large number of cut marks were uncovered. Despite the limited nature of this evidence, the sites have been interpreted as butchering and hunting sites on the basis of the taphonomic research (Svoboda et al., 2005). At Yudinovo (Russia) – Late Upper Palaeolithic – cut marks were recorded on a mammoth tibia, and the presence of a number of holes and the breakage pattern of the skulls and scapulae suggest human involvement (Germonpré et al., 2008). Cut marks on mammoth bones have been recorded at the Late Upper Pleistocene site of Algar de Joao Ramos (Portugal) (Zbyszewski, 1943; Antunes and Cardoso, 1992). Finally at Lugovskoye (Siberia), the thoracic vertebra of a proboscidean with a fragment of quartzite inside it has been interpreted as direct evidence of mammoth hunting (Maschenko et al., 2003; Zenin et al., 2003).

4. The archaeological site of PRERESA

The area of study is a fluvial terrace located on the lower segment of the River Manzanares, to the southeast of Madrid (Fig. 1a). This fluvial system is affected by synsedimentary subsidence due to evaporite dissolution, a well known process in the large tertiary continental basins in Spain, like 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, 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 are the youngest levels of the second half of the middle Pleistocene, as well as the Upper Pleistocene ones. All these terraces form the Complex Terraces of Butarque, hereafter CTB (Goy et al., 1989).

The site of PRERESA is located close to the upper section of the CTB stratigraphic sequence (Figs. 1b and 2b), into a gravel pit (PRERESA) on the right bank of the lower course of the River

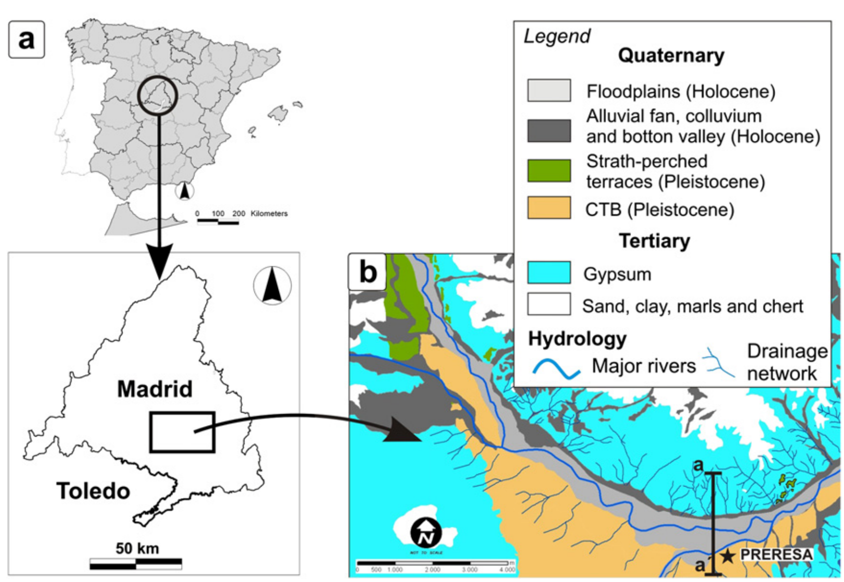

Fig. 1. a. Location of the site of PRERESA in central Spain. b. Geological sketch of the valley of the Manzanares river around Madrid capital and position of the PRERESA site in the Complex Terrace of Butarque (CTB).

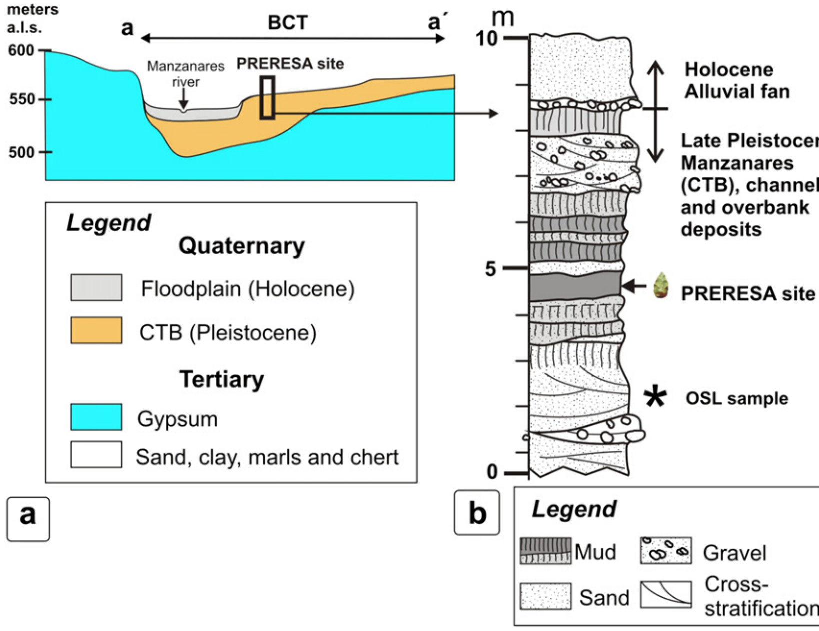

Fig. 2. a. Geomorphological transversal section, North to South, (a–a′) ot the valley of the River Manzanares showing the different relationships between the Miocene bed rocks, the aggradational Pleistocene fluvial deposits of the CTB and the Holocene floodplain. b. Stratigraphical section of the Complex Terrace of Butarque (CTB) in the quarry of PRERESA company, and location of the site and OSL dating sample.

Manzanares. There is an open mining front of 14 m depth where Carrillo et al. (1978) and Arche (1986) established different fluvial cycles characterized by fining-upward sequences, that begin with channel facies of gravel and sand deposits and ends with overbank facies. A great deal of paleontological and archaeological sites can be found in these fluvial facies and areas of subsident alluvial sedimentation (Fig. 2a). Some of these sites have been found *in situ*, and have been the object of systematic archaeological excavations since the middle years of the 20th century (Rubio-Jara et al., 2002).

The site at PRERESA is located between two fluvial sequences deposited during the second half of MIS 5, according to the absolute date of 84 $\pm$ 5.6 ka obtained by OSL in feldspar grains, at the Laboratory of Dating and Radiochemistry, Autonoma University of Madrid.

An area 255 m^2 was excavated at PRERESA. 754 lithic pieces were recorded, as well as the remains of molluscs, amphibians, reptiles, birds, micromammals (Sesé et al., in press) and macromammals. Zooarchaeological study has identified *Bos primigenius*, *Dama* sp., *Cervus elaphus*, *Capreolus capreolus*, *Equus* sp., and *Palaeoloxodon/Mamuthus*, as well as carnivores such as *Vulpes vulpes*, *Lynx pardinus*, *Meles meles* and *Canis lupus*. These species are associated with a mild palaeoclimatic event. From a biostratigraphic point of view, they are consistent with sets identified at other sites in the Madrid area (Sesé and Soto, 2002). Taphonomic analysis shows that preservation conditions of the fauna are excellent. Low amounts of carnivore action were recovered, and there is evidence of human activity on the bones of large sized animals (800–2000 kg, Bunn's type 4 1982) and on proboscidean bones. Notable among the assemblage is the almost complete skeleton of *Bos primigenius*, with a number of anatomical connections, recovered over an area 120 m^2. Lithic industry from the site is rich in knapping remains and unretouched flakes. The assemblage consists of 754 pieces showing very sharp edges, all worked from flint apart from six pieces of quartz. The flint *chaîne operatoires* are complete. Cores were exhaustively exploited. Short operative chains prevail, as well as flakes with greater width than length. The lack of macro-tools and the low occurrence of retouched tools are remarkable. Among these, the most common are retouched flakes, followed by denticulate and compound tools. A scraper and a burin were also recorded.

The scattering and arrangement of the faunal remains, together with the characteristics and distribution of the lithic industry, as well as the cut and percussion marks on a number of the bones retrieved, suggest that parts of a number of the animals recovered from the site were subject to processing by humans. For this, unretouched flakes were used and, judging by the presence of knapping remains and refits, these flakes were shaped *in situ*.

5. Sample characteristics and method of analysis

The site at PRERESA has so far uncovered 82 elephant bones belonging to one only individual, including carpals, tarsals, phalanges, fragments of tusk, metapodials, vertebrae, ribs, one complete scapula, one partial ulna, and several fragments of long bone diaphyses as tibiae (Fig. 3 and Table 1). This study focuses solely on those elephant bones on which man-made marks were recorded. There are no diagnostic elements present to distinguish whether the remains belong to *Elephas* or *Mammuthus*, although dates (84 $\pm$ 5.6 ka) and biostratigraphical data suggest a mammoth (Álvarez-Lao and García, 2010). None the less, possibility of the presence of *Elephas* cannot be ignored (Stuart, 2005). The lack of teeth, which could help to the taxonomical identification of the remains, is outstanding. Teeth could be found, however, at the not yet excavated area of the site.

According to the method of Blumenschine (1995), bones were screened with hand lenses using a magnification of 10×, 15× and 20× at the Department of Geodynamics and Geology, Complutense University of Madrid. The bone surfaces were then directly analyzed for cut and percussion marks with an optical microscopy 40× 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. The identification of the cut marks has been based on Binford (1981), Shipman (1981) and Bunn (1982). Trampling and cut marks have been

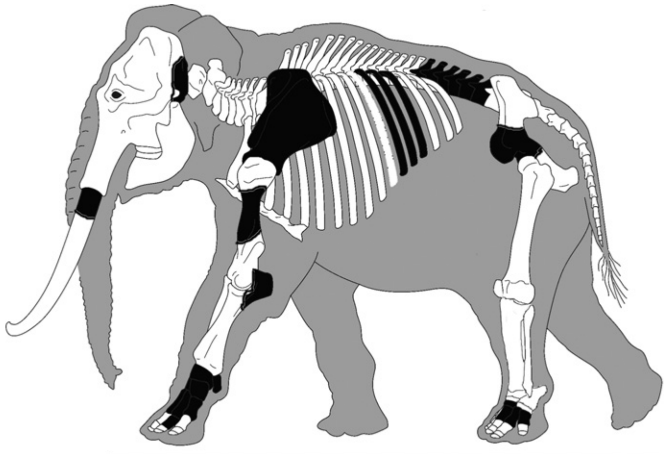

Fig. 3. Anatomic representation of the elephant remains found at PRERESA.

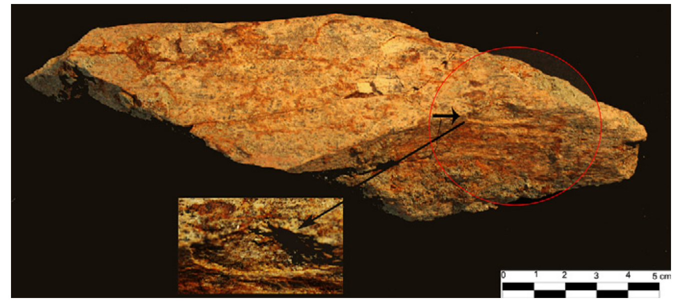

Fig. 4. Green-bone fracture and percussion marks on specimen 05/88/0998. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

distinguished according to Olsen and Shipman (1988) and Domínguez-Rodrigo et al. (2009). Teeth and percussion marks have been established according to Blumenschine (1988, 1995), Blumenschine and Selvaggio (1988), Pickering and Egeland (2006) and Galán et al. (2009). Breakage patterns were analyzed from a multifaceted analytical approach and included the analysis of notches and breakage planes. The notches have been analyzed according to the experimental works carried out by Capaldo and Blumenschine (1994) and Galán et al. (2009). The breakage planes were also analyzed following Villa and Mahieu (1991).

6. Results

05/88/0998. Fragment of diaphysis with impact notches. Measurements: 16 cm length, 5 cm width, 2 cm thick. The bone surface shows good state of preservation, although with some abrasion. A green-bone fracture was present on the fragment. An impact notch mark associated with a second notch was also recorded (Fig. 4). Two isolated thin grooves with V-shaped sections, microstriations, and other straight lines on the bone may be interpreted as cut marks.

04/37/594. 13 cm long fragment of diaphysis with good bone surface preservation. No percussion marks were recorded, but there were two notches associated with green-bone fracturing of the diaphysis. These were possibly man-made, as suggested by the presence of cut marks identified on the bone (Fig. 5) and the location of the fracture on the diaphysis. Cut marks and notches can be seen in detail in Fig. 5. Three cut marks were observed, one of which measured 2 cm in length, with oblique orientation, V-shaped in section and microstriation. The other two marks show similar orientation and shape in section; however they could not be measured due to the high fragmentation of the bone.

05/88/0989. 12 cm long fragment of diaphysis. Well preserved bone surface showing green-bone fracture and percussion marks. Due to the presence of a chip on the surface of the bone, identification of a further cut mark is unclear.

05/88/0827. 7 cm long fragment of diaphysis, good preservation of the bone surface. Green-bone fracture with notch associated with a percussion mark (Fig. 6). Two parallel, short, V-shaped in section cut marks were present on the fragment. Their location on the edge of the shaft fragment meant that they could be viewed in section and this suggests that they were produced by chance, due to the momentum of a hammer striking the bone.

05/88/0900–1000. No. 240. 24 cm long fragment of diaphysis, green-bone fracture and good preservation. One isolated mark cut, V-shaped in section, straight and with microstriations was recorded (Fig. 7). The cut mark measurements are unknown, as it was incomplete and located to the edge of the bone. Neither percussion marks nor notches were visible on the fragment, although a green-bone fracture was present on one of the faces.

05/88/0072. Bone fragment 20 cm in length with green-bone fragmentation fractures. The bone surface is well preserved and shows cut marks 4 mm in length. As well as these six fragments which show evidence of human intervention, further bone flakes and green-bone fractured bones have been identified (Fig. 8a and b), revealing man-made fractures on elephant bones. Percussion (Fig. 8c) and cut marks (Fig. 8d) have also been identified on bones

Table 1
Skeletal profiles and elephant bones showing man-made cut and percussion marks.

	NISP	Cut mark	Percusion mark and impact notche mark	Tooth mark
Tusk	5			
Craneal	3			
Vertebrae	6			
Rib	3			
Escapule	1			
Humerus	1			
Ulna	1			
Compact bones	16			
Metacarpal	5			
Metatarsal	3			
Phalange	4			
Shaft indet. bones	34	6	7	
Total	82	6	7	0

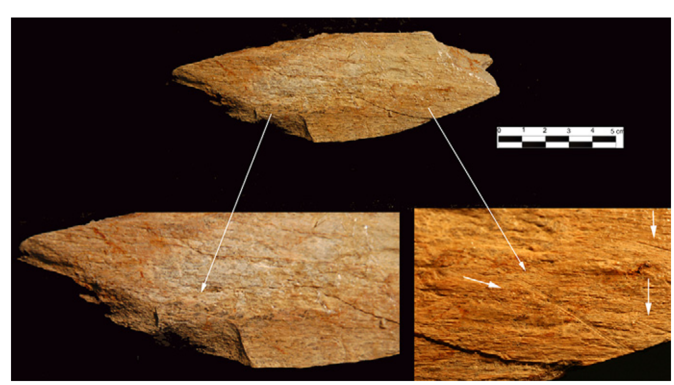

Fig. 5. Green-bone fracture. Close-up of notches due to fracturing and cut marks on fossil 04/37/549. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Fig. 6. Fragment of diaphysis, green-bone fracture. Close-up of the notches which occurred as a result of percussion and cut marks on fossil 05/88/0827. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

of other large animals such as aurochs, revealing that human activity at the site was not confined to proboscidean bones.

7. Discussion and conclusions

Exploitation of proboscideans during the MIS 5a (84 ± 5.6 ka) has been observed at the site at PRERESA through the identification of cut marks on six diaphysis fragments. Additionally, the intentional breaking of bones is suggested with the presence of percussion marks and green-bone fractures on other bone fragments recovered from the site. The purpose of this bone processing was not only gleaning meat from the carcass, but bone marrow as well.

The presence of tooth marks on some bones at PRERESA suggests that carnivores might have played a role on the breakage of proboscidean remains. However, the taphonomical analyses show that the impact of carnivores on the collection was not significant. Tooth marks have not been found on pachyderm bones. Regarding the remaining species, the percentage of identified tooth marks is lower that 1% of the total NISP of the site. Furthermore, only one or two marks per bone are usually identified, and these are found on the edges of ribs and diaphyses. Finally, pits are never longer or wider than 3 mm, which according to Selvaggio and Wilder (2001) and Domínguez-Rodrigo and Piqueras (2003) means that they were caused by small carnivores.

Therefore, no evidences confirm that the breakage of the proboscidean bones found at PRERESA was due to the action of carnivores, but by human causes. Considering that PRERESA is located on an area rich in flint and quartzite and that bone tools

Fig. 7. Large fragment of diaphysis with green-bone fracture and cut marks.

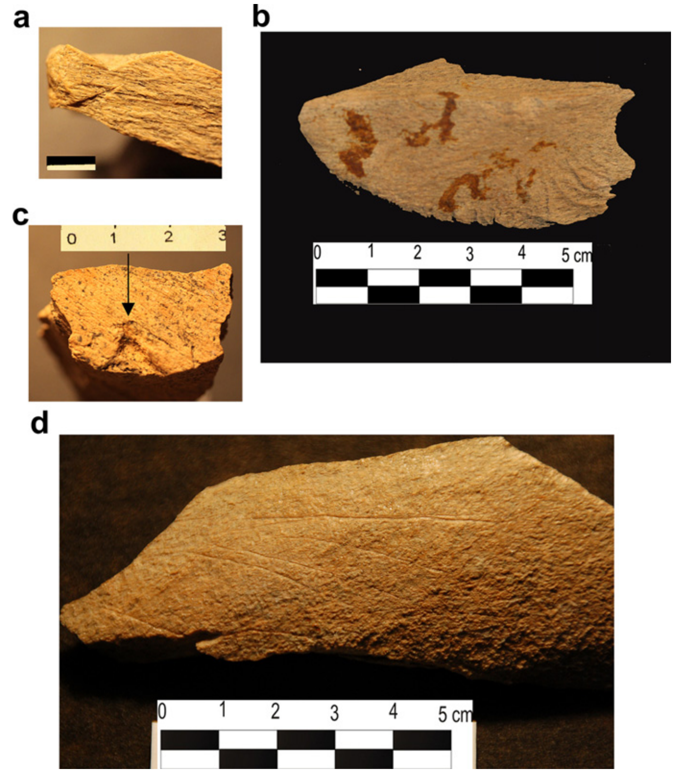

Fig. 8. Fig. 8a. Unidentified diaphysis fragment of Bunn's (1982) size 6 animal 05/88/0064. Fig. 8b. Bone flake from an unidentified diaphysis fragment of Bunn's (1982) size 6 05/88/0736, showing biochemical marks as those identified by Domínguez-Rodrigo and Barba (2006). Fig. 8c. Percussion mark on diaphysis fragment of Bunn's (1982) size 4, fossil No. 05/88/0855. Fig. 8d. Cut marks on diaphysis fragment of Bunn's (1982) size 4. Fossil No. 04/37/579.

have never been found on any known site with proboscidean bones at the terraces of Rivers Jarama and Manzanares (Sesé and Soto, 2002), it seems unlikely that the production of bone tools be the main purpose of breaking elephant bones. This seems to be opposite to what has been recorded on several European sites (Segre and Ascenzi, 1984; Radmilli and Boschian, 1996; Villa et al., 1999, 2005; Anzidei et al., 2004; Gaudzinski et al., 2005), although taking into account the small size of some of the remains, we cannot totally rule out that they were, actually, debris caused by production of bone tools.

Therefore, it can be suggested that not just were the proboscidean bones used in PRERESA for extracting meat, as shown by the cut marks, but also that the bones were broken in order to take the marrow.

The only sites dated to before the Upper Palaeolithic from which cut marks on elephant bones indicating the exploitation of these big mammals were recorded are Gesher Benot Ya'Akov (Goren-Inbar et al., 1994), Ambrona (Shipman and Rose, 1983; Villa et al., 2005), Áridos 2 (Yravedra et al., 2010), Bilzingsleben (Mania, 1990), La Cotte de St. Brelade (Scott, 1980, 1986) and Castel di Guido (Mussi, 2005). Those sites from which elephant meat exploitation has been deduced from indirect evidence, such as Áridos 1, Lehringen and Göbern (Ollé, 2005; Movius, 1950; Weber, 2000), can also be included in this list. Most of these sites are located in Europe and date to the Middle Pleistocene. Sites with evidence of the exploitation of proboscideans during the Upper Palaeolithic, although more common, are still relatively rare: Spytihnev-Dochonce (Nývltová Fisáková, 2008), Krakow Spadzista Street b (Svoboda et al., 2005); Yudinovo (Germonpré et al., 2008) and Algar de Joao Ramos (Zbyszewski, 1943; Antunes and Cardoso, 1992). Lugovskoye (Maschenko et al., 2003; Zenin et al., 2003), where one vertebra was found with a quartzite flake, must also be included.

Remains of rhinoceros and hippopotamus with cut marks have been found on European Middle Pleistocene sites; hippopotamus on Valparadis (Martínez et al., 2010) and rhinoceros on Boxgrove (Parfitt and Roberts, 1998) and La Biache Sant Vast (Auguste, 1995). There are also several African sites, located in the Middle Awash (Ethiopia), dating to the same period, where cut marks on hippopotamus remains have been recorded (de Heinzelin et al., 2000). Thus, in opposition to those who consider that only *Homo sapiens* took advantage of these taxa on a regular basis (Frison and Todd, 1986; Frison, 1989; Surovell and Waguespack, 2008; Gaudzinski et al., 2005), it appears to be now established that the exploitation of extremely large mammals was not only a marginal strategy before Upper Palaeolithic, but that it was practiced at least since Middle Pleistocene (Yravedra et al., 2010). On the other hand, the number of Upper Palaeolithic sites with direct evidence of proboscideans exploitation is still low. It is evident that the lack of cut marks at most sites in which these taxa have been recorded together with evidence of lithic industry, can be explained by the fact that the elephant bones show very little alteration after lithic tools were used on them (Biberson and Aguirre, 1965; Clark, 1977; Haynes, 1991; Villa, 1990; Fosse, 1998; Mussi, 2005; Villa et al., 2005; Mussi and Villa, 2008).

This hypothesis is corroborated at the site of PRERESA. Additionally, it is evident that limb-bone marrow was also consumed, at least sporadically, since the Upper Pleistocene.

Intentional breakage of proboscidean bones can be associated exclusively with marrow extraction at Ambrona and Notarchirico. However, in Ambrona the marks do not appear to be conclusive (Villa et al., 2005) and they have not been properly described in Notarchirico (Mussi, 2005). At Castel di Guido (Boschian and Saccà, 2010), La Polledrara (Anzidei et al., 2004), and Fontana Ranuccio (Segre and Ascenzi, 1984) bone breakage exclusively linked to tool manufacture cannot be ruled out.

Considering the importance of lipids on the human diet - providing calories, substituting carbohydrates functions and facilitating nutrients absorption (Speth, 1983) – it is not easy to understand why evidence of proboscidean bones breaking is so uncommon. Perhaps it may be explained by a combination of several factors, such as the absence of limb bones in many sites, their bad preservation in others, and the lack of modern taphonomic research on most of them with the exception of Haynes and Krasinski (2010), as well as by nutritional explanations such as those pointed by Haynes (1991). Finally, the fact that brain matter is another important source of lipids must be taken into account. In modern African elephants, the brain can weigh up to 4.5, and even 5.5 kg. Such an amount could easily satisfy the immediate nutritional needs of a group of hominins. Since the Early Middle Pleistocene, and throughout this whole period, there is evidence of intentional breakage of elephant skulls, at least at Gesher Benot Ya'akov (Goren-Inbar et al., 1994), La Cotte de St. Brelade (Scott, 1986), and probably Áridos 1 (Soto, 1980).

The analysis of the assemblage from PRERESA proves that exploitation of extremely large mammals was not just a marginal practice before the Upper Palaeolithic. Additionally, it has confirmed for first time that the bone marrow of these taxa was also consumed.

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Appendix. Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jas.2011.12.004.

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