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Carnivore activity in the Sima de los Huesos (Atapuerca, Spain) hominin sample

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ABSTRACT

The Sima de los Huesos (SH) site is the largest accumulation of human remains from the Middle Pleistocene known to date. Studies in the last two decades have proposed different hypotheses to explain carnivore activity in the SH human sample. This study provides new data in order to test these different interpretations, and therefore to understand the role of the carnivores in site formation at SH. Carnivores are usually not the origin of large accumulations of hominin fossils in the Eurasian record. The results show that marks of carnivore activity in the SH sample appear very infrequently, which we interpret as indicating that carnivore activity was very sporadic at the site. This is in stark contrast with previous studies. The comparison of bone modification patterns at SH to actualistic carnivore data allows us to suggest that bears were likely to have been the carnivore responsible for the modification observed on both human and bear fossils.

1. Introduction

The study of carnivore activity on bones is crucial to understanding the carnivores' role in the site formation since some carnivores are able to accumulate bones in cave dens. Most carnivores produce a distinct pattern of bone modification and have different accumulation behaviours. For this reason, the characterization of these two parameters is important to facilitate understanding of the role played by carnivores in paleontological and archaeological sites.

Carnivores are not the main culprits responsible for the origin of most large accumulations of human fossils in Eurasia. Generally, the large human fossil accumulations in the Eurasian Pleistocene record are interpreted as: i) cannibalism, e.g. *Homo antecessor* from Gran Dolina (Fernández-Jalvo et al., 1996) or *Homo neanderthalensis* from El Sidrón cave (Rosas et al., 2006) and Moula-Guercy (Defleur et al., 1999); ii) intentional or natural burial, e.g. *H. neanderthalensis* from Sima de las Palomas (Walker et al., 2011), La Ferrassie (Bouysonie, 1954; Heim, 1976; Maureille and Peer, 1998), Krapina (Trinkaus, 1985; Bocquet-Appel and Arsuaga, 1999), La Chapelle-aux-Saints (Rendu et al., 2014), Amud and Kebara (Tillier et al., 1991; Gargett, 1999) or early *Homo sapiens* from Predmostí (Svoboda, 2008), Skhul (Grün et al., 2005) or Qafzeh (Vandermeersch, 1981; Gargett, 1999). On the other hand, the *Homo erectus* accumulation in Locality 1 of Zhoukoudian has been interpreted as a human assemblage collected by *Pachycrocuta brevirostris* (Boaz et al., 2004). Nevertheless, some human fossils from the European record display carnivore tooth marks associated with carnivores' scavenging or are found in carnivore accumulation contexts, e.g. Baigara (Kuzmin et al., 2009), Kalamakia (Harvati et al., 2013), Cova Negra (Arsuaga et al., 2007), Cueva del Camino (Arsuaga et al., 2012), Valdegoba (Quam et al., 2001), Jarama VI (Lorenzo et al., 2012). None of the latter constitutes significant human accumulation, since they are typically isolated human remains.

The Sima de los Huesos (SH) site (Atapuerca, Burgos, Spain) is the largest accumulation of human remains from the Middle Pleistocene discovered to date. With respect to carnivore modification in the SH human sample, a previous study suggested that carnivores can be excluded as major agents involved in the accumulation of human remains due to the absence of both tooth marks and herbivore remains (Arsuaga et al., 1990).

A later taphonomic study (Andrews and Fernández-Jalvo, 1997) maintained that carnivore tooth marks are very common in the SH sample, since they are present on over half of the SH human assemblage. The same authors argue that at least two sizes of

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carnivores had access to the human bodies, a lion-sized carnivore first and a fox-sized canid, which scavenged the remains left by the former (Andrews and Fernández-Jalvo, 1997). Furthermore, the same paper argued that tooth marks made by cave bears were observed only on bear bones.

In other work, Arsuaga et al. (1997) argued that the tooth marks documented by Andrews and Fernández-Jalvo (1997) could have been produced by carnivores who became trapped in the caves, including bears. Therefore, there has never been a consensus regarding the influence of carnivore activity on the human remains from SH.

The present study concerning the taphonomy of the SH sample aims to provide new data in order to evaluate the different interpretations proposed. Furthermore, the objective of the present work is to describe and to quantify the carnivore modification observed in the SH sample, to understand the role of carnivores in the site formation. In order to establish coherent interpretations, we have approached this study through actualistic research with living carnivores.

2. Materials and methods

2.1. The Sima de los Huesos site

The Sima de los Huesos (SH) is well-known for yielding the largest collection of Middle Pleistocene hominin fossils ever found at a single site. This site has yielded a large collection composed of thousands human fossils (Martínez et al., 2013) belonging to at least 28 individuals (Bermúdez de Castro et al., 2004). The skeletal remains were described by their discoverers as belonging to the Neandertal lineage (Arsuaga et al., 1993; Martínez and Arsuaga, 1997) and classified as *Homo heidelbergensis* in a broad sense, which includes incipient Neandertal fossils. To Stringer (2012), this taxon should be restricted to fossils not exhibiting any Neandertal apomorphy and thus the SH hominins should be excluded. However, a recent study shows that the mitochondrial DNA of a Sima de los Huesos hominin shares a common ancestor with Denisovan mtDNA rather than with "classic" Neandertal mtDNA (Meyer et al., 2014), which could be interpreted as the result of gene exchanges between the Neandertal lineage and the *H. heidelbergensis* (in the restricted sense) populations. Together with the human bones, more than 176 individuals of *Ursus deningeri* (García and Arsuaga, 2011) and other carnivores have been recovered, including: *Vulpes vulpes, Canis* sp., *Panthera leo* cf. *fossilis, Panthera* sp. (jaguar size), *Felis silvestris, Lynx pardinus spelaeus; Martes* sp., *Mustela nivalis, Mustela putorius* and *Meles meles* (García et al., 1997; García, 2003; García and Arsuaga, 2011) as well as microfaunal remains (Cuenca-Bescós et al., 1997). As yet, no ungulate remains have been found at the site.

The site is a small subterranean gallery deep inside the Cueva Mayor Karst system, far from the present day entrance. The site has an inclined area (Ramp), where three stratigraphic sections (SRA, SRM and SRB) have been excavated, and a pseudo-horizontal area called Sima de los Huesos (SH) *sensu stricto*. Within the SH site, the pseudo-horizontal area has been excavated in extension, whereas the excavation of the ramp has been carried out with pits. Inside this chamber, there are twelve lithostratigraphic units (LU), but only two of them (LU-6 and LU-7) are fossiliferous stratigraphic levels (Fig. 1) (Aranburu et al., submitted). The lower fossiliferous level (LU-6) is referred to as "Red Clay", and is rich in human and carnivore fossils. The red clay is pure, devoid of extraclasts, and indicates low energy accumulation (decantation), which is compelling evidence that the fossils were not subjected to long-distance transport and likely accumulated in situ at SH (Aranburu et al., submitted). Above the Red Clay level there is a carnivore-bearing level (LU-7) (Aranburu et al., submitted). It can be said that there is only one hominin fossil deposit in SH (i.e., a single geological event: LU-6) because some hominin cranial fragments and teeth from SRA, SRM and SRB fit together perfectly with LU-6 remains found at SH *sensu stricto* (Arsuaga et al., 1997; Bischoff et al., 2007). Thus, human bones are present only in the red clay level (LU-6) in SH, but carnivores (especially bears) are present in both stratigraphic levels (LU-6 and LU-7).

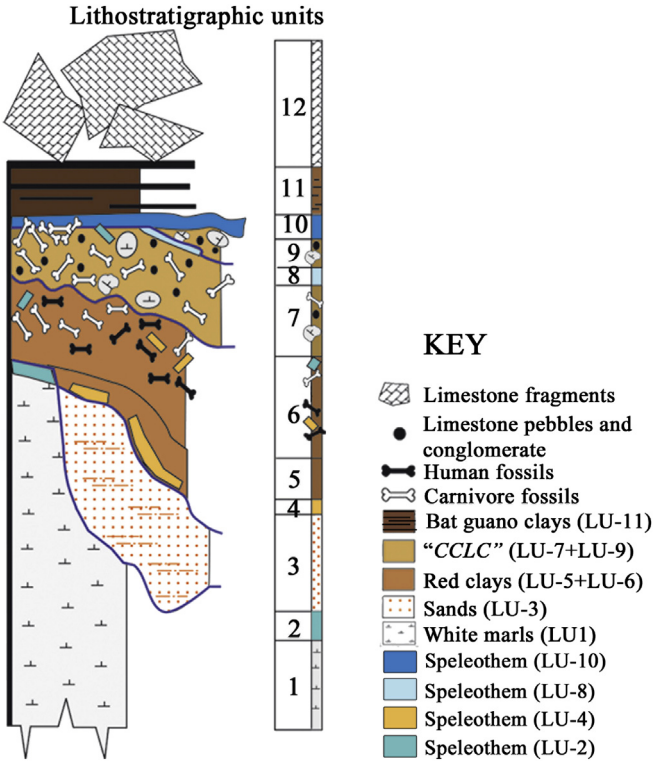

Fig. 1. Composite stratigraphic section of Sima de los Huesos site. Note that the colours correspond to the Munsell tables in wet sediment.

The biostratigraphic evidence place the site in the Middle Pleistocene (Bischoff et al., 2007; Cuenca-Bescós and García, 2007). Using a suite of independent geochronological methods the new age for the Sima de los Huesos hominin accumulation is estimated in 430 ka (Arnold et al., 2014).

2.2. The SH fossil samples

The human sample from SH is a large collection composed of thousands of bone fragments of all skeletal portions. Some of the remains fit together to form complete bones. For the purposes of this study, we have investigated the bones that provide relevant information regarding carnivore modification, e.g. long and flat bones (innominate, cranial, costal and vertebral remains). We analysed a total of 2401 human fossils from SH (see SI). These fossils correspond to skeletal elements found in all anatomical regions of the human sample. Dental remains and bone fragments smaller than 1 cm were excluded.

For the taphonomic study of the bear remains we analysed all non-dental bear remains recovered between the 2005 and 2011 campaigns. The specimens come from both LU-6 and LU-7. In order to analyse the 'non-bear' carnivore remains, we studied the entire non-dental sample in the collection. In sum, a total of 1200 carnivore skeletal remains from the site including *U. deningeri* (NISP = 464), *V. vulpes* (NISP = 634), *P. leo* cf. *fossilis* (NISP = 54),