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Zooarchaeology and Taphonomy of Late Pleistocene Macromammals in Central Portugal: The case of Abrigo da Buraca da Moira

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À la mémoire de Elvire Camille Paya (née Rodriguez),
la première à reconnaître l’archéologue en moi.

Abstract

The Abrigo da Buraca da Moira archaeological site contains a macromammalian assemblage sharing stratigraphic affinity with lithic implements. The assemblage underwent a zooarchaeological and taphonomic study. The goal was to establish the nature of the accumulation of such remains on the Upper Paleolithic layers and verify anthropic manipulation. The results show that the remains underwent little post-depositional transport and present fresh fractures and edges. The Layer 8 remains show signs of human activity, with percussion notches, cut marks and burnt bones. The determined taxa are either herbivores or lagomorphs, and the little carnivore activity observed gives good indication that the nature of the accumulation is anthropogenic.

Key words: Taphonomy, Zooarchaeology, Upper Paleolithic

Resumo

O sítio arqueológico do Abrigo da Buraca da Moira contém uma amostra de macromamíferos partilhando afinidade estratigráfica com implementos líticos. A amostra foi analisada do ponto de vista zooarqueológico e tafonómico. O objetivo foi determinar a natureza da acumulação dos restos das camadas do Pleistocénico Superior e verificar a existência de manipulação antrópica. Os resultados mostram que os restos sofreram pouco transporte pós-deposicional e apresentam fraturas frescas e arestas afiadas. Os restos da Camada 8 apresentam vestígios de ação humana tais como marcas de percussão, marcas de corte e queimaduras nos ossos. Os taxa identificados são ou herbívoros ou lagomorfos, e a pouca atividade de carnívoros observada dá uma boa indicação de que a natureza da acumulação é antrópica.

Palavras-chave: Tafonomia, Zooarqueologia, Paleolítico Superior

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Common courtesy dictates that acknowledgements be kept short and sober. I have been too short on words in thanking people in direct speech, and I already live a sober life, so indulge me in this not so short and quite informal opening text, riddled with inside jokes, song lyrics and different languages.

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The final words are dedicated to the foundation, nourishment, and conclusion of all works, my Satguru, Paramahamsa Sri Swami Vishwananda. *Seu olhos, meu clarão / me guiam dentro da escuridão / Seus pés me abrem o caminho / eu sigo e nunca me sinto só*.

Om, śānti, śānti, śānti, Śrī Gurubhyo namah, Hari Om.

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CHAPTER 1. INTRODUCTION

1.1 Zooarchaeology and Taphonomy: Reconstructing Past Human Societies and Site Formation

As we know so little about Prehistoric societies, it becomes even more imperative to take closer looks on what is recovered from archaeological sites. Not to say that immense knowledge hasn't come out of the last roughly 200 years (Sacket, 2014; Vai, 2019) of looking into the distant past, but still there is an immense blur on the glass of the window overlooking Prehistory. Zooarchaeology is the archaeological field concerned with the human-animal interactions of past societies. As Capaldo & Blumenschine put (1994, 724), "For archaeologists concerned with site-formation processes, it is especially important to distinguish hominid actors of bone modification from other biotic and abiotic actors that are active during the preburial phase of an assemblage's taphonomic history". To try and answer these questions taphonomy comes into place. A term coined by Efremov (1940), a paleontologist, that is employed on archaeofaunal assemblages to discern modifications on skeletal parts by natural and hominin agents, to understand the environmental context of deposition and subsequently the site formation history, in order to ascertain the potentialities and limitations of information retrieval from the presence of a particular set of faunal remains in an archaeological site (Lyman, 2010). This mindset of methodological procedure was borrowed from paleontologists trying to understand how the preservation processes influenced the information of a given fossil record (Behrensmeyer & Kidwell, 1985).

The preservation of faunal remains is not commonplace. Acidic soils, exposure to the elements, chemical and mechanical events usually dissolve or turn to dust most osteological matter, hence our environment is not filled with the skeletons of all vertebrates that have ever lived. The molecules composing the bones end up being part of something else, all according to the law of conservation of mass put forward by Lavoisier (1789). What Montelius (1888) wrote about the archaeological record being a very small fraction of preserved materials of what once existed is truer in regard to biological materials associated with human activity.

That being said, it becomes imperative to apply zooarchaeological and taphonomic methods to a given assemblage, which sometimes yields surprising or otherwise reassuring results. Two examples of very different contexts come to mind demonstrating this point. O’Connor (2008) describes how his analysis of the faunal remains recovered on the roman site of Caerleon (Wales) gave insight to differential butchering strategies for cattle and room specific dietary choices, as well as understanding why there were so many microvertebrate skeletons on the *frigidarium* (cold water pool) of the bath house, likely part of regurgitated pellets of barn owls using the building after its abandonment. Norton et al. (2007) use a taphonomic approach on a collection of Pleistocene bison carcasses from the Hanaizumi site (Japan). Their results show that what was previously thought to be an archaeological site is more likely a natural accumulation of faunal remains that were transported by fluvial forces, some of which had traces of human handling, but the butchery site had been elsewhere. These two examples, among many others (e.g. Fernández-Laso et al., 2015; Cheheb et al., 2019; Moura, 2021), illustrate the importance of both zooarchaeological and taphonomic analyses on faunal remains not only to investigate human activity, but also to understand the history of a site and its spoils.

1.2 Problematic and Objectives

The cave of Abrigo da Buraca da Moira (ABM) is an archaeological site in which faunal remains have been found preserved in layers rich with lithic implements. As pointed before, the presence of faunal remains in a sediment layer containing archaeological artefacts does not constitute a direct link between the human occupation and the accumulation of said remains. Furthermore, the formation of each layer and the site itself may have put together, set apart or eliminated elements of linkage or separation between the unequivocally human made lithic implements and the remains of macromammals.

With this in mind, the present work conducts a taphonomic study of the remains recovered in Abrigo da Buraca da Moira, to ascertain the nature of the accumulation. We will be looking for traces of human handling of carcasses, such as cut marks, percussion marks and evidence of burning, as well as establishing if carnivores have contributed to the accumulation or otherwise altered it. Alterations originating from transport and bioturbation will also be looked for, as it is important to understand if the location in which the remains were recovered during excavation has or not changed substantially since their deposition. Equally important to the matter at hand is the anatomical and taxonomical classification of the remains. Such endeavor will provide a look at the diversity of species in each layer, their anatomical representation and estimates on the number of elements and individuals. The combining of these two approaches will hopefully shed light on the issue of the nature of the accumulation, but also on the evidence of human subsistence, such as prey of choice and human paleoecology.

To accomplish these tasks, we will now present the structure of the present work. **Chapter 1** deals with the introductory discussion on the contribution of the fields of zooarchaeology and taphonomy, as well as establishing the work's problematic and objectives, and providing a paleoenvironmental and cultural background of the Upper Paleolithic in Iberia, more specifically, the Portuguese territory. **Chapter 2** deals with the description of the Abrigo da Buraca da Moira archaeological site in aspect to its research history, geographical context and excavation results. **Chapter 3** concerns the methodological framework applied to the archaeofaunas selected to be analyzed. **Chapter 4** presents the results of the analysis, discussed posteriorly on **Chapter 5** while comparing data obtained with the available data from contemporary sites with similar contexts. **Chapter 6** draws final conclusions and points out research pathways to go through for the retrieval of further scientific knowledge enclosed in the Abrigo da Buraca da Moira site and its dug out artefactual assemblage, spatial data, etc.

1.3 Upper Paleolithic Chronology in Portugal

The Upper Paleolithic chrono-cultural divisions in Portugal follow the classical structure first established in France: Aurignacian, Gravettian, Solutrean and Magdalenian (Straus, 1996; Haws, 2003). The uncalibrated dates proposed in the late 1990s and early 2000s were as follows: Aurignacian – 33-25 ky BP, Gravettian – 25-22 ky BP, Solutrean – 22-17 ky BP, Magdalenian – 17-10 ky BP (Zilhão, 1997).

The earliest recognized Upper Paleolithic cultural complex in Portuguese territory is the Aurignacian, based on the findings on the cave sites Pego do Diabo, Escoural, Salemas and the open-air sites Vascas, Vale de Porcos I e Vale de Porcos II (Zilhão, 1997). Afterwards, Aurignacian was also recognized in the other open-air sites of Chainça (Tacker, 2001) and Gândara do Outil (Almeida et al., 2006a, 2006b; Aubry et al., 2006, 2008a, 2008b, 2011). More recently archaeological layers with Aurignacian artefacts in layers between the Mousterian and the Gravettian were also found in Cardina (Aubry et al., 2020), Lapa do Picareiro (Haws et al., 2020) and Caldeirão (Zilhão et al., 2021a).

The major debate about the Aurignacian in central western Iberia is about the chronology of its first appearance. The earliest date for it comes from the Lapa do Picareiro cave, where a layer has been found to hold a modest assemblage including typical unretouched bladelets and carinated end-scrapers (Haws et al., 2018), dated between 41,4-38,1 ky cal BP (Haws et al., 2020; Haws et al., 2021). Underneath this layer, Mousterian occupation levels were identified. Thus, the Upper Paleolithic in Portugal would start around 40 ky BP. Zilhão (2021a, 2021b, 2022) however, argues that the Ebro River acted as a frontier (The Ebro Frontier) between the last Neanderthals and Modern Humans even after 40 ky BP, and disagrees on the early Aurignacian attribution to the Lapa do Picareiro level. This argument is reinforced when all Iberia is put into consideration.

Nevertheless, the stratigraphic profile of Lapa do Picareiro is the longest from Portugal (ca. 20 m deep) and holds Bronze Age, Neolithic, Epipaleolithic, the entire Upper Paleolithic chronology, and Middle Paleolithic (Bicho et al., 2006, Benedetti et al., 2019).

Because Picareiro and Caldeirão are the reference sites with long sequences for the Upper Paleolithic of this region, their chronology will be considered as those of reference for the present work. The Gravettian levels of Picereiro are dated roughly between 31,3-26,5 ky cal BP; the Proto-Solutrean and Solutrean levels between 25,1-20,8 ky cal BP; the Magdalenian levels dated between 19-11,3 ky cal BP (Benedetti et al., 2019, tables 1 and 2).

Gruta do Caldeirão contains Mousterian levels dated as recent as 35,8 ky cal BP, with some reservations, but surely after 39 ky BP. Meanwhile, some dates for Upper Paleolithic levels gave older than expected results. Proto and Early Solutrean predates 24 ky BP, while Late Solutrean dates to after 23,3-23,2 ky BP interval (Zilhão et al., 2021).

As demonstrated by these examples, the chronology of the Upper Paleolithic in Portugal needs a revision in terms of its transition from Middle to Upper Paleolithic, and the temporal limits of its internal chrono-cultural divisions.

1.4 Upper Paleolithic paleoenvironment in Western Iberia

The Upper Paleolithic is a chronological period that falls in the later years of the Late Pleistocene geological age, itself the later stage of the Pleistocene Epoch (2,58 My – 11,7 ky BP), the first epoch of the Quaternary Period (2,58 My – present time; Gibbard & Head, 2020). The Late Pleistocene is generally characterized by a cyclical succession of cold periods (glacial periods) and warmer intervals (interglacial periods). The Milankovitch variations explain this cycle. The Earth's orbit around the Sun is not perpetually stable, there are periods when its distance is shorter and therefore the Earth's surface receives higher amounts of energy from the Sun in the form of radiation. This causes a general increase in the planet's temperature and therefore a melting of the ice caps, higher average sea level and generally warmer climates all around. The situation is reversed during periods when the Earth's orbit is farther away from the Sun (Ehlers et al., 2011). Throughout the last century, the divisions and nomenclature of these stages have had an immense debate and research methodology associated.

The Marine Isotope Stage (MIS) division has had tremendous impact and is widely used in recent publications. It relies on the study of deep-sea cores in terms of the quantity of the stable oxygen-18 isotope in the different layers. High levels of oxygen-18 indicate colder periods, while low levels indicate warmer periods (Cronin, 2010). There are over one hundred established Marine Isotope Stages, MIS 1 representing the latest and MIS 104 the oldest. The even numbered stages correspond to glacial ones, while the odd-numbered ones correspond to interglacial. A correlation of the chronostratigraphical data for the Quaternary, compiling the information on isotope stages as well as paleomagnetic and other chronological divisions is updated regularly. The most recent version can be accessed at http://quaternary.stratigraphy.org/charts/, and can be seen on fig. 1, though this version is provisional, and the latest peer-reviewed version comes from Cohen & Gibbard (2019). The late MIS 3 and the whole MIS 2 correspond to the Upper Paleolithic in Portugal (Haws, 2012). MIS 3 is roughly dated between 60-27ky BP and corresponds to a warmer stage (Van Meerbeeck et al, 2009), while MIS 2 is roughly dated between 27-11,7ky BP and corresponds to a colder stage (Cohen & Gibbard, 2019), its end coinciding with the beginning of the Holocene epoch. During both stages there are shorter events that either slightly contradict the general climatic trend or worsen it. These are the Heinrich events (cold/arid conditions) and the Greenland Interstadials (war/humid conditions). Four Heinrich events (HS) are relevant for the timeframe in question in this work: HS1 – 18-15,6 ky BP (Sánchez Goñi & Harrison, 2010); HS2 – 26,5-24,3 ky BP (Sánchez Goñi and Harrison, 2010, Wolff et al., 2010); HS3 – 32-29 ky BP (Sánchez Goñi and Harrison, 2010); HS4 – 40,2-38,3 ky BP (Sánchez Goñi and Harrison, 2010). In relation to the Greenland Interstadials (GI), ten are worthy of mention, considering that GI-10 precedes the earliest Aurignacian at Lapa do Picareiro (Haws et al., 2021). They are dated as follows: Late Glacial Interstadial, also known as Bølling–Allerød Interstadial – 14,7-12,9 ky BP (Rasmussen et al., 2014); GI-2 – 23,3 ky BP; GI-3 – 27.8 ky BP, GI-4 – 28,9 ky BP; GI-5 – 32.5 ky BP; GI-6 – 33.7 ky BP; GI-7 – 35,5 ky BP; GI-8 – 38,2 ky BP; GI-9 – 40,1 ky BP; GI-10 – 41,4 ky BP (Wolff et al., 2010). Important events not yet mentioned are the Last Glacial Maximum, when ice sheets reached their maximum extent between 26,5-19 ky BP (Clark et al., 2009) and the Younger Dryas, the last halt to the gradually warming conditions that were taking place since around 20 ky BP. It was a sudden drop in temperature (2-6 ºC) that lasted from 12,9-11,7 ky BP (Rasmussen et al., 2014; Carlson, 2013), right after the warmer Late Glacial Interstadial, and preceding the rapid warming at the onset of the Holocene.

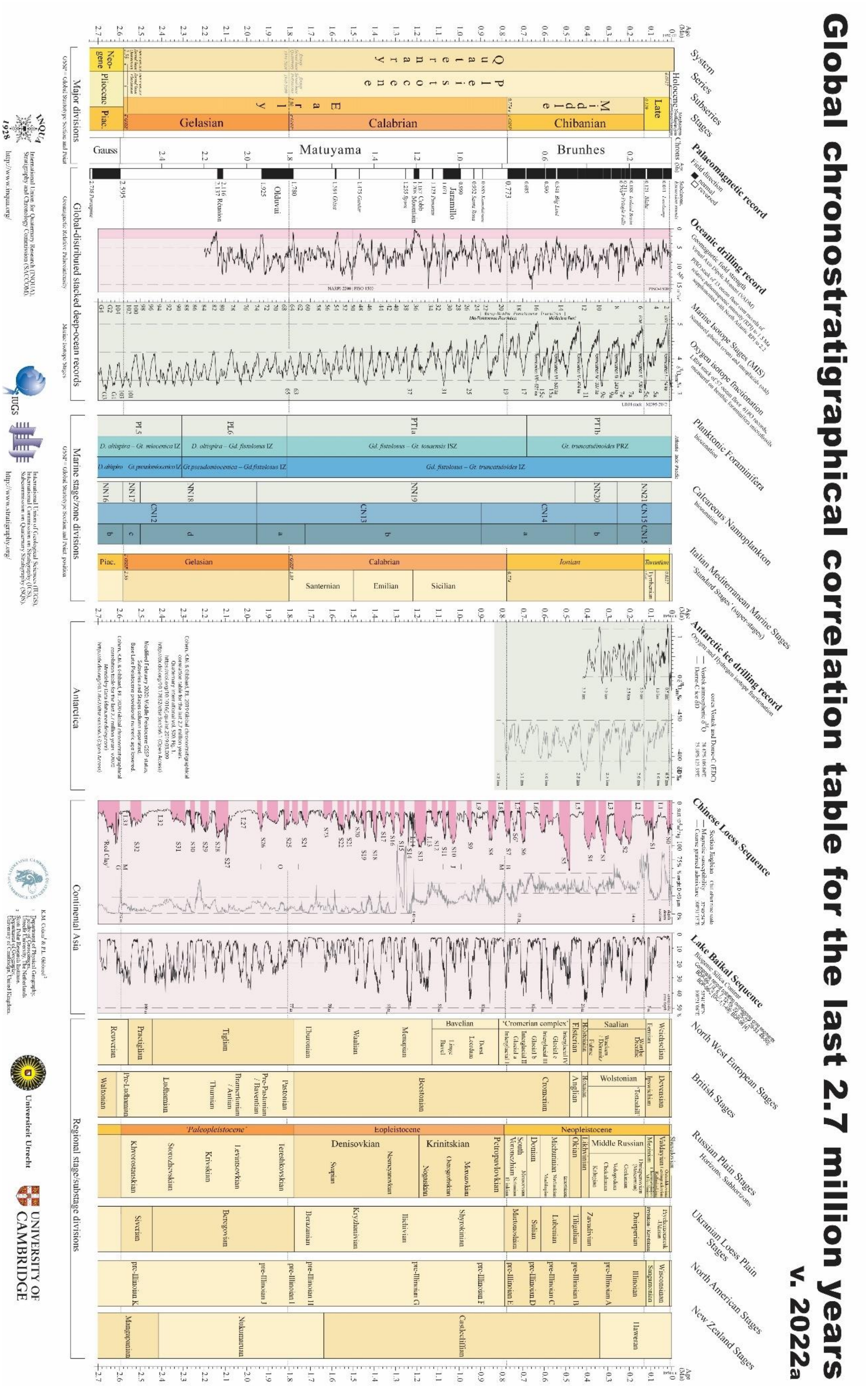

Figure 1.Global Chronostratigraphical Table for the last 2.7 MA, available at http://quaternary.stratigraphy.org/charts/ (accessed August 10th, 2022).

The paleoenvironmental background for the Upper Paleolithic is still build upon deep-sea cores, since the data on the Upper Paleolithic flora in Portugal is still limited (Haws, 2003). Nevertheless, deep-sea cores and terrestrial records give some general indications of the kind of vegetal cover one could find during MIS 3 and 2. In general terms, the cold conditions, especially during winter, as well as aridity and lower atmospheric CO_2 posed difficulties to tree growth during these stages (Huntley and Allen, 2003; Tzedakis, 2010). During the MIS 3 Greenland Interstadials, the milder conditions allowed for the thermophilous trees such as *Quercus*, *Alnus* and *Corylus* to expand their coverage area (Roucoux et al., 2005). Towards the end of MIS 3, worsening conditions such as temperature drop and lower humidity resulted in the reduction of *Quercus* and Ericaceae, as evidenced by lower pollen quantities in deep-sea cores (Roucoux et al., 2005). Some patches of forest would survive in small refuge areas along the coast (Turner and Hannon, 1988; Figueiral and Terral, 2002; Carrión et al., 2010; González-Sampériz et al., 2010; Rodríguez-Sánchez et al., 2010).

At the beginning of the MIS 2, the HS3 and HS2 events sustain herbaceous and steppe vegetation covering the Portuguese territory (Turon et al., 2003; Roucoux et al., 2005,), an obvious indication of colder and arid periods, with a great deal of Poaceae grasses. The conditions ameliorate between 25,5-19 ky BP, with generally warmer temperatures and more precipitation, even though globally this period falls in the Last Glacial Maximum. The conditions allowed for the expansion of *Quercus*, *Pinus* and heath vegetation (Roucoux et al., 2005; Naughton et al., 2007); *Alnus*, *Fraxinus*, *Corylus* and *Olea* (Turon et al., 2003) creating denser forests in the case of *Quercus* and *Pinus* and more open woodlands for the remaining genera. The HS1 once again brought harsher climatic conditions, evidenced by the increase of *Artemisia*, Chenopodiaceae and *Ephedra* (Hooghiemstra et al., 1992; Turon et al., 2003). Late Glacial Interstadial forests were predominantly of *Quercus* and *Pinus* but during the Younger Dryas the *Quercus* coverage diminishes, accompanied by an increase in *Pinus* and cold climate vegetation such as *Juniperus*, *Artemisia*, *Ephedra* and *Centaurea* (Fletcher, 2005; Fletcher, 2007).

1.5 Late Pleistocene Zooarchaeology and Taphonomy in Central Portugal

An important compilation of paleontological data from the large mammal remains housed at Serviços Geológicos in Lisbon was done by Cardoso (1993), originating from dozens of archaeological and paleontological sites. The Late Pleistocene collections included *Sus scrofa, Cervus elaphus, Dama dama, Capreolus capreolus, Bos primigenius, Capra pyrenaica, Rupicapra rupicapra pyrenaica, Equus caballus, Stephanorhinus hemitoechus, Palaeoloxodont antiquus* and *Mammuthus primigenius* for the herbivores. The carnivore guild included *Canis lupus, Cuon alpinus europaeus, Vulpes vulpes, Ursus arctos, Hyena hyena prisca, Crocuta crocuta intermedia, Crocuta crocuta spelaea, Panthera pardus, Panthera spelaea, Felis silvestris* and *Lynx pardina*.

Throughout the whole Upper Paleolithic in Portugal, *Sus scrofa, Cervus elaphus, Dama dama, Capreolus capreolus, Bos primigenius, Capra pyrenaica, Equus caballus* and *Equus sp*. could be found (Cardoso, 1993). The presence of *Rupicapra rupicapra* in the caves of Caldeirão and Salemas dated to ca. 20,4 ky BP and 24,9 ky BP, respectively, indicate this species was present only during colder periods (Antunes et al., 1989; Cardoso & Antunes, 1989).

The proboscideans disappear from the paleontological and archaeological record early in the Upper Paleolithic. The most recent straight-tusked elephant is found at Foz do Enxarrique, dated to the end of MIS 3, on a layer with Mousterian artefacts (Antunes & Cardoso, 1992), while the wolly mammoth from Algar de João Ramos is from the MIS 2, around 14 ky BP (Antunes & Cardoso, 1992), though this date and taxonomical attribution is seen as dubious (de Carvalho et al., 2020). Therefore, modern humans probably did not cross paths with proboscideans in Portugal. The same goes for *Stephanorhinus hemitoechus*, whose more recent remains come from Italy at 41 ky BP (Pandolfi et al., 2017).

As for the carnivores, *Canis lupus, Vulpes vulpes*, *Felis silvestris* are extant species, having endured the climatic fluctuations of the Late Pleistocene, while *Ursus arctos* became extinct in modern times. The hyenas, lions and cave lynx became extinct by the end of the Pleistocene. The Iberian lynx (*Lynx pardina*), however, still exits although endangered.

Cardoso's paleontological data gives a general view of the diversity of macromammalian fauna, but to understand the state of the art in terms of Zooarchaeology and Taphonomy for the region under study, one needs to look at specific archaeological sites with Upper Paleolithic occupation with preserved faunal remains (fig. 2).

Lapa do Picareiro, already mentioned in **1.3**, is a large cave chamber with Upper Paleolithic levels containing faunal remains (Haws, 2003; Haws, 2012; Bennedetti et al., 2019). Levels DD to V, dated between Early Upper Paleolithic and Gravettian, contain *Cervus elaphus*, *Capra pyrenaica, Rupicapra rupicapra* as well as leporids, toad and bird bones. No predators were identified, but the taphonomic analysis revealed some carnivore gnawing (Haws, 2012). Level U, dated to the Terminal Gravettian, contains *Cervus elaphus, Capra pyrenaica*, *Lynx* and *Canis Lupus*. Other small animals include leporidae and arvicolinae, as well as some birds (Haws, 2012). Level T, whose dates rage from roughly 27,6-22,5 ky BP, is a Proto-Solutrean and Solutrean layer (Benedetti et al., 2019) with a rich faunal assemblage containing *Cervus elaphus, Capra ibex/pyrenaica* and lower amounts of *Capreolus capreolus, Rupicapra rupicapra, Equus caballus* and *Lynx pardina*. High amounts of rabbit and bird bones were recovered (Hockett and Haws, 2009; Haws, 2012). Levels S-R, sparse Solutrean occupations, have very few faunal remains, and Levels Q-N, with both sterile and Solutrean occupations, all have faunal remains that have not been thoroughly described (Haws, 2012). Levels K-E, spanning the whole Magdalenian (Benedetti et al., 2019), contains a high percentage of *Cervus elaphus*, followed by *Sus scrofa* and fewer remains of *Bos primigenius, Capra pyrenaica* and *Rupicapra rupicapra*. One *Vulpes vulpes* tooth was recovered (Haws, 2003). But overall, the rabbit remains comprise the majority of the mammalian fauna. The taphonomic analysis established that rabbit was mainly consumed and perhaps opportunistic hunting of larger prey, with extraction of marrow (Haws, 2003).

Lapa do Anecrial is a cave site with a Terminal Gravettian (at around 23,4 ky BP, and another around 21,5 ky BP) on Layer 2, and one Solutrean occupation (around 20,5 ky BP) on Layer 1 (Almeida et al., 2007). Layer 2 contained 75 remains of Caprids and 1417 remains of leporids. Layer 1 contained 15 remains of caprids and 184 of leporids. Several leporid remains showed burnt marks, as well as some caprid bones (Brugal, 2006).

Lapa dos Coelhos, a cave located on the karstic system of the Almonda River, contains Solutrean and Magdalenian occupations with faunal remains, as well as a Mousterian level, not described here. Layer 3 has a date of 13,5 ky cal BP, with industry attributable to the Late Magdalenian, Layer 4 has a date of 14,3 ky cal BP, with industry attributable to the Upper Magdalenian and Layers 6 and 8 were interpreted as being possible Solutrean occupations (Gameiro et al., 2017). A great variety of mammalian species was identified, including *Capreolus capreolus, Cervus elaphus, Sus scrofa, Bos* (*primigenius*?), possible *Rupicapra rupicapra, Capra pyrenaica, Lepus europaeus* and *Oryctolagus cuniculus*. Carnivores such as *Ursus arctos, Crocuta* sp*., Canis lupus* and *Vulpes vulpes* were also found (Gameiro et al., 2017). Taking into consideration the percentages of red deer, horse, ibex, wild hog and rabbit, leporid bones make up almost half of the assemblage in the Solutrean layer, and rise up to over 90% in both the Upper Magdalenian and Late Magdalenian layers (Gameiro et al., 2017). The Upper Magdalenian layer also had great variety of fish taxa (Roselló & Morales, 2010). Some percussion notches on bones and the presence of combustion structures and burnt bones indicates anthropic accumulation (Gameiro et al., 2017), though the carnivore guild should not be ruled out as a factor of accumulation or alteration.

Pego do Diabo is a small cave located on the southern slope of the Loures River Valley. Valente (2004) published the results of the zooarchaeological and taphonomic study of the Level 2 assemblage, and some bone specimens from Level 1 (this layer is interpreted as a redeposition of Level 2, having modern artefacts and bioturbation). Level 2 is dated at its base to 28 ky BP where the human occupation took place. The top of Level 2 is dated to 23 ky BP and is considered as the result of a slow deposition sequence or the dated sample was contaminated. The lithic industry is attributable to the Aurignacian (Zilhão, 1997). The faunal assemblage included *Sus scrofa, Cervus elaphus, Capra pyrenaica, Rupicapra rupicapra, Equus caballus, Canis Lupus, Vulpes vulpes, Ursus arctos, Meles meles, Lynx pardina,* Cf. *Crocuta crocuta spelaea, Lepus* sp*.* and *Oryctolagus cuniculus*. One other mustelid was identified besides *Meles meles*. The layer also contained remains of birds, rodents, amphibians and bats. Red deer and horse dominate the herbivore assemblage, followed by caprids. The carnivore guild had as the main contributor lynx, followed by wolf and fox. The taphonomic analysis revealed a large number of bones had alterations done by carnivores (dissolution, gnawing, etc.), while few bones exhibited cut marks or showed evidence of burning (Valente, 2004). The accumulation seems the result of small human groups using the cave (Zilhão, 1997), with a substantial contribution of large carnivores such as wolf and hyena (Zilhão, 1997; Valente, 2004) but also smaller carnivores and raptors, such as lynx, mustelids and birds.

Gruta do Caldeirão is a cave on the Nabão River basin, located on one of its side valleys. Two sectors were excavated, where Mousterian, Upper Paleolithic and Neolithic occupations were identified. The dating of the site is not without its problems, associated with sediment deposition, site formation processes and the lack of collagen on several of the radiocarbon samples. That being said, Gruta do Caldeirão is a key site in the transition for the Middle to Upper Paleolithic transition, the Last Glacial Maximum and Tardiglacial human occupations (Zilhão et al., 2021). The Early Upper Paleolithic layers contained *Cervus elaphus, Capreolus capreolus*, Caprids and Equids for the herbivores, *Lepus sp* and *Oryctolagus cuniculus* for the leporids, and Hyena, *Ursus arctos*, *Panthera leo, Lynx pardina* and *Vulpes vulpes* for the carnivores. Red deer, caprids and equids dominated the herbivore assemblage, though their numbers are still inferior to the leporid remains. Similar tendencies were found in the Solutrean and Magdalenian levels, though more herbivore remains were found and more taxa were identified (*Sus scrofa* and *Bos primigenius*). The leporid remains are significantly higher in Solutrean and Magdalenian levels, over ten times the amount found on the EUP levels (Davis, 2002; Davis et al., 2007). Few bones showed cut marks or burnt marks, but the enlarging presence of rabbits and fewer presence of carnivores from the Middle to the Upper Paleolithic levels indicates a mostly human accumulation, with some carnivore input (Davis et al., 2007, Lloveras et al., 2011).

From Abrigo do Alecrim, a rock shelter in the Lapedo Valley, part of River Lis basin in Leiria, zooarchaeological studies have been carried out on Layer 6, dated to 21,7 ky BP. The faunal remains are in association with Terminal Gravettian lithic implements (Almeida et al., 2010). The sample includes *Equus* sp.*, Cervus elaphus* and leporidae. The presence of cut marks in 26 specimens and burnt marks on almost half of the remains leaves little doubt as to the anthropic origin of the accumulation. Furthermore, the fragmentary state of the assemblage allied to its burnt marks suggests the use of bone fat as fuel (Almeida et al., 2010).

The Abrigo do Lagar Velho rock shelter is, as with Abrigo do Alecrim, located on the Lapedo Valley. Its national importance, and global recognition, is due to the finding of the almost complete skeleton of a Gravetian 5-6 years old child (Zilhão & Trinkaus, 2002; Carvalho, 2011). The *bs* (lowest slope deposit) is dated to 33,5-29,7 ky BP, it contains numerous rabbit remains but also red deer, horse and auroch (Moreno-Garcia & Pimenta, 2002). The *tc* (transitional complex) is dated to 30,3-29,3 ky BP. The rabbits and red deer maintain their high numbers but the auroch and horse remains decrease, having been replaced by roe deer. A single wild boar specimen was recovered (Moreno-Garcia & Pimenta, 2002). The paleosurface designated as EE15 (Late Gravettian), dated to 27,2-26,7 ky BP from the hearth structure, contained mostly red deer specimens, followed by rabbit, ibex, and fox. A significant number of remains were burnt, signaling their connection to the hearth structures, even as fuel (Almeida et al., 2009). The Terminal Gravettian TP06 layer, part of the *us* (upper slope deposit) complex, yielded the 27,8-24,5 ky BP interval. Its faunal assemblage once again is dominated by red deer and rabbit. Horse, auroch and hare were also recovered, and few remains of wild boar and hedgehog, as well as birds (Moreno-Garcia & Pimenta, 2002). The Middle Solutrean layer TP09, also in the *us* complex, is dated to 24,6-23-5 ky BP. The faunal assemblage is similar: once again, red deer and rabbit are dominant, but hares are significantly less present and roe deer replaces the auroch; wild boar is scarcely present (Moreno-Garcia & Pimenta, 2002).

The sites here summarily described in terms of their zooarchaeological and taphonomic data show that generally Upper Paleolithic assemblages are diverse although with few remains. Rabbit remains become increasingly more common after the Middle to Upper Paleolithic transition (Haws, 2003, 2012; Gameiro et al., 2017), while carnivore activity becomes less frequent after the MIS 3 (Valente & Brugal, 2002; Valente, 2004)

Figure 2. Top: Iberian Peninsula with the area of study in focus. Bottom: location of the sites mentioned in the sub-chapter, and Abrigo da Buraca da Moira. 1 – Lapa do Picareiro; 2 – Lapa do Anecrial; 3 – Lapa dos Coelhos; 4 – Pego do Diabo; 5 – Gruta do Caldeirão; 6 – Abrigo do Alecrim; 7 – Abrigo do Lagar Velho; 8 – Abrigo da Buraca da Moira.

CHAPTER 2. THE ABRIGO DA BURACA DA MOIRA ARCHAEOLOGICAL SITE

2.1 Research History

The first mention to ABM comes from the land survey report of the project PNTA/98 – A Pré-História do Maciço Calcário das Serras d`Aire e Candeeiros e bacias de drenagem adjacentes (Cunha-Ribeiro, 2003), in which the site is firstly located. Subsequent surveys of the SIMLIS – Saneamento Integrado dos Municípios do Lis preventive archaeology project rediscovered the site, though similarly to previous works, no evidence of archaeological interest was identified (Carvalho, Gomes and Pajuelo, 2005; Carvalho and Pajuelo, 2005; Carvalho and Carvalho, 2007, Carvalho, 2011).

In the year 2015 the EcoPLis - Human Occupations in the Pleistocene Ecotones of the River Lis project is initiated, headed by Telmo Pareira, Vânia Carvalho and Trenton Holliday (Pereira et al., 2015a). The duration of the project was of four years, as it is customary in Portugal for research projects. The goal was to answer four main questions: what were the occupational patterns of human population in the Lis river Basin during the Pleistocene; what were the roles of the natural passageways that connect the inland to the coastline on the lifestyle of those populations, in particular during intense climate changes; how attractive was the concentration of resources such as shelters, caves, flint, water, salt, biodiversity (flora and fauna) in those natural passageways and ecotones, namely during the phases of climatic degradation, when the coastline was farther away; in what way do the cognitive abilities and social complexity of those populations reflect on the use and exploitation of the landscape, namely the marine resources (Pereira et al., 2018). Extensive surveys were conducted to discover potential raw material sources, new archaeological sites and determine which sites showed higher preservation and interest for intervention. In total, four sites were excavated: Gruta da Buraca da Moira (cave), Abrigo da Buraca da Moira (cave), Abrigo do Poço (rock shelter) and Praia de Pedrógão (open-air, nowadays a beach). Gruta da Buraca da Moira was excavated in 2015 but the test pit yielded no artefacts. Praia de Pedrogão was excavated in 2016 following the 2022 excavations by Aubry and colleagues (2005) and Mousterian implements were recovered, though in less quantity than those collected during the site’s initial discovery (Aubryet al., 2005; Pereira et al., 2018). Abrigo do Poço was excavated in four summer campaigns from 2015 to 2018. Its rich artefactual package included lithic implements (mostly of flint), charcoal and seashells, on two main occupational horizons, one attributable to the Epipaleolithic, with abundant seashells, and a second one attributable to the Solutrean, interpreted as being the result of the exploitation of a flint outcrop just above the shelter, nowadays almost completely exhausted of raw material (Pereira et al., 2021a, 2021b).

During one of the EcoPLis surveys the Abrigo da Buraca da Moira was once again located. At the time of its relocation, dense vegetation impeded the access to the site and blocked the view of most of the karstic formation. It was only after partial clearing of the dense thorny bushes that a gallery and a shelter were properly observed. The compact sediment under the shelter seemed undisturbed and no materials were visible on the surface, while on the inside of the gallery burrows had moved the sediment profusely. On the surface of this loose sediment rested human bones, lithic artefacts, pottery shards, and faunal remains (Pereira et al., 2015b). ABM was excavated concurrently to the Abrigo do Poço campaigns of 2015-2018. In 2021, a second phase of the EcoPLis project was approved, resuming ABM excavations during the summer of that same year, this time with no other sites being intervened simultaneously.

2.2 Geographical and Geological Setting

The Abrigo da Buraca da Moira site is located on the civil parish of Boa Vista e Santa Eufémia, municipality of Leiria, district of Leiria. Its coordinates are -39°46'38.57"N | 8°44'36.15"W | 113 m. In the national cartography it is represented in the Carta Militar de Portugal 1:25000 – Marrazes and the Carta Geológica de Portugal 1:50000 nº 23C – Leiria. It corresponds to a cave gallery filled with sediment. The cave has been sectioned by am artisanal quarry that exploited limestone during Medieval to Modern age times.

The geomorphological setting is the Western Portuguese Mesocenozoic Edge, on the northern border between the Estremenho Karstic Massif and the Condeixa-Sicó-Alvaiázere System (Martins, 1949; Teles, 1992). The site is on the left bank of the Ribeiro dos Murtórios, which is the stream that gives the name to the Ribeiro dos Murtórios Valley. This stream runs its course between the villages of Boavista and Fonte do Oleiro. Upstream of the village of Machado, the stream crosses Cretaceous, Lower Cenomanian, Albian, Aptian and Neocomian levels. From the Machado village until the mouth of the Leão Valley stream, the Murtórios stream crosses the Turonian limestone, and the valley configuration becomes significantly steeper with narrow banks. As it approaches its mouth at the Ribeiro dos Frades right bank, a right tributary of the River Lis, the landscape turns to a broad alluvial plain.

2.3 Excavation and Stratigraphy

Prior to any earth removal, the surface topography was recorded, the visible artefacts were 3D-located, and all were collected and recorded with an individual ID number. To get a better idea of the sedimentological potential of the site, a test pit of 1x1m (1m^2) was set outside the gallery (which was not visible at this stage), with the designation of J20 (fig. 3).

Figure 3. The J20 square, after vegetation removal and prior to the excavation (Pereira et al., 2015).

Due to the finding of human bones in J20, the excavation area was widened to its double as recommended by the DGPC (Direção Geral do Património Cultural), the state institution responsible for Portuguese cultural heritage. The expansion was directed north, the new square designated I20. The earth removal was done manually, following stratigraphic layers, with artificial subdivisions of 5 cm spits and each of the 1x1 m squares were subdivided into 0,50 cm and excavated accordingly. All artefacts found during excavation were coordinated three-dimensionally. The sediment from the top layer was sieved in water with a 3 mm mesh, while deeper layers' sediment was collected in its entirety to undergo flotation. Samples for parasite and phytolith were also collected. This intervention on the J20 and I20 squares was done during the month of September 2015 (Pereira et al, 2015b) and the month of August 2016 (Pereira et al., 2016). The stratigraphic profiles can be seen on Figure 4. The layers identified on the test pit were described as follows, according to Pereira et al. (2015b, 2016, 2017, 2018, 2021):

- Layer 1 (U.E. 1) – 50 cm thick. Heterogeneous silty deposit, with abundant organic matter, carbonated and highly bioturbated by burrows and roots. It contained limestone blocks (5-15 cm diameter), few pebbles, pieces of plastic, rusty nails, pottery, charcoal, microfauna, a complete badger (*Meles meles*) skull, a burnt animal bone, a shell of *Cerastoderma edule*, a fragment of *Scrobicularia plana* shell and two perforated *Littorina obtusata* shells. Being a heterogeneous layer, it had three subdivisions: 1A, 1B and 1C.
- Layer 2 (U.E. 2) – 10 cm thick. Corresponds to a burrow on the lower deposit of Layer 1. Made up of loose silty sediment, light brown in color and more organic in nature. It contained one faunal remain and some limestone blocks (5 cm diameter).
- Layer 3 (U.E. 3) – 45 cm thick. Silty deposit, highly carbonated, with marked presence of collapsed blocks of 20-30 cm diameter, beige/light gray in color. It rests under Layers 1 and 2. It contained fauna, pebbles, a small flint flake and a flint bladelet, as well as human osteological remains. A complete dog skeleton in anatomical connection was found on the artificial level 9 (N.A. 9). This dog has since been radiocarbon dated to ca. 170 BP (Detry, personal communication).
- Layer 4 – 5 cm thick. A pocket of silty gray sediment found next to the east stratigraphic profile on square J20, under Layer 3. Rich in organic material.

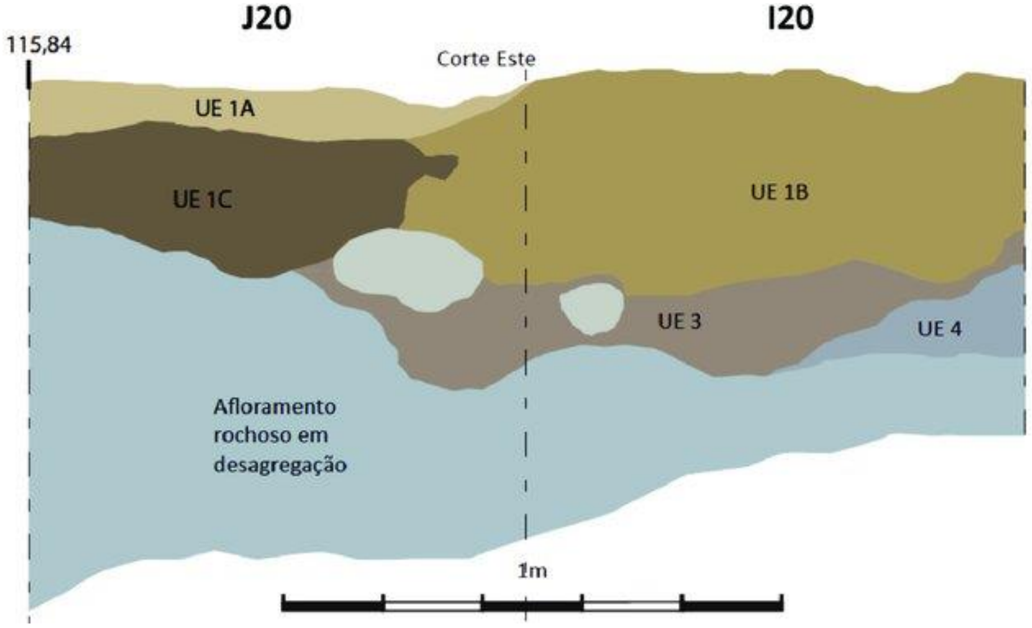

Figure 4. Eastern stratigraphic profile of the J20 and I20 squares.The bottom layer (light blue) corresponds to disintegrating bedrock. Adapted from Nora et al. (2017).

The results of this test pit were interpreted as a highly bioturbated necropolis dating to the Late Neolithic/Chalcolithic, with scarce burial objects and few small human remains, possibly due to removal of the large bones to be deposited elsewhere (Pereira et al., 2015; Assis et al., 2016; Nora et al., 2017; Assis et al., 2018). One important realization of the 2015 campaign was that the site did not constitute a rock shelter as previously thought (hence the denomination of *Abrigo*, Portuguese for *shelter*) but a sectioned cave, cut by quarrying in an undetermined chronology, meaning the excavated area, now only slightly covered, was once part of a gallery or corridor in a cave system (Pereira et al., 2015; Nora et al., 2017).

Figure 5. General aspect of the gallery, prior to excavation (Pereira et al., 2015)

Figure 6. Map of the excavation areas (adapted from Pereira et al., 2018).

Since bedrock was found in the bottom of the I-J20 test pit and the goal of the project was the Pleistocene, in the EcoPLis subsequent years, the area of intervention shifted towards the interior of the gallery (fig. 5 and 8) (Pereira et al., 2018; Pereira et al., 2021). Six squares were opened, not all to the same degree: P24-26 and Q24-26 (fig. 6). The methodology for the interior area was slightly altered. The excavation still followed stratigraphic units, and the 1x1 m squares were subdivided in 0,50x0,50 m quadrants, but no artificial units were established. Instead, earth removal was done according to 10-liter buckets in each quadrant. Altitude was measured prior to excavation and after the bucket had been filled. This allowed a more refined stratigraphy as the depth of excavation reached to fill an individual bucket is roughly 2-3 cm. Except for the first centimeters of sediment (Layers 5 and 6), which were sieved with water, the remaining sediment was collected for flotation. The stratigraphic profiles of the interior excavation can be seen on Figure 7. The layers identified were described as follows, according to Pereira et al. (2021):

- Layer 5 (U.E 5) – Covers the totality of the excavated area. Silty matrix, lumpy, loose, dark beige in color, in some areas dark brown. Highly bioturbated from roots and burrows. Contains modern pottery shards as well as human osteological remains. It corresponds to the trampled top portion of Layer 6.
- Layer 6 (U.E. 6) – Covers the totality of the excavated area. Silty matrix, slightly clayey, with grains of fine and medium sand. Presents a dark brown color, with some yellow zones. Contains artefacts of Contemporary, Neolithic/Chalcolithic and Upper Paleolithic periods. Contemporary findings include nails, plastic, ragged clothes and pottery shards. Neolithic/Chalcolithic findings include abundant human osteological remains, beads on bone and stone and lithic implements, such as a triangular arrowhead. Findings attributed to the Upper Paleolithic are essentially lithic implements, such as flint, quartz and quartzite flakes, relatively irregular bladelets, core maintenance elements and knapping fragments. Besides these artefacts, small vertebrate remains were identified, possibly the result of badgers using the gallery. Also, limb shafts of medium sized mammals could be part of the Upper Paleolithic occupation.
- Layer 7 (U.E. 7) – Covers the totality of the excavated area. Silty matrix, with coarse sand grains, lumpy and compact due to limestone precipitation. Presents a homogeneous beige/orange color, with punctual white spots, brown, light and dark orange lines. Extensively bioturbated by burrows and roots. At its base, it contains abundant tiny charcoal bits and ash, as well as limestone blocks and stalagmitic slabs, probably resulting

from the unsealing of the cave entrance during the Neolithic to make the necropolis.

- Layer 8 (U.E. 8) – Clay matrix. Quite compact. Brownish orange colored with white limestone inlays. It is homogeneous, suggesting that bioturbation did not spread across it, though one can see in the more interior squares that burrows have crossed this layer. It contained abundant lithic industry, faunal remains and charcoal, but no pottery shards.
- Layer 9 (U.E. 9) – Silty-clayey layer, with slightly more clay and more compact than Layer 8. Brownish orange color, like Layer 8, with white limestone inlays, less than Layer 8. It contained lithic industry, faunal remains and charcoal.
- Layer 10 (U.E. 10) – Found only on square P24 and topographically higher than the rest of the stratigraphic sequence. Silty layer with a high degree of carbonation resulting from precipitation originating from a ceiling dripping point, on which it is leaning. Orange pink color. Extremely compact, had to be excavated using an electric drill hammer. Contains abundant lithic, faunal, and charcoal elements.
- Layer 11 – Silty-clayey matrix, with more clay than Layers 8 and 9. Only sparsely excavated after removal of collapsed blocks embedded in the sediment. Contains lithics and faunal elements.

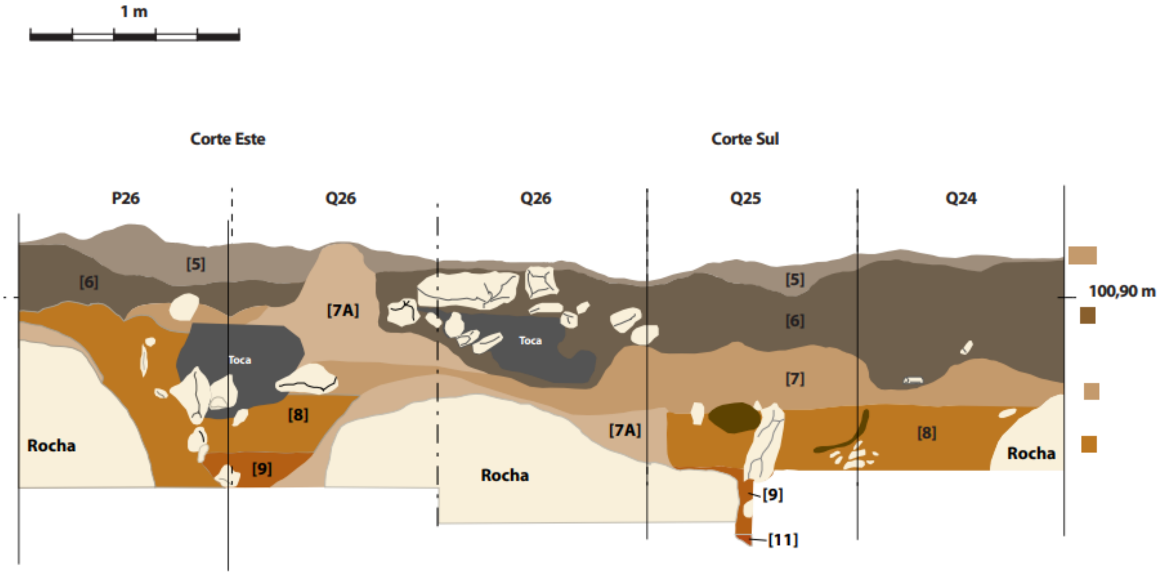

Figure 7. East (left) and South (right) stratigraphic profiles of the gallery intervention. Adapted from Perera et al. (2021).

So far, only cautious interpretations were put forward for the gallery layers, based on preliminary observations of the material culture and the site stratigraphic composition, since processing of the radiocarbon samples sent for dating has not been concluded. Listed here are the most recent interpretations made for each layer, according to Pereira et al. (2021):

- Layer 5 – Top of the mixed context of Neolithic/Chalcolithic (confirmed chronology and with ongoing further analysis) necropolis with the Modern Period. Trampled part of Layer 6.
- Layer 6 – Neolithic/Chalcolithic (confirmed chronology and with ongoing further analysis) necropolis context with Modern Period occupation. It is a single recent bioturbation layer caused in great part by badger burrows, mixing materials from all these chronologies.
- Layer 7 – Original necropolis context dated to Neolithic/Chalcolithic (confirmed chronology and with ongoing further analysis). The charcoal at the base might be the result of a cleaning process (ritualistic or not) prior to the deposition of human remains. This process, the deposition of remains and subsequent retrieval, as well as burrowing, might have disturbed the top of the paleolithic occupations and could explain the appearance of lithic implements attributable to this period.
- Layer 8 – Late Gravettian (presumable chronology; samples sent for radiocarbon dating) occupational context. The flint, quartz and quartzite industry, mainly in quartz, includes backed elements and a strong bladelet component. This and the fact that it is topographically lower than a find interpreted as a Vale Comprido point (a typical Proto-Solutrean artefact – recent observation of this artefact puts doubts to this classification), is coherent with this chronological attribution. The material package points to a recurrent occupation, though the low ceiling may indicate that the main occupation was elsewhere with a higher ceiling, probably in what is now the outside of the cave, at the time the front room of the cave.
- Layer 9 – Gravettian (presumable chronology; samples sent for radiocarbon dating) occupational context. The industry is in flint, quartz and quartzite, with a higher component of bladelet production made of

flint than of quartz. The type of occupation is once again seen as ans habitational one, again with the ceiling constraint.

- Layer 10 – Solutrean (presumable chronology; samples sent for radiocarbon dating) occupational context. Although there were no diagnostic artefacts, the package includes flakes, with multidirectional patterns, some with thermic alteration, which, altogether, seem to be bifacial thinning flakes. This, and the fact that is topographically higher than the aforementioned Vale Comprido point, suggests a Solutrean chronology.
- Layer 11 – Paleolithic occupational context. The volume excavated has been low, and so the materials are scarce. The package includes pieces of bladelet production, but also other very different implements, that may indicate a Mousterian industry. That being said, it is early to draw any conclusions on chronology or nature of occupation.

Figure 8. Interior of the gallery at the end of the 2021 campaign (Pereira et al., 2021).

CHAPTER 3. MATERIALS AND METHODS

3.1 Materials

The faunal remains used in this study consist of the mammalian bones and teeth retrieved from layers 7 to 11. Layer 7 yielded 16 3D-located faunal remains. Since all sediment underwent flotation, a lot more was retrieved in the coarse fraction, but the presence of human remains in the layer could mean that unidentified remains or bones from medium sized mammals, may correspond to human remains, thus they could contaminate the sample. On top of this, the coarse fraction from Layer 7 has not undergone sorting and cleaning, therefore no faunal remains from it are included in this study. From Layer 8, 74 remains were 3d-located. Furthermore, 383 remains were identified among the coarse fraction.

A 15mm minimum length or thickness of bone consistent with a small to large mammal was the criteria of selection of bones from the coarse fraction to include in the analysis. Of the 383 fragments, 62 either had a length of over 15mm or were otherwise fragments of small to large sized animals, therefore macrofaunal remains. These 62 fragments were included in the Layer 8 sample undergoing thorough observation, to a total of 136. The remaining fragments were counted, discriminated between bone and tooth, and checked for burnt marks. As several burrows were identified during the excavation, the choice to eliminate such small fragments from the detailed study seemed prudent so as not to contaminate the sample with more recent remains accumulated by badgers or other small carnivores.

Since there is no cut-line for 3D-plotting, some remains belonging to very small sized mammals were recovered during the excavation and have 3D coordinates. Those remains were accounted for in the taxonomical and anatomical analysis, to gain a complete view of the assemblage, something valuable at a project level, not so much as to the focus of this study – macromammals.

The lagomorph specimens will be featured on the data tables, and a brief commentary will be given.

The analysis of the burnt bones will include the remains of the coarse fraction not thoroughly analyzed (e.g. <15 mm specimens).

From Layer 9, 11 3D-located remains were recovered, and 5 others collected while sorting the coarse fraction, of which 1 fragment had a length of over 15mm, included in the analysis. The remaining fragments were dealt with as with the previous layer. Layer 10 yielded 6 3D-located remains and none were accounted for while sorting its coarse fraction. Layer 11 has been scarcely excavated so far, so only 1 3D-located bone fragment has been recovered.

3.2 Methodology

3.2.1 Washing and Sorting

The sample had not undergone any kind of treatment or cleaning process. The 3D-located samples were washed with water in a container and were carefully stroked manually to remove dirt and concretions. No brushing was done, to avoid damaging the surfaces. The water was regularly changed. On top of that, when cleaning of the samples from one layer had finished, the water was always thrown out and the container washed with soap, rinsed and dried.

The samples from the coarse fraction had already undergone some type of cleaning, since flotation or water sieving had been done. Still, some fragments needed additional cleaning, mostly due to persisting concretions. The procedure was identical as with the 3D-located samples.

Some of the bags containing the coarse fraction had not been sorted. Bone, shell, lithic artefacts, and micromammal remains such as rodent or herpetological ones were still mixed together. So, before the washing of the bone remains, labels were duplicated and the bone remains separated, washed and put in a new bag with the duplicate label.

3.2.2 Anatomical and Taxonomical Determination

The reference collection housed at the Catalan Institute of Human Paleoecology and Social Evolution (IPHES) was used for comparison of anatomical features and determination of taxa, and additionally the reference collection at the Laboratory of Archaeociences (LARC), in Lisbon, was consulted once. Additionally, these atlases of animal bones and teeth were consulted: *Atlas ostéologique pour servir à l'identification des mammifères du quaternaire* (Pales et al., 1971), *Atlas of Animal Bones: For Prehistorians, Archaeologists and Quaternary Geologists* (Schmid, 1972) and *Teeth* (Hillson, 2005), *inter alia*. This allowed for determining the anatomical element and taxon (at a species, genus, subfamily, or family level). Unidentified remains were classified as fragments of long bones, flat bones, or unidentified. When taxonomical identification was uncertain, a weight category was attributed, if possible. The categories follow Fernández-Laso et al. (2015): very small size – less than 5 kg; small size – between 5 kg and 100 kg; medium size – between 100 kg and 300 kg; large size – between 300 kg and 1000 kg; very large size – over 1000 kg. General dimensions (length, width, thickness) were taken for each specimen. Furthermore, when possible, the specimen was characterized in terms of portion (1-5; 1 – proximal epiphysis; 2 – proximal metaphysis; 3 – diaphysis; 4 – distal metaphysis; 5 – distal epiphysis), present surfaces (anterior; posterior; lateral; all four), laterality, estimated age and sex.

3.2.3 Quantification

The terminology of quantification units used in zooarchaeological analyses is not as clear as one would like in any given scientific field, as evidenced by the lists of terms compiled by Casteel & Grayson (1977) and subsequently by Lyman (1994a), which show overlapping of definitions, synonymic or redundant terms and erroneous or unclear definitions. With this in mind, the quantitative units used in this work are hereby presented and defined as clearly as possible.

The Number of Identified Specimens (NISP) is the sum of each “single bone or tooth or fragment thereof assigned to some taxonomic unit” (Grayson, 1984, p. 17). This calculation was discriminated by species (Klein & Cruz-Uribe, 1984; Davis, 1987, Lyman, 2008) and in some cases by genus, subfamily or family, when attribution to a species could not be achieved with certainty. The total of all NISP of a taxon was then calculated to give a better idea of the identified specimens in each layer. This quantification stands in contrast to the Number of Unidentified Specimens (NUSP) and the sum of both gives the Number of Specimens (NSP).

The second quantitative unit used in this work was the Minimum Number of Elements (MNE). Lyman (1994b, p. 289) provides a definition of skeletal elements as being “anatomical units that may be represented by fragments or by whole bones; that is, skeletal elements may be partially or completely represented respectively, by specimens”. As he also points out (Lyman, 1994b, 289), the distinction between specimen and element where concretely put forward previously by Voorhies (1969), Grayson (1984) and Badgley (1986). So, the MNI corresponds to the minimum number of single natural anatomical units (individual bone or tooth) that accounts for all the identified specimens (Lyman, 1994b). A comprehensive history of this quantitative unit and the debates surrounding it can be found in Lyman (2008, pp. 215-218).

The third and last quantitative unit used in this work was the Minimum Number of Individuals (MNI). It is a quantification of the lowest number of individual animals required to account for all the identified specimens of a given assemblage (Binford, 1981; Lyman, 1994b), calculated so by the most abundant element of each taxon (Gifford-Gonzalez, 2018). The MNI was subsequently divided into age groups (infantile, juvenile, adult, senile), similarly to Fernández-Laso et al. (2015, table 11), Cheheb et al. (2019, table 2), and Pineda et al. (2020, table 4).

3.2.4 Taphonomic Alterations

Taphonomy is the study of the transitional processes biological remains go through until they attain the fossilized state (Efremov, 1940). This field is of importance to zooarchaeology as it provides a methodological framework to observe and analyze the alterations that happened to bone and tooth since the death of the animal until its recovery in an excavation, or even until its publication (Lyman, 2008). Taphonomy aids in understanding the processes that have preserved, altered or destroyed the evidence of human-animal interactions in past societies (Behrensmeyer & Kidwell, 1985). As this study equally focuses on the taphonomic history of the sample, through observation of the bone surface modifications, here we present the main types of processes that cause said modifications and the kind of traces one is expected to observe. The observation of bone surface modifications was done by naked eye, and recurring to stereo microscope and Hirox digital microscope, both housed at IPHES.

3.2.4.1 Cut Marks

“Cutting marks can be inflicted on bone during dismemberment, defleshing, skinning, and removal of periosteum” (Gifford-Gonzalez, 2018, p. 282). Leaving a cut mark on a bone is not in itself an intentional action. The goal is not to leave a mark on the bone, but to remove soft tissues. In doing so, the cutting edge may come into contact with bone tissue and leave a mark. Shipman & Rose (1983) describe four main characteristics of cut marks: a V-shaped cross section, though U-shaped may also occur; elongated marks; presence of striations on the wall of the mark parallel to it; “shoulder effect” (striae parallel to the main mark depression) and/or “barbs”, curved striations at one or both ends of the depression. These characteristics must be taken into conjunction and not as isolated characteristics that safely establish a given score as being a cut mark (Lyman, 1994c). Bromage & Boyde (1984) also point to the fact that cut marks might produce Hertzian fractures, and therefore give directionality. Hertzian fractures are triangular shaped flake negatives on the margins of the cut mark, resulting from the conical (Hertzian fracture cone) distribution of energy on impact, like what happens with lithic industry when a hammerstone (or other striking object) strikes the core to extract flakes or blades/bladelets).

The presence, or absence, of the aforementioned features was the criteria for the determination of certain scores as cut marks. Extensive literature exists on location of cut marks in terms of skeletal element and bone portion (e.g. Guilday et al., 1962; Lyman, 1987; Noe-Nygaard, 1989; Gilbert & Jimenez, 1991), but as **Chapter 4** will expose the results, such determinations were unsuccessful.

3.2.4.2 Bone Breakage

The methodology applied to the description of fractures on long bones is based on the works of Haynes (1983), Gifford-Gonzalez (1989) and Villa & Mathieu (1991). Three characteristics were observed: the angle, the outline and the surface of each fracture. The angle was discriminated as right (*r*), oblique (*o*) and mixed (*m*) (along the fracture the angle changes). The outline was discriminated as transverse (*t*), curved (*c*), though the fractures attributable by the Villa & Mathieu (1991) to the category of ‘intermediate’ were bundled with the ‘curved’ ones, and longitudinal, consisting of straight fractures that follow the axis of the bone (Haynes, 1983; Gifford-Gonzalez, 1989). The edge of the fracture was described as either smooth (*s*) or irregular (*i*), otherwise known as ‘jagged’ (Villa & Mathieu, 1991). All preserved fractures on long bone shafts were analyzed using these parameters, though because of sample size, only the Layer 8 remains were statistically treated in terms of their frequency, to find patterns.

This method is very useful to identify if the main fractures in the assemblage were produced in green (fresh) or in the dry state of the bone.

Percussion notches, usually observed on long bone shafts, are described as being broad, with negative flake scars surrounding the impact point (Bonnichsen & Will, 1980; Bunn, 1981; Johnson, 1983; Blumenschine & Selvaggio, 1991; Pickering & Egeland, 2006). They may result by either hitting the stabilized bone with a semi-blunt, pointed object, or the bone is swung against the stabilized object (Noe-Nygaard, 1989; Blasco et al., 2014). The distinction between percussion notches and carnivore marks proves difficult (Binford, 1981; Haynes, 1983), but attempts at quantification have showed promising results (Blumenschine & Capaldo, 1994; Oliver, 2015). The goal of breaking open long bone shafts is the access to the highly nutritious bone marrow contained inside (Blasco et al., 2004). Bone marrow on ungulates contains fat, minerals, vitamins, and fatty acids (Steiner-Bogdaszewska et al., 2022), a desirable trove of nutrients for both carnivores and humans.

3.2.4.3 Burned Bones

The exposure to fire causes alterations on bones that include color change, morphological changes at a microscopic level, crystalline structural changes, and general size reduction of the specimen (Shipman et al., 1984).

For the present work, the degree of burning was established using the parameters set by Stiner et al. (1995, Table 3).

Table 1. Degree of burning of remains, following Stiner et al. (1995, Table 3).

Degree	Characteristics
0	Not burned (cream/tan)
1	Slightly burned; localized and <half carbonized
2	Lightly burned; >half carbonized
3	Fully carbonized (completely black)
4	Localized <half calcined (more black than white)
5	>half calcined (more white than black)
6	Fully calcined (completely white)

3.2.4.4 Gnawing Damage

Here we use this concept as it is described by Lyman (2008). It includes the damage caused by carnivores, rodents and ungulates to bones, in detriment to the expression ‘tooth marks’ as that is the common result of this process. Later stages of gnawing alter the bone in such a fashion that one can hardly observe a tooth mark per se (e.g. furrowed or forked epiphyses).

3.2.4.5 Root etching

As far back as the 1930s there were descriptions of modifications on bone surfaces hypothesized of being the result of the contact of the bone with plant roots (Pei, 1938). This effect has been called root etching (Binford, 1981) or alternatively dendritic erosion (Gifford-Gonzalez, 2018). Effectively, the acidic action of roots on the bone produces “irregular networks of shallow grooves” (Gifford-Gonzalez, 2018, p. 344). Alternatively, the acidic action comes not from the roots themselves, but from the fungi decomposing the roots attached to the remain (Grayson, 1988). For the present work, the distinctive marks were characterized according to their disposition (clustered, generalized, isolated) and their distribution (on how many sides of the bone was it present, from 1 to 4).

3.2.4.6 Other Alterations and Processes

Abrasion refers to the mechanical action caused by several agents that results in rounding, polishing, scratches, and striations (Gifford-Gonzallez, 2018). It may be caused by aeolian action, as sediment particles clash with and slide along the bone surface as they are transported by the wind, usually affecting only the exposed surfaces of the bone (Shipman & Rose, 1983). During fluvial transport (or any other kind of moving water body) the bones tumble on the riverbed pebbles and sediments, suffering the impact of sediment particles in suspension on the passing water, causing abrasion by rounding, flaking, polishing and scratching bone surfaces (Behrensmeyer, 1982; Fernandez-Jalvo & Andrews, 2003; Domínguez-Rodrigo et al., 2018). The cycles of freeze-thaw present in colder climates can cause striations, fissures, breakage and disintegration of faunal remains (Behrensmeyer, 1978; Ubelaker, 1997; White & Folkens, 2005).

Weathering was defined by Behrensmeyer (1978, p. 153) as “the process by which the original microscopic organic and inorganic components of bone are separated from each other and destroyed by physical and chemical agents operating on the bone *in situ*, either on the surface or within the soil zone”. Simply, put, weathering entails the destruction of bone tissue by its exposure to the natural cycles when at a surface level or a subaerial one, sometimes rendering difficult the extraction of information and interpretation (Brain, 1967; Hill, 1976). Behrensmeyer (Behrensmeyer, 1978). The sample was looked at to see if any weathering stages could be established, but the nature of the depositional context did not allow for such alterations (see **Chapter 5**).

3.2.5 Selection of Samples for Radiocarbon Dating

Unfortunately, the results of the radiocarbon dating for the layers analyzed will not be known before the conclusion of this work, but we are hopeful the preservation of collagen is good enough to obtain much needed results concerning the chronology of the Pleistocene occupation of the site.

CHAPTER 4. RESULTS

4.1 General Observations

As the site is part of a karstic system, some alterations were expected. The totality of the remains from all layers analyzed show calcium carbonate concretions. It presents itself as a generalized distribution on all sides. The washing process eliminated a great deal of the concretions, which in some cases were a complete cover of the remain forming a layer of up to 1 mm, sometimes even rendering the identification of the material in question as bone quite difficult. With most of the concretions eliminated, remains of it could still be found on all surfaces, especially lodged in depressions, holes, but also on more regular surfaces. This condition became especially troublesome when selected samples were subjected to microscopic observations.

4.2 Layer 7

From Layer 7, 16 mammalian remains were recovered, of which 9 (56,25%) were identified at species, genus, subfamily, or family level.

Table 2. Layer 7 remains by Number of Identified Specimens (NISP), Number of Unidentified Specimens (NUSP) and Number of Specimens (NSP).

Layer 7	NSP	%NSP
NISP	9	56,25
NUSP	7	43,75
Total	16	100

The anatomical representation of the sample can be seen on Table 3, and the NISP, MNE and MNI of the macromammal specimens on Table 4. The taxa identified were *Equus sp., Cervus elaphus*, Caprinae and Leporidae. The small macromammal sample is made up mostly of limb bone specimens (9), along with two rib fragments of *Cervus elaphus*, and one vertebra fragment of a small sized mammal, making a total of 3 axial remains.

For all the identified taxa the MNE was 2, corresponding to a MNI of 1, all adults. Besides the identified taxa, a fragment of vertebra and of long bone of a small sized animal represent two elements and subsequently one individual of unidentified taxon. It is possible that they may be from the same individual as the one identified as Caprinae, given that all specimens are of small sized animals, but no attributions of that kind may be done without analyses of a chemical nature.

Table 3. Layer 7 remains divided by taxon and anatomical element. In brackets is the Minimum Number of Elements for that specific skeletal element. In blue are the microfaunal remains, not central to this study.

Anatomical Element	***Equus* sp.**	***Cervus elaphus***	**Crapinae**	**Leporidae**	**Large Size**	**Medium Size**	**Small Size**	**Very Small Size**	**Total**
Rib	-	2 (1)	-	-	-	-	-	-	2
Vertebra	-	-	-	-	-	-	1	-	1
Humerus	-	-	-	1	-	-	-	-	1
Femur	-	-	1	-	-	-	-	-	1
Sesamoid	1	-	-	-	-	-	-	-	1
Metapodium	-	2 (1)	-	-	-	-	-	-	2
Phalanx	1	-	1	-	-	-	-	-	2
Long bone	-	-	-	-	1	1	1	1	4
Unidentified	-	-	-	-	-	-	1	1	2
Total	**2**	**4**	**2**	**1**	**1**	**1**	**3**	**2**	**16**

Table 4. Layer 7 Number of Identified Specimens (NISP), Minimum Number of Elements (MNE) and Minimum Number of Individuals (MNI) for each taxon.

				MNI by Age Group
Taxon/Size	**NISP**	**MNE**	**MNI**	**Adult**
Equus sp.	2	2	1	1
Cervus elaphus	4	2	1	1
Caprinae	2	2	1	1
Leporidae	1	1	1	1
Total	**9**	**7**	**4**	**4**

4.2.1 Taphonomic Aspects of the Layer 7 Assemblage

As for the taphonomic alterations, fractures, rounding and burnt marks were identified, other than the general concretions.

Specimen Q26-360, a femur diaphysis of a Caprinae, showed signs of rounding. Such an alteration can be the result of many phenomena, and the agent of this alteration was not identified.

Specimen Q25-354, a complete phalanx of a Caprinae, showed signs of thermal alteration through exposure to fire, to a degree of 5 (see Table 1 for degrees of burning on bones).

Four specimens of long bones had fractures:

- Specimen Q26-333 – fragment of proximal epiphysis and metaphysis of a *Cervus elaphus* metacarpus. Three fractures.
- Specimen Q25-289 – fragment of long bone diaphysis (possibly the metaphysis) of a large sized mammal. Five fractures.
- Specimen P25-175 – fragment of long bone diaphysis of a medium sized mammal. Four fractures.
- Specimen P26-331 – fragment of long bone metaphysis of a small sized mammal. Three fractures.

Since no impact marks were identified, the nature of these fractures cannot be ascertained. Any number of agents, human and non-human, may have contributed to the fracturing of these remains.

In sum, the lack of distinct taphonomic features identified leaves us with the question of the nature of the accumulation on Layer 7. The burnt metapodium may have been accidentally exposed to the cleaning fire, mentioned in the interpretation of the site discussed in point **2.3**, prior to the deposition of human remains, or may have been an intentional addition to the fire. At present, its origin is still unknown, as with the remaining assemblage. A carnivore accumulation is plausible, as is a human one. Transport by earth movement or by water seems unlikely, as more severe damage would be expected.

4.3 Layer 8

Of all the layers selected for this study, Layer 8 is the richest in fauna. 137 mammalian remains were studied (Table 5), of which 28 (20,44%) were identifiable at a species, genus or family level.

Table 5. Layer 8 remains by Number of Identified Specimens (NISP), Number of Unidentified Specimens (NUSP) and Number of Specimens (NSP)..

Layer 8	**NSP**	**%NSP**
NISP	28	20,44
NUSP	109	79,56
Total	137	100

The anatomical representation of the sample can be seen on Table 6, and the NISP, MNE and MNI of the macromammal specimens on Table 7. The taxa identified were *Equus* sp.*, Cervus elaphus*, *Bos primigenius*, *Sus* scrofa for the macrofauna. Some Leporidae (*Oryctolagus cuniculus, Lepus* sp*.* and undetermined Leporidae) also made part of the sample, either because they were 3D-located remains, or because they were coarse fraction remains with >15mm maximum length. The lagomorphs are not part of the central question of this work, but a brief commentary will be provided, as to their origin and the burnt marks present on a portion of them (analyzed remains and counted remains of the coarse fraction; see point **3.1**)

Tabela 6. Layer 8 remains divided by taxon and anatomical element. In brackets is the Minimum Number of Elements for that specific skeletal element or the inferred element from the identified isolated teeth.

Anatomical Element	***Equus* sp.**	***Cervus elaphus***	***Bos primigenius.***	***Sus scrofa.***	**Leporidae**	**Large size**	**Medium size**	**Small size**	**Very Small Size**	**Unidentified**	**Total**
Horn/antler	-	1	-	-	-	-	-	-	-	-	1
Cranium	-	-	-	-	2	-	-	-	-	-	2
Maxilla	0 [1]	-	-	-	0 [1]	-	-	-	-	-	0 [2]
Mandible	0 [1]	-	0 [1]	-		-	-	-	-	-	0 [2]
Isolated tooth	3	-	1	-	1	-	-	-	-	1	6
Rib	-	1	-	-	-	-	2	-	-	-	3
Coxal	-	-	-	-	1	-	-	-	-	-	1
Scapula	2 (1)	-	-	-	1	-	-	-	-	-	3
Humerus	-	2	-	-		-	-	-	-	-	2
Radius	-	-	-	-	1	-	-	-	-	-	1
Tibia	-	-	-	-	2	-	-	-	-	-	2
Carpal/Tarsal	2 (2)	1	-	-		-	-	-	-	-	3
Metapodium	-	5 (4)	-	-	1	-	-	1	-	-	7
Phalanx	-	-	-	1	-	-	-	-	-		1
Long bone	-	-	-	-	-	2	23	7	23	1	56
Flat bone	-	-	-	-	-	4	13	4	3	4	28
Unidentified	-	-	-	-	-	-	6	3	2	9	20
Total	**7 [2]**	**10**	**1 [1]**	**1**	**9**	**6**	**44**	**15**	**28**	**15**	**136**

Limb bone specimens (47) comprise roughly half (47,47%) of the macromammal bone assemblage (Table 8), followed by the flat/undetermined specimens (43; 43,43%) the axial bones (4; 4,04%) and finally the tooth specimens (5; 5,05%). It is important to note that the flat/undetermined bones may have been part of either limb or axial bones, therefore roughly a third of the assemblage is not possible to discriminate in this skeletal division. Alternatively, if we take into consideration the isolated teeth and their inferred skeletal element, maxilla or mandible, then the number of directly observed and inferred specimens is 13 in a total of 84 (15,47%).

Table 7. Layer 8 macromammal tooth remains. On the category, uppercase indicates maxillar tooth, lowercase indicates mandibular tooth.

Specimen	**Taxon/Size**	**Category**	**Side**
Q26-395	*Equus* sp.	Unidentified	Unidentified
Q25-551	*Equus* sp.	Decidual P3	Right
Q26-437	*Equus* sp.	m3	Left
Q25-467	*Bos primigenius*	m3	Right

Table 8. Layer 8 remains distributed by limb bones, axial bones, flat/undetermined and teeth of macromammals.

	***Equus* sp.**	***Cervus elaphus***	***Bos primigenius***	***Sus scrofa***	**Large Size**	**Medium Size**	**Small Size**	**Unidentified**	**Total**
Axial Bones	0	2	0	-	-	2	-	-	4
Limb Bones	4	8	-	1	2	23	8	1	47
Flat/ Unidentified	-	-	-	-	4	19	7	13	43
Isolated Teeth	3	-	1	-	-	-	-	1	5
Total	7	10	1	1	6	44	15	15	99

As for the MNI, *Equus sp.* is the most represented taxon, albeit with only 2 minimum individuals, one juvenile and one adult. *Cervus elaphus*, *Bos* sp. and *Sus sp.* all have a minimum of 1 individual in Layer 8, each dead at adult age.

Table 9. Layer 8 Number of Identified Specimens (NISP), Minimum Number of Elements (MNE) and Minimum Number of Individuals (MNI) for each taxon. N/A – not applicable.

				MNI by Age Group	
Taxon/Size	**NISP**	**MNE**	**MNI**	**Juvenile**	**Adult**
Equus sp.	6	5	2	1	1
Cervus elaphus	10	8	1	-	1
Bos sp.	1	1	1	-	1
Sus sp.	1	1	1	-	1
Oryctolagus cuniculus	1	1	1	-	1
Lepus sp.	3	3	1	-	1
Leporidae	5	4	N/A	N/A	N/A
Total	**27**	**23**	**7**	**1**	**6**

4.3.1 Taphonomic Aspects of the Layer 8 Assemblage

On Layer 8 there are several indicators of human activity. These are: cut-marks, intentional bone breakage and burnt bones. That being said, other taphonomic alterations were observed, namely caused by carnivore activity, root-etching, and a few alterations of unknown agent(s), other than the general concretions.

Cut Marks

One specimen, Q25-694, shows evidence of butchering activities in the form of cut marks. It is a fragment of flat bone of an unidentified middle-sized animal. Q25-694 presents two incisions rather close to each other (fig. 9 and 10), in a cluster. They have a V-shaped cross section, but concretions do not allow for better observation of other common features such as Hertzian fractures, which could give directionality (Bromage & Boyde, 1984), parallel striations on the groove (Potts & Shipman, 1981), shoulder effect and barbs (Shipman & Rose, 1983).

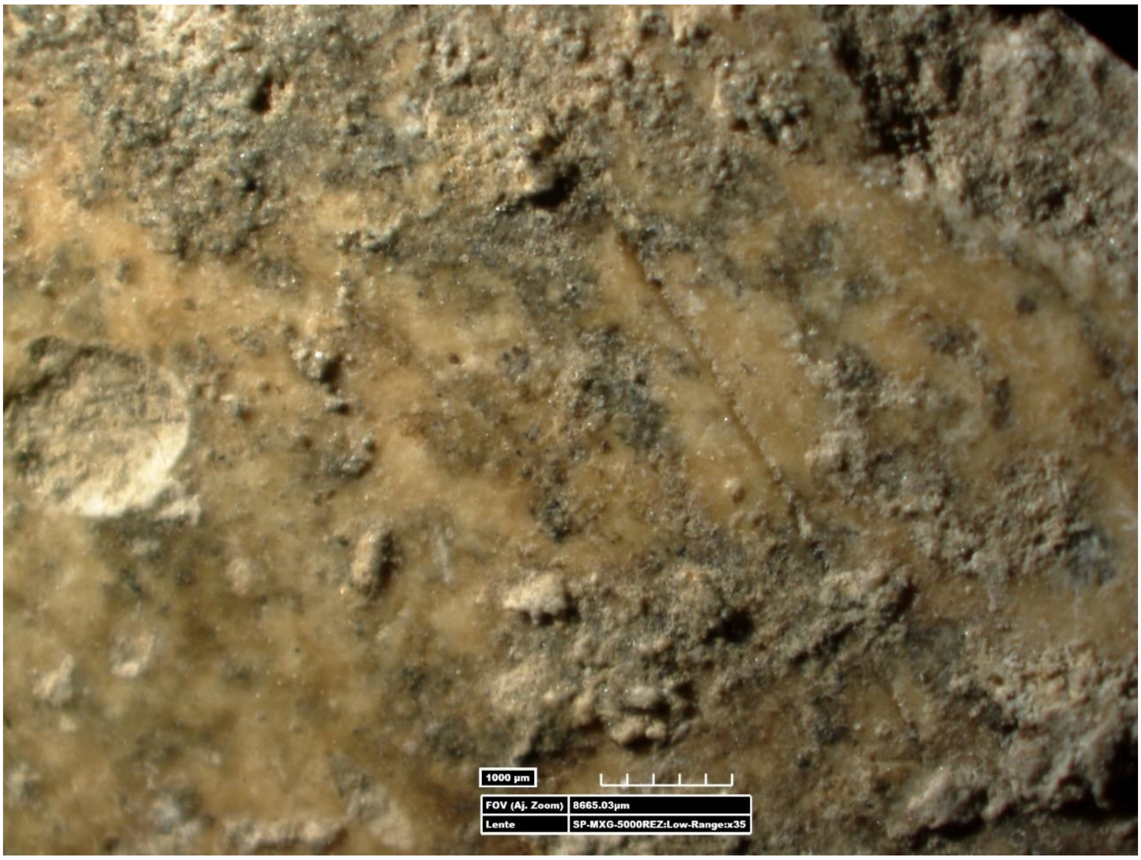

Figure 9. Microscopic image of the two possible cutmarks on specimen Q25-694.

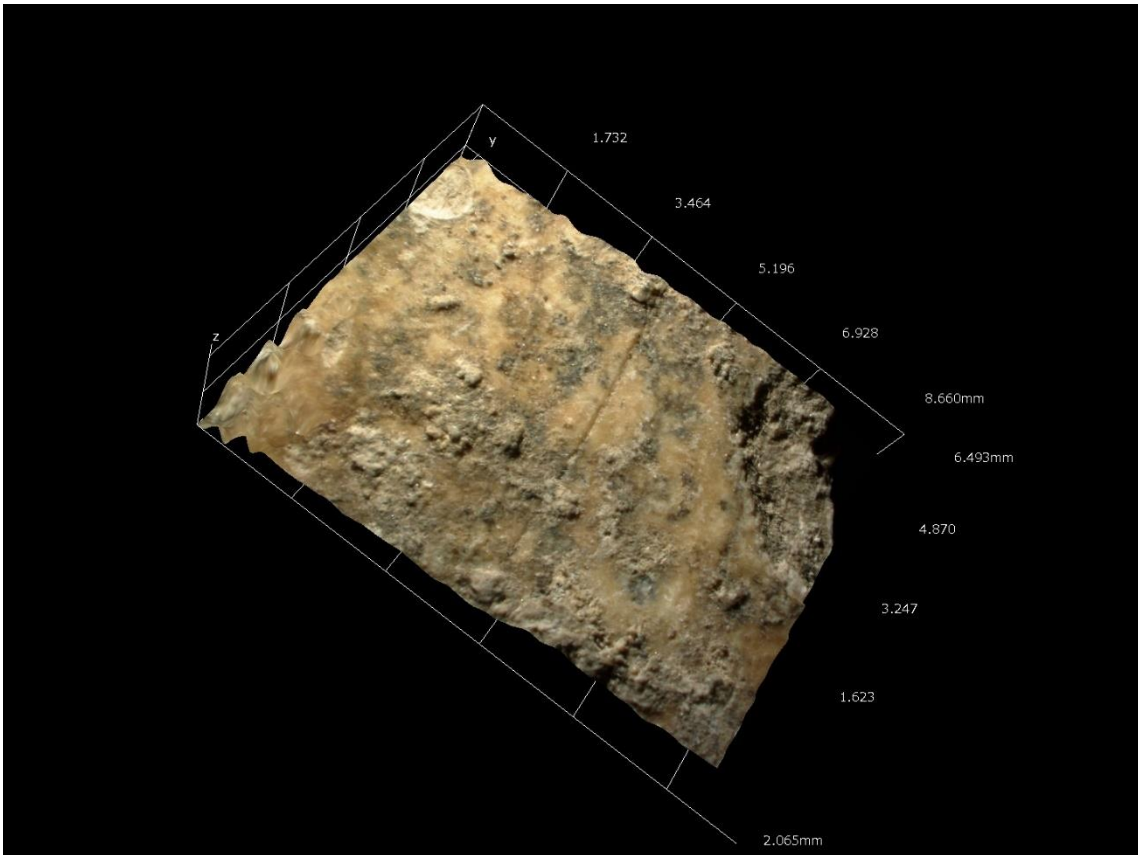

Figure 10. 3D model of the specimen Q25-694 area with the possible cut marks.

Percussion Marks and Fractures

Specimen Q25-495 is a fragment of left humerus of *Cervus elaphus*, specifically the distal end of the diaphysis, presenting partially the posterior and interior surfaces, and only a remnant of the exterior surface. Four percussion notches were observed, resulting from three consecutive strikes on the interior surface and one counterstrike on the exterior surface (fig. 11 and 12). An adhering flake stands beside the counterstrike, the result of another impact. This many notches, with broad morphology, arcuate morphology, negative flake scars (Bunn, 1981; Johnson, 1983; Blumenschine and Selvaggio, 1991) the adhering flake and their respective location in relation to each other and on the bone, leave little doubt as to an intentional anthropogenic action to extract marrow)

Figure 11. Q25-495 with all impact notches and adhering flake visible. a, b, c, d – impact notches; e – adhering flake.

Figure 12. Lateral interior surface view of Q25-595 with the three consecutive impact notches indicated.

Specimen Q25-550 is a fragment of a humerus of *Cervus elaphus*, side undetermined. It is a portion of the anterior and lateral surface of the proximal end of the diaphysis. It is possible to observe two consecutive impact notches on the lateral surface (fig. 13). It is important to point out that the surface of the bones has been altered by extensive root-etching, an alteration which will be discussed further down.

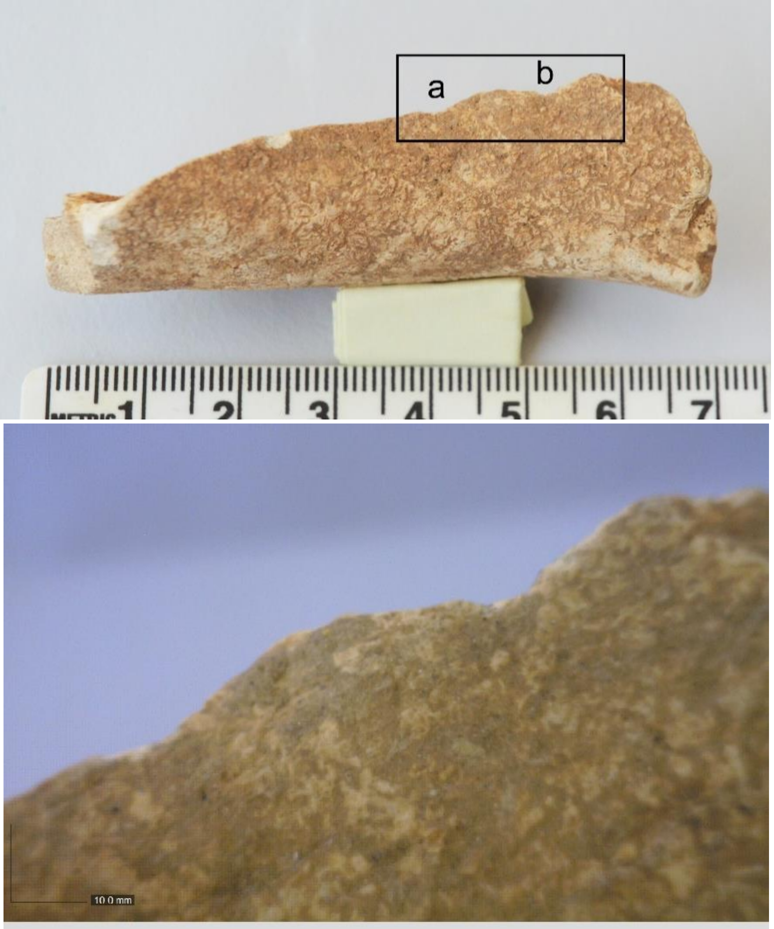

Figure 13. Q25-550 with the two observable notches (a, b; upper picture), and a close up (lower picture)

Specimen Q25-459 is a fragment of a long bone diaphysis from a medium sized animal (fig. 14). It displays what seems to be a bulb, hence its interpretation as being a flake caused by an impact on the shaft of the long bone, possibly to extract marrow.

Figure 14. Specimen Q25-459 with the bulb indicated.

In regard to the fractures on long bone shafts, the results can be seen on Table 10 and Figure 15.

The results show no clear pattern of bone fracturing, though fractures with oblique angles and irregular surfaces generally stand out in transversal and curved orientations. Longitudinal fractures display straight and oblique angles the most, regardless of fractures smoothness.

Table 10. Layer 8 Fracture characteristics. The left column indicates the orientation of the fracture. The top line, with the pairs of letters, indicates angle of fracture in relation to the cortical surface, and the surface of the fracture in regard to its smoothness. *rs* – straight angle and smooth surface; *ri* – straight angle and irregular surface; *os* – oblique angle and smooth surface; *oi* – oblique angle and irregular surface; *ms* – mixed angle and smooth surface; *mi* – mixed angle and irregular surface.

Layer 8 Fracture Characteristics							
	rs	**ri**	**os**	**oi**	**ms**	**mi**	**Total**
Longitudinal	11	9	8	8	5	5	46
Transversal	1	5	2	11	1	4	24
Curved	7	7	9	14	6	8	51
Total	19	21	19	33	12	17	121

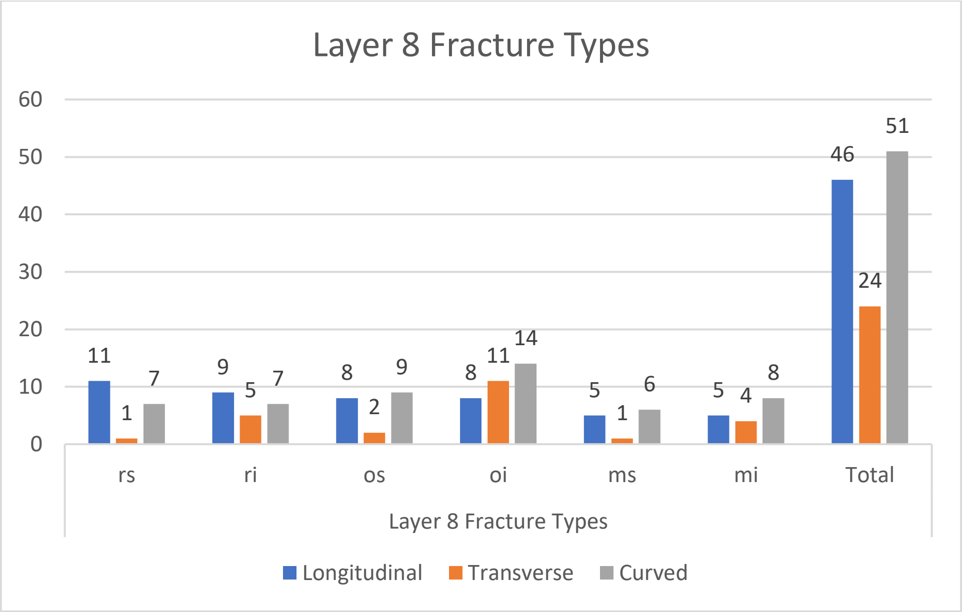

Figure 15. Bar chart displaying the fracture characteristics on Layer 8. On the bottom, the pairs of letters indicate angle of fracture in relation to the cortical surface and the surface of the fracture in regards to its smoothness. *rs* – straight angle and smooth surface; *ri* – straight angle and irregular surface; *os* – oblique angle and smooth surface; *oi* – oblique angle and irregular surface; *ms* – mixed angle and smooth surface; *mi* – mixed angle and irregular surface.

Burned Bones

As it was described in **3.2**, the coarse fraction of the Layer 8 was looked at to retrieve specimens bigger than 15 mm in length or otherwise compatible with macromammal skeletal parts. The remaining faunal remains were discriminated as bone or tooth and checked for burnt elements. So, 457 – 136 from analyzed sample and 321 from coarse fraction remains <15 mm in length – remains were observed to establish degrees of burnt elements. The results can be seen on Tables 11, 12 and 13 and on Figure 16.

Table 11. Layer 8 faunal remains (analyzed sample and remaining coarse fraction) by their degree of burning, following methodology of Steiner et al. (1995).

Layer 8 Burned Bones		
Degree of Burning	**Number of Remains**	**%**
0	390	85,34
1	6	1,31
2	3	0,66
3	39	8,53
4	2	0,44
5	12	2,63
6	5	1,09
Total	**457**	**100**

Table 12. Layer 8 burned and non-burned faunal remains from the sample and remaining coarse fraction.

	Sample + Fraction	**%**
Burned	67	14,66
Non-Burned	390	85,34
Total	**457**	**100**

Table 13. Layer 8 burned and non-burned faunal remains discriminated between sample remains and remaining coarse fraction remains.

	Analyzed Sample	**%**	**Coarse Fraction**	**%**
Burned Bones	13	9,56	54	16,82
Non-Burned	123	90,44	267	83,18
Total	136	**100**	321	**100**

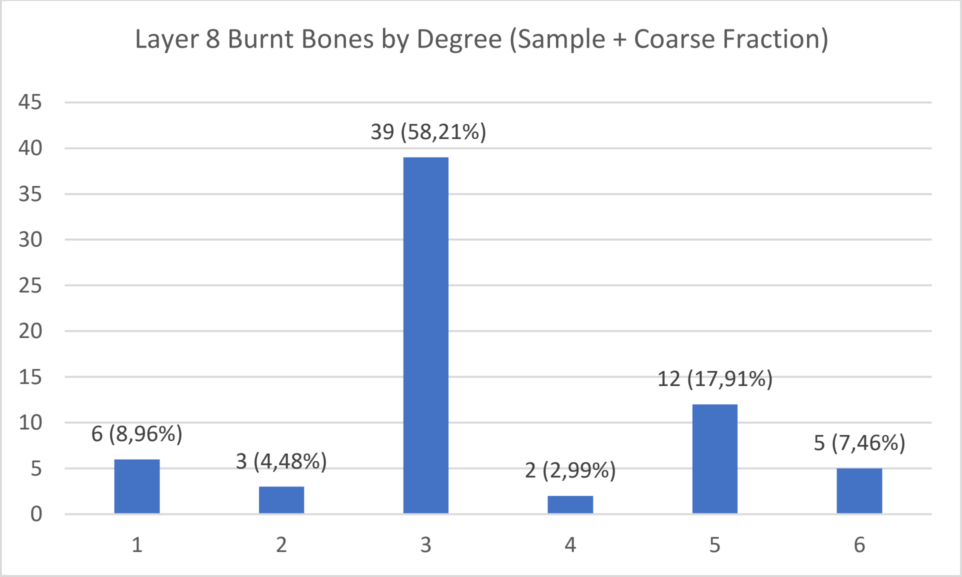

Figure 16. Bar chart displaying Layer 8 burned faunal remains (sample and remaining coarse fraction) by degree.

The vast majority of bones do not display burnt marks, whether in the analyzed sample (90,44%), the remaining coarse fraction (83,13%) or when combining both (85,34%). Burnt marks give evidence to the presence of fire, and their presence in a cave context live little doubt as to the anthropic origin of the fire, which will be discussed in **Chapter 5.**

Regarding the bones with burnt marks, the major degree present is 3 with 58,21%, followed by degree 5 with 17,91%, degree 1 with 8,96%, degree 6 with 7,46%, degree 2 with 4,48% and finally degree 4 with 2,99%.

The skeletal representation of burnt specimens from the analyzed sample can be seen on Table 14. The sample is too small to make any concrete remarks, but long bones, 1 Leporidae radio and 6 long bone fragments from very small to medium sized mammals, make up the majority of identified specimens (9,09% + 54,55% = 63,64%).

Table 14. Layer 8 skeletal representation of burnt bones by taxa/size.

Skeletal Element	**Leporidae**	**Medium Size**	**Small Size**	**Very Small Size**	**Unident.**	**Total**	**%**	**% Identified elements**
Radio	1	-	-	-	-	1	7,69	9,09
Long	-	3	1	2	-	6	46,15	54,55
Flat	-	1	1	-	2	4	30,77	36,36
Unident.	-	2	-	-	-	2	15,38	
Total	**1**	**6**	**2**	**2**	**2**	**13**	**100**	**100**

The coarse fraction specimens, not fully analyzed, were discriminated between bone and tooth and the burnt marks distribution can be seen on Table 15. Bone fragments comprise the vast majority of the burnt remains, at 88,89%, with tooth specimens making up the remaining 11,11%.

Table 15. Layer 8 coarse fraction remains smaller than 15 mm displaying burnt marks, discriminated by bone and tooth specimens. NSP – Number of Specimens.

Material	**NSP**	**%**
Bone	48	88,89
Tooth	6	11,11
Total	54	100

Specimen Q25-459, the impact flake discussed on the **Percussion Marks** taphonomy section, is one of the specimens with a burnt degree of 6. No burnt marks were observed in the other specimens with evidence of anthropogenic action.

Gnawing Damage

Specimen Q25-690, a fragment of diaphysis of a medium sized mammal, has an isolated score with transversal orientation consistent with carnivore mark (fig 17). It is sections at a straight angle what seems to be another score, but this is less safe to say.

The relatively small width of the score indicates a small carnivore. The possibility of a rodent mark is not left out.

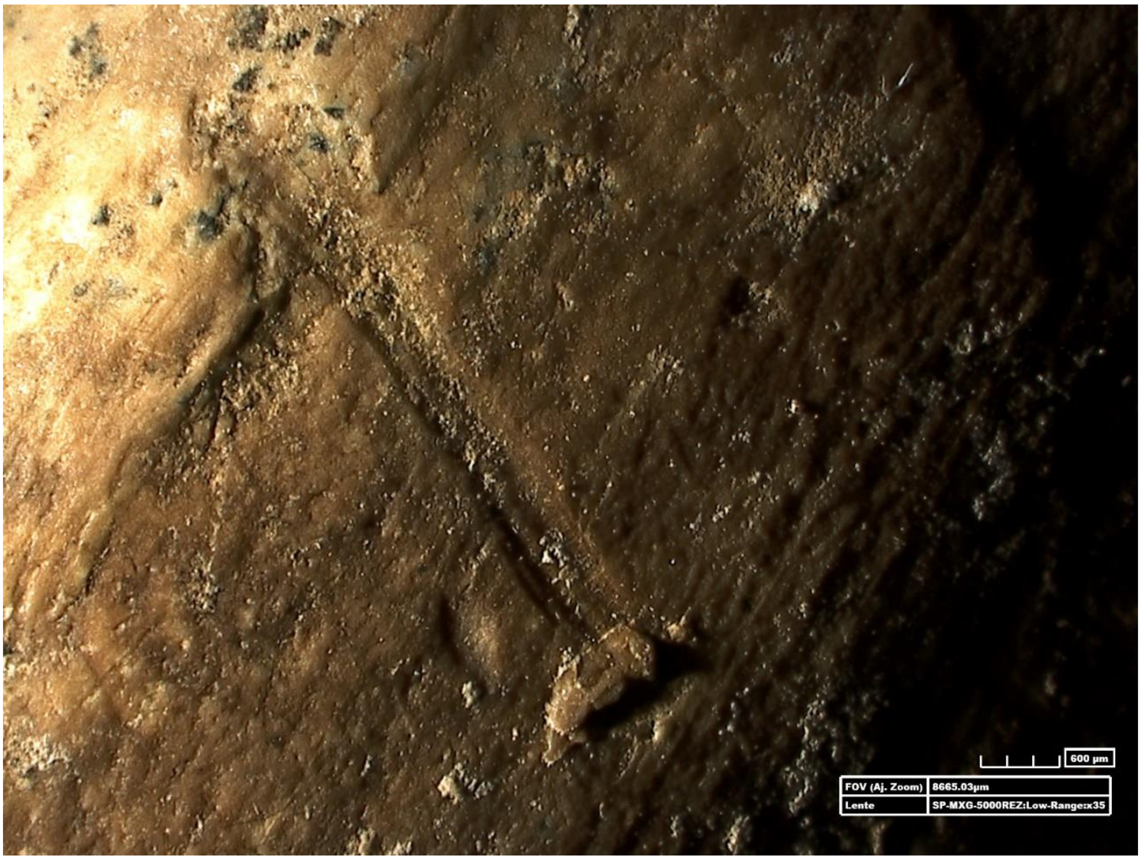

Figure 17. Microscopic image of the carnivore score on specimen Q25-690.

Root etching

On Layer 8, 11 macromammal specimens showed alterations attributed to root etching (Table 16). Except for of Q25-690, which had a modern root still attached, all other remains were no longer enveloped by roots and their scores looked ancient (example and comparison on fig. 18 and 19), as concretions had filled the negative impressions of the grooves.

Table 16. Layer 8 specimens with surface alterations caused by root etching

Specimen	Taxon/Size	Disposition	Side
Q25-550	*Cervus elaphus*	Generalized	All
Q25-615	*Cervus elaphus*	Generalized	Cortical
Q25-590	Large	Generalized	All
Q25-690	Medium	Isolated	Cortical
Q25-577	Medium	Generalized	All
Q25-328	Medium	Clustered	Cortical
Q25-618	Medium	Generalized	All
Q25-360	Medium	Cluster	Cortical
Q25-525	Medium	Generalized	Cortical
Q25-522	Small	Generalized	Cortical
Q25-632	Unidentified	Generalized	All

Figure 18. Specimen Q25-690 with traces of a recent root, highlighted.in red. The root was still attached and was removed during cleaning.

Figure 19. Specimen Q25-550, with extensive root etching with concretions filling the scores.

Other Bone Surface Alterations

Specimen Q25-423, a fragment of flat bone of a middle-sized animal, presents an isolated scratch/incision (fig. 20 and 21). Concretions prevent a clear observation of characteristic traces of cut marks such as Hertzian fractures (Bromage & Boyde, 1984); parallel striations (Potts & Shipman, 1981), shoulder effect and barbs (Shipman & Rose, 1983). Furthermore, the cross section of the groove is U-shaped, in contrast to the more common V-shaped cross section (Shipman & Rose, 1983). While the anthropic origin of this mark should not be entirely ruled out, trampling might be a probable cause for it.

Figure 20 Microscopic image of specimen Q25-423, presenting a scratch/incision.

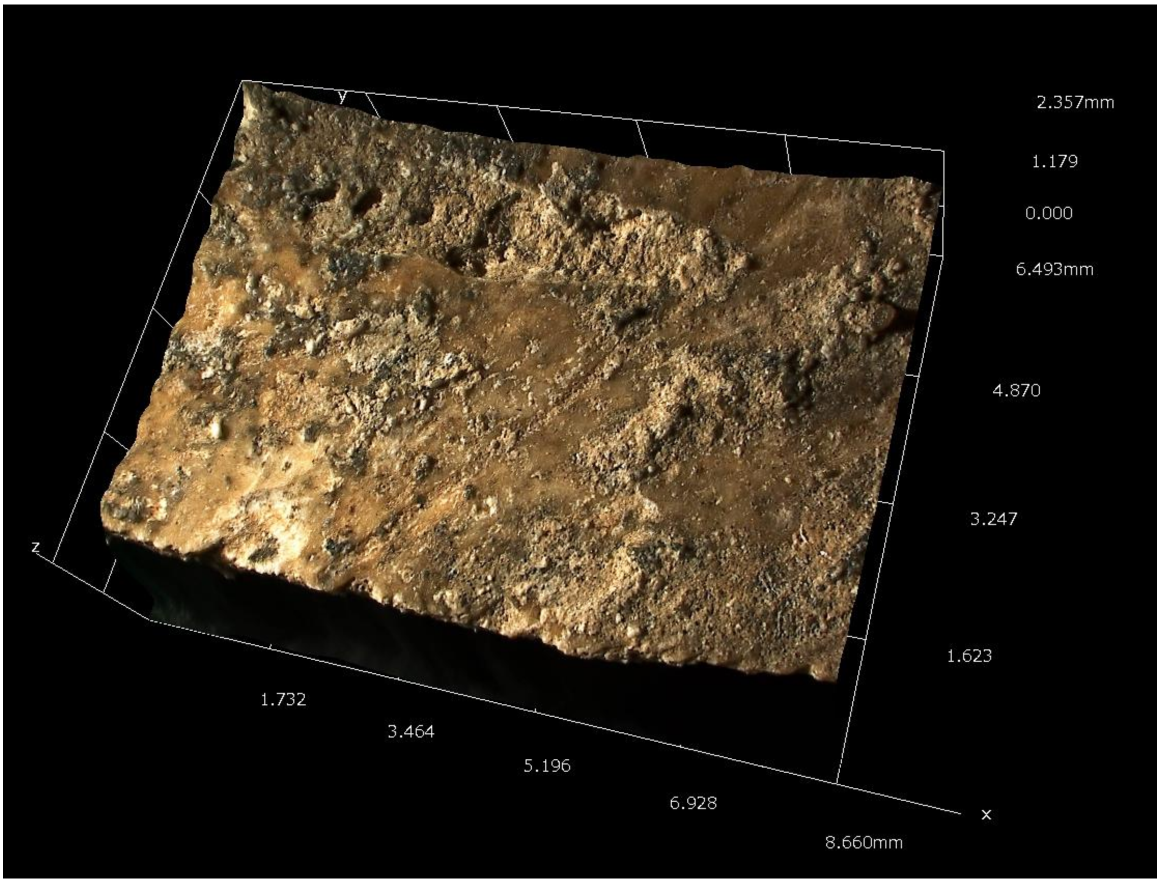

Figure 21 3D model of the specimen Q25-423 area with the scratch/incision.

Two specimens, Q26-428 and Q25-413/415, had all edges rounded. Q26-428 is a fragment of a diaphysis of a *Cervus elaphus* metapodial, and Q26-428 is a fragment of diaphysis of a long bone from a medium sized mammal. No other taphonomic alterations that could explain the agent were observed.

Nine specimens (Q25-693, Q25-529/546, Q25-301, Q25-328, Q25-555/565, Q26-470/471, Q25-602, Q25-297/297, Q25-529/546) had fissures, either by cracking or by scaling. Of these, Q25-328 had root etching alteration, which could explain the destructive agent causing the fissures. The remaining eight specimens showed no other alterations. Temperature and humidity spikes, either during post deposition or during excavation, storage and handling could be the cause of fissuring.

Specimen P26-359/374, a fragment of a long bone metaphysis from a medium sized mammal, presents a misshapen pit likely caused by chemical corrosion. Roots, fungi and microbial beings might have been the agent(s), but no other taphonomic alterations were observed, namely root etching.

4.4 Layer 9

From Layer 9, 12 mammalian remains were recovered, of which 2 (16,67%) were identifiable to family level (Table 17).

Table 17. Layer 9 remains by Number of Identified Specimens (NISP), Number of Unidentified Specimens (NUSP) and Number of Specimens (NSP).

Layer 9	NSP	%NSP
NISP	2	16,67
NUSP	10	83,33
Total	12	100

The taxa represented are Cervidae and Leporidae. The Cervidae remain belongs to a small sized taxon, therefore not compatible with *Cervus elaphus*. The anatomical representation of the sample can be seen on Table 18. The highest number of specimens correspond to long bone fragments of a medium sized animal, 4. This layer’s assemblage, though small, shows the presence of a variety of animal sizes, from large to very small.

Tabela 18. Layer 9 remains divided by taxon and anatomical element. In brackets is the Minimum Number of Elements for that specific skeletal element.

Anatomical Element	**Cervidae**	**Leporidae**	**Large size**	**Medium size**	**Small size**	**Very Small Size**	**Total**
Cranium	-	-	1	-	-	-	1
Carpal/Tarsal	-	1	-	-	-	-	1
Metapodium	1	-	-	-	-	-	1
Long bone	-	-	1	4 (1)	1	-	6
Flat bone	-	-	1	1	-	-	2
Unidentified	-	-	-	-	-	1	1
Total	**1**	**1**	**3**	**5**	**1**	**1**	**12**

Table 19. Layer 9 Number of Identified Specimens (NISP), Minimum Number of Elements (MNE) and Minimum Number of Individuals (MNI) for each taxon. Note that MNI calculation is Not Applicable (N/A) to the small sized specimen, as it could belong to the small sized Cervidae.

				MNI by Age Group	
Taxon/Size	**NISP**	**MNE**	**MNI**	**Infantile**	**Adult**
Cervidae	1	1	1	-	1
Leporidae	1	1	1	-	1
Large size	3	3	2	1	1
Medium size	5	2	1	-	1
Small size	1	1	N/A	N/A	N/A
Total	**12**	**8**	**5**	**1**	**4**

Table 19 shows the calculation of NISP, MNE and MNI of the macromammal specimens of Layer 9. The MNE for Cervidae (small sized) was 1, as well as Leporidae and Medium sized mammal. The 3 specimens of large sized mammals belong to a MNI of 2, as the long bone fragment is consistent with an infantile large sized mammal, while the other two fragments (cranial and flat bone) belong to an adult.

4.4.1 Taphonomic Aspects of the Layer 9 Assemblage

As for the taphonomic alterations, burnt marks, gnawing damage, root etching and fissures were identified, other than the general concretions.

Burnt Marks

One specimen, Q25-660, a long bone diaphysis of a small sized mammal, showed burnt marks to a degree of 3 (black, fully carbonized).

Gnawing Damage

One specimen, Q26-533, a long bone diaphysis of a large sized mammal, had two scores consistent with tooth marks (fig. 22) and a crenulated edge.

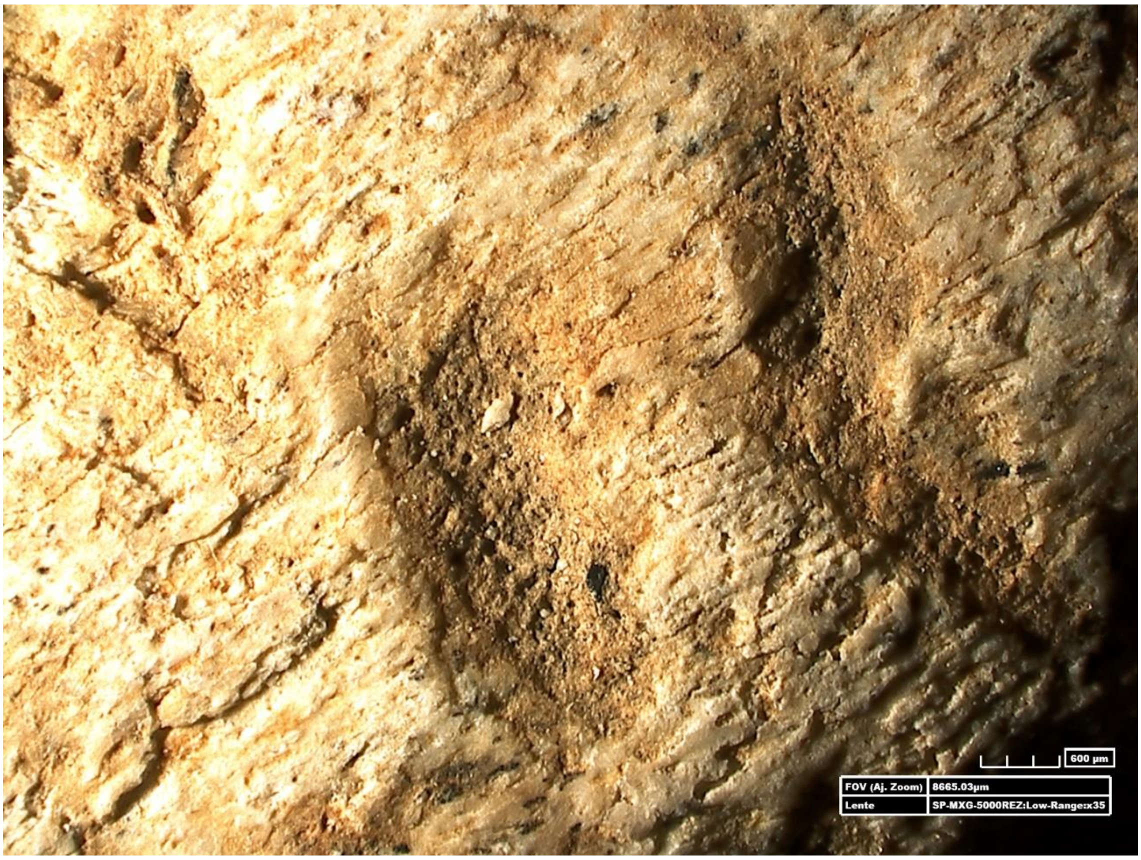

Figure 22. Carnivore marks on specimen Q26-533, two sub-parallel scores. The specimen also presented a crenulated edge.

Root etching

Two specimens, Q25-663 and Q25-665, had root etching grooves:

- Q25-663 – Fragment of long bone diaphysis from a medium sized mammal. Presents generalized grooves on all surfaces.
- Q25-665 – Fragment of flat bone diaphysis from a medium sized mammal. Presents an isolated groove on one surface.

Other Bone Surface Alterations

Specimen Q25-658, a long bone diaphysis of a medium sized animal shows fissures causing exfoliation. No other taphonomic alterations were observed. Temperature and humidity spikes, either during post deposition or during excavation, storage and handling could be the cause of the exfoliation.

4.5 Layer 10

From Layer 10, 6 mammalian remains were recovered, of which 3 (50%) were identied to species or genus level (Table 20).

Table 20. Layer 10 remains by Number of Identified Specimens (NISP), Number of Unidentified Specimens (NUSP) and Number of Specimens (NSP).

Layer 9	NSP	%NSP
NISP	3	50
NUSP	3	50
Total	6	100

The taxa represented are *Cervus elaphus* and *Lepus sp.* The anatomical representation of the sample can be seen on Table X. Other unidentified taxa belong to large and small sized mammals. Half of the sample are tooth specimens (table 22), and the other half are fragments of long bones, a *Cervus elaphus* femur and one large and one small mammal long gone fragment.

Tabela 21. Layer 10 remains divided by taxon and anatomical element.

Anatomical Element	***Cervus elaphus***	***Lepus* sp.**	**Large size**	**Small size**	**Total**
Isolated tooth	1	1	1	-	3
Femur	1	-	-	-	1
Long bone	-	-	1	1	2
Total	**2**	**1**	**2**	**1**	**6**

Table 22. Layer 10 tooth remains. On the Category, uppercase indicates maxillar tooth (upper), lowercase indicates mandibular tooth (lower). In the case of specimen P24-46, the position in relation to being upper or lower tooth was undetermined.

Specimen	**Taxon/Size**	**Category**	**Side**
P24-86	*Cervus elaphus*	m3	Left
P24-103	*Lepus* sp.	p3	Left
P24-46	Large Size	Molar/Premolar	Undetermined

Tabela 23. Layer 10 Number of Identified Specimens (NISP), Minimum Number of Elements (MNE) and Minimum Number of Individuals (MNI) for each taxon.

				MNI by Age Group
Taxon/Size	**NISP**	**MNE**	**MNI**	**Adult**
Cervus elaphus	2	2	1	1
Lepus sp.	1	1	1	1
Large size	2	2	1	1
Small size	1	1	1	1
Total	6	6	4	4

Table 23 shows NISP, MNE and MNI values for Layer 10. The total NISP and MNE are the same, and all taxa and animal sizes infer a minimum of one adult individual each.

4.5.1 Taphonomic Aspects of the Layer 10 Assemblage

As for the taphonomic alterations, burnt marks, gnawing damage and fissures were identified, other than the general concretions.

Burnt Marks

One specimen, P24-46, the large sized animal tooth fragment, presented burnt marks to a degree of 5 (>half calcined, more white than black).

Gnawing Damage

On one specimen, P24-126, a fragment of femur diaphysis, a cluster of scores consistent with carnivore activity (fig. 23) was observed. The scores overlap frequently and have varied orientation and length. Some depressions might be tooth marks or punctures but are filled with concretion therefore a safe diagnostic is at present impossible. A fragment of this specimen, resulting from recent fracturing, perhaps during excavation or storage, was sent to radiocarbon dating, prior to the knowledge on the presence of such marks.

Figure 23. Specimen P24-126 with several overlapping scores.

Other Bone Surface Alterations

P24-174, a long bone diaphysis of a large sized mammal, has fissures causing exfoliation. The specimen showed no other alterations. Temperature and humidity spikes, either during post deposition or during excavation, storage and handling could be the cause of the exfoliation.

4.6 Layer 11

Only one remain was recovered from Layer 11. A fragment of flat bone from what appears to be a large sized animal. This fragment was sent to radiocarbon dating as it was the only organic remain found so far on this scarcely excavated layer. No taphonomic alterations were observed, other than the generalized calcium carbonate concretions. Thus, the nature of this sample is still unknown and further excavation is required.

4.7 Overview of Abrigo da Buraca da Moira Mammalian Assemblage

The total assemblage studied totaled 171 specimens. Firstly, the taxa identified on the whole stratigraphic sequence selected for this study was *Cervus elaphus*, *Oryctolagus cuniculus, Equus* sp., *Bos primigenius*, *Sus scrofa*, *Lepus* sp., Leporidae und., Caprinae und., and (small) Cervidae und. Considering only the macromammal remains (Table 24), limb bone specimens dominate the assemblage, with 51,16%, followed by the flat or unidentified specimens with 37, 21%. Axial bones constitute only 6,2% of the assemblage.

Table 24. ABM assemblage distributed by axial, limb, flat/unidentified bones and teeth. Only macromammal remains considered (no Lagomorpha or very small sized).

Layers 7 to 11	**Axial Bones**	**Limb Bones**	**Flat/Unidentified**	**Teeth**	**Total**
Layer 7	3	9	2	-	14
Layer 8	4	47	43	5	99
Layer 9	1	7	2	-	10
Layer 10	-	3	-	2	5
Layer 11	-	-	1	-	1
Total	8	66	48	7	129
%	6,2	51,16	37,21	5,43	100

In terms of the taphonomic aspect of the assemblage, the anthropogenic alterations (Table 25) are *quasi* exclusive to Layer 8, being the only layer with presence of percussion marks and cut marks, whilst also holding almost all burnt remains of the assemblage. This could be the result of sample bias, as all remaining layers are virtually devoid of a statistically workable number of remains. Additional aspects will be discussed in **Chapter 5**.

Table 25. Anthropogenic alterations of ABM faunal assemblage.

	Percussion Marks	Cut Marks	Burnt Bones
Layer 7	-	-	1
Layer 8	3	1	67
Layer 9	-	-	1
Layer 10	-	-	1
Layer 11	-	-	-
Total	3	1	70

Regarding the non-human modifications (Table 26), the most common is root etching, followed by fissures. Residual rounding, incision, chemical corrosion and a few carnivore marks were also observed. No weathering was observed on the ABM sample. Again, the biggest assemblage, Layer 8, brought more diversity and number of observable alterations, which help with the interpretation on the nature of the faunal accumulation, a topic discussed in **Chapter 5**.

Table 26. Compilation of non-human alterations observed on Layers 7-11.

	Root Etching	Rounding	Fissures	Scratch (Trampling?)	Chemical Corrosion	Carnivore Marks
Layer 7	-	1	-	-	-	-
Layer 8	11	2	9	1	1	1
Layer 9	2	-	1	-	-	1
Layer 10	-	-	1	-	-	1
Layer 11	-	-	-	-	-	-
Total	13	4	11	1	1	3

CHAPTER 5. DISCUSSION

5.1 What We Can and Cannot Say About ABM from the Study of its Upper Paleolithic Faunal Assemblage

The faunal assemblage recovered so far in ABM is sparse. Most of the layers attributed to the Upper Paleolithic have no more than a few bones. Layer 8 is the richest in fauna by far, but still, its macrofaunal remains do not reach 200 in number. Therefore, not a lot can be said on relative abundances, nature of accumulation and so on. But a few preliminary points can be discussed.

Firstly, the taxa identified are either herbivores or lagomorphs, none are carnivores. *Cervus elaphus* is present on all layers, but not always with the highest minimum number of individuals. The sample size might explain this, as 10 deer remains may belong to a sole individual and on the same layer 1 *Bos* remain brings the MNI to the same value. So, size sample bias is a main factor on the problems with quantitative units.

On Layer 8, the microfaunal remains dominate the assemblage. The non-inclusion of their study was justified with the identification of extensive burrowing, which could be indicative of the activity of small carnivores or of the lagomorphs. The macrofaunal remains have a high number of limb specimens, some indicators of percussion, cut marks and burnt bones while carnivore activity is low. This, coupled with the absence of carnivore remains, indicates a more likely anthropic accumulation of the remains. The presence of burn marks on the microfauna does not necessarily indicate human processing, as accidental burning might have happened. Further study of the coarse fraction remains could solve this issue. As to the site function, the structure of the gallery presents a low ceiling where the excavation is being conducted. It is unlikely that human groups would be using the cave on that location for carcass processing or lithic tool production. With this is mind, and given the fact that the assemblage shows little sign of fluvial transport or other, this part of the cave might very well be a refuse location. Low energy transport might also have played a part in the moving of the artefacts to a natural “containment zone”, a corner of the gallery. This in fact could be said of all the remaining layers, though the origin of the accumulation cannot be ascertained for the moment, as the samples of layers 7, 9, 10 and 11, are just too small.

Being a closed environment, and in what apparently seems the end of a gallery, the remains show no sign of exposure to the climatic elements such as sun radiation, rain or wind, which explains the freshness of the fractures and sharpness of the edges. Roots though have contributed to the alteration of the surfaces of some of the bones. Nowadays the excavation area is close to shrubs, bushes and small trees, which easily explain the recent root etching. For the more ancient root etching marks, they could either be the result of the aftermath of the quarry exploration, at an unknown time, which would leave up to a few centuries of roots infiltrating the layers. Another explanation could be that the original gallery was not immensely large and would be directly connected to the outside, certain plant species near the entrance could have thoroughly infiltrated the cave sediment, as it is usually rich in water and minerals.

Root activity and burrowing have certainly altered the vertical and horizontal integrity of the layers, as the Neo/Chalcolithic necropolis surely did as well. But the fact that microfaunal remains and lithic implements of very small size are present is a good indicator of the preservation of the site, even if the artefacts are not *in situ* in strict terms.

5.2 Abrigo da Buraca da Moira in Relation to Contemporary Sites in Central Portugal

The small sample of ABM does not permit a fair comparison with sites which so far have yielded a bigger faunal sample. But some preliminary links can be established.

The absence of carnivore remains in ABM, whose layers are thought to date to Gravettian-Solutrean, goes in hand with the reality of the scarcity of carnivores after MIS 3 seen in other cave contexts (Valente & Brugal, 2002; Valente, 2004).

The high number of rabbit remains followed by red deer is seen at Lapa do Picareiro (Haws, 2003; Haws, 2012; Bennedetti et al., 2019), Lapa do Anecrial (Brugal, 2006), Abrigo do Alecrim (Almeida et al., 2010), Lapa dos Coelhos (Gameiro et al., 2017), Gruta do Caldeirão (Davis, 2002; Davis et al., 2007) and Abrigo do Lagar Velho (Moreno-Garcia & Pimenta, 2002; Almeida et al., 2009). Similarly, other taxa present in small numbers is *Equus.*, *Bos, Sus* and Caprids.

Considering these factors, one could say that, so far, the remains recovered at Abrigo da Buraca da Moira mirror the reality found in Upper Paleolithic contexts of Central Portugal.

CHAPTER 6. CONCLUSION

6.1 Concluding Remarks

The Abrigo da Buraca da Moira archaeological site is in its embryonic state of research, but the excavation preliminary assessments and artefactual research has proven its interest for the study of Pleistocene human groups in areas considered ecotones and refuges during harsh environmental conditions. The present work served as one more scientific approach to the data recovered, specifically the macromammal remains.

The results show that the ABM assemblage is small, and only one layer shows clear signs of anthropic action, through percussion notches, cut marks, burnt marks and skeletal representation. The taphonomic history reveals that preservation of remains is good all around, despite the concretions that impede a clearer observation of the bone and tooth surfaces. The spatial integrity has its issues, but different layers still maintain a clear distinction. Therefore, ABM is a well preserved record of Pleistocene human activity, which brings us to the last section of this work.

6.2 Future Prospects

A focused study on a particular set of artefacts, such as the macromammal remains in this work, enables a specialized and better detailed treatment of data. But without a holistic approach to the interpretation of a site, combining the most data possible, we end up with more questions than answers. In this regard, listed here are but a few trails of research to be done in ABM:

1. A thorough geoarchaeological analysis, including both geochemistry and micromorphology.
2. The analysis of the lithic technology (presently underway) and its relation to the fauna.
3. A zooarchaeological approach to the malacofaunal remains.
4. The study of the charcoal remains (presently underway), and the spatial relation to the burnt bones.
5. Though with its own problems of bias and contamination, the study of the lagomorph remains and microfauna. The burnt marks could be used as a

discriminator of ancient/modern remains. Microfauna such as rodent and herpetofauna could give us climatic and environmental clues.

As shown by the previous seasons on ABM, the archaeological potential of the site is unquestionable. At present, the surface area of excavation and total volume of sediment extracted provide us with only a sample of what lies within the gallery. This is especially regarding the macromammal remains. For most layers, the sample available does not allow for a relevant statistical analysis in terms of MNI, MNE, taphonomic analysis, etc. It is therefore highly beneficial that further excavation seasons be done. Enlarging the area of intervention would contribute to a better understanding of layers 7-10, whilst going deeper into layer 11 would hopefully bring to light more data on its nature of formation and its faunal package. The aim of the 2022 season is to widen the area and going deeper (Pereira, 2022). The cases of Gruta do Caldeirão and Lapa do Picareiro revealed deep stratigraphic profiles through persistent excavation during the course of several years.

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