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### ► To cite this version:

Juan Marin, Antonio Rodríguez-Hidalgo, Josep Vallverdú, Bruno Gómez de Soler, Florent Rivals, et al.. Neanderthal logistic mobility during MIS3: Zooarchaeological perspective of Abric Romaní level P (Spain). *Quaternary Science Reviews*, 2019, 225, pp.106033. 10.1016/j.quascirev.2019.106033 . hal-02637615

**HAL Id: hal-02637615**

**<https://hal.science/hal-02637615>**

Submitted on 20 Jul 2022

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# Neanderthal logistic mobility during MIS3:

## Zooarchaeological perspective of Abric Romaní

### Level P (Spain)

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# Abstract

Mobility strategies of Neanderthal groups are studied through the characterization and analysis of archaeological sites and traditionally compared to the types of settlements present-day hunter-gatherer groups, based on their mobility strategies. The faunal record of level P of Abric Romaní is a unique source of information for analysing the foraging behaviour developed by Neanderthals during MIS3. The assemblage is divided into two separate and well-defined sublevels: Pa and Pb. Through the taphonomic study of the remains and their spatial distribution, it was possible to define the characteristics of these human occupations. The analyses indicate that the assemblage was the result of at least two different types of occupations: 1) A transitory residential camp during short halts, focusing on the exploitation of red deer; 2) A hunting camp / intermediate butchering site for the specialized capture of horses. The presence of occupations focusing on the supply of specific resources is typical of collector groups. The results of the zooarchaeological study of level P characterize the Neanderthals of Abric Romaní as groups involved in a logistic mobility system, who moved throughout the territory depending on the availability of large ungulates.

*Keywords: Pleistocene; Europe; Paleogeography; Zooarchaeology;*

*Taphonomy; Neanderthals; Logistic Mobility; Campsite; Hunting camp*

## 1. Introduction

According to Kuhn and colleagues (2016), human group mobility is driven by four interrelated phenomena: the internal need for movement (rewards and decisions), mobility skills (biomechanical limitations), the ability to navigate (cognitive challenges of movement) and external factors. The external factors that influence movement include the environmental context, distribution and abundance of resources, or the associated climatic and habitat changes, among others. Kelly (1992) argued that the mobility and settlements of modern hunter-gatherers are largely determined by the availability of resources on which they base their survival. Most groups

depend on temporally and spatially restricted resources (Kelly, 1992, 1983), forcing them to adopt mobile strategies for the management of the distribution area of these resources. Mobility enables hunter-gatherers to balance the unequal distribution of resources in the territory (Kelly, 2013), to avoid food deficits caused by over-hunting, and other negative effects of the long-term occupation of a local ecosystem (Hamilton and Watt, 1970). Other benefits of mobility include flexibility in group size and the ability to relocate settlements near periodically abundant resources, mainly plant and, animal resources and their by-products, and access to water (Lee, 1979, 1972; Perlman, 1985; Smith, 1981; Tanaka, 1976). However, foraging groups may also develop high mobility in their territory for reasons other than water availability or irregularities in food distribution (Jones, 1983), such as the Aché (Paraguay). In any of these variants, mobility leads to a reduction of social stress and conflict between co-resident groups (Woodburn, 1980, 1972), exposure to a wider range of potentially exploitable resources (Kuhn et al., 2016) and guarantees a higher success rate in hunting (Jones, 1983). This is linked in many cases to food management, which can range from the storage of surpluses to the equitable sharing and consumption of food obtained on a daily basis (Binford, 1980; Gould, 1981; Jones, 1983; Lee, 1979; Marshall, 1961).

Binford (1980) developed an approach focusing on settlement patterns, to describe the movements of hunter-gatherer groups, based on the study of the /Gwi San (Silberbauer, 1972) and the Nunamiut (Binford, 1978). He classified groups into foragers, with residential mobility, and collectors, with logistic mobility. The main difference between them is that foragers move consumers to resources with frequent residential movements, while collectors move resources to consumers, generally with fewer residential movements (Binford, 1980). Foragers make seasonal residential movements between a series of resource patches (Binford, 1980). Their residential mobility can vary considerably between sites, both in time and space, and they do not store food, but consume all the resources obtained daily. They mainly generate two types of places, residential bases, in which the group the entire group socialites and developed their domestic activities, and locations, where extractive tasks are exclusively carried out. On the other hand, collectors are characterized by their logistic organization, as specialized task groups provide them with specific

resources, and by the storage of food for at least part of the year (Binford, 1982). Specialized task groups leave a residential location to collect a specific resource. These groups are often small and seek to procure a specific resource in a specific context. In addition to the places generated by foragers, three further possible places are used by collectors: the field camp, station, and cache. However, the forager and collector models are not two types of substantially antagonistic settlement systems, but rather a graduated series from simple to complex, in which settlement dynamics are strongly linked to the spatial and seasonal distribution of resources in the environment (Binford, 1980). Nevertheless, not all foragers are highly mobile, nor are all collectors almost sedentary (Kelly, 2013).

Similarly, Mortensen (1972) established two models based on mobility patterns. These are: the circulating model (the residential group moves in predictable seasonal rounds with a single, self-sufficient, settlement type) and the radiating model (places of specific activity supply resources to residential places). Both models produce spatial regional exploitation as one would expect from foraging and logistic models, respectively (Binford, 1980). Based on these categories, archaeological work has attempted to characterize the subsistence of past human groups.

There is no doubt that most archaeological sites are palimpsests (Bailey, 2008; Bailey and Galanidou, 2009). This means that in most cases our object of study is the result of an indeterminate number of events that can incorporate and remove materials (LaMotta and Schiffer, 1999). It is generally impossible to discriminate between or identify the length of sequences in these sequences of events (Vaquero, 2008a). On account of the overlapping of episodes of activity, it is difficult to address the duration of occupations of archaeological sites in temporal terms, although this has not led to the abandonment of these topics by archaeologists (Audouze and Enloe, 1997; Clark, 2016; Enloe, 2012; Gaudzinski, 2004; Pettitt, 1997; Riel-Salvatore et al., 2013; Spagnolo et al., 2018). Stiner (2013) proposed two models of occupation for the Middle Palaeolithic based on the function and intensity of occupations: ephemeral occupations with high mobility and relatively intense occupations with a higher input of materials. These two categories are usually

based on the density of materials, the existence of living floor structures and/or the types of modifications present on the materials.

Information from detailed zooarchaeological and taphonomic studies elucidates characteristics of Neanderthal group subsistence strategies, such as prey selection, transport strategies, seasonality of occupations, carcass processing, food exchange or group cooperation. These elements enable us to characterize the nature of settlements and differentiate between long and short occupations (e.g., Faith, 2007; Faith and Gordon, 2007; Marín et al., 2017a, 2017b; Rodríguez-Hidalgo et al., 2017; Saladié et al., 2011; Speth and Clark, 2006; Stiner et al., 2009; Stiner and Kuhn, 2006). These data, associated with the studies of lithic assemblages and raw materials, allow us to characterize the mobility of hominin groups through analogies with contemporaneous hunter-gatherers (Adler et al., 2006; Boyle, 2000; Burke, 2004; Carbonell, 2012; Conard and Adler, 1997; Courty et al., 2012; Daujeard and Moncel, 2010; Delagnes and Rendu, 2011; Gaudzinski, 2000; Lieberman and Shea, 1994; Niven et al., 2012; Patou-Mathis, 2000; Turq et al., 2017; Valensi and Psathi, 2004). As a result, mobility strategies have been proposed in Europe for Middle Palaeolithic groups, which vary mainly according to regional characteristics. Thus, for example, in Central and Eastern Europe, the low frequency of base camps in comparison to temporary camps, has been identified as an indicator of the predominance of multidirectional (radial or star pattern) logistic mobility strategies (Patou-Mathis, 2000). In the Rhone Valley (France), settlements have been associated with a far-sighted circulating models (Daujeard and Moncel, 2010; Moncel et al., 2014). In the south-western French Atlantic basin, hunting strategies, prey type and seasonality, show that groups associated with the Quina system and the discoid-denticulate system were logistically mobile, while groups with a laminar Levallois system were associated with a more residential foraging system (Delagnes and Rendu, 2011; Niven et al., 2012; Turq et al., 2017). In the south French Mediterranean basin, Neanderthal groups have been linked to a circulating mobility strategy, where small communities scattered throughout the territory sought day-to-day supplies (Boyle, 2000). In the Mediterranean basin of the Iberian Peninsula, most studies agree that Neanderthal groups are characterized by highly mobility, developing in most cases accumulations resulting from repeated occupations of

short duration, which could be related to logistic organization (Martínez-Moreno et al., 2004; Real et al., 2018; Rosell et al., 2017; Vallverdú et al., 2005; Zilhão and Villaverde, 2008). In the Middle Palaeolithic sites of the Near East, hominin groups have been associated with two mobility strategies: radiating type multi-seasonal logistic mobility related to archaic populations, and a highly seasonal residential circulating mobility related to anatomically modern populations (Lieberman and Shea, 1994; Marín-Arroyo, 2013).

Although Neanderthal mobility strategies display variability, especially as regards circulating or radiating mobility, the logistic strategy it seems that it could be predominant in the Mediterranean basin of the Iberian Peninsula, France and part of Central Europe. In all these regions, group subsistence relied on the capture of large ungulates. Neanderthals in the Iberian Peninsula also based their meat economy on large ungulates, especially deer, large bovids, horses and caprines (Altuna, 1990; Arsuaga et al., 2012; Blasco, 1997; Fernández-Laso et al., 2010; Fernández-Peris et al., 2008, p.; Gabucio et al., 2018a, 2018b, 2014; Galván et al., 2001; Iturbe et al., 1993; Martínez-Moreno et al., 2004; Morin et al., 2016; Real et al., 2018; Romero et al., 2019; Salazar-García et al., 2013; Sanchis et al., 2019; Sanchis Serra et al., 2013; Steele, 2004; Utrilla et al., 2010; Villaverde et al., 2017; Yravedra et al., 2012; Yravedra and Cobo-Sánchez, 2015; Zilhão and Villaverde, 2008).

In the Abric Romani sequence, accumulations interpreted as resulting from long-term occupation events or short-term and/or non-residential occupation events have been identified (Carbonell and Vaquero, 1998; Carbonell, 2002, 2012; Vallverdú et al., 2005, 2010, 2012a; Vaquero et al., 2012). In both scenarios, archaeological levels correspond to the superposition of an indeterminate number of occupational events (Vallverdú et al., 2005, 2010, 2012a; Vaquero et al., 2015). Through the analysis of the faunal record of the recently excavated level P (seasons 2006-2013), had conducted a study focusing on the type of occupations generated by this assemblage. To this end, have been characterized Neanderthals settlement types in the rock shelter and the associated mobility strategies.

## 2. Abric Romaní

The Abric Romaní archaeological site is a rock-shelter located in the gorge of the Cinglera del Capelló, 45 km northwest of Barcelona (Spain). The stratigraphy consists of 30 m of well-stratified travertine sediments. Rock fragmentation and alluvial and biochemical sedimentary processes generate beds of consolidated stones, gravels, calcarenites and calcilutites interspersed with very fine archaeological levels (Vallverdú et al., 2010). U-series and radiocarbon dates place the Abric Romaní sequence between ~ 110 and 40 kyr (Sharp et al., 2016). The sedimentation rate is estimated at around 0.6 m / kyr (Bischoff et al., 1994, 1988). Except for level A, all the archaeological units of the sequence correspond to the Middle Palaeolithic.

Discovered in 1909 by Amador Romaní, the site was excavated at different periods throughout the Twentieth century. The current excavation covers the entire extension of the rock shelter (*circa* 300 m<sup>2</sup>). The sequence comprises 17 archaeological levels. Numerous exceptionally well-preserved combustion structures have been documented in all the excavated levels (Vallverdú, 2002; Vallverdú et al., 2012a; Vallverdú and Courty, 2012). In addition, casts of wooden objects have also been recovered (Allué et al., 2012; Carbonell, 2012, 2002; Castro-Curel and Carbonell, 1995; Solé et al., 2013).

The lithic assemblage is characteristic of Middle Palaeolithic technological systems, with predominant flakes, and relatively sparse cores and retouched flakes (Chacón and Fernández-Laso, 2007; Martínez and Rando, 2001; Vaquero, 2008b; Vaquero et al., 2012, 2004, 2001). Chert of regional origin is the most abundant raw material in the Abric Romaní sequence (Gómez de Soler, 2016; Gómez de Soler et al., in press). In levels H, I and K, the percentage of chert drops by 70%, and is associated with an increase in raw materials of local origin; quartz in levels I and K, and limestone in level H. The fourth most represented raw material in the whole sequence of the deposit is schist, which is also from a local catchment area (Chacón et al., 2007; Gacia-Antón and Morant, 2000; Gómez de Soler, 2007; Vaquero et al., 2012).

Macro-mammal remains are very abundant in the sequence. A total of 38,228 remains belonging to 13 taxa have been recovered. Red deer (*Cervus elaphus*) and equids (*Equus ferus/Equus hydruntinus*) are the most abundant ungulates. Aurochs specimens (*Bos primigenius*) are also present in levels I, J, K, L, M, N and O and the chamois (*Rupicapra pyrenaica*) in A, B, D, E, F, G, H and J. Rare rhinoceros remains (*Stephanorhinos cf. hemitoechus*) have been documented in several levels. The diaphysis of a proboscidean femur was recovered in level E. The zooarchaeological studies carried out on different levels indicate that the faunal record is the result of Neanderthal activity, characterized by primary access to animal carcasses and complete processing (Fernández-Laso et al., 2010; Gabucio et al., 2014; Marín et al., 2017a, 2017b; Rosell et al., 2012b, 2012a). Specific activity areas have been identified through the analysis of the density of faunal remains, taphonomic modifications, and refits, which sometimes define sleeping areas, cleaning areas and animal processing areas (Carbonell, 2012; Gabucio et al., 2014; Vallverdú et al., 2005, 2010, 2012a). Carnivore modifications are scarce, and carnivore activity has been defined as the result of the secondary ravaging of remains abandoned by human groups (Carbonell, 2012, 2002; Rosell et al., 2012a; Vallverdú et al., 2005; Vaquero et al., 2001). Faunal anatomical profiles are the result of a highly variable transport of animal carcasses, ranging from complete animals to only a few elements. This differential transport may be related to diverse constraints, such as animal weight, tactical factors or the number of carriers (Marín et al., 2017a, 2017b).

### 3. Materials and method

Level P was excavated between 2006 and 2013 over a total area of 247 m<sup>2</sup>. This level is dated to 54.24 ±0.42 Ka BP (top) and 55.0 ±2.6 Ka BP (bottom) (Bischoff et al., 1994, 1988; Vallverdú et al., 2012b; Vaquero et al., 2013), and is in pollen zone 3 characterized by a cold and dry climate (Burjachs et al., 2012; Burjachs and Julià, 1994).

Level P was excavated using Cartesian coordinates on a grid divided into square metres. Two archaeological sublevels were differentiated in some areas, but it was not possible to identify them

over the whole surface. A total of 4,890 remains were recovered, comprising faunal specimens (1,233 remains larger than 2 cm), lithic remains (2,633 larger than 1 cm), malacofauna (45 remains), charcoal (950 remains) and wood casts (29 remains).

Have been projected and analysed a series of 25-cm-wide vertical profiles (longitudinal and transversal profiles), in order to identify the sublevels observed during fieldwork over the entire surface, using ArchePlotter v1.35.4-beta, developed by IPHES, and ArcGIS 10.4.1 (Desktop, Engine) software.

Faunal remains were refitted for the spatial study, taking into consideration anatomical and mechanical refits (Marean and Kim, 1998). In all cases, distances between the refitted pieces were recorded, as well as their taphonomic modifications. Have been considered whether the bone had green or dry fractures, and whenever possible, the actor of bone breakage was identified.

To observe the redistribution of carcasses between identified activity zones, has been applied the proposed redistribution index (RI) of Jones (1983), although with modifications. The formula is:  $RI = \frac{MNIf}{(MNIs * n)}$ ; where MNIf is the MNI by hearths, the MNIs is the total MNI and n is the number of hearths.

Carcass distribution over a living floor surface can be related to the distribution of ungulate meat.

In settlements with a high distribution of animals, the index values are approximately one.

However, when animal tissues were not shared, the index is the inverse of the number of hearths.

In these cases, the MNI per hearth should be similar to the MNI for the whole settlement surface, and its sum much higher than the total MNI. In cases where there is no redistribution of meat, the

sum of the MNI per hearths is similar to the total MNI count of the assemblage. To apply the

formula to level P of Abric Romaní, the index was calculated according to taxa (*Cervus elaphus* and *Equus ferus/hydruntinus*). In addition, since it is not possible to clearly separate the remains for

each hearth, the MNIf was calculated for each aggregation of materials related to combustion

structures. It should be noted that this only applies to sublevel Pa where these accumulations could be discriminated in more detail.

To identify the different areas of accumulation of remains has been followed the proposal of Romagnoli and Vaquero (2016), using combined kernel density analysis (Baxter et al., 1997) and the calculation of k-nearest neighbour distances (Baddeley et al., 2015).

The distribution of red deer and horse remains was evaluated using Ripley's K function of the "spatstats" library of version 3.2.3 of the R software (R Core Team, 2015; Baddeley et al., 2015). This function is used to describe how a point process occurs in any specified spatial window. The curve of the observed data was interpreted as a grouping process (above the theoretical random process line), a regular process (below the theoretical random line) or CSR (complete spatial randomness) (if it is within the confidence intervals). The confidence intervals were obtained through a Monte Carlo simulation process with 30 random samples of the original data. The proposal of Reeves et al. (2019) to analyse patterns of discarding material in palimpsests was used, adapting its code of analysis in R to our study. This proxy allows for the visualization of the statistical significance of the horizontal distribution patterns of red deer and horse remains. For this, first, the spatial variation of a series of taxonomic representation indices is calculated by means of a Moving Window Analysis, where each observation represents a value resulting from the calculation of that ratio in its neighbourhood. Subsequently, the statistical significance of the spatial variation of these values is tested by means of the Local and Global Moran's I test of spatial autocorrelation, leading to the identification of statistically significant concentrations of high and low values.

In this case, a circular window with a 2 m radius was used for the calculation of the following indices: number of *Cervus elaphus* remains / number of taxonomically identified remains; number of *Equus ferus* remains / number of taxonomically identified remains; number of remains of *Cervus elaphus* / sum of remains of *Cervus elaphus* and *Equus ferus*; number of remains of *Equus ferus* / sum of remains of *Cervus elaphus*.

Taxon, age of death, size and weight category, element, side (anterior, posterior, medial, lateral, superior and inferior) and the portion (epiphysis, metaphysis, and diaphysis) and position

(left/right) were described when possible. To evaluate anatomical representation, the carcasses were divided into anatomical segments: axial cranial (horns, skull, mandible, hyoid and teeth), axial postcranial (vertebrae, ribs and coxal) and appendicular (long limb bones, carpal/tarsal and phalanx). The scapula was grouped within the axial skeleton since its responses to taphonomic processes are similar to those of the axial skeleton (Yravedra and Domínguez-Rodrigo, 2009). The long bones were divided into upper appendicular bones (humerus and femur), intermediate (radius/ulna and tibia) and inferior (metapodials) (Domínguez-Rodrigo, 1997). Two weight categories were used: large animals weighing between 200 and 800 kg; medium-sized animals weighing between 50 and 200 kg.

Have been used four measures of abundance: Number of Specimens (NSP); Number of Identified Specimens (NISP); Minimum Number of Elements (MNE); Minimum Number of Animal Units standardized (%MAU); and Minimum Number of Individuals (MNI) (Binford, 1984; Grayson, 1984; Lyman, 1994). To calculate the MNE, has been considered the superposition of anatomical markers, and considered the age, side or landmarks. In the case of long bones, has been followed the recommendation of Marean and Spencer (1991), modified by Saladié et al. (2011). To establish the degree of taxonomic diversity, the Shannon uniformity index (E) and the Simpson diversity index (D) were used on the NISP of the different identified species.

Spearman's rank order was used to test the correlation between the %MAU and the data provided by Lam et al. (1999) for bone mineral density, taking into account the MNE of each element portion. The significance of the Spearman correlation coefficient used in this work is 95% (0.05).

The transport strategy analysis was carried out following the method proposed by Faith and Gordon (2007), by means of the statistical correlation of Spearman's rho between the standardized food utility index (SFUI) and the %MAU and by applying the Shannon uniformity index (E) to the anatomical profile. The following high-survival elements were considered: skull, mandible, humerus, radius/ulna, metacarpal, femur, tibia, and metatarsal (Marean and Cleghorn, 2003). In

addition, the %MAU of the high-survival elements was correlated with the unsaturated marrow index (UMI) proposed by Morin (2007).

The age at death of the individual and the seasonality of the settlements was calculated based on the time of eruption and replacement of the teeth and the degree of wear of the occlusal surfaces (Azorit, 2011; Bignon, 2006a; Brown and Chapman, 1991; Fernandez and Legendre, 2003; Klein and Cruz-Urbe, 1983; Mariezkurrena, 1983; Steele and Weaver, 2002). The birth period for red deer and horses was between the end of spring and the beginning of summer (horse: Levine, 1982; Burke, 2002) (deer: Clutton-Brock et al., 1982; Habermehl, 1985). Given that the period of birth and the replacement of deciduous teeth occur at predictable times of the year, it is possible to calculate the annual cycle and estimate the death season (Stiner, 1990). Once the age of death was identified, the individuals were grouped into juveniles, prime adults and old individuals (Stiner, 1990), and plotted within triangular charts following the separation of mortality profiles proposed by Stiner (1990) and Discamps and Costamagno (2015) for red deer and horses.

In order to establish the degree of fragmentation and the actors responsible for fragmentation processes, has been followed the method proposed by Bunn (1983) and modified by Villa and Mahieu (1991). For this, had been considered the diaphysis length and circumference, description of the delineation (longitudinal, transverse and curved / V-shape), angle (straight, oblique or mixed) and the surface (smooth or jagged) of fracture planes.

Taphonomic analysis was completed by the observation of bone surface modifications, through the binocular stereomicroscope (OPTHEC 120-Hz model). The focus was on the study of changes produced during the nutritional phase (Capaldo, 1998) of modifications. Damage produced by hominins and carnivores was described according to the anatomical region and the portion on which they were found. The identified anthropogenic modifications include cut marks (Binford, 1981; Domínguez-Rodrigo et al., 2009; Potts and Shipman, 1981; Shipman, 1981; Shipman and Rose, 1983), and percussion marks (Blumenschine and Selvaggio, 1988; Capaldo and Blumenschine, 1994). The type, delineation, situation and position of the cut marks per element allowed us to

infer butchery activities. For this, were used ethnoarchaeological sources (Abe, 2005; Binford, 1978), experimental data (Frison, 1974; Nilssen, 2000) and our own experiments on multiple animals. For percussion marks were identified percussion notches and pits and adhering flakes (Blumenschine and Selvaggio, 1988; Capaldo and Blumenschine, 1994; Vettese et al., 2017). For the study of cremations, changes in the coloration of the bones were into account, following the proposal of Stiner et al. (1995). The six coloration stages used are: 0) unburned; 1) small brown or black areas; 2) brown bones; 3) black bones (charred); 4) grey bones (calcined); 5) white bones (calcined). Finally, carnivore modifications were identified through the presence of tooth marks, mainly pits and scores (Blumenschine, 1995; Bunn, 1981; Domínguez-Rodrigo and Barba, 2006; Fisher, 1995; Shipman, 1981), along with furrowing or chipping of the back edge. The breakage strategies of humans and carnivores generate impact flakes that are difficult to differentiate (Brain, 1981; Bunn, 1981, 1982b; Potts, 1988b; Capaldo and Blumenschine, 1994). Although they are more common in anthropic breakage, they are not used as a diagnostic element when they show no signs (percussion marks or tooth marks) that allow their assignment.

The analysis of tooth microwear patterns (microscopic features present on the surface of the enamel) was carried out to establish the relative duration of the occupation events in the rock-shelter. The characteristics of microwear were examined for the most represented species in the assemblage, *Equus ferus* and *Cervus elaphus*. The analysis was performed following the protocol established by Solounias and Semprebon (2002) and Semprebon et al. (2004). High-resolution dental casts were observed under transmitted light with a Zeiss Stemi 2000C stereomicroscope at a magnification of 35x. The microwear features (i.e., scratches and pits) were quantified on the paracone of the upper molars or the protoconid of the lower molars. Two measurements of the variability of scratch density i.e., the standard deviation (SD) and the coefficient of variation (CV) were used to estimate the duration of the accumulation of faunal associations (Rivals et al., 2015). The integration of these two measures of variability allows for the classification of each case in one of the following three categories: [A] seasonal or shorter events, [B] events longer than a season

(i.e., two or more contiguous seasons), [C] distinct events that occurred in different and non-contiguous seasons.

Finally, catchment areas were analysed in order to evaluate the mobility ratio of the Neanderthal of level P. This involved 1) a petrographic study of the predominant raw material (chert); 2) systematic geoarchaeological explorations generating specific regional mapping of the possible source areas of siliceous rocks; 3) chert abundance ratio (CAR) was applied as a quantitative approximation to estimate the availability of primary material in a territory (Soto et al., 2018).

## 4. Results

### 4.1 *Archaeo-stratigraphy of level P*

The separation of the two sublevels was possible over the whole surface of the rock shelter.

Sublevel Pa (NR = 979) contains a greater number of faunal remains than sublevel Pb (NR = 254)

(Figure 1). This allowed us to develop the spatial study of faunal specimens and to distinguish

possible accumulation events in the sublevel. The spatial distribution of the remains shows cluster patterns in which numerous accumulations are associated with hearths (Pa=4, Pb=3), and

characterized by high densities of debris. In sublevel Pa, accumulations were discriminated from densities greater than 14-20 specimens and in Pb, at densities greater than 7-9 specimens (Figure

2). As a result of the analysis of k-nearest neighbour distances, the z-score in the two assemblages indicates that there is a probability of less than 1% that the clustered pattern can be the result of

random likelihood (Table 1). A total of seven accumulations were identified; four in Pa (1, 2, 3 and 4) and three in Pb (5, 6 and 7). Of these, four can be considered as main accumulations, located

around combustion structures, three in Pa (1, 2 and 4) and one in Pb (6).

p

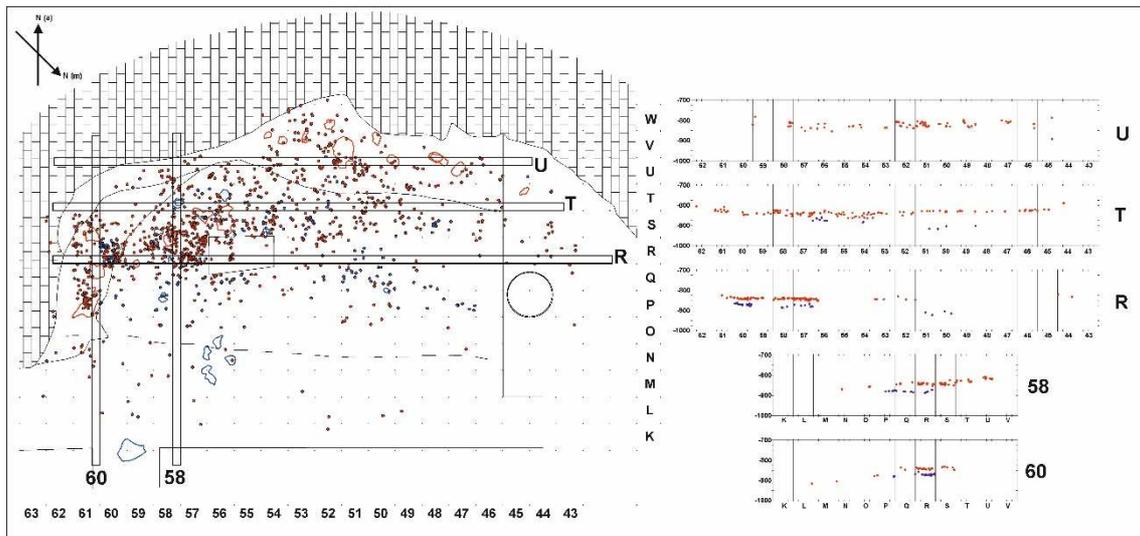


Figure 1. Site plan (left) and sections (right) of the transversal (60 and 58) and longitudinal (U, T, R) projections developed for the identification of sublevels a (red) and b (blue) of level P.

	Pa	Pb
Average distance observed	0.1346 m	0.2511 m
Average distance expected	0.2428 m	0.4062 m
Nearest neighbour ratio	0.554110	0.618245
z score	-26.662815	-11.570512
p value	0.000000	0.000000

Table 1 Summary of the average distance to the nearest neighbour.

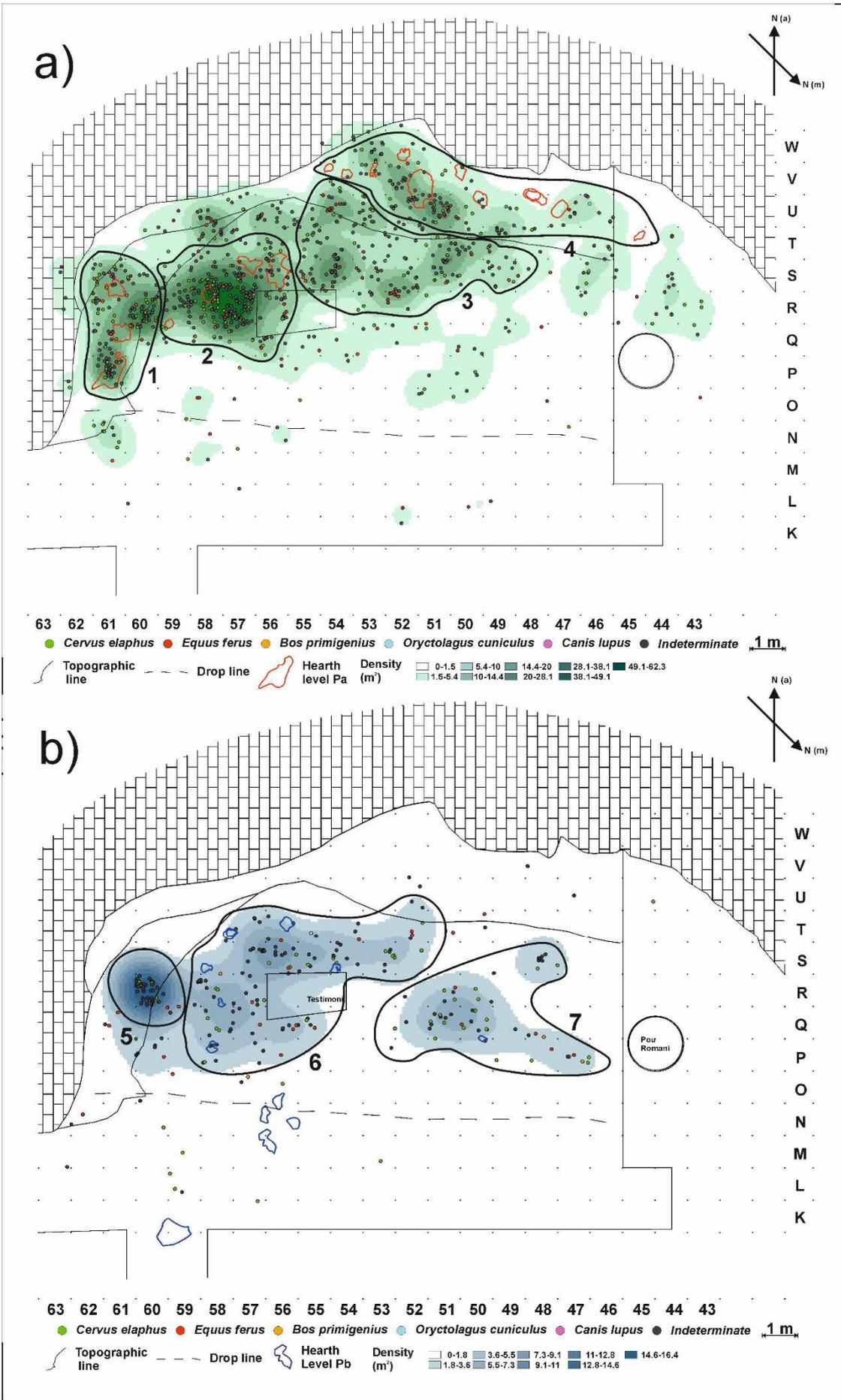


Figure 2 Spatial distribution of faunal remains in sublevels Pa (a) and Pb (b).

## 4.2 Taxonomic anatomy and age composition

As in the other levels in the Abric Romaní sequence, level P presents a low taxonomic diversity dominated by large and medium-sized ungulates. The best represented species is *Cervus elaphus* (Pa=63%; Pb=60% NISP), followed by *Equus ferus* (Pa=22.6%; Pb=32.2% NISP) and *Bos primigenius* (Pa=10.7%; Pb=6.7% NISP) (Table 2). The sum of the three taxa represents 96.3% NISP in sublevel Pa and 98.9% NISP in Pb. A mandible fragment belonging to an adult *Canis lupus* individual in Pa and a dozen rabbit remains between both archaeological levels complete the assemblage. Due to the absence of anthropogenic and carnivore modifications on rabbit and wolf remains, as well as their low number, it is difficult to interpret the role of these two taxa in the assemblages. The Shannon diversity index (E: Pa=0.622, Pb=0.6506) and the Simpson index (D: Pa=0.4601; Pb=0.5048) indicate slightly diversified and relatively uniform assemblages, in which no single taxon dominates in respect to the total.

Taxa	P					Pa					Pb				
	NISP	%NIS	MN	%MN	MN	NIS	%NIS	MN	%MN	MN	NIS	%NIS	MN	%MN	MN
	P	E	E	I	P	P	E	E	I	P	P	E	E	I	
<i>Cervus elaphus</i>	224	62.2	64	48.1	10	170	63	37	45.1	6	54	60	27	52.9	4
<i>Equus ferus</i>	90	25.0	43	32.3	8	61	22.6	25	30.5	3	29	32.2	18	35.3	5
<i>Bos primigenius</i>	35	9.7	17	12.8	2	29	10.7	12	14.6	1	6	6.7	5	9.8	1
<i>Canis lupus</i>	1	0.3	1	0.8	1	1	0.4	1	1.2	1	0	0	0	0	0
<i>Oryctolagus cuniculus</i>	10	2.8	8	6.0	3	9	3.3	7	8.5	2	1	1.1	1	2	1
Total	360		133		24	270	100	82	100	13	90	100	51	100	11
Indeterminates	NSP	%NSP				NSP	%NSP				NSP	%NSP			
Medium size	299	34.2				226	31.9				73	44.5			
Large size	115	13.2				95	13.4				20	12.2			
Indeterminate	459	52.6				388	54.7				71	43.3			

Total NSP	873	100				709	100				164	100			
<b>Total</b>	123					<b>979</b>					<b>254</b>				
	3														

Table 2 NISP, NSP, MNE and MNI of taxa and weight size groups of sublevels Pa and Pb.

The MNE is 133 (124 of which correspond to ungulates) (Table 2), comprising to a minimum of 24 individuals, 75% of which are red deer (Pa=6; Pb=4 MNI) and horses (Pa=3; Pb=5 MNI) (Table 2).

Due to the high fragmentation of long bones, a lot of remains could not be taxonomically identified, but could be assigned to a weight size category (NSP=29.6%). Approximately half of them were assigned to a weight size category. Most of them belong to medium-sized (Pa=31.9%; Pb=44.5%) and large animals (Pa=13.4%; Pb=12.2%) in accordance with the distribution of the identified specimens. A high proportion of remains are indeterminate anatomically, taxonomically and by weight size category (Pa=39.6%; Pb=27.9%).

Skeletal profiles indicate a differentiated pattern for the two most abundant taxa, red deer and horses. These patterns are broadly similar in both sublevels but present some variations (Table A.1, A.2, A.3 and A.4). In general, the most represented elements for red deer in Pa and Pb are long bones, especially intermediate and upper long bones. Conversely, cranial elements, especially mandibles, predominate among horse elements. The postcranial axial skeleton and small and compact bones, such as carpals, tarsals and phalanges are especially rare in both taxa and in both sublevels (Figure 3). A more in-depth analysis of anatomical representation shows small differences by taxon and sublevel. Thus, red deer carcasses are represented by more cranial elements in Pb while the opposite occurs with the girdle portion, which is better represented in Pa. The appendicular elements show very similar pattern in both sublevels. Tibias dominate the long bones. A similar proportion of upper, intermediate and inferior appendicular elements was observed in both sublevels with the posterior appendicular elements predominating anterior elements. On the other hand, horses display a peculiar pattern, as we observe a balanced proportion of mandibles and skulls in sublevel Pb, whereas in Pa, only mandibles and hyoids were present. However, in

general axial skeletal elements are scarce, although in sublevel Pb, the abundance of metatarsals and the absence of metacarpals are striking.

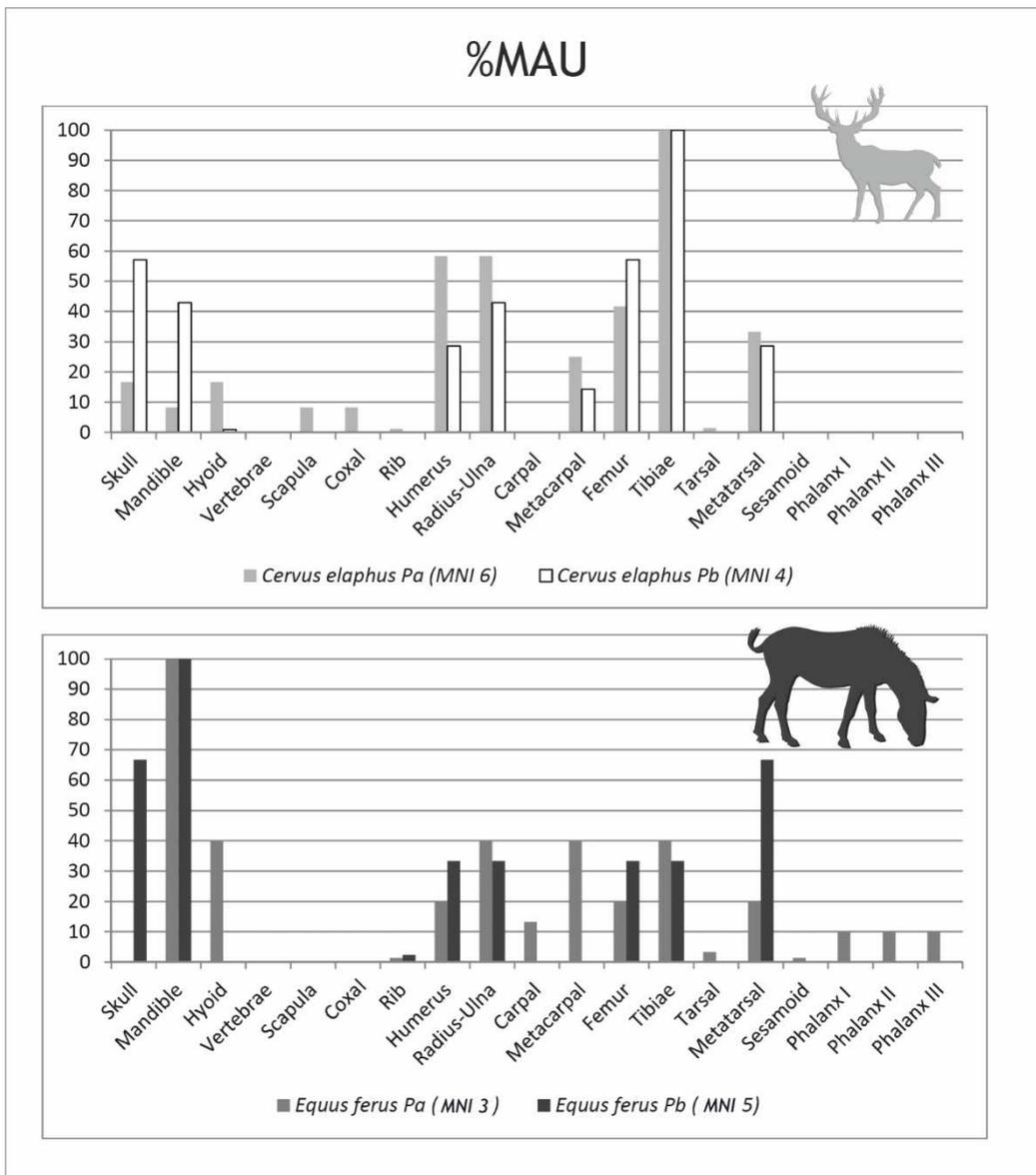


Figure 3 %MAU of the main species of ungulates represented in sublevels Pa and Pb of Abric Romaní.

The estimation of the age at death of the ungulates of level P is disparate due to the lack of cranial elements for some taxa and sublevels. The cranial MNI (13 compared to the 20 individuals estimated with the postcranial skeleton), corresponds to four individuals in sublevel Pa and nine in Pb. Based on the analysis of the eruption and tooth wear sequences for the red deer, was calculated the age of five individuals, one in sublevel Pa and four in sublevel Pb. For horses, were

calculated the age at death of all individuals in both sublevels. For all the ungulates, four individuals have enough dental remains to estimate the season of death. This involves two horses and two red deer (Figure 4). The absence of aurochs dental elements did not enable us to estimate the age of the two individuals present in this group.

The mortality profile for horses indicates a predominance of prime adult individuals in both sublevels. The two identified juvenile individuals, one per sublevel, were slaughtered during the summer. In the case of red deer, sublevel Pb shows a pattern of attritional mortality. Due to the scarcity of individuals in sublevel Pa, we must interpret the mortality profile for this latter sublevel with caution. In the same way, seasonality indicates that red deer were killed in sublevel Pb during the autumn or early winter while the absence of juveniles in Pa does not allow us to establish the exact moment of death (Figure 4).

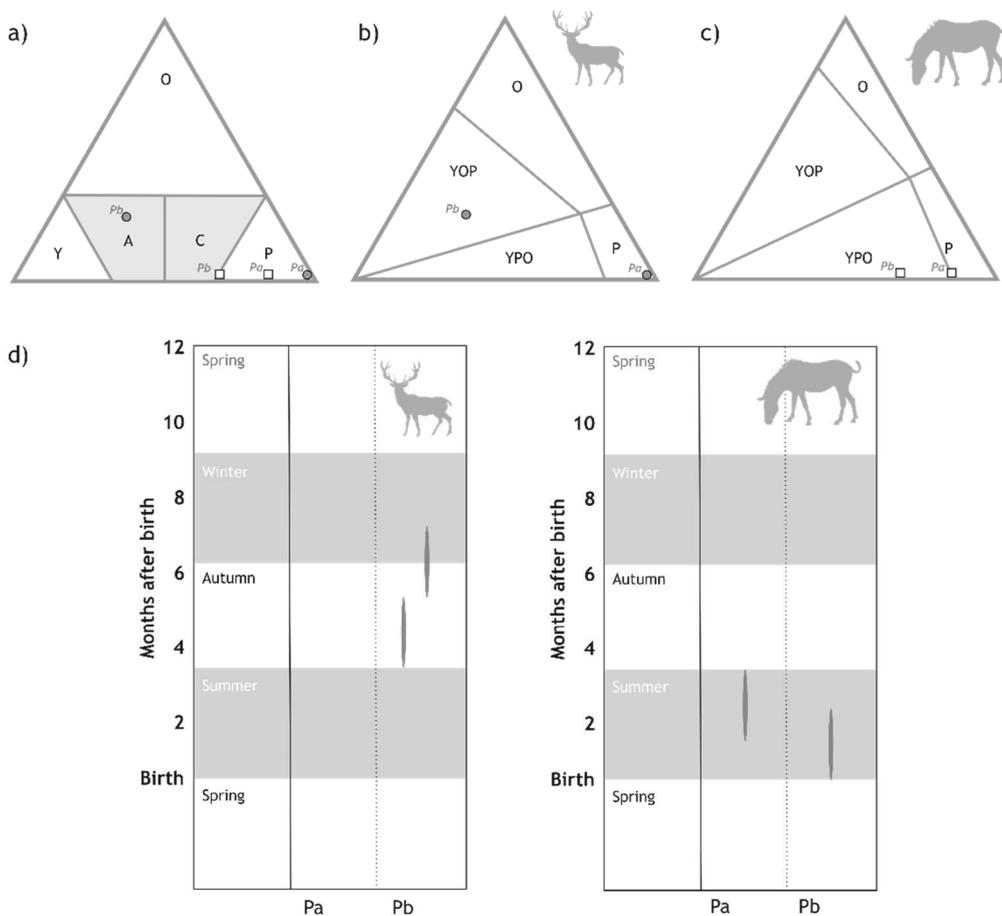


Figure 4. Summary of the pattern of mortality and seasonality in level P of Abric Romani. A) Representation of the mortality of deer (grey circles) and horses (white squares) by sub-levels in a triangular plot in which the classical areas are indicated according to Stiner (1991). b) and c) The same results plotted on the diagrams modified by Discamps et al., 2015. d) Seasonal scheme for deer and horses of the different levels of the Abric Romani P level (Y = Young; P = Prime adult; O = Old; YOP = Young-Old-Prime; YPO = Young-Prime-Old). Total MNI: deer Pa=1, Pb=4; horse Pa=3, Pb=5.

The analysis of the inter-individual variation of dental microwear patterns in red deer and horses indicates low SD and CV values for both species, in Pa and in Pb (Table 3). These values are plotted in area [A] of the heat map indicating that the four samples correspond to animal remains accumulated during short-term events, of one season or less (Figure 5). It is not possible to establish the season of death for the horse due to the lack of extant populations for comparison. In the case of red deer, the low scratch values, compared to extant wild populations of red deer and other cervids (Rivals et al., 2015), indicate a season of death in autumn or winter.

		MNI	Pits		Scratches		CV
			M	SD	M	SD	
<i>Equus ferus</i>	Pa	3	11.78	0.67	20.56	0.75	0.04
	Pb	3	15.17	1.61	21.92	0.63	0.03
<i>Cervus elaphus</i>	Pa	2	16.25	1.06	11.00	0.71	0.06
	Pb	2	14.75	1.06	13.50	1.41	0.10

Table 3 Summary of microwear data for the horse and red deer assemblages from Abric Romani sublevels Pa and Pb. Abbreviations: MNI = Minimum Number of Individuals; M = Average number of pits or scratches; SD = standard deviation (for pits and scratches); CV = coefficient of variation (for scratches).

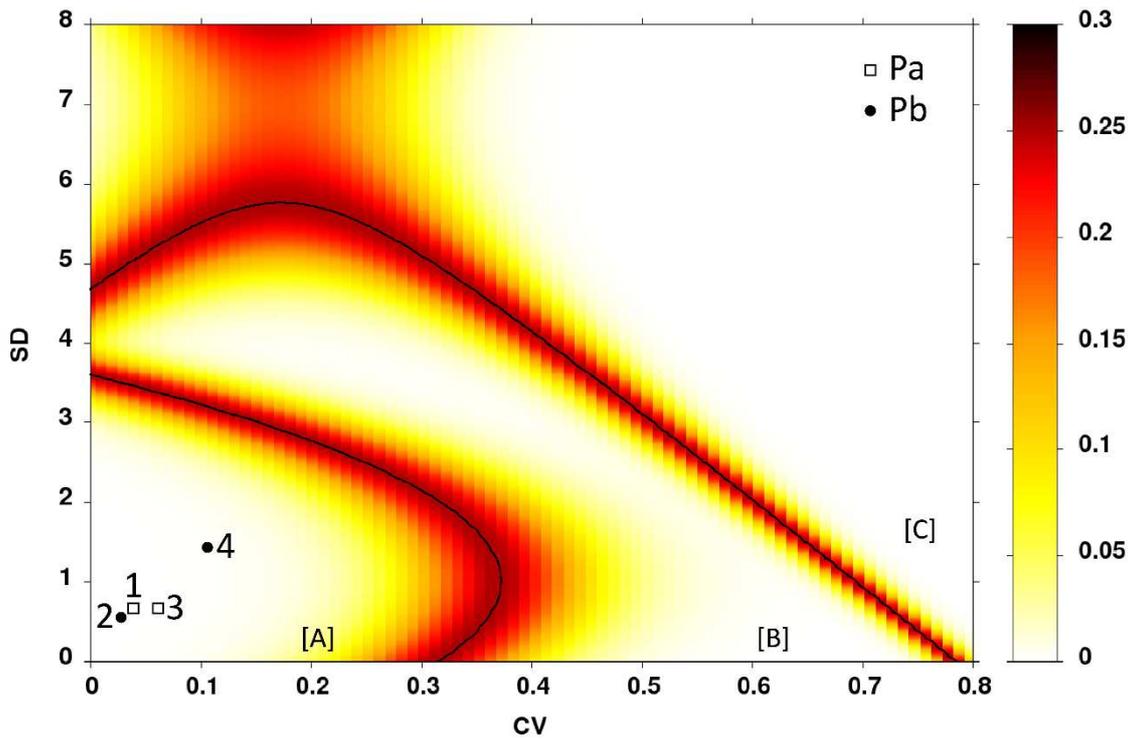


Figure 5 Boundary lines with the error probability (heat map) based on SD and CV values of microwear data used for the classification of samples into short events (region A), long-term events (region B), or two separated short events (region C) and positions of the assemblages of *Equus ferus* (1-2) and *Cervus elaphus* (3-4) from Abric Romaní sublevels Pa and Pb.

Correlations between (S)FUI and %MAU indicate that there is a statistical correlation for red deer in sublevel Pa. This result suggests that these animals could be subjected to unbiased or gourmet transport strategies according to the proposals of Faith and Gordon (2007) (Table 4). No other statistical correlations were identified, although the red deer shows a positive trend in sublevel Pb (Figure 6). The values of the horse in both sublevels are inversed to bulk and unbiased strategies (Figure 6). For the aurochs, the trend is negative in Pa and positive in Pb. There is no significant statistical correlation between the UMI and the %MAU in any of the taxa (Table 4).

			%MAU/SFUI		%MAU/UMI	
	Taxa	Evenness	Spearman's (rs)	P	Spearman's (rs)	P

Pa	<i>Cervus elaphus</i>	0.883	0.80241	0.021131	0.63775	0.2
	<i>Equus ferus</i>	0.908	-0.17522	0.70536	-0.09759	1
	<i>Bos primigenius</i>	0.971	-0.32733	0.48571	-0.29277	0.7
Pb	<i>Cervus elaphus</i>	0.928	0.46068	0.25159	0.7537	0.11111
	<i>Equus ferus</i>	0.824	-0.02554	0.96429	0.67612	0.2
	<i>Bos primigenius</i>	0.595	0.50709	0.25	0.62106	0.26667

Table 4 Evenness values and correlations of the different sublevels analysed by taxa.

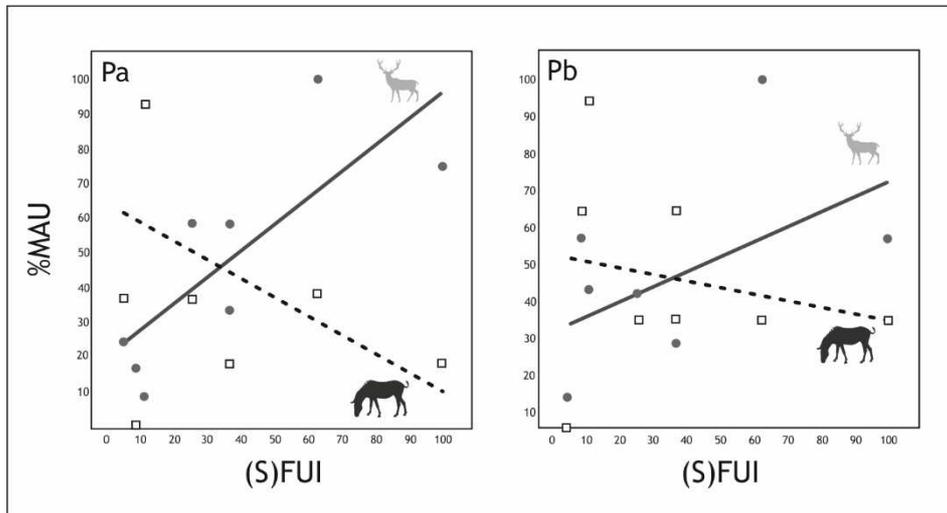


Figure 6 Scatter diagrams of skeletal representation in %MAU and (S)FUI for the two taxa represented in the level P faunal assemblage of the Abric Romaní. The grey points represent *Cervus elaphus* and the white squares represent *Equus ferus*.

The results of the Spearman coefficient between the %MAU and mineral density indicate that there are positive and statistically significant correlations in the red deer sample from Pa and Pb, in the sample of horses from Pb and the aurochs from Pa (Table 5). This indicates that there is a positive relationship, although it is low, between the representation of the anatomical parts and their mineral density.

Almost all the specimens in the faunal assemblage are fragmented (97.4%). Only 2.5% of the remains are complete, corresponding mostly to isolated teeth and articular bones. Long bone diaphysis in sublevels Pa and Pb conserve less than one third of their circumference and one quarter of their total length in 84.8% and 85.7% of the cases, respectively. The most common combination of characters in Pa sublevel is a predominance of longitudinal delineations, right angles and smooth edges (41.1%) and curved, oblique and smooth edges (36.5%). In sublevel Pb, curved, oblique and smooth fractures are the most represented (47.05%), followed by longitudinal, straight and smooth fractures (11.2%). These patterns indicated a predominant green bone fracture at sublevel Pa and Pb.

Taxa	Pa		Pb	
	Spearman's (rs)	p	Spearman's (rs)	P
<i>Cervus elaphus</i>	0.26321	0.0088306	0.32883	0.0009466
<i>Equus ferus</i>	0.18555	0.068825	0.25222	0.012693
<i>Bos primigenius</i>	0.21021	0.03877	0.12504	0.22235

Table 5 Values of significance analysis between bone mineral density and %MAU.

### 4.3 Bone surface modifications

Human-induced modifications are the most common modifications in the assemblage of level P and result from the nutritional phase of carcasses processing. Anthropogenic modifications are present on 37.2% of the bones in sublevel Pa and on 14.9% in sublevel Pb. These consist primarily of cut marks (Pa=12.6%; Pb=6.3%), percussion marks (Pa=5.7%; Pb=5.1%) and burnt bones (Pa=26.9%; Pb=5.1%).

Red deer is the taxon with the highest number of remains with cut marks, with 39 remains in Pa (24.4%) and 8 in Pb (16%). Nine horse specimens present cut marks in Pa (22.5%) and four in Pb (19%). Eleven aurochs specimens have cut marks in Pa (39.2%) and none in Pb. Most of the

identified cut marks correspond to slicing marks (Pa=90.3%; Pb=87.5%). The rest of the marks are scraping marks (Pa=8.7%; Pb=12.5%). The identified butchery activities are defleshing (Pa=84.3%; Pb=100%), skinning (Pa=10.8%), disarticulation (Pa=3%) and periosteum removal (Pa=2%). By species, in red deer at sublevel Pa defleshing suppose the 86.7% of butchering activities, disarticulation 8% and skinning 5.3%, and in sublevel Pb the unique butchering activity identified was defleshing. For horse in sublevel Pa the cut marks were related with the 77.8% with defleshing, 11.1% with disarticulation and the 11.1% with defleshing, in sublevel Pb the unique butchering activity identified was defleshing. For aurochs was identified remains with cut marks only in sublevel Pa, with a 50% of defleshing and a 50% of skinning, disarticulation marks were not found. In sublevel Pa for medium size animals the main activity identified was defleshing with 92.8% of cut marked remains, and disarticulation and skinning with a 3.6% each. For large animals in sublevel Pa defleshing was the 93.3% and skinning the 6.7%. In sublevel Pb for medium and large size animals the only butchering activity identified was defleshing.

Cut marks are more common on proximal appendicular elements in both sublevels, followed by intermediate appendicular elements in Pa and distal appendicular elements in Pb (Table 6). Cut marks are located mainly on midshaft portions (71.4%) of long bones, and then on the metaphysis (28.6%). Epiphyses are not cut marked.

	Pa						Pb						Total
	C. <i>elaphus</i>	E. <i>ferus</i>	B. <i>primigenius</i>	Larg e size	Mediu m size	Total	C. <i>elaphus</i>	E. <i>ferus</i>	Larg e size	Mediu m size	Total		
Cranium	0/1	0/0	0/1	0/0	1/1	1/3	0/0	0/3	0/1	0/0	0/4		
	0	0	0	0	100	3.3	0	0	0	0	0	15.3	
Mandible	1/3	1/8	1/5	2/2	0/1	5/17	0/7	0/4	0/0	0/0	0/11	10/58	
	33.3	12.5	20	100	0	29.4	0	0	0	0	0	17.2	

Hyoid	0/0	1/1	0/0	0/0	0/0	1/1	0/0	0/0	0/0	0/0	0/0	2/2
	0	100	0	0	0	100	0	0	0	0	0	100
Ribs	0/4	0/1	0/0	1/9	0/2	1/16	0/0	0/2	0/1	0/4	0/7	2/46
	0	0	0	11.1	0	6.3	0	0	0	0	0	4.3
Upper limb	15/42	0/6	2/7	0/0	0/1	17/56	5/13	1/4	0/0	0/0	6/17	46/146
	35.8	0	28.6	0	0	30.4	38.5	25	0	0	35.5	31.5
Intermediate limb	20/77	6/16	4/9	0/0	0/0	30/102	2/23	2/5	0/0	0/0	4/28	68/260
	26	37.5	44.4	0	0	29.4	8.7	40	0	0	14.3	26.1
Lower limb	3/33	0/5	4/6	0/0	0/0	7/38	1/7	1/3	0/0	0/0	2/10	18/102
	9.1	0	66.7	0	0	18.4	14.3	33.3	0	0	20	17.6
Phalanx	0/0	1/3	0/0	0/0	0/0	1/3	0/0	0/0	0/0	0/0	0/0	2/6
	0	33.3	0	0	0	33.3	0	0	0	0	0	33.3
Long bone	0/0	0/0	0/0	10/57	22/181	32/238	0/0	0/0	1/13	1/73	2/86	68/648
	0	0	0	17.5	12.2	13.4	0	0	0.1	0.1	2.3	10.5
Flat bone	0/0	0/0	0/0	2/15	6/26	8/41	0/0	0/0	0/3	0/20	0/23	16/128
	0	0	0	13.3	23	19.5	0	0	0	0	0	12.5
Total	39/160	9/40	11/28	15/83	29/212	103/515	8/50	4/21	1/18	1/97	14/186	234/1,410
	24.4	22.5	39.2	18	13.6	20	16	19	5.6	1	7.5	

Table 6 NISP (NISP%) of cut marks.

Anthropogenic breakage marks were identified on 69 bones (NSP: Pa=56; Pb=13). The most common signals in this category are percussion notches (NSP: Pa=33, Pb=7) and followed by

percussion pits (NSP: Pa=22, Pb=6). Related with fresh bone breakage were impact flakes (NSP: Pa=65, Pb=10) and adhering flakes associated with anthropogenic marks (NSP: Pb=1). By taxonomic distribution, the remains of red deer with anthropogenic breakage in sublevel Pa the 63.6% were percussion notches (NSP=7) and 36.4% were percussion pits (NSP=4), and in sublevel Pb only were identified percussion notches (NSP=2). For horse remains with anthropogenic breakage in sublevel Pa the 75% were percussion pits (NSP=3) and 25% percussion notches (NSP=1), and in sublevel Pb were identified only percussion pits (NSP=2). Remains of aurochs with anthropogenic bone breakage were identified exclusively on sublevel Pa, were 60% of percussion notches (NSP=3) and 40% of percussion pits (NSP=2). Anthropogenic breakage are situated on appendicular bones (98.5%), except one large-sized vertebra from sublevel Pa. Percussions notches and pits are located on the diaphysis (Pa=71.4%, Pb=69.2%) and metaphysis of long bones (Pa=28.6%, Pb=30.8%), although one percussion mark was identified on the proximal epiphyses of a horse metatarsal in sublevel Pb.

Modifications caused by fire affect 26.9% of the specimens in Pa and 5.1% in Pb. Different degrees of cremations were identified (Table 7). Single-coloured cremations are the most common and account for 88.5% of the burnt bone sample, while double or multiple colorations are relatively rare. Degree 1 (13.3%) is the most frequent, followed by degree 3 (5.1%) (Table 7).

Burned stages	Unburned	1	2	3	4	5
NSP Pa	715	163	30	64	27	10
%NSP	70.8	16.2	3	6.3	2.7	1
NSP Pb	241	8	1	2	3	1
%NSP 256	94.2	3.1	0.4	0.8	1.1	0.4

Table 7 Number of burnt remains presenting some evidence of burning. The elements presenting more than one degree of alteration have been marked in each relevant category.

In sublevel Pa carnivore-induced modifications are present on 5% (NR=48) of the specimens. On 0.8% of the assemblage, carnivores were also responsible for bone breakage. In terms of taxa, red

deer specimens present the most tooth marks (5.9%), followed by the horse (2.6%) and the aurochs (0.7%). In addition, a rabbit humerus with carnivore tooth marks was also identified. In sublevel Pb, carnivore tooth marks affect 3.14% (NR=8) of the assemblage. Four remains are directly associated with fracturing caused by carnivores. The percentage of red deer remains with tooth marks is 5.5%, and 2.2% on horse specimens. No aurochs remains bear tooth marks.

A total of 12 remains, in all sublevel Pa, bear both anthropogenic and carnivore modifications. However, there is no overlapping of tooth marks on anthropogenic marks or vice versa. The cut marks identified on eleven specimens are related to filleting, and on one specimen, the slice marks are associated with the skinning of carcasses. In this assemblage, it also documents a specimen with percussion pits.

The most common post-depositional modifications in sublevel Pa are water abrasion (10.7%) and vermiculation produced by the action of plants roots (10.4%). In addition, it has been possible to identify processes of chemical dissolution (5.2%), manganese oxide deposition (5.5%) and trampling (4.8%). In sublevel Pb, vermiculation is the most common post-depositional modification (22%), followed by manganese oxide stains (12.6%), chemical dissolutions (11%), water abrasion (7.4%) and, finally, trampling (2.7%).

#### *4.4 Faunal refitting*

In total, 65 coordinated faunal remains were refitted, forming 26 refit groups (Table 8). In sublevel Pa, 23 refits were found, and only three refits come from sublevel Pb. Were distinguished between anatomical (Pa=5; Pb=1) and mechanical (Pa=18; Pb=2) refits, most of which are formed by two elements (NR=16). However, in five cases, three specimens were joined together, and on two occasions, four and five remains were connected. The study of refits established the existence of connections between the accumulations delimited within each sublevel (Figure 7). In addition, it can be argued that there are no vertical movements between them.

The distances separating the refits are variable, as can be seen in table 8. The anatomical refits from sublevel Pa display short distances between each other and belong to horse remains. However, the mechanical refits display short and long distances. They consist of three mandibles, a carpal bone plus the metacarpal, and one metatarsal plus phalanges. The details of these refits are presented in table 8. Mechanical refits have been defined in all cases as a result of green bone breakages. In addition, in most cases, cut marks and percussion marks were observed, indicating the extraction of meat and percussion marks related to bone marrow extraction (refits 1, 2, 7, 9, 13 and 21). In Pb, short distances separate two of the refits while the other is a long-distance refit. The first two are mechanical refits of a horse metatarsal with cut marks and a Cervidae tibia with percussion pits. The anatomical refit is an equid mandible (Table 8).

Refits Nº	Sublevel	Taxa	Element	Number of remains	Type	Anthropic modifications	Distance	Connecting areas
Refits 1	a	<i>Cervus elaphus</i>	Tibiae	3	Mechanic	Percussion marks+burned	1m+5m	1-2
Refits 2	a	<i>Cervus elaphus</i>	Radius	2	Mechanic	Percussion marks+Cut marks+Burned	6m	2-4

Ref its 3	a	<i>Cervus elaphus</i>	Metatarsal	2	Mech anic	Burned	3m	-
Ref its 4	a	<i>Cervus elaphus</i>	Humerus	2	Mech anic	Cut marks+Bu rned	4m	-
Ref its 5	a	<i>Cervus elaphus</i>	Tibiae	2	Mech anic	Percussio n marks	1m	-
Ref its 7	a	<i>Cervus elaphus</i>	Tibiae	4	Mech anic	Percussio n marks+Cu t marks+Bu rned	1m+5m +3m	1-2
Ref its 8	a	<i>Cervus elaphus</i>	Femur	3	Mech anic	Percussio n marks+Cu t marks+Bu rned	3m+5m	-
Ref its 9	a	<i>Cervus elaphus</i>	Tibiae	3	Mech anic	Cut marks+Bu rned	1.5m+6 m	3-4
Ref its 10	a	<i>Equus ferus</i>	Radii	2	Mech anic		4m	-

Ref its 11	a	<i>Cervus elaphus</i>	Tibiae	2	Mech anic	Cut marks+Bu rned	>1m	-
Ref its 12	a	<i>Cervus elaphus</i>	Femur	2	Mech anic	Burned	>1m	-
Ref its 13	a	<i>Cervus elaphus</i>	Humerus	2	Mech anic	Cut marks	4m	2-4
Ref its 14	a	<i>Equus ferus</i>	Mandible	4	Anato mic		>1m	-
Ref its 16	a	<i>Equus ferus</i>	Mandible	3	Anato mic		2m+1m	-
Ref its 17	a	Large size	Long bone	2	Mech anic		>1m	-
Ref its 18	a	<i>Equus ferus</i>	Mandible	2	Mech anic	Cut marks	>1m	-
Ref its 19	a	<i>Equus ferus</i>	Tibiae	2	Mech anic	Cut marks+Bu rned	1m	-
Ref its 20	a	<i>Equus ferus</i>	Femur	2	Mech anic	Burned	>1m	-

Ref its 21	a	<i>Bos primigenius</i>	Humerus	3	Mech anic	Burned	1m+1m	3-4
Ref its 23	a	<i>Bos primigenius</i>	Tibiae	2	Mech anic	Percussion marks	1m	-
Ref its 24	a	<i>Equus ferus</i>	Metatarsal+Sesamoid+ Phalanx I+II+III	5	Anato mic	Cut marks	>1m	-
Ref its 25	a	<i>Equus ferus</i>	Metacarpal+Pisiform+Tr apezoid+Os Hamatum +Capitatum	5	Anato mic		>1m	-
Ref its 26	a	<i>Equus ferus</i>	Mandible	3	Anato mic		>1m	-
Ref its 6	b	<i>Cervus elaphus</i>	Tibiae	2	Mech anic		4m	-
Ref its 15	b	<i>Equus ferus</i>	Mandible	2	Anato mic		>1m	-
Ref its 22	b	<i>Equus ferus</i>	Metatarsal	2	Mech anic	Cut marks	1.5m	-

Table 8 Refits from sublevels Pa and Pb. The sublevel, taxon, element, anthropogenic modifications and distance between the specimens are indicated in the table.

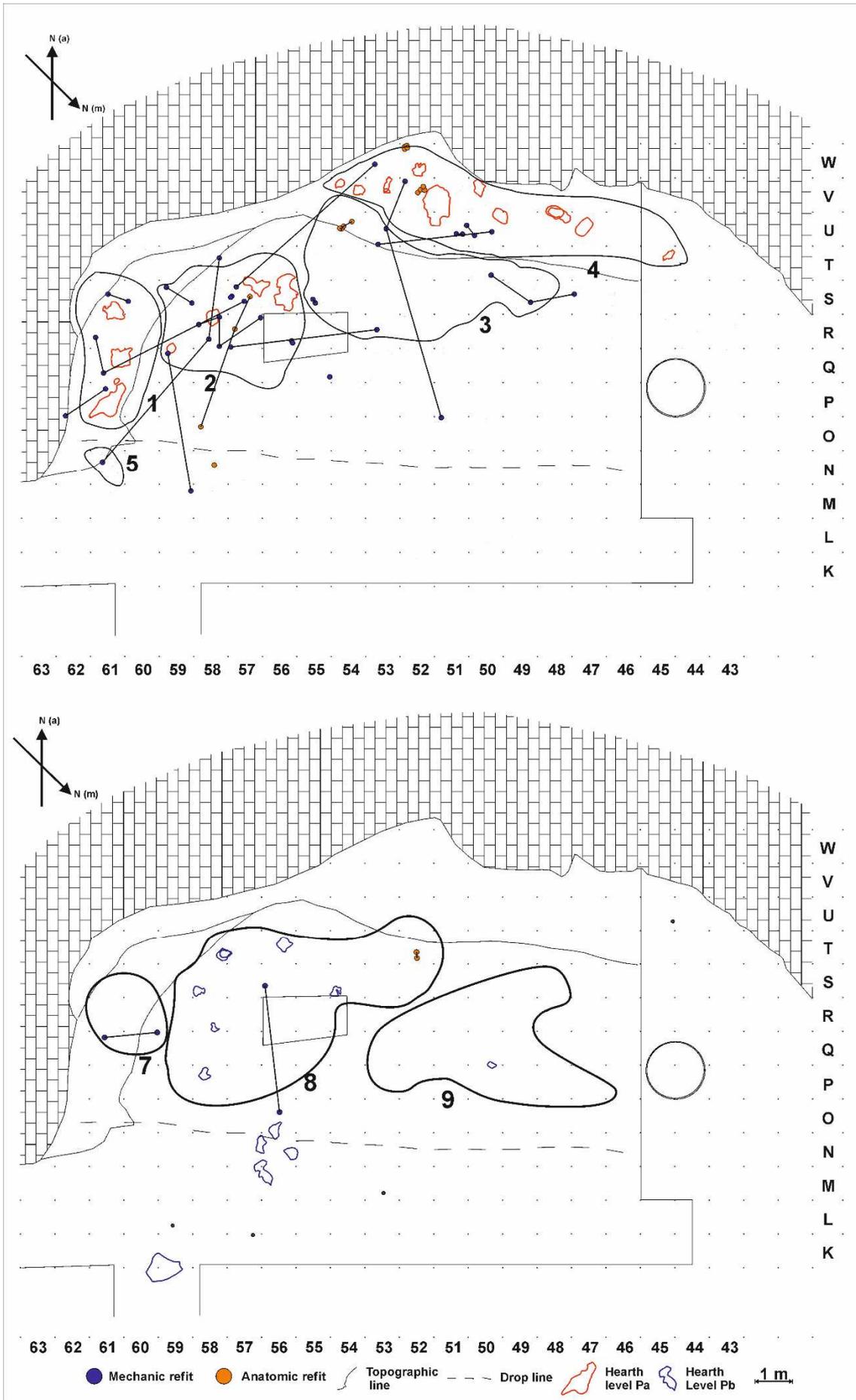


Figure 7 Distribution of mechanical and anatomical refits in sublevel Pa (upper) and Pb (lower).

The MNI per accumulation is lower than the total MNI in both red deer and horses. Although the sum of the total MNI per area is greater than the total MNI, there is a difference of two individuals in red deer and one in horses (Table 9). In addition, the redistribution index is far from 1, and shows an inverse value to food distribution. This is an indicator of low food sharing the activity areas in sublevel Pa. In sublevel Pb, this analysis was not carried out as it was not possible to establish a clear separation between the activity areas and individual hearths.

	<i>C. elaphus</i> / MNIs=6			<i>E. ferus</i> / MNIs=3		
	MNIf	n	RI	MNIf	n	RI
Area 1	3	3	0,2	1	3	0,1
Area 2	4	4	0,2	2	4	0,2
Area 4	2	9	0,04	1	9	0,04

Table 9 MNI by accumulation area (MNIf), number of hearths (n) and redistribution index (RI) for red deer and horse in Pa.

#### 4.5 Catchment areas of lithic raw materials

The vast majority of the 2,633 lithic remains larger than 1 cm, are in chert (91.1%, or 2,398 remains). A petrographic study was conducted on nearly two-thirds of these (62.8%, or 1,506 pieces). Lithics with strong post-diagenetic alteration (e.g., patinas, concretions, cremations), were excluded from the study, as they cannot be assigned to any specific raw material type.

Only three types of chert located within a 30 km radius of Abric Romaní, were identified in level P. The most represented chert is the Sant Martí de Tous type (SMT) with 824 pieces (54.7%), followed by the Panadella type (PAN) with 651 elements (43.2%), and finally, the Muschelkalk type (MUSCH) with 31 pieces (2.1%) (Table 10). For the first time in the sequence of Abric Romaní, SMT and PAN chert type percentages are similar.

	Cores	Retouched artifacts	Flakes	Flake fragments	Fragments	Total
SMT	24	17	339	416	28	824
	2.91%	2.06%	41.14%	50.49%	3.40%	54.7%
PAN	20	4	327	283	17	651
	3.07%	0.62%	50.23%	43.47%	2.61%	43.2%
MUSCH	2	2	16	11		31
	6.45%	6.45%	51.61%	35.49%		2.1%
Total	46	23	682	710	45	1,506
	3.06%	1.53%	45.28%	47.14%	2.99%	100%

Table 10 Technological categories by chert lithotypes in level P.

The near absence of chert in the main fluvial courses rules out possible procurement from secondary sources. Primary outcrops were thus defined as the main procurement source, and the CAR was calculated for a territory of about 30 km from Abric Romani.

The regional zones with abundant siliceous outcrops are mainly located in the vicinity of Sant Martí de Tous (SMT). Consequently, the raw material procurement strategy in level P of Abric Romani is regional for the SMT and PAN type cherts, which are located 16 km and 24 km from Abric Romani, respectively. The use of MUSCH type chert, with primary outcrops within a local (<10 km) and regional (>10 km) radius, points to a combined local and regional procurement strategy (Figure 8).

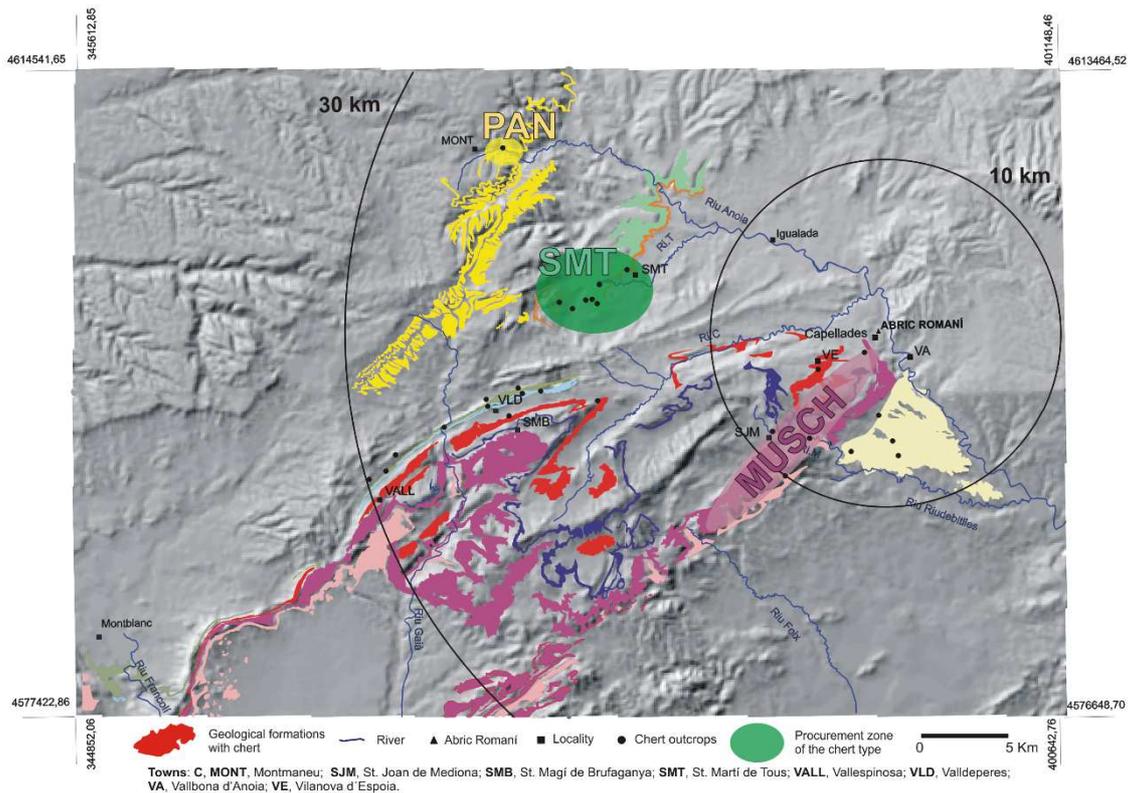


Figure 8 Map of outcrop showing chert procurement areas within a 10- and 30-km radius, documented for level P of Abric Romaní. Overlay of the digital terrain elevation model (1:50.000) with the digitization of geological formations with chert.

Due to the almost absence of chert in river courses, we calculate the Chert Abundance Ratio (CAR) to obtain a quantitative approximation of the amount of chert provided by the territory. This calculation (Soto et al., 2018), which is always approximative, gives us an overview of where the possible accumulations of raw materials are located. In this case the geological calculations for obtaining the CAR resulted in siliceous representation for the three types of chert in the territory: 16.99% for chert of SMT origin, 30.96% for MUSCH and 0.42% PAN type. The remaining 51.63% are geological formations with chert that are not represented in level P (Table B.1). These data show that if the SMT uptake occurs in area of regional abundance, the presence of PAN type chert in the archaeological record responds to other aspects not related to its local abundance. The same applies to the low presence of MUSCH chert, which is not comparable to its abundance in the territory. These aspects would mark a non-random capture of the lithic raw material.

## 5. Discussion

Over the past decades, intense research at the Abric Romaní has enabled us to discuss different aspects of Neanderthal behaviour. Among them, the exploitation of resources and the type of occupation of the rock shelter have been central (Allué et al., 2017; Bargalló et al., 2016; Burjachs et al., 2012; Carrancho et al., 2016; Chacón et al., 2015; Gabucio et al., 2018a, 2018a; Romagnoli et al., 2018, 2016; Solé et al., 2013; Vallverdú et al., 2010, 2005; Vaquero et al., 2017, 2015). The elevated sedimentation rate ( $0.6 \text{ m ky}^{-1}$ ) (Bischoff et al., 1988), the exceptional preservation of hearths (Vallverdú et al., 2012b, 2010) and activity areas (Gabucio et al., 2018b; Romagnoli and Vaquero, 2016; Vallverdú et al., 2010, 2005; Vaquero and Pastó, 2001), the extensive excavated surface (*circa*  $270 \text{ m}^2$ ), in addition to the assemblages resulting almost exclusively from human activity, have been key for the development of these investigations. Level P currently at the base of the archaeological sequence of this site, has been at the centre of this study.

The taxonomic uniformity of the sample, dominated by the presence of large ungulates, especially red deer and horse, as well as taphonomic modifications, together with the abundance of lithic remains and hearths in the two sublevels, show that the assemblages are of anthropogenic origin and were hardly disturbed by other biological agents. This type of deposition has often been observed in the preceding levels of the Abric Romaní sequence (Carbonell, 2012, 2002; Fernández-Laso et al., 2010; Gabucio et al., 2014; Marín et al., 2017a; Rosell et al., 2012b). The anthropogenic modifications in sublevels Pa and Pb are the most numerous. However, only the initial and final stages of the butchering processes are represented, that is, skinning and bone breakage related to the extraction of medullar marrow, indicating intensive exploitation of ungulates. The presence and frequency of anthropogenic modifications between the two main taxa of the site are similar. However, statistically significant differences between the two anatomical profiles have been observed. These differences can be summarized by a greater presence of cranial elements in horses and a greater presence of appendicular elements in the red deer sample.

Different explanations may account for these singularities. The difference between the proportion

of both taxa does not seem to be related to differential preservation. In both taxonomic groups, high survival elements (Marean and Cleghorn, 2003) are the most abundant. Indeed, low density portions are scarce in the whole assemblage, independently of taxa or animal size. These data corroborate the result of the statistical correlation between bone mineral density and anatomical presentation. The low representation of these elements could be related the sum of attrition generated by Neanderthals and other post-depositional processes. the Neanderthal activities could include the systematic and deliberate destruction during consumption or by cleaning activities (Marín et al., 2017a).

This is not the first time that significant differences between the horse and red deer have been observed In the Middle Palaeolithic sequence of Abric Romaní. Marín et al., (2017b) observed that the age at death of horses and red deer showed different profiles. Prime adult horses are predominant in all the sequence, resulting in a prime-dominated mortality profile. However, red deer showed higher diversity in these levels and could correspond to catastrophic profiles, dominated by young and prime adult mortality. These different mortality profiles could be related to different hunting strategies: selective ambush hunting for horses; and encounters or non-selective ambush hunting for catching red deer. Unfortunately, this disparity cannot be tested in level P due to the scarcity of red deer dental elements in the assemblage. The MNI was thus calculated based on appendicular elements. Consequently, has not been able to calculate the age of most of the red deer individuals identified in the assemblage. However, does note that prime adult horses were consistently selected as the preferred target.

In archaeological sites where one species dominates the assemblage, it is generally considered that they result from a specialized hunting strategy and that the contribution of other species was supplemental. In the sites of Jonzac, Les Padrelles, Pech de l'Aze IV, Roc de Marsal or Abri du Maras level 4.1 (Castel et al., 2017; Costamagno et al., 2006; Daujeard et al., 2019; Niven, 2013; Niven et al., 2012), the assemblages are dominated by reindeer remains, resulting from highly seasonal specialized hunting. The presence of horse and bison in these sites has been defined as a consequence of supplementary inputs; since they were locally available and not restricted by

seasonal migrations. In sublevels Pa and Pb, the red deer is the best represented species (NISP, MNE and MNI), but does not dominate the assemblage, as indicated by the Shannon and Simpson index. The differences between red deer and horse cannot correspond to a scenario where horses supplemented to a subsistence strategy based on red deer hunting, and vice versa.

A possible explanation for the predominance of cranial remains and a low economic returns profile in horses elements is that these portions result from scavenging events (head and feet profile) (Trinkaus, 1989). Two strategies could be considered in this scenario: passive scavenging (Binford, 1981; Stiner, 1991), and active or confrontational scavenging (Bunn, 2001; O'Connell et al., 1988). The frequency and distribution of cut marks, which are mainly on long bone diaphysis (71.4%), joints with bone breakage marks and the low number of carnivore modifications found at Pa and Pb, indicate Neanderthals access to a large quantity of animal meat. Therefore, the passive scavenging scenario of elements abandoned by carnivores can be rejected. The other alternative is confrontational scavenging based on snatching prey from other predators. However, in assemblages with horse capture by large carnivores, especially lions, mortality profiles are dominated by the weakest animals, i.e., young and old specimens (Schaller, 1972). Stiner (Stiner, 1990) indicated that Mousterian sites with high proportions of scavenging showed anatomical profiles dominated by cranial remains of red deer and aurochs, with mortality profiles dominated by old individuals. The mortality profiles of sublevels Pa and Pb are dominated by prime adults, which rules out any secondary access to horse carcasses in these assemblages.

Although it is true that anatomical profiles are the best proxies for evaluating transport strategies, the results for archaeological assemblages can be ambiguous for different reasons. The differential survivorship of some elements (Marean and Cleghorn, 2003), which has already been dismissed; a low MNE (Faith and Gordon, 2007). In addition, the combination of singular events (Marín et al., 2017a). In addition, we can add the transport decisions of each individual hunting event, which could also result in variable anatomical profiles in places of consumption and deposition, such as, for example, the places in which the animals were obtained and the first carcasses were dismembered (Metcalf and Jones, 1988; Monahan, 1998).

Other possible explanations for the divergence between deer and horse could be related to differences in animal transport strategies between the kill site and the rock-shelter. Transport strategies of animal carcasses in the upper levels of the sequence were discussed by Marín et al. (Marín et al., 2017a). Following Faith and Gordon (Faith and Gordon, 2007), the results obtained indicated that the anatomical profiles of all the weight size categories could be related to an unconstrained transport strategy, this is, the transport of all the elements of the skeleton. However, the comparison of the anatomical profiles of the levels of Abric Romaní with Hadza camps (Lupo, 2001), which generally show highly diversified types of transport, suggested that the assemblage results from mixed of transport events and various types of strategies, probably subject to different contingencies. However, in the rest of the levels, no substantial differences were observed between the different weight categories. In level P, when we examined the value of evenness with the result of the correlation between MNE and (S)FUI, following the proposal of Faith and Gordon (2007), were obtained conflicting results for both groups. These showed a positive relationship in the case of red deer and a negative relationship for horses, supporting the possibility of the existence of a reverse transport strategy for horses. In the assemblage of Pech de l'Aze IV, Niven (2013) showed that there is a high representation of reindeer heads, which is, in some cases, similar to the value of upper and intermediate appendicular elements. She related this transport to the presence of fire inside the site and therefore with more efficient processing allowing for more regular transport of skulls. Although this could account for the strong presence of horse heads, it does not explain the reverse utility curve result of a lower presence of appendicular elements, nor the shortage of red deer cranial remains. Horse profiles from sublevels Pa and Pb are similar, although not equal, to the profiles expected in a kill/butchering site (Metcalf and Jones, 1988). Enloe (2004) affirms that reverse utility curves in relation to bulk strategy values indicate the extraction of medium and high-utility elements from the kill site for later consumption in another place. The same anatomical profile and reverse utility curves have been observed in archaeological sites used as hunting camps or halts, such as the Mousterian sites of Gabasa (Blasco, 1997) and Moula-Gercy XV (Valensi et al., 2012), or the Magdalenian sites of

Tureau des Gardes (Bridault, 1995) or l'Amas d'Étiolles (Bignon, 2006a). Thus, the anatomical profile observed for the horse could be the result of transport, processing, and intermediate consumption of less profitable elements inside Abric Romaní, after which the most profitable elements were transported to another aggregation site.

The differences of anatomical profiles observed between the two taxa could also be related to distinct uses of Abric Romaní as a refuge. In logistic territorial exploitation systems, the same place can be used at different moments for different purposes (Binford, 1982). Current hunter-gatherers groups develop different mobility strategies during their movements, which ultimately generate distinct occupation types (Bartram, 1993; Binford, 1980, 1978; Gamble and Boismier, 1991; Jones, 1983; Kent, 1987; Kroll and Price, 1991; O'Connell et al., 1992, 1988; Yellen, 1977). This diversity is also observed in the archaeological record of Eurasia. In most of research characterizing the logistic mobility of Neanderthal groups, this inference was made through the functionality of the archaeological sites present in a territory, with the fundamental dichotomy between long/short-term occupation sites (Boyle, 2000; Daujeard and Moncel, 2010; Delagnes and Rendu, 2011; Moncel et al., 2014; Niven et al., 2012; Patou-Mathis, 2000; Turq et al., 2017). It has thus been possible to identify sites used as long-term residential camps (Bar-Yosef et al., 1992; Carbonell, 2012; Daujeard, 2008; Daujeard and Moncel, 2010; Marín-Arroyo, 2013; Morin, 2012; Patou-Mathis, 2000; Real et al., 2018; Romandini et al., 2014; Soressi et al., 2008; Speth et al., 2012; Stiner, 2013; Villaverde et al., 2017), others as short-term camps (Daujeard, 2008; Daujeard and Moncel, 2010; Delagnes and Rendu, 2011; Marín-Arroyo, 2013; Niven et al., 2012; Patou-Mathis, 2000; Stiner, 2013; Valensi et al., 2012; Vallverdú et al., 2005), as well as special purpose sites, such as kill sites or intermediated butchering sites (Rendu et al., 2012; Costamagno et al., 2006).

In general, it is assumed that long-term occupations generated high percentages of lithic and faunal remains, whereas short-term occupations present low quantities of remains (Bicho and Cascalheira, 2018; Costamagno et al., 2006; Daujeard and Moncel, 2010; Kuntz et al., 2016; Maroto et al., 1996; Moncel et al., 2008; Stiner, 1991; Stringer et al., 2000; Valensi et al., 2012; Vaquero and Pastó, 2001; Villaverde et al., 1996). Besides, long-term occupations usually comprise extensive

occupation surfaces and diversified provisioning strategies during a long period of a season (Audouze, 2010; Bicho and Cascalheira, 2018). Conversely, short-term occupations have small surfaces, restricted provisioning strategies and multi-seasonal occupations (Costamagno et al., 2006; Martínez-Moreno et al., 2004; Niven et al., 2012; Vallverdú et al., 2005; Villaverde et al., 2017). Following these principles, the faunal assemblages of sublevels Pa and Pb correspond to short-term occupation models. Tooth microwear analysis on horse and red deer dental remains also point to of short occupations for levels Pa and Pb.

Data of Raw material procurement in level P show that the main type of chert comes from 16 km away (SMT), a distance considered as the limit of the foraging radius of the Abric Romaní Neanderthals. However, the distance of 24 km obtained for PAN chert, representing 43% of the assemblage, indicates that Neanderthals at Abric Romaní manage the logistic territory differently at different times (Gómez de Soler, 2016). The first inference of the raw material procurement of the assemblage is the unidirectionality of the mobility pattern. All the raw materials have a north-western origin. Therefore, the south-eastern origin, i.e., the coastal route, can be rejected. The second inference is that the high percentage of PAN chert and the catchment area indicate a different occupation pattern to a long-term residential camp. Binford (1982) defined three mobility patterns: 1) half-radius continuous pattern; 2) complete-radius leapfrog pattern; 3) point-to-point pattern. Has been discard the third scenario because it is typical of low biomass environments. The first scenario would be related to unidirectional mobility, in which movement from one point to another would be related to a logistic radius, as was observed during the deposition of the PAN chert. A logistic catchment radius was inferred for this lithotype, indicating occupation events associated with a logistic territory.

In other levels of the Abric Romaní sequence, it was possible to differentiate between long-term occupations events (e.g., levels J, M, Oa) and short-term or non-residential occupations events (e.g., levels I, H, K, L) (Carbonell, 2012, 2002; Carbonell and Vaquero, 1998; Vallverdú et al., 2012a, 2010, 2005; Vaquero et al., 2012). The main difference between these two occupation models throughout the sequence is that specific activity areas could be identified and differentiated in

short-term occupation events (Vallverdú et al., 2005). Conversely, in levels resulting from long-term events, the different activity areas are superposed and cannot be differentiated from each other (Vaquero et al., 2012). However, it is not always simple to distinguish between long or short occupations in the archaeological record, since: “the locations preferred for residential camps can be expected to yield a most complex mix of archaeological remains since they were commonly also utilized logistically when the residential camps were elsewhere” (Binford, 1982:15). These occupation differences could be related to seasonal changes and with the availability of resources in the environment (Bartram, 1993; Binford, 1978; Kelly, 2013, 1983; Kroll and Price, 1991; O’Connell et al., 1992). From a taphonomic point of view, the butchering process usually show similar models in both occupations, characterized by secondary butchering exploitation and followed by the consumption of at least part of the carcasses (Chabai et al., 2006). Besides, in the case of specialized porpoise sites, as at intermediate butchering sites, exploitation of the skeletal segment for a food input and output in the same place could be observed.

The seasonal availability of most of the resources involves temporal and spatial limitations which restrict hunter-gatherer behaviour, and are often overcome through mobility over the territory (Binford, 1980; Kelly, 1992; Speth, 1987; Speth and Spielmann, 1983). The seasonal behaviour of many hunted species determined Neanderthals mobility, and, along with the predictability of some prey movements, allowed for the use of certain sites throughout generations (e.g., Adler et al., 2006; Rivals et al., 2009; Daujeard and Moncel, 2010; Rendu, 2010; Niven et al., 2012; Stiner, 2013). The dental remains of young red deer and horse individuals in sublevels Pa and Pb are scarce, but nonetheless show that the capture season of these species do not coincide. This could be considered as an additional sign that the site was used at two periods of the year depending on the species to be exploited. Tooth microwear analysis confirms the identification of seasonality based on red deer dental eruption, indicating a season of death in the autumn or winter. In addition, our results indicate that level P is a result of multisession occupations, which indicate short-term occupation events, as observed for the assemblages of Jonzac (Niven et al., 2012) or Abrigo de la

Quebrada (Real et al., 2018). Thus, although the evidence is not individually determinant, through the sum of all of them yields more robust inferences.

The distribution of remains in sublevels Pa and Pb enables us to identify different accumulations in which the materials are concentrated around combustion structures. In the Kernell density maps, it is possible to observe that there is no overlapping between the areas of major concentrations of horse and red deer remains in either sublevel (Figure 9). Besides, in the case of horse remains, the high concentration areas coincide with zones where anatomical refits were found. The Ripley's K test suggests that in both sublevels, horses are grouped at short distances, around 50 cm, and then regularly dispersed. The red deer remains show regular dispersion in the rock shelter for both sublevels (Figure 10). The multitype cross function K allows us to assume spatial independence between both taxa in sublevel Pa, and a regular distribution relationship between them in sublevel Pb for distances of more than 150 cm (Figure 11 and 12). The spatial autocorrelation Moran's I test, applied over the taxonomic representation index, confirms the pattern of the Kernell density maps. The variation in the spatial representation of taxonomically identified red deer and horse remains (Figure C.1, C.2 and C.3) and the relative sum ratios of both taxa (Figure 13) showed that the significant statistical concentration areas for high and low values do not overlap in space in either sublevel.

The domestic activity areas of hunter-gatherer groups are characterized by the concentration of faunal remains, commonly reduced to small fragments that remain in the place they were produced, normally associated with hearths (Binford, 1978; Enloe et al., 1994; Gifford, 1980; Schiffer, 1983). The regular dispersion of faunal remains, in this case, could be related to the distribution of hearths on the surface. However, the spatial statistic results for sublevel Pa point to the accumulation of spatially independent horse and red deer remains. Red deer remains were found specially in accumulations 1 and 2, and horse remains in accumulations 3 and 4 (Figure 9, Figure 13). For sublevel Pb, a major spatial independence exists between the red deer and horse remains, although the high-density accumulations are also independent (Figure 9, Figure 13). Therefore, the distribution of faunal remains, characterized by the segregation of red deer and

horses, could be related to short-term specialized occupations in search of each taxon. Otherwise, if it's take into account the results of the redistribution index (Jones, 1983) for the activity areas, in sublevel Pa a low or almost null repartition of animal carcasses was found.

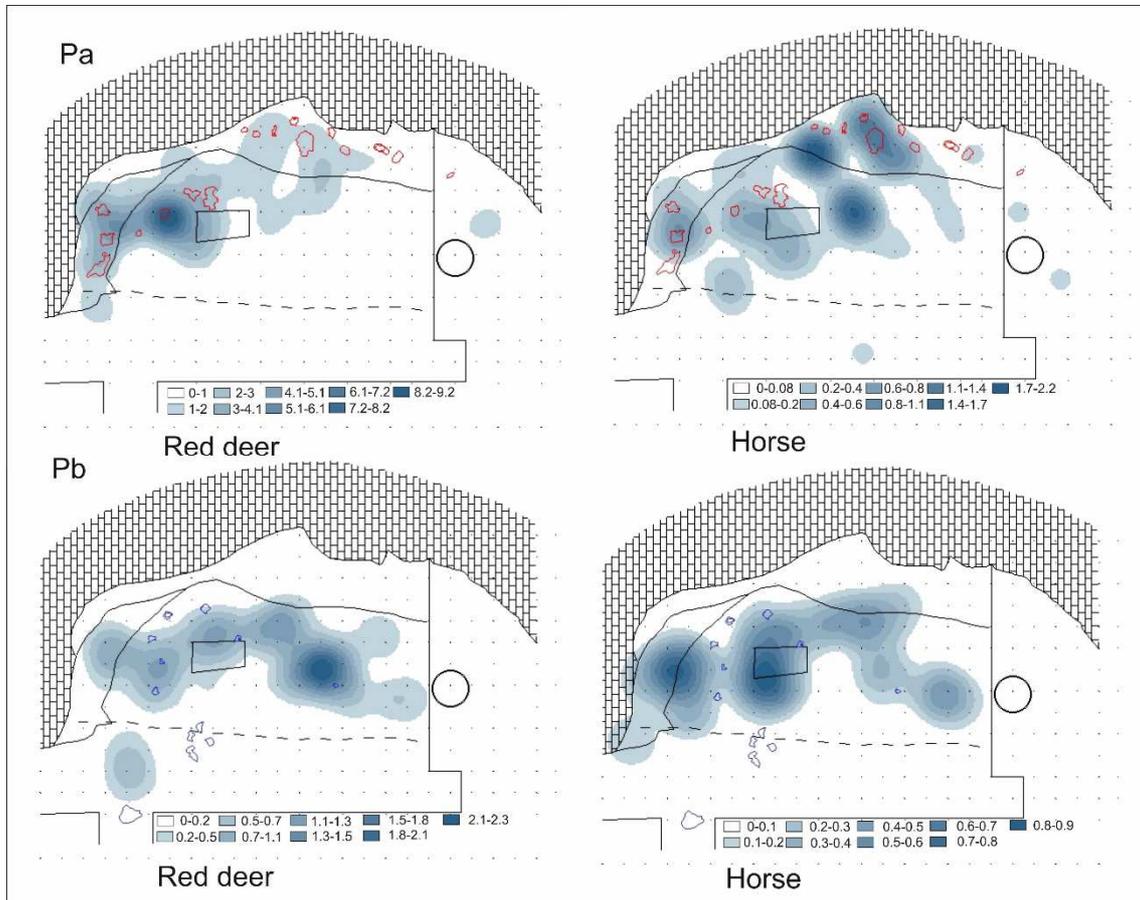


Figure 9 Kernell density maps of red deer and horse in sublevels Pa and Pb.

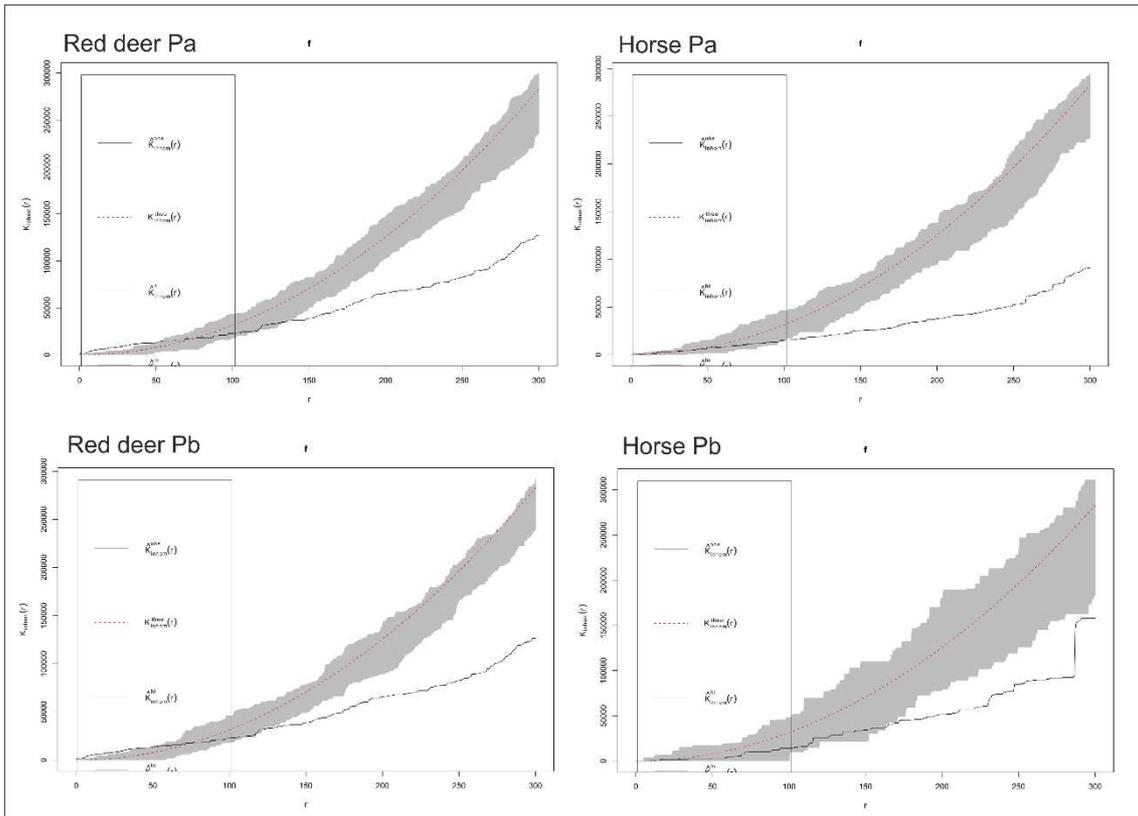


Figure 10 Ripley's K test distribution of red deer and horse remains in sublevels Pa and Pb.

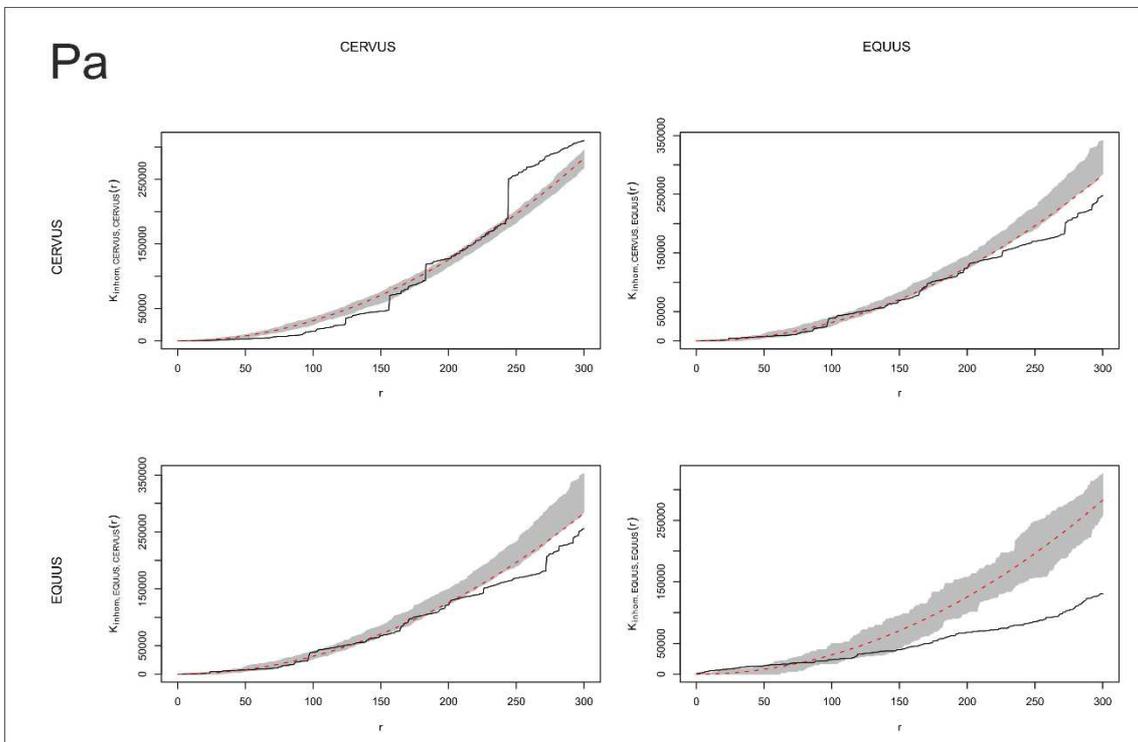


Figure 11 The multitype crossed function K of the distribution of red deer and horse remains in sublevel

Pa.

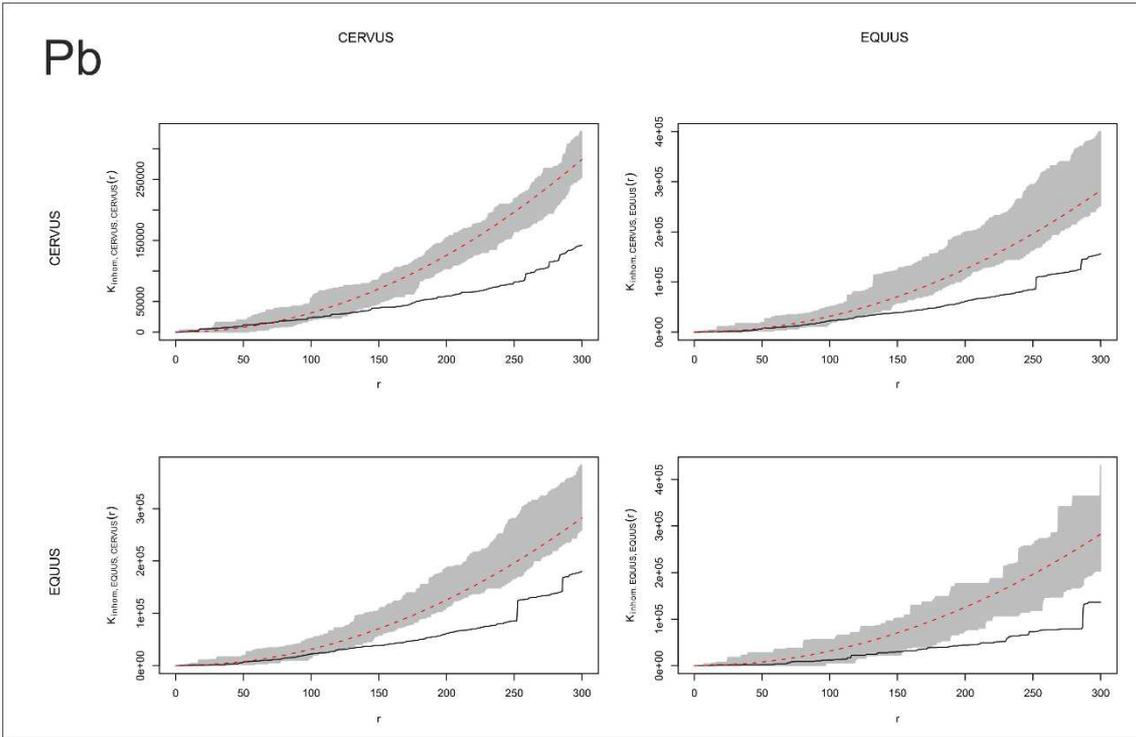


Figure 12 The multitype crossed function  $K$  of the distribution of red deer and horse remains in sublevel

Pb.

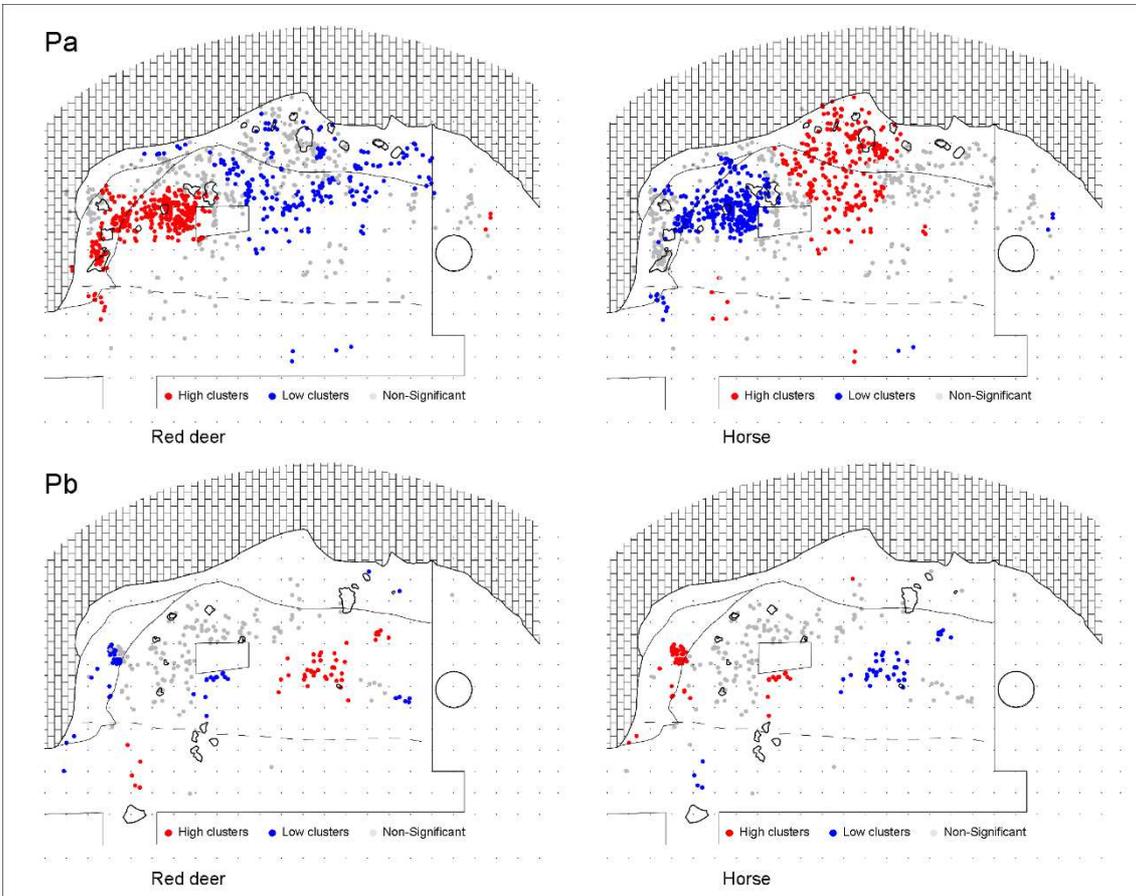


Figure 13 Spatial distribution of high and low clusters associated with the ratio of Red deer and Horse to the sum of Red deer and Horse for each sublevel. High clusters (red) are areas of statistically significant high proportions of the taxon under consideration; low clusters (blue) are areas where the proportion of the taxon under consideration is statistically significantly low; grey represents nonsignificant areas.

The indicators of the use of the site as a hunting camp for horse exploitation are multiplied if we sum up the differences between both taxa. The registered elements and their economic values show a negative correlation. This could be interpreted as the possible exportation of anatomical segments to another part of the territory. Using principal component analysis (PCA), we compared the anatomical profiles from red deer and horses of sublevels Pa and Pb with data from present-day hunter-gatherers and archaeological assemblages. The data from modern camps are from Binford (1978) for Nunamiut residential and hunting camps, and Domínguez-Solera (2017) for the Inuit hunting camp (Camp Jakob Josefsen) from West Greenland. The hunted and transported animals were caribous in both examples. The data from archaeological sites come from French Magdalenian sites, the residential campsite of Pincevent (Bignon et al., 2006) and Moulin-Neuf (Costamagno, 2000) and the hunting campsite of Tureau des Gardes (Bridault, 1995). Were selected these examples because the transported species were reindeer and horse, which allows us to compare them with the level P assemblages. The results indicate that red deer anatomical profiles are similar in contemporary and archaeological residential camps. This shows that they are related to assemblages where the input of the elements is maximized according to their utility, mainly upper and intermediate appendicular elements. On the other hand, horse assemblages are similar to the values from hunting camps, especially in sublevel Pb (Figure 14). This shows that the anatomical profiles of horses are the result of the extraction of the richest elements of the site. Therefore, the position of the anatomical profiles of red deer and horse with the PCA indicates opposing situations. A link was established between the archaeological sites of Tureau des Gardes and Pincevent, following Bignon (2006b), in which horse carcasses were transported from the first to the second. Therefore, its opposite position within the PCA corresponds to sites with a different

function. The case of Abric Romani indicates two different uses of the same site depending on the species.

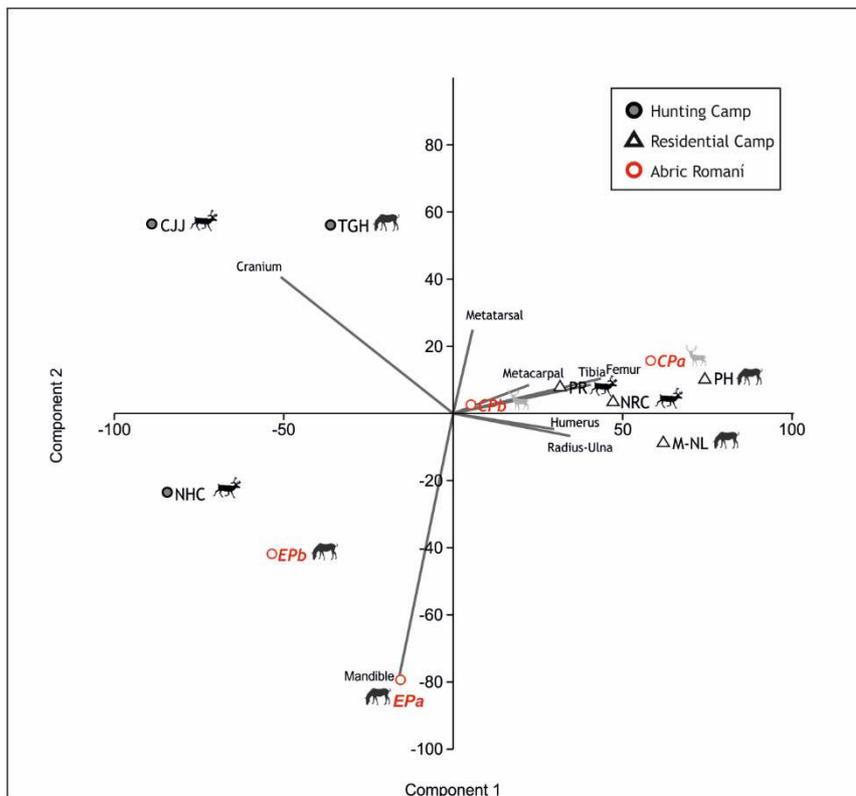


Figure 14 Principal component analysis of the anatomical profiles of high survival elements of horses and red deer in sublevels Pa and Pb (EPa, CPa, EPb, CPb), residential camps (NRC) and hunting camp of the Nunamiut and Inuit (CJJ; NHC) (Binford, 1978; Domínguez-Solera, 2017) and the assemblages of the Magdalenian sites of Pincevent (PH; PR), Moilin-Neuf (M-NL) and Tureau des Gardes (TGH) (Bignon et al., 2006; Bridault, 1995; Costamagno, 2000).

In Nunamiut hunting camps, Binford described the initial processing and consumption of the killed animals and a secondary transport from the hunting camp to a different aggregation place. Only the less useful anatomical parts were consumed, so the resulting profile is contrary to the bulk and unbiased strategies (Binford, 1978). This pattern has also been observed in archaeological sites defined as hunting camps, such as the Mousterian site of Moula-Guercy (Valensi et al., 2012), the previously mentioned Tureau des Gardes (Bridault, 1995) or the Magdalenian hunting camp of L'amas d'Etiolles (Bignon, 2006b). Therefore, the anatomical profile observed for horses could be the

result of transport, processing and intermediate consumption of the less profitable elements in Abric Romaní. After that, the most useful elements were transported to another aggregation place. However, the absence of cranial elements in sublevel Pa and the abundance of metatarsals in sublevel Pb, do not strictly correspond to expectations for this type of assemblage. Therefore, cannot rule out possible events of transport and abandonment of horse remains that do not correspond to the first scenario described.

Hunting camps are usually located in places previously used as residential campsites (Binford, 1978). These places offer additional incentives for use as stopover places, such as raw material accumulations or provisions, reusable structures, such as hearths, and accumulated dry wood or deteriorated wooden structures. The best locations combine all the aforementioned features with access to a view of a vast area for searching for prey (Binford, 1978). The Abric Romaní meets these requirements for use as a preferential location for different activities. The use of the rock shelter as a residential camp has already been broadly defined (Carbonell, 2012, 2002; Vallverdú et al., 2012a, 2005; Vaquero et al., 2017), the reuse or recycling of abandoned materials has also been documented, especially for the lithic industry (Vaquero et al., 2017, 2015). In addition, reused combustion structures and unburnt wood casts interpreted as firewood provisions for use as fuel have been recovered (Allué et al., 2017; Carrancho et al., 2016; Solé et al., 2013; Vallverdú et al., 2012a, 2010, 2005).

The environment exploitation system developed by Neanderthals in Abric Romaní has previously been defined as a logistic model (Vallverdú et al., 2005) where the mobility of groups was directly related to the exploitation of hunting resources. The results obtained for sublevels Pa and Pb indicate that two different types of occupations existed in a logistic mobility model. Raw material analysis supported a logistic territory of catchment for these groups. The two types of occupations were short-term occupations events, i.e., a transitory campsite with highly selective transport of red deer carcasses and a hunting camp occupation by specialized task groups for hunting horses, possibly to supply a larger residential camp. In this case, the site functioned as an intermediate butchering site. An alternative model would imply the abandonment and waste of the most

nutritionally productive parts of the carcasses in the kill site, which contradicts all optimal foraging models. Finally, we must add that both types of occupation were carried out during very specific times of the year. Together with spatial distribution analysis which indicate two main areas of accumulation for each specie, the result indicates that the supply of deer and horses by Neanderthals were mainly separate in time and space in the Abric Romaní.

The differential use of a place for distinct activities is typical of groups of collectors with logistic mobility types (Binford, 1980; Kelly, 1992). This strategy can also be identified by comparing the different uses of the rock shelter throughout the sequence. The site served as a referential site for Neanderthals for almost 35,000 years, for both high and low intensity occupations (Bargalló et al., 2016; Carbonell, 2012; Fernández-Laso et al., 2010; Gabucio et al., 2018b, 2014; Rosell et al., 2012a, 2012b; Vallverdú et al., 2005; Vaquero et al., 2012). The most intensive occupation events are related to residential camps as a result of moments of aggregation or related to more durable occupations (Fernández-Laso et al., 2010; Rosell et al., 2012a, 2012b). During short-term occupations, apart from the use as an intermediate butchering site identified in level P, other specific works have been documented. For example, at level I (short-term logistical occupations; Vallverdú et al., 2005), young red deer individuals around one month old were specifically exploited, possibly to retrieve their skins for specific uses (Marín et al., 2017b). In addition, some repetitive ethological behaviours show that certain species were predictable and spatially restricted targets, which means that particular sites could be systematically reused. For example, seasonal migratory movements of reindeer through the same corridors (Niven et al., 2012) or the daily displacement along established pathways at precise times of day with the presence of newborns in red deer female groups (Varin, 1980). For horses, the daily need for water, especially during the summer, restricts their movements around water spring and hydric resources (Berger, 1986; Burke, 2002).

The logistic mobility strategy has been related to a radiating type of displacement (Mortensen, 1972), characterized by the use of basecamp from which specialized task groups generate small temporary camps during the search for particular resources. This could be the mobility strategy of

Neanderthals during the formation of level P, occupying the rock-shelter for specialized tasks (horse hunting), and as a temporary residential camp (deposition of the red deer). This type of mobility is not rare in the European Middle Palaeolithic record. Although there are variations, the logistic model is the most widely accepted for Neanderthal groups (Delagnes and Rendu, 2011; Martínez-Moreno et al., 2004; Moncel et al., 2014; Patou-Mathis, 2000; Vallverdú et al., 2005; Zilhão and Villaverde, 2008). The results obtained from the study of level P situate the Neanderthal groups of Abric Romaní in a regional framework in which their movements depended on the availability of large ungulates. These displacements seem to have followed known routes, as indicated by the clear unidirectionality marked out by lithic raw material procurement and the intense reuse of the archaeological site as a place of activity.

## 6. Conclusions

Our results indicate that Neanderthal groups in level P developed two main types of low-intensity occupations: 1) a transitional residential camp; 2) a specialized hunting camp or intermediate butchering site. These occupations were closely connected to the hunting of red deer or horses. This points to a logistic mobility model close related to the exploitation of hunting resources. The seasonality and migratory behaviour approximations in this work sometimes allowed us to reaffirm the existence of differences between red deer and horses. Red deer capture was non-selective in terms of age, with transport of the anatomical parts of carcasses with a positive nutritional value to the rock shelter. On the other hand, horse hunting preferentially focused on prime adult individuals. The hunted animals were transported to the rock-shelter, where possibly after the consumption of the less useful parts, the rest was transported to a different place of aggregation. The differential use of the same place in a specialized way to obtain specific resources is characteristic of logistic behaviour.

## Acknowledgments

We want to express our deepest gratitude all the researchers and the fieldwork team of the Abric Romaní Project. We extend our sincerest gratitude to Jonathan Reeves and Shannon P. McPherron for their comments in the use of Moran's I test of spatial autocorrelation. We thank the editor Danielle Schreve, and the reviewers Camille Daujeard and one anonymous reviewer for their help and suggestions that improved the original version of the manuscript.

## Founding

This work was supported by the Ministerio de Economía, Industria y Competitividad/Fondo Europeo de Desarrollo Regional [PGC2018-093925-B-C32] and [HAR2016-76760-C3-1-P]; the Agència de Gestió d'Ajuts Universitaris i de Recerca project number [SGR 2017-1040] and [SGR 2017-836]; The Univeristat Rovira i Virgili [2014, 2015 and 2016 PFR-URV-B2-17]; the Departament de Cultura de Generalitat de Catalunya [100576, 2014] and is framed in Centres de Recerca de Catalunya Programme/Generalitat de Catalunya; Funding for fieldwork is provided by the Ajuntament de Capellades and the Departament de Cultura (Servei de Arqueologia i Patrimoni) of the Government of Catalonia. Juan Marín is the beneficiary of an Erasmus Mundus Doctorate scholarship for an International Doctorate in Quaternary and Prehistory.

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