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Neanderthal Behaviors from a Spatio-Temporal Perspective: An Interdisciplinary Approach to Interpret Archaeological Assemblages.

María Gema Chacón, Amèlia Bargalló, Maria Joana Gabucio, Florent Rivals,
Manuel Vaquero

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Edited by **Nicholas J. Conard** and **Anne Delagnes**

Settlement Dynamics of the Middle Paleolithic and Middle Stone Age

Volume IV



Tübingen Publications in Prehistory

KERNS VERLAG TÜBINGEN



*Settlement Dynamics
of the Middle Paleolithic
and Middle Stone Age*

Volume IV

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Neanderthal Behaviors from a Spatio-Temporal Perspective: An Interdisciplinary Approach to Interpret Archaeological Assemblages

María Gema Chacón, Amèlia Bargalló, Maria Joana Gabucio,
Florent Rivals, Manuel Vaquero

Abstract. *The reconstruction of human behavior is the main goal of Paleolithic archaeology. To interpret archaeological assemblages and the activities associated with them, a homogeneous and high resolution corpus of information is needed, especially to place these assemblages and activities in time and space. The way to achieve this is to use a variety of precise analytical methods in an interdisciplinary approach. The objective of this chapter is to reconstruct Neanderthal subsistence behaviors from a spatio-temporal perspective. The work focuses on obtaining more detailed and precise data that allow us to study differentiated individual events of activities (ethnographic time scale) performed at domestic activity areas. For this purpose we propose combining the following: zooarchaeology, taphonomy, lithic technology, raw material units, faunal and lithic refits, archaeostratigraphy, intra-site spatial patterning and, for the first time, tooth wear analysis.*

The selected archaeological sample comes from level O of the Abric Romani site (Barcelona, Spain) dated to around 55 ka. The fauna and lithic remains belong to the domestic activity area O10. This area was identified through archeostratigraphic and spatial analyses. The results allowed us to document the functionality of this domestic area and to distinguish the temporal formation of the archaeological assemblage and the subsistence activities performed there. Two micro-levels, separated by a thin sterile layer, were identified in the central zone. Some data suggest synchronicity between most of the remains inside this activity area, and also between some remains from this area and other activity areas of level O. However, other aspects show diachronic moments of activity. Our results permit us (1) to distinguish specific moments of the occupation in a clearly defined area and (2) to improve the interpretation of the palimpsests.

Résumé. *La reconstruction du comportement humain est l'objectif principal de la recherche en archéologie du Paléolithique. Des corpus d'information homogènes et de haute résolution sont nécessaires pour interpréter les assemblages archéologiques et les activités développées, en particulier pour les situer dans le temps et l'es-*

pace. La façon d'atteindre cet objectif est d'utiliser une variété de méthodes analytiques précises d'un point de vue interdisciplinaire. L'objectif de cet article est de reconstruire les comportements de subsistance des Néandertaliens dans une perspective spatio-temporelle. Le travail est axé sur l'obtention de données détaillées et précises qui permettent d'étudier les événements individuels et différenciés (échelle de temps ethnographique) développés dans les zones d'activités domestiques. A cet effet, nous proposons de combiner différentes disciplines: archéozoologie, taphonomie, technologie lithique, unités de matières premières, remontages de faune et d'industrie lithique, archéostratigraphie, structuration spatiale intra-site et pour la première fois nous ajoutons également une analyse de la micro-usure dentaire. L'échantillon sélectionné provient du niveau O de l'Abri Romani (Barcelone, Espagne) daté d'environ 55 ka. La faune et l'industrie lithique appartiennent à la zone d'activité domestique O10. Cette zone a été identifiée par l'analyse archéostratigraphique et spatiale. Les résultats de cette étude ont permis d'établir la fonction de cette zone d'activité domestique et de caractériser la formation temporelle de l'assemblage archéologique et les activités de subsistance effectuées. Deux micro-niveaux, séparés par une fine couche stérile, ont été identifiés dans la zone centrale. Certaines données suggèrent une synchronicité entre la plupart des restes à l'intérieur de cette aire d'activité, et aussi entre quelques restes de cette aire et d'autres aires d'activité du niveau O. Toutefois, d'autres aspects de l'étude montrent des moments d'activité diachroniques. Nos résultats ont permis (1) de distinguer des moments précis de l'occupation dans une zone clairement définie et (2) d'améliorer l'interprétation des palimpsestes.

INTRODUCTION

The majority of Middle Paleolithic assemblages are the result of a series of conflated remains from many episodes of occupation that form a palimpsest. They are a significant and constant obstacle for studying archaeological remains. Palimpsests derive from an unknown number of natural and anthropogenic depositional, erosional and postdepositional events merging into a single space (Bailey 2007; Lucas 2005, 2012). Archaeology has been defined by its ability to provide information about long-term processes (Vaquero 2008). The division of archaeological palimpsests into analytical units puts the focus on stratigraphic method and on descriptive sedimentological criteria. The use of the geological time scale provides information about the archaeological units, though they usually represent long periods of time (Bailey 2007; Machado, Hernández, Mallol et al. 2013; Vaquero 2008). To achieve historical interpretations and the recognition of the dynamic role of site formation processes of archaeological assemblages we should pay more attention to the short-term processes, those defined by specific events of activity. They are the focus of the reconstruction of the site's history and allow us to answer questions about human behavior and the formation of archaeological assemblages (Vaquero 2008).

Studies on Paleolithic palimpsests usually focus on answering questions concerning type of occupation, site function, seasonality or mobility strategies, assuming that all the artifacts of an assemblage or archaeological level are synchronous and/or impossible to separate (e.g., Brugal and Jaubert 1996; Delagnes and Rendu 2011; Lieberman 1993; Martínez-Moreno, Mora, and De la Torre 2004; Rendu, Costamagno, Meignen et al. 2012).

The palimpsest problem (Henry 2012) can be resolved thanks to high resolution archaeology (Gowlett 1997a, 1997b) which tries to capture “precise moments in the remote time” (Roe 1980) largely through the detailed mapping of various kinds of behavioral residue associated with presumed living floors (Gowlett 1997a). Nowadays, the study of archaeological assemblages uses research methodologies with analytical challenges in order to identify spatial patterning and infer its behavioral significance with the objective of reconstructing the activities performed by Neanderthals (Adler and Conard 2005; Henry 2012; Hovers, Malinsky-Buller, Goder-Goldberger et al. 2011; Malinsky-Buller, Hovers, and Marder 2011; Vaquero 2008, 2012; Vaquero, Chacón, Cuartero, et al. 2012).

The identification of individual episodes/events of activity was questioned by some authors because “we may end up with individual episodes too small or limited in number to sustain any generalization” (Bailey 2007: 209; Malinsky-Buller, Hovers and Marder 2011: 99) or because the disconnection between the ethnographic models and the archaeological units of low temporal resolution can make ethnographically derived interpretations problematic (Smith 1992). However, this is the only way to decipher the palimpsests present in nearly all archaeological assemblages. The life of hunter-gatherers, such as the Neanderthal groups, is organized by domestic areas. If we are able to interpret these units of temporal activity we can combine the data and reconstruct the ethnographic time scale, identifying then the individual events of activity. In this way, the analysis of the subsistence activities developed by these groups provides high resolution data from a spatio-temporal perspective.

As mentioned previously, the study of site formation scales faces a major challenge in employing accurate analytical units. The appropriate approach for understanding the paleoanthropological record sets out to achieve an increasingly higher temporal resolution in order to compare the archaeological and the ethnographic time scale (Machado, Hernández, Mallol et al. 2013; Vaquero 2008). This requires interdisciplinary high resolution analysis of the sedimentary and archaeological assemblages combining macro- and microstratigraphic data. In this chapter we present a new interdisciplinary approach using this type of analytical units to interpret the Neanderthal behaviors from a spatial-temporal perspective. Up to now, some similar interdisciplinary works were conducted for other assemblages from the Abric Romaní site (e.g., Level J; Carbonell 2012). The results from different disciplines were combined and compared in order to identify the subsistence behaviors of Neanderthals. The novelty of the methodology that we present in this chapter is in adding tooth wear analysis to this approach. This method can provide higher temporal resolution data to estimate the duration of individual events of activity at the site (see section on tooth wear analysis below). The objective of this approach is to acquire the highest spatial and temporal resolution possible in order to study the occupational events at the site and infer the characteristics of organization of domestic structures and activities that Neanderthal groups developed around them (occupation patterns of the site). Accordingly, it will become possible to reconstruct the spatio-temporal dimensions of the archaeological assemblages. We test the new methodology on a single domestic area identified at level O of the Abric Romaní site. This work was the first spatial pattern analysis approach for level O and is a part of two PhD dissertations defended in 2014 (Bargalló 2014; Gabucio 2014).

In order to apply this methodology, one of the most important factors is the time scale and the resolution of the archaeological assemblages. It is necessary to rely on assemblages whose time scale is as close as possible to the ethnographic time scale in order to increase the temporal resolution of assemblages as much as possible (Vaquero 2012). To achieve this goal it is important to understand the natural formation processes of the deposits and their stratigraphic resolution. Rapid sedimentary rates provide assemblages with a higher temporal resolution than in other contexts where the occupation redundancy is more difficult to identify.

The Abric Romaní (Capellades, Spain) represents an excellent site for applying this type of methodology for two reasons: (1) its sedimentary context and (2) the methodology of excavation. Its stratigraphic sequence of more than 20 m has been dated by U-series and radiocarbon to between 40 and 70 ka BP (Vallverdú, Gómez de Soler, Vaquero et al. 2012; Vaquero, Allué, Bischoff et al. 2013) (fig. 2). It is characterized by the dominance of travertine formation dynamics. This is a particularly rapid formation process—the sedimentary rate has been calculated at 0.46 mm/yr—which has produced archeological levels of high temporal resolution and created a clear vertical separation of the human occupation horizons (Vallverdú, Gómez de Soler, Vaquero et al. 2012). The archaeological levels are thin sandy layers usually separated by thick and sterile tufa deposits, which considerably decrease the temporal depth of the palimpsests. Archeological layers are vertically well delimited and the mixing of elements from different layers is unlikely to occur. Human occupations were notably discontinuous, since the rockshelter was not habitable during the periods of travertine formation. The Abric Romaní sequence can be considered as a natural sequence punctuated by short periods of human occupation (Vaquero 2012).

This type of sedimentary context must also be linked to fieldwork methods. The excavation strategy followed since fieldwork began in 1983 has been directed explic-

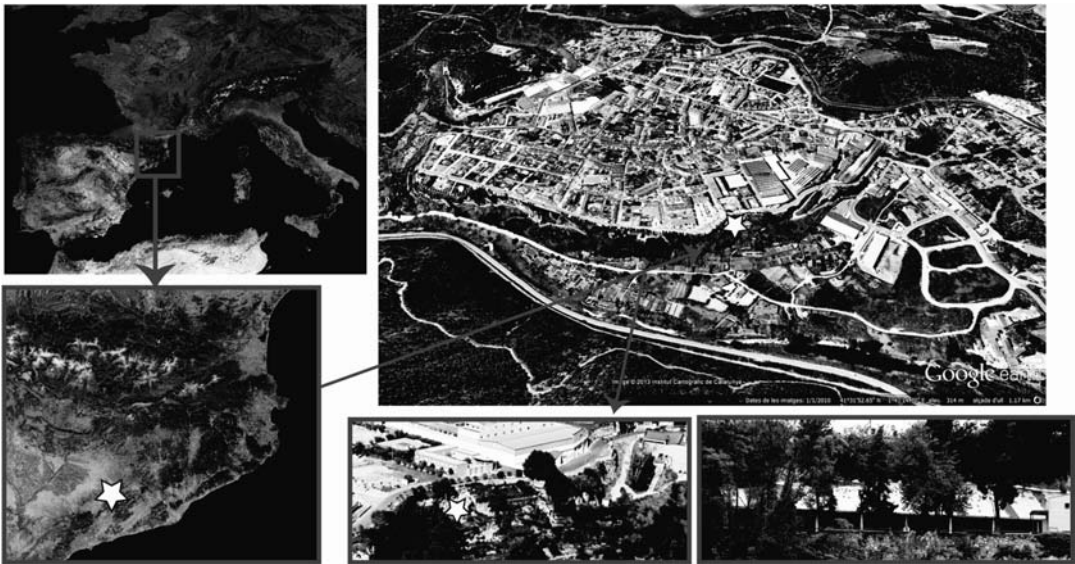


Fig. 1. Geographic location of the Abric Romaní site (Maps <http://visibleearth.nasa.gov>; photos, IPHES).

itly toward the reconstruction of behavioral strategies of the Neanderthal groups that occupied the shelter. For this reason the excavation includes most of the originally occupied surface in an area of nearly 300 m² to construct a spatial interpretation of the archaeological record. All the levels were excavated using a grid of 1 m². All materials found were recorded as individual points on a three-dimensional diagram representing the site. All objects were plotted using Cartesian coordinates (X, Y and Z). The excavation followed the natural paleorelief, which is guided by sedimentary and archaeological remains. This method allows us to visualize the three-dimensional space, paying special attention to the spatial distribution of the archeological remains and the identification of structures. This facilitates the study of activity areas and the possible spatial connections between them. Among these structures the hearths should be emphasized, as they are very abundant in all the archeological levels so far excavated, and have allowed us to characterize the formation of hearth-related activity areas (Vaquero and Pastó 2001) as one of the essential features of Neanderthal spatial behavior. These areas can be interpreted as household spaces similar to those identified among contemporary hunter-gatherer groups, a comparison that makes it possible to approach the social dynamics of prehistoric groups (Vaquero 2012).

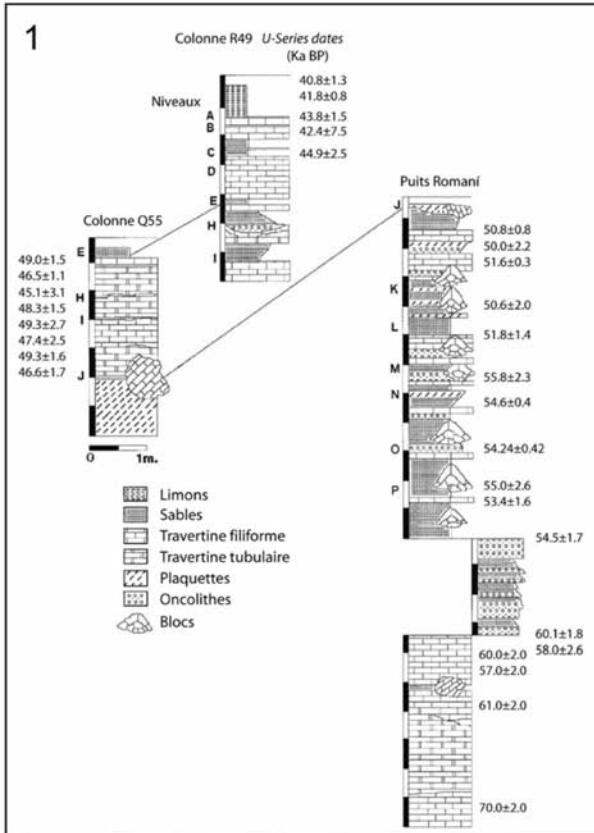
ABRIC ROMANÍ

The Abric Romaní site is located at Capellades (Barcelona, Spain) in the travertine cliff of the Cinglera del Capelló, at 280 m a.s.l. The karst formation is located on the west bank of the Anoia River where the valley forms a narrow gorge, called the Congost de Capellades. The strategic geographical and geological position of the site, at the crossroads of different ecosystems (mountains and coastal plain), offered a wide variety of resources to the prehistoric groups (fig. 1). Various layers have been identified in the stratigraphic sequence, all belonging to the Middle Paleolithic, except level A which belongs to the Aurignacian. Fifteen layers (from level B to P) have been excavated to date (fig. 2).

The paleoecological reconstruction at the site was accomplished through a multidisciplinary approach. Five climatic zones were identified on the basis of palynological analysis, which were complemented by charcoal, phytolith, herpetofauna, micro-mammals, and tooth wear analysis on ungulates (Allué 2002; Burjachs, López-García, Allué et al. 2012; Cabanes, Allué, Vallverdú et al. 2007; Vaquero, Allué, Bischoff et al. 2013). The milder conditions documented at the bottom of the sequence progressed towards the interstadial climate in evidence at the topmost levels through cycles of warmer and colder events (fig. 2). The paleoenvironmental conditions of level O (the object of study in this chapter) fall within the framework of pollen zone 3 (56.8–49.5 ka BP), a time characterized by short and abrupt oscillations of warmer and wetter episodes in intervals of 10 ka, and the period which marks the beginning of MIS 3.

Anthracological analyses confirm a predominance of *Pinus* type *sylvestris/nigra* throughout the stratigraphic sequence (Allué 2002; Vaquero, Allué, Bischoff et al. 2013) and the presence of an open forest environment with little variability and an essentially local procurement of wood resources (Allué and García-Antón 2004) (fig. 2). The sedimentary context of the site does not only mean that the archaeological assemblages are very well preserved, but that wood imprints (negative and positive

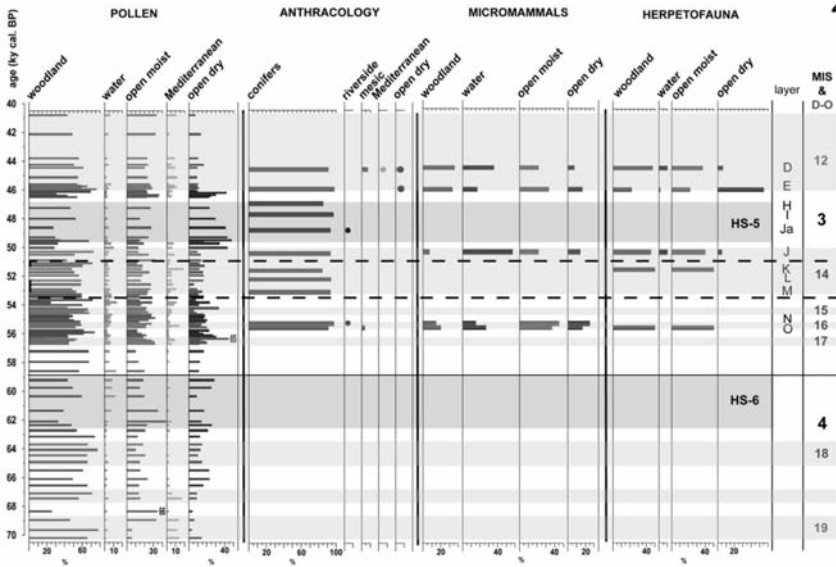
Fig. 2. Stratigraphy, dates (below, this page), paleoecological data (pollen, charcoal and micromammal analyses) (facing page, top) and macrofauna (facing page, bottom) from the Abric Romaní site (modified from Giral and Julià 1996; Bischoff, Julià and Mora 1988, Bischoff, Ludwig, García et al. 1994; Vallverdú, Gómez de Soler, Vaquero et al. 2012; Burjachs, López García, Allué et al. 2012; Gabucio and Bargalló 2012; Gabucio, Cáceres, Rodríguez-Hidalgo et al. 2014; Fernández-Laso, Rivals, and Rosell 2010; Rosell, Blasco, Huguet, et al. 2012; Rosell, Cáceres, et al. 2012; Vaquero, Allué, Bischoff et al. 2013) (photo, R. Bartroli).



sides) are in excellent condition as well as hearths (Carbonell and Castro-Curel 1992; Castro-Curel and Carbonell 1995; Solé 2007, Solé, Allué, and Carbonell 2013; Vallverdú, Alonso, Bargalló et al. 2012) (fig. 3). More than 250 hearths were identified in the entire stratigraphic sequence. Some are simple (without previous preparation) and others more complex (taking advantage of existing natural structures or partially bordered by small blocks or slabs). The dimensions of the hearths vary; the largest ones (>1 m) are associated with subsistence activities (knapping processes and skinning, defleshing and bone breaking activities), while the smallest ones (<1 m) correspond to sources of light and heat and sleeping areas (Vallverdú, Vaquero, Cáceres et al. 2010). The analysis of charcoal and phytoliths recovered from the site indicates the frequent use of *Pinus* sp. or *Pinus sylvestris/nigra* as fuel and grasses as kindling (Allué 2002; Cabanes, Allué, Vallverdú et al. 2007; Solé, Allué, and Carbonell 2013; Vaquero, Allué, Bischoff et al. 2013).

The recurrent faunal species found throughout the sequence are *Equus ferus* and *Cervus elaphus*, occasionally associated with *Stephanorhinus hemitoechus* and *Bos primigenius* (Fernández-Laso, Rivals, and Rosell 2010; Gabucio and Bargalló 2012; Rosell, Cáceres, Blasco et al. 2012) (fig. 2). Animals such as *Capra pyrenaica* are sporadically present. The most abundant anatomical parts of large animals are the portions richest in meat and marrow (the heads and proximal parts of the limbs). Medium-sized and





Macromammal taxa	Levels														
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
<i>Ursus</i> sp.															
<i>Canis lupus</i>															
<i>Panthera leo spelaea</i>										LP					
<i>Panthera pardus</i>				LP											
<i>Lynx</i> sp.															
<i>Felis silvestris</i>															
<i>Crocota crocuta</i>															
Proboscidea															
<i>Stephanorhinus hemitoechus</i>															
<i>Equus ferus</i>															
<i>Cervus elaphus</i>															
<i>Bos primigenius</i>															
<i>Rupicapra</i> sp.															

(LP= lower platform of the level)

small animals, on the other hand, were brought to the site in one piece. Skeletal remains are intensely fractured (most of the fragments ≤ 3 cm in length). Cut marks and percussion marks are the most common anthropogenic traces.

The number of burned bones is also high in almost all levels, which has led some researchers to suggest that bones were used as fuel in the hearths (Gabucio, Cáceres, Rosell et al. 2014; Rosell, Cáceres, Blasco et al. 2012). Carnivores are also present (*Ursus arctos*, *Canis lupus*, *Vulpes vulpes*, *Crocota crocuta*, *Panthera spelaea*, *P. par?*)

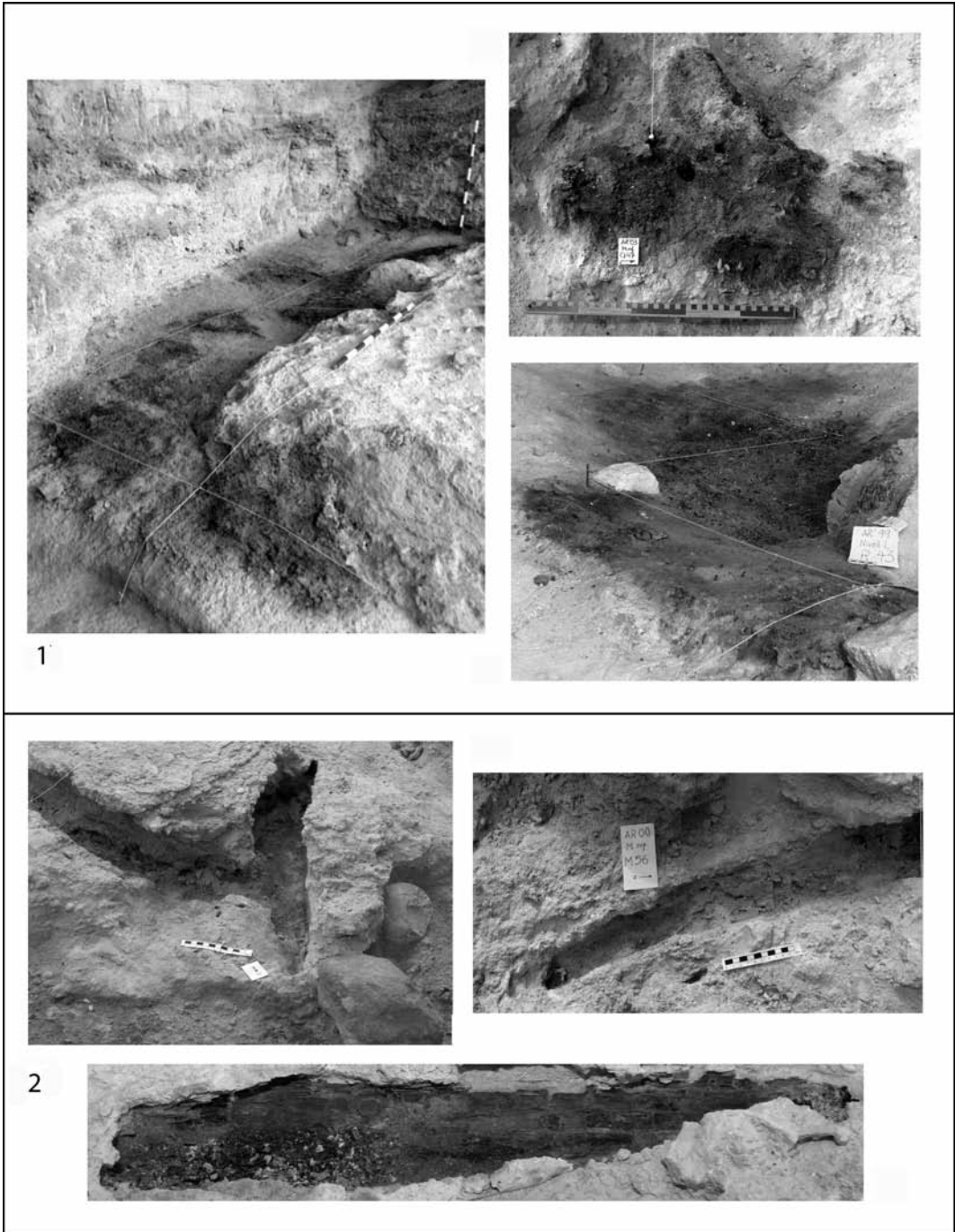


Fig. 3. Examples of hearths **1**) and wood remains (positives and negatives) **2**) from the Abric Romaní site (photos, IPHES).

dus, *Lynx spelaea* and *Felis silvestris*), but evidence of their activities at the site is rare and is associated with occasional visits to scavenge the remains left behind by hominin occupants (Rosell, Blasco, Huguet et al. 2012) (fig. 2). However, some felid remains show evidence of human activity: a cutmark on a radius of lynx from level E (Saladié and Aïmene 2000) and several elements of a wildcat from level O (Gabucio, Cáceres, Rodríguez-Hidalgo et al. 2014).

The raw materials used in the different layers of the sequence come from the local and semi-local surroundings (maximum 25–28 km) and chert is always the dominant raw material (Vaquero, Chacón, Cuartero et al. 2012). The lithic assemblages are mainly made up of knapping products. The goal of the reduction sequences was to obtain mostly small and medium-sized flakes (≤ 40 mm). Cores and retouched artifacts are rare and, although these two technical activities could be identified at the site, a considerable number of isolated objects knapped outside of the site were introduced to the rockshelter already knapped (flakes, retouched artifacts and cores in an advanced state of reduction). The predominant knapping strategy is discoidal, regardless of the raw material used, throughout the stratigraphic sequence, although Levallois artifacts and hierarchical centripetal cores have also been identified. Level O and P show different technological strategies with Levallois (level O) (Chacón, Bargalló, Gómez de Soler et al. 2013) and laminar contexts (level P). The retouched artifacts are almost exclusively denticulates and notches associated with some scrapers (Chacón 2009; Chacón, Bargalló, Gómez de Soler et al. 2013; Gabucio and Bargalló 2012; Picin, Peresani, and Vaquero 2011; Thiébaud, Mourre, Chalard et al. 2012; Vaquero 1999a, 1999b; Vaquero, Chacón, Cuartero et al. 2012). The use-wear analysis conducted on the flakes and retouched artifacts (mainly denticulates) shows their exclusive use in butchery activities and in the treatment of animal carcasses (Martínez 2005, 2008).

Previous excavations severely affected the archaeological record of the Aurignacian level A and the uppermost Middle Paleolithic levels, precluding the spatial interpretation of the occupation patterns in those levels. Starting from level H, the application of new methods and the extensive excavation of the entire archaeological surface permitted the reconstruction of the settlement dynamics at the site. The preservation of numerous hearths has been used as a proxy in the recognition of activity areas, along with the spatial distribution of the lithic artifacts and faunal remains. Hearths played a central role in spatial organization, as most activities were carried out around them. This gave rise to a spatial pattern characterized by well-defined hearth-related accumulations, which were confirmed by faunal and lithic refits (Rosell, Blasco, Fernández-Laso et al. 2012; Vaquero and Pastó 2001; Vaquero, Chacón, and Rando 2007; Vaquero, Rando and Chacón 2004). The processing of animal carcasses and bone breakage was mainly conducted in the outer zones of the rockshelter, whereas stone knapping was performed in the inner domestic areas. Refit analysis of bones and lithic items have also been used to identify synchronic and diachronic patterns of change in settlement dynamics and in the procurement and management of abiotic (stones) and biotic (fauna, plants) resources and their use at the site (Rosell, Cáceres, Blasco et al. 2012; Vaquero, Chacón, and Rando 2007; Vaquero, Chacón, Cuartero et al. 2012; Vaquero, Chacón, García-Antón et al. 2012).

METHODOLOGY

The methodology used for this research combines different methods: zooarchaeology, taphonomy, tooth wear analysis, lithic technology, raw material units, faunal and lithic refits, archaeostratigraphy and intra-site spatial patterning. The different studies are carried out in parallel, and we adapt the work of each discipline depending on the results from others during the entire analysis. The data provided by the interdisciplinary study allowed us to identify and characterize domestic areas that correspond to specific events of human activity, identifying the temporal dynamics in the formation of the archaeological assemblage.

Zooarchaeological and taphonomic analysis of faunal remains

All faunal remains recovered were analyzed anatomically, taxonomically and taphonomically. Whenever possible, the laterality (left or right), the portion (relative to the length of the complete skeletal element), the side (anterior, lateral, posterior and medial) and the estimated age at death (criteria of tooth eruption and replacement, dental wear, and epiphysial fusion) have been specified. To include non-taxonomically identifiable bones in the study, all remains have been grouped into the following weight sizes, based on a modification of criteria proposed by Bunn (1986): 1) very small size (< 20 kg); 2) small size (20–100 kg); 3) medium size (100–300 kg); 4) large size (300–1000 kg). Likewise, bones non-identifiable at an anatomical level were classified into three categories: long bones (from limbs), flat bones (axial and cranial skeleton) and articular bones (carpals, tarsals, etc.).

From this identification, we have quantified the assemblage by calculating NSP (Number of Specimens), NISP (Number of Identified Specimens), MNE (Minimum Number of Elements), MNI (Minimum Number of Individuals) and % Skeletal Survival Rate. In order to aid interpretation of skeletal profiles, the % survivorship of weight size groups was correlated with different utility indices and density values using the Spearman's rho test (Binford 1978a; Brain 1981; Emerson 1993; Lam, Xing and Pearson 1999; Lyman 1994).

Regarding bone breakage, the bones longer than 3 cm were analyzed following Villa and Mahieu (1991) to know the state of the bones at the moment of breakage (green or dry). The completeness of bone portions, in length and in circumference, was also considered (Bunn 1983). The agent(s) responsible for the fracturing were investigated by analyzing the structural damage caused during bone breakage, such as concerning percussion pits, percussion notches, impact flakes, adhering flakes and peeling (Capaldo and Blumenshine 1994; Pickering and Egeland 2006; White 1992).

Alterations on bone surfaces were observed using both macroscopic and microscopic techniques (Olympus SZ11 stereomicroscope and ESEM FEI QUANTA 600). Cutmarks have been analyzed according to their type, location, distribution, and orientation (Binford 1981; Bromage and Boyde 1984; Noe-Nygaard 1989; Potts and Shipman 1981; Shipman 1983; Shipman and Rose 1983). To study burning patterns, a modification of the stages proposed by Stiner et al. (1995) was used: (0) unburned bones, (1) bones with brown stains, (2) homogeneously brown bones, (3) black bones (charred), (4) grey bones, (5) white bones (completely calcined). Identification and characterization of carnivore damage was based on criteria proposed by Binford

(1981), Lyman (1994), Stiner (1994) and Blumenshine (1995). Water activity was analyzed studying the degree of rounding and polishing on bone surfaces (Cáceres 2002; Fernández-Jalvo and Andrews 2003). Grooves, perforations, staining and corrosion produced by plant activity were recorded (Cáceres 2002; Lyman 1994). Finally, manganese oxide pigmentation and cementation were also analyzed (Fernández López 2000; Shahack-Gross, Bar-Yosef and Weiner 1997). The degree and location of all these alterations were recorded, as well as their sequence (by taking into account the overlap between them).

Tooth wear analysis

In order to estimate the duration of occupational events at the site, we applied methods derived from tooth microwear analysis. Tooth microwear (i.e., the microscopic features produced by the food on the teeth) reflects the diet an animal had during the last days or week of its life (short temporal scale), and consequently records possible seasonal ecological changes. Tooth microwear analysis is applied to all upper and lower molar remains available in the assemblage, taking into account the results from refitting, which led us to discard teeth from the same individuals. Microwear features of dental enamel were examined using a stereomicroscope on high-resolution epoxy casts of teeth following the cleansing, molding, casting, and examination protocol developed by Semperebon, Godfrey, Solounias et al. (2004) and Solounias and Semperebon (2002). Microwear data are compiled for each sublevel and/or each area. The minimum sample size required is 10 individuals.

The method used to estimate the duration of occupational events is based on assumed changes through time in the food resources available to the animals. During each season a specific set of food resources with a specific microwear signal should be available (plant taxa as well as available plant parts). On the other hand, across seasons, a more diverse range of food should be available. If game animals died in a specific season (i.e., during a short-term occupation) then it can be expected that the dental wear signal shows a low variation. In contrast, if the animals died in different seasons with a different microwear signal one would expect more variation. Extant game animals hunted in a single season have only a dental wear signal with low variation (Rivals, Schulz, and Kaiser 2009). In contrast, game animals hunted during longer periods of time (i.e., long-term or repeated occupations) present a larger variation of their dental wear (Rivals, Schulz, and Kaiser 2009). In this way, microwear patterns in herbivorous ungulates hunted by humans provide a signal used to find differences between samples of animals hunted during a single season and those that were hunted over an entire year (or longer periods). However, this method cannot be applied to assemblages with a small sample size ($N < 10$).

Morphotechnical analysis of the lithic assemblages

The technological analysis used in this study was performed according to the Logical Analytical System (SLA), with some modifications in accordance with the method for studying Middle Paleolithic assemblages and their spatial distributions (Bargalló 2008; Carbonell, Guilbaud, and Mora 1983; Carbonell and Mora 1986; Carbonell, Mosquera, Ollé et al. 1992; Chacón 2009; Vaquero 1997). This approach is based on

the reconstruction and interpretation of the *chaîne opératoire* as a productive process that encompasses the time from the procurement of raw material until a piece is discarded, passing through all the stages of manufacture and use of the different components (i.e., the entire history of the artifact up to the moment of its analysis). Each object is understood as a tool product of human action within the environment, and we will use two levels of analysis. The first one is that of observation, involving the reading of the technical attributes (qualitative and quantitative) of each artifact in order to assess its position in the *chaîne opératoire*. The second level is one of inference. This pertains to clarifying the interdependence of artifacts in the *chaîne opératoire* to recognize the techniques and methods performed.

This morphotechnical analysis has been used in the study of all the lithics assemblages from Abric Romaní (Chacón 2009; Chacón, Bargalló, Gómez de Soler et al. 2013; Vaquero 1999a, 1999b; Vaquero and Carbonell 2003; Vaquero, Chacón, Cuartero, et al. 2012).

Groups of Raw Material (GRM) and Raw Material Units (RMU)

After performing the technological study, we reconstructed the temporal formation of the lithic assemblage, identifying the specific events of technical activity as far as possible. A technical event is an activity episode related to the manipulation of lithic resources that is performed continuously, without location changes or temporal interruption (Vaquero 2008). This approach is based on the classification of lithics in two categories: (1) Raw Material Groups (RMG) (Machado, Hernández and Galván 2011) and (2) Raw Material Units (RMU) and refitting (see *refits* section). The spatial distribution of these events (see *spatial patterning* section) allows us to discuss the temporal dynamics involved in the formation of the lithic assemblages, highlighting the time-dependent nature of assemblage variability (Vaquero, Chacón, García-Antón et al. 2012).

RMGs and RMUs are defined according to the macroscopic characteristics of the raw materials, including color, grain, size, texture, inclusions and type of cortex. RMGs encompass the pieces of the same type that are impossible to identify further as coming from the same bloc of raw material or not. RMUs incorporate the artifacts produced during the reduction of a single nodule (Machado, Hernández, and Galván 2011; Odell 2004; Roebroeks 1988; Schäfer 1990; Vaquero 2008; Vaquero, Chacón, Cuartero et al. 2012). Refitting is the most direct evidence for identifying the artifacts belonging to the same RMU. However, other kind of data may also be taken into account. In addition to the macroscopic characteristics of the raw material, the technical and volumetric consistency, together with the spatial association, can also be used to integrate different artifacts in the same RMU. Although they are coming from the same nodule, the artifacts forming a particular RMU do not necessarily correspond to the same technical event, because different episodes can be carried out at different times and places on the artifacts detached from a single nodule. According to the number and type of remains, RMUs have been characterized by taking into account two main features: how they were introduced into the site (introducing events) and what kind of intentional modification was performed inside the rockshelter (knapping events).

Refits

Refitting methods have been extensively described in the literature (Conard, Prindiville, and Adler 1998; Cziesla 1990; Hofman and Enloe 1992; Morrow 1996; Roebroeks 1988; Roth and Dibble 1998; Sisk and Shea 2008). For the lithic assemblage, we have used the methods and terminology suggested in Cziesla (1990) and Sisk and Shea (2008). Three kinds of connections have been distinguished: production-sequence, breakage and retouch refits. For production and retouch refits, connection lines have been defined according to the chronological order of detachments, from the first refitted flake to the core or tool. For the refits of broken artifacts, connection lines have been established that take into account the contacting surface (Vaquero, Chacón, Cuartero et al. 2012). Sisk and Shea (2008) point out the importance of the differentiated use of conjoin and refit: (1) Refits are sets of artifacts split from each other by controlled conchoidal fracture (e.g., a flake whose ventral side joins to the surface of a core or the dorsal surface of another flake). The refits inform us about technological strategies. (2) Conjoins are fragments of formerly whole artifacts broken by forces other than conchoidal fracture (e.g., natural flaws, bending fractures, burning, etc.).

Refitting shows that the connected artifacts correspond to the same technical sequence, but it also provides information about the temporal relationships between them because the refitted elements are temporally ordered according to the sequence of detachments. Moreover, refitting can provide information about the temporal relationships between the archaeological accumulations in which the refitted artifacts are located. Refits can be used to demonstrate that different accumulations were synchronic or diachronic, always taking into account the type of displacement, the direction and its intentionality. The bi-directional links between accumulations are normally considered the better evidence of contemporaneity. In contrast, unidirectional connections tend to be associated with a temporal succession in the formation of the activity areas (Vaquero, Chacón, and Rando 2007; Vaquero 2008; Vaquero, Chacón, Cuartero et al. 2012).

Concerning bone refits, the terminology suggested by Todd (1987) and Lyman (1994), and the methods developed by Fernández-Laso (2010) have been used. All the coordinated faunal remains larger than 1 cm were taken into account. All the groups whose remains were separated prior to the excavation process have been considered refits. Two types of refits have been observed: anatomical refits (for instance, dental series) and mechanical refits (conjoined fragments from the same broken element). In all cases the location of the remains of the same refit, the distance between them, and their taphonomic features have been noted. In addition, the analysis of the mechanical refits includes the nature (dry or green) and the origin (anthropogenic percussion, fire, carnivore damage or post-depositional process) of the fractures.

Faunal refits can provide very valuable information on taphonomic, behavioral and paleoeconomic issues related to archaeological assemblages. For instance, they can help us to understand the formation processes of the assemblages, to evaluate the role of post-depositional processes and to obtain more precise temporal data from the archaeological palimpsests (Morin, Tsanova, Sirakov et al. 2005; Villa 1982). In addition, refits are relevant in order to discern activity areas and assess the use of the space and the occupational patterns by humans (Leroi-Gourhan and Brezillon 1972; Rapson

and Todd 1992). Finally, they can also tell us about the strategies of acquisition, processing, distribution and consumption of meat resources (Enloe and David 1992; Marean and Kim 1998).

Compared with lithic refits, faunal refits can provide more reliable information regarding the temporal relationships between different items (Rosell, Blasco, Fernández-Laso et al. 2012). While lithic refits can be a result of recycling processes, faunal ones (especially those from the green bone breakage, related to the marrow consumption) can be a more accurate tool to connect different areas.

Spatial patterning

The study of spatial patterning is divided into three levels of analysis:

- 1) First we made a systematic series of vertical plots using the three-dimensional coordinates of each remain. These plots have a thickness of 20 cm. The vertical plots of archaeological materials are an effective method for identifying the temporal formation dynamics of the stratigraphic levels; even though in some cases it cannot be ruled out that the identified accumulation horizons correspond to palimpsests (Canals, Vallverdú Poch, and Carbonell 2003; Vaquero 2008). After this analysis we can assign each remain to its sublevel or micro-level.
- 2) Second, we determined the domestic areas. The identification of the domestic areas was made initially from the level or sublevel identified and from the spatial patterning of the hearths. First, the archaeological remains were grouped by level or sublevel. We also took in account the association of archaeological material by hearths that are normally the center of the domestic areas. Later, we performed the cluster analysis of the remains and hearths in order to delimit the domestic areas (Carbonell 2012; Stapert 1990; Vaquero and Pastó 2001). In addition, we made projections (fig. 4) to confirm the vertical spatial patterning of the remains of these areas. Finally the identified areas are named with the level letter (in this case O) and a correlative number. The hearths are also numbered.

For these two first levels of analysis we used Golden Surfer and Microsoft Excel software (Bresnahan and Dickenson 2008).

- 3) Finally, the spatial patterning of the archaeological remains is analyzed at two different levels (Clark 1977):

Semi-micro-level = study of the association of structures. It is the space related to the activities of the group. It shows the social spatial patterning of the archaeological remains (i.e., the relation of the domestic area(s) with the rest of the level).

Micro-level = study of the structures and individual contexts. It is a social and personal space where the cultural and individual factors are predominant (i.e., the domestic area itself).

All the archaeological remains from the level and the sample chosen (activity area O10) were plotted horizontally on the occupied floor of level O following the topography of the level and the geomorphological units. The plots are made

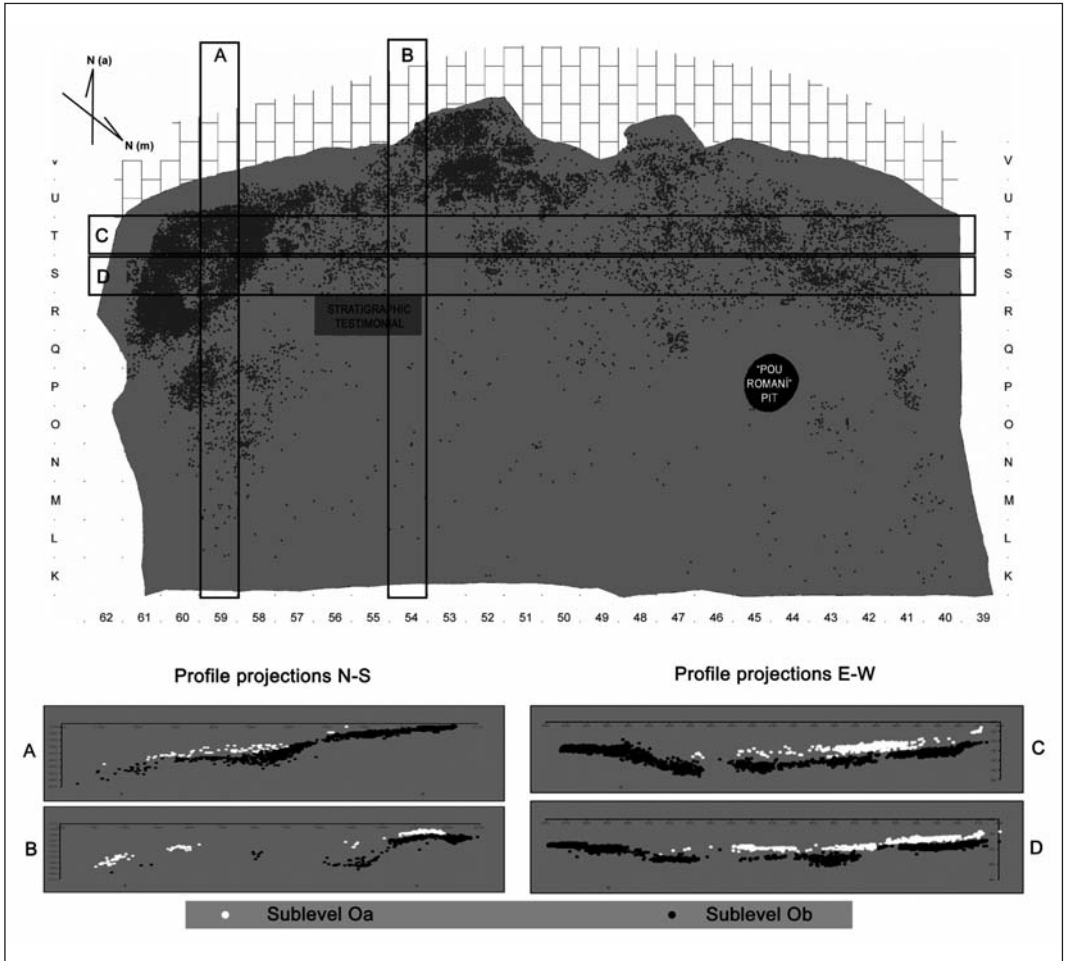


Fig. 4. Abric Romaní. Spatial pattern analysis and some projections made to identify the sublevels from level O.

to map all the archaeological remains on the surface and to identify the different domestic activity areas, normally around hearths. We understand by domestic area a zone with a high density of archaeological remains accumulated around hearths or latent structures. These areas indicate an occupation floor. Its surface is around 2–3 m² and its thickness usually around 10 cm (Carbonell 2012; Valverdu, Allué, Bischoff et al. 2005; Vaquero and Pastó 2001).

Concerning the lithics, though their spatial patterning on the level surface is very important, we mainly focused on RMGs, RMUs and distribution of refits because they provide more information on the technological activities performed from a spatio-

temporal point of view. Regarding the faunal analysis, spatial distribution of the remains according to their taxonomical identification and their taphonomic alterations were investigated. Special attention was paid to the refitted pieces: taxonomical and skeletal identification, refit type, distance, etc.

The spatial pattern analysis will be described under the section *Results* together with the presentation of the results of each discipline.

MATERIALS

The tufa layer overlying level O has been dated to approximately 54.6 ± 2.3 kyr BP (USGS 07–9) (Vallverdú, Gómez de Soler et al. 2012; Vaquero, Allué, Bischoff et al. 2013) (fig. 2). Excavated from 2004 to 2011, this level provided 36,865 remains, with an average of 85.72 remains/m² (excavated surface = 271 m²). The following remains were recorded: lithics (23,273), faunal remains (9299), charcoal pieces (4176), wood imprints (109) and combustion structures or hearths (24) (Gabucio and Bargalló 2012; Gabucio, Cáceres, and Rosell 2012; Vallverdú, Alonso, Bargalló et al. 2012). These numbers include all lithics and charcoal remains and fauna larger than 2 cm. Level O is comprised of poorly stratified sand and fine gravel and has a weathered surface. The fine-grained deposits are above a basal succession composed of gravel, blocks and megablocks that originated from the fall of travertine rocks from the cliff above the rockshelter (Vallverdú, Alonso, Bargalló et al. 2012).

The archaeostratigraphic study permitted us to subdivide the level O into two sub-levels (from top to base): Oa and Ob (fig. 4). However, in some areas of the site it was not possible to differentiate them (e.g., in the central and more exterior part where the archaeological remains are scarce). For this reason, in this area the archaeological layer has received the name of “sublevel O” (fig. 5).

The level shows a spatial patterning in which twelve clusters can be recognized (fig. 5). Three of these domestic areas belong to Oa sublevel, seven to Ob sublevel and one to O. For this paper the area O10 was selected (fig. 6). The reasons for this are as follows:

- 1) The high number of lithic and faunal remains.
- 2) The clear assignation to one of the sublevels identified at level O, the sublevel Ob.
- 3) The lower impact of the postdepositional processes.
- 4) The high number of faunal and lithic refits in this area that connect this area with the other identified at this level.
- 5) The existence of tooth microwear analysis data made on dental remains from this area.

This area has an extension of 28 m² and a maximal depth of 76 cm (fig. 6). The total number of archaeological remains (fauna and lithics) is 6130 (Table 1).

We would like to point out here that two different micro-levels have been identified in the center of the O10 domestic area (where the hearths are located, but not in the surrounding zones) through the spatial patterning analysis (a more detailed explanation is provided in sections 5 and 6). They are separated by a thin sterile level in the central part of the area (fig. 6) and correspond to two diachronic moments of activity

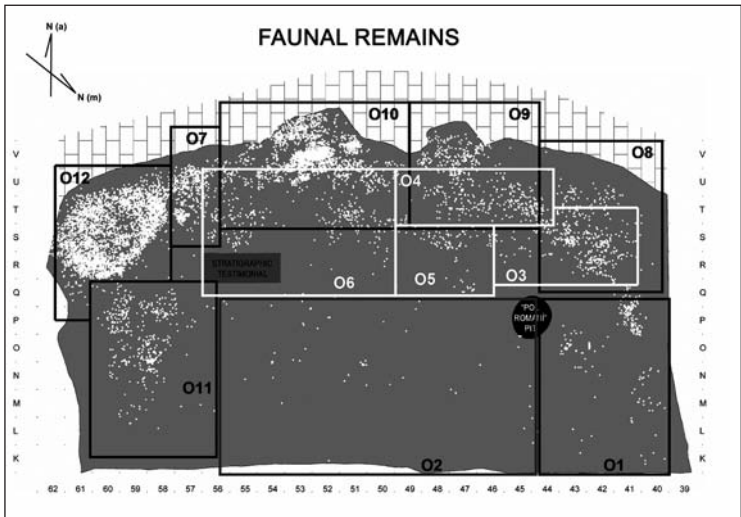
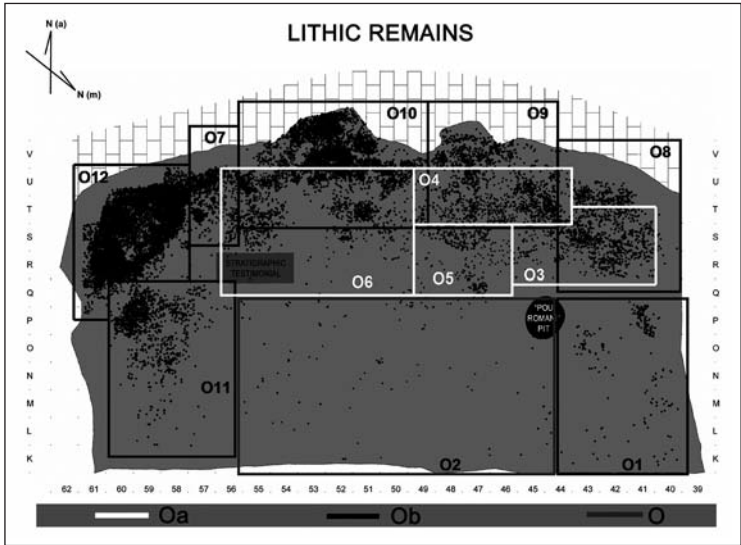
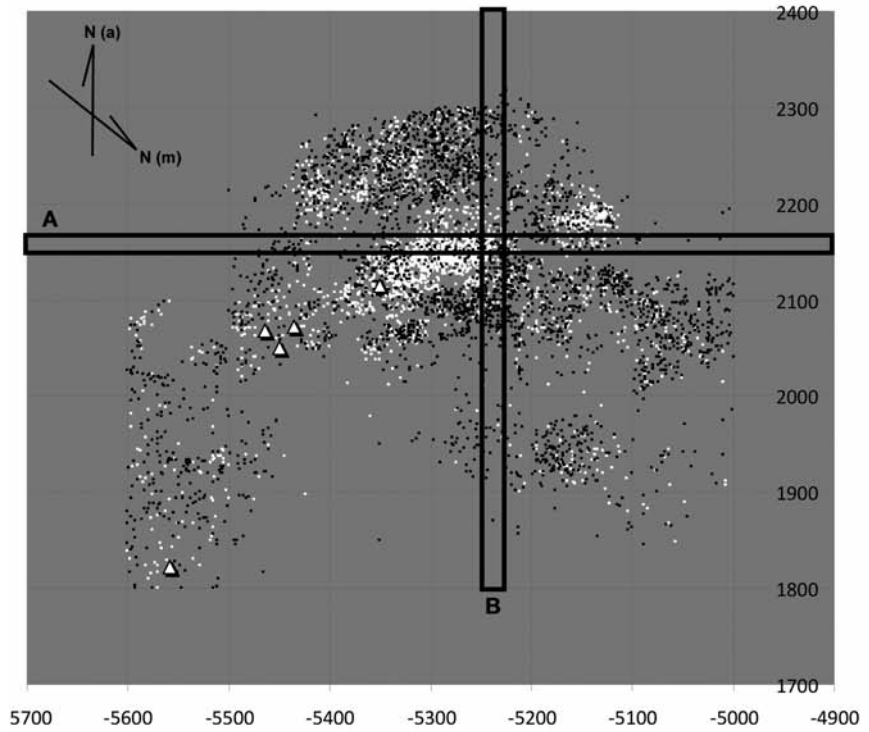
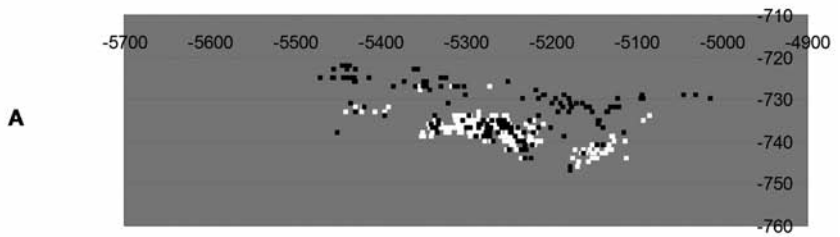


Fig. 5. Abric Romaní. Spatial patterning of the archaeological remains and identified areas on the level O surface (White circles= faunal remains, black circles=lithic remains, N(a)=archaeological North, N(m)= magnetic North).

(upper and lower micro-levels of the O10 activity area). Most faunal remains are clustered in the middle of the central combustion areas (grid squares V51–53), while lithic remains are distributed around them (fig. 6). The upper micro-level is dominated by lithic remains while the lower micro-level is dominated by bone fragments. These two micro-levels represent different moments in the O10 area, but each one can also be the result of different events of activity and in this case “little palimpsests in time.”



Y= 2150 - 2169



X = -5249 - -5230

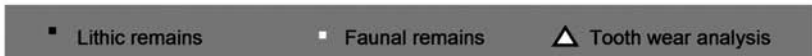
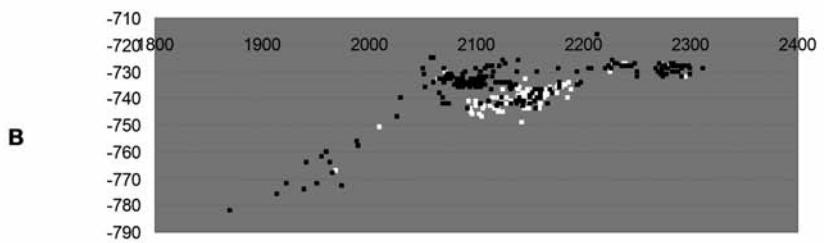


Fig. 6 (left, facing page). Abric Romani. Horizontal and vertical spatial patterning of faunal and lithic remains from area O10 with the location of the teeth used for tooth wear analysis.

Table 1 (below). Abric Romani. Archeological remains from the O10 domestic area (including all lithics and charcoal remains and fauna ≥ 2 cm).

	Fauna (n=2806)		Lithic (n=3324)									
	Teeth	Bones	Agates	Chert	Limestone	Calcite	Schist	Sandstone	Slate	Quartz	Quartzite	Other stones
O10 area (n=6130)	97	2709	57	2769	337	2	5	19	47	82	2	4

RESULTS

Fauna: zooarchaeological, taphonomical and tooth wear analysis

Among the taxonomically identified remains, *Cervus elaphus*, *Equus ferus* and *Bos primigenius* are the most abundant taxa (MNI of one adult and one immature for each animal), followed by *Stephanorhinus hemitoechus* (one immature) and *Oryctolagus cuniculus* (one adult) (Table 2). Taxonomically non-identifiable remains were classified into weight sizes, the medium-sized animals being the best represented. Regarding skeletal identification, cranial and limb elements are the most common, whereas

Table 2. Abric Romani. NSP (Number of Specimens), MNE, MNI and approximate age of death of animals of Area 10 by taxonomic groups.

	NSP	MNE	MNI	AGE
<i>S. hemitoechus</i>	1	1	1	1 im.
<i>B. primigenius</i>	15	7	2	1 ad., 1 im.
<i>E. ferus</i>	18	5	2	1 ad., 1 im.
<i>C. elaphus</i>	39	11	2	1 ad., 1 im.
<i>O. cuniculus</i>	6	6	1	1 ad.
Large size	135	3	-	-
Medium size	502	6	-	-
Small size	82	2	-	-
Very small size	13	-	-	-
Unidentified	1995	-	-	
TOTAL	2806	41	8	14 ad., 1 ad./sen., 4 im.

axial skeleton is scarcer and basipodial bones were not identified (Table 3). The anatomically non-identifiable bones were classified into long, flat or irregular bones. The long bones are the most abundant in the assemblage. Positive and significant correlations were obtained between the % Skeletal Survival Rate of the medium-sized group and both utility indices and bone density values (Table 3). % Skeletal Survival Rate of the large-sized group is also correlated with bone density, but with a low intensity (Table 3). In general, the different taxonomical and anatomical groups are distributed throughout the entire surface and in the two identified micro-levels.

Table 3. Abric Romani, Layer O. % skeletal survival rate of large- and medium-sized animals by anatomical elements. Positive and significant correlations (Spearman's rho test) between these indices and some bone density (BMD² from Bovidae and Cervidae published by Lam et al. 1999) and food utility indices (Skeletal Fat Model and Marrow Fat Model from Emerson 1993).

Skeletal elements	LARGE-SIZED ANIMALS		MEDIUM-SIZED ANIMALS			
	% Skeletal Survival Rate	Structural Bone density	% Skeletal Survival Rate	Structural Bone density	Skeletal Fat Model	Marrow Fat Model
Cranium	25	-	50	-	-	-
Maxilla	25	-	0	-	-	-
Mandible	62.5	0.94	50	1.07	-	-
Atlas	0	0.59	0	0.49	1.6	0
Axis	0	0.58	0	0.62	1.1	0
Vertebra	0	0.48	1.22	0.51	18.3	0
Rib	0.89	0.74	3.57	0.96	38.7	0
Scapula	12.5	0.78	25	1.04	53.7	1.3
Humerus	12.5	0.69	50	1.12	95.8	79.8
Radius	0	0.81	25	1.09	67.4	58.9
Ulna	12.5	0.66	25	0.84	67.4	58.9
Coxal	0	0.6	25	1.02	70.6	3.9
Sacrum	0	0.38	0	0.4	70.6	3.9
Femur	0	0.75	25	1.15	100	87
Patella	0	0.44	0	0.57	-	-
Tibia	25	0.83	25	1.13	97.1	100
Fibula	12.5	0.75	0	0.68	-	-
Carpal/tarsal	1.04	0.75	2.08	0.71	51.6	0
Astragalus	0	0.72	0	0.7	-	0
Calcaneum	0	0.73	0	0.94	-	0
Metacarpus	0	1	25	1.1	29.2	17.3
Metatarsus	12.5	0.85	25	1.08	37.5	21.1
Phalanx	0	0.61	0	0.92	25.4	3.5
CORRELATION	Coeff.	0.53677	Coeff.	0.80658	0.64998	0.76139
Spearman's rho	Sig.	0.012112	Sig.	1.0036 E-5	0.006418	0.000242

The faunal assemblage presents a high rate of bone breakage. In fact, 79.65% (NSP = 2235) of the remains are equal or shorter than 2 cm. The analysis of bone breakage patterns indicates that most of the bones longer than 3 cm were broken in green (predominance of V-shaped, oblique and smooth fractures). In contrast, many of the small fragments seem to have been broken by fire. Structural damages caused during the bone breakage, such as impact flakes and percussion notches, were also identified on 211 remains (7.52% of the remains), especially on long bone diaphyses of medium- and large-sized animals. These remains are scattered throughout the surface, but most of them are near or even inside the hearths (fig. 7).

Cutmarks are present on 120 remains (4.28%, table 4) highlighting those related with defleshing activities (incisions located on long bones shafts). However, other activities, such as periosteum removal, evisceration and skinning, were also documented. Bones with cutmarks are concentrated inside or near the hearths (fig. 7).

A total of 2090 remains (74.48% of the faunal remains) were burned (Table 4). All degrees have been identified but the higher ones (degrees 4 and 5) are the most frequent. Sometimes, two or three degrees are present on the same bone, especially the combination of degrees 4 and 5. In general, calcined bones are clustered in the focus of the central hearths, especially in the biggest one (grid squares V52–53), and are more abundant in the microlevel of area O10 (fig. 8).

Evidence of carnivore activity is scarce in the O10 activity area (eight bones with toothmarks and one digested bone, 0.32%), affecting long and flat bones from medium- and small-sized animals (Table 3). All these remains are burned (all the degrees are represented), including a calcined bone (degree 5). These remains are located in the central and the innermost zones, sometimes in contact with the hearths (fig. 7).

Other natural processes were identified from the faunal assemblage. For instance, 10.67% of the remains (NSP 406) present rounded surfaces and 7.83% (n=298) polished surfaces, both related to water activity. Most of them show low degrees. However, some bones rounded in a high degree are located inside the large central hearth (fig. 8). Cementation and manganese oxide pigmentation were also documented (8.95% and 5.31% respectively; Table 4). The remains covered by cementation over their entire surface tend to be more common towards the outermost zone, whereas the remains with more manganese oxide pigmentation are concentrated in the right zone. Plant activity also affected few remains (n=187, 4.91%) especially clustered in the innermost area. Finally, bones with trampling are very scarce (n=7, 0.25%) and they are located around the big central combustion area (fig. 7).

Tooth wear analysis was performed on 5 specimens from area O10, two teeth of *Bos primigenius* and three of *Equus ferus*, two of them belonging to the same individual (fig. 6). We sampled all the specimens available in area O10 but sample size is too

Table 4. Abric Romani. Bone surface modifications observed on faunal remains from area O10 (NSP and percentage).

	Cutmarks	Burning	Carnivore activity	Rounding	Polishing	Cementation	Mn oxide pig.	Plant activity
NSP	120	2090	9	406	298	251	149	187
%	4.28 %	74.48 %	.32 %	10.67 %	7.83 %	8.95 %	5.31 %	4.91 %

ANTHROPOGENIC ALTERATIONS

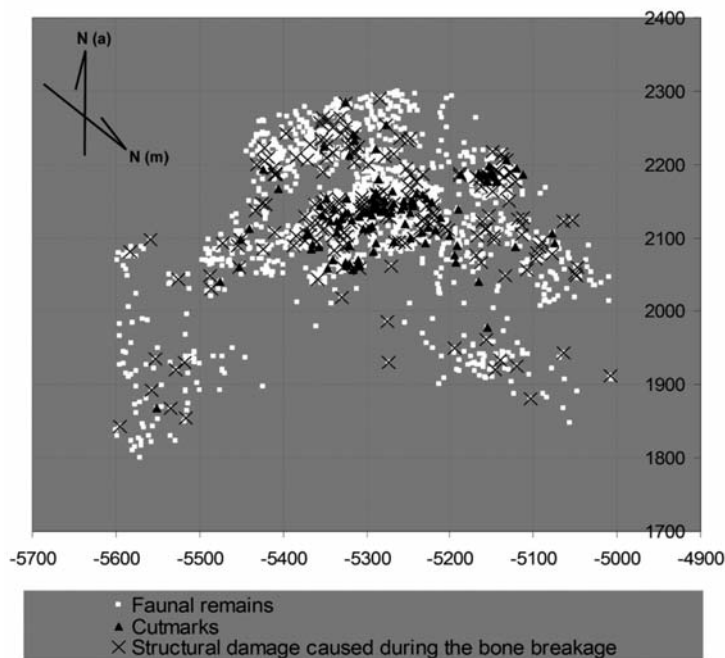
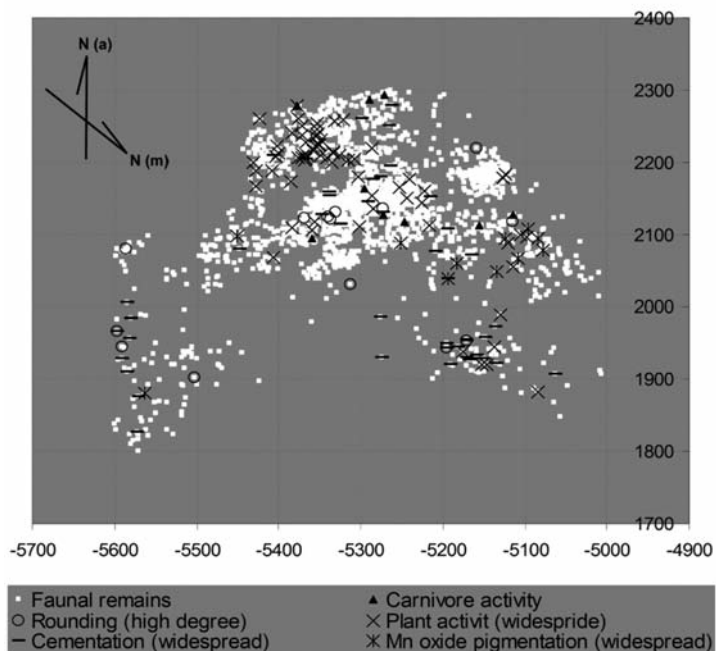
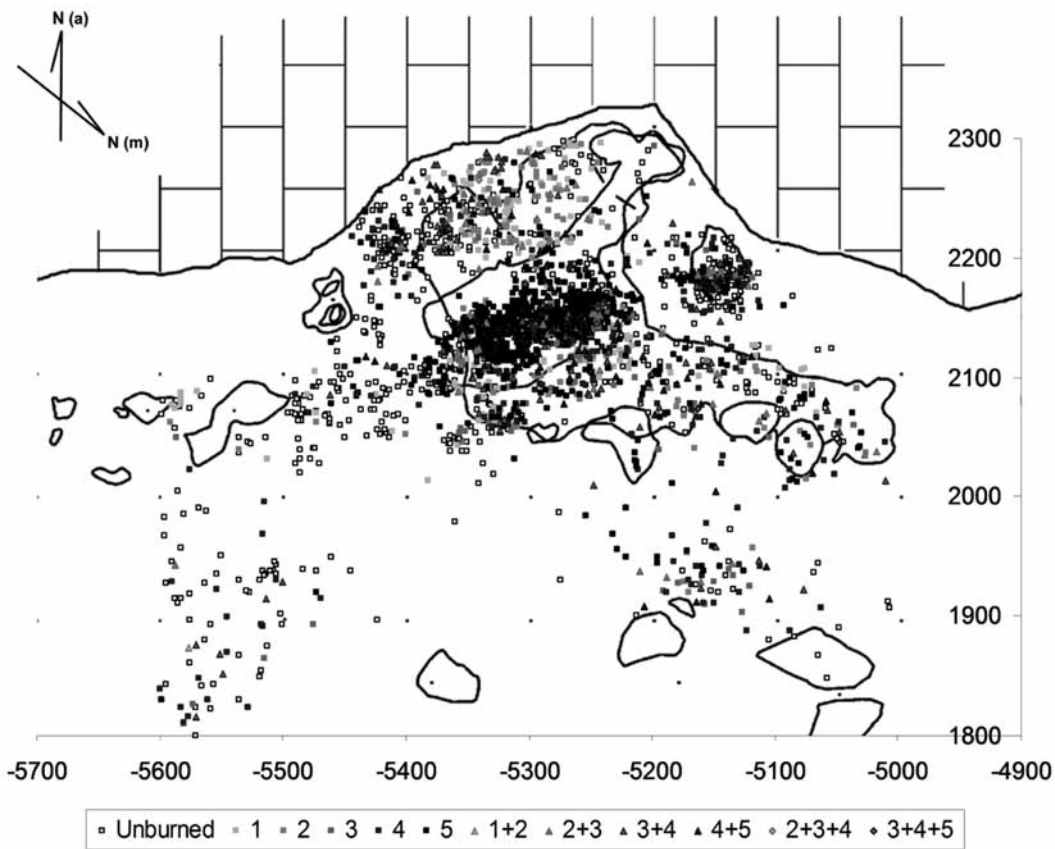


Fig. 7. Abric Romani. Spatial patterning of faunal remains with 1. anthropogenic alterations (**above left**), 2. post-depositional alterations (**below left**), concerning rounding, cementation, plant activity and manganese oxide pigmentation; only the higher degrees are considered.

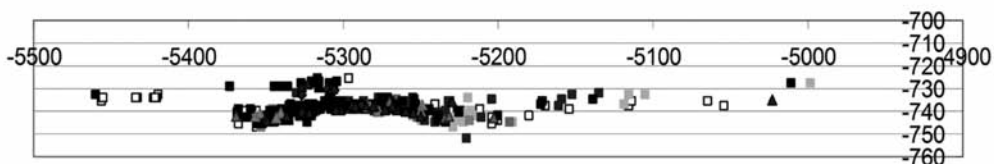
Fig. 8 (facing page). Abric Romani. Distribution of faunal remains by burning degrees in relation with the location of combustion areas (black lines).

POST-DEPOSITIONAL ALTERATIONS

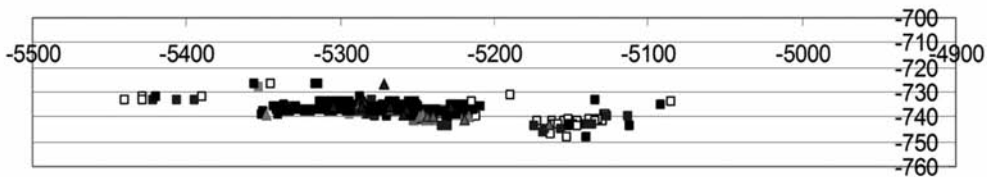




Y= 2120 - 2140



Y= 2150 - 2170



small to be used to calculate the coefficient of variation. We will thus consider the entire sample from level O which consists of three species and 26 teeth (Table 5). The sample-sized corrected coefficients of variation (CV*) vary from 0.06 to 0.21. Comparing with a previous study of CV* in archaeological sites (Rivals, Schulz, and Kaiser 2009), the results indicate a very low CV* for *E. ferus* suggesting a short event of accumulation. For *B. primigenius* and *E. ferus*, the higher CV* indicate longer events, or more probably, repeated events of short duration at various moments of the year. The area O10 would correspond to one of these events.

Lithic: morphotechnical analysis, groups of raw material (GRM) and raw material units (RMU)

The lithic assemblage from area O10 shows all the technical structural categories related with reduction sequences: (1) cores (n=25, 0.75%), (2) flakes (n=2750, 82.73%), (3) hammerstone fragments (n=15, 0.45%), (4) retouched tools (n=37, 1.11%) and fragments (n=497, 14.95%). The best represented are knapping products. The raw materials used show a high diversity of stones (Table 1). Chert (83.3%) is the most abundant, followed by limestone (10.13%) and quartz (2.46%). The other raw materials represent less than 4% of the materials used in the O10 area.

Cores display two opposing surfaces separated by an intersection plane (normally the horizontal one) with essentially bifacial strategies. This is the typical technological schema present throughout the Middle Paleolithic. The cores recovered from level O are predominantly asymmetrical: they exhibit a first surface with a plane angle resulting from preferential removals and a second opposing surface made from extractions with simple obliquity to prepare the striking platform. The knapping strategies identified are mainly Levallois (essentially recurrent centripetal and some preferential and unipolar longitudinal modalities), although evidence of other knapping strategies were documented (orthogonal, centripetal and unifacial). Levallois and centripetal cores present low percentages of trifacial and multifacial exploitation. Among the Levallois cores we identified all the exploitation modalities employed throughout all phases of knapping (dynamic model and possible change from one to another modality during the same reduction sequence). Most them are in the final knapping phase and some are completely exhausted (Chacón, Bargalló, Gómez de Soler et al. 2013).

The knapping products are small and medium-sized (≤ 40 mm) and there is no laminar tendency. The retouched tools are essentially denticulates (10.81%), scrapers (81.08%) and some notches (8.10%). Chert was mainly used in the reduction sequences as well as in the shaping sequences.

Level O shows differences in the technical patterns that we did not observe in other levels of the sequence of the site: (1) the predominance of Levallois knapping strategies and (2) the prevalence of scrapers instead of denticulates that occurs in the other levels.

Table 5. Abric Romani. Microwear results for the specimens analyzed from level O (N = number of specimens, M = Average of the number of scratches per mm², CV* = sample-sized corrected coefficient of variation).

	<i>B. primigenius</i>	<i>C. elaphus</i>	<i>E. ferus</i>
N	9	6	11
M	123.26	81.25	140.63
CV*	0.21	0.12	0.06

The lithic assemblage from area O10 has been classified into 72 raw materials groups (RMGs): 40 on chert, 13 on limestone, 5 on sandstone, 5 on slate, 5 on quartz, and 4 on agate. Among these 72 groups, 88 raw material units (RMU) have been identified. Their spatial distribution is very homogenous within the domestic area. The spatial distribution of RMUs did not allow us to identify any specific activities in this area. However, the morphotechnical attributes and the refits analysis of each RMU indicate that they can be associated to specific technical events related to percussion and knapping activities. Some examples clearly show this dynamic: an anvil broken during utilization with percussion marks; a core recycled as hammerstone after a medium reduction sequence; also, various production refits and refits of technical fractures.

Refits

A total of 93 refits were identified in area O10 (Table 6). Faunal remains show a refitting rate of 3.06% (86 conjoinable artifacts and 35 refitting groups) and lithics of 4.33% (144 conjoinable artifacts and 58 refitting groups) (fig. 9).

The analysis of lithic refits shows that 45 groups are refits and 18 are conjoins (Table 6). Among the refits, 4 are on agate, 13 on limestone and 28 on chert. All remains considered as refits are products of Neanderthal knapping activities. There

Table 6. Abric Romani. Synthesized information obtained from the faunal and lithic refits from the domestic area of O10.

		Fauna	Lithics
Total of remains	2806	2806	3324
Remains refitted	86	86	144
Number of refits	35	35	58
Refitting rate (%)	3.06%	3.06%	4.33%
Maximal number of remains by refit		7	7
Number of refits that connect O10 with other domestic areas		1	15
Type of refits connection lines			
Anatomical		1	
Mechanical	Green	7	
	Dry	24	
	Indeterminate	3	
Production	Knapping		45
Breakage	Fire action		4
	Postdepositional		14
Conjoins		18	

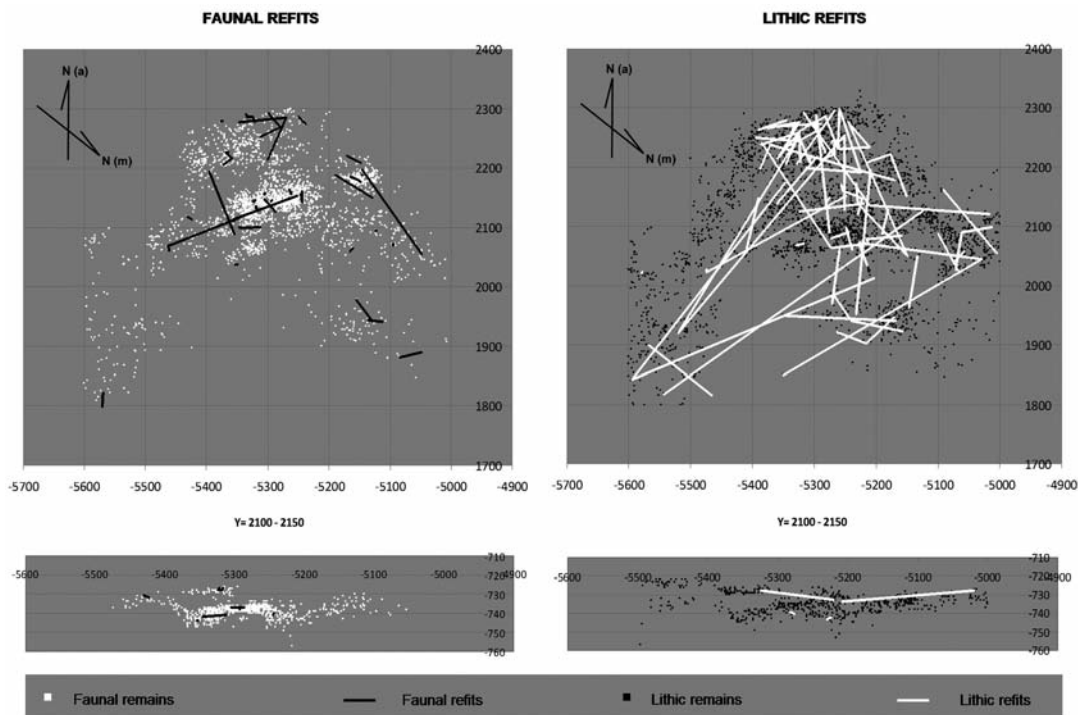


Fig. 9. Abric Romani. Horizontal and vertical spatial patterning of bone (left) and lithic (right) refits inside the area O10.

are 7 conjoins on limestone, 9 on chert, and 2 on sandstone. They are the result of post-depositional breaking, trampling, burning fractures or intentional fractures. Concerning the burning fractures, there are 8 groups: 4 groups of chert and 4 of limestone. In the majority of refit groups all the pieces are burned and only 3 groups show one piece burned. This micro-level indicates a diachrony in the life of tools (fig. 10).

Most of the lithic refits are separated by horizontal distances shorter than 20 cm (18 groups) although there are some refitted pieces separated by distances of up to 5.1 m. In general the orientation of the refit connection lines is NE-SW for the longest one and NW-SE for the shortest one (figs. 9, 11, 12). Concerning the vertical depth, the average vertical distance in the O10 area is 13 cm. The longest distances belong to the refits with the longest horizontal connection lines (3 m) and correspond to knapping sequences.

The spatial patterning of the lithic refit shows three focuses (fig. 9). The focus with a major concentration of refits is in the north area of O10. This focus connects another two small focuses, one in the zone in the southeast and the other one in the zone in the southwest of the area. The projection profile shows a lithic refit that connects the upper and the lower micro-level. This refit proves recycling processes. It is a limestone core that, after it was used for a short reduction sequence to obtain some flakes, was used as a hammerstone in another knapping activity (fig. 13).

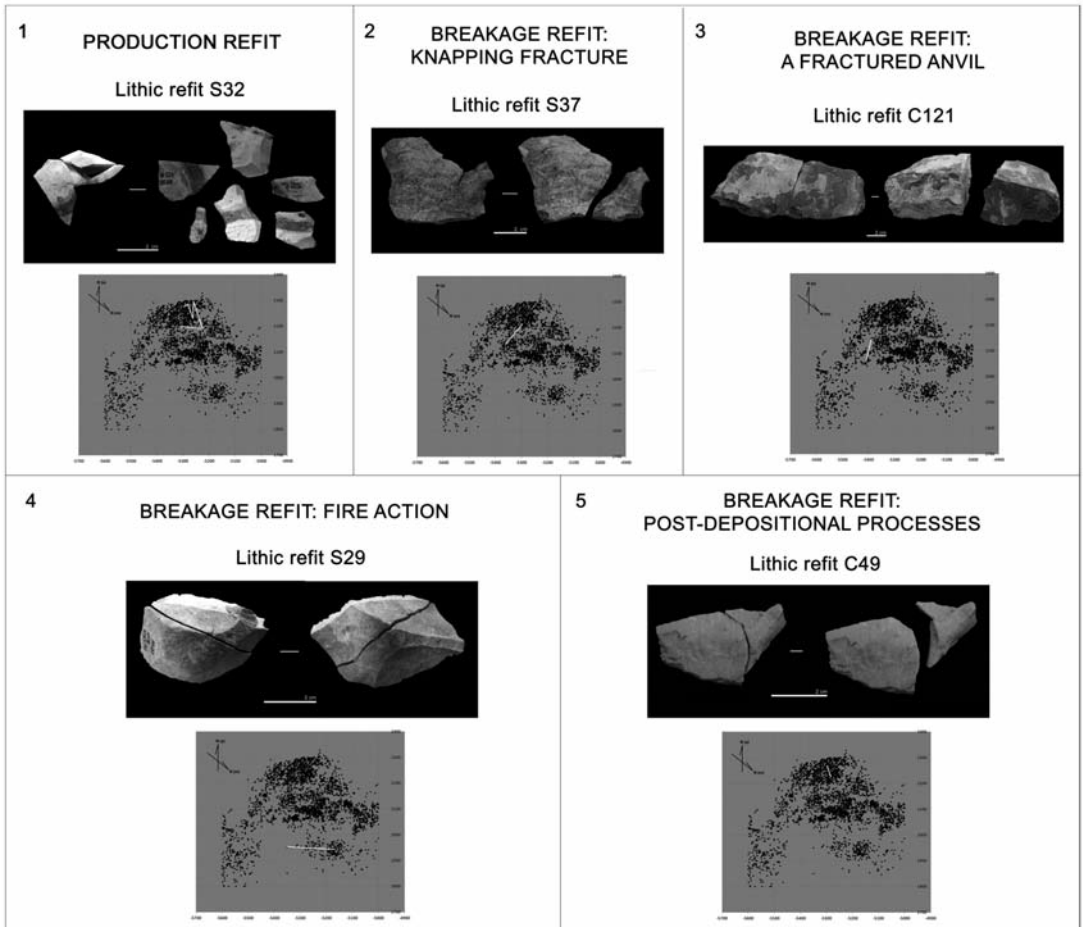


Fig. 10. Abric Romani. Examples of lithic refits identified and their localization in the area O10: **1** Production refit. **2** Knapping fracture. **3** Breakage of an anvil. **4** Breakage refit by fire. **5** Post-depositional breakage refit.

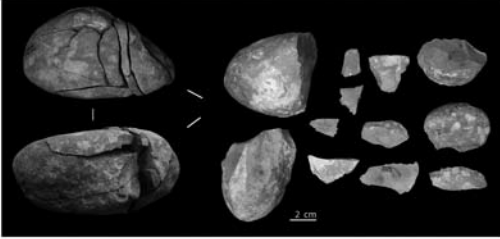
Finally, some lithic refits ($n=15$, Table 6, figs. 11, 12, 13) connect the O10 activity area with other domestic areas identified in level O (connecting lines of more than 13 m of distance). Thirteen belong to knapping activities (11 knapping sequences, 1 to a technical fracture, or sirtet, and 1 to a fracture of a hammerstone) and two to breakage (1 by fire action and 1 by postdepositional processes). Some of these refits show the intentional displacement of particular tools (essentially flakes, cores and hammerstones) to other areas:

- 3 refits belong to the fragmented hammerstone that were displaced out of the O10 area;
- 2 refits show that 2 flakes are introduced to the O10 area from another one where the knapping sequence was realized;

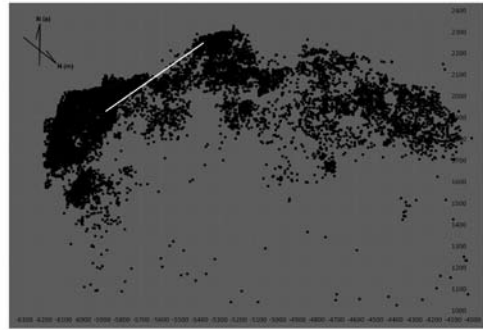
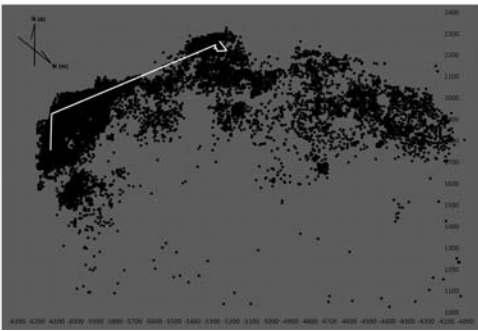
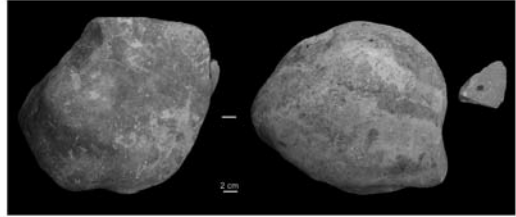
1

PRODUCTION REFITS

Lithic refit C44



Lithic refit C1



2 BREAKAGE REFIT: POST-DEPOSITIONAL PROCESSES

Lithic refit S6

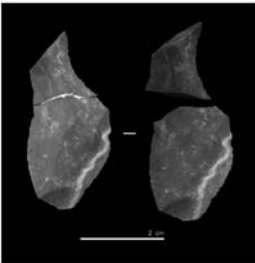


Fig. 11. Abric Romaní. Examples of lithic refits that connect area O10 with other areas of Level O: **1 (above)**. Two production refits. **2 (left)**. Breakage refit.

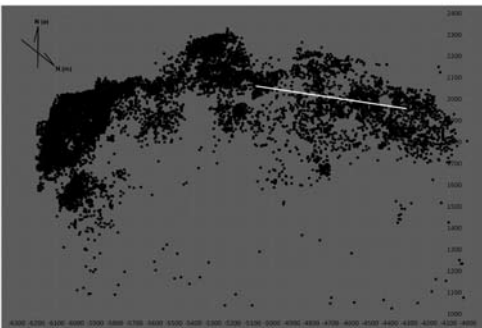
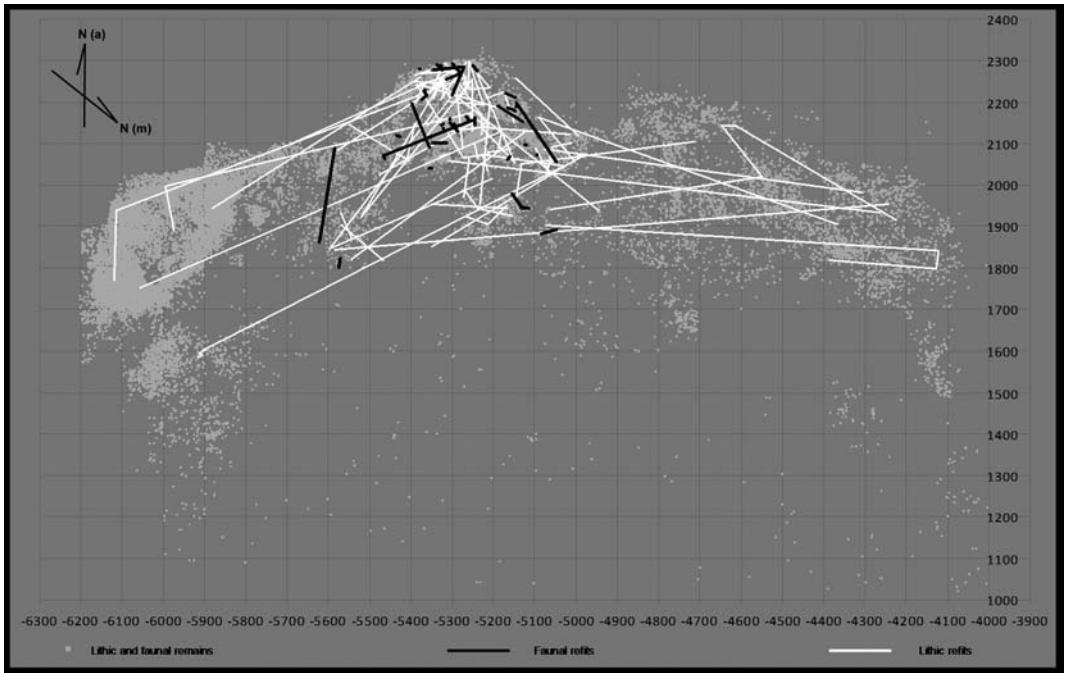


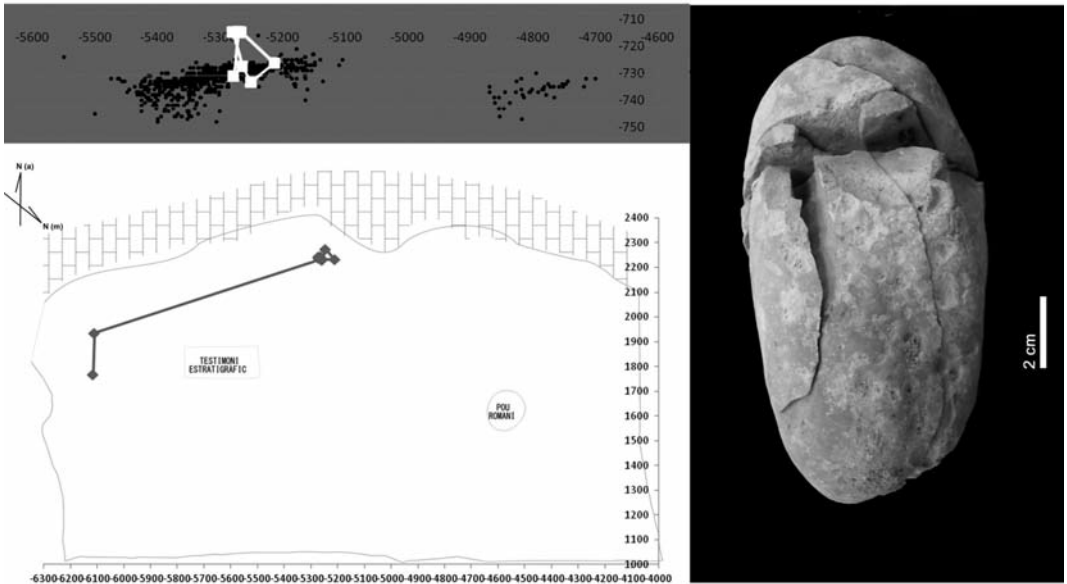
Fig. 12 (facing page, top). Abric Romaní. Spatial patterning of faunal (left) and lithic (right) refits that connect the area O10 with other areas of Level O.

Fig. 13 (facing page, bottom). Abric Romaní. Horizontal and vertical spatial patterning of one lithic refit that represents an example of a recycling process and of the connection between area O10 and other areas of level O.



RECYCLING PROCESSES

Lithic refit C44



- 2 refits show an intentional displacement of two cores from the O10 area to another area. Here, the longest knapping sequences were realized at the O10 area;
- 2 refits show knapping products.

Regarding faunal refits, 34 groups are mechanical refits and only one group is an anatomical refit (two molars of horse from the same hemimandible) (Table 6; figs. 9, 14). Among the mechanical refits, 6 groups were separated by green fractures, whereas the other 25 were separated by dry fractures. Taking into account the structural damage caused during the bone breakage (especially the impact notches and the impact flakes), the high impact of the anthropic activity in the area and the scarce evidence of carnivore activity, we can assume that most of the green fractures were made by Neanderthals. Concerning the refits separated by dry fractures, 21 groups consist in fact of burned bones, most of them burned at high degrees (4 and 5) (figs. 9, 14). Consequently, many of these fractures could be caused directly by burning or by postdepositional processes after burning. Most of the faunal refits are separated by distances shorter than 50 cm (28 groups; 13 of them being shorter than 10 cm), although there are 7 refitted pieces separated by distances between 71 cm and 2.3 m. Burned bones

1 ANATOMICAL REFIT

Faunal refit 11

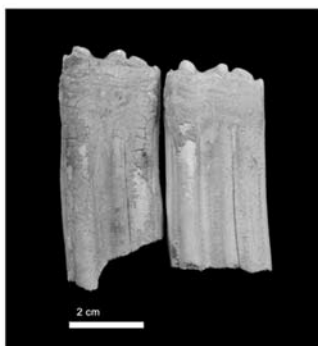
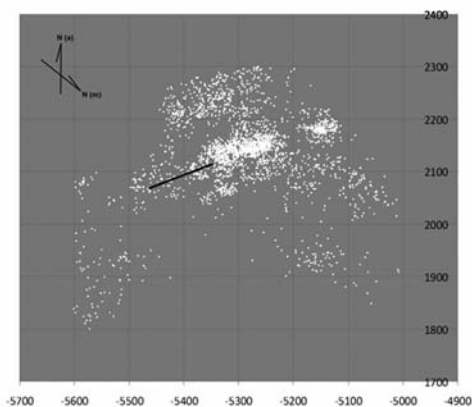


Fig. 14. Abric Romani. Examples of faunal refits identified in the area O10: **1 (left, this page)** Anatomical refit. **2 (facing page)** Refits that connect green-bone fractures.



broken in dry state tend to be connected by very short connections (figs. 9, 14). Likewise, long bones of medium- and large-sized animals are, generally, attached by longer connections than the other elements.

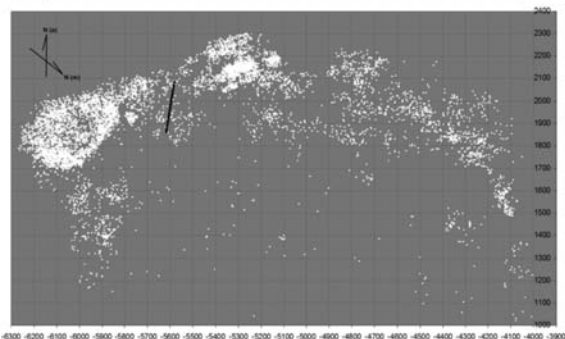
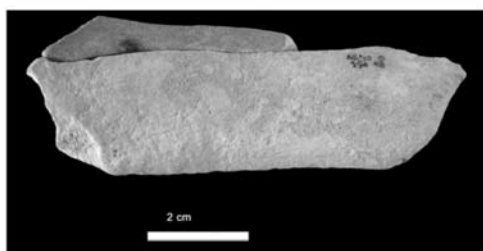
Horizontally, faunal refits are plotted in four different zones (figs. 9, 14): the innermost zone (near the rockshelter wall), the central zone, the right zone and the outermost zone. These zones are not connected, except for one mechanical refit (separated by a fracture in a green state) connecting the inner and the central zones. In the central zone, where the largest hearth is located, most of the refitted bones are non-identifiable, burned, with the distances between them tending to be very short. In the right zone, a refit connects a little hearth with an accumulation of remains located around 1 m outward.

Vertically, the upper and lower micro-levels are not connected by any faunal refits. The average vertical distance between remains from the same refit is 2.61 cm. The vertical distance increases with the horizontal length of the connection line. In fact, all the refits connected by horizontal lines of up to 50 cm have vertical connections ≤ 5 cm. The maximal vertical distance (9 cm) corresponds to the refit with the longest horizontal connecting line (fig. 14-2). This refit connects one bone from the O10 activity area with another located 3 m away (activity area O2). It corresponds to a mechanical refit that connects two fragments of a long bone of a large-sized animal which were separated when the state of the bone was green.

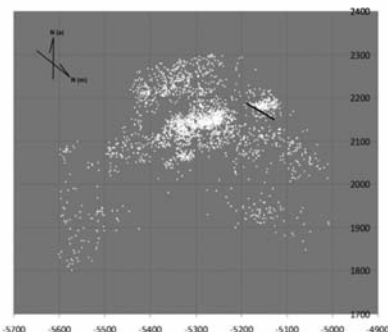
2

MECHANICAL REFITS BROKEN IN GREEN

Faunal refit 101

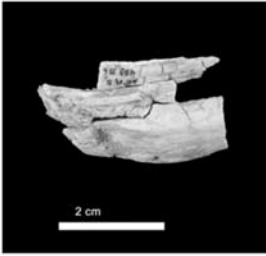


Faunal refit 43



3 MECHANICAL REFITS BROKEN IN DRY: FIRE ACTION

Faunal refit 60



Faunal refit 58

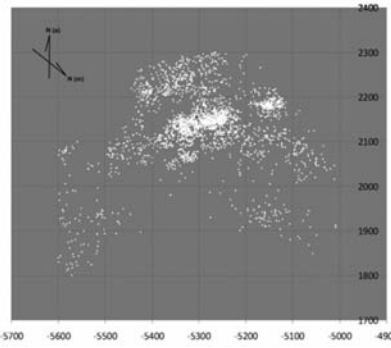
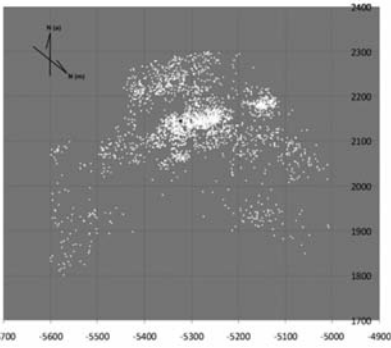
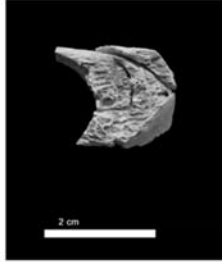


Fig. 14 (cont.). Abric Romani. Examples of faunal refits identified in the area O10: **3 (left)** Mechanical refits produced by fire. **4 (facing page)** Mechanical refits produced by post-depositional processes.

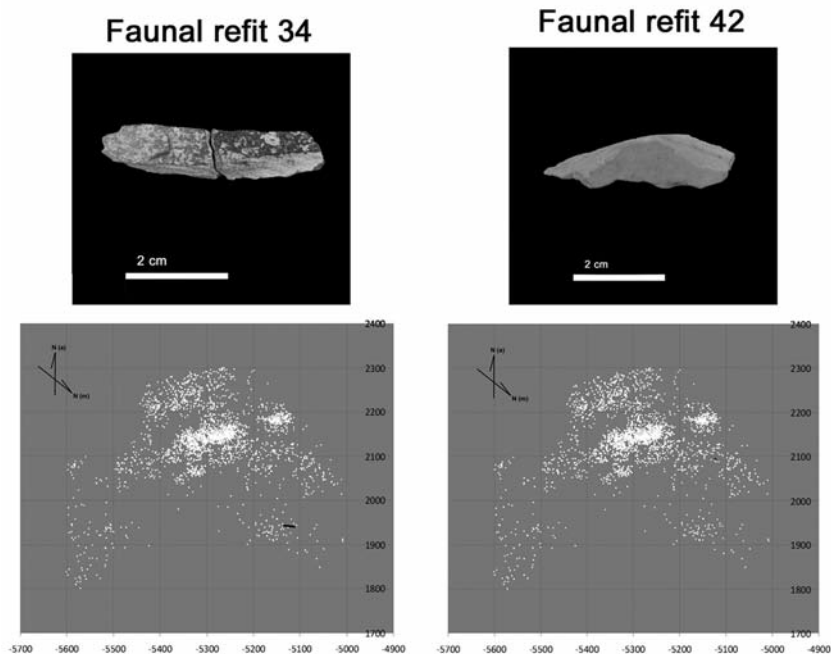
Lastly, the data from faunal and lithic refits and their spatial patterning confirmed that the two micro-levels identified correspond to different moments (little palimpsest) in the O10 area, especially in the center part where the hearths are located (fig. 9).

DISCUSSION AND CONCLUSIONS

The results of this study allowed us to identify the behavioral patterns developed by Neanderthals at the O10 domestic area. The high resolution data obtained and their interdisciplinary interpretation made it possible to document the functionality of this domestic area and to distinguish the temporal formation of the archaeological assemblage and the subsistence activities performed.

The taphonomical and the spatial patterning results show that natural post-depositional alterations are not common at area O10, suggesting that Neanderthals are the main agent responsible for the spatial distribution of the material (Table 4, figs. 6, 7, 8). Evidence for carnivore ravaging and trampling is very scarce. Plant activity, which could have caused vertical movements, is also rare. The effects of water activity (rounding and polished surfaces on bones or lithics) are slightly more frequent. However, the low degree of rounding and the abundance of small fragments (including calcined bone splinters that remained inside the hearths, some refitted and

4 MECHANICAL REFITS BROKEN IN DRY: POST-DEPOSITIONAL PROCESSES



separated by very short distances) indicate that this process did not significantly disturb the distribution of the remains. Only a few calcined bones, located outside the hearths in the most external zone, and one mechanical, dry broken refit, covering a distance longer than 1 m, seem to have been displaced by a post-depositional process.

Faunal and lithic refits suggest synchronicity between many remains inside the activity area O10, and also between some remains from this area and other activity areas (connection refitting line of more than 10 m) (Table 6; figs. 9–14). Mechanical refits of faunal remains corresponding to green fractures (including bones with evidence of intentional breakage) stress this synchronicity, suggesting an immediate nutritional purpose. The faunal refit that connects the area O10 with an adjacent area is just an example of this type of connection. Concerning the lithic remains, all the refits show a clear spatial patterning in the entire O10 area. The reduction sequences, documented by the refits, show their realization in each of the differentiated micro-levels at the O10 area. As we mentioned above, some of the refits that connect different domestic activity areas show the synchronicity of the technical events (see section *Refits*) especially the refits that indicate a movement of flakes and cores between them. But we must take into account the possibility that they can also be an example of recycling of pieces during different occupation moments. The high resolution analysis of the other domestic areas from level O will permit us to confirm one of these two possibilities.

However, there are some aspects that show diachronic moments of activity inside the area O10. The archaeostratigraphic analysis shows two micro-levels in the central zone, separated by a thin sterile layer. These two archaeological micro-levels present different ratios of lithic and faunal remains (figs. 6, 9), and different taphonomic features. Nevertheless this high resolution definition of the activity was observed only in the center of the hearth or in the accumulations with a high density of remains. In the surrounding zone these two events are merged. Thus, this thin level is a small palimpsest.

Likewise, some taphonomic data indicate a certain diachrony inside area O10. An example is the existence of bones ravaged by carnivores, burned and located inside the hearths. Carnivores are not interested in cooked bones (especially in calcined ones), so these remains could suggest an abandonment of the site by the Neanderthals, followed by a carnivore incursion and, later, a return of the humans, who had burned the remains.

Zooarchaeological analysis indicates that animal resources were obtained mainly for food purposes. The abundance of anthropogenic damage on bones (cutmarks and diagnostic elements of intentional bone breakage) points toward this direction. The presence of small impact flakes suggests that Neanderthals broke bones in the area O10 in order to obtain marrow. These small pieces usually remain in the original place of production (Rosell, Blasco, Huguet et al. 2012), whereas larger remains are often transported to toss zones (Binford 1978b). The fact that long bones of medium- and large-sized animals fractured in green are, generally, attached by longer connections than the other elements could also be related to marrow consumption.

On the other hand, the lithic analysis and refits show that this area was utilized as a domestic zone (essential expression of Neanderthal subsistence activities). This is supported by knapped tools and bones with anthropic marks, but also by their spatial patterning associated to hearths. Hearths are at the center of the subsistence activities of these human groups and represent the core area of social relations (Vaquero and Pastó 2001). This pattern was observed in other Middle Paleolithic sites (e.g., Adler and Conard 2005; Cabanes, Mallol, Expósito et al. 2010, Mallol, Hernández, Cabanes et al. 2013; Goldberg, Dibble, Berna et al. 2012; Henry 2012). In addition, the organization and structuration of this activity area is similar to the domestic space of modern hunter-gatherer groups (Binford 1978a, 1978b; O'Connell 1987; Yellen 1977) or Upper Paleolithic modern humans (Bicho, Haws, and Hockett 2006; Enloe and David 1992; Pigeot 2004).

Nevertheless, the faunal record from area O10 (especially in the lower micro-level) suggests a different and specialized use of this space related to the use of fire. Calcined bones are very abundant, more common in area O10 than in the other areas of level O (Gabucio, Cáceres, Rosell et al. 2014). The intensive burning of bones may be related to the positive correlation observed between the % Survival Rate and the density values (Morin 2010). Several actualistic and archaeological studies indicate that bones need direct exposure to fire to be calcined (Buikstra and Swegle 1989; Stiner, Kuhn, Weiner et al. 1995; Bennett 1999; Mentzer 2009). This exposure can occur when the bones are thrown for hygienic reasons into the hearth or when they are used as fuel (Morin 2010; Costamagno, Théry-Parisot, Brugal, et al. 2002; Yravedra and Uzquiano 2013). Thus, it is possible that the area was used as a cleaning zone or/and that bones were used as a fuel-complementing wood resource. In fact, the two possi-

bilities are not exclusive: bones tossed into hearths for hygienic purposes could contribute to lengthen the combustion time and to get optimal combustion properties for some specific activities, such as lighting or heating.

The results presented in this paper establish an important contribution to the characterization of Neanderthal settlement dynamics. The methodological approach proposed here usually provides the possibility of identifying units of behavioral analysis equivalent to single individual events of activity within archaeological palimpsests and the temporal dynamics in the formation of archaeological assemblage. In the case of domestic area O10 it was not possible to identify “clearly” all the events of activity in the same way as it has been done for other levels of the site or even for level O (Gabucio, Cáceres, Rodríguez-Hidalgo et al. 2014; Rosell, Blasco, Fernández-Laso et al. 2012; Rosell, Cáceres, Blasco et al. 2012; Vaquero, Chacón, Cuartero et al. 2012). In the case reported in Gabucio, Cáceres, Rodríguez-Hidalgo et al. (2014), several observations (quantification indices, faunal refits and spatial analysis) indicate that all the remains identified as *Felis silvestris* belonged to a single adult individual, whose accumulation occurred in a single event, very well delimited both in space and in time.

The data obtained about diachrony and synchrony of events in the O10 area need more data to be corroborated, especially data from lithic refits from the rest of the areas to test the intentionality of the displacement of the pieces. We need to finish the same type of analysis for the rest of the domestic areas from level O (currently under study). With this present work, we wanted to test: (1) if this methodology also works in a single domestic area and (2) if the tooth wear analysis can provide higher resolution data to decipher the activity events. The results are positive and very important because they demonstrate that we cannot obtain all possible information if we do not perform the same analysis for the rest of the archaeological assemblage in the level.

Because this study focuses only on a single activity area, certain types of analysis have failed to fulfill all their potential. Tooth wear analysis did not provide significant data for this study because of the low sample size in area O10. The analysis of the variability of the tooth wear pattern for the entire sample from level O indicated the succession of repeated events of occupation at different times of the year, supporting the diachrony in the accumulation of the remains. Further studies, including all the activity areas identified at level O (12 areas in total), will provide sufficient samples to develop this new analysis.

Our results allow us to distinguish some points in time of the occupational patterns in a clearly defined area. In this case, we are now able to improve the interpretation of the palimpsests. We provide solutions to solve the palimpsest problem with high resolution data to characterize the ethnographic time frame. The results are very important and allow us to recognize two short micro-levels of events in time isolating the Neanderthal redundancy occupation. They provide significant insights into the knowledge of general Neanderthal behavior. The identification of individual events of activity supplies information about the temporal dimension of site formation processes. This is particularly significant for obtaining information about the behavioral interpretation of the archaeological record and the context of settlement dynamics.

In conclusion, the analytical resolution of our study allows us to interpret Middle Paleolithic archaeological assemblages at a high level of behavioral understanding and constitutes a significant contribution to the knowledge of human occupation types. Contexts with rapid sedimentary rates are very important in deciphering the

occupational patterns and the subsistence activities from a spatio-temporal perspective, as demonstrated through the case of the Abric Romaní site. It is also essential to apply interdisciplinary methodologies for studying and interpreting the archaeological remains, regardless of the sedimentary context of the site under study.

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