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GIS AND GEOARCHAEOLOGICAL ANALYSIS IN SUPERFICIAL OPEN-AIR SITES: THE CASE OF RAÑA DE CAÑAMERO NEANDERTHAL SETTLEMENT (GUADIANA BASIN, SPAIN)

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ABSTRACT

Archaeological surveys and excavations carried out in two areas of the municipality of Cañamero (Cáceres, Spain) have revealed the presence of significant Middle Palaeolithic stone tool assemblages. This paper contextualizes the site at a regional scale and presents its chronological evolution over time, accounting for the different post-depositional processes. To do so, different techniques and methodologies have been implemented, including archaeology, geomorphology, and GIS analysis. The aim is to understand the genesis and evolution of these kinds of Middle Palaeolithic settlements and to characterize them in contemporary soils.

KEYWORDS: Middle Palaeolithic, open-air sites, GIS, Geoarchaeology, Neanderthal

1. INTRODUCTION

The Raña de Cañamero is situated in the central valley of the Guadiana and Tajo rivers, south west of the Iberian Peninsula (Fig. 1). It is divided into four main areas with archaeological sites of the Lower and Middle Palaeolithic. First, the plains of the Alagón River, where the site of El Sartalejo is located (Santonja, 1985; Moloney, 1992). Second, the county of Villuercas with the site of Raña de Cañamero (Álvarez-Alonso and Fernández Fernández, 2012). Third, the county of Campo Arañuelo comprising the group of archaeological sites located in the province of Cáceres, both outdoors and in caves (Barrero et al., 2004; Carbonell et al., 2005; Peña et al., 2008). Overall, the sites in this region are divided between open-air deposits and those located in karstic environments, the latter being less frequent but providing more information.

Figure 1. Location of Raña de Cañamero. Source: authors.

With regard to the open-air sites, the only chronostratigraphic information comes from fluvial deposits, mainly from the Acheulean site of El Sartalejo. It is situated in the T+24+26 terrace level at the end of the Middle Pleistocene, which provides a relative chronology within which to situate the nearby Palaeolithic sites. Unlike Raña de Cañamero, El Sartalejo is characterized by the presence of bifaces, cleavers and some examples of Levallois technology (Méndez et al., 2008). Other Acheulean sites in the Tajo basin are Galería Pesada in Estremadura, Valhe do Forno in Alpiarça (Mejías, 2009; Mozzi et al. 2000; Trinkaus et al., 2003), Pinedo (Querol and Santonja, 1979) and Puente Pino (Rodríguez de Tembleque, 2008). Moreover, the site of Enxarrique is located in the lower Tajo Valley, in the T+5-10 terrace level, comprising faunal remains and Mousterian stone tools dating back to 34 Ka BP (Cardoso, 2006). This dating allows us to refine the regional chronostratigraphy of other river systems. The closest site to Raña de Cañamero is El Millar (Canals et al., 2004; Diaz et al., 2004; Mejías, 2009). However, this site does not provide numerical dating or any other chronostratigraphic information beyond a set of stone tools assigned to the Middle Palaeolithic.

In turn, only a few archaeological sites with similar chronologies can be found in some caves of the Tajo valley in karstic environments. The cave of Sala de los Huesos in Maltravieso presents a lithic assemblage with a lack of large bifacial stone tools and with presence of elements assigned to Mode 3 that could be ascribed to the Middle Palaeolithic, found in a level situated between two stalagmite plaques dated 183+14/-12 Ka BP at the bottom and 117+17/-14 Ka BP in the upper part (Peña, et al., 2008; Mejías, 2009). The cave of Santa Ana also contains a sequence of stone tools dated to the Middle Palaeolithic (Carbonell et al., 2005).

Finally, a number of sites located in the lower Tajo valley allow us to contextualize the Mousterian period in the area: Gruta de Olivera, dated between 70 and 35 Ka BP, Gruta de Caldeirao, Gruta da Figueira Brava and Gruta Columbeira (Mejías, 2009). Therefore, according to the regional context and to the type of stone tools present in Raña de Cañamero, the site can be assigned to the Mousterian period in the Late Pleistocene, which occurs frequently along the Tajo valley, both in caves and open-air contexts.

2. LOCATION AND SETTING OF THE SITE

Raña de Cañamero is a geomorphological and sedimentary environment that differs completely from the other two main settings of Middle Palaeolithic sites: river terraces and, to a lesser extent, caves. Therefore, it is relevant to analyze the reasons why human settlement took place in such an unusual location. Given the preservation conditions of the site, it was necessary to first carry out a geoarchaeological study to assess the degree of reliability and homogeneity of the archaeological sample, following the methodology described below.

2.1 Geomorphological context

The study area is part of the Eastern-Portuguese Alcudiana region within the Iberian massif. The main geological structures of the area are oriented from north west to south east, following the Hercynian orogeny. The region is divided into three main groups:

- The Villuercas syncline, containing Ordovician and Silurian materials;
- The Precambrian anticlinoriums of Guadalupe-Ibor and of Central Extremadura; and
- The *rañas* fanglomerates are glacis with stones, flat structures formed by the tertiary and quaternary materials that fossilize the previous series.

Figure 2. Digital Elevation Model of Raña de Cañamero and location of the archaeological site. Source: authors.

Figure 3. Profile detail of the sedimentary geological formation under study, the raña. It shows a conglomerate of sub-rounded quartzite pebbles within a tertiary red-ocher colored sandy clayey matrix. Above them, a thin soil of dark colors (scale 1 meter).

The Palaeolithic lithic assemblages that are the subject of this study have been found in the *rañas* fanglomerates. These are detrital continental formations that originated during the Middle to Upper Pliocene (Hernández Pacheco, 1949; Espejo, 1987, 1988). They are present across large areas of the central and eastern Iberian Peninsula, often associated with the quartzite hills from which the rock fragments within the deposits (gravel, sub-angular blocks, and cobbles) are derived. These deposits generate large flattened platforms with an average thickness of between 4 and 7 meters, forming interfluves in the quaternary drainage network. In particular, Raña de Cañamero functions as a divisor between the Ruecas and Silvadillos-Guadalupejo rivers, situated to the north of a series of quartzite formations – the Sierra de las Villuercas – which have an average altitude of 145 meters and a maximum height of 1,600 meters.

The altitude of the surface of Raña de Cañamero varies between 645 meters in the north and 515 meters in the south, with an average longitudinal slope of 0.7% (Espejo, 1988). Other nearby *rañas* fanglomerates are the Mesa del Pinar and the Dos Hermanas in the municipality of Alia. Most Palaeolithic research in the inner areas of the Iberian Peninsula has been carried out in two main geomorphological contexts: river valleys and karstic environments. However, some researchers have started to analyze other geomorphological contexts whose characteristics can be understood from a geographic perspective, based on their spatial location, strategic position and their relationships with other nearby environments. These places are common throughout the inner areas of the Iberian Peninsula and are usually situated at altitude in order to connect basins and natural regions (e.g., river valleys). They are defined as *páramos* (moorlands) when they are made of limestone and *rañas* fanglomerates when they are composed of alluvial deposits. Previous studies on the Iberian Peninsula in such contexts carried out by F. Díez (2000) provide a framework for our investigation. During 2011, archaeological work was conducted in the municipality of Cañamero (Cáceres, Spain) with the aim of investigating a number of surface occurrences of Middle Palaeolithic lithic assemblages located on the Pliocene *rañas* bordering the mountain range of Sierra de las Villuercas. Work included a systematic surface survey and the excavation of two archaeological test pits.

3. OBJECTIVES

The main objective of this work is to apply methods of archaeological and taphonomic analysis to open-air sites situated in geomorphological contexts where researchers have usually focused on the study of stone tools exclusively. The absence of more detailed studies on these types of sites has created artificial gaps in knowledge about the Palaeolithic. The use of complementary methodologies such as geographic analyses and intra-site studies including contextual and taphonomic analyses tailored to the specific needs of the site or area under study can further our knowledge of these archaeological sites.

While the study draws on different research methodologies, the research questions go beyond methodological issues to address the interpretation of mobility and land use patterns in Neanderthal societies inhabiting this region during the Middle Palaeolithic. Therefore, the investigation is part of the large body of literature devoted to the study of open-air sites similar to the one addressed here: that is, those comprising lithic assemblages located in the surface that have been defined as 'off-site archaeology' (Dunnell and Dancy, 1983; Cherry et al., 1988; Rossignol and Wandsnider, 1992; Díez Martín, 1997). We agree with Díez Martín (1997) that it is necessary to prioritize the contextual value of artifacts in terms of their distribution and density in order to acquire an in-depth knowledge of post-depositional processes. Nonetheless, according to Clarke (1984), depositional and post-depositional processes are fundamental in archaeological research and must be taken into account even before implementing any data analysis or designing interpretive models. For Borrazzo (2006, 2007), it is essential to take into account the following criteria in the application of taphonomy to the study of lithic assemblages in open-air and superficial archaeological deposits:

1. Understanding the general dynamics of the study area and its possible effect on lithic remains. In our case, we had to take into account the geomorphological context of the *rañas* fanglomerates and the action of agricultural tillage and plows.
2. Identifying processes, mainly water and wind, which transform rocks, and identifying the traces these processes leave on them. In both cases, the effects of these processes depend largely on geomorphological contexts. The petrological characteristics of the lithic materials must be taken into account since different types of rocks respond differently to similar erosive processes.
3. Finally, off-site approaches highlight the need for spatial and distributional studies, usually drawing on GIS (see Conolly and Lake, 2006).

4. TAPHONOMIC BACKGROUND

To address our case study from the perspective of off-site archaeology, it is necessary to present the processes that prevent us from obtaining an accurate chronostratigraphic context to analyze the site, and that lead us to focus on the lithic assemblage and in the taphonomic processes affecting it.

4.1 Natural taphonomic processes

After the formation of the *rañas* fanglomerates, they were subjected to significant erosion during the Quaternary. This erosion was mainly caused by the engagement with the actual fluvial network, which dismantles these surfaces as a consequence of the headward erosion in the headers of the river channels. According to Espejo (1988), we must add to these processes the significant soil loss derived from sheet erosion. This is present in Raña de Cañamero as shown by the residual accumulation of coarse quartzite materials at the top of the convex area of the slopes. Sheet erosion produces a selection of soil particles by displacing the finer ones and leaving the thicker ones. This finding is particularly useful in assessing the post-depositional processes the site underwent. The weathering of some lithic pieces contrasts with the low weathering of others that are relatively untouched, which might show that subsequent erosion cycles have taken place affecting different parts of the deposit in different ways. The low permeability of the raña soils and the gentle slopes and reliefs of the *raña* favor the appearance of seasonal ponds. This is interesting from an anthropic viewpoint, and its relevance is corroborated by the current use of the ponds by farmers as watering holes for animals.

4.2 Taphonomic processes of anthropogenic origin

These soils have been affected by geological processes but also by agriculture and cattle farming (including grazing, deforestation, plowing, and clearing, among other activities) in different historical periods. We have corroborated this fact through interviews with contemporary farmers who have traditionally used the space for the cultivation of rye. This would have affected the circulation and leaching of surface and ground waters, the acidification of soils and their drainage, and, ultimately, led to the complete modification of soils (Butzer 1982). These processes not only alter soil components, but also their contents (lithic artifacts). Research has been devoted to clarifying the role played by agricultural tillage in altering surface deposits both internationally (e.g. Roper, 1976; Lewarch and O'Brien, 1981; Odell and Cowan, 1987; Dunnell and Simek, 1995) and in the Iberian Peninsula (Díez Martín, 1998, 2000, 2003, 2004, 2010). Our data show that agricultural activities generate or condition the following factors: horizontal and vertical displacements, and alteration of the form, content and preservation of the lithic assemblages.

5. MATERIALS AND METHODS

This study draws on three main methodologies: (1) the fieldwork and analysis of the geoarchaeological context, (2) the techno-typological and taphonomic analysis of the lithic assemblage, and (3) the spatial analysis of the site through GIS.

5.1 Fieldwork

The archaeological survey employed systematic random sampling to select and define a number of areas within two plots situated in the municipality of Cañamero (Figure 2). The aim of the systematic sampling approach was to calculate an artifact Density Index for each area (Fig. 4).

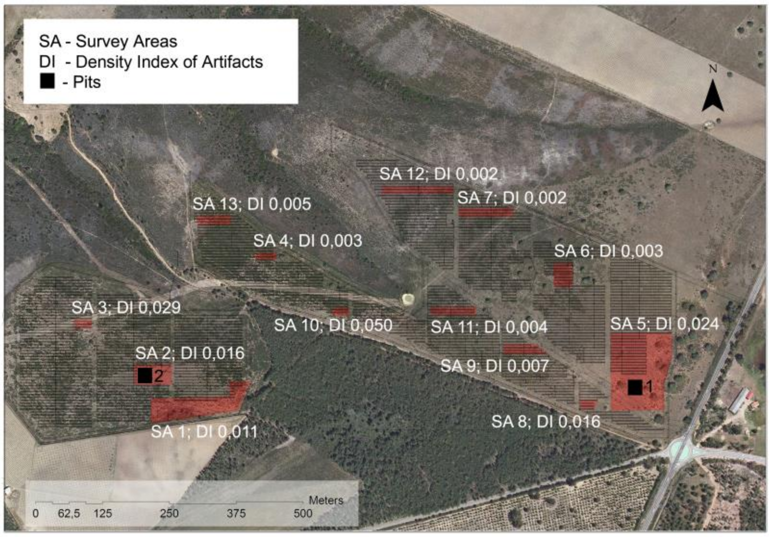

Figure 4. Survey areas, density index and location of the test pits S-1 and S-2 in aerial photography. The squares mark the location of pits and are not to scale. The map of a solar plant is overlaid on the image. Source: authors. Cartographic data: Plan Nacional de Ortofotografía Aérea.

First, a total of 13 survey areas were defined. Within these areas, all the archaeological materials were collected systematically and their spatial location recorded with GPS. Then, a Density Index by surface unit was calculated. The data were then included in a GIS to carry out an estimate of the total amount of materials in each sample unit, delimiting the areas with higher densities of lithic materials. This information facilitated the selection of high-density areas suitable for test pits (S-1 and S-2), also taking into account the state of preservation of the soil. The study area had also been affected by the construction of a solar power plant, and thus we had to choose the most intact areas among those of higher value of Density Index. Overall, the construction works were mostly surface cleanings and flattening, and did not significantly affect the conservation of the site. Then, two 2 x 1 meter test pits were excavated with the aim of establishing an approximate relation between lithic pieces found on the surface and in the plow-zone sediment.

During this process, a detailed description of the soil was carried out, identifying the position, orientation and inclination of the elements obtained in stratigraphic context. The data obtained were then analyzed in relation to the geomorphological and geological context of the *raña*.

5.2 Lithic assemblage analysis: technological, typological and taphonomic approaches

First, we performed a technological and typological study based on the development of a database comprising the typometric attributes "L", "a", and "e", typological attributes following the description of the typological list of F. Bordes and the classification of G. Laplace for the identification of lithic retouches, and technological attributes based on the comprehensive analysis of the *chaîne opératoire* or operational chain (Geneste, 1991, Pelegrin et al., 1988). This latter aspect has involved the identification of lithic reduction techniques through the analysis of the cores, and the full study of debitage products focusing on their different attributes including cortical index, number and organization of dorsal scars, platform type and angle of percussion platform. This detailed analysis has been published elsewhere and can be consulted to complement the information presented here (Álvarez-Alonso and Fernández Fernández, 2012).

In parallel with the techno-typological analysis, a taphonomic study of the lithic assemblage was carried out to classify artifacts according to their alterations, recording the degree of alteration, type of alteration and its characteristics. This classification system was developed specifically for the lithic assemblage under study, identifying features such as edge-wear, damage, patination and particle size at both macroscopic and microscopic scales using 10x and 20x loupes and a 40x petrographic microscope.

Given that erosive processes could have been behind the selection of materials of different sizes, we assessed the relationship between the degrees of alteration of the pieces in terms of their size. We calculated this relationship through correlation analysis, of the approximate volume (length x width x thickness) and the degree of wear of the patina. The analysis of the patina revealed three distinct patterns of alteration, which were applied to the typological analysis. The three groups can be characterized as follows:

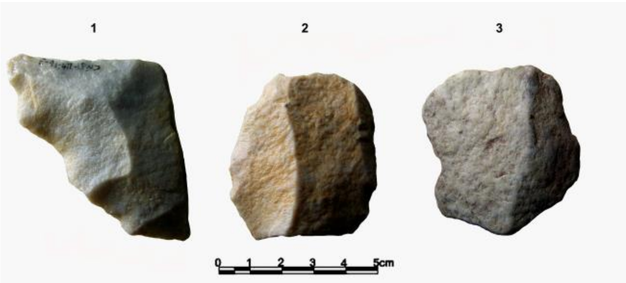

Figure 5. Degrees of alteration according to the taphonomic analysis of the lithic assemblage. The number refers to a variation from a lower to a higher degree of alteration. Source: authors.

- Grade 1: the material does not show oxidation or pitting; the brightness and morphology of quartz grains can be clearly discerned on the entire surface; edges and borders are undisturbed and present a 'fresh' aspect; the dorsal negative scars and their organization can be clearly distinguished, thus not presenting any problems for diacritical analysis.
- Grade 2: the material shows oxidation and pitting; the brightness of some quartz grains can be observed as well as their morphology; the dorsal scars are distinguishable, although diacritical analysis is more difficult.
- Grade 3: the material is greatly rusted with pitting and polished surfaces; it is not possible to discern the brightness or morphology of the quartz grains; the edges are fully polished and blunted; it is difficult to identify individual dorsal scars; and they often present pseudo-retouch, both reverse and direct in the same piece (dorsal and ventral).

The results allowed us to cross-match data between taphonomic and techno-typological information.

5.3 GIS and spatial analysis

The artifact collection was accompanied by a taphonomic study and GIS analysis in order to understand the geomorphological and post-depositional processes the archaeological material underwent, such as agricultural tillage. To complement the information obtained from the whole assemblage, a database linked to a GIS was developed in order to facilitate the spatial visualization of the results and to carry out different types of analyses, at multiple scales. Intra-site spatial analysis revealed information about the post-depositional processes in the area based on the characteristics and distribution of the materials using GIS analysis, such as the degree of alteration of the materials, and considered typological variables by in relation to the size of the artifacts. This allowed us to further assess the impact of some post-depositional processes in the formation of the site. Artifact density was analyzed using kernel density analysis (Conolly and Lake, 2006), applying a 15 meter buffer radius in order to offset the cumulative errors of GPS, cartography and some post-depositional processes such as plowing of agricultural fields. The aim here was to isolate patterns of sets from an intermediate level of resolution.

At a broader scale, GIS analysis allowed the information to be framed in a wider geographical context in order to understand the land occupation patterns in the *longue durée* or long term of Palaeolithic time. This allowed us to specifically relate technological aspects with environmental processes and land use. To implement this model, a GIS platform and a Digital Elevation Model (DEM) were used, given that topography is the most significant factor influencing artifact movement patterns. A mobility algorithm was applied over the DEM with the aim of transforming slope values into time values. This procedure has already been tested in other research (Fernández Fernández, 2010). After developing a friction template, we elaborated a model of optimal displacement accumulation (Fábrega, 2006; Fábrega and Parcero, 2007), using the hydrology tools which are usually used to create maps of the local direction of drainage basins. In this case, instead of using a DEM, these tools were directly applied to the friction template. This allows for the independent assessment of the pattern in terms of effort displacement between different points. To do so, a number of points were situated at the margins of the study area from which the calculation was made. This vector layer was transformed into a raster format, giving a '1' value to all the pixels through which the resulting network passed. Subsequently, density estimation was performed using the kernel method (with a 500 meter radius) in order to better identify the nodal areas, that is, areas with a greater connectivity or confluence between 'paths'.

6. RESULTS

A total of 467 lithic artifacts of quartzite were recovered from the surface and a further seven in stratigraphic contexts attributed to the Middle Palaeolithic period, based on their techno-typological features. Table 1 presents the density indices and estimated artifact density and for each of the 13 survey areas. This information facilitated the selection of the areas to carry out the test pits S1 and S2.

Table I. Results of the archaeological survey and the test pits carried out

Survey Areas	Number of Artifacts	Surveyed area (m2)	Artifact/Area ratio
ZM1	66	6,070	0.011
ZM2	41	2,500	0.016
ZM3	17	590	0.029
ZM4	3	1.000	0.003
ZM5	270	16,143	0.016
ZM6	5	1,600	0.003
ZM7	4	1,798	0.002
ZM8	8	500	0.016
ZM9	11	1,520	0.007
ZM10	26	525	0.050
ZM11	6	1,500	0.004
ZM12	4	2,000	0,002
ZM13	6	1,300	0.005
Total	467	37,046	0.012

Test pits

Number of pits	Area	Depth	Collected materials	Liters of sediment	% of artifacts /20 l.
2	4m²	25-30 cm.	7	1,200	1.66

6.1 The lithic assemblage

The lithic sample from Raña de Cañamero consists of a total of 466 artifacts (297 flakes, 100 retouched tools, 38 cores, 8 core fragments, 3 debitage products, and 20 preparation products). There are no macro-tools, but there an emphasis on tools made on flakes, particularly denticulates and notches.

The assemblage is mainly devoted to the production of small blanks to be retouched, mostly through the use of methods of multifacial or bifacial reduction methods, such as discoid and, to a lesser extent, Levallois. Fifty percent of cores (n=19) are hierarchical (1 multifacial, 3 Levallois, 11 bifacial discoids, 3 unifacial discoids, and 1 multifacial discoid). The preferred methods employed were those of centripetal type, using flakes or plane clasts. The main reduction method is multifacial, probably as a consequence of the type of raw materials locally available, mostly angular quartzite clasts. Furthermore, although the Levallois technique is present in 3 cores, it is not a preferred method, probably due to the natural form of the raw materials. The presence of many cores (n=38) and flakes (n=297), as well as various preparation products (tablets, core-sides, and core-edges), shows that the different products and stages of the chaîne opératoire documented are present. Therefore, in spite of its open-air site context, the assemblage seems to have a low degree of typological bias.

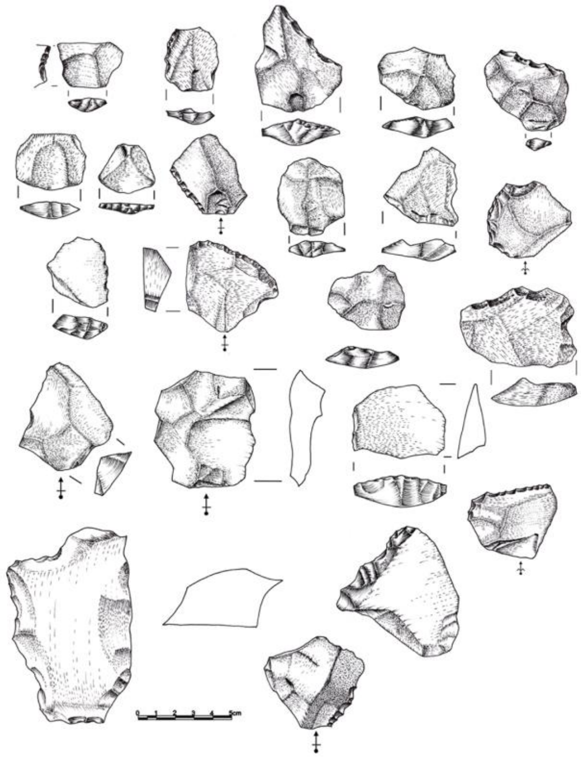

Figure 6. Lithic assemblage of Raña de Cañamero. Levallois flakes, racloirs, denticulate and different Levallois tools. Source: authors.

In the following sections we carry out a more detailed assessment of the degree of preservation and the representativeness of the surface sample, analyzing the post-depositional alterations affecting the site. These technical characteristics have been the subject of a previous detailed study (Álvarez-Alonso and Fernández Fernández, 2012), allowing us to characterize the lithic techno-complex of Cañamero in the Middle Palaeolithic.

6.2 Taphonomic analysis

First, we carried out a study of the surrounding area to assess the impact of different post-depositional processes, such as the use of plows. The results from the two test pits reveal that the archaeological horizons coincide with the soil layer altered by agricultural tillage, 25–30 centimeters deep (SU1, archaeological stratigraphy - Horizon A, soil classification). Consequently, it is impossible to locate archaeological contexts unaffected by these processes. It was necessary to carry out an estimate of the amount of visible surface artifacts in comparison to non-visible sub-surface artifacts in horizon A-SU1 in order to correct the deviations present in the surface analysis of lithic materials. Some authors (Díez Martín, 1998, 2001), have performed experiments to establish the ratio between hidden artifacts and artifacts exposed by the action of the plow and the representativeness of samples from a qualitative and quantitative point of view (e.g., the relationship between flakes and cores). In general, it has been observed that plow action tends to bring less than 10% of the total lithic materials to the surface, leaving 90% hidden from surface survey detection. In addition, elements of larger sizes tend to be better represented than smaller ones, preventing any attempt to establish the ratio between cores or macro-tools and flakes (Díez Martín, 1998, 2001). The stratigraphic analysis showed similar results. Two main horizons were identified, a humic layer of 25–30 centimeters thickness (Stratigraphic Unit 1 [SU1]) and the geological substrate beneath it (Stratigraphic Unit 2 [SU2]), composed of detrital materials of tertiary origin.

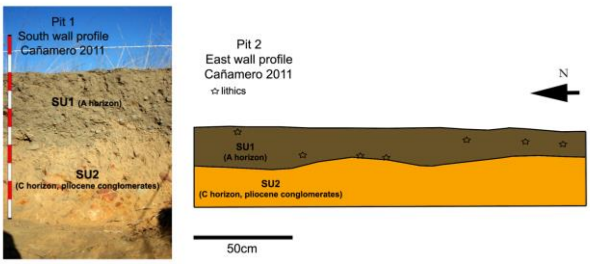

Figure 7. Stratigraphy and profile of the test pits. Source: authors.

Test pit S1 did not provide any archaeological material in stratigraphic context. By contrast, test pit S2 provided seven lithic artifacts, all of them in SU1. Their distribution in the vertical profile and in the horizontal plane shows a random arrangement of the archaeological material in the sequence with no stratigraphic or spatial order. Clearly, these materials are located in a secondary position. In order to compare our context with other similar studies, such as those by Díez Martín (2003) in the Duero basin, we calculated an artifact density index based on the percentage of artifacts per 20 liters of sediment. Excavations removed 1,200 liters of sediment in total; the percentage of artifacts per 20 liters has yielded a total of 1.66%. In Díez Martín's (2003) study, where he carried out 29 test pits in 6 different locations, artifact density ranged between 0.02% / 20 liters and 2.2% / 20 liters.

At Raña de Cañamero the percentage of surface artifacts is low in relation to those included within the sediment. According to our data, only 0.7% of the archaeological items would be visible. For this calculation we have taken into account the total number of surface artifacts (466) in the 13 areas surveyed and the estimated average in stratigraphic contexts from the two test pits. According to this calculation, the area should contain, in theory, more than 64,000 artifacts included in the sediment, at a rate of 0.006 pieces per liter. In short, the area surveyed presents a low Density Index of surface artifacts with an average of 0.0134%. Moreover, there is a low representativeness of the surface sample (0.7%), although we estimate that the number of tools included within the sediment provides data that can be considered normal (1.66% / 20 liter). All this information points to the low alteration of the substrate when compared to the reference works used (Díez Martín, 1998, 2000, 2003, 2004, 2010), where surface samples are usually around 10% and the percentage per 20 liters of sediment is 1%. These variations could be due to differences in agricultural tillage. The characteristics of the ultisols of the *raña* fanglomerate make them unsuitable for agricultural use because of their poor mineral substrate and high acidity (Mariscal, 2008). Consequently, agricultural tillage should not be of an intensive type, focusing primarily on rain fed crops and with the regeneration of soils after long fallow periods.

Additionally, during construction of a photovoltaic solar power plant in the area, clearing work uncovered some surface layers and left other partially intact areas, as in the one identified as Survey Area 5 (Density Index, 0.016). In these areas, there were no remarkable differences between the artifact density patterns in the surfaces, most of them altered by clearings (e.g., Survey Area 5: Density Index 0.024). Because clearing work was more intensive in the southern area, the alteration of the surface is greater. Therefore, we are aware of the existence of a significant variation between the actual number of materials and the sample collected in these areas that have had different uses over time. We also note that the estimates of the amount of archaeological material in stratigraphic contexts collected from the two test pits can only be approximate. In fact, the test pit sample material comes exclusively from test pit S2.

In summary, this site has been altered by different erosion processes during the Quaternary; however, these have not displaced the archaeological materials from their original context in the *raña* fanglomerate. The subsequent impact of agricultural tillage can be considered more relevant in the bias of the materials that can be found. Therefore, although the collected sample is small, it is considered to be sufficiently representative because there are not great qualitative differences between the material preserved on the surface and in the sediment. Having analyzed the types of natural and anthropic agents affecting the surrounding area, a second phase of analysis included the interpretation and cross-matching of these results with those obtained from the analysis of the archaeological material itself. The lithic assemblage was divided into three groups depending on the alterations observed. The reasons for these divisions derive from their location in a *raña* fanglomerate associated with a long and intensely eroded soil horizon, and from the different degrees of alteration. The results showed the absence of typological differences between artifacts with Grade 1 and 2 alterations, while the low number of pieces of Grade 3 could not provide decisive data in the study.

Among the 465 artifacts, 189 show Grade 1 alterations, 241 present Grade 2 alterations, and 35 show Grade 3 alterations. First, it was found that, among the many alterations shown by the assemblage, there are no traces of rolling processes. Combined with the absence of pebbles in this context, this is of great importance when assessing the spatial position of the lithic assemblage, allowing us to discount transport and redeposition processes by water flows. Second, the marks and patinas documented in the assemblage are the result of weathering, mainly from the erosive action derived from eolization and agricultural tillage. This has altered the edaphic and archaeological context but has not caused substantial horizontal displacement, although vertical displacement has occurred.

It would be possible to interpret the lithic assemblage as an archaeological site situated on the surface of the *raña* but subsequently affected by post-depositional processes which caused vertical disturbance. We tried to verify this hypothesis by carrying out a spatial analysis to check the existence of specific patterns in the distribution of archaeological elements.

An area was defined (Survey Area 5, Fig. 4) to carry out density analysis based on a kernel density estimation analysis. The first attribute considered was the degree of alteration of the material. This could reveal potential diachronies between groups of artifacts and their degree of differential exposure to weathering. Because two elements of similar chronologies might present different degrees of alteration, it was necessary to confirm whether this feature was related to some other attribute, such as the size or techno-typological variables of the artifacts. After a first analysis, two areas of differential distribution were established, with a particular focus in the southern part of Survey Area 5, which presents a higher density of artifacts with less wear.

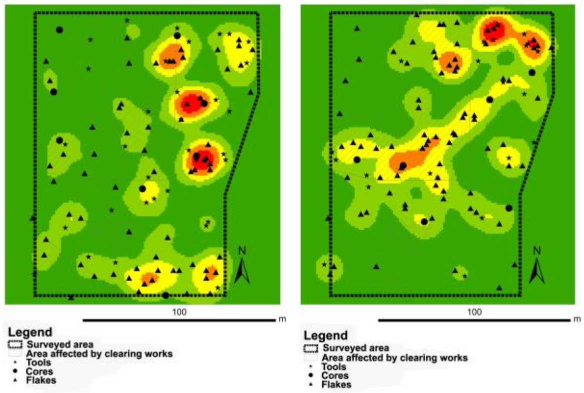

Figure 8 and 9. Kernel density analysis according to the patina. At the left, type 1-patina materials. At the right, type-2 patina materials. It is possible to discern the areas affected by the clearing works performed to construct a solar power plant in the area, which did not affect the structure of the soil. Source: authors.

There is a higher frequency of artifacts displaying greater patination in the western part of the area. The rest of the area shows a mixture of both Grades 1 and 2excluding pieces belonging to Grade 3 because of their scarcity (n=7). These results point to varying degrees of natural alterations that are less predictable and highly random compared to the effect of agricultural tillage. If agricultural tillage had been the cause, it would have also affected the surface and the sediment in a more homogeneous way, especially in such a small area.

The final result of correlation analysis is 0.0471, meaning that there is no correlation between the two factors. In the surface sample, artifact volume and degree of patination are not related phenomena. If larger or smaller artifacts had been exposed to different erosion processes, the correlation would be close to 1 or -1, which was not the case. These data are consistent with the stratigraphic study, where no difference was observed between the sizes of the pieces recovered in the sediment and surface levels. This is a further indication of the low impact of agricultural tillage in disturbing the archaeological material.

In contemporary plowed soils, the materials of larger size are better represented in a surface context. This is called a 'dimensional effect' (Baker, 1978). Another relevant fact is that the patinas of the test pit artifacts are completely variable (five pieces with Grade 1 patina and two pieces with Grade 3 patina). Thus, there seems to be no relationship between materials collected on the surface (where artifacts with all types of patinas are similarly represented) and the materials appearing in the subsoil. The size and patina ratio of both the surface and stratigraphic samples point to a similar conclusion: that there is no relationship between the degree of alteration of the artifacts and their size. It still remains to be seen whether there is any pattern of spatial distribution that associates the degree of alteration of the lithic assemblage with some technological process.

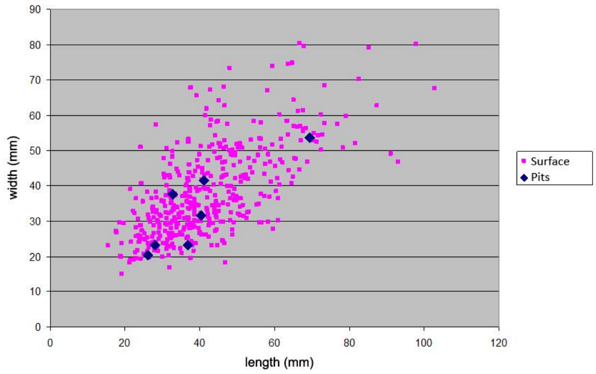

Figure 10. Size ratio between materials collected on surface and in the stratigraphy of the test pits performed. Source: authors.

The spatial analysis demonstrates that, in spite of the post-depositional processes documented through the stratigraphic study, there are observable spatial patterns in artifact distribution. However, the morphological and technological homogeneity of the lithic assemblage – conditioned by the type of raw material locally available – restricts study of the relationships between degrees of alteration, distribution, and diachrony at a spatial level.

7. DISCUSSION

Why was Raña de Cañamero occupied during the Middle Palaeolithic? Were there structural and geographic factors that determined these occupation patterns or were there other causes involved? To shed some light on this question, we conducted an analysis of the overall mobility patterns over a wide area (approximately 1,000 km²) surrounding our site of study.

The aim was to explore the hypothetical patterns of accessibility and interconnectivity between different sites. When algorithms are used in GIS to map optimal routes of lower energetic cost over a DEM, the goal is generally to identify paths between two points, usually archaeological sites (Conolly and Lake, 2006). In our case, however, the aim was to analyze patterns of mobility separately from the archaeological data from the site in order to test whether a hypothetical model complemented the archaeological findings.

We must bear in mind that we are using a contemporary DEM, that is, it does not reconstruct the topographical conditions of the Middle Palaeolithic because we lack the necessary palaeoenvironmental data. However, all current geomorphological structures had already been formed during the Middle Palaeolithic, and only the river network would have changed. In addition, the erosive action of the river network would have not affected the *rañas* fanglomerates as intensively as it does today.

The analysis shows that the area of Palaeolithic occupation is located in one of the three locations with a higher convergence of routes offering the least displacement effort in the whole 1,000 km² region under study. Therefore, it seems that the characteristics of accessibility and interconnectivity might have determined the location of the site. The point where the archaeological materials are found is an intermediate space between the headwaters of several watersheds. A quicker and more direct access between them was offered by this location, which also allows for a certain visual control over riparian resources. Therefore, Raña de Cañamero can be principally interpreted as a passageway during the Middle Paleolithic, where many sporadic visits and economic activities must have been recurrent throughout the period. In this way, the site has accumulated a great wealth of lithic materials that are now dispersed in the contemporary surface layer after undergoing multiple post-depositional processes.

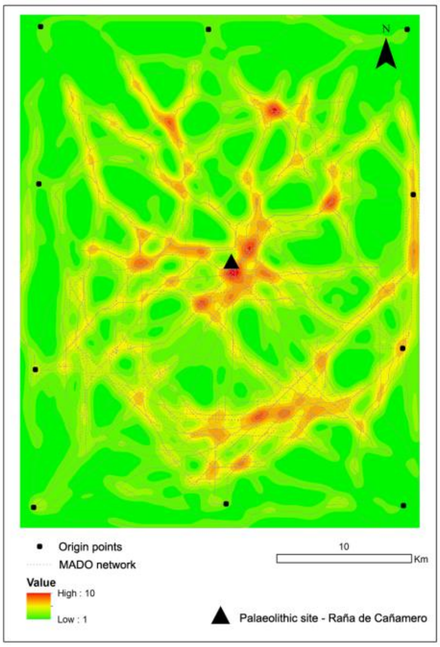

Figure 11. Optimal path network and density of nodal areas. Source: authors.

8. CONCLUSIONS

The lithic assemblage of Raña de Cañamero lacks its original sedimentation context because agricultural tillage has affected the entire soil surface. This process disturbed and decontextualized the materials but did not entirely expose the stratigraphy to surface levels. The taphonomic analysis of the lithic assemblage supports this thesis conclusively. The *raña* fanglomerate has undergone significant surface erosion as a result of the action of the wind and of water run-off. These processes have altered the different geological and archaeological materials (Espejo, 1988; Mariscal, 2008) as can be clearly observed in the alterations that occurred to the lithic assemblage. Moreover, there were no alterations derived from transport or dragging of the lithic assemblage characteristic of fluvial environments, such as striations, rolling, or knocks (Shick, 1986).

The typological and taphonomic analysis of the lithic assemblage (Álvarez Alonso and Fernández Fernández, 2012) focused on the assessment of the potential alterations in the site, which could be observed in the absence (by suppression) of materials due to the agency of natural erosive processes. The result was negative because we could not observe any kind of distribution pattern derived from natural processes. In addition, it was impossible to determine any bias with taphonomic value in the sample as a result of a largely homogeneous and complete lithic assemblage in terms of the operational chain identified (Álvarez Alonso and Fernández Fernández, 2012). Similarly, there is no technological or typological distinction with diachronic value resulting from the analysis of the patinas.

Although erosive and plowing processes have altered the primary archaeological context, the horizontal and vertical displacement of artifacts would not have introduced a significant bias in the record, nor would they have displaced the site from its secondary or quasi-primary context. The intra-site analysis revealed potential zones of differential use of the space during the Middle Palaeolithic, although it is impossible to affirm if these resulted from diachronic or natural processes. The morphological and technological characteristics of the lithic assemblage are highly homogeneous due to the locally abundant quartzite raw material. This prevents any assessment relating technological and chronological factors. In any case, our attempt suggests that this kind of analysis can prove useful in other contexts where relations between technology and chronology might go unnoticed without the implementation of the research protocol implemented in our investigation.

Finally, the study of the macro-spatial variables (networks) shows that Raña de Cañamero functioned as a key passageway, which would explain the abundance of archaeological material. This resulted from the recurring and transient presence of different human groups. These groups would have taken advantage of the available resources at each point throughout the broad temporal span of the Middle Palaeolithic, thus leading to the formation of the archaeological site of Raña de Cañamero.

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