Neanderthal settlement patterns during MIS 4–3 in Sierra de Atapuerca (Burgos, Spain)

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ABSTRACT

A 314 km² archaeological survey in Sierra de Atapuerca between 1999 and 2003 found 180 open air settlements. The objectives of this study were twofold: to develop a fieldwork methodology with full-coverage and high-intensity that would permit the discovery of all prehistoric settlements in and around Sierra de Atapuerca; and to document and study the Upper Pleistocene, the only hitherto unknown period in the Sierra de Atapuerca, as it has not been preserved in the caves under excavation, and also the groups which inhabited Atapuerca at this time, the Neanderthals. Results from 31 Middle Palaeolithic sites confirm the inhabitation of the Sierra in MIS 4–3 and show settlement patterns of hunter–gatherer groups which inhabited Sierra de Atapuerca in the Upper Pleistocene.

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1. Introduction

The Sierra de Atapuerca site complex is known to contain the history of the last 1.5 million years. Europe’s oldest known occupations (Carbonell et al., 2008; Bermúdez de Castro et al., 2011) and the earliest described evidence of regular cannibalism in human evolution (Carbonell et al., 2010; Bermúdez de Castro et al., 2013) have been found in several of Atapuerca’s limestone caves.

Sierra de Atapuerca lies 15 km east of Burgos, Spain. It contains several archaeological sites dating from the Early Pleistocene to the Holocene (Fig. 1 A). Constant work over the last 30 years has yielded information about the cave occupations, subsistence patterns and technology of the hominins who inhabited this continent. Chronologically, the strata include the Lower Pleistocene (Gran Dolina and Sima del Elefante), Middle Pleistocene (Gran Dolina and Galería), and Holocene (e.g., Cueva del Mirador and Cueva Mayor). However, no late Upper Pleistocene chronologies have been found in the caves currently under excavation.

Galería, Gran Dolina and Sima del Elefante are in the Railway Cutting zone. These are Pleistocene karst deposits that were sliced through by a railway cutting, thereby exposing their stratigraphic sequences (Ollé et al., 2013) (Fig. 2). These caves became filled with sediment at earlier dates than the MIS 4–3 occupations analysed in this paper.

Given that the anthropic impact documented inside the caves probably existed outside as well, a major project was designed to discover the remaining evidence of open air settlements and supplement this information with data exhumed from the caves. For this reason, and also to ascertain how the hunter–gatherer inhabitants of these hills articulated the space that they exploited, it was decided to conduct an exhaustive archaeological survey in a circular 314 km² area centred on the caves (Navazo et al., 2008). The fieldwork conducted between 1999 and 2003 located 180 hitherto unknown prehistoric open-air settlements, from amongst which 31 Middle Palaeolithic sites were chosen for closer analysis.

The discovery and study of these 31 archaeological sites demonstrates the presence of Neanderthal groups in Sierra de Atapuerca, completes the time gap hitherto undocumented in the caves, and points to the strategies developed by these Upper Pleistocene groups of hunter–gatherers. The ultimate goal of this work is to ascertain the distribution of the hunter–gatherer groups in a territory, i.e., their settlement pattern.

In this research, we therefore studied the stone tools recovered from each of the archaeological sites during the surveys and...
analysed the different archaeological levels, their lithic assemblages and the dating of the two sites which have been excavated so far (Hundidero and Hotel California). Luminescence dating of quartz grains at the Dating and Radiochemistry Laboratory, Autonomous University of Madrid (Spain), revealed a chronology of 70,556 ± 11,011 a (TL) for the top of Level H4, Hundidero (Navazo et al., 2011). On the other hand, optically stimulated luminescence (OSL) dating results obtained from Hotel California at the CENIEH were 48.2 ka ± 3.3 for the most recent level and 71.0 ± 5.6 ka for the base (Arnold et al., 2013).

2. Regional setting

Geologically, the study area is at the NE end of the Douro River basin, bounded to the north by the southern foothills of the Cantabrian Mountains and to the SE by Sierra de la Demanda (north Castilian branch of the Iberian Ranges) which cuts it off from the tertiary Ebro River basin with the exception of the Bureba Corridor (Fig. 1 A). Sierra de Atapuerca is structurally part of the Iberian Range, configured by a tilted anticline (Pineda, 1997). The Quaternary deposits analysed in the study area are river terraces, flood- plains and valley floors, alluvial fans and colluvia. The largest terraces are in the Arlanzón River Valley, with small terrace remnants on the south side of the Vena River valley (Fig. 1 B). Lithologically, in both valleys they consist of sand, gravel and polygenic Palaeozoic pebbles. Their chronology is Pleistocene and Holocene. The floodplain lithology associated with the main rivers (Arlanzón and Vena) consists of quartzite and -scarce- limestone gravel and cobbles, sand, silt and clay. The valley floors are small seasonal watercourses filled with alluvial input and colluvial influence, with heterometric material and occasional alternation with coarse and fine material. Both deposits (floodplains and valley floors) are attributed to the Holocene. The alluvial fans are at the base of cliffs, at the mouth of small gullies on the terrace deposits or the floodplain. Their composition is also heterometric, with varied fines and pebbles, depending on their location. Their age may be Pleistocene or Holocene. The colluvia lie on hillsides and consist of fines and rock fragments (Fig. 2) (Navazo et al., 2005; Benito-Calvo and Pérez-González, 2007, 2008).

3. Material and methods

This study aimed to ascertain the distribution of the hunter—gatherer groups in a territory, i.e., their settlement pattern. The following methodology was designed for this purpose: First, the study area was defined, drawing on ethnographic research (Lee, 1969) which establishes a theoretical 10 km radius space exploited by hunter—gatherer groups within which they obtained all their subsistence requirements: raw materials, water, game and harvest. Beyond this ideal territory, the energy employed by a group to stock up on a particular resource is not profitable in terms of two parameters, cost and benefit. The 10 km radius study area was centred on Cueva Mayor, the cave complex containing the archaeo-palaeontological record of Sierra de Atapuerca (Fig. 3).

3.1. Survey strategy

The 314 km² study area was inspected thoroughly in search of overall settlement patterns of settlement and all evidence remaining on the surface. These archaeological sites are not regarded as single, isolated areas, but rather as parts of a complete territory consisting of some spaces that contain archaeological remains and others that do not, whose interconnection gives more consistent meaning to the passage of human populations through Sierra de Atapuerca and its environs.

3.1.1. Area selection

The selection of the specific area is the starting point of a survey design as it defines the realm of the study. The large area defined for this particular research was inspected on the basis of natural criteria, i.e., it was divided up for inspection on the basis of its different geomorphological units (Fig. 3).

3.1.2. Type of survey

There are two survey models: sampling (Collins and Leigh, 2003) and full coverage, depending on the nature and the purpose of the project. In sampling, parts of an area are chosen for sampling and the rest is left uninspected. Sampling can be directed or probabilistic.
Full coverage entails systematic, exhaustive inspection of all the land in the survey area. The latter technique was employed in this study. The fieldwork, used to detect patterns of settlement and usage of the space by hunter-gatherers in the Sierra de Atapuerca-Arlanzón River complex, was the first territorial archaeology study to inspect such a large area in such a total, intensive way.

3.1.3. Intensity

This variable has been defined as “the effort devoted to the inspection of the study area” (Schiffer et al., 1978), or “the degree of detail in which the surface of the surveyed area is inspected” (Plog et al., 1978). It can be measured in two ways:

i) By the interval or distance between survey members, with the distance between them described as low intensity when they are more than 100 m apart, and high or very high when the distance is 10 m. In practice, the most common distances are 25, 50 and 75 m.

ii) By the number of person/days involved in each survey unit or the total area. This method of measuring the intensity, which
can also be expressed in person/days per km$^2$, is calculated after the survey, while the former method is direct, i.e. before or during the process. For Schiffer (1988), the likelihood of finding a site during a survey depends directly on the visibility and inversely on the distance between survey members.

Thoms (1979) observed a direct correlation between high intensity and high density of sites in a comparison between the results of two surveys with different intensities in the same part of southeast Texas. Some archaeologists in the southwestern United States have compiled data on this relationship between intensity and results. Data collated by Plog et al. (1978) on 12 surveys can be used to find information about intensity (person/days/km$^2$) and density of located sites (number of sites/km$^2$). The scatter plot of these data shows a positive linear relationship with a Pearson correlation coefficient of 0.888 for all prehistoric sites. Schiffer and Wells (1982) collected data from 12 surveys to inspect the effort (number of person/days used per km$^2$), the distance between surveyors (in metres) and the density of sites (number of sites per km$^2$). They show that the apparently direct relationship between the distance between surveyors and the effort expended on surveying is actually curved, so that when the distance between surveyors is reduced from 50 m to 10 m, the effort increases gradually to distances of less than 10 m, after which it increases considerably. This aspect should be taken into consideration, particularly in the case of isolated discoveries or areas with a low density of material which require a small distance between surveyors and a thorough inspection of the ground (Zeidler, 1995).

Although other factors affected the final results, the obtained data of the present study confirm the high return on qualified, high intensity surveys. The distance between members of our field surveys was never more than 20 m, defined as a high-intensity survey (Fig. 4). The distance between team members was much smaller in rangelands, which further intensified the effort. In some cases, information would have been lost if the surveyors had been more than 20 m apart.

3.2. Fieldwork

After deciding the fieldwork strategy, there is another important stage prior to the commencement of the direct inspection on the ground, which is the preparation of the field work. At this point, we ascertain whether the chosen type of survey is most appropriate and the way to collect all the necessary information. This initial step of the fieldwork is followed by two others, field inspection and a review of the sites.

3.2.1. Preparation

Although the ground was thoroughly inspected and in theory no information will be missed, regardless of its size, a review of the literature concerning any settlements known in the same area is useful for both preparing and reviewing the survey. Local toponyms are another valuable source of information.

In a task of this nature, the correct design and preparation of the fieldwork is one of the factors in success. Ultimately, the truly
useful materials are all the area’s topographical, geological and geomorphological details, the best way of becoming familiar with it before setting out. Good maps and other planimetric material such as previous geomorphological and geological surveys of the area are essential in the preparation of the different survey units, the entry points and the surveyors’ movements, with a view to minimizing their duration and ensuring their systematic implementation. Another indispensable preparatory step is a prior inspection of the ground. In the present case, the authors visited the area previously in order to define each survey unit and decide which team members will work in each one.

Another essential prior step is the gridding of the survey area to systematize the recovered material. A map of the survey unit is subdivided into quadrats, which in the present case measured 250 m per side. This allows the organisers to decide whether the planned time and number of team members is realistic or whether the methodology needs to be readjusted to increase or decrease the number of team members, the area or the time, but under no
circumstances the nature of the survey, as the duration can be extended or reduced from the initial estimate, without abandoning the high-intensity coverage under any circumstances.

3.2.2. Fieldwork

Once all the available information is compiled, the team, consisting of an average of 11 members on flat ground with good visibility, and 5–7 members in shrub or rangelands (Fig. 4), can be set to work, walking along the pre-established lines in search of any evidence that might denote prehistoric human activity.

3.2.3. Revisiting the sites

Once all the points are defined and the survey units are marked on the plot maps, they should be revisited to recheck the coordinates, dispersal, concentration, etc. We also returned to the sites to study their geomorphologic position and the deposits. Surveys (test-pits) were conducted. Once the stratigraphy of the deposits has been studied, several were excavated further.

3.3. Laboratory

After washing, tagging and drawing, the material was analysed. In the present case, analysis of the lithic assemblages included all the steps of the chain operatoire to permit the dating of the chronocultural assemblage.

Raw material sources, technology, typology and post-depositional processes were studied. The technological analysis of each recovered assemblage has allowed us to typify each one chronoculturally, designating those from the Middle Palaeolithic. Analysis of items with double patina, recycled tools and different percentages of structural categories, as well as their geomorphological situation, also allowed us to detect whether sites represented short and/or recurrent occupations.

3.3.1. Raw materials

In the present case, the study area was surveyed with the aid of GPS to map the flint and quartzite outcrops and analyse the location of the raw material sources (primary or secondary characteristics) (Luedtke, 1978; Demars, 1982; Turq, 2000). The quartzite was found in secondary deposits such as river terraces and two outcrops (Fig. 5). Two types of flint were distinguished in this area, in association with two geological formations: a layer of Middle Miocene lacustrine limestone (Astaracian), and Upper Cretaceous marine dolostone and limestone (Turonian Lower Santonian). Sierra de Atapuerca contains a large range and quantity of available raw material. One of these varieties is the type most commonly used by palaeo-settlers, flint.

Microscopy, mass spectrometry and X-ray diffraction methods were used to analyse 415 samples of natural and archaeological flint from the study area (Sierra de Atapuerca, Burgos, Spain) in order to define the different types of Neogene and Cretaceous formations in the study area (Fig. 5), infer their genetic context and ascertain the supply sources used by the hunter–gatherers who exploited this area in the Upper Pleistocene (Navazo et al., 2008).

3.3.2. Technology

The lithic assemblages were studied using the Logical Analytical System (LAS) (Carbonell et al., 1983, 1992; Rodríguez, 2004). The LAS approaches the study of technological processes on the basis of the stage at which the objects were produced during the reduction sequence, striving to avoid fixed typological preconceptions. The LAS classifies objects into several structural categories, depending on their position in the production chain (Table 1, LAS categories). When a natural object (Natural Base, nB) is worked, it undergoes a transformation. As a consequence of this first modification (Time 1), two or more objects are produced from the initial block (nB). One, the initial matrix (i.e., the flaked item) retains one or more negative scars that correspond to the removals, which are in turn the corresponding “positives” (i.e., flakes or detached pieces). This paper thus refers to first-generation negative bases (1GNB, cores) and first-generation positive bases (1GPB, flakes). Further work on a 1GNB gives rise to new 1GPBs. If any of the 1GPBs is picked up again and retouched, a new stage of the process begins (Time 2). This transformation turns what was previously 1GBP into a second-generation negative base (2GNB), thus beginning the production of second-generation positive bases (2GBP). This process can continue, producing subsequent generations of objects.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Terminological comparison between the Logical Analytical System and the most common English language terms in archaeological literature (adapted from Carbonell et al., 1999, Ollé et al., 2013).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Logical Analytical System</strong></td>
<td><strong>Common terms</strong></td>
</tr>
<tr>
<td>Natural Base (nB)</td>
<td>Pebbles, cobbles or blocks selected in order to flake them or use them as hammers (percussion material)</td>
</tr>
<tr>
<td>First Generation Negative Base (1GNB)</td>
<td>Pebbles, cobbles or blocks once flaked. They show the scars of the flakes detached from their surfaces. They can be either tools or cores.</td>
</tr>
<tr>
<td>First Generation Positive Base (1GBP)</td>
<td>Complete flakes detached from the 1GNB</td>
</tr>
<tr>
<td>Second Generation Negative Base (2GNB)</td>
<td>Flaked flakes whose blanks were 1GBP. That is, flakes that have been retouched or modified. These usually are denticulates, notches, sidescrapers, etc., as well as handaxes, cleavers, etc. on flakes</td>
</tr>
<tr>
<td>Second Generation Positive Bases (2GBP)</td>
<td>Small complete flakes (debris) detached when retouching First Generation flakes</td>
</tr>
<tr>
<td>Fragmented Positive Bases (FBP)</td>
<td>Broken flakes; flakes with preserved point of percussion but incomplete margins</td>
</tr>
<tr>
<td>Fragments of Positive Base (Frag of PB)</td>
<td>Flake fragments; flakes with absent butt</td>
</tr>
<tr>
<td>Indeterminate (INDET)</td>
<td>Angular fragments</td>
</tr>
</tbody>
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3.3.3. Post-depositional processes

Two agricultural fields were chosen to study the way that farm machinery scatters artefacts. Wheat and barley are grown in both fields, as is the case in the fields containing the surveyed archaeological sites. Planting takes place in October and November, and involves four operations by the farmer’s machinery: ploughing, cultivating, seed drilling, and rolling. In the experiment, these activities were done immediately after our placement of experimental stone artefacts. The artefacts were numbered, placed in a 1 m² quadrat and mapped.

In order to assess the vertical displacement of artefacts by modern farming, we dug a test unit in an archaeological site that had been impacted by ploughing. In 2000, the Los Pedernales site was identified during a survey in a contemporary wheat field, and was found to contain a surface assemblage of Pleistocene and Holocene artefacts. This site was selected to compare surface and subsurface lithic scatters. A 1 m² excavation unit was defined within the site. All sediment was sieved with 0.5 cm screens.

Once we had analysed all the material in each concentration or dispersal area, and understood the origins of each site and the post-depositional factors that had transformed it, we were in possession of all the data that could supply the information necessary to reach our goal. At this point, we could thus make inferences about the problem to be tackled and fulfill the research goals of the entire project.

4. Results

4.1. Surveys

A total of eight surveys were conducted, starting in 1999 and ending in 2003. A total of 6295 h and 1122 persons were involved, defined by person/days: there were roughly 60 different surveyors who were counted several times, depending on the number of days that they worked. The average number of surveyors at work on each day was seven.

A total of 180 archaeological sites were located, some of them (21) with more than one chronocultural occupation (up to 201 sites). For detailed study, we selected the 31 Middle Palaeolithic sites whose recovered lithic assemblages matched the Mode 3 technological characteristics (Fig. 2).

We later conducted archaeological surveys to ascertain which of these 31 locations contained deposits and how many were only surface scatters. The final step involved the excavation of those that contained well-preserved Pleistocene deposits. To date, test pits have been dug at Hundidero (Benito et al., 2005; Navazo et al., 2011) and Hotel California (Arnold et al., 2013). We are currently focusing on a third, Fuente Mudarra, where work is still underway and more sites are to be investigated.

4.2. Sites

4.2.1. Raw materials

At each of these 31 open-air sites, the most commonly used raw material was Neogene flint, followed by Cretaceous flint. The percentages of other raw materials in the assemblage were not higher than 5% in any case. Most sites are on flint outcrops or secondary deposits. Characterization of the archaeological flint by microscopic and geochemical analysis revealed the use of local raw material (Fig. 5).

Microscopic analysis distinguished two types of flint: Neogene flint, with generally anisotropic textures, including many shades of lenticular crystals ranging in size from 0.10 to 1 mm, corresponding to silicified gypsum crystals; and Cretaceous flint with generally homogeneous, microcrystalline textures and highly fragmented, unidentifiable fossil remains (bioclasts).

The final result shows that most of the Neogene samples are from what we have called “Flint Avenue”, a Neogene flint outcrop that predominates in Sierra de Atapuerca, or from Castrillo del Val, part of the same formation as Flint Avenue. In the case of the Cretaceous samples, the sources are the San Vicente plane and the area known as Orchid Valley, part of the same Cretaceous formation (Fig. 2).

4.2.2. Technology

The technological features observed in the assemblages indicated that the aim was to generate products by exploiting a core. These flakes (BP) were functionalized directly (Fig. 6 d, f) or used in configuration series.

The most widely represented structural category was BP, followed by retouched flakes (BN2Gc). Cores only outnumbered retouched flakes at three of the 33 sites. Typometric analysis of these flakes found that small sizes were best represented (Bagolini, 1968) (Figs. 6 and 9). As with the retouched flakes, these flakes had non-cortical, unifaceted platform butts, and non-cortical dorsal faces in most cases.

The retouched flakes were larger than the flakes, both within the small format category. The best represented morphotypes were denticulates (Figs. 8 c, f; 7 a), followed by sidescrapers (Fig. 6 a–c), and many flakes with abrupt retouches. We found a few more points and burins at sites on high ground than on terraces, where more points were found.

Amongst the exploitation systems, the orthogonal knapping method was predominant in cores, and centripetal in the case of cores on flakes. In general, there was minimal or no conditioning prior to the extraction process on cores, and little complexity in the knapping strategies (Figs. 6–8).

4.2.3. Post-depositional processes

To study the horizontal and vertical distortion of the tool associations in the croplands where they were found, we placed lithic assemblages on the surface of ploughed areas. We monitored their dispersal and burial in each crop cycle, and counted the items in one of the surveys at the Los Pedernales site. The aim of this test was to determine to what extent the items recovered during an archaeological survey reflect the original models related to the total populations (Navazo and Díez, 2008).

Two sets of 50 lithic items were formed and placed in a 1 m² area in two different fields. After two complete crop cycles, the survey of the two fields yielded the following results:

1. Representativeness of the surface survey: Only five of the 50 items left in one field were visible, with nine recovered in the second, suggesting that only 10% and 20% of items can be expected to be recorded by direct inspection on the ground.
2. Distance travelled by objects: In the first field, the five recovered items were 2.9 m, 70.6 m, 76 m, 107.6 m and 110 m from where they had been left. A different pattern was detected in the second field, where the nine recovered items were 95 cm, 35 cm, 54 cm, 53 cm, 114 cm, 147 cm, 159 cm, 556 cm and 400 cm from their original position.
3. Movements by types: The recovered items had practically the same size, with three small flakes and one broad flake in the flake category (Bagolini, 1968).
4. Ploughing direction: The recovered items lay in the same direction as the ploughing.
5. Distortion of the original pattern: The original pattern covered a 1 m² area, which spread to 731 m² in the first field and 3.4 m² in the second, while the density of items clearly declined.
To study the vertical movements, i.e. the quantitative and typometric relationship between the assemblage of surface items and the ploughed soil, we opened a 3.2 m deep test pit measuring 1 × 1.5 m at a site known as Los Pedernales, where we had documented a lithic tool scatter. All sediment was screened and the industrial complex was retrieved for quantification. The results of this experiment led to conclusions about aspects such as:

1. Loss of stratigraphic structure. The farm machinery removed the subdivisions of the topsoil, creating a distinctive, homogeneous horizon, Ap, that was differentiated from the horizon beneath it. There was a transfer of items from the surface to a depth of 30–40 cm, destroying the stratigraphy and mixing assemblages with different ages.

2. Ploughing moves objects in different ways. We wanted to test the veracity of the so-called dimensional effect, i.e., whether the materials found on the surface are larger than those within the sediment matrix. The typometric analysis of the items retrieved on the surface and those in the ploughed soil showed that small items were preserved in the latter.

3. Representativeness of surface samples. The retrieved surface sample represented 1.32% of the total, which allowed us to calculate the tool density as 6.66 items per m².

5. Discussion and conclusions

The aim of this study was to document the Neanderthal settlements in Sierra de Atapuerca in order to learn more about the
strategies developed by these groups of Upper Pleistocene hunter-gatherers. We consider that such strategies can be detected from these groups’ repeated behaviour over time, manifested in the production, use and abandonment of stone tools whose analysis shows patterns that clarify these strategies. In order to study the Neanderthal groups’ occupation model in Sierra de Atapuerca, it was therefore necessary to compile a representative sample, hence the full coverage model of the fieldwork design and implementation, which ensured that no evidence was left undetected.

The 31 Upper Pleistocene sites were chosen from amongst the 180 discovered settlements on account of the relationship between the technological tradition documented for this period (Mode 3), and the models detected in these settlements. This selection is based on a technological study of the assemblages, which permits the differentiation of the sites containing Mode 3 lithic assemblages which were occupied by Neanderthal groups.

The time span of the study covers part of the Middle Palaeolithic cultural period (MIS 4–3), delimited by several levels of two studied archaeological sites, Hundidero and Hotel California. Luminescence dating of quartz grains at the Dating and Radiochemistry Laboratory, Autonomous University of Madrid (Spain), revealed a chronology of 70,556 ± 11,011 a (TL) for the top of Level H4, Hundidero (Navazo et al., 2011). On the other hand, optically stimulated luminescence (OSL) dating results obtained from Hotel California were 48.2 ka ± 3.3 for the most recent level and 71.0 ± 5.6 ka for the base (Arnold et al., 2013).

The Pleistocene settlements in this study area coincided with the formation of terraces T9 (+19–30 m) to T12 (+8–10 m) (Benito-Calvo and Pérez-González, 2007; Moreno et al., 2012; Benito-Calvo and Pérez-González, 2014). They were found in all the geomorphological units in this area, with sites on high ground, associated with sinkholes, on colluvium and river terraces, and also in caves. This diversity reflects the fact that the settlement locations depended on the availability of basic subsistence resources (animals, plants, stone and water), and that the groups adapted their movements to the distribution of these food and subsistence sources.

During the final third of the Upper Pleistocene, the Neanderthal groups in Sierra de Atapuerca lived at an altitude range of 902–1086 m asl, where the climate was less harsh. We documented 15 sites on moors and high ground, 12 on river terraces (some associated with ponds), and 4 on gentle slopes (Fig. 2).

The lithic resources were local. 90% of the Upper Pleistocene open air archaeological sites in Sierra de Atapuerca were on secondary deposits of Neogene flint (Fig. 2).

From the study of the assemblages, we conclude that all sites were visited for short but recurrent periods of time, with the exception of the four sites located on gentle slopes (Fig. 2, VF, PD, SE and DE), which may have had a more stable occupation. Several occupation levels have been identified at the two settlements excavated to date, Hundidero and Hotel California, corroborating the reoccupation of the same sites over thousands of years.

The absence or minimal presence of patina on butts and dorsal faces of the products seems to match the characteristics of the raw material available at these locations. As these were secondary deposits, the flint blocks were already broken down and in many cases lacked a patina. The vast majority of butts were platform and uni-faceted, which seems to be due to the major weight of the initial knapping sequences in these assemblages.

The sites were generally spread over a large area, possibly due to several issues. First, the dynamics of the occupation of sites, with recurrent visits, and secondly, the disturbances of the assemblages
caused by farming. The ploughing experiment in the same area showed that archaeological sites in ploughed areas undergo an increase in their area, a decrease in the density of the archaeological record and a loss of any spatial or stratigraphic relationship.

A pervasive feature of the MIS 3–4 open air settlements in Sierra de Atapuerca is that exploitation in these assemblages focused on manufacturing products which in most cases were not retouched. Most of the items resulting from the exploitation of cores, both flakes and retouched flakes, were small and micro-sized, which cannot be explained by either the large dimensions of the original raw material or exhaustive utilization of the raw material. We define these people as veritable wasters of flint, as the cores were in the early stages of exploitation. Given the abundance of flint in Sierra de Atapuerca, neither the size of the products nor the existence of cores recycled as tools can be explained by a scarcity of raw material (Fig. 5).

In some cases, cores were recycled as tools without any plausible explanation based on a hypothetical shortage of raw material. The reuse, in some case recycling, of items should therefore be explained as an opportunistic strategy at a site that was known to contain reserves of raw material, with the manufacturing task further facilitated if a better item was already there.

Assemblages containing small-size items at settlements in Europe and the Levant have been known and debated for some time (Burdukiewicz and Ronen, 2003), and explained on the basis of factors such as climate, impositions of the raw material, the functions and duration of the occupation, and culture. Climate-based interpretations of this phenomenon suggest that these microindustries occurred in Central Europe during interglacial periods (Valoch, 2003). Evidence of these microindustries in Western Europe dates to 500 ka (Otte, 2003). However, occupations at the open air sites in Sierra de Atapuerca occurred during a glacial phase preceded by a warmer period, MIS 5, when these small-micro-size industries were also present, and were followed by another cold phase (MIS 3), which contains microlithic assemblages with evidence of exhaustive block exploitation, intense recycling and resharpening (Navazo et al., 2011). These data confirm that Spain’s northern tableland was occupied in cold periods, but does not explain the microlithic tendency. Arguments that postulate a relationship between tool size and raw material are based on the absence of large blocks, which is totally inappropriate in the case of the Atapuerca open air sites.

Duration-related explanations suggest that Middle Palaeolithic occupations with microindustries were short-term sites, visited repeatedly by mobile groups who handed down knowledge about them from generation to generation (Moncel, 2003; Navazo et al., 2011). There is evidence that visits to the Atapuerca sites were short-term and repeated in time, reinforcing the plausibility of information being transmitted between generations. However, this detail sheds no light on the tool types and small sizes, perhaps one of the most interesting aspects, as it permits inferences such as the planning of Neanderthal strategies in Sierra de Atapuerca, in the sense of an ability to formulate strategies based on past experience, and act on them in a group context (Soressi, 2005).

In short, we can conclude that the majority of the open air sites documented in Sierra de Atapuerca were short-term settlements where edges were produced and used without retouching in most cases. All of the chosen sites were part of these groups’ cultural landscape, and were visited recurrently. This may provide an explanation for the stockpiled raw materials as places where stone tool manufacturers could leave a stock or reserve of raw material and artefacts, in anticipation of their future requirements. It also lends weight to the idea that Upper Pleistocene hunter—gatherers used Sierra de Atapuerca as a stable area of residence with different locations. The exploitation of a known environment seems to be an...
indication of behaviour with foresight, in which sites are reoccupied in response to varied stages through the territory where they develop their occupation model (depending on the biotopes, seasons and/or topographies) (Moncel et al., 2012). The recurrent occupation of these locations suggests not particularly large territories where consistent strategies were developed over time.

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