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Cover figure: Last mining event at Casa Montero, Madrid (c. 5200 cal BC). Illustration by Juan Álvarez-Cebrián

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Mining tools use in a mining context or how can the expected become unexpected

Xavier TERRADAS, Ignacio CLEMENTE and Juan F. GIBAJA

Abstract

In archaeological research it is common practice to infer the function of prehistoric tools from their typology and the context in which they were recovered. However, analysis of function based on the inspection of macro- and microscopic use-wear evidence is the only way to provide credible support for such inferences. The present work reports data gathered during the use-wear analysis of a sample of antler and stone artefacts found in the Neolithic mine of Casa Montero. These data certify that the antler tool recovered were not mining tools, while the knapped stone tools provide new information regarding activities undertaken in this flint mining context, as well as the taphonomic processes occurring at the site. The proposed uses of these tools indicate human habitation near the site.

Keywords

Mining tools. Antler picks. Lithic production context. Use-wear analysis. Neolithic. Casa Montero.

1. Introduction

In certain archaeological contexts, affirmations are all too often made without having gone through the necessary steps to justify them. Such affirmations are often made with regard to the production contexts of ancient societies. In mining complexes – places specialised in the acquisition of lithic raw materials and the first steps in their transformation into products – the tools found are commonly associated with the specialised tasks of these production processes. However, detailed use-wear analysis of these tools' actual use shows that such associations should not be lightly made. The aims of the present work are to:

- Present the data gathered during the analysis of function of tools recovered from the Neolithic flint mine of Casa Montero. This analysis involved the examination of the macro- and microscopic evidence of the use made of flint and antler tools (i.e. that visible on the surfaces and edges of these instruments). Comparisons were made with experimental reference tools with the goal of obtaining diagnostic data regarding their use, the material worked, and the taphonomic process at work at the site. There have been very few such studies on materials recovered in mining contexts.

- To study the supposed flint and antler mining tools collected following a sampling strategy (which, in the case of the flint tools involved waste materials, blanks and retouched pieces). The results of this work provide evidence to help determine whether the recovered artefacts were mining tools, whether they were used in complementary activities (maintenance and repair), or whether they were used for other purposes.

2. The Casa Montero flint mine

The Casa Montero mining complex is found in Vicálvaro -southeast of the Madrid region-, in the centre of Iberia. It lies on a small plateau at an altitude of some 650m, near the confluence of the Rivers Jarama and Henares. The site was discovered as a result of the archaeological impact assessment of Madrid's M-50 highway belt and has been subject to different phases of excavation between 2003 and 2006 (Consuegra *et al.* 2004; Díaz-del-Río *et al.* 2006, 2008; Capote *et al.* 2008), during which some 4000 vertical shafts were recorded over an area of some 4ha. To date, 324 of these shafts, which are between 1 and 10m deep and nearly 1m wide, have been excavated. The excavation work focused exclusively on the material filling the shafts since no associated work or dwelling areas have been identified. These filling materials include a very large amount (about 65t) of lithic production waste.

The site lies on a small anticline of alternate green clays (illite and smectites) and carbonates (dolomitic marls and

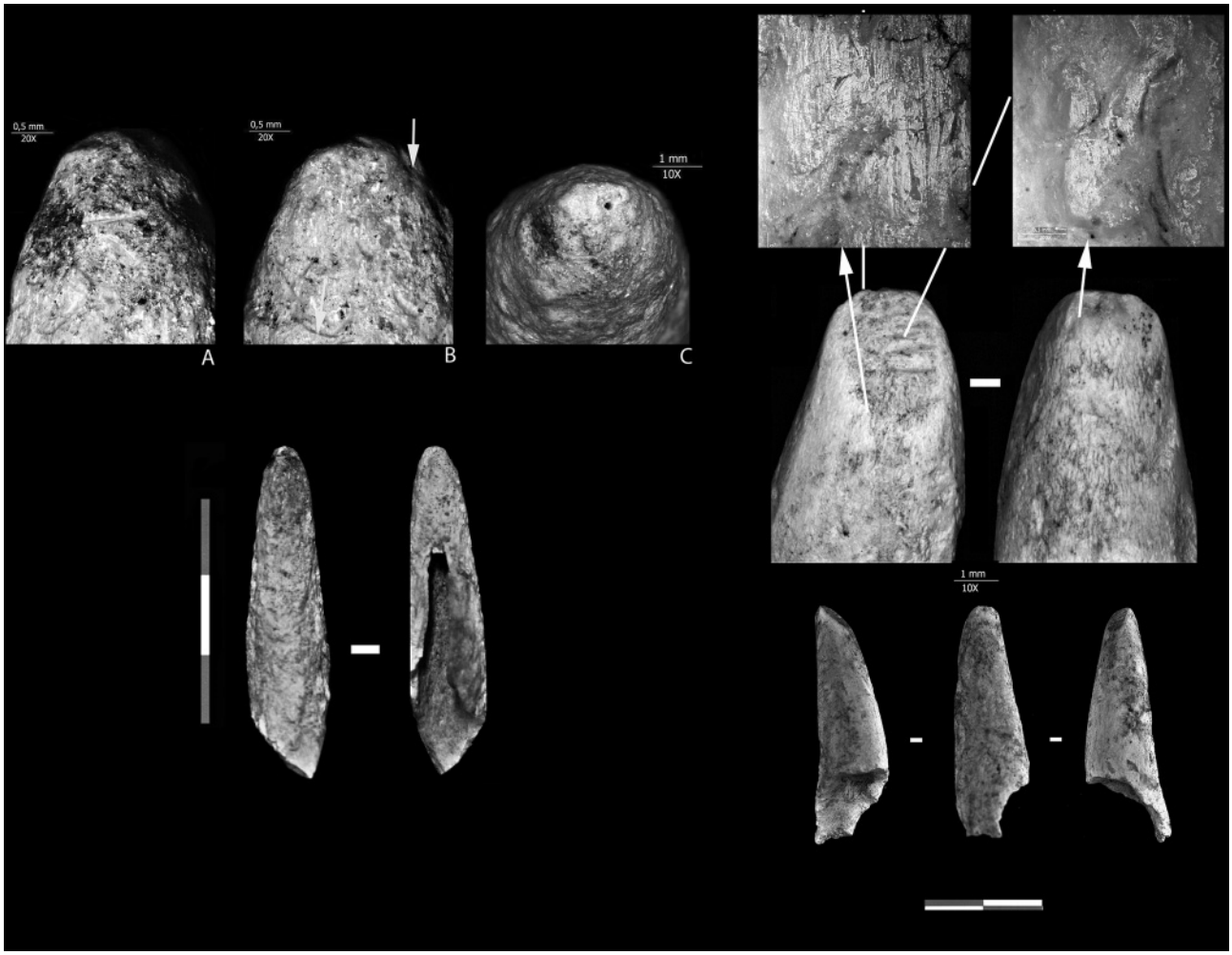

Figure 1. Pieces nº 9562 (left) and 7142 (right) elaborated on antler. The images on the top have been obtained by means of a metallographic microscope (200X).

dolostones), attributable to an intermediate Unit of the Miocene (Bustillo and Pérez-Jiménez 2005). Four flint layers can be seen over this sequence, although the exploitation of this material focused preferentially on obtaining the opaline cherts in the upper layers (Castañeda *et al.* 2008).

Although other stages of exploitation are known, the greater part of the site's mining activity was undertaken over a relatively short period of the early Neolithic (5400–5200 cal BC) (see Díaz-del-Río and Consuegra in this volume); this period is discussed in the present work. Exploitation focused on the digging of mine shafts for the extraction of blocks of flint, the transformation of which was mainly directed towards obtaining cores for the production of blades. Neither the distribution of these raw materials nor of the products made from them is currently known; this is largely the consequence of our not knowing of other, contemporaneous Neolithic sites in the area.

Dating studies (see Díaz-del-Río and Consuegra in this volume) suggest that the Casa de Montero mine was exploited for just a few hundred years during the early Neolithic. The many shafts dug, the fact that they do not overlap, and the lack of any dwelling structures in the area suggest that the mine grew over a series of short, repeated visits linked to obtaining siliceous raw materials and the first stages of its transformation.

3. Antler tools

The material recovered from the Casa Montero mine includes only three fragments of deer antler. Given the finds made in analogous mining contexts, in which different types of antler mining tool were made (Gurina 1976; Boguszewski 1995; Lech 1997; Russell 2000; Bostyn *et al,.* 2005), one might think that those from Casa Montero might also correspond to tools used in the excavation of the mining shafts. However, such a conclusion was in doubt even during the first observations of these materials; indeed, they were finally linked to purposes other than mining (Capote *et al.* 2008; Yravedra *et al.* 2008). Consuegra *et al.* (2004) and Capote *et al.* (2008) indicated that only a study of the evidence of the use of these artefacts could provide valid information regarding their true function.

Reference experimental studies

The majority of experimental investigations into the use of antlers for the digging of mine shafts have been prospective, i.e., preliminary work into the questions posed, the elements involved and their properties (Clemente 1997; Terradas and Clemente 2001; Gibaja 2003). The control of variables has often been scant, but the results obtained, although not definitive, have been useful for laying the ground for future experimental work and determining what variables might be of importance. Two main types of experimental work have been undertaken:

- To determine the efficiency of antler picks and to make estimates regarding the time that would be required to dig out a certain volume of earth. Such was the pioneering work of Lane Fox in 1875 (cited in Russell 2000), which centred on the Neolithic mining galleries of Cissbury (England), and the work undertaken by French researchers on the Neolithic quarries of Plancher-les-Mines (Jeudy *et al.* 1995).

- To determine the working efficiency of antlers on different rocks and sediments. For example, Semenov and Korobkova (cited in Gurina 1976), who worked on the Byelorussian mines of Krasnovo Sela and Karpovtsev, reported antler picks to be more efficient than stone picks for digging galleries in chalk.

Controlled experiments in this context, which have been much fewer in number, have focused on the study and recording of the traces of use left on tools. Such experiments require the design of an experimental program that focuses on specific objectives and hypotheses, a methodology to be followed that identifies the variables to be controlled and the techniques to be used, and the rigorous and systematic recording of the results obtained (Clemente 1997; Terradas and Clemente 2001; Gibaja 2003).

Work of this kind has been undertaken by Maigrot for the Flins-sur-Seine site (Bostyn *et al.* 2005), which followed on from earlier work on the mines of Jablines (Bostyn and Lanchon 1992). Boguszewski (1995) suggested that antlers were not used as picks but as wedges and/or levers, and attributed the splintering of antler material at the point of the cutting tine to such use. Most experimental works use as their reference the picks recovered at Grimes Graves (Russell 2000); these were configured from thick antlers, the crown and the lateral tines being removed, leaving only the basal tine which formed the active digging point.

Bostyn *et al.* (2005) showed that the evidences of use on antler tools fell into two main areas:

- On the trunk of the antler where the tool is held. Here, the wear on the surface can be very extensive and invasive, sometimes occupying the entire gripping area. The location of these evidences is completely different to these documented on the antlers of free-living deer, which is usually seen on the tips of the tines. In fact, the wear seen in experimental work tends to regularise the natural ridges of the antler, and to increase its whiteness. Under the microscope, the surface is seen to acquire a uniform sheen and granular texture. The invasive polishing caused by use is associated with numerous, relatively fine crisscrossed striations, which are organised in a transversal way to the longitudinal axis of the antler.

- On the basal tine, that acts as a pick point. The apex becomes squashed and cracked, causing antler material to splinter and be lost. These removals can become large, reaching 3-5cm in length and 1-1.5cm in width. The experimental use of an antler pick over two hours on limestone led to the loss of 2cm (7g) of material at the active point (Teno and Delgado 2002-2003).

- On the external curvature of the basal tine. Under the microscope, this wear appears as numerous lines orientated along the longitudinal axis of the tine. These striations can be several centimetres long and over 1mm wide, and are encrusted by other, finer striations. Microscopic observation of these striations reveals them to be linear depressions with irregular but clear outlines. In contrast, the striations seen on the antlers of free-living deer are much wider and shorter, and lie obliquely to the longitudinal axis of the tine.

The antler tools of Casa Montero

The post-depositional changes that have occurred at Casa Montero have provoked the degradation of its antler artefacts to the extent that the microscopic analysis of their surfaces is sometimes impossible. Such is the case of the largest antler artefact (nº 5580) which, from its shape, might correspond to a basal tine. An additional problem is the degree of fracturing of some pieces (nº 7142 and 9562), which impedes an understanding of their original size and hinders the reconstruction of the correct use of these tools. However, despite these limitations, the preliminary diagnoses of Capote *et al.* (2008) and Yravedra *et al.* (2008), which indicate these pieces were not picks, is here confirmed.

Given the state of preservation of the antler items from the Casa Montero mine, only two could be examined. Object nº 9562 (Figure 1) was originally described as a pointed object made from antler that showed evidences of hollowing and abrasion along the perimeter of its fractured area (Yravedra *et al.* 2008). Some small scars can be seen along with areas of abrasion parallel to the long axis of this piece of tine. The latter were possibly caused by pressure at the tine point. The artefact looks as though it may have been rubbed down to conform to a circular, pointed shape. The internal spongy bone tissue has been removed, perhaps related to the way the tool was held during use. Although the tool was suggested to be a pressure flaker (Capote *et al.* 2008), it shows none of the characteristic evidences of such instruments. Pressure flakers show numerous traces

along their sides, while the contact area appears as a bevelled edge. In addition, they show deep, wide striations running backwards from the point (Maigrot 2003).

Piece nº 7142 (Figure 1), made from an antler tine, was originally interpreted as a small spatula-chisel, the surface of which was crossed by traces transversal to the long axis of the object, and with slight scarring on the back side (Yravedra *et al.* 2008). Indeed, on the bevelled edge several deep and wide grooves can be seen that invest the piece with a certain roughness and which are clearly functional in nature. This is the active area that made contact with the material worked. The pressure exerted on the tool during its use led to the small scars on its back side. On the edge running along the platform, and in raised areas between the grooves, areas of bright, closed/compact-patterned micropolishing and of rough appearance can be seen. Over this micropolished surface there are a number of striations of different morphology that run perpendicular to the distal border of the bevelled edge. The location and characteristics of all these traces indicate this tool came into contact with a material that was rigid and rather hard. The instrument was used such that the bevelled edge would lift a fine layer of the material being worked, and the raised areas would wear down the surface of the cut material like a file. The optical characteristics of the micropolished surface suggest the tool may have been used on a woody material.

The entire tool is impregnated with a red pigment. This is characteristic of pieces representing the antler industry at Casa Montero (Yravedra *et al.* 2008), although its function remains unknown.

4. Knapped stone tools

Sampling strategy and conservation of collected lithic material

The study of the function of knapped stone tools in the context of the Casa Montero mine presents challenges for two reasons. Firstly, the number of items recovered is huge (more than 65t have been collected), and secondly, the context of the site is one of production, in which the great majority of items found are lithic wastes with no use at all. Clearly, the microscopic analysis of the surfaces and edges of these artefacts obliges a reduced number of samples be studied. Thus, in the present work, representative sampling of the material was necessary, both from a qualitative and quantitative point of view. A total of 221 pieces were finally examined. The selection criteria outlined below were followed:

- Shafts located in grid squares B4, D3, D5 and G3 (Capote *et al.* 2008; Díaz-del-Río *et al.* 2008) were selected for general sampling; this allowed for a good spatial representation of the excavated area.

- All the retouched materials gathered in these grid squares were examined to determine whether the transformation of their edges might be related to their use.

- Unretouched flakes and blades with sharp edges from shafts located in grid squares B1, B3, B4, D1, D2 and E4 were examined; such objects are sometimes associated with specific activities such as the cutting of meat, skins or vegetables.

- Special attention was paid to certain stone tools, such as a number of picks showing modifications at their apices, and blades with shiny edges perhaps used as sickles.

- No remains with surface patinas nor which showed scaring along their perimeters were examined.

- Finally, all objects under 3cm in length were excluded from analysis.

The selected pieces were subjected to a preliminary examination with the aim of detecting organic and inorganic residues adhered to their surfaces. The pieces with no such residues were then cleaned with a soapy solution. All the remains were examined under a binocular microscope (10-90X) and metalographic microscope (50-400X).

The number of pieces showing evidence of use was relatively small (n=40), perhaps due to:

- The lithic production context of the samples (Terradas 2002); it is to be expected that the majority of items should be wastes produced by the mining and initial transformation of the raw material.

- The abundance of raw material. This might have led to the use of tools in an expedient and opportunistic manner; the necessary conditions for leaving evidences of use may not often have arisen.

- The very large number of altered remains; many of the collected pieces could not be adequately examined.

The macro- and microscopic analysis of the recovered lithic material showed it to have suffered different natural and man-made alterations, hindering its use-wear analysis. For example:

- Many of the recovered items had a white patina on their surfaces making it difficult to identify the micropolishing produced by the working of any material.

- All the recovered items showed strong soil sheen, both in the raised and lower parts of their microtopograhy (Figure 2). This prevented the inspection of some micropolishings, especially those produced via contact with soft materials (meat, fresh skin and fish) as well as those still in their initial stages but produced via contact with harder materials.

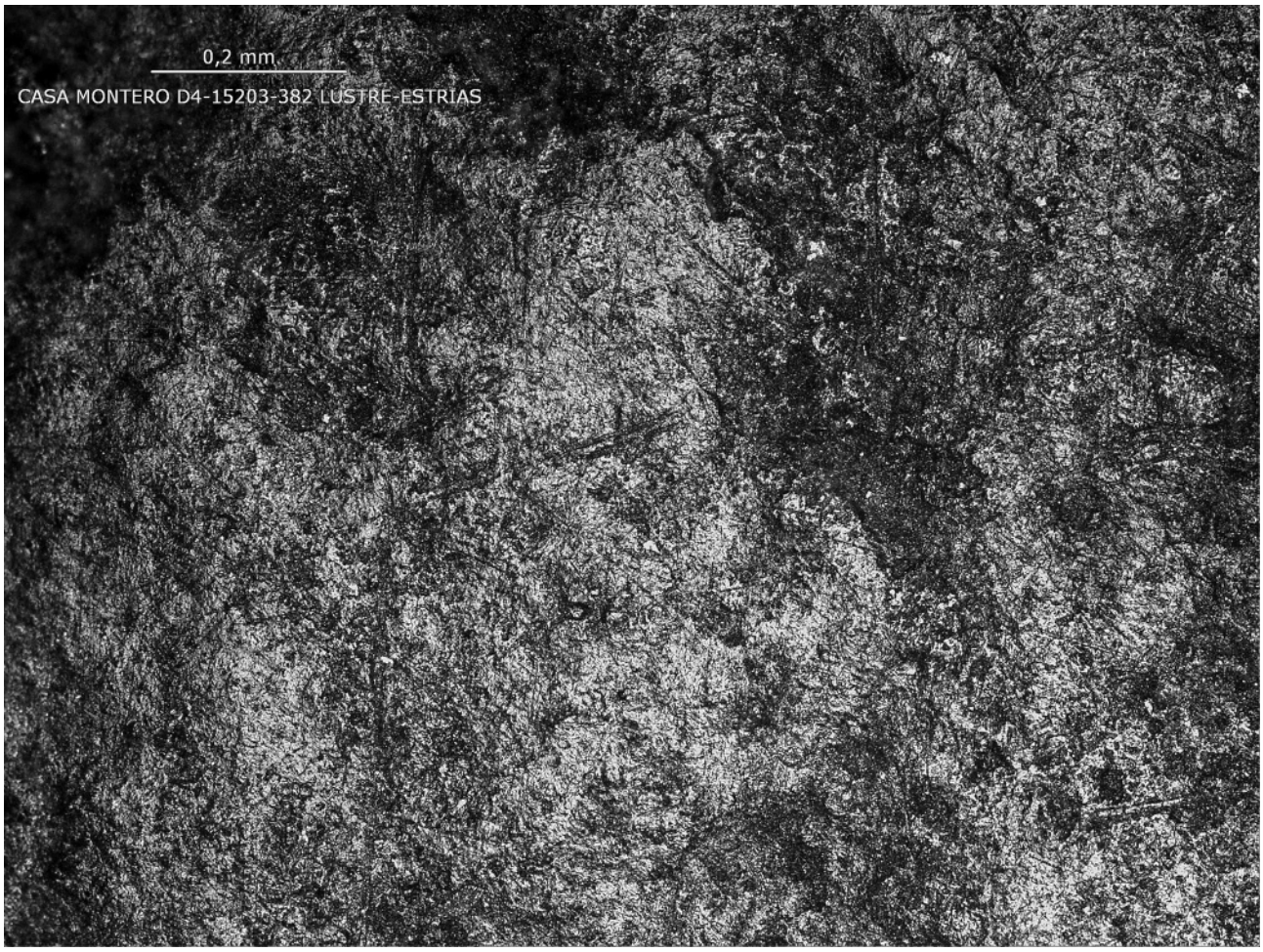

Figure 2. Microscopic evidences of soil sheen and striations chaotically arranged on the surface of a flint flake.

- Some pieces showed characteristic evidences of thermal alterations (cracking, scales, gloss,); however, in no case could this be associated with any intentional heating.

- A considerable number of items showed evidence of mechanical alteration, the consequence of the taphonomic processes to which they were subjected during their knapping, accumulation and eventual discarding in the shafts. Some pieces showed scars of variable size along their edges, abundant striations with no apparent organisation, or compact, flat polished plaques (known as 'G-polished plaques'), characteristic of rubbing between stone objects.

Another problem was the scant development of any trace of use on the majority of the tools examined, a consequence of their being used for little time. This is coherent within the context of Casa Montero where the abundant availability of raw materials made it unnecessary to use tools until they were no longer usable (Russell 2000; Terradas 2002). This poor evidence of traces made it difficult to identity the materials worked with the tools.

Together, these problems explain the large number of pieces that could not be analysed, the scarcity of used tools, and the impossibility of identifying the materials worked by many used tools.

Use-wear analysis

Of the 221 pieces selected for analysis, only 40 (18%) showed possible evidences of use. Forty two (19%) were unused and 139 (63%) were un-analysable owing to the alterations they had suffered. Twenty (50%) of the used tools provided insufficient evidence for the materials they worked to be clearly identified. However, the types of activity performed with all 40 of these instruments were discernable.

- The tools used on soft material were employed in cutting actions. These pieces were blades over 50mm in length with sharp, unretouched edges (20-30º). These morphological features are similar to those of tools used in butchering.

- The tools used with harder materials were for scraping. The majority of these tools were retouched flakes (scrapers and side-scrapers) with obtuse edges (40-80º), and were of considerable size (60-130mm). These features confer great effectiveness for the transformation of hard materials.

The type of material worked and the mode of use was discernible for the 20 best lithic remains. Special attention is paid to types of instrument, picks and sickles, owing to their singularity and clear traces of use preserved. It is difficult, however, to reach firm interpretations or establish proposals based on such a small number of items; this paper therefore dares provide only more general contributions regarding the processing of the materials worked.

The processing of animal materials

Seven tools showed evidences of the processing of different animal materials; four with butchering, and three with the scraping of hard animal parts.

The butchering tools were a flake and three blades with very sharp, unretouched edges (20-50º) – very effective for this type of work. Their function was discerned from the presence of small scars associated with open-patterned polishings and compact micropolished spots, possibly arising through contact with bone while butchering.

The scraping of hard materials –bone or antler– was performed with a blade (88x29x15mm), the distal right side of which showed semi-abrupt retouching associated with very compact micropolished spots. Given the length of the used area (some 50mm) this tool may have been used for very little time in some activity related to the sharpening or repair of another bone/antler tool.

Two flakes were used to scrape a semi-hard material, probably bone/antler but perhaps wood. These pieces, whose use-wear analysis suggests they were used for only a short period of time, are very different in size (74x63x30 and 35x25x8mm).

The processing of plant materials

Seven tools were found that were used to work wood, as well as another for cutting plants, along with two sickles or blades used for harvesting cereals. None of these pieces showed well developed evidences of use; they were probably used for only a short period after their manufacture. Of these seven tools, five were used to scrape, one to cut and one for cutting and scraping. The tools used to scrape were all retouched flakes (three side-scrapers, one scraper and one denticulate flake) and were probably very effective given their edge angle (70-90º), the length of the active area (over 20mm but reaching 70mm in one case), and their large size. The cutting tool was a blade 79mm in length, with an unretouched active area. With its 40º cutting edge angle the tool would be ideal for this function. The blade used to simultaneously cut and scrape was fragmented and had been slightly modified by abrupt retouching, thus adapting it to the scraping activity it was to perform.

It is likely that these types of instrument were used in the repair and maintenance of mining tools made of wood. Other authors have made similar proposals when examining side-scrapers or denticulate or notched tools from mining contexts in England and Italy. However, their hypotheses were not confirmed by use-wear analysis (Russell 2000; Galiberti *et al.* 2001).

Sickles

During the preliminary examination of the collected material, two blades showing a harvesting gloss similar to that generated by the cutting of cereals were noticed. This function was confirmed by use-wear analysis.

- One of these sickles (70x25x5mm) showed a modification to its distal curvature via abrupt retouching. One of its edges showed a well developed harvest micropolishing with striations, probably caused by abrasive soil particles. This suggests that cutting was performed close to the ground in order to harvest the grain and the stalk together. Over time the edge became dull and was re-sharpened. The distribution of the polishing shows that the blade was inserted diagonally into the handle.

- The extremes of the other sickle (42x10x3mm) were modified by abrupt retouching to produce a rather straight blank probably designed to facilitate the tool's setting in a handle. This sickle was also used over a long period and close to the ground. The distribution of the polishing on the blade surface indicates that it was inserted diagonally into its handle. The presence of remains of ochre indicates the possible use of this mineral in the resin that fixed the tool to the handle (Figure 3).

The finding of these sickles suggests that the group that exploited the mine practiced agriculture, despite the lack of evidence of any dwelling areas. The use of local flint for the manufacture of the sickles, the abundance of raw material (which would obviate the need to bring tools from elsewhere), and the fact that these sickles seem not to have been used in other activities, suggests there were cultivated fields in the vicinity of the mine.

As part of a wider research project (Ibáñez *et al.* 2008), we have compared the sickles of Casa Montero with those from other contemporaneous contexts in the Iberian Peninsula and southern France. The present sickles are intermediate between those from Andalusia and the Levant (made from blade fragments or flakes set diagonally and in-line into the handle to form a toothed instrument) and those of the Peninsular northeast and southern France (whole blades or fragments of blades arranged parallel to the handle).

The Casa Montero sickles are similar to those from La Draga (Banyoles, Girona) and Revilla del Campo and La Lámpara sites (Ambrona, Soria) (Gibaja 2008), all of

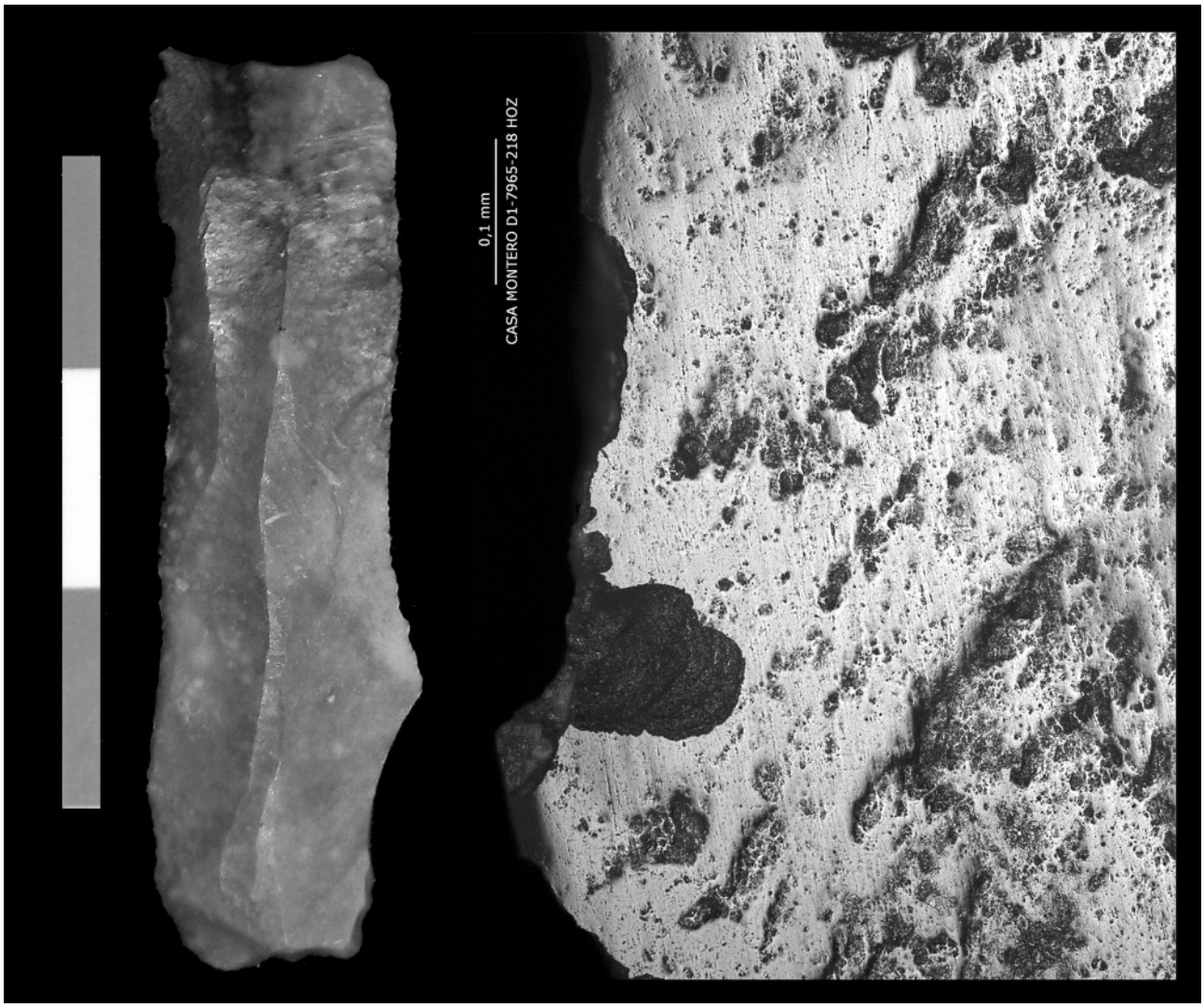

Figure 3. Blade used as a sickle where remains of ochre can be observed. Detail (100X) of polishing developed from its use for harvesting cereal.

which are early Neolithic and made from a single flint blade set diagonally into the handle.

Mining picks

Five pieces were examined that showed evidences of having been used as mining picks. These were pointed flakes about 150mm long, obtained during the first stages of the exploitation of flint cores. Use-wear analysis confirmed three had been used in mining activities.

- Item UE134-135-431 showed numerous longitudinal striations at its distal end, as well as compact-patterned polished plaques. These evidences of use gradually disappear away from the active area, and are practically absent at the centre of the tool. However, some areas the edges of the central and proximal areas also showed striations, chaotically arranged, and perhaps linked to the tool's hafting (Figure 4).

- Item UE113-249 is very similar to the above piece, showing modifications in the distal area caused by use. These include compact, smooth polished plaques with numerous longitudinal striations. These polished plaques might be related to contact with other stone elements.

- Item UE9623-E4-694 is a crested blade of notable smaller size (90x31x16mm). The traces of use it shows are less developed but are of the same type as those above: very compact polished plaques associated with striations and hinged or abruptly ended scars that suggest the apical area was subject to percussion.

Given the light, relatively fragile nature of these tools, which show no clear evidence of having been set in handles, and the absence of the fractured, rounded and abraded areas typical of violent percussion, they may have not have been used as picks in the strict sense. Rather, they may have been tools (employed for only a short period) for use with clayey sediments, but which from time to time came into non-violent contact with harder rock. Given the diversity of lithologies recorded at the Casa Montero context (Bustillo and Pérez-Jiménez 2005; Bustillo *et al.* 2009) and the diversity of mining tools recovered (Capote *et al.*

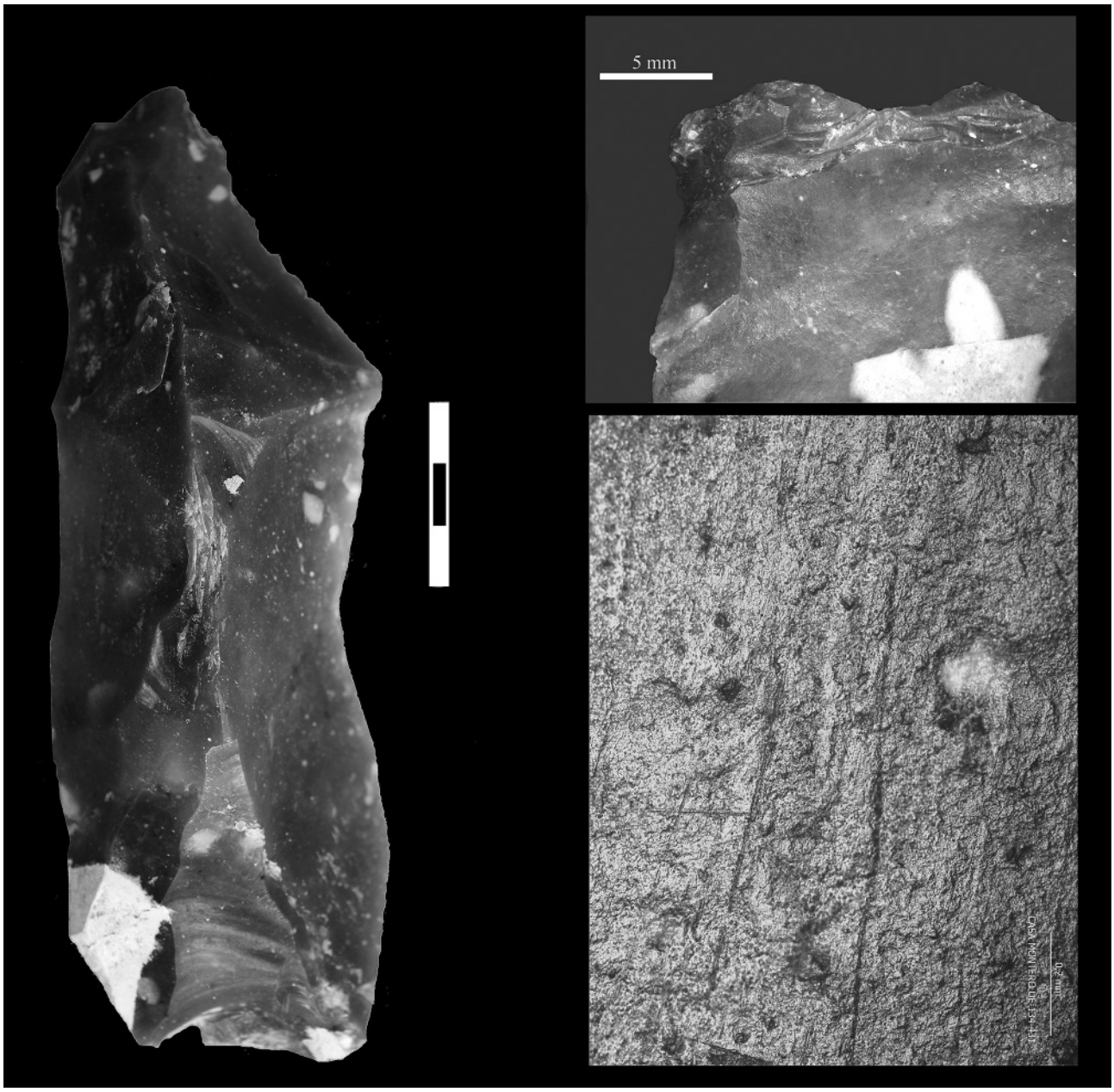

Figure 4. Pointed flake used as a mining tool with distal hinged or abruptly ended scars related to percussion, and detail of a compact-patterned polished plaque with longitudinal striations (100X).

2008; see also Capote in this volume), they may have been used in the extraction of flint blocks (to unseat them) for later fracturing with hammers and mallets, or for freeing them from their clay matrix following their fracturing.

5. Conclusion

The function of the antler and stone tools from Casa Montero is very difficult to analyse. This, plus the mining context of the site and the limited number of tools recovered, limits the making of any interpretations. Paradoxically, the majority of the supposed mining tools recovered show no evidence at all of having been used in the extraction of flint. Such is the case of the antler tools, which cannot be interpreted as picks, unlike those found in other mining contexts in France, the United Kingdom or Poland where such tools were profusely used. This might be related to the geology of the Casa Montero mine, where flint layers are found between others of clay and carbonates, quite unlike that of other European mining sites which usually have a limestone setting. In further support of the present results, at the Italian mine of Defensola, which has a calcareous setting, no antler mining tools have been found either (Galiberti 2005).

The antler tools recovered at Casa Montero cannot even be linked to mining-associated activities such as knapping; they were used neither as pressure flakers nor retouching

tools. The situation is similar for the stone tools recovered; only the flint picks had an undoubted mining function. However, these tools cannot really be considered picks or wedges; without handles, they appear to have been used in the extraction of the raw flint material from its background matrix.

Some tools seem to have been used in activities complementary to mining, such as the working of wood and the repair and maintenance of wooden tools (stakes, levers, handles etc.).

Clearly, the mining tools used at Casa Montero show great diversity (Consuegra *et al.* 2004; Capote *et al.* 2008), including mallets and hammers made mainly from quartzite (see Capote in this volume), the flint tools described in the present work, and wooden stakes (detected via their imprints left on the clay walls of the mine shafts). The association between the diversity of lithologies and mining tools in Casa Montero suggests the specialisation of mining tools according to the nature of the matrix to be excavated (clays, carbonates, flint). This hypothesis, however, needs to be rigorously tested by means of experimental works and use-wear analyses. In this respect, future work should include the examination of the imprints conserved in the walls of the mine shafts. Silicon casts have been made of some of these imprints, which should allow virtual microscopic examinations of the supposed wooden stakes.

Finally, the analysis of function of some items showed that subsistence activities suggestive of habitation were undertaken at the site, such as the harvesting of cereals or butchering. Bone rings have also been found in the past (Yravedra *et al.* 2008). Although no evidence of habitation has been found in the immediate vicinity of Casa Montero, these data show there must have been a settlement close by, or that small groups travelled to the area and stayed for short periods while they extracted flint in order to produce cores for their ulterior transformation into blades.

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