Use wear analysis of quartzite lithic implements from the Middle Palaeolithic site of Lagoa do Bando (Central Portugal)

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Abstract:

The Middle Palaeolithic site of Lagoa do Bando is an open air site in a lacustrian context located at 570 m a.s.l. in the municipality of Mação in the center of Portugal. The site was discovered in 2011, during an emergency excavation, and resulted on the recovery of a Middle Palaeolithic lithic assemblage mainly composed of fine grained quartzite implements of expedient, discoid and Levallois technology. Use wear analysis was conducted on 41 artifacts formed through discoid and Levallois technology. Twenty one of these artifacts revealed use wear traces. Ten of them show traces of wood work, five have traces of butchering activities, three present traces of meat processing and two present undetermined traces. The site is located at an atypically high elevation for an open air site and there is evidence of a high rate of woodworking activity, rare in the Middle Palaeolithic occupations. The woodworking activities are possibly linked to the exploitation of woody local resources (maybe for the construction of hunting blinds) and not only with to the manufacture and maintenance of spears and shafts. These results converge with the interpretation of this site as a temporary hunting site integrated in a complex pattern of occupation of the area between the river valleys and the top of low mountains.

Keywords: Middle Palaeolithic; quartzite; use-wear analysis; Central Portugal; Neanderthal behaviour

1. Introduction

The work addresses the use wear analysis of a sample of quartzite implements from the lacustrian open air site of Lagoa do Bando. The site is located on the top of a small mountain (570 m a.s.l.) of the metamorphic complex in the middle Tagus region (Central Portugal) (see Figure 1). So far, there is no absolute dating for the site, nevertheless the techno-typological

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study allows the interpretation of the site as a result of a Middle Palaeolithic occupation. This interpretation is reinforced by the comparison of the Lagoa do Bando lithic assemblage with the main sites of this period identified in the Middle Tagus region. The detailed descriptions of these sites will be offered, below, to serve as a baseline for comparison with the Lagoa do Bando assemblage.

The Middle Palaeolithic occupation of this region is represented by open air sites located on the fluvial terraces of the valleys of small rivers and streams, tributary of the Tagus River, being part of its sedimentary basin. Respectively from east to west, Foz do Enxarrique (Cardoso 1993; Brugal & Raposo 1999; Raposo *et al.* 1985; Zilhão 2006), Vilas Ruivas (GEPP 1983; 1995; Toscano *et al.* 1999; Zilhão 1992; 2001), Ribeira da Ponte da Pedra (Graziano 2013), Santa Cita (Bicho & Ferring 2001; Lussu 2001; Pedergnana 2011) and Estrada do Prado (Chácon & Raposo 2001; Mateus 1984) (see Figure 2) are the excavated open air reference sites. The occupation of caves is recorded in the limestone border in Caldeirão cave (Davis 2002; Zilhão 1993; 1997; 2006), and Oliveira Cave (Angelucci & Zilhão 2009; Marks *et al.* 2001; Richter *et al.* 2014; Trinkaus *et al.* 2007; Willman *et al.* 2012; Zilhão *et al.* 2010) (see Figure 2).

The open air site of Foz do Enxarrique is located on the right bank of the Tagus River at the mouth of the Enxarrique stream. Excavations in the fluvial deposits revealed a single archaeological level with a very rich lithic assemblage associated with bones and teeth of large mammals. The lithic implements are characterized by numerous discoid and Levallois recurrent centripetal cores. There is a high incidence of Levallois products, mainly flakes, but also some points and blades. Entire reduction sequences are represented in the site, evidencing the exploitation of local raw materials represented by quartzite and quartz. Retouched tools are mainly notches and denticulates and side scrapers are rare. (Brugal & Raposo 1999). Preliminary use wear analyses indicate a considerable utilization of many types of flakes, including both Levallois and non Levallois flakes (Pereira 1993). The faunal assemblage includes red deer and horse, together with some remains of aurochs and elephant, rabbit, fox, hyena, rhinoceros, birds and fish and some mollusc shells (Brugal & Raposo 1999).

The particular importance of Vila Ruivas site results from the two preserved, curved structures which might represent the bases of wind-breaks protecting fire structures as suggested by the accumulation of thermoclast elements. Four circular structures have been interpreted as post holes. Following L. Binford's ethno-archaeological model, J. Zilhão considers the hypothesis of a hunters' camp, and he interprets the two curved structures as "hunting blinds" (Zilhão 2001). The lithic industry includes Levallois and discoid cores, knapping products and some retouched tools, such as scrapers and denticulates (Cardoso 2006).

Located on a slope on the left blank of the Atalaia stream, a tributary of the Tagus, the open air site of Ribeira da Ponte da Pedra contains Lower, Middle and Upper Palaeolithic lithic artifacts, and an Upper Palaeolithic hearth (Cura 2014). A total of 442 Middle Palaeolithic artifacts were found in the top of the sedimentary sequence of the T5 Tagus fluvial terrace, the majority in quartzite and very residually in quartz. The assemblage is mainly composed of simple flakes, together with predetermined Levallois and discoid flakes, worked pebbles, cores and retouched flakes (Graziano 2001).

The open air site of Santa Cita is associated with a low terrace on the right bank of the River Nabão, near the mouth of the tributary Bezelga. The archaeological works published in Lussu 2001 revealed the existence of two Mousterian levels. The raw materials include quartz, quartzite and flint. Levallois and centripetal methods are present. The presence of tools is not mentioned in this study.

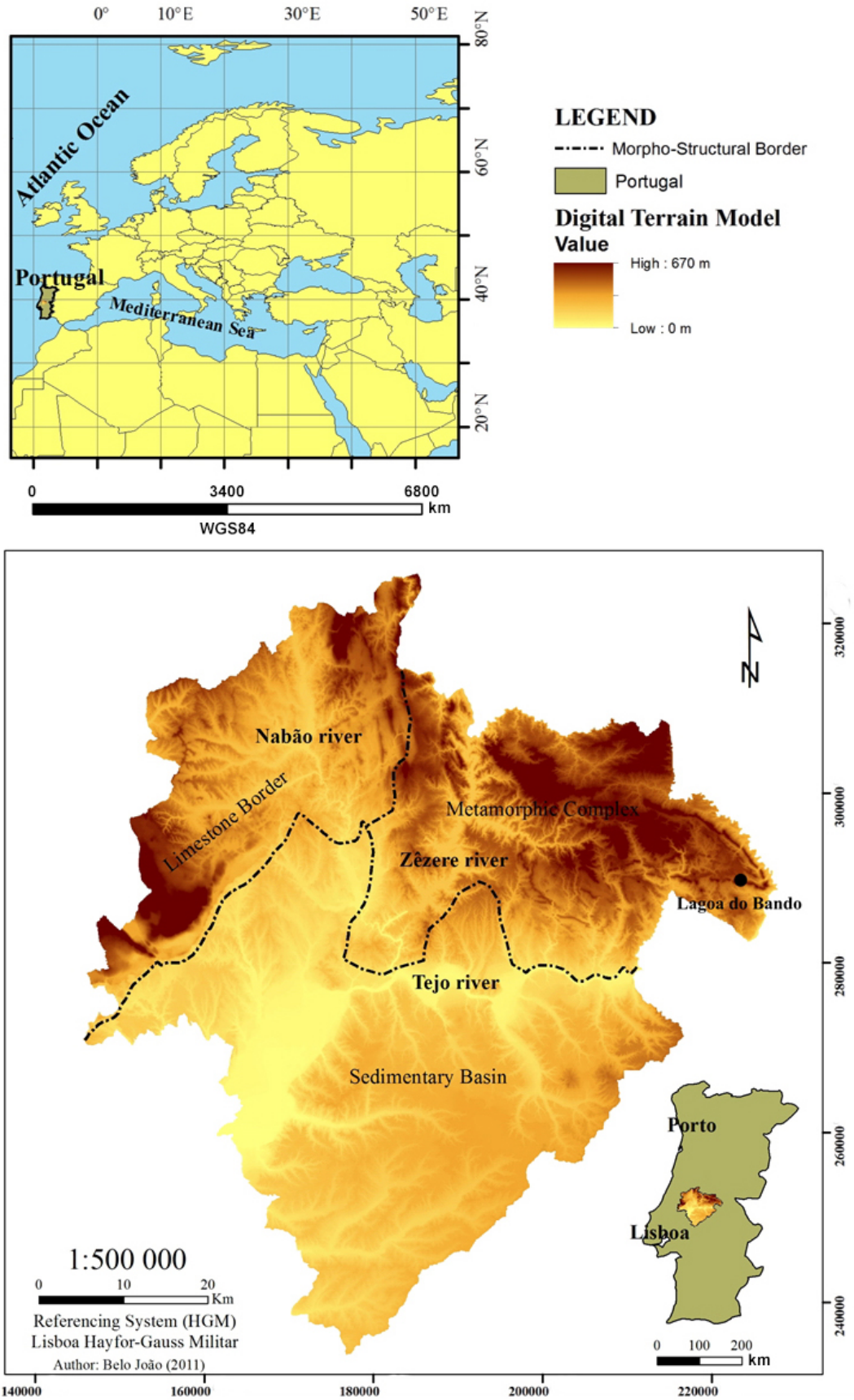

Figure 1. Geographic localization of the site in the Middle Tagus region (Referencing System HGM; Lisboa Hay for-Gauss Militar. (Created by Belo João, 2011.) (Cartographic basis: Carta Militar de Portugal (série M888), 1:25000, Instituto Geográfico do Exército, (digital format); Carta Geológica de Portugal, 1:500,000, 5a Edição, S.G.P., (digital format).) Referencing system (HGM) Lisboa Hayfor-Gauss Militar.

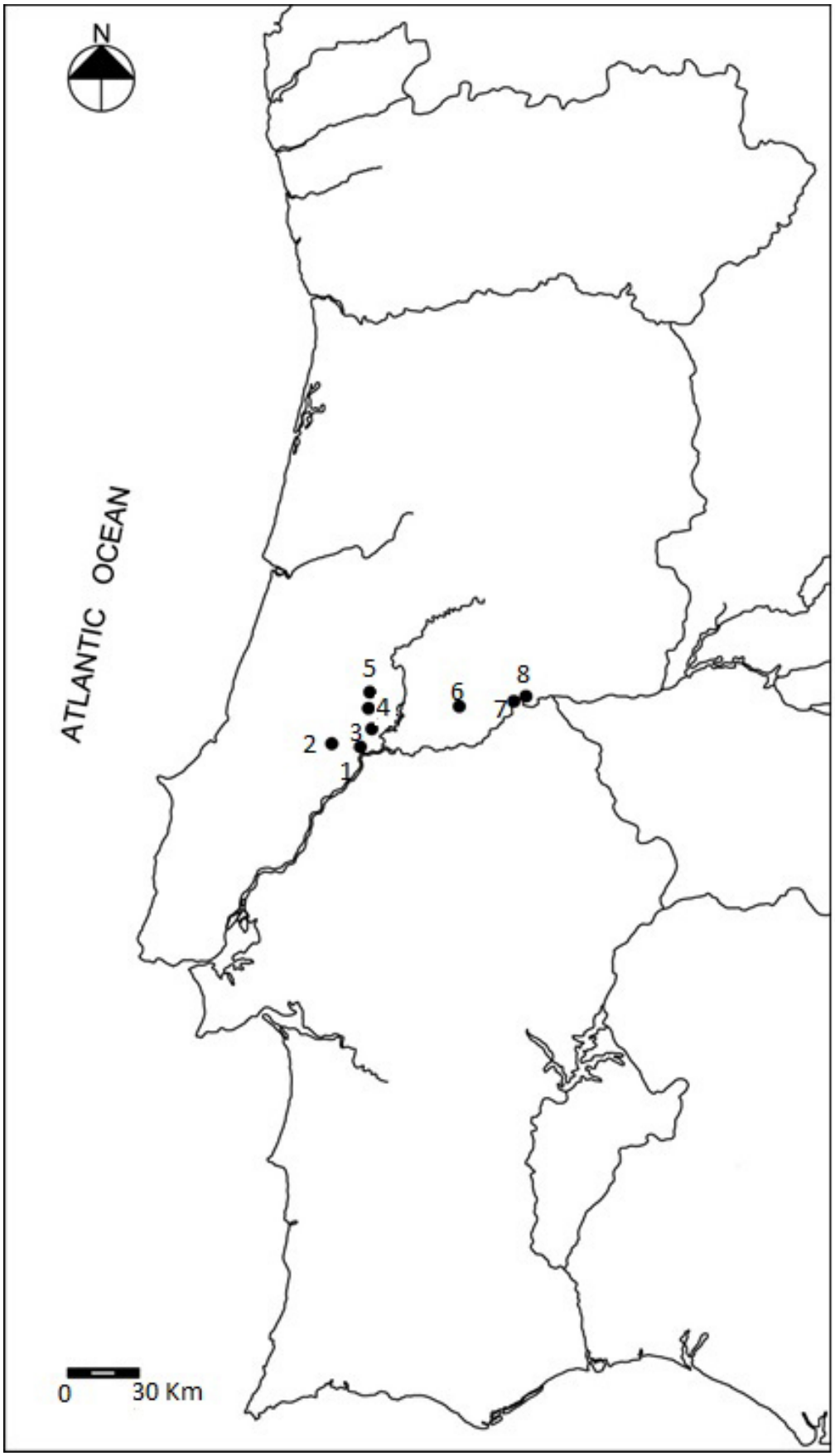

Figure 2. Location of the Middle Palaeolithic sites mentioned in the text. 1. Ribeira da Ponte da Pedra; 2. Gruta da Oliveira; 3. Santa Cita; 4. Gruta do Caldeirão; 5. Estrada do Prado; 6. Lagoa do Bando; 7. Vilas Ruivas; 8. Foz do Enxarrique (modified from Cardoso, 2006).

A more recent study on these materials points to the absence of Levallois, presence of discoid products and cores and abundant undifferentiated cores (Pedergnana 2011). The work led by Nuno Bicho (Bicho & Ferring 2001) also indicates the presence of two levels but points to different conclusions. According to this author the older level indicates a more intensive occupation associated with a possible structure consisting of 5 post holes describing a trapezoidal circuit. This work mentions the application of discoid method and more rarely Levallois, especially on flint, this being heavily exploited. Scrapers, denticulates and notches were identified amongst other items.

Located in a middle terrace of the Nabão River the open air site of Estrada do Prado resulted in the excavation of 2932 artifacts in quartzite, quartz, shale, sandstone and flint. Despite the importance of the site only a preliminary report has been published (Mateus 1984) and only the flint implements have been studied in detail. This study shows the application of Levallois and centripetal methods. Cores were highly exploited and blanks show a high incidence of transformation into tools such as scrapers (Chacon & Raposo 2001).

The Middle Palaeolithic sequence of the Caldeirão cave has been identified, approximately 1 m deep (Levels N to L). Few artifacts have been recovered from all the levels and these are mixed with numerous remains of carnivores. Level K revealed the presence of some Levallois implements in association with many bone remains, suggesting a natural accumulation, possibly due to hyena activity (Cardoso 2006).

The Gruta da Oliveira is a collapsed entrance of the multilevel karstic system associated with the spring of a tributary of the Tagus, the Almonda River. The site contains a Middle Palaeolithic sequence excavated to a depth of around 7 m. The preliminary study of lithics coming from layers 8-9 present an industry of mostly quartzite, followed by flint and quartz. Both layers held Levallois products and the number of tools is low, mainly notches, denticulates and irregularly retouched implements. Authors mention that in levels 10-14 there are backed microliths associated with some prismatic and pyramidal blade and bladelet cores, together with discoidal, Levallois and Kombewa flake production schemes (Marks *et al.* 2001). Faunal assemblages include red deer, ibex, horse, aurochs, rhino and tortoise: large carnivores are rare and the presence of hyenas is attested in some layers by coprolites (Angelucci & Zilhão 2009).

Middle Palaeolithic human remains from layers 9, 10, 17, 18, 19 and 22 consist of a proximal manual phalanx, an ulna, a partial postcanine tooth, a humeral diaphysis, a distal mandibular molar, and a mandibular premolar (Trinkaus & Zilhão 2007; Willman *et al.* 2012).

The lithic raw material procurement systems of these sites are overwhelmingly based on the exploitation of local resources mainly quartzite and quartz, even in areas where flint is available within a short distance (Zilhão 2001). The composition of the faunal assemblages also suggests the exploitation of the immediate environment (Zilhão 2001). Analyzing the Middle Palaeolithic settlement of Portugal, in 2001, Zilhão pointed out that while “small, temporary, highly specialized sites located in mountainous country are well known in the Upper Palaeolithic, such types of occupation are totally unknown in the Middle Palaeolithic” (Zilhão 2001: 606). Despite the fact that further research is required, Lagoa do Bando high location seems to reveal a different pattern of settlement than the one “of a residential mobility inside relatively small territories” (Zilhão 2001: 606).

The chronological data currently available for the Middle Palaeolhitic of this region indicates the occupation of the open air site of Ribeira da Ponte da Pedra as the earliest one. The ESR age 80 ±9 ka for sediments holding Middle Palaeolithic artifacts confirms its attribution to MIS 5 (Rosina *et al.* 2014). Also attributable to the MIS 5 is the Mousterian Cone considered to be the exposure of the basal levels of Oliveira cave which is U-Th dated between 80,400 BP and 46,800 BP (Richter 2014). Oliveira Cave presents the largest number

of dates for the Middle Palaeolithic of the middle Tagus region: 14C-AMS dating of burnt bones of level 9 are between 45,955 BP and 43,555 BP and level 11 point between 48,934 BP and 44,335 BP, charcoals from level 13 have been dated by the same method from 44,391 BP to 42,891 BP, also with the same method charcoals from level 14 point 49,861 BP to 42,912 BP and level 15 from 42,774 BP to 41,667 BP, a burnt bone from level 18 still with the same method is dated between 42,503 BP to 41,387 BP and recent TL datings of heated flint are between 59.6 ±12.1 ka and 52.1 ±11.6 ka for layer 13 and from 79.2 ±20.5 ka to 75.1 ±14.8 ka for layer 14 (Richter *et al.* 2014). Also of this MIS 4 is the open air site of Vilas Ruivas with TL dates of ca. 68 ka ago and ca. 51 ka ago (Zilhão 2001). The late MIS 3 human occupation is testified by the open air site of Foz do Enxarrique U-Th dated between 32,938 ±1005 BP and 34,093 ±920 BP (Raposo & Cardoso 1998) and more recently by OSL to between 38.5 ±1.6 ka and 31.6 ±1.3 ka (Cunha *et al.* 2008). The Oliveira cave burnt bone of level 8 is dated by 14C-AMS to between 38,552 BP to 36,835 BP and by U-Th from 40,580 BP to 35,770 BP (Richter 2014). The Middle Palaeolithic sequence of Gruta do Caldeirão presents a radiocarbon date of 27,600 ±600 BP (Raposo & Cardoso 1998). However this date has been questioned and according to Zilhão the date cannot be considered much earlier than ca. 35 ka cal. BP (Cardoso 2006).

1.1. The Lagoa do Bando site and its regional setting

The Mação region, where the site is located, is geologically characterized by the contrast between the Tagus sedimentary basin in the extreme south and east and the ancient Hesperian massif on the north and west. This distinction is visible, not only in the lithologic characteristics of each complex, but also in the relief. To the north there are formations like Bando dos Santos reaching 640 m a.s.l. which are among the highest reliefs in Middle Tagus region. Lagoa do Bando is located on these reliefs and according to the geological map of Portugal (28-A, Mação) belongs to the quartzitic complex of the Bando dos Santos formation (Romão 2000) (see Figure 3).

From a geomorphologic point of view the site corresponds to a unique context of Palaeolithic human occupation of the middle Tagus, since it is located on a lacustrian environment on a significantly elevated hill while considering the relief of this region. Its context is in contrast with the known Middle Palaeolithic evidence found in fluvial terraces and caves indicating a diverse territorial exploitation that conjugates different geomorphologic settings and resources.

The stratigraphy observed in the several machine excavated trenches and in the open-area excavation corresponds to a typical lacustrian sequence mainly composed of clays and very fine sands. The archaeological works (mechanical trenches and excavation) revealed a stratigraphic uniformity in the number of layers and in their respective topography in all 6 mechanical trenches and open area excavation (see Figure 4).

1.2. The lithic assemblage

The lithic assemblage is composed of 368 artifacts, coming from two layers (B* and P: Layer B* is not represented in Figure 4 because it was identified in another trench, nevertheless it is very similar to Layer B, instead of orange is dark orange. Further sedimentological analysis will clear if it’s the same layer), mainly in fine and very fine quartzite and residually in quartz and flint. While being minimal, the presence of flint, represented by 3 flakes and 1 debris, indicates an extensive territorial occupation since this raw material is only found in the limestone massif, several tens of kilometres to the west of the site (Figure 1). The very fine dark blue quartzite (the most used raw material) is found in primary context and angular fragments in the valleys of small streams around 10 km down the

hill and in secondary context in Pleistocene conglomerate deposits, in the form of pebbles. The quartzites near the site are of poor quality for knapping activities and were not used. The surveys carried out to find the possible sources of the utilized quartzite showed that they are very difficult to find, thus proving a deep knowledge of the territory by the human communities that occupied this region during Middle Palaeolithic.

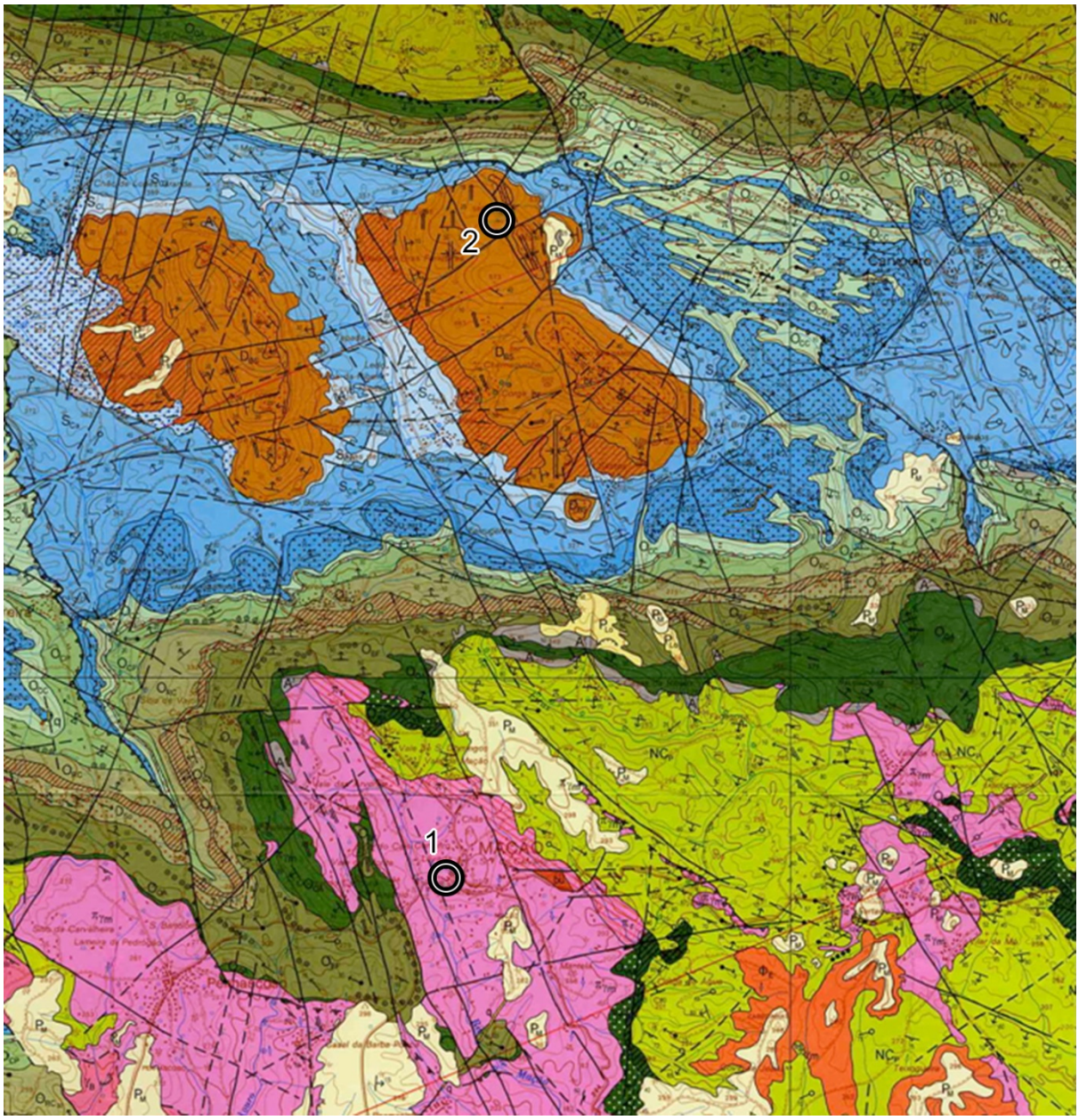

Figure 3. Localization of the site in the geologic map of Portugal. 1 - Village of Mação; 2 - Lagoa do Bando.

The assemblage, composed of cores and flakes, represents the techno-functional choice for 3 different methods of débitage: expedient, discoidal and Levallois (see Table 1 and Figures 5 and 6).

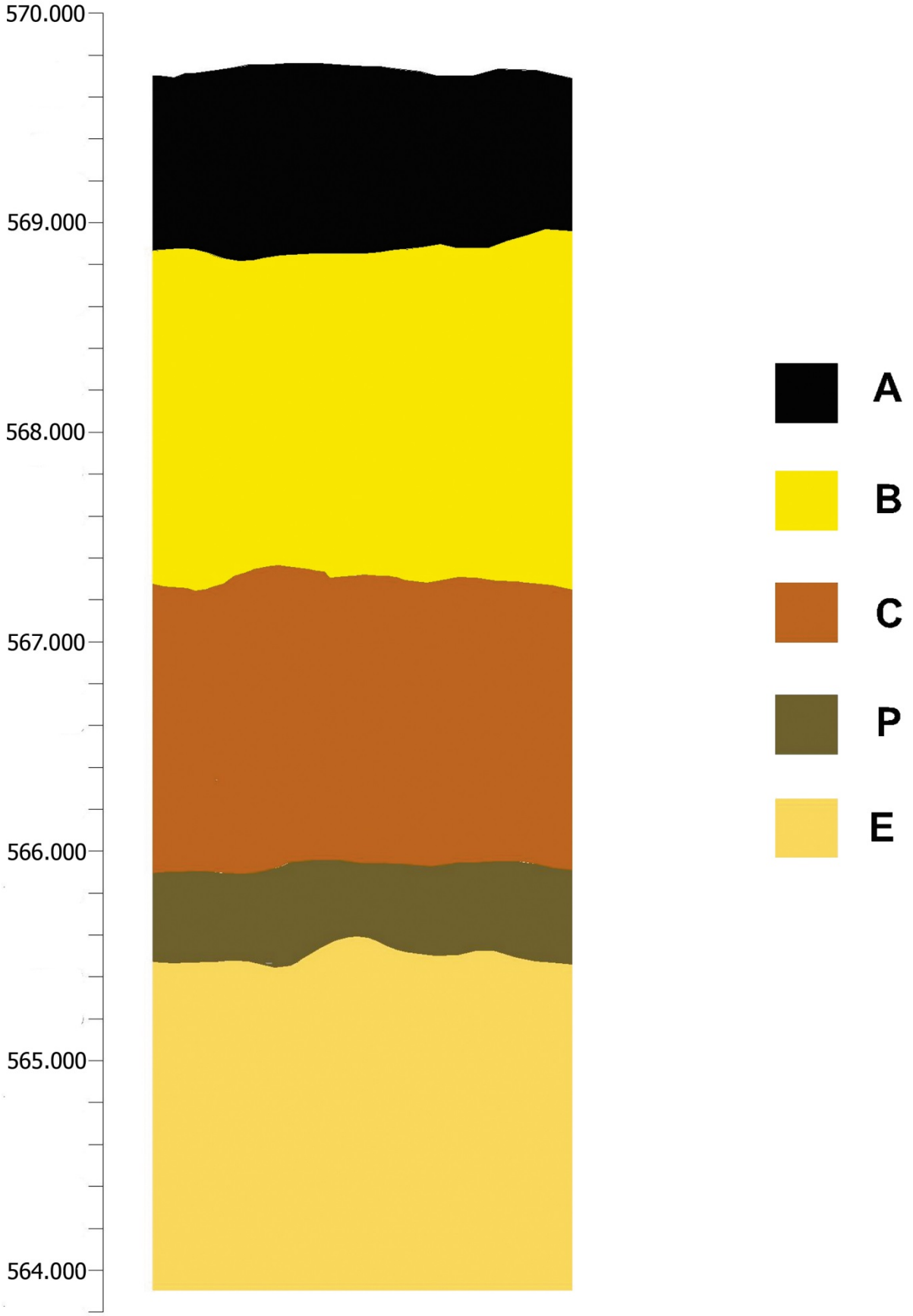

Figure 4. Stratigraphic profile of trench 6: A - Dark clay and fine sand with many organic elements in decomposition; B - Orange clay with brown silt inclusions; C - Orange clay; P - Dark brown clay; E - White and yellow clay.

Table 1. Techno-typological lithic categories.

Techno-typological category	Layer B*	Layer P	Total
Multifacial core	5	12	17
Prismatic core		1	1
Preferential Levallois core	3	4	7
Recurrent Levallois core		1	1
Discoidal core	2	1	3
Core on flake	4	1	5
Worked pebble		2	2
Flake	37	51	88
Retouched flake	6	5	11
Discoidal flake	20	11	31
Levallois flake	5	15	20
Blade flake	1	7	8
Levallois point	1	1	2
Debris	33	42	75
Retouched debris	1		1
Core Fragment	2		2
Flake Fragment	11	27	38
Undetermined fragment	12	17	29
Total	**143**	**225**	**368**

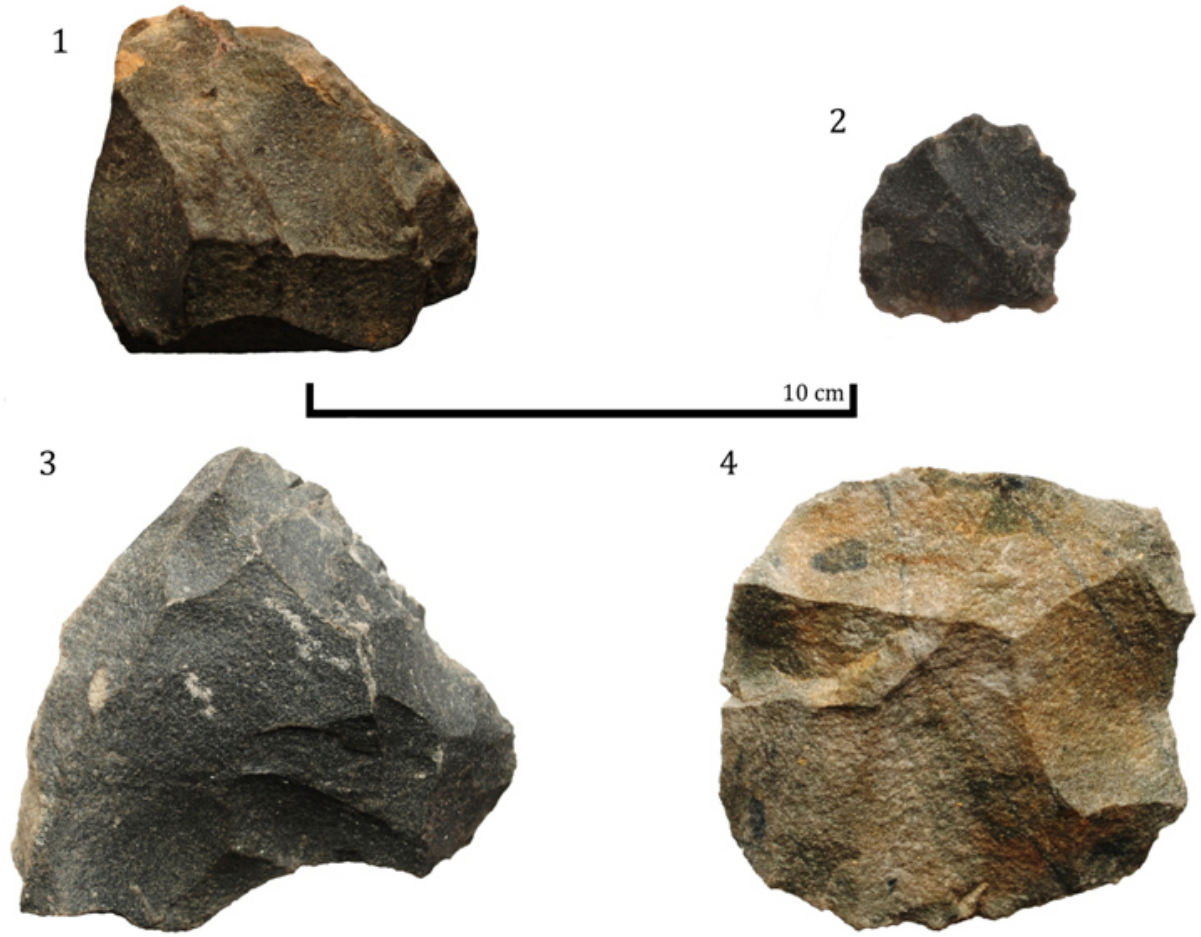

Figure 5. 1: Quartzite multifacial core; 2 & 3: Quartzite Levallois cores; 4: Quartzite discoid core.

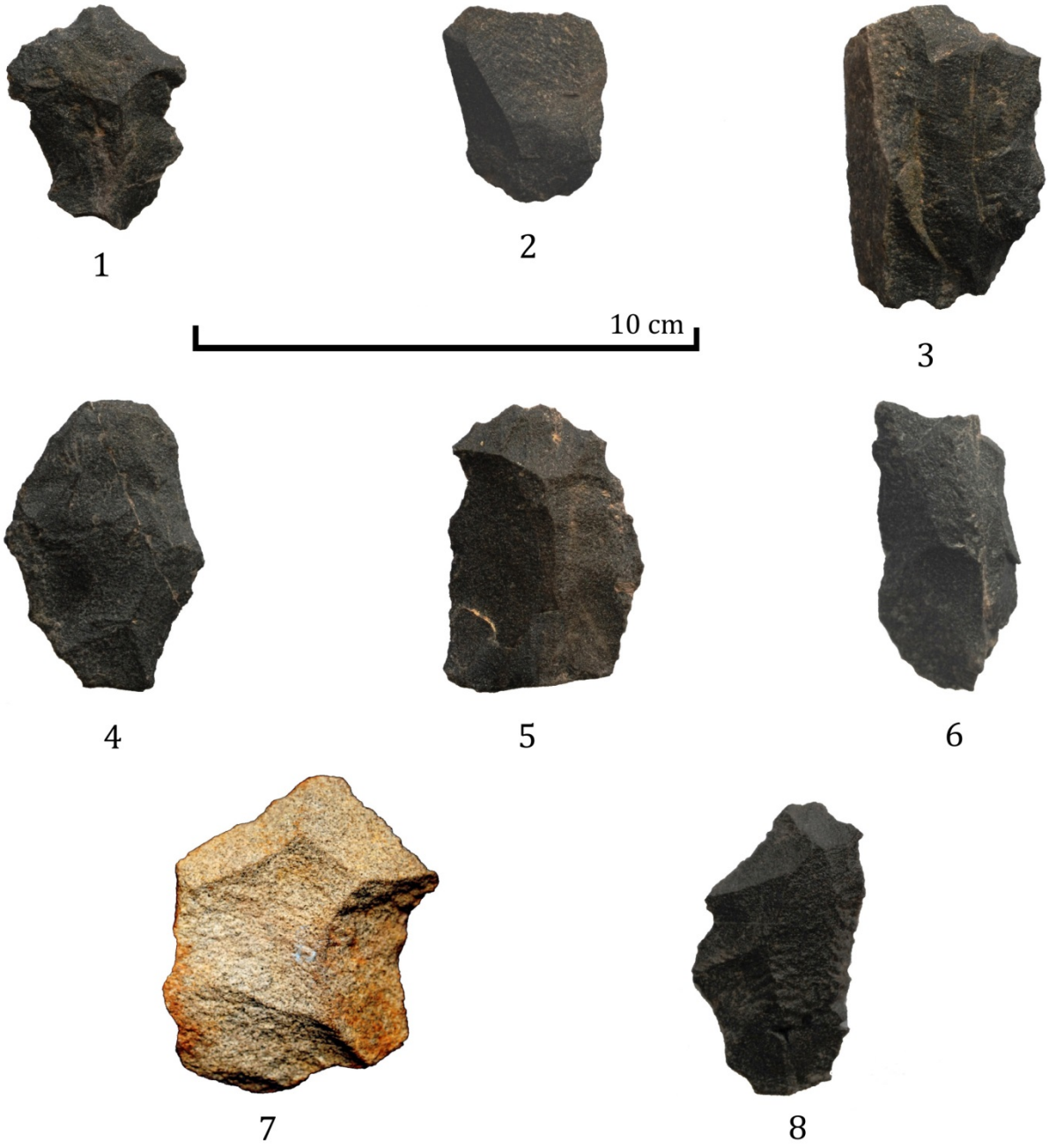

Figure 6. 1, 4-8: Quartzite Levallois flakes; 2: Quartzite discoid flake; 3: Quartzite side scraper.

The expedient method was the main option represented by multifacial cores and simple flakes, while among the predetermined methods the discoid is more represented in flakes, while the Levallois (preferential and recurrent) is more represented in cores. This might be related to the minor production of flakes from Levallois preferential cores and higher productivity of discoid cores, thus we consider that both methods are equal in their presence. Concerning the stages of the reduction sequences of the 3 methods, the initial phases are absent: all cores are in advanced stage of exploitation and the majority of flakes are non-cortical. This indicates that raw material acquisition and first stages of exploitation and configuration took place elsewhere revealing a pattern of transport and use where only the final products where brought to the site to be used. Such a pattern is certainly linked to the setting of the site on the top of the hill, far from raw material sources, and the specific activities undertaken here. Nevertheless the high quantity of debris indicates that knapping activities took place in the site. These probably correspond to the maintenance of blanks,

namely of Levallois and discoid cores. The considerable quantity of fragments might be related to the discard of unusable implements. Formal tools consist only of 11 retouched flakes (sidescrapers) and 2 Levallois points, evincing a preference for the utilization of unretouched blanks.

2. Materials and methods

At the present day, a lot of use-wear studies are carried out using Scanning Electron Microscopy (SEM). SEM has the advantage of a wider depth of field and it is also useful for the analysis of highly reflective raw materials such as a quartz and quartzite (Knutsson & Lindé 1990; Ollé & Vergès 2014). However, scanning electron microscopes present three disadvantages: they are not as readily available as optical light microscopes, not transportable to the field, and very expensive in terms of time and resources. For this study, we used a metallographic microscope to carry out the analysis of the lithic artifacts (archaeological and experimental) (Clemente & Gibaja 2009; Gibaja *et al.* 2002; Gibaja & Carvalho 2005; Gibaja *et al.* 2009). With this kind of microscopy two techniques of visualisation are available to reduce the glare of highly reflective raw materials (such as the quartz-rich raw materials) (Igreja 2009; Lemorini *et al.* 2014): equip the microscope with a Differential Interference Contrast Capability (also known as Nomarski contrast) or use high-resolution epoxy casts of the edges of the artifacts (Banks & Kay 2003; Plisson 1983). We used also the second methodology with a little modification since the observations were made only on the moulds (negative replicas) rather than making casts (positive replicas) of each mould surface. This protocol, already used by C. Lemorini (Lemorini *et al.* 2014) has as advantages the lowering of the laboratory expenses by eliminating the need for casting material, the reduction of the loss of fine detail that can occur when using casts and a better placement of the edges under the microscope. The use of moulds, in addition to being cheap also allows the easy transport of the samples to be analysed (Plisson 1983), without move the archaeological artifacts (eliminating conservation, legal and insurance problems).

To perform this study a three step methodology has been followed. First, a macroscopic preliminary observation assessed the suitability for the use-wear study of the lithic remains from Lagoa do Bando and to select the best preserved edges for the investigation.

In second instance a reference collection with flakes made of the same raw materials used by the Neanderthals of Lagoa do Bando was produced. Several specific activities were then carried out on different materials with the experimental lithic tools, to link the use-wear features to tool motions and to the processed materials. A use-wear study was done on a selected group of lithic artifacts. The above mentioned steps are considered here.

2.1. Initial examination of the archaeological materials

This study began with the preliminary evaluation of part of the lithic assemblage with the aim of identifying suitable lithic artifacts for the use-wear study. The sample was composed of all the Levallois and the discoid products. Five criteria were applied to select artifacts for the use-wear analysis: completeness, presence of at least one functional edge (artifacts without potential functional edges were excluded from the analysis), morphology suitable for prehension or hafting, surface preservation (absence of marked post depositional alterations), and presence of removals and rounding localized on the edges of the artifacts which are probably related to an ancient use. This preliminary phase was divided in two parts. The first examination was carried out by naked eye observation, followed by a second inspection with one stereo-microscope in reflected light. In this way it is possible to minimize the likelihood of confusing the modifications due to artifact's use, rather than post-depositional processes. The main features that differentiate traces of use from post-depositional alterations are the

combinations of the trace attributes: the contact with the worked material produces specific combinations of attributes, which rarely are replicated by post-depositional agents (*e.g.*, Asryan *et al.* 2014; Keeley 1980; Lemorini *et al.* 2014; Mansur-Franchomme 1986; Vaughan 1985). As testified by the experimental reference collections, the traces of use are always distributed in a localized portion of the artifact, usually in close proximity to the edge. The post-depositional marks are randomly spread over the lithic surface (Shea & Klenck 1993). There are three types of post-depositional surface alterations detectable by the naked eye: post-depositional edge damage (Flenniken & Haggarty 1979; McBrearty *et al.* 1998), generalized rounding of the surface (Plisson & Mauger 1988) and widespread glossy and bright appearance of the quartzite cement matrix (Stapert 1976; Plisson & Mauger 1988). Although superficially all the Lagoa do Bando collection appears well preserved some edge removals are visible on some of the artifacts. Through a stereo-microscope in reflected light it is possible to detect on the surfaces of some artifacts a light widespread gloss. All the artifacts with marked post-depositional alterations or that did not satisfy at least one of the other five criteria were discarded from the sample. After this preliminary screening phase, the Lagoa do Bando sample dataset is reduced to 42 quartzite artifacts, of which 16 are discoid flakes, 26 are Levallois flakes (16 are preferential Levallois flakes and 6 are centripetal Levallois flakes) and 4 simple flake. After this selection, no formal tools are registered in the dataset. This is probably due to their under-representation in the lithic assemblage. Forty five percent of the selected artifacts present a small amount of post-depositional edge removals.

2.2. Reference collection

The reference collections of quartzite flakes used to process different materials during controlled experiments were necessary to interpret the use-wear on the Mousterian artifacts. These collections come from two different sources. The first reference collection is the experiments carried out with quartzite flakes in the CIAAR (Centro de Interpretação de Arqueologia do Alto Ribatejo, Vila Nova da Barquinha) laboratory. This reference collection has been made with the same quartzite found at Lagoa do Bando. A total of 25 quartzite flakes were used in the experiments to link specific types of edge modification to the processing of specific types of materials and to specific processing tasks (see Table 2). The second reference collection is the experimental reference collection of quartzite implements of the Instituto Terra e Memória of Mação (I.T.M.): this collection was realized for others use-wear studies on-the quartzite lithic industries conducted by the Institute. The collection has more than one hundred quartzite flakes used on different materials (*e.g.*, butchering activities, fresh hide, bone, fresh and dry wood). For each flake of the I.T.M. experimental collection the following data are registered on a label: material worked, time of working, direction of the action done and name of the operator. The flakes of the CIAAR reference collection were washed first with water and soap. After this procedure the artifacts were placed for 48 hours in a mixture of alcohol (50%) and distilled water (50%). At the end the artifacts were washed with distilled water (75%) and alcohol (25%) in an ultrasonic cleaner for 5 minutes. The flakes of the ITM reference collection were only washed with distilled water (75%) and alcohol (25%) in an ultrasonic cleaner for 5 minutes.

2.3. Microscopic analysis of Lagoa do Bando artifacts

The analysis of the lithic artifacts was carried out using three different types of microscope: a stereoscopic microscope Seben Incognita III with magnification from 10x to 80x, a metallographic microscope Optika B 600 MET supplied with 5 objectives PLAN IOS MET with 5-10-20-50-100 objectives and 10x oculars equipped with a Optika camera B5. and

a Microscope Camera Dinolight Am413T). The macro-traces were observed with the stereo-microscope in reflected light and micro-traces with the metallographic microscope.

The analysis of the macro-traces provides information about the potential activities carried out (*e.g.*, cutting, scraping, piercing, *etc.*) together with a first hypothetical interpretation of the hardness of the worked materials. The hardness categories used to describe the worked materials are: soft (*e.g.*, animal soft tissue, herbaceous plants and some tubers), medium (*e.g.*, fresh wood and hide) and hard (*e.g.*, bone, horn, antler, dry wood and stone). Some materials display intermediate hardness or resistance such as soft-medium materials (*e.g.*, fresh hide, wet softwood) or medium-hard materials (*e.g.*, softwood, wet antler) (*e.g.*, Lemorini *et al.* 2006; Lemorini *et al.* 2014; Odell 1981; 2004; Rots 2010; Semenov 1964; Tringham *et al.* 1975). The analysis of the micro-traces is the study of micro-edge rounding, polishes, abrasions, and striations. This study was conducted to provide a more detailed understanding of the activities carried out with the lithic artifacts, and to define the diagnosis of the processed materials (*e.g.*, Beyries 1987; Christensen 1996; Moss 1983; Keeley 1980; Lemorini *et al.* 2014; Lemorini 2000; 2006; Plisson 1985; Rots 2010; Vaughan 1985; Ziggiotti 2011.).

Table 2. Reference collection. Materials worked with the experimental quartzite flakes.

	Work Time (minutes)		
Processed materials	**20**	**30**	**45**
Butchering (rabbit and wild boar)	2	2	2
Fresh bone (rabbit and wild boar)	2	2	2
Dry wood	1	1	-
Fresh wood	1	1	1
Dry antler (red deer)	1	1	-
Fresh skin (wild boar)	1	1	1
Dry bone (goat)	1	1	1
Total time: 25 minutes	**9**	**9**	**7**

3. Results

The analysis of the reference collections allowed to identify different type of micro wear traces on the quartz crystals and on the silica matrix surrounding them. The different extent of the use-wear traces, the texture and the topography of the polish, the presence of striations together with their depth and shape allow the definition of the hardness of the worked materials and, in some cases, they could be used to gain a specific diagnosis of the processed material (see Table 3).

Table 3. Microwear attributes used to diagnose the material being worked with quartzite tools

Material being processed	**Wear on the crystals**	**Wear on the cement matrix**
Meat	Widespread light rounding	Rough polish
Bone	Domed (convex) topography and possible striae on the upper parts.	Patches of flat polish
Wood	Lightly domed (convex) topography, possible striae and edge rounding.	Rough polish on domed and irregular micro holes.
Skin	Widespread rounding.	Possible striae
Butchering	Domed (convex) topography, widespread rounding and possible striae.	Rough polish and striae

The location and the orientation of the traces permits the diagnosis of the direction of the actions carried out with the tool (cutting or scraping) (Clemente & Gibaja 2009; Gibaja *et al.* 2002; Gibaja *et al.* 2009; Igreja 2009; Lemorniet *et al.* 2014; Pereira 1992a; 1992b; 1993; 1994; 1996). Twenty-one of the 42 archaeological quartzite artifacts (50%) selected for the analysis showed use-wear traces. Thirteen of them show no post-depositional alterations and five show minimal post-depositional edge damages. Three have post-depositional edge damages due to the mechanical excavation activities. The morphological features of the traces that allow interpretation of the kinetic actions and of the properties of the worked material are readily observable thanks to the excellent preservation of the surfaces of the artifacts.

During the study of the selected lithic assemblage, three instruments were identified with two different edges used. Cutting motions were recognized on 14 functional edges, linked to the processing of soft animal tissue (n = 5), butchering activities (n = 3), and wood working (n = 6). Scraping activities (nine of 24 functional edges) are related to wood working (n = 6) indeterminate medium-hard material (n = 1) and indeterminate hard material (n = 2) (see Figure 7 and Table 3). All of the three instruments with two edges used show use-wear traces of the same materials on the two edges, two of them present traces of wood working (one with longitudinal motion and the other one with transversal motion), the last one presents traces of longitudinal motion referable to a butchering activity. One artifact presents traces of indeterminate medium-hard material processing with a mixed action (see Table 4).

Table 4. Table with the use-wear traces found on the Lagoa do Bando artifacts Abbreviations: ZU - zone of use; SU. - stratigraphic unit; p - Layer P; b* - Layer B*; LP - Levallois preferential flake; LRC - Levallois recurrent centripetal flake ; Opp. – opportunistic flake; Qzt - quartzite; m. - medium; tran - transversal; long - longitudinal; unk. - unknown; SAT - soft animal tissue.

					ZU 1			ZU 2		
no.	**SU**	**technology**	**material**	**ZU**	**hardness**	**action**	**material**	**hardness**	**action**	**material**
17	p	LP	black Qzt	1	hard	tran	wood			
52	b*	Discoid	black Qzt	1	hard	tran	wood			
5	b*	Discoid	black Qzt	1	hard	long	wood			
118	b*	LRC	black Qzt	1	soft	long	SAT			
6	p	LP	black Qzt	1	soft	long	SAT			
7	p	Opp.	black Qzt	2	hard	long	wood	hard	long	wood
1	p	LP	black Qzt	1	m. soft	long	SAT			
1	b*	Discoid	grey Qzt	1	m. hard	long	wood			
64	b*	LRC	grey Qzt	1	m. soft	long	butchering			
18	p	LP	black Qzt	1	m. hard	tran	unknown			
60	b*	Discoid	black Qzt	1	m. hard	long	butchering			
17	b*	Discoid	grey Qzt	1	hard	tran	unknown			
15	p	Discoid	black Qzt	1	hard	long	wood			
75	b*	Discoid	black Qzt	2	hard	tran	wood	hard	tran	wood
61	b*	Discoid	grey Qzt	1	m. hard	unk.	unknown			
35	p	LP	black Qzt	1	hard	tran	unknown			
2	p	Discoid	black Qzt	2	m. hard	long	butchering	m hard	long	butchering
35	b*	LRC	black Qzt	1	m. hard	tran	wood			
12	b*	LP	black Qzt	1	hard	long	wood			
8	p	Discoid	black Qzt	1	hard	tran	wood			
47	b*	LRC	flint	1	m. hard	long	butchering			

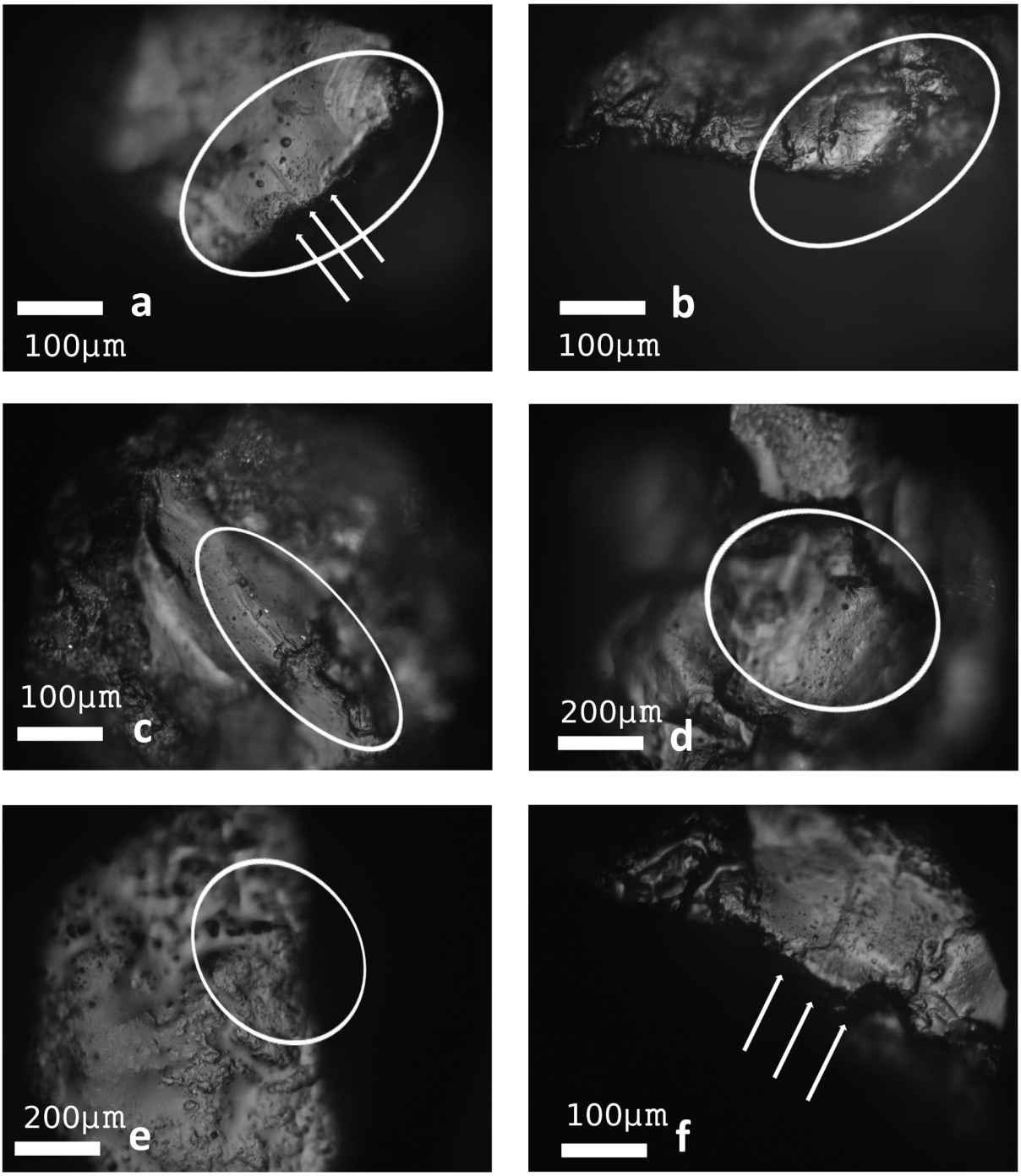

Figure 7. Use wear traces on Lagoa do Bando lithic artifacts: (a) Levallois flake B* 12 with wood-working traces on the edge; (b) Levallois flake P 1 with well-developed meat-working traces; (c) Discoid flake B* 75 with wood-working traces on the edge; (d) Edge of the Levallois Flake B* 35 wood-working traces; (e) Edge of the Levallois Flake P 6 with meat-working traces; (f) Discoid flake B* 60 with butchering traces on the edge.

4. Discussion and conclusions

Through the use-wear study of the lithic assemblage of Lagoa do Bando it is possible to describe part of the activities that were carried out on the site. The use-wear traces identified on the artifacts of the selected assemblage are linked to wood working activities and to the acquisition of meat resources. For four artifacts was impossible to define the type of the material worked. In these case just the hardness of that worked materials was identified: two artifacts were used to work hard materials and two were used to work medium-hard materials.

Dividing the artifacts into the two different stratigraphic units it is possible to see that the edges of the artifacts of the two different units show the same types of use wear traces, more or less in the same proportions (see Table 4).The low efficiency of quartzite cutting-edges for wood scraping was experimentally observed in the collective research project "Des Traces et de Hommes" (Thiébaut *et al.* 2009a; 2009b). Probably the choice of this raw material is due to the abundance of quartzite near the site and to the lack of better raw materials in the area: vein quartz presents the same problem (Berruti & Arzarello 2012) and flint is not present. The use of quartzite instruments for woodworking is also documented in all the other use-wear studies conducted on sites of the same area (Fonte da Moita, Ribeira Ponte da Pedra), but unfortunately these are Lower Palaeolithic sites (Cristiani *et al.* 2009; Lemorini *et al.* 2001). The high presence of tools with use-wear traces linked to wood working activities is very interesting because it is very rare to identify this type of trace in Middle Palaeolithic sites (Claud *et al.* 2013). Some other functional studies on Middle Palaeolithic industries show some diversity in the activities practiced in the sites and usually slaughter activities are dominant and wood-working is absent or scarce (Tares-Dordogne (Geneste & Plisson 1996); LaCombette - Vaucluse (Lemorini 2000); Vault Romani - Catalonia (Martinez 2008); Grand Champ - Loire (Igreja 2009) and La Mouline - Dordogne (Pasquini 2008); Ciota Ciara - Piemonte (Daffara *et al.* 2014). Although, a few functional studies conducted on others Middle Palaeolithic series, have highlighted a high proportion of artifacts used for a wood-working activities such as: Sesselfelsgrotte - Germany (Rots 2009) and San Quirce - Castile (Clemente *et al.* 2012). The abundance of wood-working activities in both of the stratigraphic unit of Lagoa do Bando, suggests the presence of a wide range of activities, not only shaft or spear manufacture.

This data may suggest a long term occupation. On the other hand, if the hearths were social spaces and the center of the activities (Foley & Gamble 2009; Rosell *et al.* 2012; Vallverdú *et al.* 2012; Vaquero & Pastó 2001), their absence in Lagoa do Bando together with the small quantity of lithic artifacts found, could suggest that the site is an ephemeral occupation site (such consideration remains to be confirmed through future excavations). Considering the available data in our opinion, the Lagoa do Bando remains might be related to two (or more) ephemeral and specialized occupations of the site (Stiner 2013).

These occupations were probably linked to the exploitation of woody local resources, maybe of lacustrine plants (*e.g.*, the Gravettian site of Bilancino (Aranguren and Revedin 2001), and to hunting activities. The presence of wood working traces on the edge of the Lagoa do Bando artifacts can be interpreted also as part of the "*chaîne opératoire*" for the realization of "hunting blinds" like the ones found in the Vila Ruivas site (Zilhão 1992; 2001). Lagoa do Bando could be interpreted as a butchery site (Manuel Domínguez-Rodrigo 2008) probably linked to the hunt of animals coming to drink. This interpretation, agrees with Zilhão (2000; 2000b; 2001) and Raposo's (2000) hypothesis that the Middle Palaeolithic people of the area were highly mobile and exploited predominately locally available raw materials especially quartzite.

The Lagoa do Bando site is one of a group of Mousterian open air sites of the middle Tagus area, like the nearest sites of Foz do Enxarrique, Vila Ruivas, Santa Cita, Estrada do Prado and Ribeira da Atalaia. But unlike these sites Lagoa do Bando is located in a relatively high mountainous environment, suggesting a more complex strategy of territorial exploitation for the Middle Palaeolithic of this region. Despite this different setting the lithic industry is similar to the mentioned open air sites where Levallois and Discoidal methods are present although not dominant and formal tools are not abundant, mainly represented by notches and denticulates. The predominance of unretouched flakes might be explained by the exploitation of the abundant local raw materials with technological exploitation resulting in adequate functional morphologies suitable for use without the need for retouch.

The Lagoa do Bando site contributes to understanding the behaviour of the Neanderthals who occupied open air sites in wetland environments. This behavior is documented across Europe from England (Hosfield 2005) to Greece (in the terra rossa, or "red beds") and Germany (*e.g.*, Wallertheim) (van Andel 1998; van Andel & Runnels 2005; Haws *et al.* 2010;).

In order to obtain a more accurate reconstruction of the activities that took place in Lagoa do Bando during the Middle Palaeolithic and to determine with more precision the type of occupation of the site (long or short term occupation) new excavation campaigns will be needed. This will increase the lithic assemblage and consequently the sample for the use-wear analysis (*e.g.*, in this study only flakes have provided functional diagnostics because the few formal tools were too weathered).

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