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Use-Wear and Residue Analysis in Archaeology

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Chapter 8
Use-Wear Methodology on the Analysis of Osseous Industries

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8.1 Introduction

Bone tool assemblages are important evidence of the material culture of prehistoric populations of hunter-gatherers. These industries encompass, in general, all objects produced from organic raw materials, i.e. the set that includes all debitage debris and equipment manufacturing.

The equipment consists of objects that had a use/function and have suffered or not a transformation. It is quite diverse and includes elements such as projectiles, intermediate pieces, awls, *lissoirs*, needles, beads, statuary, among other tools.

The osseous material industry includes objects made from mammal bone, ivory, dentine, antler, shells, horn, shell egg, shellfish, tortoise shell and baleen.

Use-wear analysis attempts to help to reconstruct how a tool was manufactured/modified and used through a microscopic analysis of traces left on the osseous surface. One important factor that should be kept in mind is that when tool morphology is identified it does not necessarily mean its function was also identified.

Their function is sometimes difficult to identify due to the fact that osseous material, such as bone or antler, were used in various states, that is dry, wet, fresh and heated. This fact influences the morphology of the traces left on the bone surface along with the mineral nature of the tools and their type, used to work and modify the bone surface. Also, some tools break during their use, and were recycled and used again in a different task. On the other hand, the active parts of a tool may deteriorate and it may have been reshaped in order to be used again.

Another important factor to keep in mind is that there are taphonomic modifications to which the osseous materials are submitted. These can alter the bone surface in different ways, to the point of creating pseudo-tools (Brain 1981; Dominguez-Rodrigo et al. 2009). That said, experimental programs and ethnographic studies are

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important complements of the use-wear analysis of bone surfaces, because the last traces seen on the bone surface are the result of its last function.

8.2 Current Status on Use-Wear Analysis of Bone Artefacts

Use-wear research on osseous materials is mainly based on use-wear studies on stone tools.

According to Banks (1996) there are two major schools that dominate this field of research—ethnography and experimentation.

By the end of the nineteenth century and during the twentieth century some authors such as Nilsson (1838), Evans (1897), Vayson (1922) and Gould et al. (1971) (all cited in Banks 1996), examined the edges of stone tools for macroscopic damage or evidence of use. They used ethnographic analogies to explain what types of activities or tool use could have produced the edge damage that they observed.

In the twentieth century, experimentation played an important role in use-wear analysis. Photography and registering of the length of time that a tool was used was introduced by Curwen (1930). Through experimentation programs, the wear seen on the tool's surface was recognised not to always be the result of cultural activities, as noticed by Levi-Sala (1986). By using Experimentation, Levi-Sala (1986) has demonstrated that natural processes sometimes leave wear traces on tools. These traces resemble and some are even identical to wear traces left by humans on the tool's surface (Levi-Sala 1986).

Experimentation was also carried out by Bouchud (1977), Dauvois (1977), Semenov (1985), Knecht (1991), d'Errico (1993) and Christensen (1999), among others, for complementing microscopic analysis of manufacturing and polish *stigmata* on completed organic projectile points and other tools so it would provide clues to the production sequence.

Experimentation turned out to be an important factor on use-wear analysis, because the *stigmata* seen on the experimental tools allows the process of analogy and parallels with the archaeological artefacts. Simultaneously, it creates a reference collection that makes possible the understanding of tool kinematics and techniques used to manufacture and modify the tool surfaces (Christensen 1999).

According to Banks (1996), LeMoine (1997), Christensen (1999) and Gibaja Bao (2002) there are authors who identify and interpret wear features at low magnifications (<100×), and others who use higher magnifications (typically 100×–500×). Each of these methodologies presents advantages and disadvantages. Low-power magnification studies are conducted with the use of stereomicroscopes and outside light sources and usually use magnifications ranging from 10×–80×. Their major advantage is to allow the analysis of large samples of artefacts; they also have a good depth of field in their optimal range of magnification; and finally, because they are less expensive. On the other hand, the disadvantages are the loss of resolution at magnifications above 50× and having poor light-gathering capabilities. The low-power approach is not effective in identifying tools that did not suffer any edge damage during use. Also, it is difficult to interpret a sequence of tool use when the utensil edge has been used multiple times on different worked materials, because only the last phase of tool use will be readily visible on the edge.

LeMoine (1997) states that with low-power microscopes only flake scars and striations are the main features that are observable. According to Sidera and Legrand (2006) the macroscopic analysis is efficient to use on those artefacts that had volume alterations and traces of use well developed in their surface.

High-power methodologies, on the other hand, have been used on the identification and interpretation of use-generated polishes (d'Errico 1993; Christensen 1999). This method was introduced by Semenov (1985) in his book "Prehistoric Technology" first published in 1957 in the Russian version (Christensen 1999). Semenov's research described the traceology or kinematics related to tool use and accomplished this through an analysis of striations, edge damage and abrasive polishes. Polishes tend not to vary according to the manner of the tool's use. One problem is the complexity of the polishing description. High-power microscopes are very expensive and not available everywhere.

Recently, there are researchers using digital cameras to document some features. These cameras are used in conjunction with software packages that allow many attributes to be measured and quantified in a variety of ways (Banks 1996). Knecht (1991) and Christensen (1999) also used high-power magnification—Scan Electron Microscope (SEM)—for the use-wear analysis of organic artefacts and lithic artefacts used in the manufacture of organic tools. Use-wear analysis with SEM has some advantages, like increased magnification, depth of field and image quality. But some bone artefacts cannot be seen under SEM because their size is far too large to fit in the microscope chamber, and this means they would have to be cut to size or replicas would have to be made. In these instances, the artefact has to be coated with a conductive material such as gold, carbon or alloy (LeMoine 1997). The disadvantage of SEM is that some characteristic polishes are not distinctive under this high-power microscope. Some researchers also use another technique together with SEM, the X-ray analyser for detecting residues of polishes (LeMoine 1997).

8.3 Methods

I present here a methodology for the use-wear analysis of the osseous industry, based on research from previous works by Averbouh (2000), Bertrand (1999), Camps-Fabrer (1977), d'Errico et al. (1984), d'Errico and Puech (1984), d'Errico and Giacobini (1985), d'Errico and Giacobini (1986), d'Errico and Espinet-Moucadel (1986), d'Errico (1993), d'Errico and Cacho (1994), LeMoine (1997), Knecht (1991), Maigrot (1997, 2003a, 2003b), Pétillon (2006) and Tartar (2003). The methodology of use-wear analysis serves both to understand the techniques of manufacturing the tool and its possible function. It will be necessary, thus, to document the artefact as precisely as possible. To do that, it can be created a database where it will be first registered what we can verify through the naked eye observation or macroscopically. It is important that, if possible, one distinguishes the raw material (Bouchud 1974; Poplin 1974), for it may give us clues about the techniques and procedures used in blank acquisition and modification. This is due to the fact that different debitage techniques are sometimes applied to various osseous materials, because they have different mechanical properties and do not react (brake) the same way.

The observation of the bone surface's preservation state is important because it permits to identify several factors, such as the presence or absence of spongy tissue and of the cortical tissue and in what state of preservation they are. It is also possible to identify taphonomic alterations through traces left by physical-chemical agents and also by actions of natural agents such as plants and animals.

The analysis of bone surface modifications will also track vestiges of substances such as adhesives, colorants, micro-splinters of chert stuck to the bone surface, or changes caused by fire (superficially or deeply) (Behrensmeyer 1978; Blumenschine et al 1996; Lyman 1994; Manne 2010; Juana and Domínguez-Rodrigo 2011; Outram 2002; Orton 2010; Semenov 1985).

As noted by Knecht (1991) and LeMoine (1997) sometimes the preservation state of the artefact does not allow for an analysis of its surface, either caused by its deterioration or by other natural reasons. Sometimes, some artefacts are very fragile and eroded to the naked eye, not allowing a microscopic examination of its details. Others, on the other hand, seem to be well preserved but they are in fact eroded and weathered at a microscopic scale (LeMoine 1997). Knecht (1991) also refers to another problematic issue: the common practice over the last century to cover up the surface of the bone artefacts with a layer of varnish in order to prevent it from disintegrating. This method makes it quite difficult to analyse the artefact's surface because the coating does not allow the observation of *stigmata* of manufacturing and/or use with a binocular microscope (Évora 2008) or a reflected light microscope. It will also prevent the use of the Scanning Electron Microscope (Knecht 1991). Removing this varnish can also destroy the surface, and so its information will be lost.

8.3.1 Artefact Orientation

In graphical representation and photography, the artefact is always oriented with the proximal part downwards and the top surface (cortical surface) towards the observer. Except for the finished artefacts, the question of the orientation of the artefact is not simple. Since some artefacts are fragmented, others are manufactured using bone leftovers, or are either blanks or unfinished tools. This situation does not allow to define properly its future active area. So for these particular pieces, when registering their graphic orientation or photography, the artefact can be displayed following their anatomical orientation if it does not have any technical *stigmata*. For the debitage debris, the displayed orientation is either the anatomical or the technical surface always indicating, in these cases in particular, the orientation that was possible to use (Averbouh 2000).

8.3.2 Artefact Recording

For each artefact, the following list should be registered:

- Archaeological site where the artefact comes from and, whenever possible the level/stratigraphic layer;
- Identification of the raw material and respective species (and whenever possible anatomical location);
- Typology of the artefact;
- Type of contour/profile of the artefact;
- Morphological information: maximum length (proximal, mesial and distal); maximum width (proximal, mesial and distal); maximum thickness (proximal, mesial and distal);
- State of preservation (if the artefact is complete or broken, and if so which part has been preserved) and changes in the surface;
- Type of fracture and its location;
- Morphology of the distal and proximal ends;
- Type of section (proximal, mesial and distal).

After this initial macroscopic recording, we can move on to the microscopic analysis of bone surfaces, making use of various methods, some easy, others more difficult and expensive, as the case with some high power microscopes.

8.3.3 Microscopic Analysis

In the process of microscopic analysis of osseous surface several technical and use traces are recorded:

- The schematic representation of all technical *stigmata* (negative withdrawal, striations, *pan de fracture*, grooves) and use (the active regions can be located anywhere, but they are usually in the proximal and distal ends and, more rarely, in some artefacts over the cortical surface) and their location;
- The description of each *stigma*: their type; location details; their orientation in accordance with longitudinal axis of the artefact; their inclination or incidence to the surface (rough, oblique, vertical, diagonal); their extent (marginal, moderate, invasive coverage); their distribution (continuous or discontinuous); their organisation; their morphology; as to discriminate striations also its density, size and orientation relative to the longitudinal axis of the artefact.

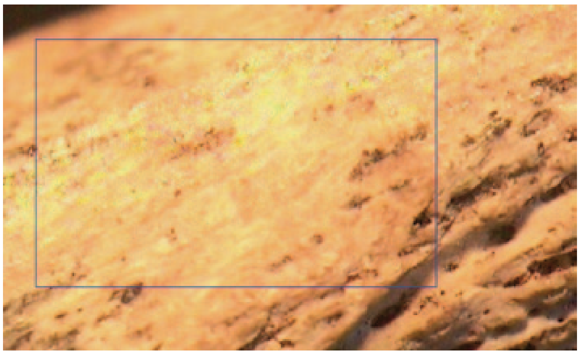

Fig. 8.1 Manufacturing *stigma* showing the area where the lithic tool stopped on an antler projectile point from Buraca Grande site. 30× magnification (all photos by M. A. Évora)

This record, made in detail, will provide information as to any primary changes (debitage and manufacturing techniques) and secondary changes (finishing of the pieces) (LeMoine 1997) employed in the manufacture of the artefact. It will also provide information on possible functions the artefact had and, based on the analysis of the debitage debris, information on the economy of the raw material (Tartar 2003) (Figs. 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 8.8, 8.9, 8.10, 8.11, 8.12, 8.13, 8.14, 8.15, and 8.16).

8.4 Final Remarks

Since the natural characteristics of osseous materials are very different from the characteristics of stone tools, their use-wear analysis is more difficult to interpret. Because this raw material is usually found fractured and its surface is modified by several different ways of preservation. It is the case of fresh, heated or dry states. In the case of mammal bone and antler, some tools have had more than one function, and some others, after being broken, were also recycled and gain a new function. It all depends on what specific tool the artisan wanted or needed to manufacture, for a specific task or several tasks. These working techniques and changes made during the life time of a tool have great influence on what we see under the microscope, because the traces left are not always the same. Also we have to add the fact that bone material goes through natural surface alterations due to taphonomical agents that sometimes deeply modify its surface. The basic knowledge of taphonomical alterations is, thus, fundamental when analysing bone surfaces.

From what was mentioned above, we see that the interpretation and understanding of several types of traces left on the bone surface, through use-wear analysis, is mostly based on comparisons with traces left on experimental tools. For this reason, functional studies are very important and must be complemented with ethnographic information.

Ethnographic studies of recent Hunter-Gatherers populations provide insights into the many ways an osseous raw material could be transformed and what kind of tools could be produced from it.

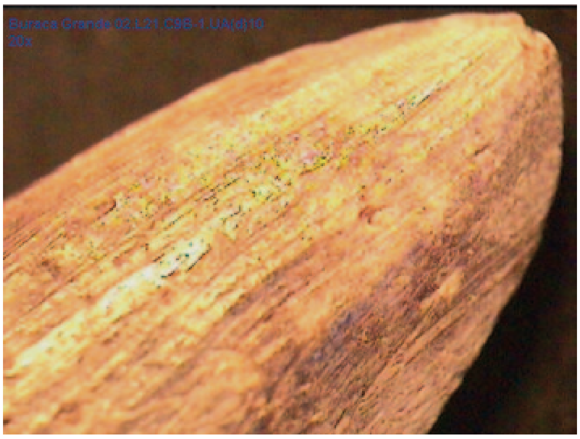

Fig. 8.2 Distal end of an antler tool from Buraca Grande site. 20× magnification

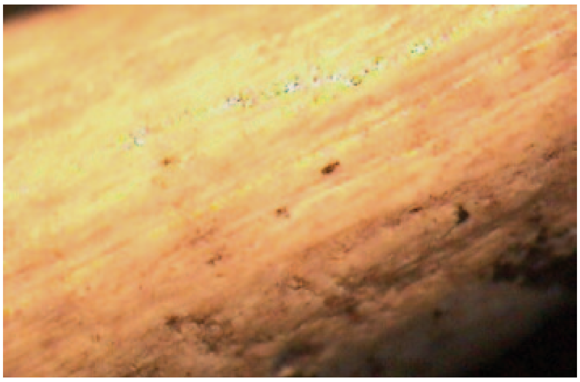

Fig. 8.3 Surface of an antler (?) projectile point with bevel from Buraca Grande site. 30× magnification

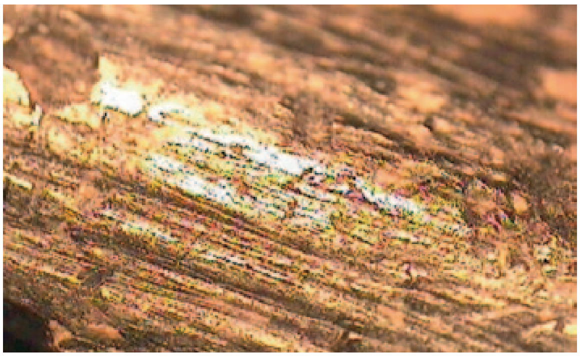

Fig. 8.4 Surface of a fusiform bone tool from Vale Boi site. 20× magnification

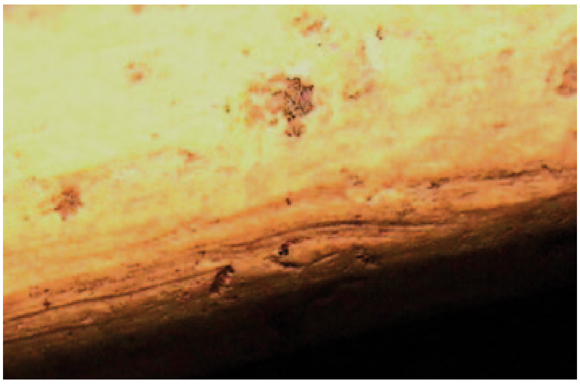

Fig. 8.5 Manufacturing *stria* on an antler projectile point from Vale Boi site. 16× magnification

Fig. 8.6 Tongue fracture on an indeterminate raw material tool from Buraca Grande site. 10 × magnification COLOR

Fig. 8.7 Saw fracture on an indeterminate raw material tool from Buraca Grande site. 10 × magnification

Fig. 8.8 Impact marks on a distal end of an antler tool from Vale Boi. 10 × magnification

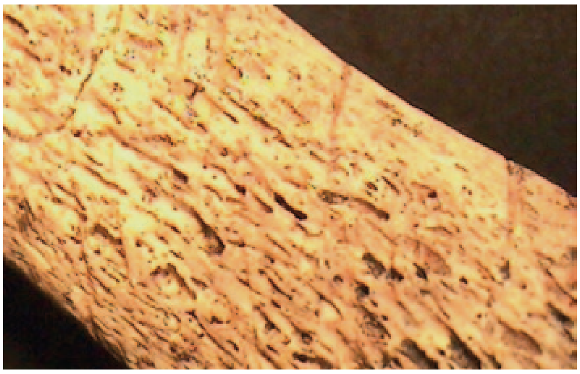

Fig. 8.9 Incisions on the lower surface of an antler massive based point from Buraca Grande Site. 10 × magnification COLOR

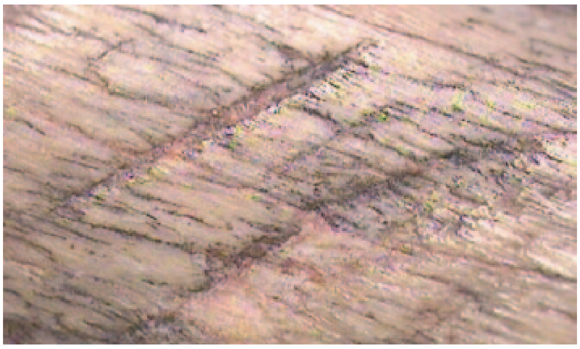

Fig. 8.10 Incisions on the surface of a fusiform bone tool from Caldeirão Cave. 30 × magnification

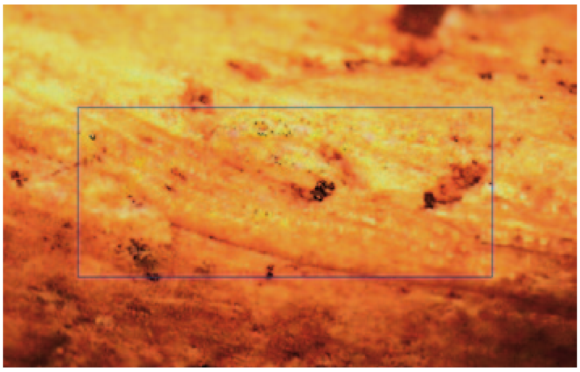

Fig. 8.11 Microwave pattern inside the manufacturing *stria* on the surface of a bone tool from Vale Boi site. 30 × magnification

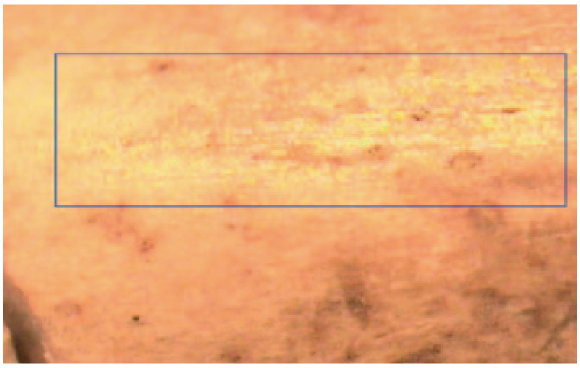

Fig. 8.12 Bumps pattern (usually left by an unretouch tool like a burin) on the surface of an antler projectile point from Vale Boi. 40 × magnification

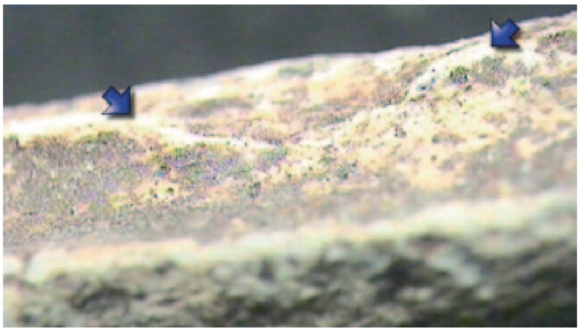

Fig. 8.13 *Stigma* on the bone surface left by a wedge used to separate, by bipartition, a metacarpus of *Cervus elaphus*. Vale Boi site. 10 × magnification

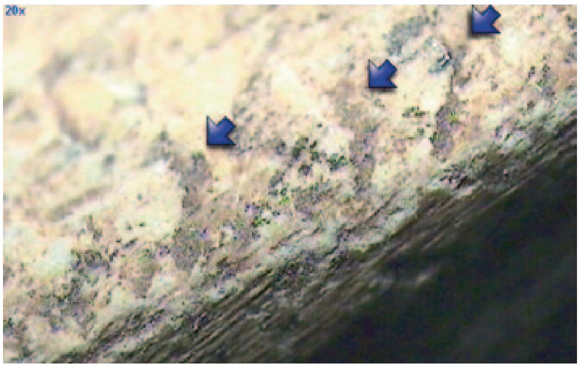

Fig. 8.14 *Stigma* on the bone surface left by a wedge used to separate by bipartition a metacarpus of *Cervus elaphus*. Vale Boi site. 20× magnification

Fig. 8.15 Experimentation: scraping *stria* over an antler *spongiosa* surface showing the area where the chert tool stopped. 14× magnification

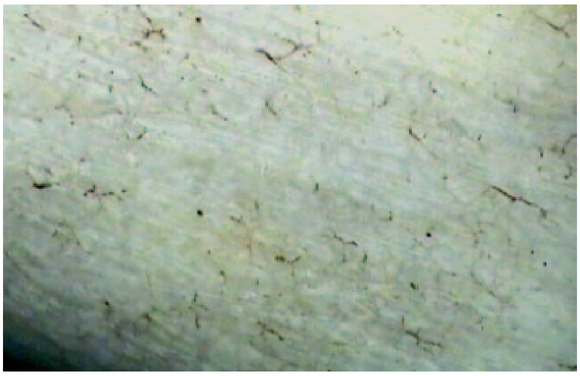

Fig. 8.16 Experimentation: scraping *stria* made with unretouched chert splinter over antler surface. 20× magnification

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