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SEARCHING FOR THE FUNCTION OF THE EARLY HOLOCENE HEAVY DUTY BEVEL-ENDED TOOLS: REMARKS FROM EXPERIMENTAL AND USE-WEAR STUDIES

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Heavy duty bevel-ended tools, such as axes and mattocks, belong to the category of the most frequently discovered artefacts on the early Holocene hunter-gatherer European archaeological sites. These objects are distinguished by c.a. 50-degree bevelled working edge and the raw material used to produce them was mostly deer antler. The main objective of the presented study is to classify, analyse, interpret and correlate the macro and microscopic traces formed on the experimental replicas of this kind of tools. During the experiments conducted directly for the purpose of this project, a wide variety of household activities were tested, taking into the account many possible variables, such as: the kind of worked material (soil, wood, hide, flesh, ice), the type of activity performed (chopping, digging, scraping, hewing, hitting) and the duration of work. The effectiveness and suitability of the selected tools for those varying activities were also examined.

Keywords: experimental archaeology, Stone Age, Europe, osseous artefacts, use-wear, heavy duty bevel-ended tool.

Introduction

Tools made of red deer antler (*Cervidae*) constitute a distinctive group among the wide range of categories of artefacts made from osseous materials, discovered on the Stone Age sites in Poland. The popularity of this raw material was largely owed to both favourable physical and technical properties (hardness, elasticity) (MacGregor, Currey, 1983. P. 71) and its fairly universal availability. Antler stags were acquired not only as through of hunting, but also by collecting of the so-called sheds - antlers annually lost by male deer before the period of re-growing the new antler stags (Chapman, 1975. P. 131; Goss, 1983. P. 172; Krzemień, 1984, P. 65; MacGregor, 1985. P. 11).

Many kinds of tools were produced from this material, including the so-called *heavy duty bevel-ended tools*. These objects were made mainly from the proximal end of the beam, i.e. the area of the burr and the place from which the first tine sprung (the so-called brow tine) and from the central part of the beam, on the level of so-called trez tine (fig. 1). They feature a characteristic bevelled blade with an angle of c.a. 50-degree, opposed to the blunt end and a relatively large perforation, mostly 2–2.5 cm in diameter allowing for settling of the haft (Smith, 1989. P. 272; Jensen, 2001, P. 165; Riedel *et al.*, 2004. P. 199; Elliott, 2015. P. 228). Because of the differences in the arrangement of the working edge to shaft hole, these tools are customarily divided into axes, in which the working edge is parallel to the handle and mattocks/adzes, in which the working edge is situated perpendicularly or at a slight angle relative to the tool's handle (Pratsch, 2006. P. 196).

Initially, it was thought that these tools, because of their shape, character of the working edge and the size, could be applied for multiple purposes. In the early stages of the research, they were considered to be items used for wood chopping, and their presence was linked to the first woodland clearance events in the early Holocene (Clark, Piggott, 1965. P. 145). Later, as their morphological differentiation was taken into the account, it was suggested that they could have been used as digging implements (Smith, 1989. P. 272). Yet another theory claims, that because of the numerous finds of this kind of artefacts at coastal sites (often in association with seal or even whale bones), they can be interpreted as tools used for hunting or butchering of the hunted game (Turner, 1889. P. 789; Woodman, 1989. P. 19).

Experimental archaeology methods were used in the attempts to provide an answer to the question of the purpose of those tools. Early studies of this type concentrated mostly on the question of the suitability of these artefacts for various kinds of household activities, especially for woodworking. For this purpose, experiments including, among other activities, chopping, splitting and debarking of wood material, were conducted (Jensen, 1991. P. 15; Pleyer, 1995. P. 161; Riedel *et al*., 2004. P. 204; Van Gijn, 2005. P.51; Bell, 2007. P. 131). There were fewer experiments involving digging activities (Jensen, 1991. P. 15) and hide working (Van Gijn, 2005. P. 51). Some important information, regarding the potential function of this kind of artefacts, was provided through of anthracology analysis, carried out for the finds originating from gravel quarries in the villages of Koldingen and Gleidingen (Riedel *et al*., 2004. P. 205). The examined particles, obtained from the spongy material of selected artefacts, allowed for the identification of the material as the remains of deciduous wood. This can be used as an argument in favour of the theory which interprets these tools as woodworking instruments.

Despite the relatively large number and versatility of the studies carried out so far, the contemporary knowledge of the probable function of these objects remains incomplete. The problem here arises primarily from lack of detailed characterization of damage observed on these tools and resulting from work in a variety of raw materials, that could be used as a comparative basis for the interpretation of the function of these archaeological artefacts. This issue became the basis for planning and carrying out experimental program described below, which tries to fulfil two main objectives: verification of the suitability of these tools to perform various activities and processing of various types of raw materials and the identification, analysis and classification of macro and microscopic traces formed on their working surface during work.

Methodology

Methodology of use-wear analysis assumes that processing of any type of raw material with tools, results in leaving characteristic traces on the used item, and the analysis of the traces may allow for identification of the type of work carried out. As already mentioned, an integral part of all such analyses are the experimental patterns, which constitute the basis for observations and examining of archaeological finds (i.a., Semenov, 1964. P. 1–4; d`Errico, 1993. P. 30; LeMoine, 1997. P. 18; Christensen, 1999. P. 11; Van Gijn, 2014. P. 167).

The antler tool replicas used during experimental works were made with use of contemporary tools. However, all working parts were additionally grinded on a fine-crystalline sandstone, which led to the removal of traces associated with the use of electric tools and gave them the features typical for blades of prehistoric artefacts. Experimental tools were divided into three groups: axes, mattocks/adzes and specimens representing imitations of tools which were recycled (compare Van Gijn, 2005. P. 55), i.e. those which, although damaged, (e.g. a crack in part of the shaft hole, preventing from embedding tools on the handle) could be further used for other tasks (further below – reutilized forms). This division determined, to a certain extent, the possible ways of use of individual items for particular activities, because forms with working edges set perpendicularly toward the shaft would be unsuitable for woodworking, and as such they would have been used in digging activities. This issue has previously been mentioned by Graham Clark, among others, (Clark, 1954, P. 158).

Microscopic observation and photographic documentation of use-wear traces was carried out using low (<100×) and high magnifications (typically from 100× to 500×). Each method has its advantages and disadvantages, which were widely described in the literature (Semenov, 1964. P. 22; d`Errico, 1993. P. 298; LeMoine, 1997. P. 15; Christensen, 1999. P. 106; Sidera, Legrand, 2006. P. 295). Therefore, the reported studies applied all the methods to maximise the potential. (Buc, 2011. P. 546; Van Gijn, 2014. P. 167; Evora, 2015. P. 160). Microscopic observations with low magnification were conducted with the use of microscope-computer set Zeiss™ SteREO Discovery V8, equipped with a two point fiber-optic illuminator with white xenon light. It allows obtaining actual magnification up to about 80x. The micrographs shown in fig. 4. were made with it. For the observation of micro-polishes, a microscope-computer set Zeiss-Axiotech was used, as it enables actual magnifications of up to 500×. It was also used to make micrographs shown in fig.5. Additionally, the surfaces were examined using scanning electron microscopy SEM/FIB Quanta 3D FEG, which was also used to take pictures presented in fig.6.

The terminology introduced here was based on a conceptual system, existing in the literature and applied to stone and bone artefacts (i.a., Vaughan, 1985. P. 10–13; Van Gijn, 1989. P. 16–20; LeMoine, 1997. P. 21–22; Juel Jensen, 1994. P. 20–27; Korobkowa, 1999. P. 17–21; Legrand, 2007. P. 23–25; Osipowicz, 2010. P. 25–35; Buc, 2011. P. 546); the system was adapted to the needs and requirements of the conducted analysis.

All signs of damage observed were documented in terms of their distribution on both the bevelled surface of the tool (bottom) and on the upper side. This distinction was made because of the different shape, porosity, topography and degree of contact of both surfaces with the worked material. This division proved to be an important aspect of the analysis, because in some cases the destruction occurred only on one side.

Before microscopic analysis of all the experimental tools were cleaned with warm water and a detergent.

Experimental works

During the experimental works, processing of four raw materials was conducted: wood, soil, flesh/hide and ice (fig. 2). In order to provide a complete characterization of formed use-wear traces, the experimental work carried out aimed to account for to the basic variables characteristic for different types of raw materials, including its hardness, moisture content and brevity. Tested activities included chipping, hitting, digging, hewing and scraping. The work was also organized in a way that allows for factoring in the most likely ways of using various morphological forms in particular household activities. This selection was based on the results of previous studies known from the literature. At this stage of the study, limiting of the scope of research was a necessary procedure, due to the large range of activities and materials that should be included in the project, if it aimed to deal with the problem in a comprehensive way. Therefore, the study cannot be consi-dered to be complete or finished. However, the research carried out represents a good base for further experimental works, as it covers many different kinds of activities and types of raw materials. As it will be shown later in this study, the results can also be used for preliminary use-wear analysis of prehistoric artefacts.

The experimental works were carried out by different persons. Variable duration of the experiments (an average of from 30 to 120 minutes) allowed for the analysis of the development process of emerging traces.

A total number of 26 experiments were conducted. The tool replicas were made of deer antler (*Cervus elaphus*), obtained from animals of similar age (ab. 4 years old). The raw material was obtained from farm animals.

In most cases (apart from work involving processing of hides), tools were seated on wooden shafts. Archaeological findings suggest that originally they had a length of about 60–70 cm and were usually made of ash, rowan, viburnum, hazel and alder (Jensen, 2001. P. 166; Riedel *et al*., 2004. P. 204). Replicas used in the presented study were fitted with shafts 60 cm long and with diameter of approx. 2.5 cm; made of hazel wood. The full summary of the conducted experiments is shown in Table 1.

Wood Processing

Ten experiments of this type were performed. The works included two actions: chopping and hewing. The experiments of the first type consisted of chopping various tree species using axes. The raw material was divided into two main categories, according to its hardness. Division and selection of appropriate species was based on the Janka wood hardness scale (Janka, 1906; Krzysik, 1975. P. 583–585).

In the experimental works involving chopping, trees were classified as soft (pine or birch), ab. 20-25 cm in diameter, or hard (young acacia, maple), ab. 10-15 cm in diameter. The works were carried out in the spring. Hard/young trees were cut at a height of approx. 20-30 cm from the ground. In this way, the total number of several trunks were acquired, which served, among others, to reconstruct the Mesolithic hut located at the Institute of Archaeology of the Nicolaus Copernicus University in Torun (Osipowicz, Nowak, Kuriga, 2015. P. 1). As for the softwood, besides felling trees, lying trees from fresh felling in forests were chopped. A total of seven experiments involving chopping wood were carried out, which lasted a total of about eight and a half hours. Used tools can be considered relatively efficient, although certainly not as good as artefacts made of raw stone.

The carpentry experiments involved a multi-stage removal of scorched, charred layers of birch wood. Two morphological mattocks were used for this purpose. The starting point for this part of the experiment was the current knowledge of the possible techniques for making dugout boats in Prehistoric times. Ethnographic analogies and individual archaeological finds from the Stone Age indicate in this case the use of a burning technique (Clark, 1936. P. 109; Kozłowski, 2009. P. 57). The effectiveness of this method is also confirmed by the experimental works (Powell, 2001. P. 183). During the experiments, trunks no larger than 25 cm in diameter were placed in a fire for about 10 minutes, giving approx. 1-2 cm thick layer of charred wood. This layer was removed with the experimental tools and the action was repeated several times. The total time of two conducted experiments in this case was one and a half hour. The tools used for this task were quite effective.

Digging in the soil

Mattocks were used in the experiments. They were applied for loosening the topsoil and digging small pits and gullies, up to 30 cm deep. In order to achieve the fullest possible range of damage appearing on the tools of this type, as a result of work in different kinds of soil, the experiments were performed in three types of deposits: compact sandy clay, fine loose sand and rocky, grassy humus. The work was carried out in spring and autumn. Six experiments were performed with experimental tools, approximating a total time of nine and a half hours.

Processing of flesh and hide

Among hunter-gatherer communities, flesh and hide were the basic raw materials used in processing. For this reason, one of the proposed probable functions of heavy duty bevel-ended tools was butchering of meat from hunted prey (Clark, 1957. P. 84). In order to test for this possibility the experiments involved, i.e., hitting and butchering swine and cattle carcasses with axes. Four experiments of this type were carried out, their duration was three hours.

Another type of experiments was directly related to the treatment of hide. There are two basic methods of work in this raw material: dry – hide hard, dried up and wet – hide fresh or soaked (Van Gijn, 1989. P. 27). In the present study, it was decided to test the usefulness of the reutilized forms for two basic activities associated with the processing of this raw material. The first group of replicas was used for scraping the fresh deer hide i.e., clearing of the flesh side and flesh remains. Tools of the second group were used as smoothers in works related to smoothening and softening of the partially dried fresh deer hide. In both cases the skin was stretched out on the ground, and the tools were kept directly in the hands (not hafting). In this case, four experiments were performed, which lasted a total of six hours.

Tools for chipping a blowhole

In the Stone Age, one of the ways of obtaining food in winter was probably fishing from under the ice. For this reason, it was decided to test the suitability of the described tools for making blowholes. Experiments of this type were carried out on ice of the thickness of approx. 25 cm. Two experiments were performed with the replicas, with the duration of about two and a half hours. As a result, 7 blowholes were made with a diameter of about 20 cm. It was concluded that the tools fulfilled their function well.

Characterization of the use-wear traces observed on the experimental tools

The experimental works had a relatively small scope, but the performed microscopic examination led to documenting of a number of the usage related traces, whose characteristics can be a significant source for comparative analyses with the prehistoric artefacts. Detailed information on this subject is synthesized in Table 2.

Among the basic usage damages, typical for the tools used for chopping wood, large (more than 1 cm in diameter) breakages in the spongiosa should be mentioned. Similar observations were made previously by Danish and German researchers (Jensen, 2001, p. 168; Riedel et al., 2004. P. 204). Processing of hard and young raw material leads to the formation of invasive damages on the working edge, including large breakages (greater than 0.5 cm in length and width) on the upper side (fig. 3A). Deep particles of wood wedged into the spongiosa and scar bends turned out to be characteristic for this type of activity. When used for soft wood (both coniferous and deciduous), the damage is far less invasive (fig. 3B). Breaking practically did not occur, a subtle damage (peck ness) was visible instead. Imaging with a scanning electron microscope revealed the presence of very visible micro-cracks in the structure of antler for all chopping tools, which is indicative of strong blows directed into the processed material (fig. 5A). The observed striations, both for hardwood and softwood are multidirectional, intersecting and scattered all over the working edge. Their occurrence is connected with the areas covered by micro-polish (fig. 4B, C). Polish formed on the tools used for woodworking is very noticeable macroscopically. Attention should be paid here primarily to the tools used for the processing of young and hard raw material. In their case, the micro-polish destroys (smoothens) the original surface of the antler in a very invasive way. Its topography is flat and texture depends on the type of worked raw material (degree of its "contamination") and localisation on the working edge. It includes the entire relief of the antler, leaving only the deepest parts of it non polished (fig. 4B). Sometimes it also occurs at the spongiosa and it is relatively flashing (gloosy) in the appearance. In the case of mature, soft wood, the micro-polish is much duller, less invasive (less destructive for the antlers relief) and its texture is more uniform (fig. 5C). Differences in intensity and nature of observed micro-polishes can probably be seen as a result of the diversity of hardness and moisture of the raw material, which depend, among others, of its species. Another significant factor in the research is the devastating effect of organic acids contained in hemicellulose, which occurs in higher levels in young wood (Krzysik, 1997. P. 120–122). During the analysis of the experimental replica tools under high magnifications, relatively well distinguishable osteons (concentric bone layers which surround the haversian canal (fig. 4C) were observed.

Working edges of tools used for hewing burnt wood were observed to be completely different in appearance. Due to the constant contact with hot material they have been overheated, causing discolouration of the surface to dark brown and make the surface glossy (fig. 3C; 4D). The high temperature was also a reason for the appearance of distinctive, scattered polygonal cracking pattern on their surfaces, apparently as a consequence of dehydration, which in turn is a result of temperatures equal or greater than 285°C (Schipman *et al*., 1984. P. 314). Blades underwent intense chipping, which covered almost all of their surfaces. The difference in the extent of surface erosion of the tools, which were used to work in burnt and fresh wood, is well illustrated in the photographs taken by using a scanning electron microscope (fig. 5A, B).

As a result of continuous breaking out during working, the edges retain sharpness, however they were shortened quickly during the works. Striations proved to be well developed and could be seen in two different forms. In case of working parts remaining in direct contact with the charred wood they are long (up to about 1 mm) thick and parallel to each other (fig 3D). On the other hand, in parts of the blade slightly away from the overheated wood, they are scattered, multidirectional and resemble traces observed on the tools used for chopping unburned wood.

Characteristics of traces observed on the tools used for digging in the soil highly depend on the sediment's grain and compactness. Generally, roughness and visible rounding of the working edge should be considered as the most important changes visible macroscopically and at low magnifications. In the case of performed experiments, traces of this type were the most visible on the replicas used for digging humus. The working edges of these tools were blunted and wore small breakages, visible macroscopically, mostly on the upper side of the tool (fig. 3E). The situation looks a little bit different in case of work in loose, fine sand. The blades of the artefacts used in such way underwent an intense abrasion and polishing, and to some extent, even the self-sharpening (fig. 3G, see also Korobkova, 1999. P. 146). Similar traces were also observed on the tools used for digging in clay, however there was no effect of polishing up of the working edge, and in some cases it has been slightly roughened (fig. 3H). Different properties of the soil, in which digging was performed, also had a significant effect on the characteristics of generated striations. In the case of mattocks used to work in humus, the traces are definitely most visible and take on the form of broad, diverse in terms of length and depth, highly invasive, destructing the antler surface furrows (fig.3F). On the tools used for digging clay and sand, traces are definitely less visible. The differences in the extent of surface erosion of the blades of both types of artefacts are illustrated by images taken using a scanning electron microscope. The furrows and micro-cracks visible on the tools used to work in rocky humus (fig. 5C) and much smoother and less damaged working surface of replicas used for digging of fine sand (fig. 5D) are especially worth noticing. The preservation of the observed micro-polish differs depending on the type of deposit. It is poorly preserved at the replicas used for digging humus, which should be attributed to the intense destruction of the tools surface during work (fig. 4E). In the observed cases, it occurs in individual, small spots and covers (destroys) upper parts of the antlers relief, giving it a rough texture. It is definitely more visible on tools used for digging in the clay and sand (fig. 4G, H). In these cases, it also takes on the form of polish/abrasion, but cover larger areas of the working edge (however it is still concentrated on the upper parts of the antler relief), and it can be seen as bright plastic streaks, with a rough texture. Described differences in the characteristics of use-wear traces, observed on the experimental tools, used for digging in soil of different grain seem to be quite important. However, it should be kept in mind that these observations are based on a few experiments conducted in very specific conditions. In fact, even the humus can look very different, because its nature depends on the type of the underlying layer and the prevailing environmental conditions. Similarly, in case of sand and clay, which occur in many variations and even within a small area they can show high variability. The observations made here, should not therefore be interpreted as evidence of willingness for compiling a classification of the use-wear traces or aiming at creation of a system that allows to distinguish between tools used to digging the various soils, but as (as previously mentioned) an attempt to create the fullest possible profile for this type of damages.

Use-wear traces observed on the tools used for working with the animal carcasses were completely different in its characteristics. On the working edges of these objects there is a noticeable light damage (peck ness) and individual, intersecting striations, arranged perpendicularly or oblique to its orientation (fig. 3I). The micro-polish has limited range (it is present almost exclusively on the blade) and has a spotted distribution (fig. 4H). It rounds off the working edge and occurs mainly in the upper parts of the antler relief, but it also penetrates its lower parts. The micro-polish gives a slightly ovoid shape to the relief of the raw materials, and is visible as areas of flat or corrugated topography and relatively smooth or slightly rough texture. It is dull / "greasy" in appearance and usually is visible only at higher magnifications. Within its area there are relatively shallow and narrow striations (fig. 4I).

The use-wear traces, appearing on the tools used for scraping the hide are far more visible. However, some differences in the damage traces visible on the replicas, used to work on different types of raw material were observed here. Working edges of tools, which were used for working in the fresh hide are slightly rounded. A “greasy”, flashing micro-polish with smooth topography and invasive intrusion, suffusing (non-destructively) the antlers microrelief was observed on the tools. Unlike the traces of this type described earlier, it is visible also in the deeper parts (fig. 3J). Just like in the case of tools used to work in fresh wood, on the blades of tools used for the described function, there are clearly visible exposed osteons (fig. 5E). Striations are scattered across the whole surface of the working edge and they are similar to those observed on the specimens used to work with wood (fig. 4J).

Damages with different characteristics than in the case of fresh raw material, were observed on the tools used for scra-ping dry hide. These differences are visible already at the macroscopic level. The striations observed with low magnifications are in this case far more numerous, densely arranged and unidirectional (perpendicular to the orientation of the blade - fig.3K). The origin of these differences should be sought in the variable hardness of these two types of raw material (Buc, 2008. P. 61) and more abrasive agents occurred during the scraping of dry hide (Mansur, 1982. P. 219). What's interesting is that photos taken using a scanning electron microscope revealed in this case the presence of numerous small microcracks (fig. 5F). Their origin at this stage of a research is however uncertain. The micro-polish observed on the described tools is a linear, dull polish / abrasion of the invasive intrusion and rough texture (fig. 4K). It is giving the antlers` micro-relief a slightly ovoid shape, but it is usually poorly visible due to the impact of abrasive factors (numerous striations), destroying its topography, which is gaining by this a grooved profile. In the areas less exposed to damaging factors, the micro-polish is visible also in the deeper parts of the microrelief.

The analysis of tools which were used to making blowholes also provided some interesting observations. Despite intensive use, no major damages were observed on these artefacts. On their working edges only slight damage (peck ness) is visible, but it didn`t affect their sharpness (fig. 3L). Striations (scratches) in this case are poor visible and are limited to single scratches. The micro-polish, however is clearly visible (fig. 4L). It is bright and has a rough texture. On most of the surfaces it consists of a groups of wavy linear marks (plastic streaks), inside which there are numerous long and narrow, parallel scratches. Micropolish covers mainly the upper parts of the microrelief (in these areas smoothly abraded and domed), its topography is similar to a flat one. However, it also occurs in the deeper lying parts (however, here it is much duller). The observed effect of the exposure of the antlers` structure (clearly visible osteons with systems of lamellar bone around haversian canals) at the same time with lack of invasive abrasion of the surface is a result of the moisture in the worked material, in this case water, which was acting as a lubricant (LeMoine, 1994. P. 325). This effect was also noticeable in the case of tools used for work on fresh, moist hide, and to some extent, on those used for work on the fresh wood. In the latter case, organic acids contained in wood are responsible for the exposure of the osteons (from the histological point of view) (LeMoine, 1994. P. 324).

Experimental studies have confirmed that the tools like heavy duty bevel-ended could be used for a variety of activities. Observations made at the macroscopic level and using low magnification (up to 100x) can tell us a lot about their potential functions. The presence of damage, such as chipping or breaks on the tools may suggest high hardness of processed material and the type of work being done (mostly hitting). Striations and their arrangement on the surface of the tools are closely linked to the presence of abrasive elements. They are also a good indicator of the direction of work (Semenov, 1964. P. 15; Mansur, 1982, P. 213). No less important are the polishes observed on the surface of the tools, characteristics of which may indicate, among others, the presence of organic acids, moisture or hardness of the processed raw material, for example, like in case of processing tools for different hide types. However, as the conducted experiments have shown, certain types of damage caused to the working edge of a tool, as a result of processing of different raw materials, may appear very similar, as in the case of traces found on the tool used to work on the fresh hide and other ones used for soft wood. Other potential problems with interpretation may come from artefacts used for activities in which, despite the relatively intensive use of, working edges were not significantly changed (macroscopically). A good example of this are tools used for making blowholes, where the identification based on the prehistoric material can be extremely difficult, if not impossible. Despite these complications, conducted microscopic analysis allowed the registration of a number of various traces created on this type of tools as a result of work on different raw materials. Observations that have been made can now be used for preliminary interpretation of the function of prehistoric artefacts, although their fully reliable analysis still needs to be verified by a number of experimental trials and related to the microscopic observations.

Example results of analyzing the functions of archaeological artefacts

The damage traces examined in this study is, to a varying degree, observable in prehistoric artefacts. For the purposes of this paper, it was decided to present the study results of the use-wear analysis of two prehistoric artifacts of the described type. Both relics are examples of the so called "stray finds", namely artefacts which were discovered by accident. The first of the artefacts (fig. 6) is a mattock found in Troszczyn, Nowy Tomyśl district (Greater Poland region). The tool had a radiocarbon dating of 6610 ± 40 BP, which means, that it may be connected to hunter-gatherer societies of the late Mesolithic (Goslar *et al*., 2006. P. 9). Currently this item can be found in the collection of the Archeological Museum in Poznań. Regarding the other analyzed artefact, we have practically no data at our disposal, no information regarding the location or context of its discovery (fig. 7). Its chronology may be in the most general sense be described as early to mid Holocene (Mesolithic / Neolithic). The only hint as to the possibility of dating this artifact can be found in the clearly visible technological traces in the form of cutting marks running around the tine, which are associated with removal of unnecessary parts of antler. Studies of the production techniques of these types of artefacts in the context of early Holocene materials from the territory of northern Germany (Hohen Viecheln 1, Friesack 4 and 27a) and Poland (Dudka 1 and Pobiel 10) have proven, that in the process of dividing antlers the cutting technique begins to gain in significance only in the late phase of the boreal period (Pratsch, 2006. P. 49–50). This information may be a suggestion as to the lower chronological boundary of the analyzed artefact. Currently it can be found in the collection of the Wojciech Kętrzyński Museum in Kętrzyn.

Both artefacts are typologically homogenous, however the observed traces of use differ from each other, which confirms the multifunctional nature of these types of artefacts postulated in literature. The first one is characterized by a relatively intense smoothing of the entire working edge. Its blade is cracked, minor chippings occur on the upper, as well as the lower side of the tool (fig. 6A, B). Their origin, however, is ambiguous and may also be associated with post deposition factors (their color seems to differ from that observed on the tool, which may be evidence, that they may have occurred after discovery). Therefore, they should not be treated as distinctive marks, certainly connected to the original function of that artefact. The mattock bears clearly visible, bright and linear micro-polish which damages the relief of the antler (rounding out its upper parts), with a relatively flat topography and rough texture (fig. 6C). Its intrusion is invasive and accompanied by striations in various directions.

The characteristic of macroscopic damages observed on the artefact (primarily the peck ness of the working edge) indicates, that it could have been used for hitting / digging. However, a lack of clear striations or roughing of the blade surface, characteristic of working in the soil, seems to rule out the tool's direct, intensive contact with this material. The recorded micro-polish is similar to one which occurs as a result of contact with plant material (presence of acids), which indicates work in wood.

The second artefact bears traces of damages of a completely different type. Its working edge is severely shortened practically along the entire length, as a result of intense breaking off of the compact material to the upper side. The series of negatives here are very clear, in some places arranged in multistep relation to each other (fig. 7A). In certain bends, as well as in the spongiosa, it is possible to notice fragments of a light-brown plant material, possibly wood (fig. 7A, marked with arrows). Unfortunately, their origin is not clear, which makes it impossible to associate them with the possible function of the item. Intense breakages are also visible in the context of the spongiosa. Despite significant damage of the entire working edge and major erosion of the original surface of the tool, in certain locations of its blade (spots) feature clear, bright, linear micro-polish/wear, which damages the upper sections of the antlers' relief (fig. 7B). This is accompanied by one-directional, relatively uniform striations, perpendicular to the orientation of the artefact's blade.

This tool has most assuredly been intensely used, most likely for hitting, probably hewing. However, in light of the use-wear analysis results of the experimental replicas included in the study, the interpretation of its original function remains impossible. The traces observed in this case, especially the micro-polish, are not reflected in the observations made in regards to the experimental tools. Its spotted nature, linearity and relatively rough texture, mostly correspond to the micropolish recorded on tools used for digging in the soil. It is, however, too bright and its topography is too flat for damage corresponding to such a function. It also does not go together with the characteristic of observed striations and the general appearance of the described tool's working edge (deep breakages and lack of blade roughing). Maybe the artefact was used for activities not replicated during the experiment. Micro-polish with a characteristic similar to a certain extent is seen on flint tools used for the working in bones. Unfortunately, flint items cannot be compared to the same extent with organic material tools, which is why the solution to the described issue will require further experimental and use-wear studies.

Summary

The conducted experimental studies made it possible to compile a set of traces of use characteristic of certain activities performed using tools made out of antlers, formally corresponding to prehistoric artefacts described as heavy duty bevel-ended tools. It is obvious, that modern treatment of individual types of materials or the specific duration of conducted experiments make the characteristic of damage due to use recorded on the tools used during the experiments may to some extent differ from the wear observed on prehistoric materials. In contrast to experimental tools, whose "life cycle" ends with the conclusion of the controlled, usually homogenous trial, prehistoric tools may have been used multiple times for various activities. Apart from that, it should be taken into account that their current condition was also severely influenced by secondary phenomena. Thanks to long-term studies of taphonomic notions and their contribution to the bone material degradation process, decay of this type have been relatively well characterized in literature of the subject (incl. Fisher, 1995. P. 12–46). This includes transformations resulting from different types of post deposition factors, including the type of sediment and acidity/alkalinity of soil, where the artifacts were deposited (Buc, Loponte, 2007. P. 144; Orłowska, 2007. P. 1), but also changes associated with so called tramping (in equal measure arising from the activity of humans, as well as wild animals (incl. Olsen, Shipman, 1988. P. 536) and other transformations caused by plants and animals (incl. Olsen, 1989. P. 124–134; Jin, Shipman, 2010. P. 95–99). Despite studies conducted on a relatively large scale, knowledge regarding the influence of such phenomena is still incomplete, for example in the context of the effect of deposit environments on the observed micro-polish. Therefore, the classification of use-wear traces conducted in this study should be approached with caution, especially considering that, as shown by the use-wear analysis of the latter of the studied artifacts, it did not cover all possible materials and types of activities, which may have been performed using heavy duty bevel-ended tools in prehistoric times. Most assuredly, the conclusions drawn here will undergo multiple modifications, also as a result of studies conducted by the article's authors. One should remain hopeful, that studies of this type will be conducted with increasing intensity, as the issue of the

possibility of interpreting damage resulting from use of bone material tools is examined to a far lesser degree, than in the case of, for example, stone materials.

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About the authors:

Orłowska Justyna. Magister, PhD.- student. Institute of Archaeology, Nicolaus Copernicus University. 44/48 Szosa Bydgoska str., Toruń, 87-100, Poland; orlowskajustyna@wp.pl

Osipowicz Grzegorz. PhD. Institute of Archaeology, Nicolaus Copernicus University. 44/48 Szosa Bydgoska str., Toruń, 87-100, Poland; grzegorz.osipowicz@umk.pl

К ВОПРОСУ О ФУНКЦИЯХ РАННЕГОЛОЦЕНОВЫХ РОГОВЫХ ОРУДИЙ СО СКОШЕННЫМ КОНЦОМ (ПО РЕЗУЛЬТАТАМ ЭКСПЕРИМЕНТАЛЬНЫХ ИССЛЕДОВАНИЙ И ИЗУЧЕНИЯ СЛЕДОВ ИЗНОСА)

Ю. Орловская, Г. Осипович

Массивные орудия со скошенным концом, такие как топоры и мотыги, принадлежат к числу наиболее часто встречающихся вещей на стоянках охотников-собирателей раннего голоцена Европы. Установлено, что рабочий край этих орудий скошен под углом примерно 50 градусов, а основным сырьем для их изготовления служил, главным образом, рог оленя. Главная цель настоящего исследования – классификация, анализ, интерпретация и корреляция макро- и микроследов, образующихся на экспериментальных репликах орудий такого рода. В ходе экспериментов было опробовано большое количество разных рабочих операций. При этом учитывалось возможное влияние множества факторов, таких как вид обрабатываемого материала (почва, дерево, шкура, мясо, лед), тип выполняемых действий (рубка, копание, скобление, теска, долбление) и продолжительность работы. Изучалась также эффективность орудий их пригодность для разных операций.

Ключевые слова: экспериментальная археология, массивные орудия со скошенным концом, следы износа, роговые изделия, каменный век.

Информация об авторах:

Орловская Юстина, магистр, аспирант, Институт археологии, Университет Николая Коперника (г. Торунь, Польша); orlowskajustyna@wp.pl

Осипович Грегор, доктор, Институт археологии, Университет Николая Коперника (г. Торунь, Польша); grzegorz.osipowicz@umk.pl

Table 1. Experimental database.

Number	Tool	Activity	Working material	Hafting	Kind and state of the material	Working angle	Use time
1	Axe	Chopping	Wood	Wooden handle	Hard, young broadleaf	High	20 min.
2	Axe	Chopping	Wood	Wooden handle	Hard, young broadleaf	High	30 min.
3	Axe	Chopping	Wood	Wooden handle	Hard, young broadleaf	High	60 min.
4	Axe	Chopping	Wood	Wooden handle	Hard, young broadleaf	High	120 min.
5	Axe	Chopping	Wood	Wooden handle	Hard, maturity, broadleaf	High	60 min.
6	Axe	Chopping	Wood	Wooden handle	Soft, maturity broadleaf	High	60 min.
7	Axe	Chopping	Wood	Wooden handle	Soft, maturity coniferous	High	60 min.
8	Axe	Chopping	Wood	Wooden handle	Soft, maturity coniferous	High	90 min.
9	Mattock/adze	Hewing	Wood	Wooden handle	Charred, broadleaf wood	High	30 min.
10	Mattock/adze	Hewing	Wood	Wooden handle	Charred, broadleaf wood	High	60 min.
11	Mattock/adze	Digging	Soil	Wooden handle	Black earth	High	80 min.
12	Mattock/adze	Digging	Soil	Wooden handle	Black earth	High	90 min.
13	Mattock/adze	Digging	Soil	Wooden handle	Sand	High	120 min.
14	Mattock/adze	Digging	Soil	Wooden handle	Sand	High	180 min.
15	Mattock/adze	Digging	Soil	Wooden handle	Clay	High	30 min.
16	Mattock/adze	Digging	Soil	Wooden handle	clay	High	60 min.
17	Axe	Hitting	Flesh	Wooden handle	Fresh, pork carcass	High	30 min.
18	Axe	Hitting	Flesh	Wooden handle	Fresh, pork carcass	High	60 min.
19	Axe	Hitting	Flesh	Wooden handle	Fresh, beaf carcass	High	30 min.
20	Axe	Hitting	Flesh	Wooden handle	Fresh, beaf carcass	High	60 min.
21	Reutilized form	Scraping	Hide	None	Fresh deer hide	Low	60 min.
22	Reutilized form	Scraping	Hide	None	Fresh deer hide	Low	120 min.
23	Reutilized form	Scraping	Hide	None	Dry deer hide	Low	60 min.
24	Reutilized form	Scraping	Hide	None	Dry deer hide	Low	120 min.
25	Mattock/adze	Hitting	Ice	Wooden handle	Frozen lake	High	60 min.
26	Mattock/adze	Hitting	Ice	Wooden handle	Frozen lake	High	90 min.

Table 2. Characterization of the use-wear traces observed on the experimental tools.

Damages			Worked material and activity									
			Digging			Chopping		Hewing	Hitting	Scraping		Hitting
			Humus	Clay	Sand	Hard, Young Wood	Soft,maturity Wood	Charred Wood	Flesh	Fresh deer skin	Dry deer skin	Ice
Rounding and other damages on the working edge	Working edge lightly rounded			X	X		X	X	X	X	X	X
	Working edge strongly rounded		X			X						
	Peck ness		X	X		X	X		X			X
	Micro bends and cracks		X	X	X	X	X	X			X	
	Grinding		X	X	X						X	
	Roughness		X	X				X				
Breakages	Location	Working edge	X			X	X	X				
		Spongiosa	X			X	X					
	Distribution	Single	X			X	X					
		Dense						X				
	Complexity	One-step	X				X					
		Multistage				X		X				
	Size	Under 5 mm	X				X	X				
		Above 5 mm				X		X				
Striations	Distribution towards the working edge	Perpendicular	X	X	X		X	X	X		X	X
		Diagonal	X						X			X
		Multidirectional	X			X	X	X		X		
	Morphology	Long (above 1mm)	X	X	X	X	X	X	X	X	X	X
		Short (below 1mm)	X	X	X	X	X	X	X	X	X	X
		Narrow	X	X	X	X	X	X	X	X	X	X
		Broad	X	X		X		X	X			
		Shallow	X	X	X	X	X	X	X	X	X	X
		Deep	X	X	X	X		X	X		X	
	Arrangement	Single	X	X		X	X	X	X	X	X	X
		Dense	X	X	X	X	X	X			X	
		Crossed	X			X	X	X	X	X		
		Spread	X	X	X	X	X	X	X	X	X	X
		Parallel	X	X	X		X	X			X	X
Micro-polish	Degree of intrusion	Marginal (below 1cm)	X	X				X	X			
		Invasive (above 1cm)			X	X	X			X	X	X
	Distribution	Isolated spots	X						X			
		Spread		X	X	X	X	X		X	X	X
		Streaks		X	X						X	X
	Degree of linkage	Only higher parts of relief	X	X	X	X	X	X	X	X	X	X
		Also lower parts of relief								X	X	X
	Texture	Smooth				X	X		X	X		
		Rough	X	X	X			X	X		X	X
	Topography	Domed	X	X	X			X	X	X	X	
		Flat				X	X	X	X	X		X
		Corrugated							X		X	
		Unrecognizable	X	X	X							
	Brightness	Bright	X	X	X							X
		Dull					X		X		X	
		Greasy							X	X		
		Glossy				X		X		X		
Other		Exposed osteons				X	X			X		X

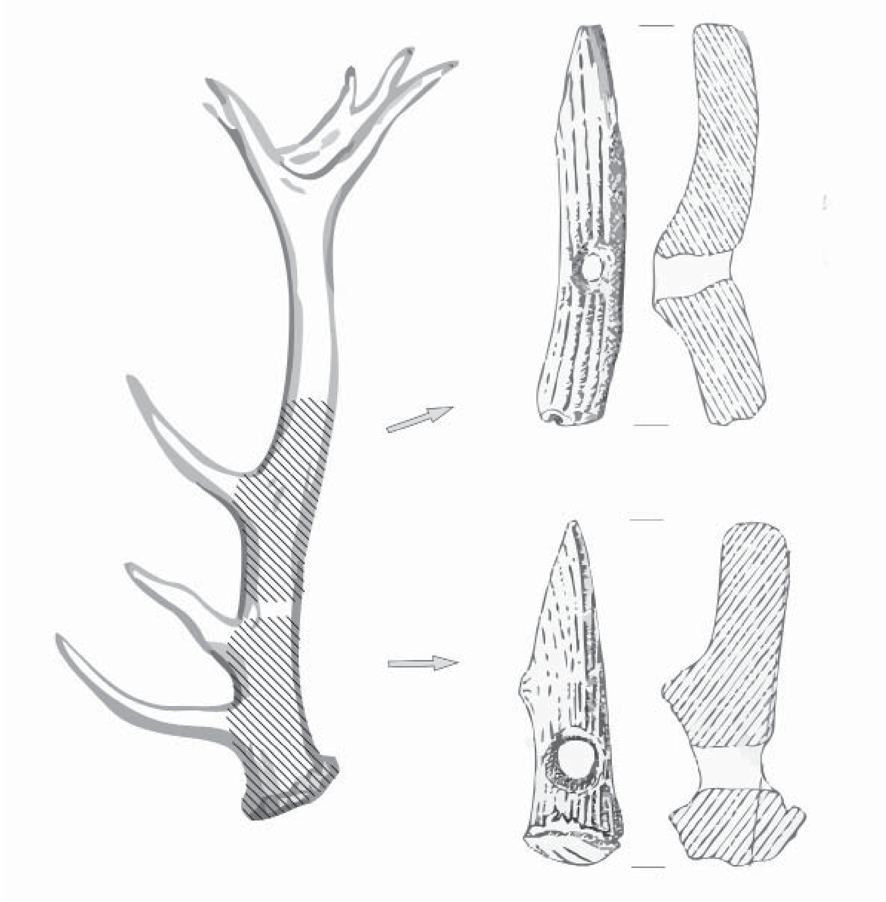

Fig. 1. Example of red deer antler with marked elements of beam used for making heavy duty bevel-ended tools.

Fig. 2. Examples of photographs illustrating the experimental works. a) chopping young/hard wood; b) chopping soft wood c) hewing burnt wood; d) digging rocky, grassy humus; e) digging fine loose sand; f) digging compact sandy clay; g) hitting cattle carcass; h) scraping fresh deer hide; f) making a blowhole.

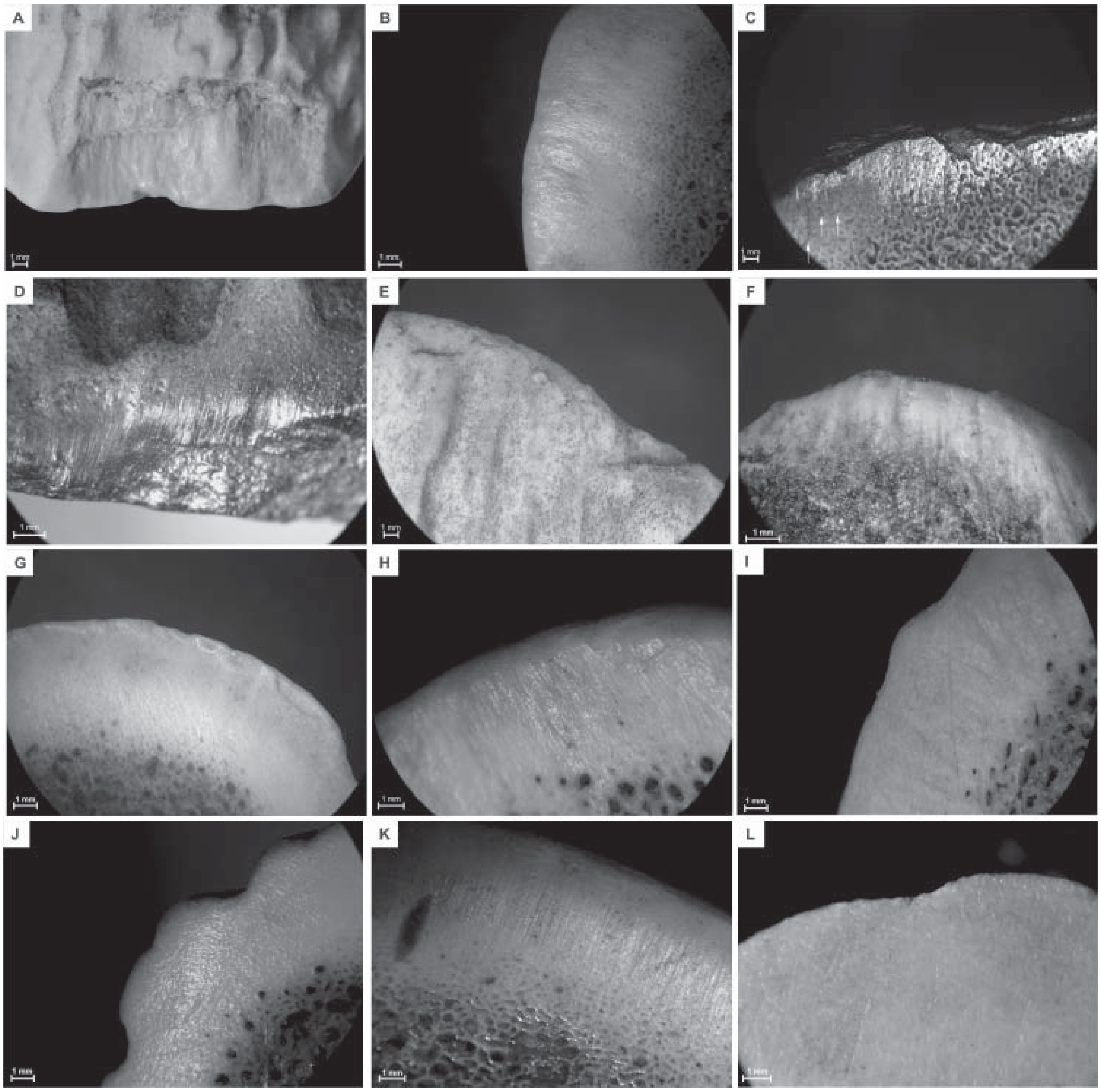

Fig. 3. Micrographs of use-wear traces visible with naked eye and small magnifications (>100×). A – chopping young/hard wood – large breakages on the upper side of the working edge; B – chopping soft wood – subtle damage (peck ness) of the working edge; C – hewing burnt wood – intense chipping and glossy surface. Arrows show scattered polygonal cracking pattern; D – hewing burnt wood – long, thick and parallel to each other scratches; E – digging rocky, grassy humus – small breakages, mostly on the upper side of the tool; F – digging rocky, grassy humus – broad, diverse in terms of length and depth, highly invasive, destructing the antler surface furrows; G – digging compact sandy clay – slightly roughened working edge; H – digging fine loose sand – intense abrasion and polishing; I – hitting animal carcasses – light damage (peck ness) and individual, intersecting striations, arranged perpendicularly or oblique to its orientation; J – scraping fresh deer hide – a "greasy", glossy micro-polish with smooth topography and invasive intrusion; K – scraping dry deer hide –numerous, densely arranged and unidirectional (perpendicular to the orientation of the blade) striations; L – working in ice – slight damage (peck ness) of the working edge, single scratches.

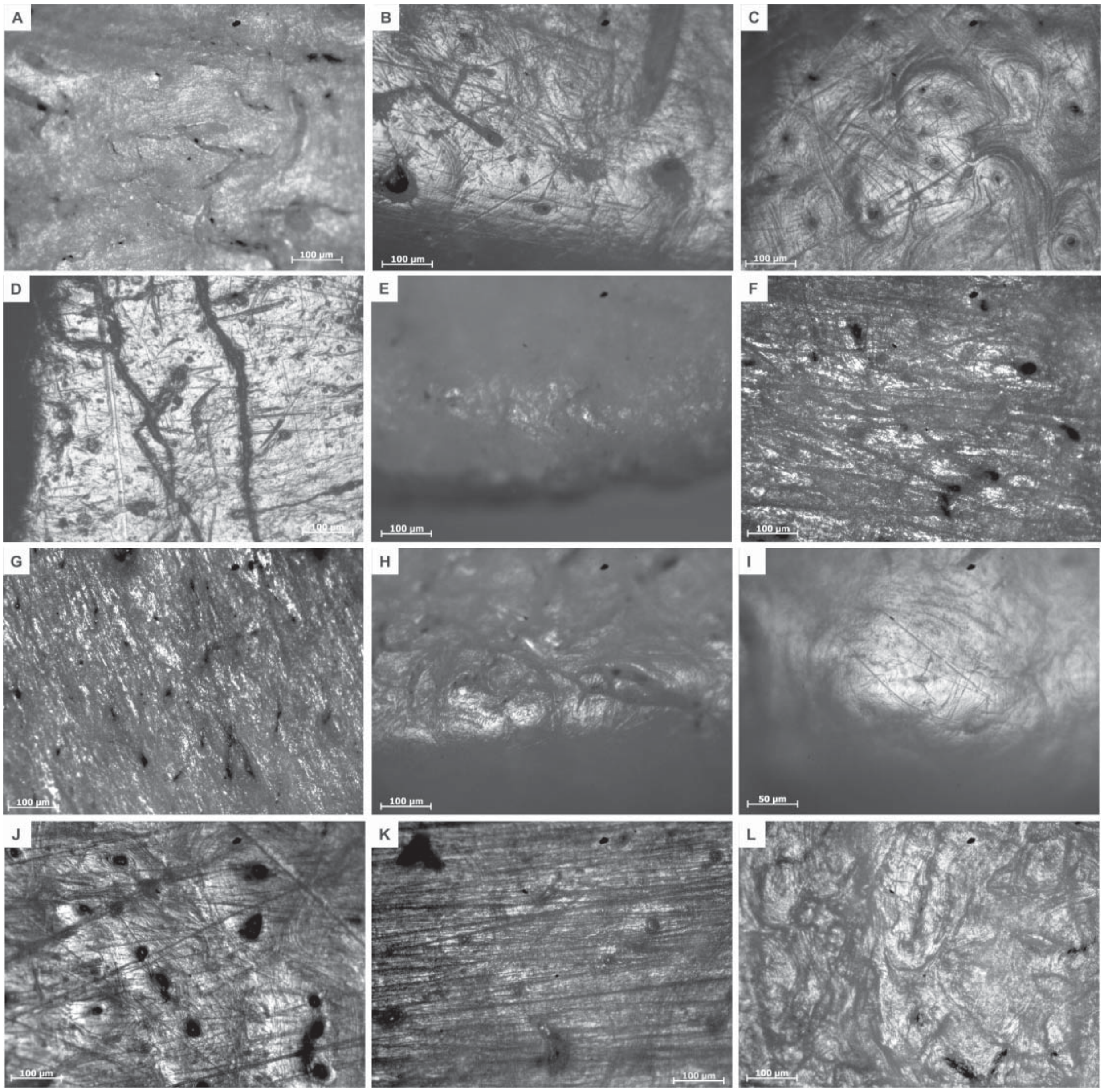

Fig. 4. Micrographs of use-wear traces visible with high magnifications (<100×). A – antlers` surface before use; B – chopping young/hard wood – invasive micro-polish (flat topography, glossy); C – chopping soft wood –much more duller and less invasive micro-polish; D – hewing burnt wood – invasive, bright and glossy micro-polish; E – digging rocky, grassy humus – intense destruction of the tools surface with spotted, rough micro-polish; F – digging compact sandy clay – micro-polish in a form of bright plastic streaks, with a rough texture; G – digging fine loose sand–micro-polish in a form of bright plastic streaks, with a rough texture; H – hitting animal carcasses – dull/"greasy" spotted micro-polish I – hitting animal carcasses – relatively shallow and narrow striations coexisting with micro-polish; J – scraping fresh deer hide – "greasy", glossy micro-polish with smooth topography; K – scraping dry deer hide – linear, dull polish / abrasion of the invasive intrusion and rough texture; L – working in ice – bright, clearly visible micro-polish consists of a groups of wavy linear marks (plastic streaks).

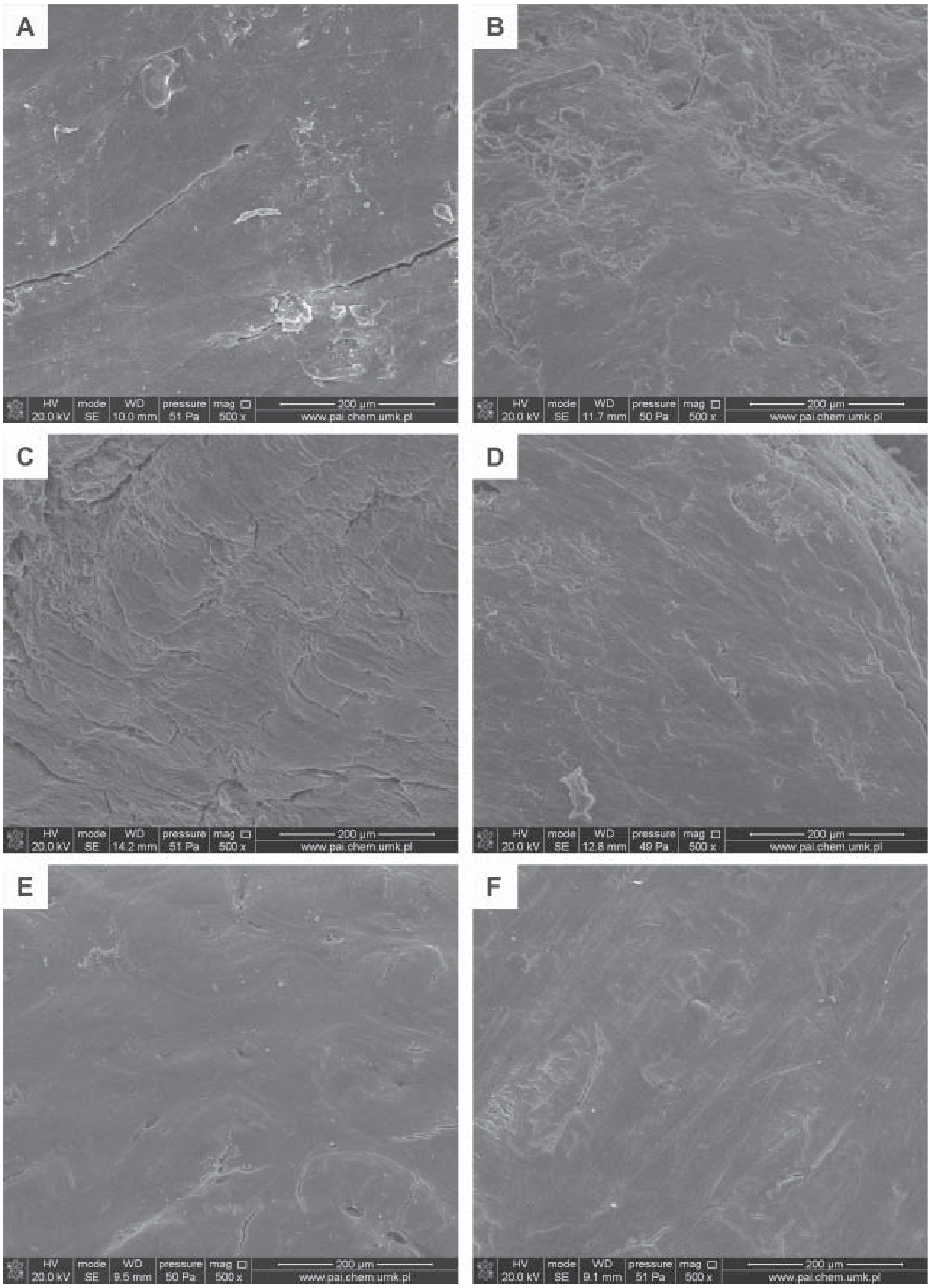

Fig. 5. Photos taken using a scanning electron microscope (SEM). A – chopping young/hard wood – visible micro-cracks in the structure of antler; B – hewing burnt wood – good visible surface erosion; C – digging rocky, grassy humus – strongly eroded surface with furrows and micro-cracks; D – digging fine loose sand – surface smoother and less damaged than in case of humus; E – scraping fresh deer hide – clearly visible exposed osteons; F – scraping dry deer hide – abrasion and small microcracks.

Fig.6. The mattock from Troszczyn, Nowy Tomyśl district (Greater Poland region) with examples of visible use-wear traces.

Fig.7. The mattock (town unknown) with examples of visible use-wear traces. Arrows indicate the location of fragments of a light-brown plant material, possibly wood.

УДК 903.01 903.03

ОБРАБОТКА БИВНЯ МАМОНТА НА ВЕРХНЕПАЛЕОЛИТИЧЕСКОЙ СТОЯНКЕ КЛИМЭУЦЬ II НА СРЕДНЕМ ДНЕСТРЕ

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В 1989 году в результате спасательных работ, была исследована верхнепалеолитическая стоянка Климэуць II, расположенная на Среднем Днестре, с многочисленными остатками мамонтовой фауны. В настоящей работе рассматриваются предметы, изготовленные из бивня мамонта, а также их интерпретация и назначение в хозяйственной деятельности человека.

Ключевые слова: археология, верхний палеолит, стоянка Климэуць II, мамонт, обработка бивня мамонта, технология.

Стоянка Климэуць II находится в центре села Климэуць де Жос Шолдэнешского района (Республика Молдова) (рис. 1), на правом берегу Днестра на высокой, предположительно, третьей надпойменной террасе, представляет собой неровную поверхность, ограниченную с запада крутым склоном долины, нарушенным глубокими оврагами оползнями (Билинкис, Друмя, Дубиновский, Покатилов, 1978. С. 62–78).

Стоянка была обнаружена Т. Обадэ в 1989 г. при проведении строительных работ. В раскопках 1989 г. принимали участие сотрудники Академии наук Молдовы археологи С. Коваленко, И. Артюх, А. Левинский, И. Мельничук, А. Высоцкий, В. Гукин, археозоолог Т. Обадэ, палеогеографы А. Гольберт, С. Медяник, В. Моток, под руководством И.А. Борзияка (Borziac, Chirica, David, Obadă, 2007. С. 74). В самом начале исследований на площади 25×30 м, на глубине 1,5-2,5 м, были обнаружены многочисленные кости мамонта и других видов животных. В том же году было заложено два шурфа в 30 м от раскопа, которые дополнили данные о стратиграфии памятника (Борзияк, Гольберт, Медяник, Моток, 1992. С. 33–34). В результате археологических изысканий 1989 г. была исследована площадь около в 164 м^2, на которой были обнаружены и комплексно изучены два культурных слоя, с кремневыми находками ориньякоидного облика (Borziac, Chirica, David, Obadă, 2007. С. 80).

По образцу гумусного экстракта из нижнего слоя, получена дата в 24840±410 BP (ЛУ-2351). Верхний культурный слой отделен от нижнего слоем лессовидных суглинков. По образцу зуба мамонта из этого слоя получена дата в 20350±230 BP (ЛУ-2481) (Борзияк, Давид, Обадэ, 1992. С. 91-92).

Верхний слой стоянки содержал многочисленные остатки костей мамонта (черепа, бивни, челюсти, берцовые и т.д.), бизона, лошади, благородного оленя и другие (Obadă, David, Borziac, 1994. С. 252), которые образовывали округлое скопление, в центре которого находился обожженный участок грунта, диаметром 30-35 см кирпичного цвета с небольшими вкраплениями золы, рядом с которым, к востоку, находилась небольшая ямка, заполненная остатками горения и мелкими обгоревшими и раздробленными костьми. Данное скопление, вероятнее всего, представляет собой остатки жилища костного типа, в строительстве которого использовали черепа, челюсти, трубчатые и берцовые кости мамонта (Borziac, Obadă, 2001. С. 13). Вход жилища, скорее всего, находился в юго-восточной части скопления, где наблюдается разрежение костных остатков. Также в данной зоне наблюдается довольно большая концентрация кремневых предметов и отходов расщепления, представляющие собой так называемую зону «топталища» (Пидопличко, 1969. С. 18). На данный момент, данный памятник является самым ранним и южным в Восточной Европе, на площади которого было изучено жилище костного типа.