Światowit • LXI • 2022

Stepanchuk Vadim N.
National Academy of Sciences of Ukraine, Institute of Archaeology, Stone Age Archaeology Department,
Vadim.Stepanchuk@gmail.com
ORCID: 0000-0002-5476-2284

Naumenko Oleksandr O.
Taras Shevchenko National University of Kyiv,
National Museum of the History of Ukraine, Sector "Archaeology of the Stone and Bronze Ages" of the Research Department of Archaeology.
alexandr.naumenko.jr@gmail.com
ORCID: 0000 0003 3931-603X

Experimental cut mark replication as a means for understanding linear marks on archaeological bones from the Medzhibozh Lower Palaeolithic sites

Abstract

The paper presents the first results of experimental modelling of a series of cut marks on bones in different states of preservation. We used experimental (quartz, flint) and technogenic (granite) flakes with sharp and blunt unretouched working edges and trimmed edges produced by the bipolar-on-anvil technique. V-, П-, and U-shaped cut marks and surface damage were obtained. The data gained are useful for the reconstruction of conditions of occurrence of cut marks on bones found in the uppermost culture-bearing horizons of the Lower Palaeolithic sites near Medzhibozh, located in the upper reaches of the Southern Bug River and dated to MIS 11. The data can also be used for differentiating between anthropogenic and natural damage and as a significant statistical point of reference.

Key words: experiments, cut marks, V-, П- and U-shaped grooves, Lower Palaeolithic, Medzhibozh.

1. Introduction

It is generally accepted that the archaeozoological aspect of studying Palaeolithic site materials is an important source for reconstructing the socio-economic behaviour of early hominins and detailing the culture-bearing layer formation processes. In particular, archaeozoological data constitutes a rare and valuable source for studying the Plio-Pleistocene Lower Palaeolithic sites[1]. Many authors have reported the high variability of taphonomic circumstances and technological and behavioural features that lead to the appearance of different types of modifications on bones found in the context of ancient sites[2]. These observations emphasise the need for including a thorough verification phase in the studies of Palaeolithic bones showing signs of any modifications. One way to perform such verification is through experimental simulation, which aims to clarify the circumstances and causes of specific damage similar to that observed on archaeological relics. The morphological patterns established by the analysis of experimental data provide a basis for a more reasoned reconstruction of the probable causes of damage on bones from archaeological contexts and reproduction of the characteristics of the tools involved as well as the resulting movements. Ideally, the study of bone remains from a Lower Palaeolithic site requires an integrated approach that combines taphonomic, experimental, use-wear, and technological aspects[3]. In our case, the research focuses mainly on the experimental aspect of studying anthropogenically modified bones from the Lower Palaeolithic sites of Medzhibozh, bones with cut marks in particular. We conducted experiments using bones in various states of preservation to simulate the actions that may have occurred at the site. This was deemed justified, because the materials found at the site suggest that ancient hominins may have interacted with bones in different states of preservation and the petrographic composition of the stone tools found there indicates that a wide variety of rock types were used for cutting and splitting. One of the most common finds in the Lower Palaeolithic materials of Medzhibozh 1 and, to a lesser extent, Medzhibozh A are faunal remains[4]. Frequent among them are pieces with signs of likely intentional fragmentation and, less frequently, bone fragments with cut marks, notches, percussion dents, and removal scars. The collection of bones with anthropogenic modifications is the most representative in Layer III of Medzhibozh 1[5]. Most of the modifications are related to the utilisation of animal carcasses and bones and result from breaking, cutting, chopping, and splitting. A smaller portion of the bones reflects, probably intentional, processing of bone fragments by knapping or retouching. Almost all of the bones were found crushed, probably due to intensive bone marrow extraction. The morphology of cut marks is diverse. There are thin cut marks, presumably left by the feathery edge of an unretouched flint flake; coarser cut marks, possibly associated with a retouched flint edge; wide cut marks, probably left by the edges of a non-flint instrument; and grooves resembling cut marks that leave burin-like edges. The inconsistency of cut marks'

---

[1] Potts, Shipman 1981; Blumenschine 1991; Domínguez-Rodrigo *et al.* 2005; McPherron *et al.* 2010; Stepanchuk, Moigne 2016; Zutovski, Barkai 2016; Pawłowska 2017; Konidaris *et al.* 2018; Domínguez-Rodrigo *et al.* 2022.

[2] Fisher 1995; Olsen, Shipman 1988; Domínguez-Rodrigo *et al.* 2009; Manifold 2012; Dupras, Schultz 2013.

[3] Blumenschine 1995; Domínguez-Rodrigo 1999; Domínguez-Rodrigo *et al.* 2012; Mateo-Lomba *et al.* 2020; Domínguez-Rodrigo *et al.* 2021.

[4] Stepanchuk, Moigne 2016; Stefaniak *et al.* 2021; Stepanchuk *et al.* 2019.

[5] Stepanchuk *et al.* 2021.

morphology corresponds well to the highly variable characteristics of edges of available lithic products. Hominins used various rocks for manufacturing implements in Medzhibozh 1 and A: flint, quartz, quartzite, granite, limestone, sandstone, slate, etc. The different properties of the used stone probably determined the various parameters of flakes and their edges, either unmodified or processed by retouching, knapping, or a specific trimming-on-anvil technique. It is also assumed that sharp edges of bone splinters and shell fragments were used situationally for cutting. The diversity of linear traces of anthropogenic nature in the Medzhibozh sample is supplemented by linear marks, presumably as a result of various taphonomic processes.

2. Materials and method

2.1. Archaeological context

The multilayered Lower Palaeolithic sites of Medzhibozh 1 and Medzhibozh A, located in the upper reaches of the Southern Bug (Fig. 1), contain an Oldowan-type core-and-flake archaic stone industry and date back to 1.2 to 0.4 Ma[6].

Medzhibozh 1 and Medzhibozh A sequences comprise Lower and Middle Pleistocene sod-podzolic, meadow, and marsh soils and lake-alluvial floodplain sediments deposited on Archean granites and overlain by Upper Pleistocene loesses and buried soils. The youngest culture-bearing layers of Medzhibozh 1 (Layer III) and Medzhibozh A (II and I) are correlated with the beginning of the Zavadivian (zv1, MIS 11), the oldest Medzhibozh A layers (VI and V) are correlated with the Shirokinian stage (sh, MIS 35–21)[7]. Palaeomagnetic testing of the Medzhibozh A section has not provided reliable data on the Matuyama-Bruhnes boundary in the lower part of the sequence[8]. The available biostratigraphic data on large and medium-sized mammals[9], the micro-mammalian fauna[10], and ESR dates[11] are in good agreement and corroborate the Holsteinian age of the uppermost layers of the Medzhibozh Lower Palaeolithic sites.

All artefact-bearing horizons contain items made of small flint and quartz pebbles, as well as other rock fragments and debris. Artefacts are accompanied by remains of proboscides, rhinoceroses, horses, deer, bears, large felines (lion or leopard), wild boar, etc., although in varying composition and variable frequency. Most numerous faunal remains are revealed in Medzhibozh Layer III[12]. In

---

[6] Stepanchuk 2022.

[7] Matviishina, Karmazinenko 2014; Matviishina, Karmazinenko *in press*.

[8] Hlavatsky *et al.* 2021.

[9] Stepanchuk, Moigne 2016; Stefaniak *et al.* 2021.

[10] Rekovets 2017.

[11] Qi *et al.* 2018.

[12] Stepanchuk, Moigne 2016; Stefaniak *et al.* 2021.

Medzhibozh A, fauna is relatively scarce, intensely fragmented, and partly fossilised, especially in the lower layers[13].

The size and composition of bone fragments from the Holsteinian layers I and II of Medzhibozh A closely resemble materials from the synchronous Layer III of Medzhibozh 1[14]. Despite the worse preservation of fauna from Medzhibozh A, fragments with various marks and evidence of intentional splitting of bones were also revealed there. Bone splinters demonstrate diverse anthropic transformations, such as intentional fragmentation, cut marks, chop marks, and percussion marks[15].

The Holsteinian lithic industry is based on flint and quartz pebbles, supplemented by small quantities of vein quartz, quartzite, sandstone, limestone, slate, and granite. Artefacts are represented by a small number of choppers, fragmented pieces of stone, a small number of flakes and flake tools, including isolated asymmetrical points, end scrapers, and side scrapers (Fig. 2: 1–10). A characteristic feature is the predominant use of bipolar-on-anvil splitting, segmentation, and edge trimming with a minimal role for freehand knapping, flaking, and retouching. The typological and technological characteristics make attributing Medzhibozh MIS 11 assemblages to the so-called Mode I core-and-flake industries reasonable.

Periodic flooding of the area which yielded artefacts and fauna, and the resulting saturation of the sediments with moisture, has given the finds a specific type of preservation, particularly the rounded ridges on the bones and flints. Some bones have sandy cement on the surface and are stained with manganese and iron oxides.

The most representative series of bones with anthropogenic modifications are found in Layer III of Medzhibozh 1. The materials contain bone fragments with different types of linear cut marks, including thin and deep V-shaped, wide, broad, and less deep U-shaped, as well as Π-shaped with steeper laterals, which resemble burin-produced grooves. These cut marks are found mainly on fragments of the diaphysis of large bones and fragments of ribs of large and medium-sized animals, such as deer and rhinoceros, as well as on bird remains. They partly appear to be accidental damage caused during the dismembering of animal carcasses (Fig. 3: 1–2, 8a), except for a small skull fragment of an uncertain species (Fig. 3: 6) and a group of cut marks on the claw phalanx of a white-tailed eagle, which are rather specific (Fig. 3: 3). This last find is unique given the age of the site and clearly demonstrates the interest of the MIS 11 hominins in predatory bird remains. The collection also contains bones with linear marks of trampling nature (Fig. 3: 4a, 7, 8b) and isolated tooth marks (Fig. 3: 4). There are also marks of, presumably, scraping (Fig. 3: 9b) and ripping (Fig. 3: 5), although the anthropogenic origin of either or both of these patterns is ambiguous and needs

---

[13] Stepanchuk *et al.* 2019.

[14] Stepanchuk *et al.* 2021.

[15] Stepanchuk, Moigne 2016, Figs. 11, 12.

experimental verification. Some of the suspected cut marks have V-shaped profiles, while others are U-shaped or Π-shaped with furrows. We intend to determine whether all or part of them, regardless of cross-sectional shape, may indeed be of anthropogenic origin.

2.2. Experiments: general information

The main series of experiments were conducted by the authors in July 2021 at the State Historical and Cultural Reserve "Mezhybizh", additional ones in the fall of 2021 in Kyiv at the National Museum of History of Ukraine and in a field station in the Zhytomyr region in July 2022.

The purpose of the experiment. The focus of our experiments is to clarify the conditions and, to some extent, to model the circumstances of the appearance of morphologically different types of cut marks on archaeological bones. The aim was to obtain a sample of Π-shaped, U-shaped, and V-shaped cut marks on bones in different states of preservation. This experimental procedure involved: *a)* the use of tools made of different rock types and organic matter (quartz, flint, granite, bone, and antler) and *b)* the use of morphologically different edges (sharp, blunt, trimmed-on-anvil edge). The applied movements' kinetics were: towards oneself, from oneself, and reciprocating (i.e. sawing motion). The cut mark features that could be analysed included the shape in plan view, shape in cross-section, depth and width, and presence or absence of groove bifurcation and micro-scratches (micro-furrows)[16]. The present study concentrates on showcasing specific aspects of bone damage morphology, such as the cross-sections, the entry and exit properties of cut marks, and cutting depth variations based on movement dynamics.

Protocols, recording, and laboratory processing. During the active phase, the instruments were held in the right hand (dominant for the experimenters). The bone to be treated was primarily placed on a horizontal surface and held by the left hand (less often – fixed in free hand). During the movements away from and towards oneself, a single passage of the instrument was applied; only in the case of reciprocating movements did the number of effective actions increase (7 to 8 on average). Different tools could be used to simulate damage on a particular bone, and a particular tool could be used to experiment with different bones. The so-called "separate experiment" and "element of the experiment" were distinguished to facilitate data organisation and systematisation of results. The former denotes an act of using a specific tool on a specific bone in the same type of movement. Since the physical dimensions of the involved bone fragments differed, the number of experiments performed for different bones was not the same and had to be determined situationally. For example, the surface area of one of the dry bones (Bone B, a fragment of the diaphysis of the

---

[16] See Domínguez-Rodrigo *et al.* 2012; López-Cisneros *et al.* 2019.

long bone of *Bovinae*) allowed for 15 experiments, while the small size of the fresh Bone D (fragment of the humerus of *Sus scrofa*) afforded only three experiments. Each experiment contained several elements (most often 3 to 4). An element is a discrete result of the same type of movement of a stone tool (for example, toward oneself), which resulted in a cut mark on the bone surface. For instance, in Bone B the total number of individual elements of the above-mentioned 15 experiments reached 57, while in the case of Bone D, there were only 14. The course of the experiments was recorded in protocols, accompanied by photo and, partially, video recording. The descriptive data are stored in Microsoft Excel databases. The experimental samples were processed using magnifying equipment, particularly magnifying lenses, a binocular microscope MBS-9, Bresser Advance ICD trinocular, Sigeta Expert, and Biwyily USB500xDM electron microscopes with appropriate software.

The bone sample. The experiments used predominantly fragments of long limb bones from cows, deer, pigs, and hens. A total of 10 limb bone fragments were involved, of which five were fresh (*Bovinae* and *Sus scrofa* bones), two dry (*Bovinae* and *Gallus gallus*), and three eroded (*Cervidae* and *Equidae*). Several types of raw materials were distinguished by their state of preservation: fresh bone (with remnants of meat, cartilage, and tissue, as well as boiled), dry bone (25 years old), and partially eroded bone (approximately 200 years old). This selection of objects for processing is due to the context of the Medzhibozh sites, whose culture-bearing layers could occasionally be exposed to the aquatic environment and eroded. Thus, an indefinite time could have passed between the bone being discarded and its intentional or accidental anthropogenic modification[17]. All samples, except the eroded ones, were stored in protected conditions. However, all the involved bone types showed no intense signs of change due to natural factors. The most significant difference between the "fresh" boiled and "dry" bone is the degree of hardness: over time, the bone becomes harder (and thus less elastic) and much harder to process. Greater saturation with organic matter, fat particles, the presence of periosteum, etc., characterise samples of fresh bone. These bones were boiled and cleaned of organic matter after the experiment. Samples of dry bone do not retain any organic matter or periosteum on the surface. Partially eroded bones are less tight and much easier to process.

Tools used. Flakes of flint, quartz, granite, as well as fragments of bone and antler were used. The experimental replicas made according to the technological model of the Medzhibozh sites, particularly Layer III of Medzhibozh 1[18], were used as quartz and flint tools to simulate anthropogenic damage on the bones. Among such instruments were bipolar-on-anvil primary flakes

---

[17] Stepanchuk, Naumenko 2022.

[18] Ryzhov *et al.* 2019.

(Fig. 4: 1) and local Southern Bug flint and quartz pebbles (Fig. 4: 2–3), and free-hand flakes of the Dniester flint (Fig. 4: 8–11). The technogenic flakes and fragments of fine-grained pink and medium-grained dark-grey Zhytomyr granite were also used as stone tools (Fig. 4: 4–7). Apart from stone implements, fragments of tubular cow bone and antler were used as tools (Fig. 4: 12). Different types of edges were used to model the cut marks, namely: a) sharp edges without secondary processing; b) blunt edges without secondary processing; and c) edges formed by trimming-on-anvil technique.

3. Results

As noted, bones of various types of preservation were used as objects on which cut marks had formed. We distinguished between three preservation types: fresh bones (up to one year old), dry bones (several decades old), and eroded bones (several hundred years old). The effect of experimental cutting was manifested to varying degrees on bones in different states of preservation. We suggest that the softer surfaces of the more eroded bones enhance, to a certain extent, the effects of applying force during the productive movement. Note also that the cutting parameters on fresh bones were not constant. After the loss of organic components, the length, width, and depth appeared different. The disappearance of cartilage and periosteum can entail a complete disappearance of any visible damage (Fig. 8: A).

The experiment involved flint and quartz fragments produced mainly with the use of the bipolar-on-anvil technique. The raw materials were pebbles of quartz and flint from the Southern Bug Valley near Medzhibozh. The selection of potential tools was based on the morphology and metric parameters of experimental replicas of stone tools and the features of V-shaped, U-shaped, and Π-shaped damage found on archaeological bones. Granite instruments were also used, namely flakes and fragments created by the industrial crushing of rocks. The thin edge areas of flakes (angle of sharpness below 25°), straight in plan and profile, were used by experimenters, as well as medium-angled blunt (angle of sharpness of ca. 40–65°) and thick blunt edges (ca. 90°) produced with the trimming-on-anvil technique. Figure 5 presents either empirically observed or predicted co-transformation of flake edges and cut marks’ morphologies. Such parameters of the edges fully correspond to the morphology of the working edges of stone products observed, for example, in the assemblage from Layer III of Medzhibozh 1[19]. The bone tool involved was an elongated fragment of dry bone (2 years old) with acute longitudinal fractures but without additional treatment. A fragment of a deer antler (dry state, 25 years old) was also used as a tool, particularly its rounded tip

---

[19] Stepanchuk *et al.* 2021.

and the sharp edge at its break. Thus, the used instruments were consistent with the parameters observed in the sample of archaeological tools.

In total, we conducted 81 experiments, which combined 281 elements, i.e., isolated cut marks (Fig. 6). This way, we generated a sufficiently representative database for a preliminary assessment of the morphology features of the cuts resulting from the experimental tools, varying by raw materials and working edge characteristics.

As soon as attention was turned to the shape of cross-sections, the cut marks' entry and exit properties, as well as cutting depth variations based on movement dynamics, we focused particularly on comparing the relevant parameters, taking into account important additional aspects, such as the instrument's material, parameters of the edge, and type of bone preservation.

We have collected as much data as possible on the various cases of correlations, although there are gaps that should be filled in the future (Tab.1). Within the frame of the discussed experiment, the current database should be expanded by cut experiments with local limestone and quartzite flakes, unmodified and trimmed. Besides, we need to statistically assess the correlation between different tool parameters, state of preservation of bones, and cut mark metrics. Nevertheless, already at this stage, some observations provide valuable material for discussing and studying the archaeological cut marks.

There is a certain correlation between the movement of the tool and the location of the deeper and shallower sections of the cut mark. According to the data obtained, almost a third of the cuts had greater depth in the first half of the length when moving *towards oneself*. On the contrary, when moving away *from oneself*, there were half as many comparable cuts (Tab. 2). Instead, when moving away *from oneself*, there were significantly more cuts with greater depth in the second half of the length (more than 25%). In comparison, during movement *towards oneself*, there were three times fewer cuts of this kind (approximately 8%). The depth of the cut reflects the degree of force applied. The observed difference is likely objective in nature and does not depend on the individual characteristics of the experimenters.

When analysing the correlations between the cut mark types' entry and exit and movement kinetics (Tab. 3), we found a fundamental similarity in the distribution of all types of cuts. In general, *gradual* entry and exit of cuts prevail (more than 70% on average). Such morphology indicates a predominance of smooth penetration and gradual release of tool edge from the bone body. The exception is a series of cut marks formed in a movement *from oneself*. Here, the group of cut marks with a gradual start makes up only about 30%, while cut marks with a sharp entry prevail, reflecting intense penetration of the edge into the bone body during the initial phase of the productive movement. It should be noted that 14 cuts with the most abrupt exit were recorded for a series formed with the movement *away from oneself* performed with broken and trimmed edges of flint flakes on an eroded bone.

A definite relationship between the type of working edge and morphology of the entry and exit of cut marks has been recorded. In any case, trimmed and fractured edges appear to produce a higher proportion of sharp penetration and release on the bone surface (Tab. 4). There is also a correlation between the frequency of cut marks with the above-discussed features and the state of preservation of bones. Thus, the proportion of recorded cut marks with sharp entry and sharp exit of a lithic edge is approximately 16%, 24%, and 39% for fresh, dry, and eroded bone, respectively. These data may indicate that the cut marks in question occur more frequently when a greater physical force is exerted.

The shape of a cut mark's cross-section depends on the morphology of the edge used. Statistically processed data for this parameter are shown in Table 5. We consider the cut marks with combined cross-sections as belonging simultaneously to each relevant type in order to simplify the perception and handling of the data. For instance, 12 cut marks with combined U/V and V/U profiles were assigned to the U and V types, 12 units to each group. Table 6 shows the information after the data was organised in this way for cut marks with combined cross-sectional profiles.

The minimal number of Π-shaped cut marks among the sharp edges of stone tools is noteworthy (Fig. 4: B4). The number of U-shaped and, especially, Π-shaped cut marks (and proper areas of cut marks with a combined profile) is expectedly high for cuts produced by the trimmed and broken edges (Fig. 4: A1–3, 8a, 9a, 10b; B2, 4). This distribution is in line with other observations of cut marks' profiles caused by unretouched edges and burins[20]. Worth noting is also the significant number of cuts with U-shaped and Π-shaped cross-sections in the experimental series (more than 25% and 14%, respectively) (Tab. 6).

It is possible that two subjective reasons can simultaneously explain the increased frequency of cut marks with such cross-sections in the experimental series. Firstly, we consciously and actively used blunt and trimmed edges, which was dictated by the specificity of the archaeological stone industry of the Medzhibozh sites. Secondly, the damage caused by relatively thin edges broken at approximately 90° angle (e.g. Fig. 4: B4) was attributed to the Π-shaped cut marks. In the case of cuts of considerable depth, such narrow cut marks are easy to classify as V-shaped when examined without magnification.

The type of a cut mark's cross-section is related to the material used to make the tool (Tab. 7), regardless of the kinetics of movement, and the state of bone preservation. Flint and quartz flakes with thin, feather-like edges tend to produce characteristic single deep grooves with a straight

---

[20] Moretti *et al.* 2015.

(rarely arched) trajectory and a narrow V-shaped cross-section (Fig. 4: A5, 6, 8b, 9b, 10a; B3). U-shaped cut marks were often formed by edges of granite and bone tools (Fig. 5: B). In these categories, they account for more than 40% and 50%, respectively. Fine- and medium-grained granite was used in our experiments. The edges of the former variety demonstrate greater stability, but all the used granite tools became blunt quickly. As a result of their use, V-, U-, and Π-shaped cut marks appeared (Tab. 7).

Dry bone splinters with sharp edges cause slightly different damage than those left by the edges of stone flakes. Depending on the hardness of the bone being worked and the force exerted, the bone tool leaves V-, U-, or Π-shaped cut marks (but not in the same proportions as the granite edge) and also strips of surface damage and soft polishing (Tab. 7) (Fig. 4: B6). Similar results for bone tools have been obtained by other experimenters[21]. The reciprocating (sawing) motions resulted in deep and wide grooves with a considerable number of micro-scratches and furrows (Fig. 4: B5). Irrespective of the used edge sharpness, traces of work with antler, a relatively tough and viscous material, if observable at all, are represented either by strips of continuous shallow strips and irregular polish or discontinuous areas of such strips (Fig. 4: B7, 8).

Furrows correlate somewhat more frequently with the U- and Π-shaped cut marks made with trimmed edges and with the Π-shaped cuts in general (Tab. 8). The presence of furrows correlates more clearly with the texture and structure of the material used to make the tools (Tab. 9). Thus, the largest number of cut marks with visible furrows is observed in the group of quartz tools (Fig. 4: B1, 2, 4), followed by granite (Fig. 5: B), flint (Figs. 4: A2–4, 7, 9), and bone (Fig. 4: B5). The hardness of the rocks involved was almost identical on the Mohs scale and ranged between 7 and 8. In effect, there exists a correlation between the frequency of furrows and the structural monolithicity of the stone tool material. The dependence of the frequency of furrows on the condition of the bone is not so clear (Tab. 10), although there are significantly more U- and Π-shaped cut marks with furrows in the group of eroded bone. Similar findings were obtained in other experimental programs[22].

4. Discussion

The main purpose of the work was to develop an experimental comparative base facilitating a more objective reconstruction of some key conditions of occurrence of cuts on bones originating from the Lower Palaeolithic sites near Medzhibozh. The operation of cutting bones of different states of

---

[21] Shipman, Rose 1988; Gürbüz, Lycett 2021.

[22] Fernández-Jalvo *et al.* 1999, Fig. 8.

preservation was simulated. Not only fresh but also dry and eroded bones were used. This latter aspect was dictated by the specific natural context of the Medzhibozh sites, whose culture-bearing layers would periodically become exposed, which could draw the attention of hominins to bones in different conditions. In this case, we are talking not about dismembering carcasses or defleshing bones but about probable hominin interaction with bones discarded earlier. The species composition of the bones used in the experiments (*Bovinae, Cervidae, Equidae, Sus scrofa*, and *Gallus gallus*) was fundamentally analogous to the animal remains bearing cut marks recorded at Medzhibozh, i.e. large and medium mammals and birds. Following the peculiarities of typology and raw material structure of the Medzhibozh lithic assemblages that belong to the circle of core-and-flake industries, the instruments involved were of different rock types and characterised by different edge morphology. The tools were of experimental (quartz, flint) and technogenic (granite) origin, with sharp and blunt non-retouched working edges and edges trimmed on the anvil. Thus, the used instruments were consistent with the essential features of Medzhibozh lithic artefacts. Bone and antler were also used as tools.

Quite exceptional are blunt and trimmed-on-anvil edges involved in the experimental cut mark simulations, even if unmodified flakes or natural pieces were used[23]. The use of eroded bone in such studies has also been uncommon. Note that a bone with a softer surface snaps under a smaller amount of force. We used both approaches. Admittedly, a cut mark's cross-section is markedly easier to identify on an old bone. This is an obvious function of reduced bone density. While bone remains fresh, its density may essentially affect cut marks' morphology[24]. At the same time, the damage morphology on old bones does not show any new specific details and features. With this in mind, it can be assumed that cutting over a bone with an eroded surface is, in a sense, a model of cutting over a bone with a stronger surface, provided that considerable force is applied. We believe there are no special reservations about using the data obtained for such bones when comparing them with other experimental and archaeological materials.

The morphology of the experimentally-formed cut marks depends on the raw material of the tool, type of edge, kinetics of movement, force of pressure, as well as bone's shape. This last aspect, often resulting in a discontinuity in the straightness of a linear cut mark, has not been addressed in the article. Regularities have been observed in the distribution of U-shaped and Π-shaped cut marks when compared to the V-shaped cut marks, which are more commonly presented in archaeological and experimental studies[25]. It should be particularly emphasised that in our experiments, the U-

---

[23] See Domínguez-Rodrigo *et al.* 2012; Malassé *et al.* 2016; Boschin *et al.* 2021.

[24] Braun *et al.* 2016; Krasinski 2018.

[25] For example, Domínguez-Rodrigo *et al.* 2005; Garcia *et al.* 2013; Roche *et al.* 2018, Fig. 6; Sahnouni *et al.* 2018, Fig. 4; Daujeard *et al.* 2020.

shaped cut marks were regularly produced while working with granite and bone edges. It is important to note that this type of damage is often described not as cutting marks but either tooth marks (evidence for gnawing) or trampling marks, i.e. a result of mechanical damage of various origin[26]. More data is still necessary to distinguish between anthropogenic and natural U-shaped linear damage. Nevertheless, we believe that the extent of blunt edge use in the Lower Palaeolithic and the bone damage caused by such edges are greatly underestimated, reflected by only a few relevant references[27]. The issue is complicated by post-deposition alterations that can modify relatively shallow Π-shaped and U-shaped cut marks. For instance, rounding could lead to a significant reduction in the diagnostic potential of a cut mark, due to the degradation of sharpness of walls and profile and further loss of other anthropogenic signs. In the materials from Medzhibozh 1 (Layer III), there are bones with wide and relatively shallow grooves, which we classify as cut marks (Fig. 3: 2). In the experimental series, we obtained similar parameters of artificial damage (Fig. 8: B1, 3), which supports this interpretation.

The morphology of cut marks is linked to the parameters of the working part of the edge. In turn, the edge parameters – resistance to loads and duration of use in a stable state – depend directly on the material from which the tool was manufactured. Hard, fine-grained isotropic rocks allow the manufacture of flakes with thin edges leaving V-shaped cuts or, in the event of breakage, narrow and deep Π-shaped cut marks. The strong structure of quartz and flint ensures the durability and stability of the tool's working edge. The durability of quartz edges has been confirmed by a number of experimental studies in which tools made of this type of rock left mostly V-shaped cuts with a straight trajectory. In this case, the appearance of U- and Π-shaped cut marks, as well as furrows, is associated with the structural and textural characteristics of the raw material rather than secondary processing or damage to the edge[28]. In contrast, intrusive igneous rocks, such as granite, though capable of yielding sharp flakes while knapped, are prone to much more intense fracture during use. The rate of edge breakage depends on the composition, granularity, and strength of the stone's structure. Accordingly, over time, a tool that initially left a thin and straight cut can begin to produce rough and wider cuts, which can even be mistaken for traces of another tool[29]. The process is exacerbated by unavoidable damage to the edge during cutting. For example, Figure 7B: 3 presents a significant number of thin cut marks produced by the feather-like edge of a quartz flake. Figure 7B: 4 shows a wide cut mark with furrows formed in the same area but by a part of an edge already shattered (the breakage occurred due to the considerable strength of the dry bone surface).

---

[26] For example, Pineda *et al.* 2020.

[27] For example, Echassoux 2012, 303–304.

[28] Buccheri *et al.* 2016; Moclán *et al.* 2018.

[29] e. g., Greenfield 2006; Moretti *et al.* 2015; for quartzite and limestone tools, see Fernandez-Jalvo, Andrews 2016, 42, 44, 50, Figs. A.66–67; 47–48, Figs. A.53–54, 57.

Shallow grooves with amorphous profiles and shapes produced by dull parts of antler and bone tools, sometimes accompanied by small indistinct scratches, may resemble trampling marks[30].

The lithic tool-produced cut mark is often a combination of furrows, which are all formed by a single movement. A blunted or damaged sharp edge may produce a set of furrows: a central furrow, deep and extended, and accompanying furrows, shallower and interrupted, sometimes without a noticeable point of entry (Fig. 7A: 2–4, 9a, 10b; 7B: 1–2, 4–5). The trimmed-on-anvil edge is significantly more likely to result in a multiplication of the central furrow than the thin feather-like edge of a flake. This is true of secondarily-treated edges in general[31]. The cut mark is less profound than those produced with a sharp edge of a similar tool but wider. During the reciprocating movements (sawing), a flint flake with a sharp edge leaves the deepest cut; the trimmed edge is also effective but leaves a wider groove and modifies the bone surface more slowly. Furrows are more commonly associated with Π-shaped cut marks in general and U-shaped and Π-shaped cut marks made with the trimmed edge (Tab. 8). The presence of furrows correlates more evidently with the texture and structure properties of the involved tool's material (Tab. 9). The relationship between non-siliceous rocks and the abundance of furrows in cut marks has been observed in previous studies for limestone[32], quartz[33], or quartzite[34], among other materials.

Multicluster cut marks with an X- or Y-shape attract attention. They are regularly recorded in experimental cutting studies and are associated either with the sinuous edge of the tools used[35] or with a change in edge angle during operation[36]. The irregularity of the secondary worked edge forms an X-shape when it changes the angle of inclination while passing through the bone surface[37]. In our experiments, such cut marks were mainly formed using tools with a trimmed working edge (Fig. 7: A2, 9a, 10b; B1, 2) or with a thick, worn edge (Fig. 8: B2). The X- or Y-shaped cut marks result from a single productive action. However, the irregular morphology of the edge (in particular damaged or sinuous), the change of pressure force, and the differences in bone morphology ~~relief~~ (Fig. 7: B1) together give the damage a multi-component structure that eventually looks like a result of several distinct, independent motions. The appearance of such cut marks is less dependent on the type of raw material used to make the tool[38].

The relationship between the kinetics of tool movement and the location of the deepest part of the cut mark has been traced. Nearly a third of the cut marks left when moving *towards oneself* are

---

[30] Compare Fig. 3: 5 and Fernandez-Jalvo, Andrews 2016, 51, Fig. A.71; 53, Fig. A.77.

[31] Fernandez-Jalvo, Andrews 2016, 41, Fig. A.30–31.

[32] Espigares *et al.* 2019.

[33] Buccheri *et al.* 2016; Moclán *et al.* 2018.

[34] Fernandez-Jalvo, Andrews 2016, 42; Malassé *et al.* 2016.

[35] Domínguez-Rodrigo *et al.* 2009; de Juana *et al.* 2010.

[36] Fernández-Jalvo *et al.* 1999, Fig. 8.

[37] Fernandez-Jalvo, Andrews 2016, 38–40, 50, Figs. A.16, 17, 23–26, 65.

[38] Buccheri *et al.* 2016.

deeper at the beginning, in the first half of the length (Tab. 2). On the other hand, the number of cut marks with greater depth in the second half of the length is more frequent among products of cutting *from oneself*. We also found a similarity in the distribution of all cut mark varieties in the relationship between the kinetics of movement and the type of start and end of the cut mark (Tab. 3). However, there is a noteworthy exception, namely a series of cut marks formed by moving *from oneself*. Among them, cut marks with an abrupt entry dominate, witnessing a deep plunge of the edge into the bone body at the beginning of the productive action. Significantly, more cases were recorded for trimmed and broken edges with a sharp entry into and a sharp edge exit from the bone surface (Tab. 4).

The shape of a cut mark's cross-section predictably depends on the edge morphology. For instance, the number of Π-shaped cut marks in the case of sharp edges of stone tools is minimal. On the other hand, the number of U-shaped and, especially, Π-shaped cut marks (and areas in cut marks with combined cross-section) increased in the case of trimmed and broken edges. According to our data, the cut mark cross section is directly related to the tool's material (Table 7), irrespective of the kinetics of movement and the state of preservation of the bone. The differences were noted by other authors for marks left by tools made not only from different raw materials but also from the same type of material with different granularity[39].

In general, the morphological features of the experimental cut marks produced by thin, thick, and trimmed edges of stone tools made from different types of raw materials have analogies with the archaeological materials from the Medzhibozh sites. In particular, among bones with cut marks (Fig. 1) one can distinguish: V-shaped incisions, made by three short movements of partially fragmented, thin, sinuous flint (quartz) tool edge (Fig. 3: 1); U/Π-shaped cut marks, probably caused by the reciprocating motion of a dull edge of a granite (?) tool (Fig. 3: 2); thin V-shaped notches resulting from extended controlled cutting with the thin edge of a flint (quartz?) flake (Fig. 3: 6; 8a); and Π-shaped notches resulting from several short movements with trimmed-on-anvil, blunt, or damaged edge of heterogeneous material (granite, quartz?) (Fig. 3: 3). The archaeological linear marks, presented, for example, in Figure 3: 5 and 9, have so far remained outside the scope of the recent experiments. These marks may witness deliberate scraping (Fig. 3: 9b) or ripping of tissue remains in a manner of abrasion on a hard and grained surface (Fig. 3: 5a-c). As long as no experimental models are available, these marks should be currently classified as trampling marks. The undoubted trampling features include minor linear grooves shown in Figure 3: 4, 7, 8c, caused by mechanical damage to the surface.

---

[39] Courtenay *et al.* 2019.

5. Concluding remarks

The experimental results and observations provide rich cognitive and comparative material for the study of cut marks on bones found in the context of the Lower Palaeolithic sites of Medzhibozh. Among the aforementioned observations and preliminary findings, the following can be emphasised. There is a direct correlation between the type of raw material, the type of edge, and the morphology of cut marks. The cut mark morphology of a stone tool depends on the raw material's structure monolithicity and texture peculiarities. As the edge wears down, the morphology of the cut marks changes: from a thin V to an overextended U. When the bone splinter operates on a fresh bone, the latter may show distinctive damage. When antler is used, whether with a blunt or sharp edge, it leaves almost no visible marks.

Thus, not all U-shaped grooves on the surface of bones are attributable to tooth marks or constitute mechanical damage. Some of the U-shaped linear marks result from using blunt edges. Similarly, anthropogenic damages produced by blunt parts of antler and bone tools may resemble trampling marks. Π-shaped cut marks formed as a result of trimmed edge use, thus resembling the burin marks. In terms of the morphology of anthropogenic damage, there is no difference between fresh, dry, and eroded bones. The greater exposure of eroded bone (due to the softness of the material) to anthropogenic modifications can be used to simulate cut marks made with higher muscle effort. Cut mark parameters on fresh bones are not constant: length, width, and depth appear different after the loss of organics, and the disappearance of cartilage and periosteum may result in the inability to identify signs of anthropogenic damage.

Some criteria for the analysis of cut mark morphology seem not informative enough. Nevertheless, making use of a large set of variables to assess experimental samples is justified by providing more complete comparisons with archaeological samples. Based on the experimental data obtained and partially presented in this paper, a further more in-depth analysis of the Medzhibozh archaeological finds is also possible. Thus, the cognitive usefulness and scholarly perspective of experimental modelling in the archaeozoological studies on the Lower Palaeolithic sites of Ukraine are quite evident.

Bibliography

Blumenschine R. J. 1991, Hominid carnivory and foraging strategies and the socio-economic function of early archaeological sites, *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences* 334 (1270), 211–221. https://doi.org/10.1098/rstb.1991.0110

Blumenschine R. J. 1995, Percussion marks, tooth marks, and experimental determinations of the timing of hominid and carnivore access to long bones at FLK Zinjanthropus, Olduvai Gorge, Tanzania, *Journal of Human Evolution* 29 (1), 21–51. https://doi.org/10.1006/jhev.1995.1046

Boschin F., Moretti E., Crezzini J., Arrighi S. 2021, Geometric morphometrics reveal relationship between cut mark morphology and cutting tools, *Acta Imeko* 10 (1), 109–113. http://doi.org/10.21014/acta_imeko.v10i1.846

Braun D. R., Pante M., Archer W. 2016, Cut marks on bone surfaces: influences on variation in the form of traces of ancient behavior, *Interface Focus* 6 (3). http://doi.org/10.1098/rsfs.2016.0006.

Buccheri F., Berte D. F., Berruti G. L. F., Caceres I., Volpe L., Arzarello M. 2016, Taphonomic analysis on fossil remains from the Ciota Ciara Cave (Piedmont, Italy) and new evidence of cave bear and wolf exploitation with simple quartz flakes by Neanderthal, *Rivista Italiana di Paleontologia e Stratigrafia* 122 (3), 41–54. https://doi.org/10.13130/2039-4942/7674

Courtenay L. A., Yravedrad J., Aramendid J., Mate-González M. Á., Martîn-Perea D. M., Uribelarre D., Baquedano E., González-Aguilera D., Domínguez-Rodrigo M. 2019, Cut marks and raw material exploitation in the Lower Pleistocene site of Bell's Korongo (BK, Olduvai Gorge, Tanzania): A geometric morphometric analysis, *Quaternary International* 526, 155–168. https://doi.org/10.1016/j.quaint.2019.06.018

Daujeard C., Falguères C., Shao Q., Geraads D., Hublin J. J., Lefevre D., El Graoui M., Rué M., Gallotti R., Delvigne V., Queffelec A., Ben Arous E., Tombret O., Mohib A., Raynal J. P. 2020, Earliest African evidence of carcass processing and consumption in cave at 700 ka, Casablanca, Morocco, *Scientific Reports* 10 (1), 4761. https://doi.org/10.1038/s41598-020-61580-4

de Juana S., Galán A. B., Domínguez-Rodrigo M. 2010, Taphonomic identification of cut marks made with lithic handaxes: an experimental study, *Journal of Archaeological Science* 37 (8), 1841–1850. https://doi.org/10.1016/j.jas.2010.02.002

Domínguez-Rodrigo M. 1999, Flesh availability and bone modifications in carcasses consumed by lions: palaeoecological relevance in hominid foraging patterns, *Palaeogeography,* *Palaeoclimatology, Palaeoecology* 149 (1–4), 373–388. https://doi.org/10.1016/s0031-0182(98)00213-2

Domínguez-Rodrigo M., Courtenay L. A., Cobo-Sánchez L., Baquedano E., Mabulla A. 2022, A case of hominin scavenging 1.84 million years ago from Olduvai Gorge (Tanzania), *Annals of the New York Academy of Sciences* 1510 (1), 121–131. https://doi.org/10.1111/nyas.14727

Domínguez-Rodrigo M., de Juana S., Galán A., Rodríguez M. 2009, A new protocol to differentiate trampling marks from butchery cut marks, *Journal of Archaeological Science* 36, 2643–2654. https://doi.org/10.1016/j.jas.2009.07.017

Domínguez-Rodrigo M., Gidna A., Baquedano E., Cobo-Sánchez L., Mora R., Courtenay L. A., Gonzalez-Aguilera D., Mate-Gonzalez M. A., Prieto-Herráez D. 2021, A 3D taphonomic model of long bone modification by lions in medium-sized ungulate carcasses, *Scientific reports* 11, 4944. https://doi.org/10.1038/s41598-021-84246-1

Domínguez-Rodrigo M., Pickering T. R., Bunn H. T. 2012, Experimental study of cut marks made with rocks unmodified by human flaking and its bearing on claims of∼ 3.4-million-year-old butchery evidence from Dikika, Ethiopia, *Journal of Archaeological Science* 39 (2), 205–214. https://doi.org/10.1016/j.jas.2011.03.010

Domínguez-Rodrigo M., Pickering T. R., Semaw S., Rogers M. J. 2005, Cut marked bones from Pliocene archaeological sites at Gona, Afar, Ethiopia: implications for the function of the world's oldest stone tools, *Journal of Human Evolution* 48 (2), 109–121. https://doi.org/10.1016/j.jhevol.2004.09.004

Dupras T. L., Schultz J. J. 2013, Taphonomic bone staining and color changes in forensic contexts, in J. Pokines, S. A. Symes (eds), *Manual of Forensic Taphonomy*, 315–340. https://doi.org/10.1201/b15424-13

Echassoux A. 2012, Comportements de subsistance et modifications osseuses à l'aube de l'Acheuléen à Konso, Éthiopie, *L'anthropologie* 116, 291–320. http://doi.org/10.1016/j.anthro.2012.06.002

Espigares M. P., Palmqvist P., Guerra-Merchán A., Ros-Montoya S., García-Aguilar J. M., Rodríguez-Gómez G., Serrano F. J., Martínez-Navarro B. 2019, The earliest cut marks of Europe: a discussion on hominin subsistence patterns in the Orce sites (Baza basin, SE Spain), *Scientific Reports* 9, 15408. https://doi.org/10.1038/s41598-019-51957-5

Fernandez-Jalvo Y., Andrews P. 2016, *Atlas of taphonomic identifications: 1001+ images of fossil and recent mammal bone modification*. https://doi.org/10.1007/978-94-017-7432-1

Fernández-Jalvo Y., Carlos-Díez J., Cáceresd I., Roselle J. 1999, Human cannibalism in the Early Pleistocene of Europe (Gran Dolina, Sierra de Atapuerca, Burgos, Spain), *Journal of Human Evolution* 37 (3–4), 591–622. https://doi.org/10.1006/jhev.1999.0324

Fisher J. W. 1995, Bone surface modifications in zooarchaeology, *Journal of Archaeological Method and Theory* 2 (1), 7–68. https://doi.org/10.1007/bf02228434

Garcia J., Landec G., Martínez K., Carbonell E. 2013, Hominin dispersals from the Jaramillo subchron in Central and South-Western Europe: Untermassfeld (Germany) and Vallparadís (Spain), *Quaternary International* 316, 73–93. https://doi.org/10.1016/j.quaint.2013.03.005

Greenfield H. J. 2006, Slicing cut marks on animal bones: diagnostics for identifying stone tool type and raw material, *Journal of Field Archaeology* 31 (2), 147–163. https://doi.org/10.1179/009346906791071972

Gürbüz R. B., Lycett S. J. 2021, Did the use of bone flakes precede the use of knapped stone flakes in hominin meat processing and could this be detectable archaeologically?, *Journal of Anthropological Archaeology* 62, 101305. https://doi.org/10.1016/j.jaa.2021.101305

Hlavatskyi D. V., Stepanchuk V. N., Kuzina D. M., Poliachenko Ie. B., Shpyra V. V., Skarboviychuk T. V., Yakukhno V. I., Bakhmutov V. G. 2021, Rock magnetic and palaeomagnetic studies of loess-palaesol sections — Lower Palaeolithic sites within the Southern Bug Valley (Medzhybizh, Holovchyntsi), *Geophysical Journal* 1 (43), 3-37. (https://doi.org/10.24028/gzh.0203-3100.v43i1.2021.225539), (in Russian).

Konidaris G. E., Athanassiou A., Tourloukis V., Thompson N., Giusti D., Panagopoulou E., Harvati K. 2018, The skeleton of a straight-tusked elephant (*Palaeoloxodon antiquus*) and other large mammals from the Middle Pleistocene butchering locality Marathousa 1 (Megalopolis Basin, Greece): preliminary results, *Quaternary International* 497, 65–84. https://doi.org/10.1016/j.quaint.2017.12.001

Krasinski K. E. 2018, Multivariate evaluation of criteria for differentiating cut marks created from steel and lithic implements, *Quaternary International 466,* 145–156. http://doi.org/10.1016/j.quaint.2016.04.025

López-Cisneros P., Linares-Matás G., Yravedra J., Maté-González M. Á, Estaca-Gómez V., Mora R., Aramendi J., Rodríguez Asensio J. A., Barrera-Logares J. M., González-Aguilera D. 2019, Applying new technologies to the taphonomic study of La Lluera (Asturias, Spain). Geometric morphometrics and the study of bone surface modifications (BSM), *Quaternary International* 517, 107–117. https://doi.org/10.1016/j.quaint.2019.02.020

Malassé A. D., Moigne A. M., Singh M., Calligaro T., Karir B., Gaillard C., Kaur A., Bhardwaj V., Pal S., Abdessadok S., Sao C. C., Gargani J., Tudryn A., Sanz M. G. 2016, Intentional cut marks on bovid from the Quranwala zone, 2.6 Ma, Siwalik Frontal Range, northwestern India, *Comptes Rendus Palevol* 15 (3-4), 317–339. https://doi.org/10.1016/j.crpv.2015.09.019

Manifold B. M. 2012, Intrinsic and extrinsic factors involved in the preservation of non-adult skeletal remains in archaeology and forensic science, *Bulletin of the International Association for Paleodontology* 6 (2), 51–69.

Mateo-Lomba P., Fernández-Marchena J. L., Ollé A., Cáceres I. 2020, Knapped bones used as tools: experimental approach on different activities, *Quaternary International* 569, 51–65. https://doi.org/10.1016/j.quaint.2020.04.033

Matviishina Zh. M., Karmazynenko S. P. 2014, Results of paleopedological studying of Quaternary deposits of Medzhibozh Paleolithic locality, (in:) V. N. Stepanchuk (ed.), *Medzhybizh locality and problems of Lower Paleolithic studies on the East European plain*, Medzhybizh-Ternopil-Kyiv, 49–69, (in Ukrainian).

Matviishina Zh. M., Karmazynenko S. P. (in press), New data on paleopedological study of Late Cenozoic sediments at archeological sites of Medzibozh A and Golovchyntsi-1 in Khmelnytsky region, (in:) V. N. Stepanchuk (ed.), *Medzhybizh locality and problems of Lower Paleolithic studies on the East European plain* 2, (in Ukrainian).

McPherron S. P., Alemseged Z., Marean C. W., Wynn J. G., Reed D., Geraads D., Bobe R., Béarat H. A. 2010, Evidence for stone-tool-assisted consumption of animal tissues before 3.39 million years ago at Dikika, Ethiopia, *Nature* 466, 857–860. https://doi.org/10.1038/nature09248

Moclán A., Huguet R., Márquez B., Domínguez-Rodrigo M., Gómez-Miguelsanz C., Vergès J. M., Laplana C., Arsuaga J. L., Pérez-González A., Baquedano E. 2018, Cut marks made with quartz tools: an experimental framework for understanding cut mark morphology, and its use at the Middle Palaeolithic site of the Navalmaíllo Rock Shelter (Pinilla del Valle, Madrid, Spain), *Quaternary International* 493, 1–18. https://doi.org/10.1016/j.quaint.2018.09.033

Moretti E., Arrighi S., Boschin F., Crezzini J., Aureli D., Ronchitelli A. 2015 Using 3D Microscopy to Analyze Experimental Cut marks on Animal Bones Produced with Different Stone Tools, *Ethnobiology Letters* 6 (2), 267–275. https://doi.org/10.14237/ebl.6.2.2015.349

Olsen S. L., Shipman P. 1988, Surface Modification on Bone: Trampling versus Butchery, *Journal of Archaeological Science* 15 (5), 535–553. https://doi.org/10.1016/0305-4403(88)90081-7

Pawłowska K. 2017, Large mammals affected by hominins: Paleogeography of butchering for the European Early and Middle Pleistocene, *Quaternary International* 438, 104–115. https://doi.org/10.1016/j.quaint.2017.03.043

Pineda A., Channarayapatna S., Lemboc G., Peretto C., Saladié P., Thun-Hohenstein U. 2020, A taphonomic and zooarchaeological study of the early Middle Pleistocene 3 colluvio level from Isernia La Pineta (Molise, Italy), *Journal of Archaeological Science: Reports* 33. https://doi.org/10.1016/j.jasrep.2020.102469

Potts R., Shipman P. 1981, Cut marks made by stone tools on bones from Olduvai Gorge, Tanzania, *Nature* 291, 577–580. https://doi.org/10.1038/291577a0

Qi K., Blackwell B. A. B., Singh I. K., Stepanchuk V. N., Blickstein J. I. B., Florentin J. A., Skinner A. R. 2018, Preliminary results of dating for the Lower Paleolitic sites of Ukraine (Medzhibozh 1 and Medzhibozh A, Khmelnitskii region) by electron spin resonance method, *Geophysical Journal* 4 (40), 155–177. https://doi.org/10.24028/gzh.0203-3100.v40i4.2018.140614), (in Russian).

Rekovets L. I. 2017, Pleistocene small mammals from the Medzhybizh locality in Ukraine, *Proceedings of the Theriological School* 15, 35–48, (in Ukrainian).

Roche H., de la Torre I., Arroyo A., Brugal J. P., Harmand S. 2018, Naiyena Engol 2 (West Turkana, Kenya): A case study on variability in the Oldowan, *African Archaeological Review* 35 (1), 57–85. https://doi.org/10.1007/s10437-018-9283-5

Ryzhov S., Stepanchuk V., Vetrov V., Naumenko O., Pogorilets O. 2019, Experience in the Implementation of Experimental Studies in Stone Age Archaeology: education, science and museum studies, *Vita Antiqua* 11, 78–91. https://doi.org/10.37098/VA-2019-11-78-91, (in Ukrainian).

Sahnouni M., Parés J. M., Duval M., Cáceres I., Harichane Z., Van der Made J., Pérez-González A., Abdessadok A., Kandi N., Derradji A., Medig M., Boulaghraif K., Semaw S. 2018, 1.9-million- and 2.4-million-year-old artifacts and stone tool–cut marked bones from Ain Boucherit, Algeria, *Science* 362 (6420), 1297–1301. https://doi.org/10.1126/science.aau000

Shipman P., Rose J. J. 1988, Bone tools: An experimental approach, (in:) S. L. Olsen (ed.), *Scanning Electron Microscopy in Archaeology*, BAR International Series, Oxford, 303–335.

Stefaniak K., Kovalchuk O., Marciszak A., Stepanchuk V., Rekovets L., van der Made J., Yanenko V., Tsvelykh A., Ratajczak-Skrzatek U., Kotowski A., Gornig W., Barkaszi Z. 2021 Middle Pleistocene fauna and palaeoenvironment in the south of Eastern Europe: A case study of the Medzhibozh 1 locality (MIS 11, Ukraine), *Quaternary International* 633, 103–117. https://doi.org/10.1016/j.quaint.2021.07.013

Stepanchuk V. 2022, Early human dispersal at the western edge of the Eastern European plain: data from Ukraine, *L'Anthropologie* 126 (1). https://doi.org/10.1016/j.anthro.2021.102977

Stepanchuk V. M., Zhuravlov O. P., Nezdolii O. I. 2019, Paleontological remains from the Medzhibozh A locality: materials for the studying interactions between LP man and environment, in P. F. Gozhik (ed), *Paleontological Investigation of Don-Dnieper Downwarp*. Materials of International scientific conference and XXXIX session of the Paleontological Society NAS of Ukraine (Hradyz'k, May 14–16, 2019), Kyiv, 100–101, (in Ukrainian).

Stepanchuk V., Moigne A.-M. 2016, MIS 11-locality of Medzhibozh, Ukraine: Archaeological and paleozoological evidence, *Quaternary International* 409, 241–254 https://doi.org/10.1016/j.quaint.2015.09.050

Stepanchuk V., Naumenko O. 2022, A new aspect of post-depositional alterations of lithic artefacts: the case of Medzhibozh Lower Palaeolithic assemblages. *Materials and studies on archaeology of Sub-Carpathian and Volhynian area* 26, 11–31. https://doi.org/10.33402/mdapv.2022-26-11-31

Stepanchuk V., Ryzhov S., Veklych Y., Naumenko O., Matviishyna Zh., Karmazynenko S. 2021, The Lower Palaeolithic assemblage of Medzhibozh 1 layer III (Ukraine) and its palaeoenvironmental context, *Materiale şi cercetãri arheologice (Serie nouã)* 1 (1), 37–69. https://doi.org/10.3406/mcarh.2021.2202

Zutovski K., Barkai R. 2016, The use of elephant bones for making Acheulian handaxes: A fresh look at old bones, *Quaternary International* 406, 227–238. http://doi.org/10.1016/j.quaint.2015.01.033

Fig. 1. Location of the Lower Palaeolithic sites of Medzhibozh 1 (M1) and Medzhibozh A (MA).

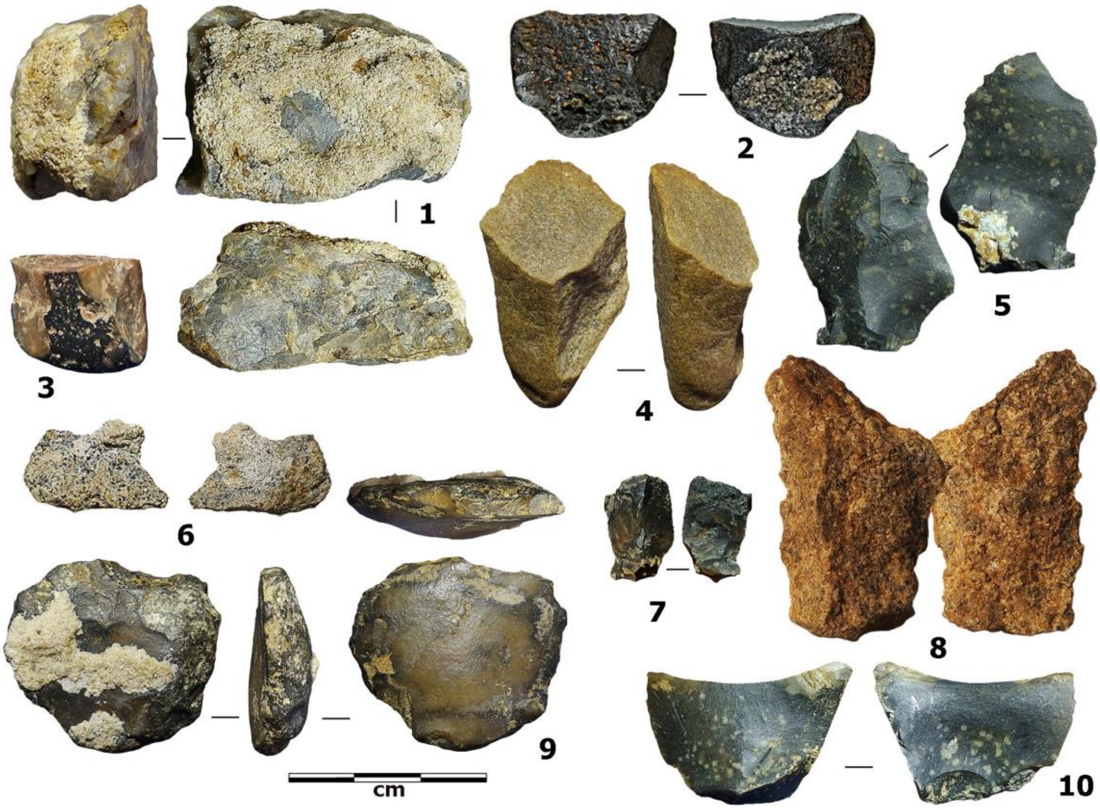

Fig. 2. Lithic artefacts from the MIS 11 layers of Medzhibozh 1 and Medzhibozh A. **Raw materials**: 1 – quartz; 2–3, 5, 7, 9–10 – flint; 4 – quartzite; 6, 8 – granite. **Type of support**: 1 – chunk; 2–4 – pebbles; 5–10 – flakes.

Fig. 3. Bones with linear and dent marks from MIS 11 Layer III of Medzhibozh 1. **Marks**: 1 – a group of deep and thin V-shaped marks; 2 – isolated deep and wide U-shaped mark; 3 – a group of U-shaped marks with furrows; 4 – isolated shallow U-shaped and carnivore tooth marks; 5 – numerous continuous linear U-shaped marks, mostly shallow; 6 – isolated, consisting of continuous separate deep V-shaped marks; 7 – isolated shallow U-shaped mark; 8 – isolated marks: thin and deep V-shaped (a), superficial V-shaped (b), and shallow Π-shaped with furrows; 9 – tooth mark (a), scraping mark (b), superficial V- and U-shaped marks (c). **Bones**: 1–2 — fragments of an ungulate long bone diaphysis; 3 – claw phalanx of a white-tailed eagle; 4 – flat bone fragment; 5 – rib fragment; 6 – skull fragment; 7 – fragment of a wild boar metacarpal bone; 8 – fragment of an ungulate tibia; 9 – proximal fragment of a deer metacarpal.

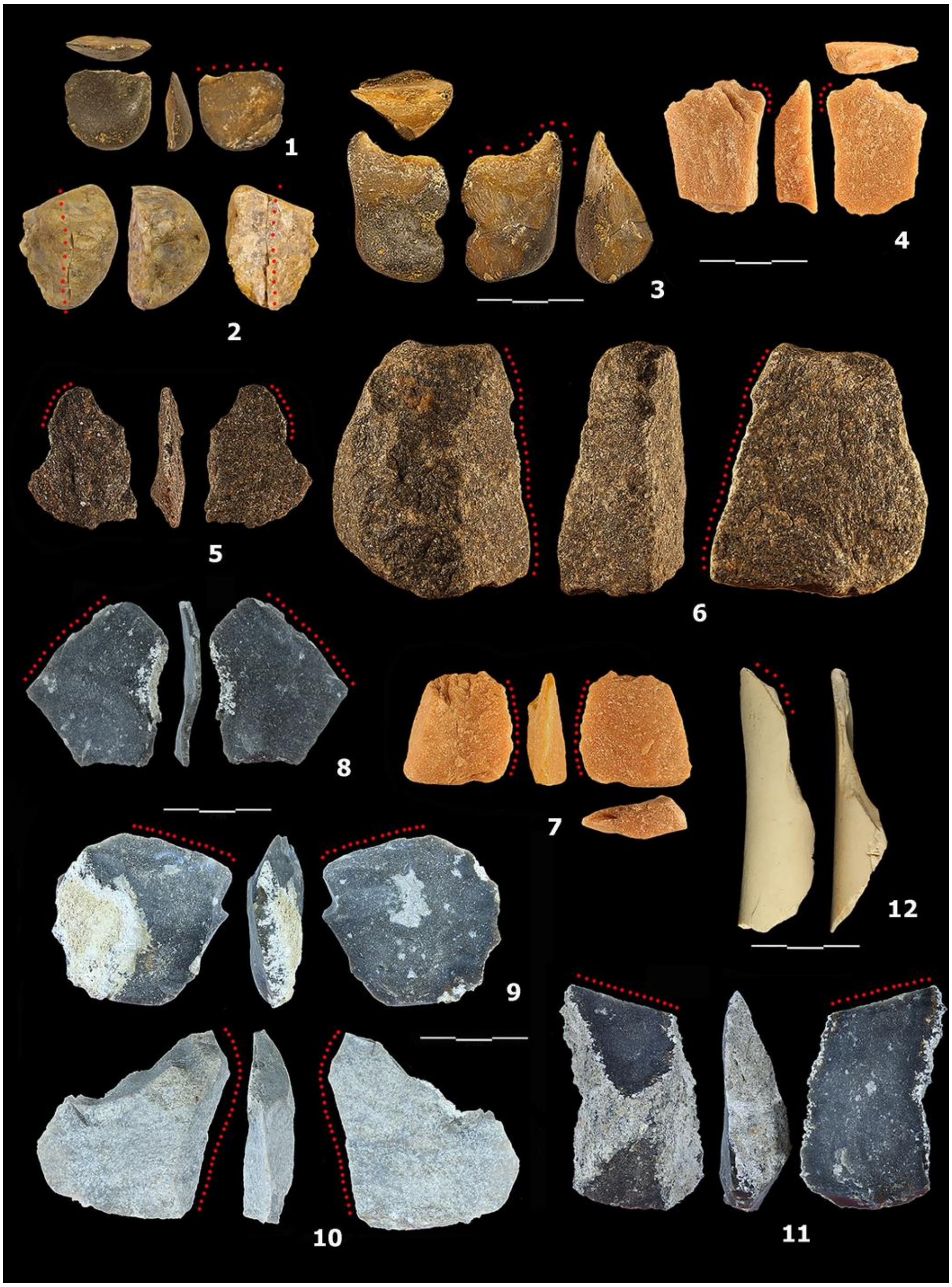

Fig. 4. Simulated bone (12) and stone tools used in the cutting experiments: bipolar-on-anvil knapping (1–3), technogenic flakes (4–7), and freehand knapping (11). Note that the profiles provide information about the morphology of working edges; dots indicate the edges' locations. **Raw materials**: 1, 3 – Medzhibozh pebble flint; 2 — Medzhibozh pebble quartz; 4, 7 – Zhytomyr pink granite; 5–6 – Zhytomyr grey granite; 8–11 – Dniester flint; 12 – long bone of cattle. **Type of support**: 1–3 – pebbles, 4–11 – flakes, 12 – bone splinter. **Type of edge**: 1–3, 5, 7, 8–12 — sharp edge; 4 – trimmed-on-anvil edge; 6 – blunt edge.

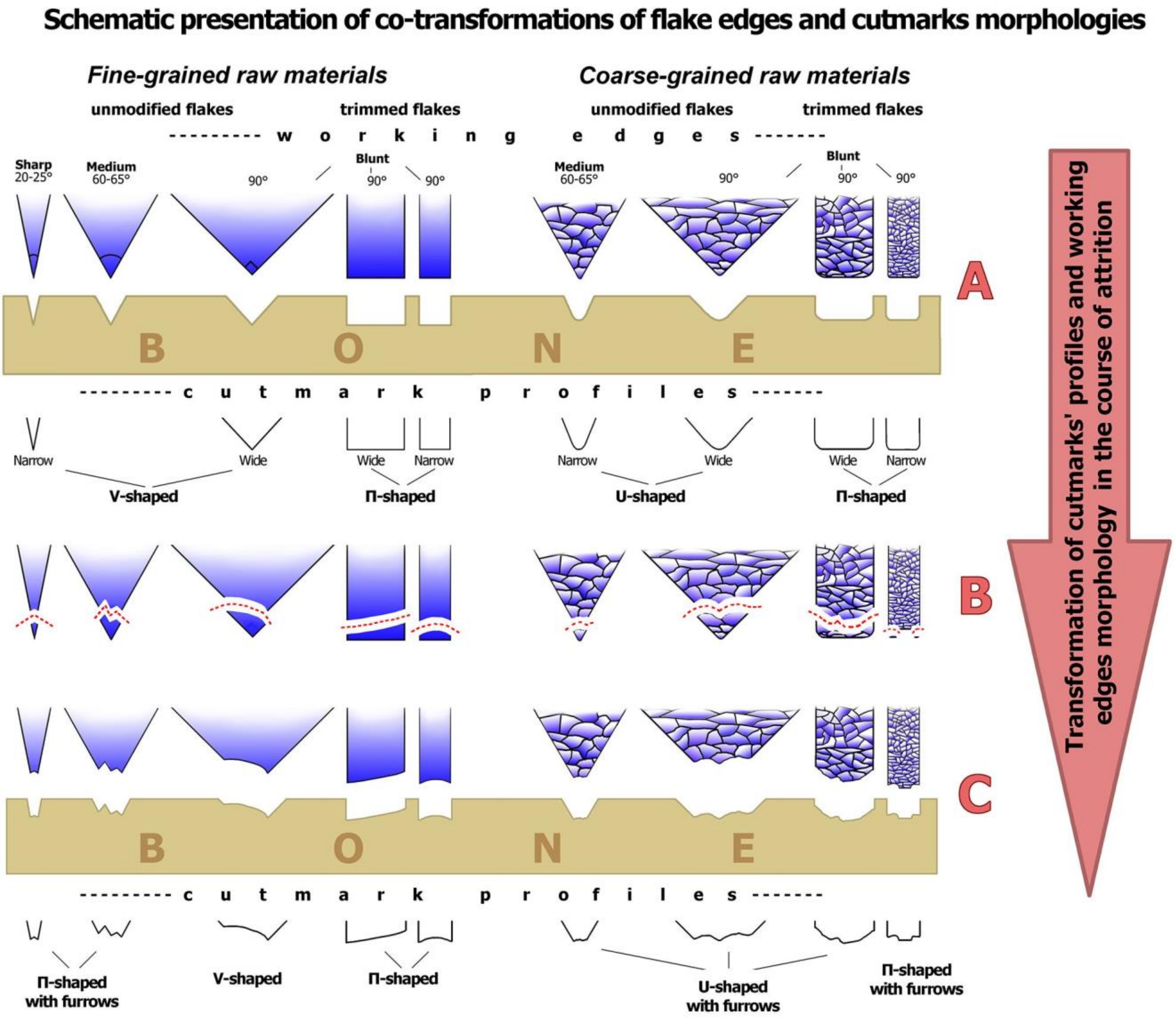

Fig. 5. Schematic presentation of co-transformation of flake edges and cut mark morphologies. Stage A — previously intact edges; stage B — initial edge destruction and stabilisation; stage C — already transformed edges.

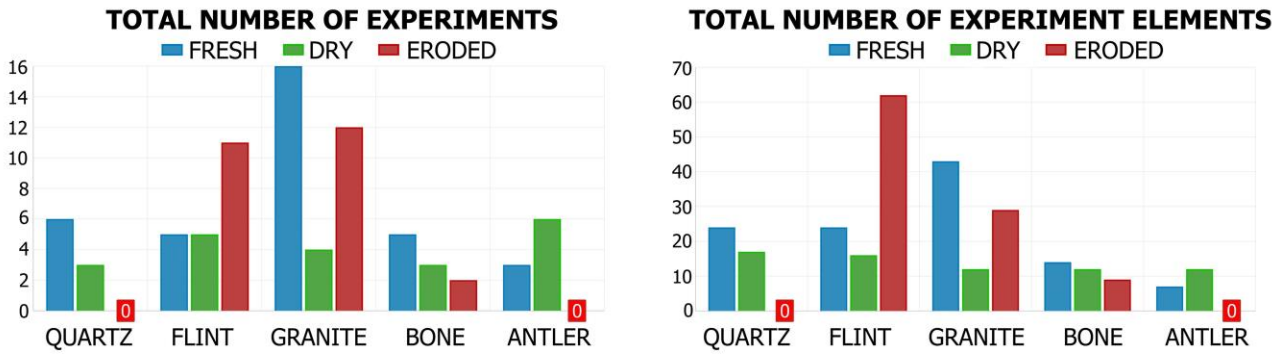

Fig. 6. Total number of experiments and their elements (i.e. isolated cut marks) in relation to the raw material of the tool and the type of preservation of the bone.

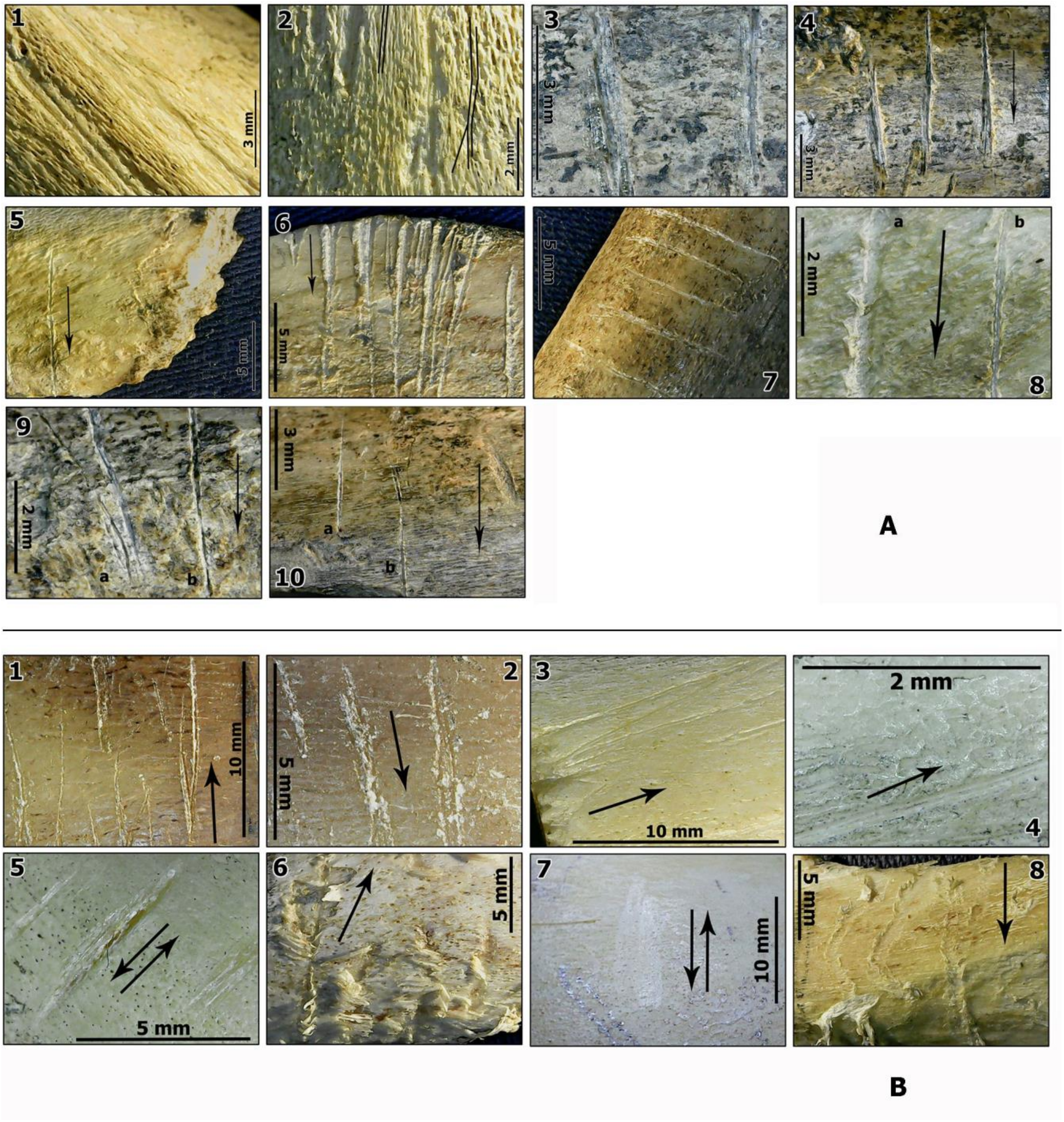

Fig. 7. Experimental cut marks on dry (A1–2; B3–5, 7), eroded (A3–4, 7, 9–10), and fresh bones (A5–6; B1–2, 6, 8). **Tool material**: A1–10 – flint; B1–4 – quartz; B5–6 – bone; B7–8 – antler. **Type of working edge**: A1–4, B1–2 – trimmed or thick (blunt); A5–6, 8b, 9b, 10a, B3 – sharp and feather-like; A7, B4 – worn (damaged) feather-like; A8a – thick blunt; A9a, 10b — trimmed; B5–6 – sharp bone edge; B7–8 – sharp antler edge. Arrows indicate the direction of cut marks; a pair of opposing arrows indicate reciprocating movement.

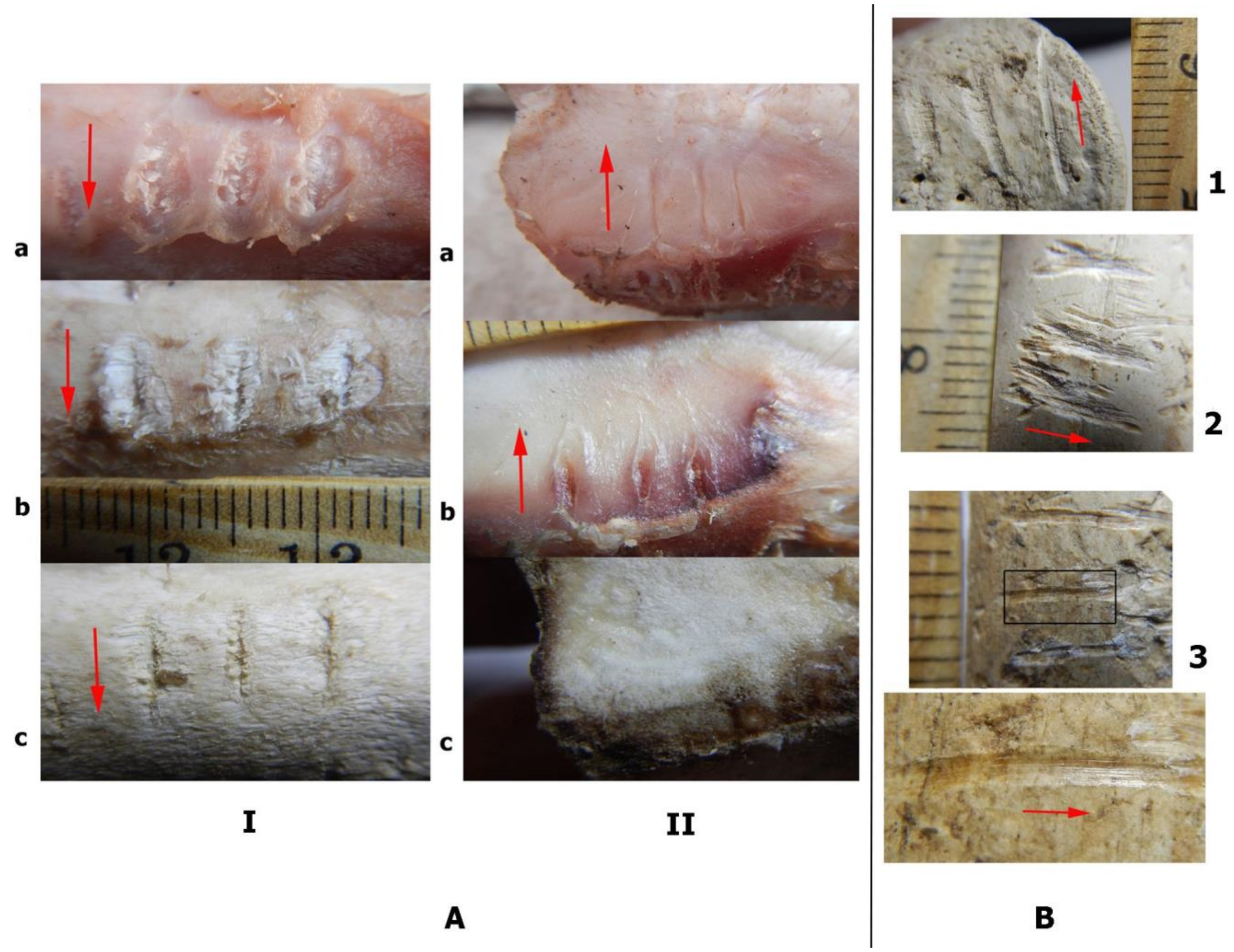

Fig. 8. Experimental cut marks. **AI** — cutting (*on oneself*) with a blunt working edge of a granite tool on a fresh bone: a) the initial appearance of cut marks; b) after boiling; c) almost no flesh remains. **AII** — cutting (*from oneself*) with a sharp working edge of a granite tool on a fresh bone: a) the initial appearance of cut marks; b) before boiling; c) without leftover meat. Particularly noticeable are either the changes in the physical parameters of the cut marks after the removal of tissue remnants (1) or their complete invisibility (2). **B.** Cutting with a granite tool on eroded bone. 1 — with a trimmed working edge *from oneself*; 2 — with a blunt working edge *on oneself*; 3 — trimmed working edge *on oneself*. The large number of furrows and the mostly U-shaped cross-section should be noted.

Tables

Raw material	**Type of edge, type of bone, number of experiment elements**														
	Sharp			Blunt			Trimmed			Broken			***Total***		
	Fr	Dr	Er	Fr	Dr	Er	Fr	Dr	Er	Fr	Dr	Er	Fr	Dr	Er
Quartz	14	17	—	10	—	—	—	—	—	—	—	—	***112***	***69***	***100***
Flint	24	10	32	—	6	—	—	—	18	—	—	12			
Granite	21	6	15	12	3	7	10	3	7	—	—	—			
Bone	14	12	9	—	—	—	—	—	—	—	—	—			
Antler	7	6	—	—	6	—	—	—	—	—	—	—			
Total	80	51	56	22	15	7	10	3	25	—	—	12			
	187			***44***			***38***			***12***			**281**		

Table 1. Parameters of the working edge of tools made of different raw materials concerning the type of bone and the total number of experiment elements. Bone type: "Fr" – fresh; "Dr" – dry; and "Er" – eroded.

Cut mark depth features	**Kinetics of movement**							
	Towards oneself		*From oneself*		*Reciprocating*		***Total***	
	N	%	N	%	N	%	N	%
Deeper at the beginning	43	29.7	13	15.9	—	0	56	22.7
Deeper at the end	12	8.3	21	25.6	—	0	33	13.4
Constant along the entire length	90	62	48	58.5	20	100	158	63.9
Total	***145***	100	***82***	100	***20***	100	***247***	***100***

Table 2. Correlation between the depth of the cut and the kinetics of movement. N marks the number of cuts.

Entry and exit of cut mark	**Kinematics of movement**							
	Towards oneself		*From oneself*		*Reciprocating*		***Total***	
Entry of cut mark:	N	%	N	%	N	%	N	%
Gradual	33	67.3	7	29.2	6	75	46	56.8
Sharp enough	16	32.7	17	70.8	2	25	35	43.2
Total	49	100	24	100	8	100	***81***	***100***
Exit of cut mark:	N	%	N	%	N	%	N	%
Gradual	93	71	56	73.7	28	80	177	73.1
Sharp enough	38	29	20	26.3	7	20	65	26.9
Total	131	100	76	100	35	100	***242***	***100***

Table 3. Correlation between the types of cut entry and exit and the kinetics of movement. N marks the number of cuts.

Entry and exit of cut mark	**Type of edge**							
	Sharp		Blunt		Trimmed + broken		***Total***	
Entry of the cut mark:	N	%	N	%	N	%	N	%
Gradual	27	69.2	5	22.7	14	70	46	56.8
Sharp enough	12	30.8	17	77.3	6	30	35	43.2
Total	39	100	22	100	20	100	***81***	***100***
Exit of the cut mark:	N	%	N	%	N	%	N	%
Gradual	119	78.3	31	77.5	27	54	177	73.1
Sharp enough	33	21.7	9	22.5	23	46	65	26.9
Total	***152***	100	***40***	100	***50***	100	***242***	***100***

Table 4. Correlation between the type of edge and the types of entry and exit of cuts. N marks the number of cuts.

Type of cut mark profile and other damage variation		**Type of edge**									
		Sharp		Blunt		Trimmed		Broken		***Total***	
		N	%	N	%	N	%	N	%	N	%
Stone instruments	U-shaped	9	4.8	5	11.4	9	23.7	—	—	23	8.2
	U/V, V/U combined	12	6.4	10	22.7	3	7.9	—	—	25	8.9
	U/П, combined	1	0.5	7	15.9	7	18.4	—	—	15	5.3
	U/strips	13	7	—	—	—	—	—	—	13	4.6
	V-shaped	131	70.1	6	13.6	13	34.2	—	—	150	53.4
	V/П, combined	—	—	—	—	3	7.9	12	100	15	5.3
	П-shaped	—	—	10	22.7	3	7.9	—	—	13	4.6
Bone, antler	Strips	11	5.9	2	4.6	—	—	—	—	13	4.6
	Areas	7	3.7	—	—	—	—	—	—	7	2.5
	Not visible	3	1.6	4	9.1	—	—	—	—	7	2.5
Total		***187***	100	***44***	100	***38***	100	***12***	100	***281***	100

Table 5. Correlation between the edge type and the types of a cut cross-section. N marks the number of cuts.

Type of cut mark cross-section	**Type of edge**									
	Sharp		Blunt		Trimmed		Broken		***Total***	
	N	%	N	%	N	%	N	%	N	%
U-shaped	35	19.6	22	40	19	37.3	—	0	76	24.6
П-shaped	1	0.5	17	30.9	13	25.4	12	50	43	13.9
V-shaped	143	79.9	16	29.1	19	37.3	12	50	190	61.5
Total	***179***	100	***55***	100	***51***	100	***24***	100	***309***	100

Table 6. Correlation between the type of edge and the type of a cut cross-section. N marks the number of cuts together with individual areas of the same profile in cuts, showing a combined cross-sectional shape.

Type of cut mark profile and other damage variation	**Raw material**											
	Quartz		Flint		Granite		Bone		Antler		***Total***	
	N	%	N	%	N	%	N	%	N	%	N	%
Not visible	—	—	—	—	—	—	—	—	4	21	4	1.2
Areas	—	—	—	—	—	—	—	—	7	36.9	7	2.1
Strips	—	—	—	—	—	—	12	27.3	8	42.1	20	5.9
U-shaped	—	—	—	—	46	41.1	23	52.3	—	—	69	20.3
П-shaped	7	17.1	26	21.1	15	13.4	1	2.3	—	—	49	14.5
V-shaped	34	82.9	97	78.9	51	45.5	8	18.2	—	—	190	56
Total	***41***	100	***123***	100	***112***	100	***44***	100	***19***	100	339	100

Table 7. Correlation between tool material and types of cut cross-sections. N marks the number of cuts together with individual areas of the same profile in cuts, showing a combined cross-sectional shape.

Type of cut mark profile	**Type of edge and the presence of furrows N and % according to the type of cut mark cross-section**									
	Sharp, N, and % in this variation		Blunt, N, and % in this variation		Trimmed, N, and % in this variation		Broken, N, and % in this variation		***Total***	
	N	%	N	%	N	%	N	%	N	%
U-shaped	1 in 35	2.9	8 in 22	36.4	12 in 19	63.2	—	—	21	27.6
П-shaped	—	—	9 in 17	52.9	11 in 13	84.6	7 in 12	58.3	27	64.3
V-shaped	73 in 143	51.8	9 in 16	56.3	6 in 19	31.6	7 in 12	58.3	95	50
N and % of cuts* with furrows in the given edge group	74 in 179	41.3	26 in 55	47.3	29 in 51	56.9	14 in 24	58.3	143	46.3

Table 8. The presence of furrows in relation to the morphology of the edge and the type of cut mark cross-section

* together with individual areas of the corresponding profile in cuts with a combined cross-sectional profile

Type of cut mark profile	**Raw material used to make tools and the presence of furrows N and % according to the type of cut mark cross-section**									
	Quartz, N, and % in this variation		Flint, N, and % in this variation		Granite, N, and % in this variation		Bone, N, and % in this variation		Antler, N, and % in this variation	
	N	%	N	%	N	%	N	%	N	%
U-shaped	—	—	—	—	21 in 46	45.7	4 in 30	13.3	—	—
Π-shaped	5 in 7	71.4	12 in 20	60	10 in 15	66.7	0 in 1	0	—	—
V-shaped	20 in 34	58.8	44 in 97	45.4	28 in 51	52.9	4 in 8	50	—	—
N and % of cuts* with furrows in the given raw material group	25 in 41	61	56 in 117	47.9	59 in 112	52.7	8 in 44	18.2	—	—

Table 9. Presence of furrows in relation to the tool material and the type of cut section

* together with individual areas of the corresponding profile in cuts with a combined cross-sectional profile.

Type of cut mark profile	**Bone condition and the presence of furrows N and % according to the type of cut mark cross-section**					
	Fresh bone, N, and % in this group		Dry bone, N, and % in this group		Eroded bone, N, and % in this group	
	N	%	N	%	N	%
U-shaped	4 in 62	6.5	7 in 25	28	14 in 42	33.3
Π-shaped	5 in 23	21.7	0 in 3	0	19 in 45	42.2
V-shaped	31 in 83	37.3	30 in 50	60	35 in 97	36.1
N and % of cuts* with furrows in the given bone group	40 in 168	23.8	37 in 78	47.4	54 in 187	28.9

Table 10. Presence of furrows according to the correlation between the bone condition and the type of cut cross-section

* together with individual areas of the corresponding profile in cuts with a combined cross-sectional profile.