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Middle Paleolithic Bone Retouchers: Size or Proportions

Bone retouchers are the most common tools for processing lithic raw material in the Middle Paleolithic of Eurasia. Typically, they are perceived by Paleolithic researchers as informal, unmodified tools made from bone blanks accidentally obtained during the extraction of marrow. In this article, we introduce new data on a large collection of bone retouchers from Chagyrskaya Cave (in the Altai Mountains). Their dimensions demonstrate a high standardization of blanks, indicating the intentional selectivity of Neanderthals. Selection also concerned animal species and the anatomical positions of bones. We found that morphological characteristics such as the number of active areas and the degree of their modification did not affect the size of the retouchers and attest only to the reorientation of tools during lithic processing. In the course of retouching, cross-sections of diagnostic traces in the active areas underwent significant changes: whereas at the early stages they reveal "furrows" with V-shaped cross-sections, multiple blows against the processed lithic resulted in the deformation of the original form, which eventually resembled an upturned trapeze. The comparison of bone retouchers from several multicultural Middle Paleolithic complexes in Eurasia (Chagyrskaya and Denisova caves in the Altai, Kabazi V site in the Crimea, and Barakayevskaya Cave in the Caucasus) evidences similar proportions but considerable variation in size. Proportions, then, are an inherent functional characteristic of bone retouchers, which does not depend on either the cultural context or the raw material base.

Keywords: *Middle Paleolithic, Neanderthals, Altai, Chagyrskaya Cave, bone retouchers, bone industry.*

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Introduction

Along with lithic hammers, bone retouchers were tools used in lithic reduction in the Middle Paleolithic. Bone retouchers started to be mentioned in the scholarly literature already in the late 19th century (Leguay, 1877; Daleau, 1883). Since the 20th century, their description has become an integral part of the analysis of artifacts (Bonch-Osmolovsky, 1934; 1940: 121–122; Zamyatnin, 1934; Gvozdover, Formozov, 1960; Leonardi, 1979; Kolosov, 1986: 183; Valoch, 1988; Kolosov, Stepanchuk, Chabai, 1993: 39, 116, 133, 155; Filippov, Lyubin, 1994; Yevtushenko, 1998; Khlopachev, 2013; Claud et al., 2012; Mallye et al., 2012; Tartar, 2012; Blasco et al., 2013; Neruda, Lázničková-Galetová, 2018; Costamagno et al., 2018; Moigne et al., 2016). Bone retouchers have been widely analyzed in Western European scholarship (Mozota, 2018), and therefore we will focus on key stages in the study of this tool-type in the works of the Eastern European researchers.

After studying the morphology of bone retouchers and retouching on flint tools, as well as conducting experiments, three approaches for using retouchers were proposed: as anvil, pressure tool, and hammer. The term "anvil" (*enclume*) was associated with the use of retouchers as passive tools for applying counter-impact retouching at the La Ferrassie and La Quina sites (Capitan, Peyrony, 1912; Martin, 1906). When analyzing the evidence from the Ilskaya site, S.N. Zamyatnin used the terms "small anvil" and "retoucher" for describing the same bone fragments (1934: 213, pl. III, 15–17).

G.A. Bonch-Osmolovsky reasonably rejected the interpretation of anvil proposed by French scholars, and pointed out that the "asymmetric arrangement of incisions at the ends of double small anvils, and their oblique direction with respect to the axis of bone fragment, testify to the use of the latter as active retouchers, which were pressed against the flint blade" (1934: 134). Somewhat later, comparing retouchers from the collections of the La Quina, Shaitan-Koba, and Kiik-Koba sites, he made a number of important observations that remain relevant today: 1) "incisions are grouped in small zones at one or both" ends of the bone; 2) "zones of incisions are shifted to the left of the midline"; 3) "incisions are directed obliquely, at an angle of 45° relative to the longitudinal axis of the bone"; 4) they were made "with a sharp edge of a flint, which was directed, not perpendicularly, but slightly obliquely to the bone surface", the angle of inclination was "about 30–35°" (Bonch-Osmolovsky, 1940: 120). These observations led Bonch-Osmolovsky to the conclusion that "incisions could only have been made using one technique—active retouching of blades on flint tools. With a bone fragment tightly held in the right hand (I emphasize, in the right hand, which is confirmed by the invariable inclination of the facets from left to right), the artisan pressed on a flint blade, which was held in his left hand and was slightly inclined upward" (Ibid.).

One of the first specialized studies of bone retouchers was carried out by S.A. Semenov in 1957 using the materials from the Eastern European Paleolithic sites of Kiik-Koba and Kostenki. Having compared the data of use-wear analysis of archaeological artifacts and experimental standards, he identified the traces of use on retouchers resulting from pressure retouching at the edge of the lithic tool (Semenov, 1957: 206). In the same study, Semenov confirmed the conclusions of Bonch-Osmolovsky, and interpreted diagonal uniform traces on bone retouchers as evidence of working with the right hand (Ibid: 208).

A.K. Filippov and V.P. Lyubin studied numerous bone retouchers from Barakaevskaya Cave, and subdivided them into five typological groups with different locations of wear-marks (1994). V.N. Stepanchuk analyzed flint-processing tools at the Middle Paleolithic site of Prolom I, and observed that lithic retouchers were made using river pebbles of relatively soft, tuffaceous, and sandstone rocks (1990). A.I. Yevtushenko pointed out the similarities in the morphology of traces (incisions and grooves) on the surfaces of lithic and bone retouchers from Kabazi V (1998). Taking into account specific features of striking platforms on the spalls and these similarities, he concluded that pebble and bone retouchers were used as hammers, and not as pressure tools (Ibid.: 316), which means that the incisions resulted from blows, while the grooves resulted from abrasive processing of tool blades. The evidence from new excavations at Chokurcha I confirmed this observation (Chabai, 2004a: 408–412). V.P. Chabai proposed a classification of bone and pebble retouchers in accordance with the number and location of active areas, and took into consideration their metric features, such as length, width, and thickness. Thus, he established the similarity of many shape-related parameters of bone and pebble retouchers (Ibid.). A.P. Veselsky supplemented Chabai's classification by such features as intensity of use and weight. Studying the collections from Kabazi V, he made a number of important observations: retouchers typically occurred in the layers with the Micoquian artifacts, while they were rare or completely absent in the Levallois-Mousterian layers; the weight of bone retouchers was much less than those made of lithic; intense use of retouchers was manifested not only by the microflaking of active areas, but also by the presence of the second active area (Veselsky, 2008). These observations brought Veselsky to the conclusion about the use of bone retouchers for manufacturing bifacial tools. Moreover, taking into account the weight of retouchers, it was suggested that these were used for manufacturing only distal tool-parts, i.e., points—the thinnest parts, where excessive weight in the retoucher could lead to unintentional damage of the tool (Ibid.). Indeed, in Eastern Europe, retouchers are associated with manufacturing bifaces in the Micoquian technocomplex starting from MIS 5d (Kabazi II, VI/11–14) up to the final stages of MIS 3 (Kiik-Koba, upper layer) (Chabai, 2005: 125; Khlopachev, 2013).

In the Altai Mountains, Middle Paleolithic bone tools were first identified in 2016 in the complexes of Chagyrskaya Cave (Kolobova, Markin, Chabai, 2016; Kolobova, Rendu, Shalagina et al., 2020). The industry of the site was attributed to the Sibiryachikha facies of the Altai Middle Paleolithic, which is the most eastern manifestation of the Micoquian technocomplex widespread in Central and Eastern Europe (Kolobova, Roberts, Chabai et al., 2020). Currently, 1080 bone tools have been identified in the materials from Chagyrskaya Cave, including 1052 retouchers. This is one of the richest collections of bone tools of the Middle Paleolithic of Eurasia. This article presents the results of morphometric analysis of the sample of retouchers from Chagyrskaya Cave. In addition, we will give extensive comparisons with tools of this type from the described Middle Paleolithic assemblages of the Altai, Crimea, and Caucasus, for establishing their functional features.

Materials and methods

After re-examining old artifacts and obtaining new paleozoological collections from Chagyrskaya Cave (2008–2018), complete and fragmented bone tools were identified: weakly modified tools similar to points but with rounded noses, intermediate tools, tools with lateral retouch (Baumann et al., 2020), and retouchers. The retouchers come from layer 6. One hundred bone retouchers were selected for morphometric analysis (Fig. 1). The overwhelming majority of bone retouchers in the collection were fragmented with fractures in the active areas. In the process of sampling, preference was given to complete or slightly fragmented specimens. The probable integrity of the tools was established from the nature and color of postdepositional surfaces of fracture. The sample included most of the presumably

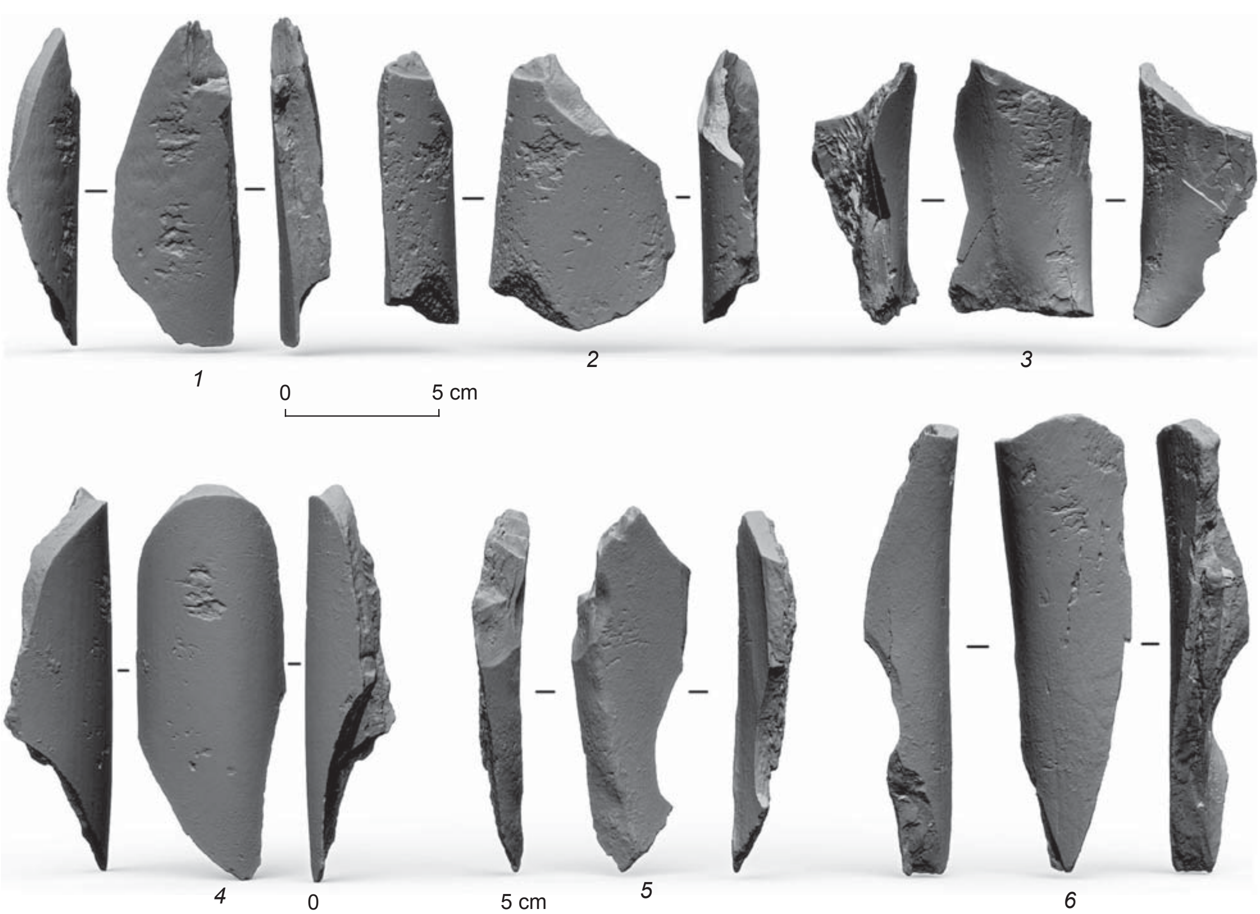

Fig. 1. Bone retouchers from the Middle Paleolithic complexes of Chagyrskaya Cave.

complete bone retouchers; it is representative, and allows for conducting statistical analysis without any restrictions.

Several similar methods based on the classification of morphological features and metric characteristics are applied to the analysis of bone retouchers (Lyubin, 1994; Armand, Delagnes, 1998; Malerba, Giacobini, 1998; Veselsky, 2008; Mallye et al., 2012). We chose the method used by Veselsky (2008) for the following reasons: it was employed in the analysis of the Kabazi V complex, which belongs to the Micoquian, as well as archaeological materials from Chagyrskaya Cave; and a preliminary analysis of retouchers from this cave conducted following this method has shown its exceptional informative significance (Kolobova, Markin, Chabai, 2016). We identified the following features: 1) number of active areas; 2) degree of use/modification on each area; 3) maximum metric parameters: length, width, and thickness, and 4) weight. The measured weight of bone retouchers was undoubtedly different from the original weight of tools made from fresh bones; its decrease resulting from drying and post-depositional mineralization in long bones and ribs of large herbivores could have been differential. Nevertheless, we included this parameter in the study in order to assess its research capacity. The published data on bone retouchers from Kabazi V (Crimea), Barakaevskaya Cave (Caucasus), and Denisova Cave (Altai) were used for establishing variability of studied tools within the single industrial variant (the Micoquian, Kabazi V, Barakaevskaya and Chagyrskaya caves) and differences between different variants (the Micoquian and Denisova variant of the Altai Middle Paleolithic) (Filippov, Lyubin, 1994; Veselsky, 2008; Kozlikin et al., 2019).

During the study, the samples were illuminated by an electric light with changing illumination angle for the qualitative determination of characteristics of surfaces, including both anthropogenic (traces of retouching, removal of the periosteum, cuts, deliberate modification of tools along the edge) and biogenic (fresh breaks, bite marks, traces of roots) modifications. Traces of bone use as a retoucher were the dents in the active area. All tools were oriented along the long axis with obligatory location of the active area in the upper part; if there were two or more active areas, the upper one was considered that with the greatest degree of modifications.

Analysis of the paleontological complexes of Chagyrskaya Cave has shown that the main hunting prey were young and female bisons (*Bison priscus*), and to a much lesser extent Ovodov horses (*Equus* (*Sussemionus*) *ovodovi*) (Kolobova, Rendu, Shalagina et al., 2020). The overwhelming majority of retouchers come from lower layers 6c/1 and 2, which were the least disturbed by post-depositional processes. The data obtained were processed using mathematical statistics methods. All calculations were carried out in the PAST software. The metric parameters of retouchers were compared depending on their distribution across the number of active areas and on the relative degree of modification of the main area. The preliminary stage of data processing included creating descriptive statistical tables and establishing the adequacy of data distribution in the analyzed samples, using the Shapiro-Wilk test. This test has shown that the bulk of the data in the samples was distributed abnormally. Therefore, it was decided to apply the Kruskal-Wallis one-way analysis of variance, which is used for comparing three or more samples (Hammer, Harper, Ryan, 2001). Since it establishes the similarity/difference between several compared samples across one variable, in the case of statistically significant differences, a pairwise comparison was carried out using the Mann-Whitney test with Bonferroni correction to minimize the probability of type I error (Grzhibovsky, 2008).

Visualization of statistical data was carried out by constructing box plots and ternary plots in the PAST software. The ternary plot is the most convenient tool for displaying the relationship between several variables—in our case, metric parameters. For this purpose, a triangular coordinate system on a plane is used, where the relative share of each metric parameter is limited by their sum taken as 1 (100 %), and the vertices of the triangle are the maximum values of length, width, or thickness, also equal to 100 %.

Visualization of retouchers was performed by creating textureless 3D-models: they show a clear advantage in accuracy over schematic drawing, and better display the active areas, as compared to high-quality photography, because of the lack of texture. The models were obtained using a RangeVision PRO 5M structured illumination scanner. After scanning, they were processed using the RangeVision ScanCenter and ScanMerge software (Kolobova, Fedorchenko, Basova et al., 2019). Post-processing of the models, including creation of profiles and elevation maps, was carried out using Autodesk Netfabb, Geomagic Design X, and Geomagic Wrap (trial versions).

Study results

Relatively large fragments of flat bones and diaphyses of long tubular bones were used for manufacturing the retouchers under study. In half of the cases, it was possible to identify the anatomical position of the blank (femur, tibia, radius, less often ribs, various vertebrae, and mandibles) (Kolobova, Chabai, Shalagina et al., 2019). One, two, or three active areas, which resulted from the contact with the processed lithic tools, have been recorded on the retouchers. Most of the areas are located in accordance with the natural relief of the surface of cortical layer of the bone in convex and, less often, flat zones. The diagnostic features of the use of retouchers are closely-spaced deep "furrows" with V-shaped cross-section and "pits" rounded in plan view. Different morphology of traces is associated with the different intensity of operations performed, the morphology of the retouched edge of the tool, and the quality of lithic raw materials. Notably, the V-shaped profile of the depressions was observed on the weakly modified retouchers (Chase, 1990). Using the example of a three-dimensional model of a highly modified retoucher from the complex of Chagyrskaya Cave, we have managed to create longitudinal and transverse cross-sections for the most typical traces within the active areas (Fig. 2). The V-shaped cross-section has not been recorded; the profile of both "pits" and "furrows" rather has a shape of an upturned trapeze. This shape probably resulted from intense use of a retoucher, when there was more than one blow per a unit of the active area, which modified the original V-shaped cross-section. The impact function of retouchers is confirmed by preliminary experiments on modeling bifaces (Shalagina et al., 2019).

The length of the examined tools varies from 38.8 to 156.0 mm; width from 18.7 to 61.3 mm, and thickness from 2.1 to 12.0 mm; the weight of the artifacts ranges from 7 to 107 g. For analyzing metric parameters, bone retouchers were grouped according to their morphological features: with different numbers of active areas on the cortical surfaces (Fig. 3), and with different degrees of modification of active areas (Fig. 4). When more than one active area was observed on the retoucher, this meant that it was reoriented after the primary use and was used secondarily.

The majority of retouchers in the sample under consideration have one (45 %) or two (48 %) active areas; only 7 % of retouchers have three active areas (Table 1). The materials from Chagyrskaya Cave manifest fairly intense retouching of lithic tools. Intensity of retouching can be described as extremely high as compared to the Middle Paleolithic complexes of other industrial variants in Altai (Kara-Bom and Denisova) (Kolobova, 2006; Kolobova, Krivoshapkin, Pavlenok et al., 2012). However, in the context of the Micoquian industries, it corresponds to the mean degree typical of the complexes of the Staroselye facies (Chabai, 2004b: 236–238; Kolobova, Chabai, Shalagina et al., 2019).

We have compared metric parameters of retouchers with different numbers of active areas on cortical surfaces. Judging by the box plot, specimens with three active areas were slightly longer than those with one and two (Fig. 5, *1*). However, the Kruskal-Wallis analysis of variance did not reveal statistically significant differences ($H(\chi^2) = 4.24$; $p = 0.085$). The same applied to the values of width ($H(\chi^2) = 0.59$; $p = 0.744$) and thickness ($H(\chi^2) = 0.093$; $p = 0.95$) (Fig. 5, *2*, *3*). The weight of retouchers with three active areas was slightly larger (Fig. 5, *4*), but the difference was not statistically significant ($H(\chi^2) = 4.63$; $p = 0.098$).

In total, on 100 bone retouchers, 162 active areas have been recorded. Weakly worn areas constitute 52 %; moderately worn 32 %, and highly worn 16 %

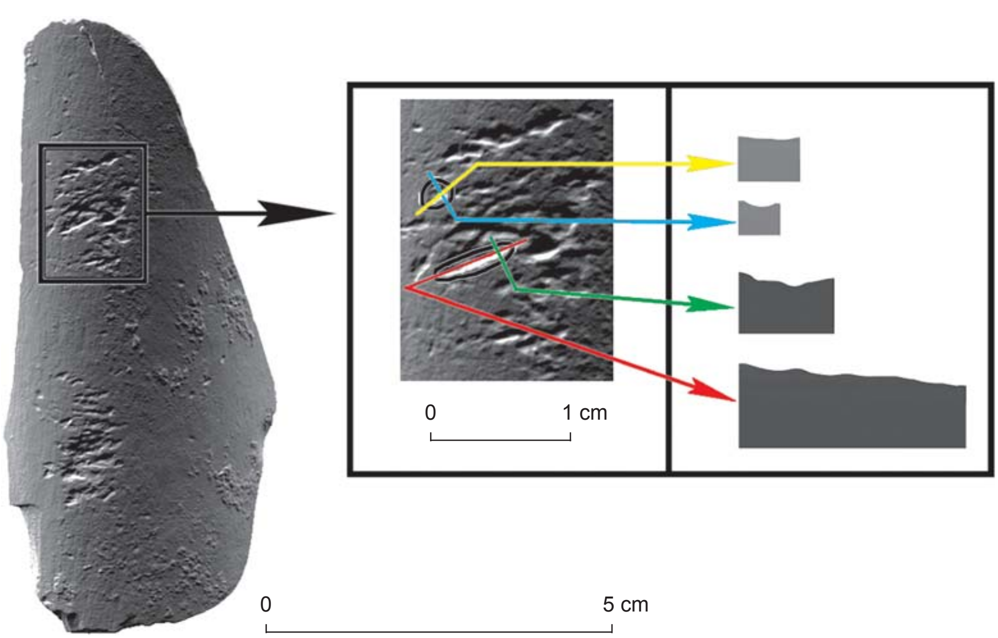

Fig. 2. Cross-sections of a "pit" and a "furrow" on the retoucher.

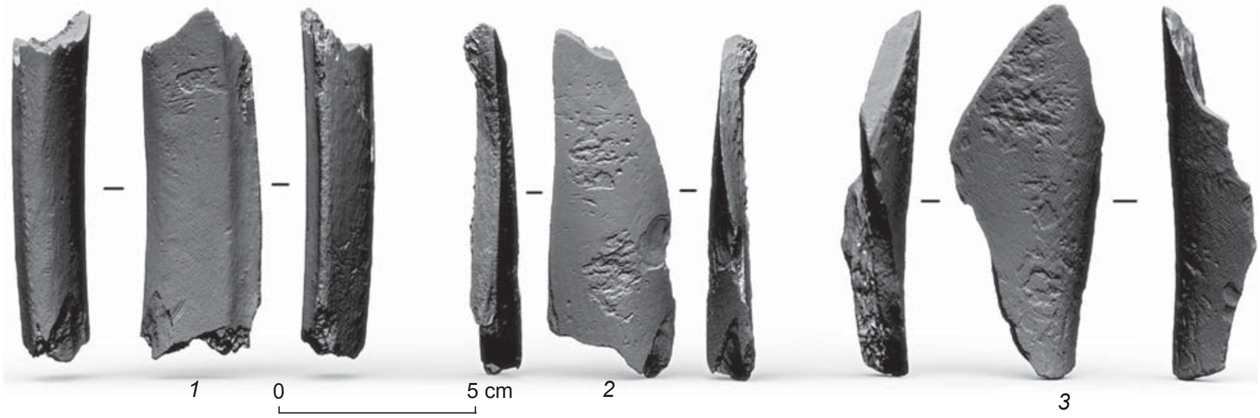

Fig. 3. Bone retouchers with one (*1*), two (*2*), and three (*3*) active areas.

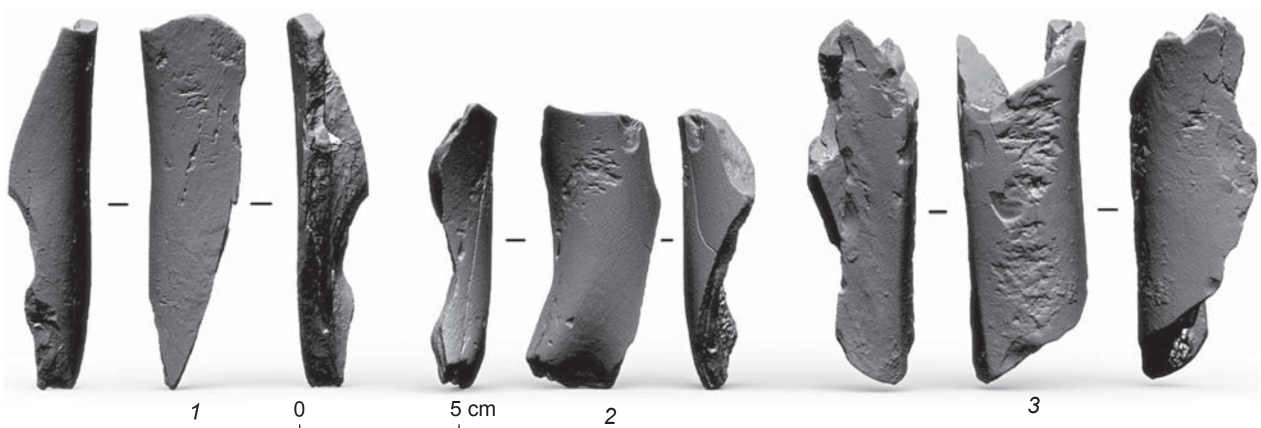

Fig. 4. Weakly (*1*), moderately (*2*), and highly modified (*3*) bone retouchers.

Table 1. **Mean values of metric parameters of bone retouchers from Chagyrskaya Cave, depending on the number of active areas**

Number of active areas	Number of retouchers, %	Length, mm	Width, mm	Thickness, mm	Mass, g
1	45	85.79	36.87	7.61	33.47
2	48	90.36	36.94	7.70	37.04
3	7	102.66	37.90	7.61	48.14

(Table 2). When comparing the length of retouchers with different degrees of utilization, the Kruskal-Wallis test manifested a difference at the limit of statistical significance ($H(\chi^2) = 6.1$; $p = 0.047$) (Fig. 6, *1*). Therefore, the Mann-Whitney test was used. Pairwise comparison has shown that highly and weakly modified retouchers were the most statistically dissimilar ($U = 264.5$; $p = 0.029$). Since we observed a statistically significant difference between the three samples, it was necessary to apply the Bonferroni correction to exclude type I error. This correction takes into account the critical level of significance for several samples; in our case, $p = 0.0253$. The level of significance that we have obtained exceeded the critical level, which means that the null hypothesis as to the equality of length of the retouchers could be accepted, and it could be concluded that the groups compared across this parameter did not differ statistically. Significant differences in width ($H(\chi^2) = 1.38$; $p = 0.55$) (Fig. 6, *2*), thickness ($H(\chi^2) = 2.6$; $p = 0.26$) (Fig. 6, *3*), and weight ($H(\chi^2) = 5.58$; $p = 0.06$) (Fig. 6, *4*) have also not been recorded.

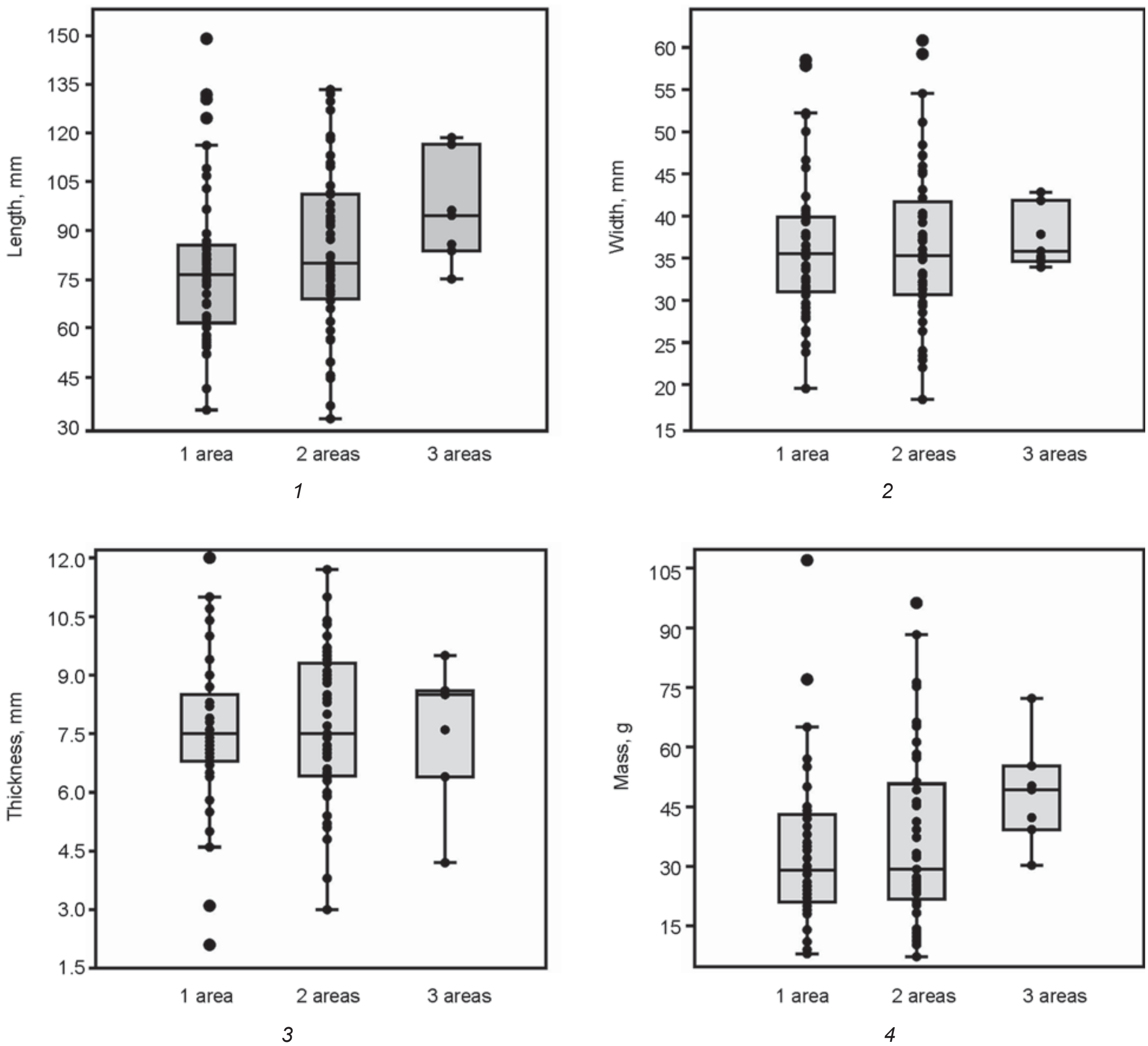

Fig. 5. Box plots of metric parameters of retouchers depending on the number of active areas.

Table 2. **Mean values of metric parameters of bone retouchers from Chagyrskaya Cave, depending on wear degree**

Wear degree	Number of retouchers, %	Length, mm	Width, mm	Thickness, mm	Mass, g
Weak	52	84.43	36.90	7.63	32.79
Medium	32	92.18	35.64	7.38	36.88
High	16	98.51	39.91	8.28	47.88

Discussion

Experimental modeling of manufacturing bifacial tools from Chagyrskaya Cave has demonstrated the use of retouchers at the final stages of shaping lithic bifaces, and obvious advantages of their use as compared to hard mineral hammers and retouchers (Shalagina et al., 2019). These data are in direct agreement with the archaeological assemblage. Evidence for the use of soft hammers—absent or diffuse bulb, combined with pronounced lip —

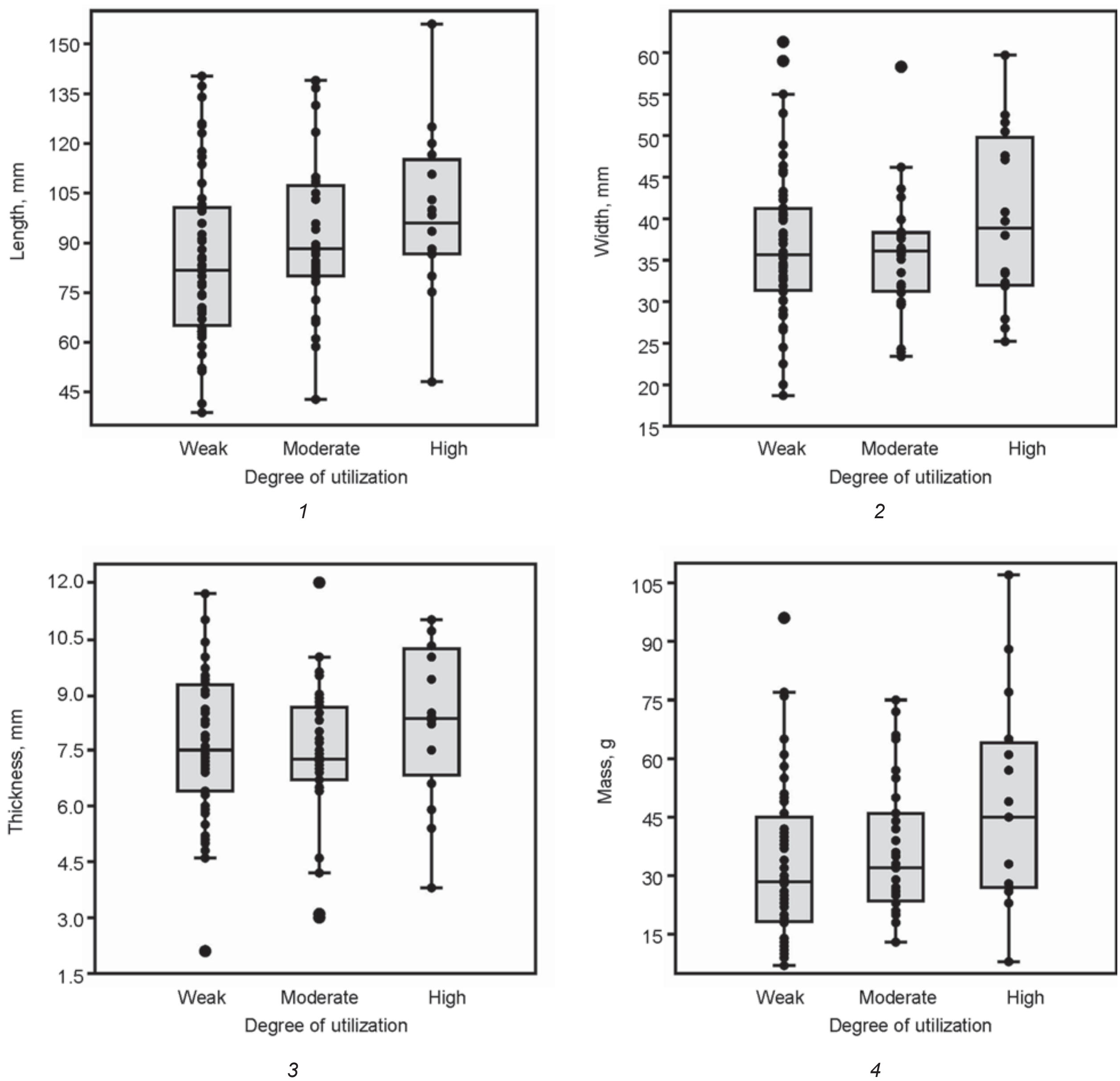

Fig. 6. Box plots of metric parameters of retouchers depending on modification of active areas.

has been found in the proximal zones of all studied bifacial thinning tools (Kolobova, Shalagina, Chabai et al., 2019). A preliminary geometric morphometric analysis of the shape of retouchers from Chagyrskaya Cave has revealed small influence of the anatomical position of blanks on the overall morphological variability of the sample, which most likely indicates deliberate selectivity. At the same time, a sufficiently high degree of uniformity among these tools has been observed (Kolobova, Chabai, Shalagina et al., 2019).

Analysis of morphometric parameters may provide valuable scholarly information about the technological features of the bone industry of Chagyrskaya Cave. In the study of Paleolithic complexes, fragmentation of bone retouchers is an objective obstacle to this kind of research. Analysis of the main metric parameters in one hundred complete or slightly fragmented (still in ancient times) bone retouchers from Chagyrskaya Cave has revealed the high level of their metric standardization. We have not identified any statistically significant differences between retouchers with different numbers of active areas and retouchers with different degrees of their modification. Standardization became apparent after comparing three metric parameters (length, width, and thickness) together. On ternary plots, all retouchers were concentrated in one area, demonstrating the same proportions regardless of their morphological features (Fig. 7).

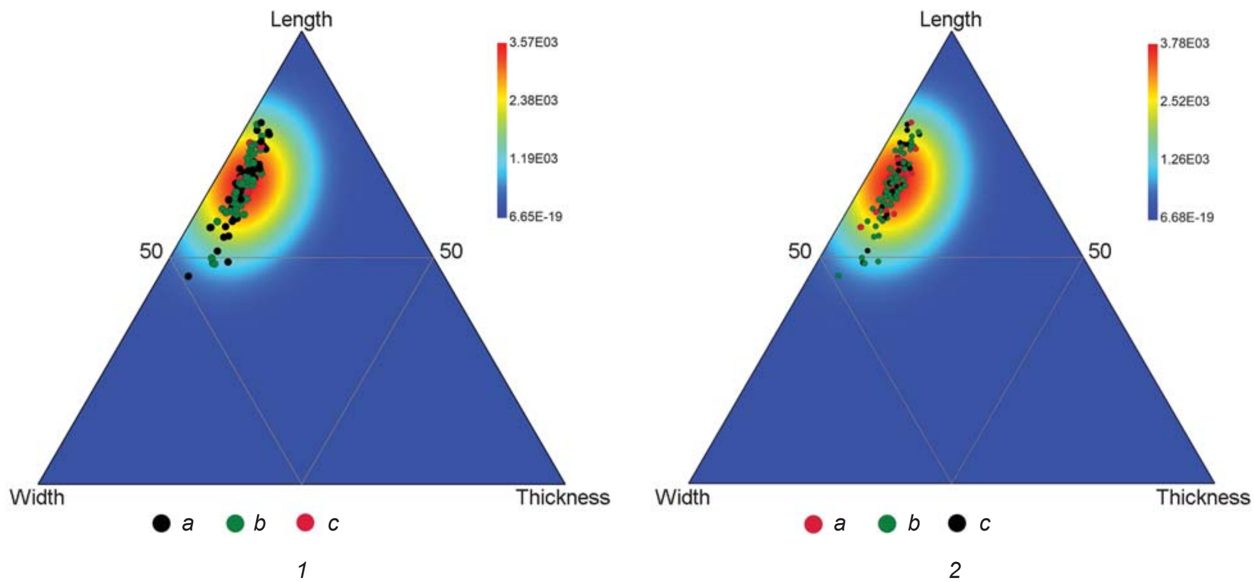

Fig. 7. Ternary plot showing proportions of main metric parameters in bone retouchers from the complex of Chagyrskaya Cave (the point density map, designed using the method of nuclear density estimation, is shown in color).
1 – retouchers with a different number of active areas: *a* – with one area, *b* – with two areas, *c* – with three areas; *2* – retouchers with varying wear degrees: highly (*a*), moderately (*b*), and weakly modified (*c*).

In order to establish any cultural or functional preferences in the use of Middle Paleolithic bone retouchers, we employed the published data on several Middle Paleolithic sites in the Crimea, Caucasus, and Altai: Denisova and Barakaevskaya caves, and Kabazi V (Kozlikin et al., 2019; Filippov, Lyubin, 1994; Veselsky, 2008). The complexes from Kabazi V and Barakaevskaya Cave, as well as the complex from Chagyrskaya Cave, are a part of the Eastern Micoquian industries. The assemblages chronologically belonging to the period from the late MIS 4 to the early MIS 3 typically show a combination of flake-based reduction and plano-convex bifacial processing of tools. The toolkits contain bifacial symmetrical and asymmetrical points and side-scrapers, along with simple and convergent side-scrapers and retouched points. The published data include metric parameters of retouchers (Chabai, 2004a; Veselsky, 2008; Filippov, Lyubin, 1994; Kolobova, Roberts, Chabai et al., 2020).

Two hundred and five bone retouchers were found at the Middle Paleolithic site of Kabazi V. Most of these came from two units of horizons III/1 and III/5. These were most likely manufactured from fragments of bones of hydruntines, whose remains prevailed in the paleozoological collection of the site. Such tools are distinguished by only one working surface and one, rarely two, active areas. Fragments of tubular bones and, in sporadic cases, of ribs were used as blanks (Veselsky, 2008). The article by Veselsky provides the mean values of metric parameters of bone tools by layers. We take into account only the published metric parameters of 43 bone retouchers from the layers with individual finds

Table 3. **Mean values of metric parameters of bone retouchers from the complexes of Kabazi V, Chagyrskaya, Barakaevskaya, and Denisova caves**

Site	Number of retouchers	Length, mm	Width, mm	Thickness, mm	Mass, g	Elongation index (length/ width)	Massiveness index (width/ thickness)
Chagyrskaya Cave	100	89.16	36.98	7.90	36.42	2.41	4.68
Kabazi V	43	72.58	26.07	9.40	17.51	2.78	2.77
Barakaevskaya Cave	12	86.28	31.06	10.00	…	2.78	3.10
Denisova Cave	9	115.50	42.80	14.20	74.70	2.69	3.01

(Table 3); therefore, we believe that it is incorrect to use the mean values of the samples.

One hundred and nine retouchers made from fragments of tubular bison bones were identified in the complex from Barakaevskaya Cave. They occurred in four horizons of the Mousterian layer. A significant proportion of bone tools showed traces of deliberate chipping or retouching. According to the published data, we have reconstructed the metric parameters of twelve complete retouchers (Table 3); information on their weight is absent (Filippov, Lyubin, 1994).

In Altai, three Middle Paleolithic industrial variants are known: the Sibiryachikha, the Denisova, and the Kara-Bom. The Sibiryachikha complexes of Chagyrskaya Cave differ technically and typologically from the Denisova and Kara-Bom complexes (Derevianko et al., 2015; Krivoshapkin et al., 2018; Shalagina et al., 2018; Kolobova, Shalagina, Chabai et al., 2019). In Denisova Cave, bone retouchers occur in tool assemblages from the Pleistocene deposits of the Main Chamber and East Chamber. At the present stage of research, 28 specimens have been found. Nine complete retouchers came from layer 12 of South Chambert (MIS 4) (Table 3); these were made from fragments of the diaphyses of tubular bones, probably of horse, bison, rhinoceros, or mammoth. All have morphologically identical wear-traces of varying degrees; one, two, or three active areas have been identified in each retoucher. In some bone artifacts, secondary processing (lateral and/or transverse trimming) has been observed (Kozlikin et al., 2019).

Thus, we have data on complete retouchers from four Middle Paleolithic sites, three of which belong to the Micoquian (Kabazi V, Chagyrskaya and Barakaevskaya caves), and one to the Denisova Levallois-Mousterian variant of the Altai Middle Paleolithic (Denisova Cave). Undoubtedly, our comparisons are rather approximate owing to the small number of samples from Barakaevskaya and Denisova caves. Nevertheless, we can draw some preliminary conclusions.

Taking into account the different species membership of bone materials, the small size of the samples makes it unreasonable to compare metric parameters of bone retouchers. However, a significant difference across the metric parameters can be observed between these complexes. It is also unreasonable to compare retouchers by weight, owing to the different preservation of bones and their different density (Table 3). Comparison of the indices of elongation (ratio of the retoucher's length to its width) and massiveness (ratio of the retoucher's width to its thickness) shows the significant similarity of these parameters in retouchers from all the sites (Table 3). The same picture is demonstrated by all three metric variables in the aggregate (Fig. 8).

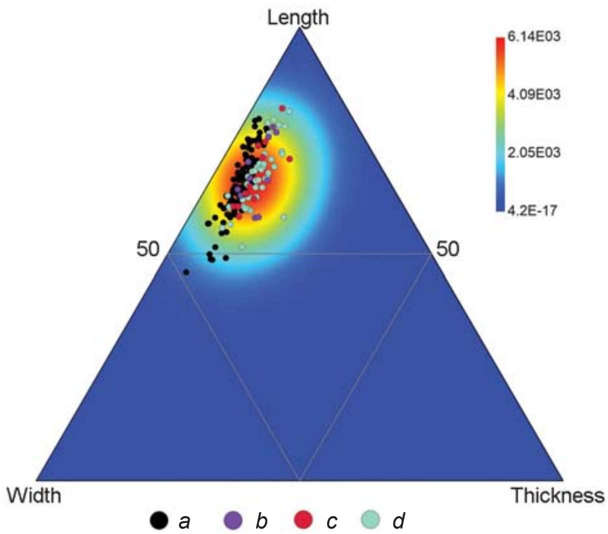

Fig. 8. Ternary plot showing the proportions of the main metric parameters in bone retouchers from the complexes of Chagyrskaya (*a*), Denisova (*b*), and Barakaevskaya (*c*) caves, as well as Kabazi V (*d*).

Conclusions

The available experimental and archaeological data on the Chagyrskaya complex testify to widespread use of bone retouchers for shaping and rejuvenation of lithic tools. The analysis of cross-sections of bone retouchers has shown that their shape depended on the degree of modification of active areas. Multiple blows by the tool against the processed lithic material lead to deformation of the original V-shape, which takes the shape of an upturned trapeze. After comparing the length and width of bone retouchers from Chagyrskaya Cave, it has been found that tools with different number of active areas or degree of modification show small differences. This may indicate the preferences of the Neanderthals in terms of sizes and their selectivity in choosing the blanks. Blanks were also selected by animals' species and the anatomical positions of bones.

Comparison of metric parameters in retouchers from Middle Paleolithic complexes belonging to different cultures (the Micoquian and Denisova industrial variants), which are distant from each other, has demonstrated substantial differences. Moreover, almost the same proportions of tools made from different raw materials have been observed. Thus, we have obtained the functional characteristic of bone retouchers that does not depend on either the cultural context or raw materials. On average, these tools have an elongation index from 2.41 to 2.78, and a massiveness index from 2.7 to 4.7. These proportions were caused by the size and weight of fresh bone, required for successful retouching.

Possibly, such fragments of bones were selected as were the most convenient for holding during work and did not have sharp protrusions along the edges of the part held by the hand. However, the question concerning intentional modification of bone tools still remains: did the Neanderthals take the blanks that were ready for use, or did they modify the blanks until the required shape was achieved. Many scholars mention the selectivity of Neanderthals in choosing bone fragments for retouchers and their special processing before use (see, e.g., (Blasco et al., 2013; Mallye et al., 2012)). The studies of retouchers from Chagyrskaya, Barakaevskaya, and Denisova caves have revealed the traces of additional processing on isolated artifacts (Filippov, Lyubin, 1994; Kozlikin et al., 2019; Kolobova, Chabai, Shalagina et al., 2019). This fact requires a detailed study, since bone blanks were often reshaped into several tools (for example, retoucher and intermediate tool on one blank) (Baumann et al., 2020). Thus, additional processing may not necessarily be a part of shaping the retoucher, but of shaping another tool.

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