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**S.N. Skochina and Y.V. Kostomarova**
*Institute of Northern Development, Siberian Branch,*
*Russian Academy of Sciences,*
*POB 2774, Tyumen, 625003, Russia*
*E-mail: sveta_skochina@mail.ru; jvkostomarova@yandex.ru*

# THE FUNCTION OF PEBBLE-TOOLS FROM LATE BRONZE AGE SITES IN THE TOBOL FOREST-STEPPE: AN EXPERIMENTAL TRACEOLOGICAL ANALYSIS

*Late Bronze Age pebble-tools from the Tobol forest-steppe sites associated with the Fedorovka, Cherkaskul, and Pakhomovskaya cultures were subjected to a comprehensive analysis with regard to raw material and technology. Pebbles requiring no retouch were preferred; and in rare instances the working-surface was processed by direct percussion. Types of wear such as crumbling, polishing, various deformations etc. are described, on the basis of the results of the traceological analysis. The analysis of microwear traces, and of their co-occurrence, has allowed us to subdivide the tools into four groups. To assess the tentative function of each group, a series of experiments in processing hides, dressing skins, and polishing clay vessels, stone axes, and metal tools, was conducted. Experimental tools, too, were subjected to use-wear analysis. The comparison of experimentally derived wear-marks with those revealed microscopically on ancient tools has made it possible to attribute the groups, and to relate them to various manufactures. Most pebble-tools from Late Bronze Age sites were multifunctional. They were used for dressing hides and skins, and for burnishing clay vessels. Monofunctional pebbles used in a single manufacture (skin-dressing, or the production of ceramic or metal tools) are less frequent. The use of small quartzite pebble-tools may be seen as a cultural and chronological marker of the Andronovo, primarily the Cherkaskul, tradition.*

Keywords: *Late Bronze Age, Tobol River, forest-steppe, pebble-tools, experimental traceological analysis.*

## Introduction

Small-sized river pebbles showing use-wear traces are relatively often found at the Late Bronze Age sites associated with the Andronovo and Andronovo-type traditions. Researchers studying the Andronovo economy interpreted such artifacts as tools used for polishing clay vessels (Krivtsova-Grakova, 1948: 82, 144; Potemkina, 1985: 70, 100, 128; Kuzmina, 1994: 111–112; Potemkina, Korochkova, Stefanov, 1995: 50; Serikov, 2006: 45). Archaeological publications also offer different versions of how these pebbles were exploited, allowing their use for polishing metal artifacts, particularly the surface of casts (Kungurova, Udodov, 1997: 78), and also for techniques of processing hides and skins, such as unhairing and burnishing (Semenov, Korobkova, 1983: 137, 147; Zakh, 1995: 63; Korobkova, 2001: 159; Korobkova, Shaposhnikova, 2005: 175, 193).

It should be noted that, firstly, the functional attribution of Andronovo materials was often carried out without the use of traceological analysis; secondly,


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the authors of publications based on this approach (and focused on other cultures) described the wear-characteristics of such tools only in general terms, providing no illustrations of use-wear traces; thirdly, a tentative microanalysis of pebbles found at the Bronze Age Tobol sites has allowed us to identify several variations among their use-wear features, suggesting a functional differentiation of tools.

Thus, the issue regarding the functionality of pebbles remains open. In order to resolve it, an experimental traceological analysis of the whole assemblage of such objects has been carried out. This has made it possible to obtain data on the use of pebbles in a specific manufacture, and on its stages; and also to provide more insights into the characteristics of economic activities of people inhabiting this area during the Late Bronze Age.

## Study materials

Our study focuses on pebbles showing use-wear traces, found at the Late Bronze Age Tobol forest-steppe sites: Khripunovskoye-1, Olkhovka, Imbiryai, Bolshoi Imbiryai-2, -10, Krivolukskoye-7, Shchetkovo-2, Cheremukhovyi Kust, Chepkul-5 (Matveyev, 2000, 2007; Matveyev, Anoshko, Izmer, 2002, 2003; Matveyev, Kostomarov, 2011; Anoshko et al., 2003; Zakh, 1995: 63; Zakh et al., 2014). The most representative assemblages came from the sites of Khripunovskoye-1 and Olkhovka that are associated with the Cherkaskul culture, including 22 and 12 objects, respectively. Three pebbles deriving from the site of Imbiryai-3 are also associated with this culture. A total of 6 specimens was found at the Cherkaskul-Pakhomovskaya site of Bolshoi Imbiryai-10. The sites of Krivolukskoye-7 and Cheremukhovyi Kust yielded isolated finds dating as far back as the Fedorovo stage. We attributed ten pebbles to the Fedorovo assemblage recovered from the Shchetkovo-2 site, most of which were surface-finds identified during the survey-works. One artifact came from the site of Chepkul-5, and it possibly pertains to the Koptyaki assemblage. Two pebbles showing use-wear traces were found in the filling of the Pakhomovskaya dwelling at the site of Bolshoi Imbiryai-2. Thus, such artifacts are recognized mainly among the records of the Cherkaskul and Fedorovo cultures, and more rarely in those of the Pakhomovskaya and Barkhatovo cultures (Fig. 1).

The traceological analysis and microimages of use-wear traces detected on pebble-tools were made using an Olympus BX-51 metallographic microscope with a ProgRes C10 camera, and a MSP-1 zoom microscope with a Canon EOS-1100 camera. Under the microscope, the working-platforms of the pebbles were positioned horizontally. In order to demonstrate fully the various characteristics of their wear, the microimages were captured at two magnifications (10x and 50x).

## Manufacturing technique

Small and medium-sized flat rounded quartz pebbles, both intact and broken, were used for manufacturing tools. The working area was a convex edge, less frequently one of the surfaces (often without special treatment). In addition, some specimens revealed traces of preparation of the working-platform, including alignment of the convex edge by direct percussion; and sometimes the area of pebble-splitting was used as a working-platform.

Most of the studied artifacts are oval in shape (Fig. 1), but some show triangular (3 spec.), trapezoid (2 spec.), and rectangular (3 spec.) forms. There are tools produced on pebble-fragments (Fig. 1, *13*, *14*). The average length varies from 1.3 to 2.4 cm (only one specimen was 3.9 cm long), the width from 0.9 to 2.3 cm, and the thickness from 0.4 to 1.2 cm. In most instances, the working-area was a longitudinal lateral edge showing various degrees of wear (43 spec.). Artifacts having traces of wear on one of the surfaces (7 spec.) were also recovered. They usually had one working-platform. Some pieces revealed two working-edges separated by a ridge (Fig. 1, *14*, *22*).

The assemblages of artifacts collected at each site contain pebbles with spalls and dents resulting from direct percussion, and also pebbles without any traces. The latter appear to have been blanks for tools to be produced. One of the pits associated with structure 6 at the site of Khripunovskoye-1 revealed an accumulation of 46 pebbles without use-wear traces on their surfaces. The pieces with dents are often interpreted as hammerstones or/and retouchers, but the small sizes and, consequently, small weights of the studied pieces preclude their assignment to such a type of tool.

## Traceological analysis

After traceological analysis of an archaeological assemblage, on the basis of the recognized set of

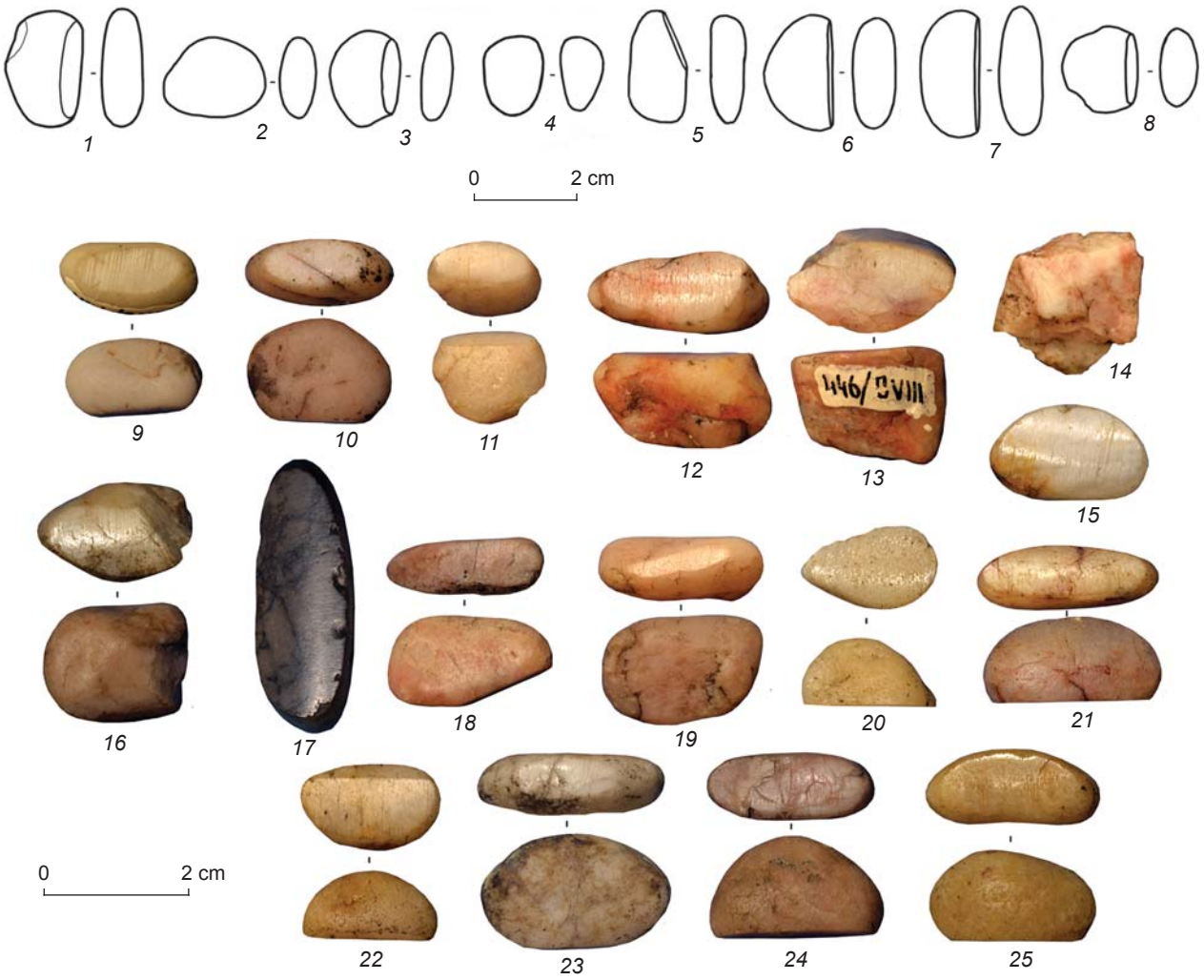


*Fig. 1.* Pebble-tools from the Bronze Age Tobol sites.
*1–3*, *8–13* – Olkhovka; *4*, *6*, *7*, *17*, *19–21*, *23–25* – Khripunovskoye-1; *5*, *16*, *18* – Bolshoy Imbiryai-2; *14* – Bolshoy Imbiryai-10; *15* – Imbiryai-3; *22* – Krivolukskoye-7.

use-wear traces, tools made of pebbles were divided into four groups. These sets were determined by such parameters as crumbling, characteristics of working-platform, polishing, voluminous traces, traces on the backed parts of tools, and various deformations.

The first group includes flat pebbles (21 spec.) with the evened working-platform located on one edge. These pieces reveal a rounded edge of the working-area, showing small facets of use with blurred contours (Fig. 2). The working-area has an even (or slightly tilted) U-shaped transverse and a longitudinal sections with rounded corners. One edge of the working-area, which appears to have contacted the worked surface most intensely, is found to be more smoothed, covered with microfacets of use, and worn. In four cases, split pebbles reveal the reorientation of a blade from the side of the fracture, resulting in two contiguous working-surfaces. Polishing is dull and heavy, spreading into the microrelief of the working-surface, and partly covering the adjacent surfaces. When slightly magnified (at 10x), it looks very bright, simply glassy; and at a 50x magnification it retains its characteristics, but becomes somewhat diffused (Fig. 2). In some cases, mat polishing typical of quartz materials, abrading the microrelief, was recognized (Fig. 2, *6b*). Linear traces represent numerous elongated or short, sharp, deep scratches and notches located perpendicular, or slightly inclined, to the long axis of the working-area. They are mainly concentrated at one edge of the working-platform, spreading as far as its center and up to the

other edge. In many cases, a surface with linear traces shows the corrugated appearance typical of tools used for processing animal-skins.

The second group includes five pebbles. The characteristics and locations of their working-areas are similar to those of the first group, but the set of use-wear traces differs. The working-surface is even, worn and smoothed at the same time, U-shaped in cross-section, with clear outlines (Fig. 3, *2*, *4*). Some pebbles reveal medium-sized facets of use around all edges of the working blade. Polishing looks like bright shiny spots, and shows a linear orientation; it is superficial, not penetrating deeply into the microrelief, and characterized by blurred boundaries with an unpolished area. Linear traces are located in the polished area. These are short parallel scratch-marks located transversely to the working-platform, and chaotic, crossing scratches.

The third group of pebbles (25 spec.), in addition to the set of traces typical of the first and second groups, features two levels of polishing (Fig. 3, *1*, *3*, *5*, *6*). The first, heavy and penetrating deeply into the microrelief, covers the working-platform completely. The second level can be recognized over the described one, and reveals an area of brighter, glossy polishing with clear outlines, including small-sized scratch-marks, crossing scratches, and circular scratch-marks. This polishing is mainly located in the center of the working-platform, without reaching the edges. The first polishing is typical of leather-processing, and the second could have resulted from working with a different material (clay or bone (?)), which attests to the multifunctional use of pebbles.

It should be noted that tools of the three groups have the ideally evened working-area. What could have led to the formation of such a surface? Firstly, we assumed that it resulted from shaping of the working-platform by abrasive grinding. However, microscopy of the archaeological tools revealed no signs indicating the use of this method. We suggest that formation of the even surface may have been caused by working on a firm base. In this manner, the processing of leather could have been performed. In addition, the rapid formation of the even surface may have resulted from the use of such a technique as alignment by trimming of the surface and edges of the working-platform, which were subsequently leveled during the work, as noted on a few specimens.

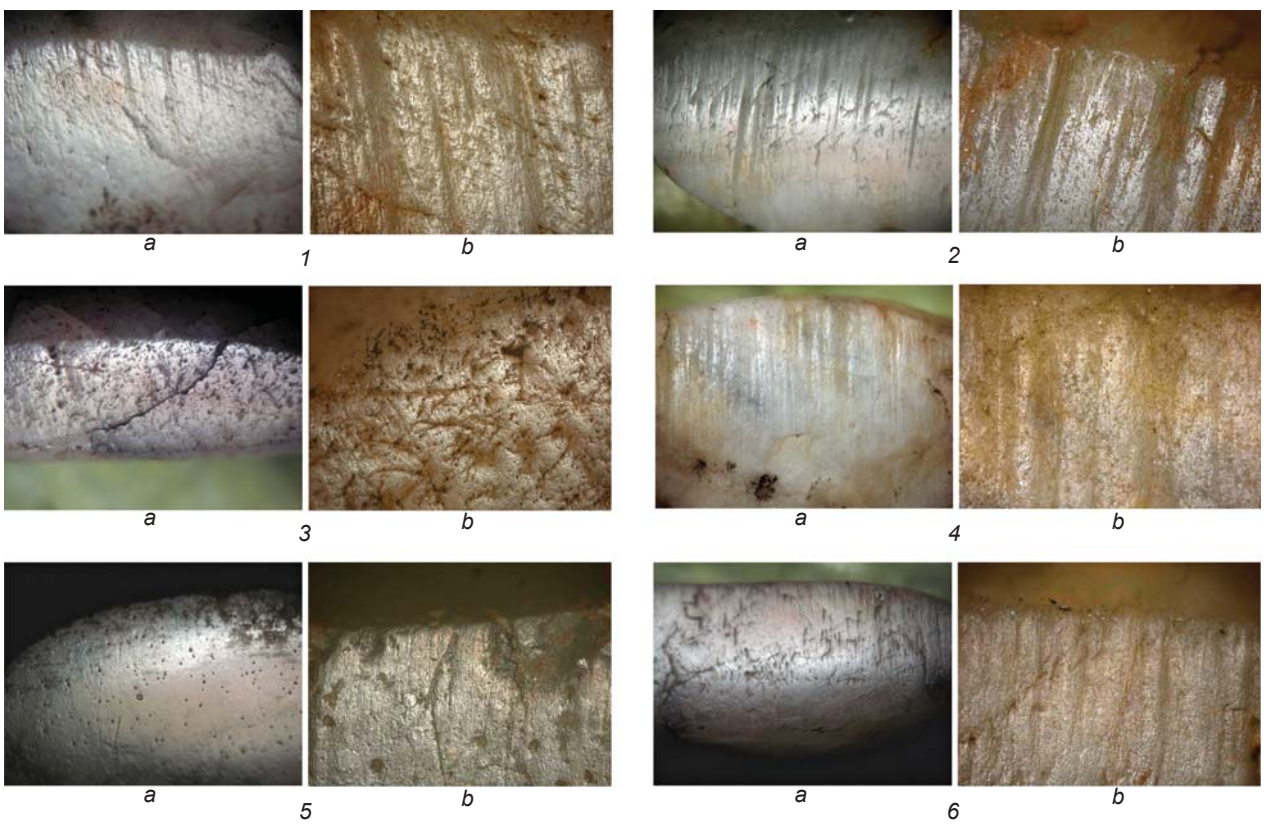


*Fig. 2.* Use-wear traces on pebble-tools used for processing animal-hides and skins.
*1* – Bolshoy Imbiryai-2; *2* – Imbiryai-3; *3–6* – Khripunovskoye-1.
*a* – 10x magnification; *b* – 50x magnification.

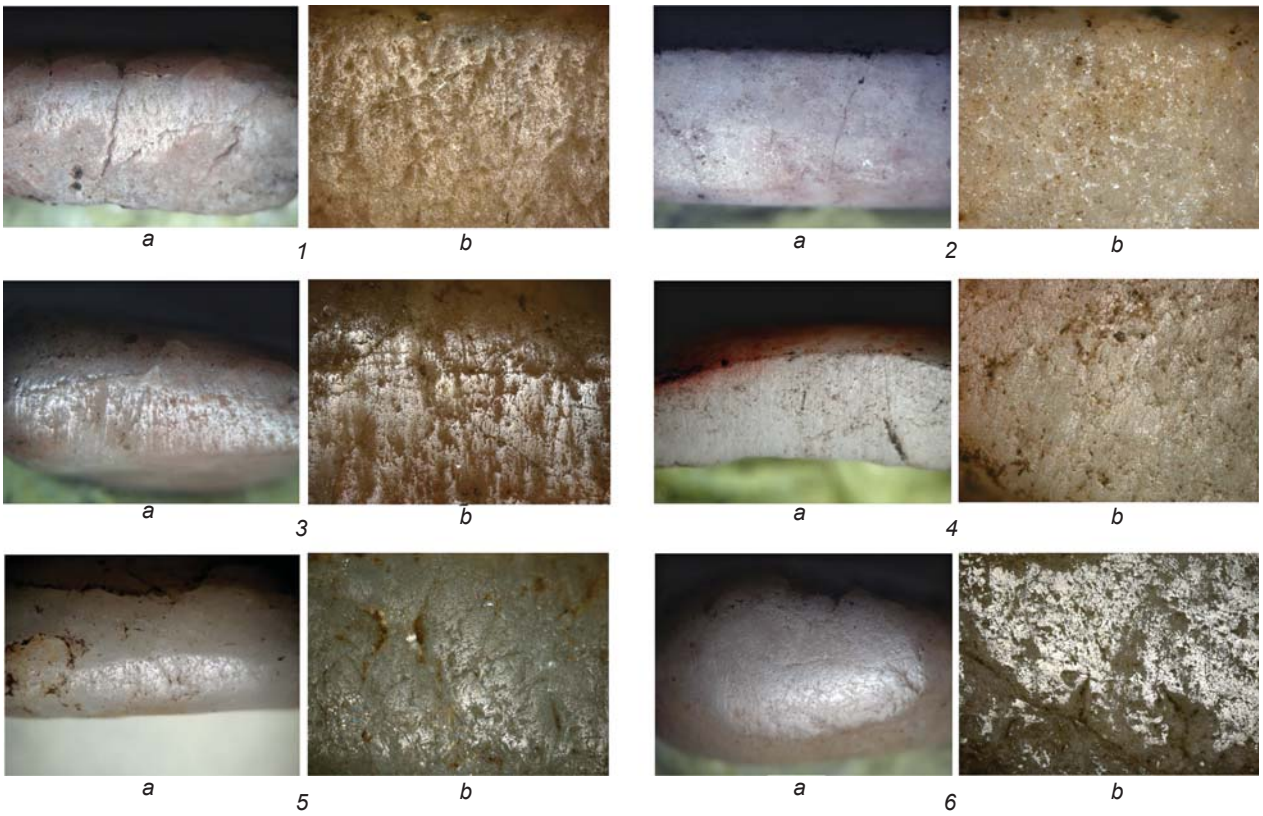


*Fig. 3.* Combined use-wear traces (*1*, *3*, *5*, *6*) and traces of treatment of the pottery-surface (*2*, *4*) on pebble-tools.
*1* – Bolshoy Imbiryai-2; *2–5* – Khripunovskoye-1; *6* – Bolshoy Imbiryai-10.
*a* – 10x magnification; *b* – 50x magnification.

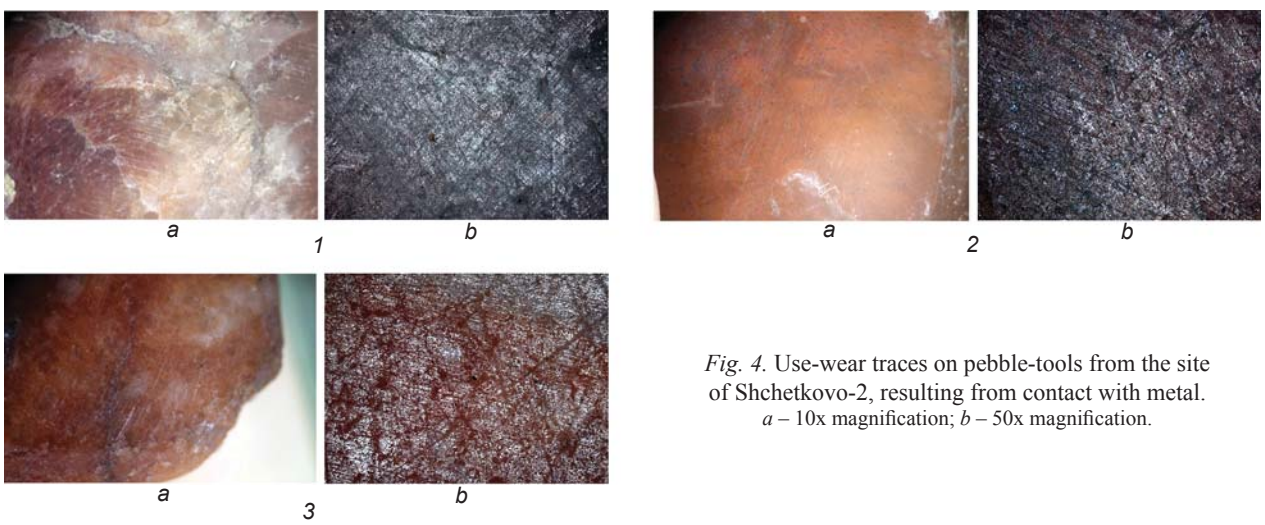


*Fig. 4.* Use-wear traces on pebble-tools from the site of Shchetkovo-2, resulting from contact with metal.
*a* – 10x magnification; *b* – 50x magnification.

Examination showed that for the pebbles included in the fourth group (4 spec.), the working-area was one of the flat surfaces. The working-area can be characterized by clear outlines; it is even, smooth, abraded, and polished to a metallic shine. Linear traces are located in the area of polishing, and look like crossing, very thin, long, even scratches (Fig. 4).

## Experimental simulation of use-wear traces on the pebbles

A series of experiments in processing hides, dressing skins, and polishing clay vessels, stone axes, and metal tools was conducted under the direction of V.E. Chibiryak and S.N. Skochina in order to assess

tentatively the function of the pebble-tools. During the experiments, small-sized rounded quartz pebbles collected on the shores of the Tobol, Pur, and Agan Rivers were used, having mineralogical properties similar to those of the archaeological specimens. The work with the pebbles lasted 1 to 3 hours. Their working-platform was not shaped intentionally, with the exception of one specimen whose platform was ground using an abrader.

In the course of the experiment, several options for the possible use of pebbles were tested. When processing hides and skins (11 spec.), the following operations were carried out: fleshing, fluffing, and polishing, including polishing suede leather with fatting and polishing leather with sand; unhairing of a soaked hide on a board; and softening and burnishing a dried hairless rawhide with fine spathic sand. Ten pebbles were used for burnishing clay vessels, three for polishing abraded stone axes, and one for polishing a bronze article. For a comparative analysis of use-wear traces, several pebbles (three quartz specimens and three carnelian specimens), used in the process of pottery polishing by researchers from the Samara expedition on experimental study of ancient pottery, were examined under the microscope*.

## Traceological analysis

The experimental pebbles used for processing hides and skins revealed similar polishing characteristics (Fig. 5). This polishing is fat, dull, penetrating deeply into the microrelief, spreading across the whole working-platform, overlapping the adjacent areas, and showing blurred boundaries with the unpolished surface (Fig. 5, *1–3*). Most part of the working-area demonstrates extensive polishing, gradually dissipating towards the edge. If a dried leather was polished, or if this process was carried out using the sand, then the polishing shows a wavy structure (Fig. 5, *4*, *5*). The edges of the working-area are almost free of crumbling; they are rounded and smoothed. The cross-section of the edge shows an arch-shaped profile. Linear traces represent numerous elongated or short scratch-marks and notches located perpendicular to the long axis of a pebble. They are uniformly distributed along the whole length of the working-platform. Most impressive are traces of such operations as fleshing with sand and unhairing of a soaked deerskin on a board, and also polishing of a dried rawhide (Fig. 5, *6–9*).

Alignment of the working-platform of a tool was tested experimentally. One pebble was shaped with an abrader and then used for polishing clay mixed with grog and pine needles. It was found out that the resulting use-wear traces do not overlap an abrasive grinding, and the latter can still be seen clearly with the naked eye (Fig. 6, *1*). Therefore, the main reason of the formation of a leveled surface on some archaeological specimens is, in our view, the processing of leather on a firm base, as attested by the experimental studies. A small fragment of leather (6 $dm^2$), dried after soaking and unhairing, was subjected to softening (from the outer hairless side) using an untreated pebble, on a flat board. During processing, a clearly visible flat working-area with use-wear traces typical of some archaeological specimens appeared on the experimental tool.

The main output of the experiment was confirmation of the effectiveness, and sufficiently high productivity, of the use of pebbles for softening rawhide. After half an hour of processing, the discussed hard, dry and friable fragment became soft, pliable, and smooth. In addition, the need to increase local pressure on the processed surface, and to ensure a firm flat base below it, was identified. Owing to the necessity of holding an accommodation-part of a pebble in the hand, traces of polish are formed as a gloss slightly penetrating the microrelief.

Experimental smoothing of outer surfaces of the dried clay vessels showed that small pebbles with naturally-flattened smooth areas are the most convenient tools for this procedure. The processing was carried out by short multidirectional smoothing movements. As a result, the surface of the pottery, previously dull and rough, obtained a polished appearance and a technologically required firmness. There was no need for increased pressure in doing this work, and the leveling of the working-area of the tool progressed slowly.

During polishing of the pottery-surface, the protruding parts on the working-area become ground and smoothed, taking an arch-like shape in cross-section (Fig. 7, *2*, *3*). Polishing-characteristics are found to be similar for all tools included in the group (Fig. 7). The polish is bright, but superficial, not penetrating into the microrelief. When using a pebble for a short period (1 hour), the polishing becomes spotty (Fig. 7, *1*, *4*, *8*), or may be diffused and linear; the boundary with an unpolished area is

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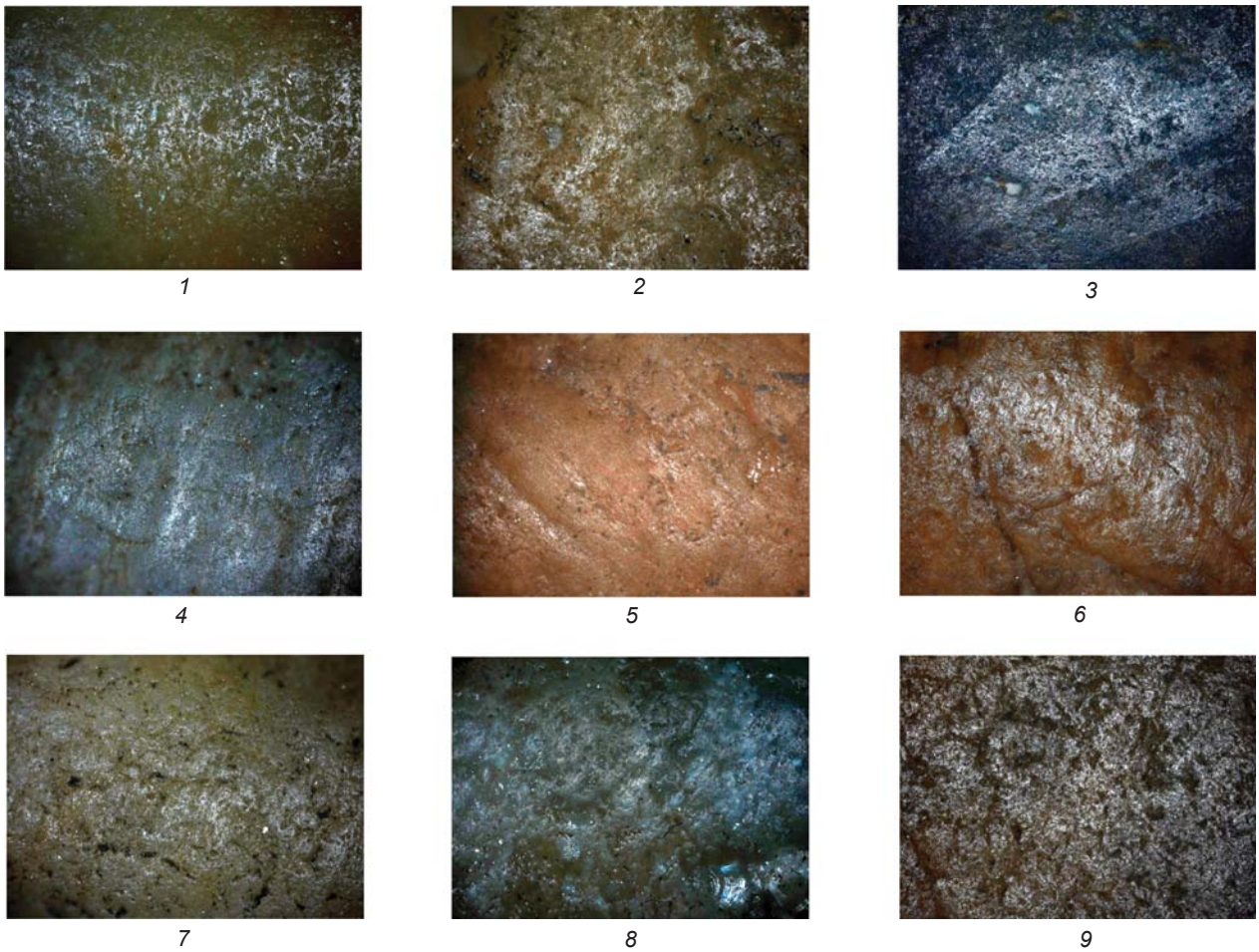


*Fig. 5.* Use-wear traces resulting from processing skins and hides (50x magnification). Experimental specimens. Quartz.
*1* – fleshing (30 min); *2* – fleshing a soaked skin with sand (30 min); *3* – polishing finished suede with fatting (1 h); *4* – polishing a dried hide (1 h); *5* – polishing a rawhide belt (1 h); *6* – unhairing of a soaked hide on a board (1 h); *7* – softening and polishing rawhide (1 h); *8* – fluffing (2 h); *9* – fleshing with sand (2 h).


*Fig. 6.* Traces resulting from abrasive grinding of the working-area and from polishing the surface of pottery (*1*), from polishing a stone-axe (*2*) and a bronze article (*3*). 50x magnification. Experimental specimens. Quartz.

clear or slightly blurred. Two specimens revealed transverse short thin scratches with soft contours, parallel to each other (Fig. 7, *2*). After three hours of work, the polishing completely covers the protruding parts of the microrelief, without going deeper into the irregularities. In the case that polishing lasts 1 or 2 hours, linear traces almost do not appear. A different pattern is observed on pebbles used for processing

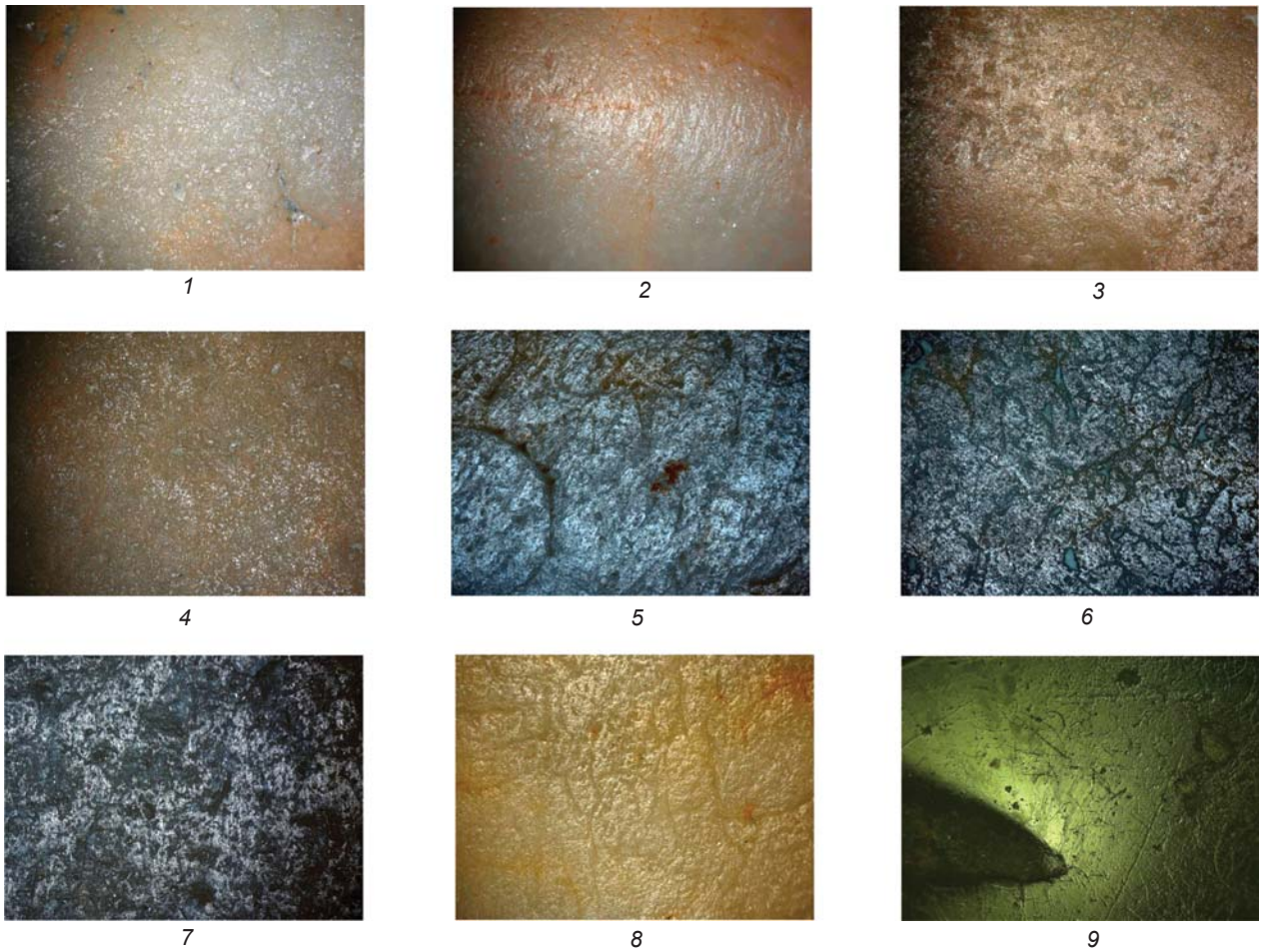


*Fig. 7.* Use-wear traces resulting from processing of the surface of pottery (50x magnification). Experimental specimens. Quartz (*1–8*), carnelian (*9*).

clay tempered with grog and sand. Their polishing attains linearity, and also thin parallel scratch-marks and chaotically arranged rough scratches appear (Fig. 7, *5–7*). It can be inferred that characteristics of traces depend directly on the composition of the fabric. In addition to the described traces, C-shaped scratches resulting from circular movements can be recognized on the working-surfaces. Similar scratches were noted on the pebbles analyzed by the Samara expedition (Fig. 7, *9*).

The working-area of pebbles used for polishing abraded stone axes is located on one of their surfaces. During the experiment, it was aligned. A bright, diffused linear polishing appeared, not penetrating deeper into the microrelief, but seemingly abrading its protruding parts. It revealed linear traces in the form of crossing and parallel scratches with blurred contours (see Fig. 6, *2*). Similar processing of a bronze article also shows abrasion of the working-area, resulting in a spotted polish with a metallic shine, which doesn't penetrate deeply into the microrelief during the initial stage (30 min) of work (see Fig. 6, *3*).

It should be noted that the archaeological specimens were worn much more than the experimental ones. This is attributed to the lack of the long-term technological series and the modeling nature of tests. However, the experimental specimens show a strong differentiation in use-wear traces, and it may be confidently stated that a set of traces on the pebbles used for experiments in the processing of animal-hides and dressing skins can be correlated with that identified on the archaeological specimens of the first group. Wear-pattern indicates the use of these artifacts for fluffing, and polishing skins and hides; and also suggests their use in other leather-making operations. The experimental polishers for clay can be compared to the pebbles from the second group.

In addition, the analysis of pottery from the sites at issue showed that the technology of manufacturing vessels involved the smoothing of their surfaces and polishing. For these operations, small river-pebbles appear to have been the most appropriate objects in terms of size and technical characteristics. This is also attested by the nature of traces recognized on pottery.

The availability of pebbles with a combined set wear traces in the archaeological assemblage provides evidence for their multi-functionality. In our view, they were used for polishing leather, pottery surface, etc. No pebble-tools used for polishing stones were identified among those subjected to traceological analysis. This is quite consistent with isolated occurrences of polished stone artifacts in materials of the Late Bronze Age cultures in the Tobol forest-steppe. Pebbles included in the fourth group demonstrate use-wear traces typical of the surface-treatment of metal articles. Such a conclusion correlates with the interpretation of similar Bronze Age pebbles found in the Kulunda steppe, as tools for finishing surfaces of bronze casts (Kungurova, Udodov, 1997: 78).

## Conclusions

Thus, the experimental traceological analysis showed that the Tobol population of the Late Bronze Age used river pebbles in several branches of manufacture. Objects with the combined use-wear traces (25 spec.) were found to be the most numerous. They were used for dressing hides and skins, and for burnishing clay vessels. It means that these tools were multifunctional. A total of 21 of the studied pebbles was used in leather production alone, whereas 5 and 4 were used for processing clay and metal articles, respectively. In their functionality, pebble-tools were as good as traditional end-scrapers and polishers made of stone, bone, and ceramics.

Extensive use of pebbles was due to the widespread availability of this raw material, which was abundant in the immediate vicinity of the ancient settlements. In addition, it didn't require any retouch and actually represented a finished tool.

The tradition of manufacturing tools from the small-sized quartz pebbles was not exclusively Trans-Urals. This raw material was commonly used, for example, by the carriers of the Pit Grave culture and by inhabitants of the Altyn-depe fortified settlement (Semenov, Korobkova, 1983: 137, 147; Korobkova, 2001: 159; Korobkova, Shaposhnikova, 2005: 175, 193). The occurrence of such tools in the Trans-Urals refers to the Andronovo population: isolated articles were recognized among Alakul materials, and the most numerous finds were noted in the Fedorovka and Cherkaskul collections.

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